Hydroponic of Chili with substrates variation

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Abstract. Climate change leads and increase the food risky because it is hard to predict the timing or severity of its occurrence, and hydroponics is a method to overcome this problem. This research was held in the green house located at Sebelas Maret University, Indonesia, from October 2016 until March 2017. This study aimed to assess the effects of using some substrates on growth and yield of the hot pepper plant. The experiment was arranged in Randomized Complete Design with single factor. The factor was kind of substrates consisted of 6 levels, i.e.: husk charcoal (as control), steamed husk, cocopeat, combination of husk charcoal + zeolite (1:1, v/v), steamed husk + zeolite (1:1, v/v), and cocopeat + zeolite (1:1), v/v. Data were analyzed using Anova and HSD test at α=0.05. The results showed that substrates effected the number of leaves, chlorophyll content, root volume, dry weight, number of fruit and total fruit weight.

1. Introduction
Climate change has caused agricultural land damage so that the land becomes infertile and unproductive. Climate change is predicted to worsen agricultural productivity and projected global agricultural productivity will decline 3% to 16% until the 2080s. The decline in agricultural productivity in developing countries will reach 10 to 25%. The decline in agricultural crop productivity in general is a result of a decrease in the availability of water for plants so that plants [1]. Hydroponic is the one alternative of the agricultural production.

Chili is one of the horticultural commodities that are in great demand by the people of Indonesia. Producing quality crops both qualitatively and quantitatively is farmers’ expectations. The development of a good root system will increase vegetative growth and increase yields in both quantity and size. Improper root development causes water absorption and nutrients inhibited causing a decrease in the quality of the chili produced [2]. The development of good roots can be improved with the use of appropriate planting media (substrate). The cultivation of chili with hydroponics system is an efforts to increase the production both qualitatively and quantitatively.

Rice-husk Charcoal is a substrate commonly used in the cultivation of fruit and vegetable commodities in the hydroponic system, as well as gravel and rockwool [3]. There are a variety of substrates that can be used in the cultivation of chili hydroponic systems such as steamed rice-husk, cocopeat and zeolite. One of the factors causing the low production of chili in Indonesia is because the minimum supply of nutrient in the substrate and also low nutrient absorption by the root [4], so that the use of a substrate with proper application of nutrients is expected to increase the growth and yield of chili.
2. Material and method
The materials used in this research were Hot Beauty chili variety, rockwool, zeolite, cocopeat, rice-husk charcoal, steamed rice-husk, and nutrient for hydroponic. The tools used were the seedling tray, 25 liters volume of buckets, mixer, polybag, cutter, scissors, measuring cups, EC meter, pH meter, label name. The design used was Completely Randomized Design, single factor with four replications. The factor was kind of media consisted of 6 levels: rice-husk charcoal (as control), steamed rice-husk, cocopeat, combination of rice-husk charcoal + zeolite (1:1, v/v), steamed rice-husk + zeolite (1:1, v/v), and cocopeat + zeolite (1:1, v/v). Data were analyzed using A and LSD test at $\alpha=0.05$.

The implementation of the research started from seeding seeds, preparation of tools and materials, transplanting, nutrition preparation, application of treatment, data retrieval and harvesting. The variables observed in the study were, leaf number, chlorophyll content, root volume, plant dry weight, fruit number and fruit weight.

3. Results and discussion
The Green House condition during the experiment can see in Table 1. Plant growth is strongly influenced by microclimatic conditions, especially temperature and humidity. Table 2 showed the Physical properties of substrates.

| Period       | Temperature (°C) | R H (%) |
|--------------|------------------|---------|
| 06.30 - 10.00 | 22.9 - 27.3      | 80 – 89 |
| 10.00 - 13.00 | 37.7 - 43.2      | 45 – 58 |
| 15.00 - 17.00 | 27.2 - 29.3      | 68 – 72 |

| Code | Kind of Substrate          | Bulk Density (g/cm³) | Particle Density (g/cm³) | Water Holding Capacity (%) |
|------|---------------------------|----------------------|--------------------------|---------------------------|
| S1   | Husk Charcoal             | 0.64                 | 1.7                      | 89                        |
| S2   | Steamed Husk              | 0.16                 | 1.60                     | 42                        |
| S3   | Cocopeat                  | 0.72                 | 1.05                     | 69                        |
| S4   | S1 + Zeolite (1:1, v/v)   | 0.92                 | 1.55                     | 28                        |
| S5   | S2 + Zeolite (1:1, v/v)   | 0.60                 | 1.71                     | 16                        |
| S6   | S3 + Zeolite (1:1, v/v)   | 0.78                 | 1.42                     | 24                        |

3.1. Leaf number
Table 3 showed the vegetative growth variables (Leaf number, chlorophyll contents, Root volume) and yield variables (Fruit number, Fruit eight and Dry weight). The number of leaves is one indicator in plant growth as a determinant in the formation of plant biomass. Environment and genetic factors greatly affect the number and shape of the leaves. The number of leaves will increase as the age of the plant is also influenced by plant genotypes.

Leaf is the main organ in the absorption of solar radiation. The more the number of leaves the greater the absorption of solar radiation that occurs [5]. Steamed rice-husk media has significantly different result tends to be lower than control treatment, it is suspected because the steamed rice-husk has a low bulk density value of 0.16 g/ml which means has a low density of the action so that the capability to plant low and leaf formation becomes less optimal.
Table 3. The vegetative growth and yield variables of Chili

| Code | Kind of Substrates | Leaf Number | Chlo. Contents | Root Volume (ml) | Fruit Number | Fruit Weight (g) | Dry weight (g) |
|------|-------------------|-------------|----------------|------------------|--------------|-----------------|--------------|
| S1   | Rice-husk Charcoal | 809 bc      | 56.9 bc        | 720 bc           | 186 b        | 673 b           | 112 b        |
| S2   | Steamed Rice-husk  | 572 a       | 56.2 bc        | 557 a            | 115 a        | 442 a           | 54 a         |
| S3   | Cocopeat           | 953 d       | 51.6 a         | 690 a            | 161 b        | 656 b           | 98 b         |
| S4   | S1 + Zeolite       | 924 bc      | 59.8 c         | 567 ab           | 175 b        | 630 b           | 109 bc       |
| S5   | S2 + Zeolite       | 540 b       | 59.6 c         | 560 ab           | 123 a        | 503 a           | 69 a         |
| S6   | S3 + Zeolite       | 1089 e      | 55.3 bc        | 667 ab           | 159 b        | 599 b           | 123 c        |

Note: Values followed by the same letter in the same column are not significantly in HSD test of 5%.

3.2. Chlorophyll content

Plant growth and development is influenced by genes, hormones, anatomical structures and plant organ morphology and chlorophyll content and other pigments [6]. The function of chlorophyll in plants is to absorb energy from sunlight for use in photosynthesis, a biochemical process in which plants synthesize carbohydrates (sugar to starch), from carbon dioxide gas and water with the aid of sunlight [7]. The greenness of the leaves is closely related to the total chlorophyll. The higher the total chlorophyll the higher the level of greenness. The content of chlorophyll in the leaves will affect the photosynthetic reaction. The cocopeat substrate has significantly different chlorophyll content than the control substrate and the other substrate, which tends to be lower. A small amount of chlorophyll will not make a maximum photosynthetic reaction. When the photosynthesis reaction is not maximal, carbohydrate compounds produced also cannot be maximized. According to Hendriyani dan Setiari [8] chlorophyll synthesis is influenced by various factors such as light, sugar or carbohydrates, water, temperature, and genetic factors. The more chlorophyll content the possibility of the process of photosynthesis will run faster so that the resulting photosynthate is higher. Photosynthesis is used to meet the needs of plants, growth as well as food reserves [6].

3.3. Root volumes

Chili plants can produce high levels of assimilate if nutrient and mineral intake are available optimally. The supply of nutrients and minerals will depend on the ability of the roots to absorb nutrients. The root uptake capacity describes the ability of the roots to absorb nutrients and minerals from the soil. High root uptake capacity is characterized by high root volume [9]. The greater the volume of roots the greater the nutrient uptake and water availability of the planting substrate, but it is also supported by optimal environmental conditions for the plant.

The highest root volume was obtained in the control treatment (rice-husk charcoal), so the assumption of using other substrates able to beat the measurement of root volume on the frequently used media. However, large roots and large root volumes do not always play a positive role in plant growth because too large a portion of the roots will consume much energy for performance, so some of the photosynthetic results that should be used for the formation of the upper part of the plant are removed for root development, growth and yield formation.

3.4. Plant dry weight

Different treatments will have different effects including the fresh weight of the plant canopy. The nature of the media relates to the ability to provide nutrients for plants. Porous media will be able to provide oxygen for root plant respiration so that root growth can be maximized with a maximum growing canopy [10] Stated that the fresh weight of plants can show the activity of plant metabolism and the value of wet weight of the plant is influenced by the water content of tissue, nutrients and metabolism results. Crop production is usually more accurately expressed by dry weight size than with
wet weight, since wet weight is strongly influenced by moisture conditions [11]. The fresh and dry weight of the plant is affected by elements such as nitrogen, phosphorus and boron. Nitrogen deficiency can lead to inhibition of growth and decreased biomass production in leaves, roots and buds.

Growth is defined as cell division (increase in number) and cell enlargement (size increase), but the most common definition is the increase in dry weight. Dry weight is generally used as a guide that gives growth characteristics [12]. The dry weight of the plant reflects the growth of the plant and the number of nutrients absorbed per unit of biomass weight produced. The higher the dry weight value of the plants produced, the better the plant growth and the more nutrient absorbed. Fresh weight is less useful because the numbers are fluctuating, depending on the state of the plant moisture. The dry weight of plants in the form of total biomass, is seen as a manifestation of the process of metabolic processes that occur in the plant body. Dry weight can show plant productivity because 90% of photosynthesis results are present in the form of dry weight [12].

3.5. Fruit number

The formation of the fruit is determined by the night temperature factor. Experience in various countries proves that too high a temperature at night causes tomato plants can not form flowers at all, whereas at temperatures less than 100 C pollen becomes a weak growing and many pollen is dead, due to only a few that occur fertilization [13]. In addition to being influenced by nighttime temperatures, daytime air temperatures can also cause flowering. Temperatures that are too high in greenhouses are thought to cause pollen to fall, making it impossible to pollinate. Lack of pollination can also be caused by limited factors that can help pollination, like wind and insects.

3.6. Fruit weight

Fruit is an organ in flowering plants which is a further development of the fruit (ovary). Fruit is usually covering and protecting a seed. Fruit is the perfect growth of the fruit (ovary). Each fruit will contain one or more ovules each containing an egg [14]. The fruit development stage includes the stages of fruit set, developing fruit, green fruit, breaker stage, turning stage, pink stage, light red stage and ripe. Fruit set marked by petal and anther senescence and finally fall. Next, a pea-sized fruit appears. From this point, until the fruit can be harvested it takes 40-50 days. Developing fruit is characterized by the fruit that is green and very hard. Intensive cell division occurs but overall fruit growth is slow, takes 2-3 weeks. Based on table 3 it can be concluded that the weight of fruit is proportional to the number of fruits, the weight of most fruit is found in the rice-husk charcoal medium and the lowest fruit weight is found in steamed rice-husk medium

4. Conclusions

The growth and yield of chili were effected by the physical properties of the substrate. The cocopeat was the best for the hydroponic substrate, while rice-husk charcoal was rather good. Steamed rice-husk was the unstable substrate.

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