ORIGINAL RESEARCH PAPER

Volume - 13 | Issue - 10 | October - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

# APPLICATION OF FREE ENERGY WATER-PUMP FOR CLEAN CROP PRODUCTION THROUGH NFT-HYDROPONIC SYSTEM IN RESPONSE TO CLIMATE CHANGE

Engineering


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## ABSTRACT

Water-based cropping is a technology that has long been used abroad but is rarely used in Lao PDR due to its high cost. several scholars type to find the solution for reducing the cost of growing vegetables and mitigating soil degradation. As this experiment efforted in optimization of water supply for the growing system to avoid using of energy in driving water but it was unsuccessful. However, the purpose of this experiment was to 1) create a calendar of market demand for vegetables to create a planting plan; 2) determine the suitability of air temperature, humidity, including pH, and EC values of water in the growing system; 3) Control the concentration of nutrients that plants need at each stage of growth. Sellers' interviews, climate monitoring, and recording, monitoring and measuring plant growth, and water quality measurement and analysis were the methods used in this experiment.



## KEYWORDS

Water-based Growing Vegetables, Water Quality For Vegetable Growth, Cropping Plans.


## INTRODUCTION

As the increase in population leads to rapid urban growth and industrialized production, the demand for food and production space increases, but on the other hand, the quality of the environment decreases. In 1990, according to the climate change strategy of the Lao PDR (2010), survey results showed that the change in land use and forests in Laos released about 16,628.67 tons of carbon dioxide ($CO_2$) into the atmosphere. Land clearing and burning in the agricultural sector are the sectors that release the most carbon into the atmosphere (IPCC, 2014; Cassia et al., 2018). which is an important variable that causes climate change (Warmh-eart, 2018). which affects many areas such as the quality and quantity of production decreases due to abnormal weather conditions and available water resources (Sharma et al., 2018).

This research is very necessary to research in detail the factors related to soilless cultivation and the use of vacuum suction machines in the soilless cultivation system with continuous flow of water (Nutrient Film Technique: NFT) including the air factor. In order to disseminate new innovations in the production of agricultural crops that can be implemented locally without the need for electricity, and may be an important part in promoting coping with climate change, especially in areas with dry/flooded land or land that lacks the properties of crops to produce better productivity in line with the direction of sustainable and green development. The purpose of this experiment is to: (1) create a calendar of market demand for vegetables to create a planting plan. (2) determine the suitability of air temperature, humidity, including pH and EC values of water in the planting system. and (3) determine the rate of flow of water into the plant and control the concentration of nutrients required by the plant for growth.

### Study Area

The experiment was conducted during a period of 2 months starting from the beginning of September to the end of October 2021, at the experimental garden of the Faculty of Water Resources of Tad Thong Campus, which is located in Tad Thong Village, Sikottabong District, Vientiane Capital, located at coordinates 17°59'22.3"N and 102°30'23.5"E, approximately 190 m above sea level. The climate is divided into two seasons, with an average rainfall of 1246.9 mm and an average temperature of 22.7 °C (National Statistics Center, 2019).

## Instruments and Methods

### Equipment and Instruments

Equipment and instruments in the experiment are divided into 2 different categories:

1. Planting equipment and plant nutrients include PCV pipe 90mm, planting cup, water sponge, plastic tray, plant nutrient solution and others.
2. Water quality and growth monitoring equipment including pH, EC, and Temperature meters, Hanna Instrument Spectrometer, digital ruler, and weighing scales.

### Planting Seedlings

The experiment used Green Oakleaf Lettuce variety. The seeds are wrapped in a cloth and kept for about 1-2 days under a temperature of 1-3 ºC, then when it is noticed that the seeds have sprouted, put the seeds in a sponge (Figure 1) and keep them in a place with little light for about 1-2 days or until you notice that they have sprouted or sprouts, then keep them in a place where the sun shines in the morning and evening so that the seedlings do not stretch out in search of light. When 3-4 leaves appear or 5-10 days old, prepare a mixture of A and B nutrients. When 15-17 years old or 4-5 leaves appear, water the roots or planting system.

**Figure 1. Nursery Seedlings and Planting in the System**

### Planting System Installation

Installation of the planting system will use 3 lines of PCV 90mm, each line is 2 m long, which are closed on both sides to prevent water from flowing out. The planting system is a floating system in which holes are drilled to place the planting cups at a distance of 0.20 m. The water level in the pipe was maintained at 70 to 80 percent of the water level in the pipe throughout the planting period. The planting base is raised from the ground level by about 0.6 m, the top of the roof system is covered with sunscreen to prevent the afternoon sunlight.

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

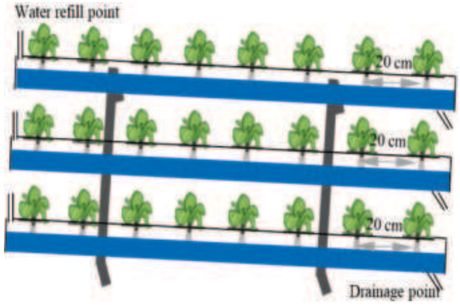


**Figure 2. Installation of the Planting System**

### Mixing Plant Nutrients

Powdered plant nutrients are divided into two types, A and B, which contain primary and secondary nutrients for plants such as N, P, K, Mg, Fe, Ca, etc. Initially, dissolve type A in 5 liters of water and B in 5 liters of water (Figure 3) to be the main germ. When the plants are 5-15 days old, mix the nutrients A and B that have been dissolved, 5 mL of each type diluted in 1L of clean water. When the plant is more than 15 days old, mix 8 mL of each species per 1L of water, as the plant grows larger, the need for nutrients increases. To prevent the water from becoming cloudy, when mixing A and B nutrients, mix A nutrients into the water to be mixed for about 30 minutes before adding B nutrients.

**Figure 3. A and B Nutrients**

### Determination of Water Quality

Water acidity (pH) and electrical conductivity (EC) are measured based on the initial water quality and the concentration of plant nutrients ($NO_3^-$ and $PO_4^{3-}$) which are contained in types A and B. Therefore, this experiment determined the concentration of plant nutrients into 3 concentration levels as shown in Table 1.

**Table 1. Concentration of Plant Nutrients in Water**

| Planting system | Concentration | |
|---|---|---|
| | NO3- (mg/L) | PO43- (mg/L) |
| T1-P1 | 3000 | 400 |
| T2-P2 | 2000 | 300 |
| T3-P3 | 1000 | 200 |

### Measuring and Analyzing Data

Monitoring and measurement were performed every 2 days. Measure water quality in planting systems such as pH, EC, T, $NO_3^-$ and $PO_3^{4-}$. Growth measurements such as center width, number of leaves, and yield weight etc. The data was analyzed using statistical principles such as Multiple Linear Regression to explain growth with independent variable and dependent variable, which will use the IBM SPSS Statistics 27 program. In addition, the calculation of the standard deviation (S.D) (Francis Galton, 1860) and the calculation of the coefficient of variation were also analyzed to explain the yield of plants.

$$S.D = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}$$

In which: S.D standard deviation; xi data (sequence 1, 2, 3,...n); x average value of the data; n Total number of data

$$C.V = \frac{S.D}{\bar{x}} . 100$$

In which: C.V coefficient of variation

## RESULTS AND DISCUSSION

### Results of Plant Growth

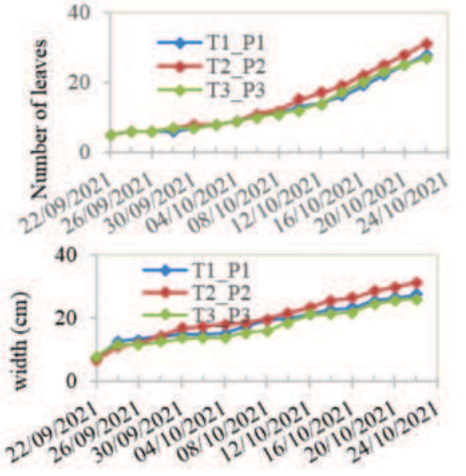


**Figure 4. Number of Leaves and Width (cm) of Lettuce**

The growth of fennel in the planting system T1_P1 and T3_P3 has faster and better growth than the system T2_P2 which grows very slowly but from the beginning to harvest.

### Relationship of Water Quality Factors

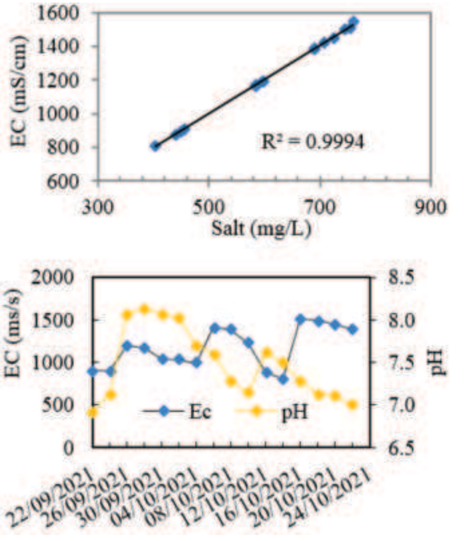


**Figure 5. EC of Salt and EC, PH of Vegetables Tested**

The pH values of all 3 growing systems are within the range that plants can adapt to, which is acidic-alkaline with a value between 6.5 - 8.19. EC value is an indicator of nutrient concentration in water with pH value as a determinant. Mr. Getter (2013) said that the pH value in an acidic state will make plant nutrients (macronutrient) dissolve well. Therefore, when the pH value is low or in an acidic state, the EC value will be high and the nutrient concentration will also be high.

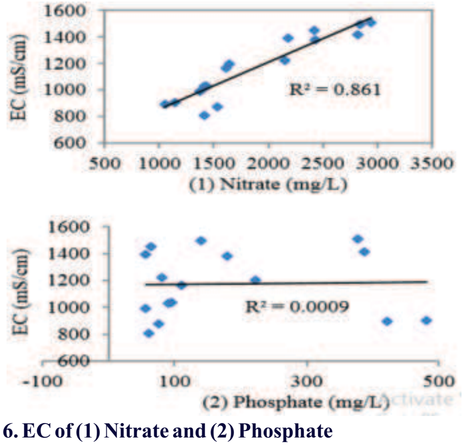


**Figure 6. EC of (1) Nitrate and (2) Phosphate**

From the data of lettuce Fig.3 has good growth in T2 system. N < 2900 mg/L, P < 500 mg/L. From Fig. 3, cilantro and onion grow well in T3 system N < 1500 mg/L, P < 300 mg/L.

### Variation in Yield Weight

Statistical analysis is the calculation of the weight of all 3 types of plants in 3 planting methods with different concentrations of nutrients to compare the growth and yield of all 3 types of plants. Application of different plant nutrient concentrations showed different yield and plant weight in each cropping system. From the calculation of S.D and C.V values, it shows that yielding by taking weight as an indicator of all 3 types of plants grown in 3 systems. Overall, lettuce, cilantro, and onion grown in the T2 system will have less variation in weight and coefficient of variation than plants grown in the T1 and T3 systems. This data shows that all 3 types of plants in T2 system have growth and more stable weight than T1 and T3, under the water quality in T2 system is between 6.91 - 8.13 (pH), 807 µS/cm -1546 µS/cm (EC), 1050 mg/L - 2940 mg/L ($NO_3^-$), and 56 mg/L – 482.5 mg/L ($PO_4^{3-}$).

**Table 2. Variation in Weight**

| System | Max | Min | Mean | S.D | C.V |
|---|---|---|---|---|---|
| T1_P1 | 110.72 | 70.59 | 90.94 | 14.99 | 16.48 |
| T2_P2 | 106.75 | 73.11 | 88.90 | 11.64 | 13.09 |
| T3_P3 | 78.16 | 32.41 | 60.93 | 13.59 | 22.30 |

## CONCLUSIONS

The study results show that cilantro and onion buy up 80.9% and 78.65%, respectively, at all times of the year, and the percentage of purchases decreases in the dry season due to there being limited vegetables in the market, particularly lettuce. a planting plan from late February to mid-September is essential to increase the number of vegetables in the market. The maximum stem width of lettuce and onion was 3.42 mm and 2.1 mm, respectively, within 10 days, under a maximum sunlight of 234 klx, T = 22C - 36.2C, and RHav = 86.2%. Onion stem width up to 1.15 mm within 4 days under maximum sunlight 235.6 klx, T = 22.8C - 36.8C, and RHav = 73.5-77%. Lettuce has a maximum shrub width of 31.2 cm in the T2 system at pH, EC, $NO_3^-$, and $PO_4^{3-}$ between 6.91 - 8.13, 807 µS/cm - 1546 µS/cm, 1050 mg/L - 2940 mg/L, and 56 mg/L - 482.5 mg/L respectively. Cilantro and onion grew up to 23.4 cm and 22.5 cm, respectively, in the T3 system at pH, EC, $NO_3^-$, and $PO_4^{3-}$ between 7.12 - 8.25, 450 µS/cm –1005 µS/cm, 480 mg/L - 1480 mg/L, and 36 mg/L - 312 mg/L respectively. In the T1 system, the vegetables applied nitrate ($NO_3^-$) and phosphate ($PO_4^{3-}$) well for photosynthesis process, which was reduced to 8,297 mg/L/plant/day. Lettuce and cilantro provided an average yield of 90.95 g/plant and 17.11 g/plant respectively in the T1 system. Onions yielded an average of only 11.32 g/plant in the T3 system. Statistical data show that lettuce and onion grown in the T1 system provided more weight than those grown in the T3 system, despite a higher standard deviation. Onion grown in the T3 system produced more weight than those grown in the T1 and T2 systems with a standard deviation of only 2.53 and C.V equal to 22.3%.

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