# The effect of three different containers of nutrient solution on the growth of vegetables cultured in DFT hydroponics

*By* S Triyono; RM Putra; S Waluyo and M Amin

IOP Conf. Series: Earth and Environmental Science **355** (2019) 012092 doi:10.1088/1755-1315/355/1/012092

# The effect of three different containers of nutrient solution on the growth of vegetables cultured in DFT hydroponics

**S Triyono, RM Putra, S Waluyo and M Amin**

Department of Agricultural Engineering, College of Agriculture, University of Lampung, Bandar Lampung, Lampung Province, Indonesia

E-mail: striyono2001@yahoo.com

**Abstract**. This study aims to test three different storage tanks (mechanical cooler, Styrofoam box, and bucket) of nutrient solution to cultivate three Brassica vegetables (pak coi, mustard green, and kai lan) in a DFT system. Randomized Complete Block (RCB) used consisted of a single treatment with 3 levels (the three vegetables) and 3 blocks (the three containers). The parameters observed in this study included air (temperature and RH), nutrient solution (temperature, pH, EC, evapotranspiration), plant (height, number of leaves, plant weight, and ash content). Air temperature and relative humidity were recorded using a data logger with delay time of 15 minutes. Daily pH and EC of nutrient solution were measured by using a TDS and pH meter. Evaporation and plant height was measured by using a rule, number of leaves was counted, and the rest were measured gravimetrically at the harvest time. The results showed that temperatures of the nutrient solutions were minimum of 15°C to maximum of 23-25°C (stored in the mechanical cooler), minimum of 24°C to maximum of 33-35°C (stored in Styrofoam box), and minimum of 24°C to maximum of 35°C (stored in the bucket). The nutrient temperature in the cooler was practically lower than that in Styrofoam box and bare bucket. Crops cultivated with nutrient solution stored in the cooler were the best for some parameters observed, followed by the crops cultured with nutrient solution stored in Styrofoam, and the worst was crops cultured in the nutrient solution stored in the bucket. Shoot fresh weights of harvested vegetables were 148.18±73.42 g plant$^{-1}$ from the cooler, 108.11±55.22 g plant$^{-1}$ from the Styrofoam box and 85.07±48.56 g plant$^{-1}$ from the bucket.

## 1. Introduction

Primary problem to cultivate leafy vegetables in tropical countries like Indonesia is because the high atmospheric temperature [1] especially for some species which originate from subtropical regions. Such vegetables possess optimal temperature to grow best although varieties and other factors also influence. For example, Gent [2] found that fresh and dry weights of lettuce are increasing when grown at 16 °C as compared to the same plants grown at 26 °C. Scaife [3] and Lee et al. [4] demonstrated better growth of lettuce when grown at atmospheric temperature of 22 °C. The optimum temperatures were practically bellow daily minimum atmospheric temperature of Indonesia although some parts specifically for high lands can reach that low temperatures [5]. Daily minimum temperature of Indonesia, specifically for Bandar Lampung City, is around 23 °C and the temperature can rise to maximum more than 32 °C. Therefore, there is a pertinent problem to increase productivity of leafy vegetables in Indonesia especially for imported cultivars whose low optimum temperatures.

For conventional farming system (soil media), modifying atmospheric temperature in tropical regions is not feasible if not impossible. More relevant environmental modification may be applied to greenhouse hydroponics systems. Even for greenhouse hydroponics, one needs to recalculate the economic aspect of modifying greenhouse temperature because this should be very costly. However, developing of greenhouse hydroponics could support the promotion of clean vegetable production [6].

Instead of controlling air temperature of the greenhouses, more effective modification may be applied to water temperatures or root zone temperature (RZT) of hydroponics farming system. The RZT needs to be controlled because suboptimal RZT can alter pH [7], promotes nutrient settling, hamper nutrient absorption [8], and finally end up with low productivity of cultivated plants. Modification of RZT to optimum ranges can improve both productivity and quality [9, 10, 11]. Tindall et al. [12] found that optimum RZT for tomato was 25 °C, while Al-Rawahy et al [13] demonstrated that 22 °C RZT produced the highest yield of cucumber. But the optimum RZT still depends on air temperature. In winter season, Nxawe et al. [14] increased spinach productivity through heating the nutrient solution to optimum nutrient temperature of 28 °C. Yan et al. [15] increased productivity of cucumber when RZT was increased from 12 °C to 20 °C. In order to get improved quality, manipulating RZT from 20 °C to 5 °C also improved some characteristics of spinach [16]. Sakamoto and Suzuki [17] regulated the RZT for carrot and improved some quality. Thus, manipulating RZT has been done to get some improvement of the cultivated products.

For static nutrient solution systems, most techniques used to modify the temperatures of nutrient solution were through cooling pipe systems of water by means of mechanical coolers, connected to the nutrient solution in growing vessels [18]. For continuous closed systems, controlling nutrient temperature was done in the storage tanks of nutrient solution [13, 17, 19]. Even there was no further description on how the cooling systems were incorporated, but because those cooling systems were for research purposes, those must be supported by proven cooling technologies.

For applied purposes, application of such cooling technology has to be technically feasible. For that reason, it is very crucial to investigate on how to cool the nutrient solution, especially for tropical regions like Indonesia. This research is to test three nutrient storage tanks (mechanical cooler, Styrofoam box, bucket) for cooling nutrient solution, and investigate the effect of the cooled nutrient temperature on growth and yield of three vegetable species of Brassica genus (Brassica chinensis, Brassica rapa L., Brassica oleracea).

## 2. Materials and Methods

### *2.1 Seedling*

After soaked with water for a couple of hours, seeds of Brassica genus of different species, namely pak choi or bok choy (Brassica chinensis), mustard green (Brassica rapa L.), and kai lan/Chinese kale (Brassica oleracea) were sown and inserted one by one on the top part of a rock wool cube (3x3x3 cm). The cubes of inserted seeds were put on a tray and moistened with water every day. The seeds were allowed to germinate and grow for two weeks. After two weeks, good baby shoots were selected and transplanted to Deep Flow Technique (DFT) hydroponics system.

### *2.2 Hydroponics system and mini greenhouse*

Hydroponics system used in this research was a DFT, closed system using PVC gutters as gullies. Three parallel gullies were used to setup the experiment. Each gully was 4 m back and fort, making total of 8 m long. Planting distance used was 20 cm, so there were about 40 plants in each gully. For the three gullies, there were total of 120 plants cultivated in these DFT hydroponics systems.

Each gully used a different nutrient solution storage tank or container. The first container used a mechanical cooling machine to maintain the solution temperature low at designed level. The second container was a 2 cm thick Styrofoam box. The third container was a bare bucket with no insulator.

By doing this, the nutrient temperatures were expected to be significantly different. Every container has volume about 50 liters, and has a small water pump (3 m height capacity) to deliver the nutrient solution.

The hydroponics system was placed in a mini greenhouse, 14% UV plastic roofed and 40 mesh screened. The tall of the greenhouse was about 2 m, while its length and width were just fit with all of the gullies. The gullies were positioned on 1 m high from soil surface. In such setup, nutrient solution was easily to be circulated from container to plants along the gully, and back to the containers.

A Commercial AB mix (Nutrimix) was used in this research. Stocks (concentrated solution) for A and B solutions were first prepared, by diluting the A and B packets to 30 liters each. From the stock, dilute solution was made by diluting the stocks with water. At the first transplanting stage, the dilute nutrient solution was made at electric conductivity (EC) of 1500 $\mu$S/cm. At the next following week, the EC was adjusted to 1750 $\mu$S/cm, and finally to 2000 $\mu$S/cm till harvest. Vegetables were harvested at 28 days after transplanting.

### *2.3 Parameters observed*

Air temperature and RH were recorded by using DHT sensors, while nutrient temperatures were recorded by using DS 10B20 sensors, assembled with an Arduino Mega 2560 microcontroller. Nutrient EC was monitored by using a pocket EC meter, while nutrient pH was also monitored by using a pocket pH meter. Plant parameters measured included height, number of leaves; shoot fresh and dry weights, ash contents.

### *2.4 Experimental Design and Analyzes*

Randomized Complete Block (RCB) was used in this experiment as done by Nxawe et al [14]. Three blocks were the three parallel gullies with the three different nutrient containers which were supposed to have different nutrient temperatures. Treatment used was the Brassica plants with three different species: pak coi, mustard green, and kai lan. Data set was analyzed using ANOVA and followed by LSD multiple comparisons at 5%.

## 3. Results and Discussion

### *3.1 Air Temperature and RH*

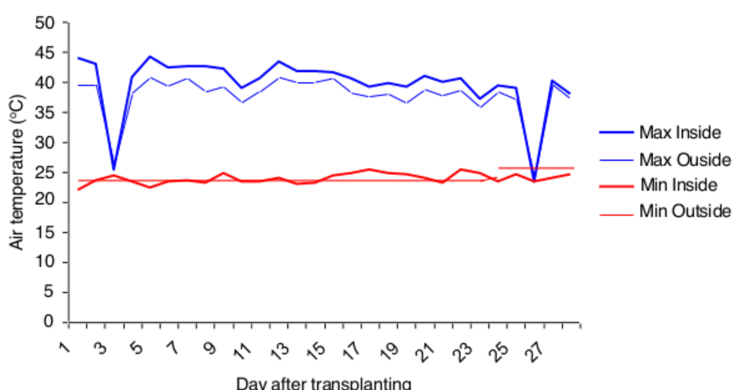


**Figure 1.** Daily maximum and minimum temperature of air inside and outside greenhouse.

Figure 1 presents daily maximum and minimum temperatures of air, inside and outside greenhouse. On the average, the minimum temperatures of air inside and outside greenhouse were about the same

(23.95±0.85°C and 23.40±0.39°C). The minimum temperature of air normally occurred after midnight until dawn. The maximum temperatures of air; however, inside and outside greenhouse were quite visible. Average maximum temperature of air inside greenhouse was 39.79±4.70 °C, while average maximum temperature of air outside greenhouse was 37.78±3.84 °C, about 2 °C difference. The difference was certainly because of greenhouse effect. In the first half growing period, most temperatures inside greenhouse were higher than 40 °C, while in the second half growing period the temperature inside greenhouse were less than 40 °C. This was because the experiment was conducted on the end of September to the end of October, so it was the end of dry season and about starting rainy season.

However, the average daily maximum temperature of air was so high that could be a detrimental effect on the plant growth and yield [20]. Mohammed et.al.[21] stated that high temperature could promote pests too, such as the green peach aphid (Myzus persicae), a major pest of leafy vegetables. The daily minimum air temperature was still above the optimum air temperature required by vegetables to grow best [2,3], suggesting to control the inside air temperature. In this research, the air temperature was not controlled. Instead, nutrient temperature was modified or maintained to the treatment levels. Using greenhouse, inside temperature is even higher. This is kind of dilemma because plastic roofed greenhouse is required to protect plants from hard rain, but the plastic roof of greenhouse tends to heat up inside room. A mechanical exhaust fan may be required to remove heat from inside greenhouse. However; attempt to lower the inside temperature in this research was not conducted, because the greenhouse was so small and the increased temperature was not much.

Figure 2 presents maximum and minimum relative humidity (RH) of air inside and outside the greenhouse. The minimum RH occurred around noon to 13.00. The outside RH was higher than the inside RH. Higher temperature of inside air was supposed to accelerate evapotranspiration of nutrient solution and increase RH, but the reality was different. High evapotranspiration did not raise RH inside greenhouse. This could be an indication that air circulation inside greenhouse was favorable. This was why inside air temperature was just 2 °C higher than the outside because heat inside greenhouse was effectively transported out the greenhouse. Another reason is that moisture holding capacity (saturation) of air is maximal when air temperature is maximal. Average RH of air outside greenhouse was 49.26±5.39%, while average RH of air inside greenhouse was 42.47±5.17%. The Low RH of air has potential negative effects on plant growth and yield [22].

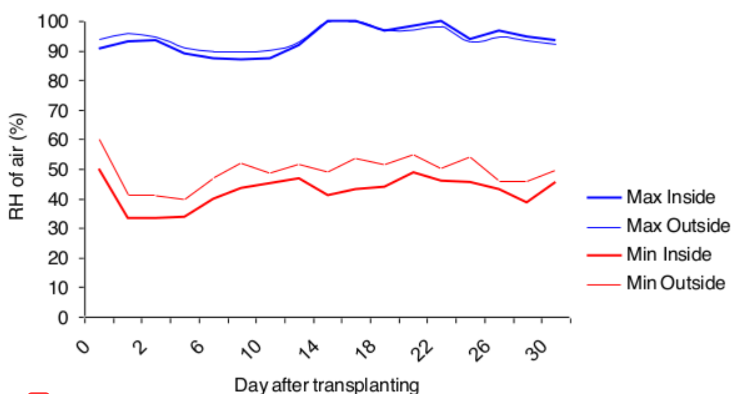


**Figure 2.** Daily maximum and minimum RH of air inside and outside greenhouse.

The magnitudes of maximum RH of air inside and outside the greenhouse were not much different, 93.76±4.41% and 94.41±3.26%. High RH normally occurred after midnight to approaching dawn when air temperature was low and air circulation was minimal. The high RH did not correspond to evapotranspiration because evaporation was minimal at night. High RH is basically because of low moisture holding capacity or low saturation point of the air at that time. This high RH may positively affect plant growth and yield [23]. Although, Palzkill et al. [24] found tipburn on young cabbage plants when cultivated at 82% (at day time air temperature of 20 °C), he got higher fresh and dry weight of cabbages as compare to that cultivated at RH of 52%.

*3.2 Nutrient temperature*

Effect of nutrient storage tank on daily minimum nutrient temperature is presented on figure 3. Minimum nutrient temperature occurred after midnight, close to dawn. We can see that daily minimum nutrient temperature stored in the mechanical cooler was lower than in the other two containers all the time. Average daily minimum nutrient temperature was 18.89±1.64 °C for nutrient stored in the mechanical cooler, and clearly lower than those stored in Styrofoam box and bucket (24.19±0.68 °C and 24.45±0.64 °C). Based on available literatures, optimum nutrient temperature was around 16 °C-22 °C [10, 11, 13]. Therefore, the mechanical cooler was so effective to maintain the daily minimum nutrient temperature at the optimal ranges. Whereas, the other storages (Styrofoam box and bucket) were not effective in that the daily minimum nutrient temperature were still above the optimal ranges.

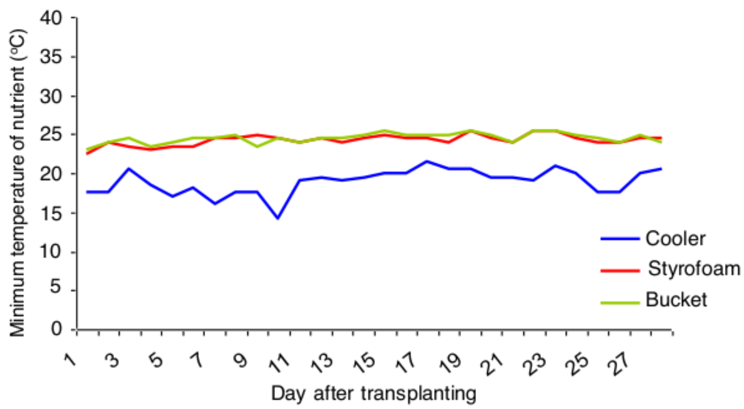


**Figure 3.** The effect of nutrient styorage tank on daily minimum temperature of nutrient.

Effect of nutrient styorage tank on daily maximum temperatures of nutrient was presented on figure **4.** Daily maximum temperature occurred at noon, to around 13.00. Average daily maximum temperature of nutrient stored in the mechanical cooler (27.73±1.70 °C) was also consistently lower than that stored in the Styrofoam and bucket (33.28±1.45 °C and 33.51±1.44 °C).

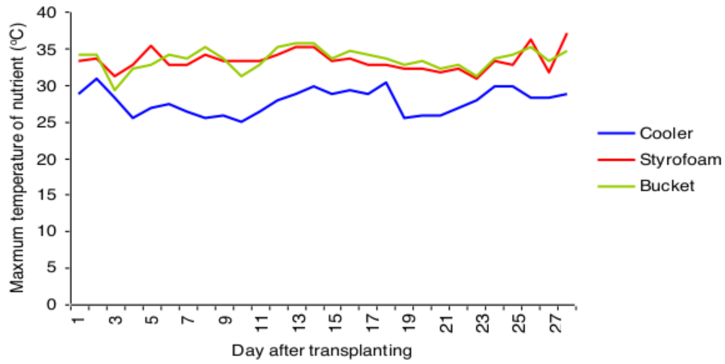


**Figure 4.** The effect of storages on daily maxmum temperature of nutrient.

However, the daily maximum temperature of nutrient stored in the mechanical cooler was still out of the optimal ranges. So, the problem was that the mechanical cooler was capable of maintaining daily minimum temperature of nutrient (which happened at night) but could not maintain daily maximum temperature at optimum level (which happened at day light). More accurate setting was probably required to get the mechanical cooler work properly.

*3.3 Plant growth and yield*

Effect of nutrient containers on plant growth is presented on figure 5. That all the plants grew hyperbolically was common sense. All plants linearly increased then tended to level off. But figure 5 clearly shows that plant growths were no difference to each other at the first stage, then those cultivated in nutrient stored in the cooler showed the best growth among the others. Plants cultivated with nutrient stored in the Styrofoam box showed the second best growth, and those cultivated in the bucket was the worst. Similar result was demonstrated by Al-Rawahy et al. [13], where cucumber cultivated in cooler root-zone temperature is grows best.

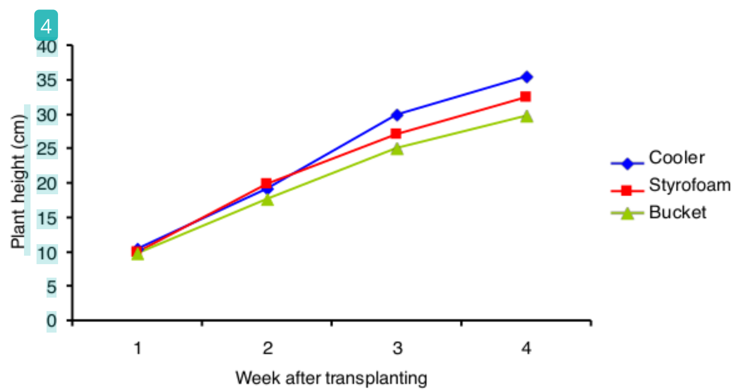


**Figure 5.** The effect of nutrient storage tanks on plant growths

Plant height of the forth week stage is presented on table 1. Because this research was to test the nutrient storage tanks, comparison among blocks (the nutrient storages) was of interest instead of comparing among treatments (vegetables). Statistical analysis showed that effect of nutrient storage tanks on plant height was significantly different at 5%. The height (35.40±11.86 cm) of plants cultivated with nutrient stored in the cooler was the same as the height (32.43±8.40 cm) of plant cultured with nutrient stored in Styrofoam box, but significantly higher than the height (29.79±8.76 cm) of plant cultivated with nutrient stored in the bucket. This was apparently the effect of nutrient temperatures. As mentioned above, daily minimum temperature of nutrient stored in cooler was 18.89±1.64 °C (just in the optimal ranges), while that in Styrofoam box was 24.19±0.68 °C and in the bucket was 24.45±0.64 °C although, all daily maximum temperatures of nutrient were above the optimal ranges. The plant responses in this study were similar to cucumber studied by Al-Rawahy et al. [13] and Moon et al. [22]. Plants cultivated in lower RZT grow faster than plants cultivated in higher RZT, for high air temperature. In this study, air temperature ranged from minimum of 23.95±0.85 °C to maximum of 39.79 °C inside the greenhouse. Sun et al. [11] also found higher lettuce when cultivated in 25 °C RZT as compared to that cultivated in 30 °C RZT.

**Table 1.** The effect of nutrient storage tanks on the plant height (cm) at the fourth week of growth.

| Plants | Nutrient Storage Tanks | | |
|---|---|---|---|
| | Cooler | Styrofoam Box | Bucket |
| Pak coi | 26.24 | 25.91 | 24.62 |
| Mustard green | 48.80 | 41.91 | 39.90 |
| Kai lan | 31.14 | 29.46 | 24.84 |
| Average | 35.40 | 32.43 | 29.79 |
| Deviation | 11.86 | 8.40 | 8.76 |
| LSD Notation | a | ab | b |

Similar pattern was shown by number of leaves parameters as presented on figure 6, about increasing from the first stage of growth. But from the first stages of growth to the harvest time, the number of leaves was almost no different among the treatments. This fact may suggest that number of leaves is not correlated to the treatments of nutrient temperatures. This similar situation is also shown by Al-Rawahy et al. [13] for cucumber and Sakamoto and Suzuki [17] for red leaf lettuce. Nxawe [14] found the same result for 2-week growth of spinach.

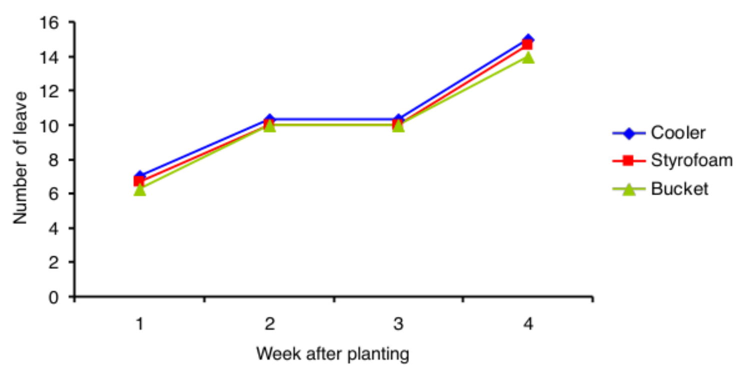


**Figure 6.** The effect of nutrient containers on number of leaves

The effect of nutrient storage tanks on shoot fresh weight of vegetables harvested was definitely significant at 5% as presented on table 2. Averaged shoot fresh weight (148.18±67.22 g plant$^{-1}$) of vegetables cultivated with nutrient stored in the cooler was significantly higher than those cultivated in nutrient stored in Styrofoam box (108.11±52.49 g plant$^{-1}$) and bucket (85.07±43.70 g plant$^{-1}$). As mentioned before, that daily minimum and maximum temperatures of nutrient stored in the cooler were lower than those of nutrient stored in the other two storage tanks. This finding was in contrast to what Sakamoto and Suzuki [17] found with red leaf lettuce, where yield dropped when the lettuce is cultured at 10 °C RZT. But they mentioned that the experiment was conducted at subtropical climate (20 °C air temperature). In winter season, Nxawe et al. [14] also demonstrated that heated irrigation water can elevate yields of spinach. In tropical regions, the responses of plants to RZT are positive and improve yields [19]. This fact remains us that not only RZT but also ambient air temperature also affects the plant growth. In our study, daily maximum temperature of air was 39.79±4.70 °C while daily minimum temperature of air was 23.95±0.85 °C.

In term of plant species, the highest shoot fresh weight of pak coi was 211.89 g plant$^{-1}$ (for cultivation with nutrient stored in the cooler). This shoot fresh weight is about comparable to the best whole fresh weight (242.19 g plant$^{-1}$) of pak coi which was hydroponically cultivated by Perwtasari et al. [25]. The same as the shoot dry weight of pak coi which was 10.78 g plant$^{-1}$, whereas Perwtasari et al. [25] found the best whole dry weight of 13.27 g plant$^{-1}$.

For mustard green, the best shoot fresh weight was 164.78 g plant$^{-1}$. This yield looked like suboptimal in that Erawan et al. [26] found the best shoot fresh weight of 400 g plant$^{-1}$ for mustard green conventionally cultivated on soil in Kendari City, Southeast Sulawesi. But other factors like cultivar, location and cultivation system should affect the yield. Erawan et al. [26] probably worked with different cultivar of the mustard green in this research. Tripama and Yahya [27] reported lower shoot fresh weight (46.96 g plant$^{-1}$) for mustard green hydroponically cultivated in Jember City, East Jawa. Munthe et al. [28] also reported lower shoot fresh weight (85.78 g plant$^{-1}$) for conventional mustard green and 84.31 g plant$^{-1}$for hydroponic mustard green, cultivated in Medan North Sumatra. Based on the last second references, the yield of mustard green in this research is still better.

For kai lan, the best shoot fresh weight was 67.89 g plant$^{-1}$. This productivity is still better that what Rugayah et al. [29] reported. Rugayah et al. [29] studied the effect of slow release fertilizers on production of kai lan, and they found that the best fresh weight was 55.51 g plant$^{-1}$. Shoot fresh weight of kai lan reported by Sinaga [30] was even lower (11.36 g plant$^{-1}$). In this research, the lowest shoot fresh weight of kai lan (34.33 g plant$^{-1}$) cultivated with nutrient stored in bare bucket was still better than what Sinaga [30] reported.

**Table 2.** The effect of nutrient storage tanks on the shoot fresh weight (g plant$^{-1}$).

| Plants | Nutrient Storage Tanks | | |
|---|---|---|---|
| | Cooler | Styrofoam Box | Bucket |
| Pak coi | 211.89 | 161.22 | 131.11 |
| Mustard green | 164.78 | 112.11 | 89.78 |
| Kai lan | 67.89 | 51.00 | 34.33 |
| Average | 148.18 | 108.11 | 85.07 |
| Deviation | 73.42 | 55.22 | 48.56 |
| LSD Notation | a | b | b |

Effect of nutrient storage tanks on shoot dry weight of vegetables harvested was also significant at 5%, as presented on table 3. Plant responses in term of shoot dry weight to the nutrient storage tanks were the same as plants responses in term of shoot fresh weight. In term of shoot dry weight, plants cultivated with nutrient stored in the cooler had highest yield (8.98 g plant$^{-1}$) as compares to those cultivated with nutrient stored in Styrofoam (6.90 g plant$^{-1}$) and in the bucket (5.52 g plant$^{-1}$). As mentioned before that daily temperature of nutrient stored in the cooler was the lowest among the temperatures of nutrient stored on other storage tanks. Patterns of the shoot dry weight as response to

IOP Conf. Series: Earth and Environmental Science **355** (2019) 012092 doi:10.1088/1755-1315/355/1/012092

the nutrient storage tanks in this study agreed with what Sun et al. [11], Nxawe et al. [14], and Zhang et al. [18], found.

**Table 3.** The effect of nutrient storage tanks on the shoot dry weight (g plant$^{-1}$).

| Plants | Nutrient Containers | | |
|---|---|---|---|
| | Cooler | Styrofoam Box | Bucket |
| Pak coi | 10.78 | 8.67 | 7.11 |
| Mustard green | 10.78 | 7.39 | 6.00 |
| Kai lan | 5.40 | 4.66 | 3.45 |
| Average | 8.98 | 6.90 | 5.52 |
| Deviation | 3.11 | 2.05 | 1.88 |
| LSD Notation | a | b | b |

Based on the ash content of plants; however, effects of nutrient storage tanks were not significantly different at 5%. Ash contents of plants were 24.15±5.81%, 23.40±3.27%, 22.12±6.03 respectively for plants cultivated with nutrients stored in the cooler, Styrofoam box, and bucket. This finding is different from what Tindall et al. [12] demonstrated on their research with tomato. They demonstrated that mineral content peaked at 25-26 °C RZT, with ambient air temperature of 21.1 °C. The differences of plant responses may the role of ambient air temperature. The ambient air temperature of their study was different from the one in this study.

**Table 4.** The effect of nutrient storage tanks on the ash content (%).

| Plants | Nutrient Storage Tanks | | |
|---|---|---|---|
| | Cooler | Styrofoam Box | Bucket |
| Pak coi | 29,93 | 24,48 | 27,20 |
| Mustard green | 24,22 | 25,99 | 23,71 |
| Kai lan | 18,31 | 19,72 | 15,45 |
| Average | 24,15 | 23,40 | 22,12 |
| Deviation | 5,81 | 3,27 | 6,03 |
| LSD Notation | a | a | a |

This finding also suggested that the use of Styrofoam box for nutrient storage was not so effective to increase yield for tropical regions. The Styrofoam box cannot compensate the effect of high temperature either ambient air or RZT. Active cooling container or mechanical cooler proved to be able to lower the nutrient temperature to optimum level at night, but could not decrease the maximum temperature of the nutrient solution at day light.

## 4. Conclusions

1. Mechanical cooler used to cool the nutrient solution was able to maintain the minimum temperature of nutrient solution to 18.89±1.64°C at night, but on day light the cooler could lower the maximum temperature of nutrient solution to 27.73±1.70°C. Styrofoam box and bucket could decrease the minimum temperature of nutrient solution to 24.19±0.68°C and 24.45±0.64°C respectively at night. While on the day light, both storage tanks could decrease the maximum temperature of nutrient solution to 33.28±1.45°C and 33.51±1.44°C respectively.
2. Leafy vegetables cultivated in nutrient solution cooled with the mechanical cooler were superior over those cultivated in nutrient solution stored in Styrofoam box and bucket, in term of plant height, shoot fresh weight, shoot dry weight. Shoot fresh weights of harvested vegetables were

148.18±73.42 g plant$^{-1}$ from the cooler, 108.11±55.22 g plant$^{-1}$ from the Styrofoam box and 85.07±48.56 g plant$^{-1}$ from the bucket. While number of leaves and ash content were not significantly different.

# The effect of three different containers of nutrient solution on the growth of vegetables cultured in DFT hydroponics

ORIGINALITY REPORT

4%
SIMILARITY INDEX

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | Kozai, T.. "Thermal performance of a solar greenhouse with water tanks for heat storage and heat exchange", Journal of Agricultural Engineering Research, 198602<br>Crossref | 50 words — 1% |
| 2 | jgsm.geologi.esdm.go.id<br>Internet | 50 words — 1% |
| 3 | www.scribd.com<br>Internet | 50 words — 1% |
| 4 | krishikosh.egranth.ac.in<br>Internet | 12 words — < 1% |
| 5 | www.infrc.or.jp<br>Internet | 11 words — < 1% |
| 6 | A. Arora. "Expression of Dwarfing Genes under Nitrogen and Moisture Stress in Wheat (Triticum spp): Dry Matter Partitioning, Root Growth and Leaf Nitrogen", Journal of Agronomy and Crop Science, 4/22/2001<br>Crossref | 9 words — < 1% |
| 7 | Rodrigo Poblete, Osvaldo Painemal. "Recovering water from brine: Assessments of feasibility and applicability to irrigation processes", Desalination, 2018 | 9 words — < 1% |

Crossref

| | | |
|---|---|---|
| 8 | Yetenayet B Tola, Obsuman D Muleta, Werner C Hofacker. " Low‐cost modified‐atmosphere hermetic storage structures to reduce storage losses of maize ( L.) cobs and sorghum ( L.) heads ", Journal of the Science of Food and Agriculture, 2019<br>Crossref | 8 words — < 1% |
| 9 | worldwidescience.org<br>Internet | 8 words — < 1% |

| | | | |
|---|---|---|---|
| EXCLUDE QUOTES | ON | EXCLUDE MATCHES | OFF |
| EXCLUDE BIBLIOGRAPHY | ON | | |