FRESH COCONUT WATER ENHANCED ORGANIC NUTRIENT SOLUTION ON HYDROPONICALLY GROWN SPINACH (*Spinacia oleracea* L.)

College of Agriculture and Natural Resources
BOHOL ISLAND STATE UNIVERSITY
Zamora, Bilar, Bohol

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A Thesis
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In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science in Agriculture

Gertrude Grace B. Solijon

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APPROVAL SHEET

This study entitled, **"FRESH COCONUT WATER- ENHANCED ORGANIC NUTRIENT SOLUTION ON HYDROPONICALLY GROWN SPINACH (*Spinacia oleracea* L.)"** prepard and submitted by Gertrude Grace B. Solijon in partial fulfillment of the requirements for the degree Bachelor of Science in Agriculture has been examined and recommended for acceptance and approval for oral defense.

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THE RESEARCHER

ABSTRACT

Spinach is a highly valued vegetable crop, and demand for organic produce is rising. Due to soil-related problems, this study was conducted to solve and augment production by applying different nutrient solutions in a passive hydroponic system. The study was conducted in a two (2) factorial randomized complete block design, factor A is the application of fresh coconut water, and factor B is the different nutrient solutions. Statistical Tool for Agricultural Research (STAR) software version 2.0.1 was used for all data analysis. Results of the study showed that the growth and yield of spinach were significantly influenced by SNAP nutrient solution without coconut water. This solution obtained the highest mean for spinach increase and yield parameters compared to all fermented nutrient solutions used. The application of fresh coconut water resulted in stunted growth of spinach regardless of the nutrient solutions used. Moreover, fresh coconut water application resulted in an acidic solution two (2) to three (3) days after coconut water application. Therefore, it is recommended to use SNAP liquid nutrient solution to solve soil-related problems and augment spinach production in a passive hydroponic solution. Thus, the null hypothesis is accepted.

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Chapter 1

THE PROBLEM AND ITS SCOPE

Rationale

Spinach (*Spinacia oleracea L.*) belongs to the family Amaranthaceae. It is an economically important leafy vegetable that is consumed worldwide. It was domesticated in Persia (Iran) around 2000 years ago and made its way to China in the 7th century (Morelock & Correll, 2008; Rebira et al., 2020). Spinach is high in beta carotene and, folate, carotenoid lutein. It is also a good source of vitamin c, calcium, iron, phosphorous, sodium, antioxidants, and potassium (Decoteau, 2000; Correll & Morelock, 2008).Global spinach production reached more than 26.7 million tons in 2016, representing a production value of 18 billion USD (FAOSTAT, 2018). Approximately 91.5% of this global spinach production is accounted for by China alone. In the Philippines, spinach harvested reached 672 tons on 286 hectares of land (FAOSTAT, 2022).

However, pre-emergence and post-damping-off spinach caused by *Pythium* and *Phytophthora, Fusarium spp,* and *Rhizoctonia solani* are most alarming in growing spinach since it causes stunted growth and plant death. These fungi produce spores or sclerotia (hard resting structures) that can survive in the soil for extended periods. *Verticillium spp* can cause spinach to wilt and die off, but generally only in older plants (Ekman et. al, 2014; ICP Australia). Fortunately, these soil-related problems can be prevented through soilless culture called a hydroponics system. Plants in the hydroponic system can achieve 20–25% higher yields than a soil-based system with productivity 2–5 times higher (UN, 2017). However, commercially formulated hydroponics is costly and, at times, creates environmental problems (Poliquit et al., 2019). Fortunately, the utilization of nutrients solution from different organic sources is proven to have significant amounts of nutrients needed by plants (Naz et al., 2011).

It can be recovered by adding coco-water as a mixture additives component to increase available nutrients and stabilize the acidity of the organic nutrient solution. However, limited studies have been carried out on the effect of coco water mixed with fermented fruit juice and plant juice.

With this premise, the researcher studied an alternative, affordable, and safest way to provide nutrients solution in hydroponics by adding coconut water to fermented fruit juice and fermented plant juice as an organic nutrient solution for hydroponic spinach production.

Time and Place of Study

This study was conducted in the greenhouse area of Bohol Island State University Zamora, Bilar, Bohol, Philippines from, March to May 2022.

REVIEW OF RELATED LITERATURE

Botanical Characteristics of Spinach

Spinach is an annual, cool-season, flowering vegetable that produces a rosette of leaves during its vegetative stage. The vegetative state is harvested for consumption. Leaf shape ranges from round to pointed, and leaf texture can be flat savoy (crinkled) or semi-savoy (an intermediate). It is a diploid 2n=12 and is typically dioecious (Morelock & Correll, 2008). Experiments have shown that spinach seeds will germinate in soil temperatures from 5 to 30 ° C, with germination percentages highest at 20 ° C and dropping abruptly between 25 and 30 ° C (Atherton and Farooque 1983 as cited on Chitwood, 2016). Spinach is a member of the subfamily Chenopodioideae and is related to swiss chard, quinoa, and sugar beet (Yamamoto et al., 2014). It is believed to have originated from Persia, where the earliest references to spinach occurred between 200 and 600 A.D., and was transported to India and Asia and then later to the Mediterranean countries and Europe (Wright, 2001). Spinach is a versatile vegetable and can be eaten raw or cooked. It is available fresh, frozen, or canned. Spinach can also be cooked, sautéed, and is incorporated into soups, pasta, and omelet (Ware M., 2018). One cup (30 grams) of raw spinach provides 16% of the Daily Value (DV) for vitamin A plus 120% of the DV for vitamin K, all for just seven calories (USDA, 2018, Food Data Central; Link, 2022).

Economic Importance of Spinach

The global spinach market overcame the adverse effects of the pandemic to grow from $37.7B in 2019 to 39.6B in 2020, mainly due to a 5% y-o-y increase in consumption from China. Rising demand for healthy produce from the growing global population will continue to be the main driver, significantly propelling the market for organic spinach. IndexBox forecasts that the world will consume 42M tonnes of spinach by 2030.

Unfortunately, according to research by the Environmental Working Group, spinach placed second in its top 12 list of produce with elevated levels of pesticide residue. This problem led to unfortunate incidents in the U.S. and the EU, so the ability to provide safe spinach to the market is becoming a critical requirement for suppliers to Western countries (IndexBox, 2014).

Spinach Production Problems

Furthermore, there is an economically significant soil-borne disease in spinach. Damping-off influence by cultivar, soil temperature, soil moisture, and disease pressure caused by *Pythium aphanidermatum, P. irregulare, Pythium sp., Rhizoctonia solani, and Alphanomyces cochliodes.* Roots of infected seedlings appear water-soaked, the upper or tip of taproot girdled by a necrotic lesion. Increasing temperatures as the plants mature leads to fusarium wilt caused by *F.o. spinaciae,* causing an infected plant to have a darkly discolored tip on the vascular systems, wilt symptoms, and chlorosis (Corell et al., 1994).

Hydroponics Production

Hydroponics comes from two Greek words, "hydro," meaning water, and "ponos," meaning labor or the cultivation of plants through water, which provides an instant as well as a long-term solution to the inability of a household to produce its vegetables under urban settings. If hydroponics is set up under a protective structure (e.g., a plastic house or greenhouse), it allows for uninterrupted year-round vegetable production. Furthermore, the vulnerabilities of vegetable crops to weeds, insects, and diseases are minimized or absent when crops are grown hydroponically (Bañez & Manipon, 2000). The aquaponics and hydroponics methods are a little more costly than traditional. However, they have many more advantages like early germination, better yield, high number of biochemical contents like carbohydrates and protein (Ranawade et al., 2017). Plants grown in hydroponics contain more minerals and chlorophyll than those produced in a conventional soil-based system (Coronel et al., 2009).

Furthermore, the Kratky hydroponic method is a deep water cultured hydroponic system for growing plants because the entire crop requires only an initial application of water and nutrients. Plants are automatically watered because the entire growing medium in the net pot below 2-3 cm becomes moistened by capillary action (Krakty, 2009). Plant growth causes nutrient solution levels to decrease, and direct capillary wetting of the substrate is impossible. However, the expanding root system can absorb the nutrient solution from the tank. The root occupying the moist air space above the solution is called oxygen roots, whose primary function is aeration. These roots experience vigorous lateral and branching growth. The nutrient solution level may remain the same or be lowered and not be raised because submerging oxygen roots causes the plant to "drawn" (Imai, 1987 as cited in Krakty, 2009).

A study conducted by Makendi (2014) on a *Comparative Analysis of Two Plant Growth Mediums of Hydroponic and Soil Based*. It was noted that the hydroponic plants germinated and grew much quicker than the soil plants. Spinach is an alternative crop in greenhouses since it allows for multiple short-duration production cycles and a much faster economic return (Brandenberger et al., 2007). In addition, Santos and Ocampo (2005) conducted a study on their conceived and designed hydroponic solution called as Simple Nutrient Addition Program (SNAP) using passive hydroponics or the Kratky method. The result shows that the growth of SNAP-grown lettuce is more rapid and was harvested earlier than soil-grown plants, and returns on investment average 57%.

Furthermore, the macro-and micronutrient composition of a hydroponic solution determines plant growth, leaf number, leaf area, marketable yield, and crop quality, including mineral and chlorophyll content (Fallovo et al., 2009). On the other hand, a high percentage of the hydroponic industry uses inorganic growing media such as nutrient solution, expanded polystyrene, urea-formaldehyde, and others (Böhme et al., 2008). Meanwhile, only 12% use organic growing media (Donnan, 1998), such as peat, bark, wood residues, compost, vermi or animal compost-tea, and others (Islam, 2008). The passage of the "Organic Act of 2010" in the Philippines promotes natural farming techniques. The act included using organic foliar fertilizer such as fermented fruit and plant juice, fish amino acid, indigenous microorganism, kuhol amino acid, and lactic acid bacteria in agricultural production. This act entails eco-friendly sources of nutrients for organic crop production.

Importance and Advantages of Organic Nutrient Solutions

Organic fertilizers are carbon-based compounds that increase the productivity of plants. Organic fertilizer reduces leaching loss because they are primarily insoluble and therefore slows the release of nutrients (Capewell, 2007). Sources of organic materials are free from inexpensive (Bolton, 2008). Several types of organic fertilizers can be selected (Koenig et al., 1999; Kupper, 2003). One is the organic foliar fertilizer that is to be applied in foliage to boost nutrient density in crops and to correct nutrient deficiencies, and it has been reported to increase yield, increase resistance to diseases and pests, and improve drought tolerance as well as crop quality (Kartika et al., 2008; Kuepper, 2003)

Liquid organic fertilizer is a product from the bio-fermentation of vegetables, fruit, and animal wastes fermented with sugar and valuable microbes. These microbes help break down nutrients in plants, making them a potentially valuable nutrient-rich organic fertilizer source. When bacteria or microorganisms process the products, substances such as proteins, amino acids, organic acids, accelerating growth hormones, vitamins, and enzymes are liberated. All of which are potentially useful for the efficient growth of the plant (Apai and Thongdeethae, 2001, as cited in Tagbilaran, 2019). Typically, organic foliar fertilizers will only be high in one of the three essential plant nutrients, namely, Nitrogen (N), Phosphorous (P), and Potassium (K).

Arachis pintoi is an herbaceous, perennial legume with low stoloniferous growth. It is also a multipurpose legume cover crop, feeds (Mannetji 1996 as cited in Rosalada, 2014), and grows well in tropical areas. The organic fertilizer made from shoot extract of *A. pintoi* has shown potential as a rich source of organic foliar material, owing to its ability to use the atmospheric N through its symbiosis with rhizobia (Kartika et al., 2008). Rosalada (2014) conducted a study entitled *Wild Peanut (Arachis pintoi) Shoot Extracts as Organic Foliar Fertilizer.* Tomatoes applied with foliar organic fertilizer *Arachis pintoi* performed better regarding horticultural yield, fruit quality, and physico-chemical characteristics. The study was found to be better tasting and have higher general acceptability than other treatments of inorganic fertilizer alone or those applied with commercial organic fertilizers of Algafer.

Fermented Fruit Juice or FFJ is made from sweet ripe fruits, fruit vegetables, and root crops. Thoroughly blended with crude sugar or molasses and stored for a short period. The fermented extract is applied to the plant setting. The carbohydrates and sugar content of FFJ serve as a source of energy for soil microorganisms, thereby accelerating their activity. Increased microbial activities result in the availability of nutrients for plant uptake (ATI, 2011). In addition, organic nutrients solution from different sources of fermented plant juice extracts such as banana peel, *Arachis pintoi, and Trichantera gigantea* have higher nitrogen and potassium content. Since fermented plant juice extracts are organically formulated nutrients from plant sap and chlorophyll, rich in an enzyme solution and microorganisms such as lactic acid bacteria and yeast that invigorate plant's growth and development (Poliquit et al.,2019).

A study conducted by Alam et al. (2017) on the effect of the fermented plant (FPJ) and fruit juice (FFJ) on the growth and yield performance of tomatoes found that the treated plants with FPJ and FFJ produced early flowers and fruits compared to untreated plants due to the enhanced production of auxin and essential nutrients. Total soluble solids were also observed to increase after ten weeks of FPJ and FFJ application. It was suggested that combinations of both concoctions, such as FPJ water spinach, enhance the vegetative growth of tomato plants and FFJ pineapple for better reproductive development of tomato plants.

Furthermore, a study of bio-organic fertilizer and the levels of the application using Fermented Fruit Juice (FFJ) and Fermented Plant Juice (FPJ) was conducted to determine the favorable response of pechay according to its growth and yield performance. It was found that FFJ responded significantly better compared to FPJ on plant height, number of plant leaves, and yield in grams per plant. The higher application level of FFJ and FPJ (60mL/L) promotes better growth and development of pechay (Tagotong, M. and Curpuz, O., 2013).

Meanwhile, seventeen microorganisms in the FPJ and FFJ showed signs of P solubilization (Sulok et al., 2021). Six microorganisms from FPJ showed K solubilizing capability. Three microorganisms demonstrated K solubilizing ability with clear halo zones formed around the isolates in the Aleksandrow media for FFJ. The result suggests that 9 of the 17 isolates can potentially solubilize both P and K. These beneficial microorganisms which showed both P and K solubilization potential were *Bacillus pseudofirmus, Sporosarcina globispora, Bacillus subtilis, Bacillus amyloliquefaciens, Bacillus licheniformis, Aspergillus niger (FPJ), Bacillus sp. PK-9, Aspergillus niger* (FFJ), and *Aspergillus terreus*. Microorganisms capable of solubilizing nutrients such as P and K are vital because they can convert insoluble P and K in soils into soluble P and K. This is done through the release of organic acids, chelation, and ion exchange.

However, Scot (2014) and his colleagues argue that using organic self-prepared nutrient solutions provided problematic leafy greens growth compared to commercial hydroponic solutions in a feasibility study investigating the effects of hydroponics media on the quality of greenhouse-grown green leaves.

Furthermore, Williams and Nelson (2016) reported that pH fluctuates more dramatically in growing hydroponics using organic fertilizer. Only limited products that meet organic certification requirements are available to adjust potential hydrogen. This occurrence might be due to the increase in acidity of fermented plant juice incurred throughout the growing period of plants which was brought about by the rapid oxidation process of starch and sugar to form acetic acid (Taiz, L. & E. Zieger, 1998; Poliquit et al., 2019).

Advantages of Coconut Water in Plant Growth and Development

On the other hand, coconut water is one of the natural sources of growth regulators or phytohormones. In micropropagation or tissue culture, coconut water is often used as a growth regulator (Prades et al., 2012). A study on the effect of coco water as an additive to fermented plant juice used as the nutrient solution on aggregate hydroponics was conducted by Poliquit et al. (2019). It was found that the addition of coco-water had significantly increased the length and diameter of leaves, plant height, percent foliage, N and K content, length, the fresh and oven-dry weight of roots, and yield relative to without coco-water addition. A significant interaction effect was obtained between coco-water and types of nutrient solutions. The application of coco-water as a hydroponics nutrient solution and as an additive to hydroponics solution was financially viable. It had a positive net present value and a higher internal rate of return (IRR) percentage.

In addition, Roldan (1995) studied the effect on growth and yield performance of pechay and its soil properties using coconut water as formulated liquid fertilizer. It was revealed that the formulated coconut water could be used as an alternative fertilizer. It is comparable to commercial liquid fertilizer (CNF) based on psycho-chemical tests, same effect on height, fresh weight, and the number of leaves in pechay. Coco water is almost comparable to CNF in terms of its effect on soil pH, organic matter, and available phosphorous. On the contrary, the effect of formulated coconut water fertilizer on exchangeable soil K is more significant than a commercial nutrient solution deficient in soil K.

Furthermore, Omo (2013) reported that finger pepper, tomato, bitter gourd, and squash applied with 75% RR inorganic fertilizer and sprayed with 50% concentration of mature coconut water produced the highest results in terms of fruit yield, fruit yield value, fruit yield increased over the control, and highest benefit-cost ratio (BCR). Similarly, the bottle gourd plants applied with the same amount of inorganic fertilizer but sprayed with a higher concentration of mature coconut water (75%) also produced the highest yield, fruit yield, the highest value of fruit yield increase, and BCR too.

Moreover, Morel (1974), as cited by Sugara and Raharjo (2009) and Domitila (2014), stated that coconut water contains elements of N and P required by microalgae in the growth process, the growth-regulating substances contained in coconut water are made up of three types of cytokinin 5.8 mg/l, auxin 0.07 mg/l and a bit of gibberellin. Coconut water is one of the sources of nutrients, such as organic fertilizer, which can stimulate growth (Domitila, 2014).

Table 1
Mineral Levels (ppm) for Specific CF Ranges for Spinach
(Sreedharan, 2015)

Mineral	***CF 10***	***CF12***	***CF18***
Nitrogen	33-100	40-120	60-180
Phosphorous	8-25	10-30	15-45
Potassium	50-150	60-180	90-270
Sulfur	13-40	16-48	24-72
Calcium	33-118	40-142	60-210
Magnesium	8-25	10-30	15-45
Sodium	3-35	3-35	3-35
Chloride	3-35	3-3.5	3-35
Iron	0.7-3.6	0.8-3.6	1.2-5.0
Manganese	0.13-1.6	0.16-1.9	0.24-3.0
Boron	0.07-0.5	0.08-0.6	0.12-0.9
Zinc	0.03-1.0	0.04-1	0.06-1.0
Copper	0.03-0.33	0.04-0.36	0.06-0.5
Ph Range	6.0-6.5	6.0-6.5	6.0-6.5

THE PROBLEM

Statement of the Problem

The main goal of the study was to determine the effect of fresh coconut water-enhanced organic nutrient solution on the growth and yield performance of spinach under hydroponics.

Specifically, this sought to answer the following questions:

1. What is the effect of coconut water enhanced organic nutrient solution on the growth performance of spinach under a hydroponics system in terms of:

    1a. Days from transplanting to harvesting

    1b. plant height (cm);

    1c. number of leaves;

    1d. leaf length (cm);

    1e. leaf width (cm) and;

    1f. root length (cm)?

2. What is the effect of coconut water-enhanced nutrient solution favoring the yield performance of spinach in terms of:

    2a. number of marketable plants;

    2b. number of non-marketable plants;

    2c. weight per plant (g);

    2d. weight of marketable plants (g);

    2e. weight of non-marketable plant (g) and;

2f. total yield (g)

3. Is there a significant difference on the effect of coconut water enhanced organic nutrient solution in growth and yield performance of spinach under hydroponics?

Null Hypothesis

There is no significant difference on the effect of coconut water- enhanced organic nutrient solution on growth and yield performance of spinach under hydroponics.

Significance of the Study

The result of the study would incorporate knowledge and information about the effect of coconut water-enhanced organic nutrient solution on the growth and yield performance of spinach under hydroponics. This study would be an aid and significant to the following concerns.

Social impact. The result of the study would be a better intervention in buying commercial nutrient solutions. Using coco water, fermented fruit juice, and plant juice extract would help the community quickly source nutrient solutions available in the locality. Simple hydroponics structures will help them guide plant hydroponics in a small or large area.

Environmental impact. The result of this study would be helpful to the environment in reducing waste from the commercial nutrient solution. Hydroponics planting will also encourage to use of less water than soil-grown crops and reduce soil-related diseases and insects.

Academe. The result of the study would be an aid and serve as a reference to the students who will conduct research related to this study. The result will provide information on the effect of coconut water, fermented fruit juice, and fermented plant juice on plants grown under hydroponics. Extension workers could also refer to this the output of this study in adding inputs for the community.

RESEARCH METHODOLOGY

The study was conducted to determine the effect of coconut water-enhanced organic nutrient solution on spinach's growth and yield performance under hydroponics.

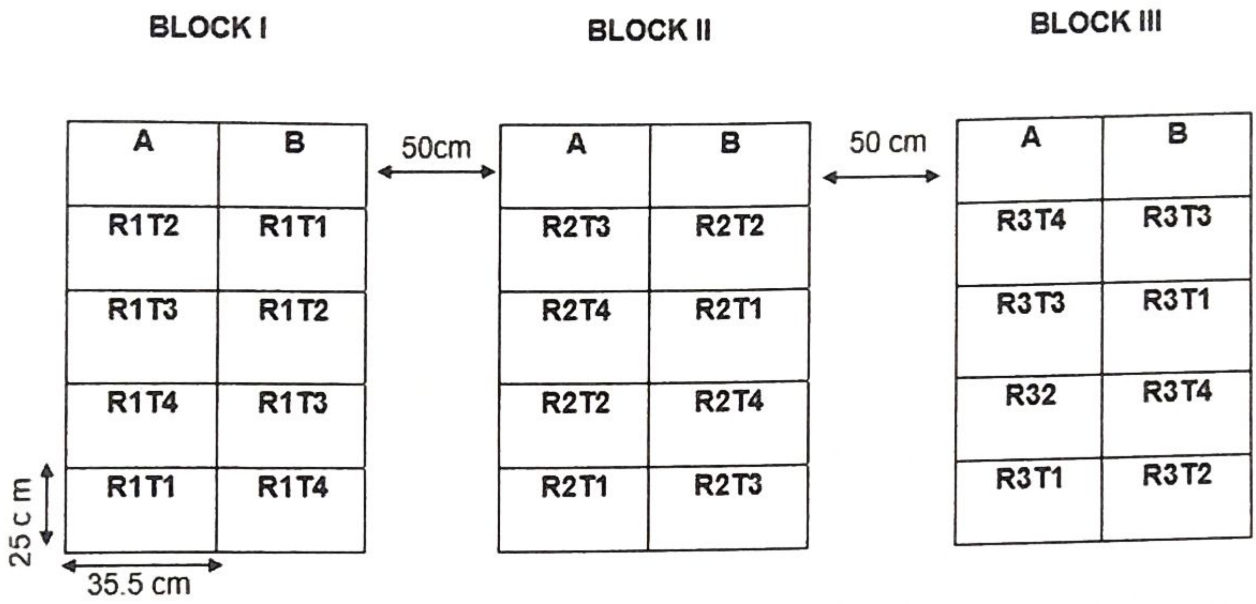
Treatments and Experimental Design

The experiment was laid out following a 2 x 4 factorial design arranged in Randomized Complete Block Design (RCBD) with three replications having four (4) samples per treatment per replication. Factor A:

A.1 – with coco water
A.2- without coco water

Factor B:
T1- SNAP A & B
T2- FFJ (60 mL/L)
T3- FPJ (60 mL/L)
T4 FFJ+FPJ (60 mL:60 mL /L)

Legend:
Commercial Nutrient Solution (CNS)
Organic Nutrient Solution (ONS)
Coco Water (CW)



Legend:

Factor A:

A – with coco water

B- without coco water

Factor B:

T1- Commercial nutrient solution (CNS

T2- FFJ (60 ml/L)

T3- FPJ (60 ml/L)

T4- FFJ+FPJ (120 ml/L)

Total Area (6mx4m) = 20.13 meters

Styro Box Size: 56 cm x 35.5cmx 9cm

Alleyway: 50 cm

Figure 1. Experimental Layout Arrange in Randomized Complete Block Design (RCBD).

Materials

The study used the following materials: Styrofoam cups, scissors, trays, seedling trays, Styrofoam boxes with eight holes, and coco peat for hydroponic preparation. Pail, bottles, Fermented Fruit Juice (banana, squash, papaya, muscovado sugar), Fermented Plant Juice (*Arachis pintoi*, sugar), manila paper, and a plastic straw for the nutrient solution. Draft sheet, weighing scale, measuring tape or ruler, pH meter, and camera for documentation and data collection

Procedure

Site Preparation. The greenhouse in the field was cleaned and sanitized to ensure it was free from contaminants, weeds, and pests. The structure also had UV plastic film roofing materials with a thickness of 0.005 inches, with a total experimental area is 20.13 meters.

Figure 2. Site Preparation

Seedling Substrate Preparation. Coco peat was used as a substrate for seedlings in hydroponics. The coco peat was washed using running water, sterilized for about 20 minutes in boiling water, and air-dried for two days. Afterward, the cocopeat was chopped to achieve a more refined texture.

Preparation of Culture Boxes. Styrofoam boxes were used as growing culture pots containing the nutrient solution. The bottom part of the box was lined with a polyethylene sheet (~0.02mm thick) to prevent the nutrient solution from draining out. On the lid or box cover, eight holes equidistant from one another were cut out with 8 inches distance from each hole. Each of these holes was enough to hold the plant in place.

Figure 3. Preparation of culture boxes.

Fermented Fruit Juice (FFJ) and Plant Juice Preparation (FPJ). For the fermented fruit juice, ripe banana and papaya, mature squash, including the seeds and peels, into tiny pieces were washed and chopped, combined with muscovado sugar with the same water (1:1:1) ratio (v/v). The same procedure was followed for the fermented plant juice using *Arachis pintoi.* Shoots of *A. pintoi* were gathered fresh, washed to remove soil debris, and finely chopped. It was then combined with muscovado sugar with the same quantity of water (1:1:1) ratio (v/v). Each fermentation was covered with clean, unprinted manila paper appropriately sealed. It was kept in a cool, clean place away from contamination. After four (4) weeks, each fermented fruit juice and plant juice were ready for harvest with its sweet-sour smell. An ordinary strainer was used to strain the fermented fruit juice and plant juice extract, and a cloth to separate the liquid thoroughly. The extracted liquid was transferred and placed using a funnel in a dark glass container.

Figure 4. Harvesting of fermented fruit juice (left) and plant juice (right).

Seedling Production. Spinach seeds were soaked in water for 24 hours, then transferred to a cloth and air-dried for an hour. Seeds were sown in seedling boxes that contained coco coir, vermicast, garden soil, and rice hull following a 1:1 ratio. Misting was done twice daily, from 9:00 -9:30 AM to 2:00-2:30 PM.

Transplanting. Seedlings were placed in a shaded area until it was ready for transplant, or two to three pieces of true leaves were present. Seedlings were hardened for some time to acclimatize to the field condition. Seedlings were carefully transplanted individually into 8-oz styrofoam cups with coco peat about 1/3 full. Each cup containing a seedling was drenched in two (2) liters of water with enough nutrient solution to reach the cup's bottom. This procedure was done five (5) days before transplanting to each final growing box to avoid transplanting shock and teach the seedlings to thrive in water.

Figure 5. Transplanting seedlings in growing boxes.

Application of the Different Nutrient Solution. For T1, a dilution guide for SNAP commercial nutrient solution formulated by UPLB was used. For T2 (FFJ), T3 (FPJ), and T4 (FFJ AND FPJ), the dilution of each treatment was 60 mL per liter for each treatment. Since seven (7) liters of water were required for each growing box, 420 mL of each fermented fruit juice and plant juice was applied throughout the study. Each treatment was applied twice a week. 60 mL of each treatment was diluted right after the transplant. A rate of 60 mL per application was applied for each treatment for the second, third and fourth week.

For factor A, 25 mL of coconut water was added to each box initially during the transplant. The second, third, and fourth weeks were done twice a week following an application rate of 50mL, 75, and 150 mL per application, respectively. Meanwhile, coconut water was not applied for every treatment (types of nutrient solution). The bottom of the cups was dipped by 2 cm into the nutrient solution.

The addition of one (1) teaspoon of baking soda per treatment was applied to correct the acidity of the organic nutrient solutions.

Figure 6. Initial application of different nutrient solutions.

Care and Management. Proper levels of the nutrient solution and pH were closely watched to promote better growth performance of the tested crop. Weeds and insects were controlled through hand picking.

Harvesting. Harvesting was done as spinach reached its commercial maturity as a vegetable. Spinach was selected for size and maximal recovery of clean leaves that are mid-maturity to young and should be uniformLy green (generally not yellow-green), fully turgid, reasonably clean, and free from severe damage (Cantwell & Suslow,2002). It was done on its 34th day after the transplant.

Data Collected

The following data was gathered during the conduct of the study:

1. **Days from Transplanting to Harvesting**. It was determined by counting the days from transplanting to harvesting.

2. **Plant Height (cm)**. This was done by using a ruler to measure the initial height one week after transplanting and the final height during harvest from the ground level up to the tip of the terminal end of the main stem.
3. **Number of Leaves**. It was determined by counting the total number of leaves one week after transplanting to harvesting in every sample plant.
4. **Leaf length (cm)**. It was determined by measuring three to five fully developed leaves per plant from five randomLy selected plants per box at harvest.
5. **Leaf width (cm).** It was determined by measuring the broadest part of five fully developed leaves per plant from five randomLy selected plants per box at harvest.
6. **Length of Roots (cm)**. It was determined by measuring the longest roots of the sample plants at the time of harvest.
7. **Number of Marketable Plants**. It was determined by counting the marketable plants per box in every treatment replication.
8. **Number of Non-marketable Plant**. It was determined by counting the non-marketable plants per box in every treatment replication.
9. **Weight per plant (g).** It was determined by weighing the individual sample plant in every treatment replication.
10. **Weight of marketable Plant (g).** It was determined by weighing the good quality free from insect and disease damage at marketable size per box at harvest.

11. **Weight of Non-marketable Plant** (g). It was determined by weighing the non-marketable harvested plant.

Total Yield (g). It was determined by weighing all the harvested plants per treatment per box in kilogram.

Temperature of the Environment.

It was determined by using an environmental thermometer twice a week until harvest within 9:00 to 9:30 am and 2:00 to 2:30 pm.

Relative Humidity

It was determined by using a hydrometer twice a week until harvest from 9:00 to 9:30 AM and 3:00 to 3:30 PM.

Sunlight

It was determined by using a lux meter twice a week until harvest from 9:00 to 9:30 AM and 3:00 to 3:30 PM.

Cost and Return Analysis

The cost and return of production were determined by recording all the expenses throughout the study and income from the crops. Gross income was calculated by multiplying the total weight of marketable plants with the prevailing market price of green spinach per kilogram. The difference between the gross income and the expenses represented the net income as shown in the formula:

Gross income = weight of marketable plants (kg) x current Price (php/kg)
Net income = Gross income (Php) - Expenses (Php)

$$\text{Return on investment} = \frac{\text{Net Profit}}{\text{Total Expenses}} \times 100$$

Statistical Analysis

The gathered data was computed and analyzed through the Analysis of Variance (ANOVA) using Statistical Tool for Agricultural Research (STAR) software version 2.0.1.

DEFINITION OF TERMS

Arachis pintoi - is an herbaceous, perennial legume with low stoloniferous growth, multipurpose legume cover crop, and feeds.

Coconut Water – is the liquid found in the center of a young, green young coconut about 6 -7 months of age.

Cocopeat – is a non-fibrous, spongy, lightweight, corky material and a byproduct of decorticating coir from coconut husk.

Fermentation- A chemical reaction in which a ferment causes an organic molecule to split into simpler substances.

Fermented Fruit Juice- is a product of the bio-fermentation process made from sweet ripe fruits, fruit vegetables, and root crops.

Fermented Plant Juice- is an organically formulated product through the bio-fermentation process made from plant sap and chlorophyll.

Hydroponic System - growing plants in a water-based, nutrient-rich solution.

Liquid Organic Fertilizer - is a product from a biofermentation of vegetables, fruit, and animal wastes fermented with sugar and beneficial microbes.

Marketable Plant - refers to harvested plants that are healthy and free from damage.

Nutrient Solutions - a carefully proportioned liquid fertilizer used in hydroponic gardening.

Non-marketable Plant Refers to plants that are infested and undersized at commercial maturity.

Passive Hydroponics- is a method where plants are grown in a very porous medium instead of traditional media such as soil, bark, or peat moss.

Spinach- is an annual, cool-season, flowering vegetable that produces a rosette of leaves during its vegetative stage.

Chapter 2

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter deals with the presentation, analysis, and interpretation of the gathered data on the fresh coconut water enhanced organic nutrient solution on hydroponically grown spinach.

General Observations

The study was conducted at the Bohol Island State University - Bilar Campus screen house for the duration of March-May, 2022. During the study, it was observed that organic liquid nutrient solutions were acidic and all hydroponic solutions (both commercial and organic) supplemented with 150 ml of fresh coconut water became very acidic (Appendix table 16). Furthermore, the smell of the solution resembles the odor of vinegar 2-to 3 days after adding the coconut water. Stunted growth was also observed on hydroponically grown spinach in organic liquid nutrient solution and on spinach grown in commercial solution supplemented with fresh coconut water.

The temperature in the study area was also higher (Appendix Table 14) than the temperature outside the screen house. This phenomenon resulted in wilting of the spinach plants from 10 a.m. to 3 p.m. All plants were also observed to exhibit yellowing of the leaves on both commercial and organic liquid nutrient solutions supplemented with coconut water.

Growth Performance of Spinach

Table 1 presents the data obtained on the plant height of spinach 30 days after transplanting. Plant height was significantly higher on crops grown in commercial hydroponic solution without supplementing fresh coconut water. This may be because a commercial hydroponic solution contains the appropriate macro and micronutrients necessary for plant growth and development. Plants grown on liquid organic nutrient solutions were recorded to have shorter and smaller plants since the solution was acidic (Appendix table 16) in nature and it has no buffer to control its pH. Moreover, spinach grown on commercial and organic liquid nutrient solution supplemented with coconut water was significantly shorter and smaller. This might be because two days after adding fresh coconut water, the hydroponic solutions become so acidic that the odor already smells like vinegar due to the fermentation of coconut water.

Table 1. Plant Height (cm) of Hydroponically Grown Spinach in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Plant Height (cm)	
	With coco-water	**Without coco-water**
T1 - SNAP A&B	6.29 bc	12.39 a
T2 - Fermented Fruit Juice (FFJ)	3.64 d	3.96 cd
T3 - Fermented Plant Juice (FPJ)	5.58 bcd	7.40 b
T4 - FFJ + FPJ	3.77 cd	5.59 bcd
CV (%)	14.64	

Means with the same letter in a column are not significantly different ($HSD_{p=0.05}$)

Table 2 illustrates the number of leaves of hydroponically grown spinach supplemented with fresh coconut water – enhanced organic nutrient solution. Results obtained show that among liquid nutrients used in the study, commercial nutrient (T1- Snap A&B) solution without the addition of fresh coconut water produced crops with the highest number of leaves. The addition of coconut water lowers the plant's ability to produce more leaves since the plant growth was stunted due to the increase in acidity (Appendix table 16) of the nutrient solution, which also hinders the availability of nutrients for plant absorption. In addition, plants are grown in organic liquid nutrient solutions, regardless of whether it was supplemented with coconut water or not obtained similar or comparable effects with each other. Among the concentrations of organic liquid fertilizer used, fermented plant juice (Treatment 3) obtained the highest number of leaves next to commercial fertilizer.

Table 2. Number of Leaves of Hydroponically Grown Spinach in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Number of Leaves	
	With coco-water	Without coco-water
T1 - SNAP A&B	5.42 bc	8.33 a
T2 - Fermented Fruit Juice (FFJ)	4.42 c	4.92 c
T3 - Fermented Plant Juice (FPJ)	6.08 b	6.08 b
T4 - FFJ + FPJ	5.50 bc	5.25 bc
CV (%)	6.65	

Means with the same letter across one parameter are not significantly different ($HSD_{p=0.05}$)

Leaf length (Table 3) and width (Table 4) of spinach were also significantly affected by the treatments used in treatment one without supplementing fresh coconut water obtained the biggest leaves at harvest. In contrast, plants grown in commercial solution supplemented with fresh coconut water obtained comparable results of leaf length to plants grown in fermented plant juice solution with and without the addition of coconut water. Regardless of supplementation of coconut water, plants in organic nutrient solutions yielded comparable results in terms of leaf length and width.

Table 3. Leaf Length (cm) of Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Leaf Length (cm)	
	With coco-water	Without coco-water
T1 - SNAP A&B	3.99 b	6.52 a
T2 - Fermented Fruit Juice (FFJ)	2.56 c	2.63 c
T3 - Fermented Plant Juice (FPJ)	3.06 bc	3.71 bc
T4 - FFJ + FPJ	2.89 bc	3.36 bc
CV (%)	12.27	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Table 4. Leaf Width (cm) of Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Leaf Width (cm)	
	With coco-water	Without coco-water
T1 - SNAP A&B	1.85 b	5.95 a
T2 - Fermented Fruit Juice (FFJ)	1.39 b	1.40 b
T3 - Fermented Plant Juice (FPJ)	1.52 b	1.94 b
T4 - FFJ + FPJ	1.26 b	1.79 b
CV (%)	18.28	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Table 5 presents the results on the root length (cm) of hydroponically grown spinach grown in fresh coconut water – enhanced organic nutrient solution. Significantly longer root growth was recorded on treatment one without supplementing fresh coconut water. Plants in treatment 1 with the supplementation of coconut water obtained comparable results to plants grown in treatment 3 with and without supplementation of fresh coconut water. Adding fresh coconut water makes the solution more acidic due to acetic acid formation, which might hinder the proper development of roots resulting in stunted growth. Moreover, shorter root growth was recorded on crops grown in fermented fruit juice and the combination of FFJ and FPJ regardless of coconut water supplementation.

Table 5. Root Length (cm) of Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Root Length (cm)	
	With coco-water	Without coco-water
T1 - SNAP A&B	17.19 bc	32.10 a
T2 - Fermented Fruit Juice (FFJ)	8.86 d	12.83 cd
T3 - Fermented Plant Juice (FPJ)	19.33 bc	21.91 b
T4 - FFJ + FPJ	15.81 bcd	17.04 bcd
CV (%)	15.67	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Yield and Yield Components

Yield and yield components were observed to have significant interactions among the treatments and the factors used. It was also observed that adding fresh coconut water resulted in no yield obtained since the crops were minimal and can be considered not saleable. Table 6 shows the results of the number of marketable plants of hydroponically grown spinach in fresh coconut water – enhanced organic nutrient solution. Only treatment one (SNAP A&B) without coconut water supplementation has yielded marketable plants. The rest of the treatment, regardless of the supplementation of fresh coconut water, did not produce plants that are big enough to be considered marketable since the growth is stunted due to the acidity of the nutrient solutions.

Table 6. Number of Marketable Plants of Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Number of Marketable Plants	
	With coco-water	Without coco-water
T1 - SNAP A&B	0.00 b	2.33 a
T2 - Fermented Fruit Juice (FFJ)	0.00 b	0.00 b
T3 - Fermented Plant Juice (FPJ)	0.00 b	0.00 b
T4 - FFJ + FPJ	0.00 b	0.00 b
CV (%)	69.99	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Moreover, since treatments supplemented with coconut water produced no marketable crops, it obtained the highest number of non-marketable crops, as presented in table 7. Same data was also recorded on crops grown in organic solution without fresh coconut water supplementation.

Table 7. Number of Non-Marketable Plants of Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Number of Non-marketable Plants	
	With coco-water	Without coco-water
T1 - SNAP A&B	4.00 a	1.67 b
T2 - Fermented Fruit Juice (FFJ)	4.00 a	4.00 a
T3 - Fermented Plant Juice (FPJ)	4.00 a	4.00 a
T4 - FFJ + FPJ	4.00 a	4.00 a
CV (%)	5.50	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Table 8 shows that among other treatments, only treatment one without supplementation of fresh coconut water obtained 20.67 g of marketable spinach. This relates to the results obtained in tables 6 and 7 since T1 is the only treatment with decent crop produce.

Table 8. Weight (g) of Marketable Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Weight of marketable Spinach (g)	
	With coco-water	Without coco-water
T1 - SNAP A&B	0.00 b	20.67 a
T2 - Fermented Fruit Juice (FFJ)	0.00 b	0.00 b
T3 - Fermented Plant Juice (FPJ)	0.00 b	0.00 b
T4 - FFJ + FPJ	0.00 b	0.00 b
CV (%)	86.92	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Table 9. Weight (g) of Non-Marketable Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Weight of Non-marketable Spinach (g)	
	With coco-water	Without coco-water
T1 - SNAP A&B	5.80 ab	7.00 a
T2 - Fermented Fruit Juice (FFJ)	2.10 bc	1.68 c
T3 - Fermented Plant Juice (FPJ)	5.20 abc	3.97 abc
T4 - FFJ + FPJ	1.93 bc	3.43 abc
CV (%)	34.77	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Tables 8 and 9 show the results on the weight of non-marketable spinach. It can be observed that a higher weight of non-marketable spinach was on treatment one without supplementation of coconut water since those crops. However, it is non-marketable and still obtained larger leaves than the crops grown in other solutions.

The treatments used in the study also significantly affected the weight of spinach. Table 10 shows the weight of spinach per plant (g) during harvest. It can be observed that plants in treatment one not supplemented with coconut water produced the heaviest average weight per plant. Plants in T1 supplemented with fresh coconut water obtained comparable results to the spinach plants grown in organic nutrient solutions with and without supplementing fresh coconut water.

Table 10. Weight (g) per Spinach Hydroponically Grown in Fresh Coconut Water Enhanced Organic Nutrient Solution

Treatment	Weight per Plant (g)	
	With coco-water	Without coco-water
T1 - SNAP A&B	1.45 b	8.42 a
T2 - Fermented Fruit Juice (FFJ)	0.52 bc	0.42 c
T3 - Fermented Plant Juice (FPJ)	1.30 bc	0.99 bc
T4 - FFJ + FPJ	0.48 bc	0.86 bc
CV (%)	19.10	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

The highest yield was recorded on spinach grown on treatment one without supplementation of coconut water, for it has bigger and healthier leaves among other treatments. In contrast, crops in T1 supplemented with fresh coconut water produced smaller crops comparable to those grown in organic nutrient solutions regardless of whether it has coconut water. This is because crops in organic nutrients and T1 supplemented with coconut were smaller and had stunted growth because the nutrient medium is very acidic.

Table 11. Total Yield (g) of Spinach Hydroponically Grown in Fresh Coconut Water-Enhanced Organic Nutrient Solution

Treatment	Total Yield (g)	
	With coco-water	Without coco-water
T1 - SNAP A&B	5.80 b	33.67 a
T2 - Fermented Fruit Juice (FFJ)	2.10 bc	1.68 c
T3 - Fermented Plant Juice (FPJ)	5.20 bc	3.97 bc
T4 - FFJ + FPJ	1.93 bc	3.43 bc
CV (%)	19.10	

Means with the same letter across column and row are not significantly different ($HSD_{p=0.05}$)

Chapter 3

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and recommendations drawn from the result of the study.

Summary of findings

The study was conducted to determine the effect of fresh coconut water enhanced organic nutrient solution on the growth and yield performance of spinach grown under hydroponics. The result of the study shows that the application of SNAP nutrient solution without coconut water produced taller spinach and obtained the highest height increment than with the application of nutrient solutions regardless of the supplementation of coconut water. Moreover, spinach grown on commercial and organic liquid nutrient solution supplemented with coconut water was significantly shorter and smaller. In terms of the number of leaves, leaf size, and root length, spinach applied with SNAP nutrient solution without coconut water supplementation consistently produced the most significant number of leaves, longest and widest leaf, and longest root. Furthermore, among the concentrations of organic liquid fertilizer used, fermented plant juice (Treatment 3) obtained the highest number of leaves next to commercial fertilizer. Regarding the number and weight of marketable and non-marketable spinach, only treatment 1(SNAP A&B) without coconut water supplementation has yielded the highest number and weight of marketable plants. In contrast, regardless of the supplementation of fresh coconut water, the rest of the treatments did not produce marketable plants and thus obtained the highest number of non-marketable crops.

Furthermore, a higher weight of non-marketable spinach was on treatment one not supplemented with coconut water. Though non-marketable, the plants still obtained larger leaves than the crops grown in other solutions. In addition, SNAP nutrient solution without coconut water obtained the heaviest weight per plant and total yield than spinach applied with fermented nutrient solution. Therefore, most of the growth and yield parameters are influenced by SNAP liquid nutrient solution application without coconut water than the application of different fermented nutrient solutions with or without coco water which shows minimal growth and yield parameters of spinach under a hydroponic system.

Conclusions

Based on the findings, the following conclusions were drawn:

1. The application of SNAP liquid nutrient solution improved the growth parameter of hydroponically grown spinach.
2. Higher yield was obtained to SNAP nutrient solution without the application of coconut water.
3. There is a significant difference in the effect of spinach applied with nutrient solutions with or without coconut water on its growth and yield performance.

Recommendations

Based on the conclusions drawn, the following recommendations were formulated:

1. Application of SNAP liquid nutrient solution is recommended for hydroponically grown spinach.
2. Extend harvest period to spinach applied with a fermented nutrient solution without coconut water under hydroponic system.
3. Conduct a similar study but on other crops preferably warm season crops.
4. Conduct a study using the same nutrient solution but on other kinds of hydroponic system.

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APPENDICES

Appendix 1a. Plant Height (cm) of Hydroponically Grown Spinach Applied with Different Nutrient Solutions

Treatment		Replication I	II	III	Total	Mean
With coconut water						
T1	SNAP A&B	7.05	5.93	5.90	18.88	6.29
T2	Fermented Fruit Juice (FFJ)	3.55	3.38	4.00	10.93	3.64
T3	Fermented Plant Juice (FPJ)	6.33	4.55	5.85	16.73	5.58
T4	FFJ + FPJ	3.80	4.83	2.68	11.31	3.77
Without coconut water						
T1	SNAP A&B	14.5	11.33	11.33	37.16	19.94
T2	Fermented Fruit Juice (FFJ)	3.88	3.85	4.14	11.87	6.62
T3	Fermented Plant Juice (FPJ)	7.80	6.83	7.58	22.21	12.21
T4	FFJ + FPJ	5.20	5.05	6.53	16.78	9.45

Appendix 1b.Analysis of Variance on Plant Height (cm) of Hydroponically Grown Spinach Applied with Different Nutrient Solutions.

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
rep	2	2.5986	1.2993	1.64	0.2285
factor	1	7.9262	37.9262	47.97	0.0000
Trt	3	107.6965	35.8988	45.40	0.0000
factor:Trt	3	27.9060	9.3020	11.76	0.0004
Error	14	11.0694	0.7907		
Total	23	187.1968			

Appendix 2a. Number of Leaves of Hydroponically Grown Spinach Applied with Different Nutrient Solutions.

Treatment		Replication I	II	III	Total	Mean
With coconut water						
T1	SNAP A&B	6.00	5.00	5.25	16.25	5.42
T2	Fermented Fruit Juice (FFJ)	4.75	4.25	4.25	13.25	4.42
T3	Fermented Plant Juice (FPJ)	6.25	6.25	5.75	18.25	6.08
T4	FFJ + FPJ	5.50	5.75	5.25	16.50	5.50
Without coconut water						
T1	SNAP A&B	9.00	8.00	8.00	25.00	8.30
T2	Fermented Fruit Juice (FFJ)	4.50	5.25	5.00	14.75	4.92
T3	Fermented Plant Juice (FPJ)	5.75	6.25	6.25	18.25	6.08
T4	FFJ + FPJ	5.25	5.00	5.50	15.75	5.25

Appendix 2b. Analysis of Variance on the Number of Leaves of Hydroponically Grown Spinach Applied with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
rep	2	0.2031	0.1016	0.69	0.5157
factor	1	3.7604	3.7604	25.72	0.0002
Trt	3	16.1458	5.3819	36.81	0.0000
factor:Trt	3	9.4688	3.1563	21.59	0.0000
Error	14	2.0469	0.1462		
Total	23	31.6250			

Appendix 3a. Leaf Length of Hydroponically Grown Spinach Applied with Different Nutrient Solutions

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	4.18	3.60	4.18	11.96	3.99
T2	Fermented Fruit Juice (FFJ)	2.66	2.51	2.50	7.67	2.56
T3	Fermented Plant Juice (FPJ)	2.97	3.11	3.11	9.19	3.06
T4	FFJ + FPJ	2.52	3.07	3.07	8.66	2.89
Without coconut water						
T1	SNAP A&B	7.73	5.91	5.91	19.55	6.52
T2	Fermented Fruit Juice (FFJ)	2.51	2.95	2.44	19.55	2.63
T3	Fermented Plant Juice (FPJ)	3.96	3.60	3.56	19.55	3.71
T4	FFJ + FPJ	3.29	3.28	3.52	19.55	3.36

Appendix 3b. Analysis of Variance on Leaf Length of Hydroponically Grown Spinach Applied with Different nutrient solutions.

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
rep	2	0.2339	0.1169	0.60	0.5610
factor	1	5.2080	5.2080	26.84	0.0001
Trt	3	24.0564	8.0188	41.33	0.0000
factor:Trt	3	5.3638	1.7879	9.22	0.0013
Error	14	2.7163	0.1940		
Total	23	37.5784			

Appendix 4a. Leaf Width of Hydroponically Grown Spinach Applied with Different Nutrient Solutions.

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	2.21	1.70	1.65	5.56	1.85
T2	Fermented Fruit Juice (FFJ)	1.54	1.28	1.35	4.17	1.39
T3	Fermented Plant Juice (FPJ)	1.68	1.50	1.39	4.57	1.52
T4	FFJ + FPJ	1.26	1.40	1.11	3.77	1.26
With coconut water						
T1	SNAP A&B	4.86	6.49	6.49	17.84	5.95
T2	Fermented Fruit Juice (FFJ)	1.31	1.44	1.44	4.19	1.40
T3	Fermented Plant Juice (FPJ)	2.15	1.84	1.84	5.83	1.94
T4	FFJ + FPJ	1.68	1.84	1.85	5.37	1.79

Appendix 4b. Analysis of Variance on Leaf Width of Hydroponically Grown Spinach Applied with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
rep	2	0.0401	0.0200	0.13	0.8781
factor	1	9.5761	9.5761	62.71	0.0000
Trt	3	25.2044	8.4015	55.02	0.0000
factor:Trt	3	16.2483	5.4161	35.47	0.0000
Error	14	2.1379	0.1527		
Total	23	53.2068			

Appendix 5a. Root Length of Hydroponically Grown Spinach Applied Different Nutrient Solutions

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	21.38	11.20	18.98	51.56	17.19
T2	Fermented Fruit Juice (FFJ)	9.05	8.87	8.65	26.57	8.86
T3	Fermented Plant Juice (FPJ)	19.30	19.25	19.45	58.00	19.33
T4	FFJ + FPJ	15.60	15.70	16.13	47.43	15.81
Without coconut water						
T1	SNAP A&B	39.75	28.28	28.28	96.31	32.10
T2	Fermented Fruit Juice (FFJ)	12.95	12.83	12.72	38.50	12.83
T3	Fermented Plant Juice (FPJ)	22.33	21.58	21.83	65.74	21.91
T4	FFJ + FPJ	16.88	17.18	17.05	51.11	17.04

Appendix 5b. Analysis of Variance on Root Length of Hydroponically Grown Spinach Applied with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr(> F)
rep	2	31.9577	15.9789	1.98	0.1750
factor	1	193.2338	193.2338	23.94	0.0002
Trt	3	627.8748	209.2916	25.93	0.0000
factor:Trt	3	176.4892	58.8297	7.29	0.0035
Error	14	113.0138	8.0724		
Total	23	1142.5692			

Appendix 6a. Number of Marketable Spinach of Hydroponically Grown Spinach Applied with Different Nutrient Solutions

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	0	0	0	0	0
T2	Fermented Fruit Juice (FFJ)	0	0	0	0	0
T3	Fermented Plant Juice (FPJ)	0	0	0	0	0
T4	FFJ + FPJ	0	0	0	0	0
Without coconut water						
T1	SNAP A&B	3	2	2	7	2.
T2	Fermented Fruit Juice (FFJ)	0	0	0	0	0
T3	Fermented Plant Juice (FPJ)	0	0	0	0	0
T4	FFJ + FPJ	0	0	0	0	0

Appendix 6b. Analysis of Variance on the Number of Marketable Spinach Grown Under Hydroponic System with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr (> F)
rep	2	0.0833	0.0417	1.00	0.3927
factor	1	2.0417	2.0417	49.00	0.0000
Trt	3	6.1250	2.0417	49.00	0.0000
factor:Trt	3	6.1250	2.0417	49.00	0.0000
Error	14	0.5833	0.0417		
Total	23	14.9583			

Appendix 7a. Number of Non-marketable Spinach Grown under Hydroponic System with Different Nutrient Solutions

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	4	4	4	5	1.7
T2	Fermented Fruit Juice (FFJ)	4	4	4	12	4
T3	Fermented Plant Juice (FPJ)	4	4	4	12	4
T4	FFJ + FPJ	4	4	4	12	4
Without coconut water						
T1	SNAP A&B	1	2	2	12	4
T2	Fermented Fruit Juice (FFJ)	4	4	4	12	4
T3	Fermented Plant Juice (FPJ)	4	4	4	12	4
T4	FFJ + FPJ	4	4	4	12	4

Appendix 7b. Analysis of Variance on Number of Non-Marketable Spinach Grown Under Hydroponic System with Different Enhanced Organic Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr (> F)
rep	2	0.0833	0.0417	1.00	0.3927
factor	1	2.0417	2.0417	49.00	0.0000
Trt	3	6.1250	2.0417	49.00	0.0000
factor:Trt	3	6.1250	2.0417	49.00	0.0000
Error	14	0.5833	0.0417		
Total	23	14.9583			

Appendix 8a. Weight of Marketable Spinach Grown under Hydroponic System with Different Nutrient Solutions.

Treatment	Replication			Total	Mean
	I	II	III		
With coconut water					
T1 SNAP A&B	0	0	0	0	0
T2 Fermented Fruit Juice (FFJ)	0	0	0	0	0
T3 Fermented Plant Juice (FPJ)	0	0	0	0	0
T4 FFJ + FPJ	0	0	0	0	0
Without coconut water					
T1 SNAP A&B	28	17	17	62	20.67
T2 Fermented Fruit Juice (FFJ)	0	0	0	0	0
T3 Fermented Plant Juice (FPJ)	0	0	0	0	0
T4 FFJ + FPJ	0	0	0	0	0

Appendix 8b. Analysis of Variance on Weight of Marketable Spinach under Hydroponic System with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr (> F)
rep	2	10.0833	5.0417	1.00	0.3927
factor	1	160.1667	160.1667	31.77	0.0001
Trt	3	480.5000	160.1667	31.77	0.0000
factor:Trt	3	480.5000	160.1667	31.77	0.0000
Error	14	70.5833	5.0417		
Total	23	1201.8333			

Appendix 9a. Weight of Non-Marketable Spinach Grown Under Hydroponic System with Different Nutrient Solutions

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	9.10	3.70	4.60	7.00	5.80
T2	Fermented Fruit Juice (FFJ)	1.80	2.50	2.00	1.10	2.10
T3	Fermented Plant Juice (FPJ)	6.00	3.00	6.60	4.00	5.20
T4	FFJ + FPJ	1.50	2.20	2.10	3.20	1.93
Without coconut water						
T1	SNAP A&B	7.00	7.00	7.00	21	7.00
T2	Fermented Fruit Juice (FFJ)	1.10	2.90	1.05	5.05	1.68
T3	Fermented Plant Juice (FPJ)	4.00	4.00	3.80	11.9	3.97
T4	FFJ + FPJ	3.20	3.40	3.70	10.3	3.43

Appendix 9b. Analysis of Variance on the Weight of Non-Marketable Spinach Grown Under the Hydroponic System with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr (> F)
rep	2	1.5140	0.7570	0.41	0.6689
trt	3	73.3811	24.4604	13.37	0.0002
Factor	1	0.4134	0.4134	0.23	0.6418
trt:Factor	3	7.6636	2.5545	1.40	0.2851
Error	14	25.6077	1.8291		
Total	23	108.5799			

Appendix 10a. Weight per Plant of Spinach Grown Under a Hydroponic System with Different Nutrient Solutions

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	2.28	0.93	1.15	4.35	1.45
T2	Fermented Fruit Juice (FFJ)	0.45	0.63	0.50	1.58	0.53
T3	Fermented Plant Juice (FPJ)	1.50	0.75	1.65	3.90	1.30
T4	FFJ + FPJ	0.38	0.55	0.53	1.45	0.48
Without coconut water						
T1	SNAP A&B	8.75	8.25	8.25	25.25	8.4
T2	Fermented Fruit Juice (FFJ)	0.28	0.73	0.26	1.26	0.42
T3	Fermented Plant Juice (FPJ)	1.00	1.03	0.95	2.98	0.99
T4	FFJ + FPJ	0.80	0.85	0.93	2.58	0.86

Appendix 10b. Analysis of Variance on Weight per Plant of Spinach Grown under Hydroponic System with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr (> F)
rep	2	0.1962	0.0981	0.82	0.4587
trt	3	79.6905	26.5635	223.28	0.0000
Factor	1	18.0050	18.0050	151.34	0.0000
trt:Factor	3	55.1665	18.3888	154.57	0.0000
Error	14	1.6656	0.1190		
Total	23	154.7237			

Appendix 11a. Total Yield of Spinach Grown under Hydroponic System with Different Nutrient Solutions

Treatment		Replication			Total	Mean
		I	II	III		
With coconut water						
T1	SNAP A&B	9.10	3.70	4.60	17.40	10.10
T2	Fermented Fruit Juice (FFJ)	1.80	2.50	2.00	6.30	5.05
T3	Fermented Plant Juice (FPJ)	6.00	3.00	6.60	15.60	11.90
T4	FFJ + FPJ	1.50	2.20	2.10	5.80	10.30
Without coconut water						
T1	SNAP A&B	35.00	33.00	33.00	5.80	33.67
T2	Fermented Fruit Juice (FFJ)	1.10	2.90	1.05	2.10	1.68
T3	Fermented Plant Juice (FPJ)	4.00	4.10	3.80	5.20	3.97
T4	FFJ + FPJ	3.20	3.40	3.70	1.90	3.43

Appendix 11b. Analysis of Variance on Total Yield of Spinach Grown under Hydroponic System with Different Nutrient Solutions

Source	DF	Sum of Square	Mean Square	F Value	Pr (> F)
rep	2	3.1390	1.5695	0.82	0.4587
trt	3	1275.0478	425.0159	223.28	0.0000
Factor	1	288.0801	288.0801	151.34	0.0000
trt:Factor	3	882.6636	294.2212	154.57	0.0000
Error	14	26.6494	1.9035		
Total	23	2475.5799			

Appendix 12. Mean of Relative Humidity where Spinach is Grown under Hydroponic with Different Nutrient Solutions

	Relative Humidity	
Week	AM	PM
1	28	30
	56	44
	31	33
	55	30
2	25	47
	28	49
	42	47
	35	30
3	25	33
	55	40
	27	30
	40	45
4	29	28
	31	28
	35	33
	33	35
5	28	25
	35	36
	33	30
	25	26
Mean	**34.8 %**	**34.95%**

Appendix 13. Mean of The Environmental Temperature where Spinach is Grown under Hydroponic with Different Nutrient Solutions

Environmental Temperature (Degree Celsius)		
Week	**AM**	**PM**
1	36.0	36.7
	27.4	29.0
	35.6	31.7
	27.3	36.7
2	38.5	30.8
	36.7	33.5
	32.7	30.8
	36.8	36.5
3	36.4	31.5
	27.0	30.0
	36.1	36.0
	30.1	28.5
4	37.7	36.5
	35.5	28.5
	36.7	36.5
	34.0	36.0
5	36.7	38.3
	36.0	37.0
	36.5	36.5
	38.5	38.0
Mean	**34.61**	**33.95**

Appendix 14. Mean of the Sunlight where Spinach is Grown under Hydroponic with Different Nutrient Solutions

	Sunlight (Lux)	
Week	AM	PM
1	3620	4700
	451	730
	4750	1615
	560	4700
2	335	1056
	2600	1900
	1284	1056
	3820	4500
3	1223	1710
	495	998
	3800	3800
	1020	680
4	4350	2432
	3890	2010
	4200	1520
	3500	1190
5	4010	4350
	3990	3500
	4020	4350
	4680	4580
Mean	**2829.9**	**2568.85**

Appendix 15. Mean on pH of Nutrient Stock Spinach Grown Under System with Different Nutrient Solutions

Treatment		Replication			Mean
		I	II	III	
With coco water					
T1	SNAP A&B	5.78	5.99	6.02	**5.93**
T2	Fermented Fruit Juice (FFJ)	4.04	4.24	4.32	**4.20**
T3	Fermented Plant Juice (FPJ)	4.7	5.06	5.37	**5.04**
T4	FFJ + FPJ	4.03	4.31	4.39	**4.24**
Without coco water					
T1	SNAP A&B	7.35	7.57	7.53	**7.48**
T2	Fermented Fruit Juice (FFJ)	4.61	4.7	4.47	**4.59**
T3	Fermented Plant Juice (FPJ)	4.93	5.38	5.89	**5.4**
T4	FFJ + FPJ	4.1	4.31	4.48	**4.30**

Appendix 16. Cost and Return Analysis of Spinach Grown Under Hydroponic System with SNAP Hydroponic Solution

Items	Quantity	Unit	Value	Total Cost
Income			29.76	
Sales			29.76	
Expenses				
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	0.5	kilo	20	20
• SNAP nutrient solution	75	mL	.70	52.5
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**174.27**
Net Income				**-159.99**
ROI%				**(100)**

Appendix 17. Cost and Return Analysis of Spinach Grown under Hydroponic System with Fermented Fruit Juice

Items	Quantity	Unit	Value	Total Cost
Income				0
Sales				0
Expenses				
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	1	kilo	20	20
• Muscovado Sugar	1.5	kilo	50	75
• Banana	.5	kilo	20	10
• Papaya	.5	kilo	15	7.5
• Squash	.5	kilo	20	10
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**224.27**
Net Income				**-224.27**
ROI%				**(100)**

Appendix 18. Cost and Return Analysis of Spinach Grown under Hydroponic System with Fermented Plant Juice

Items	Quantity	Unit	Value	Total Cost
Income				0
Sales				0
Expenses				
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	0.5	kilo	20	20
• Muscovado Sugar	1.5	Kilos	50	75
• *Arachis pintoi shoots*	1.5	kilos	10	15
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**211.77**
Net Income				**-211.77**
ROI%				**(100)**

Appendix 19. Cost and Return Analysis of Spinach Grown under Hydroponic System with Fermented Fruit and Plant Juice

Items	Quantity	Unit	Value	Total Cost
Sales				0
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	1	kilo	20	20
• Muscovado Sugar	1.5	kilo	50	75
• Banana	.5	kilo	20	10
• Papaya	.5	kilo	15	7.5
• Squash	.5	kilo	20	10
• *Arachis pintoi shoots*	1.5	kilos	10	15
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**239.27**
Net Income				**-239.27**
ROI%				**(100)**

Appendix 20. Cost and Return Analysis of Spinach Grown under Hydroponic System with Fresh Coconut Water-Enhanced SNAP Hydroponic Solution

Items	Quantity	Unit	Value	Total Cost
Sales			29.76	
Expenses				
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	0.5	kilo	20	20
• SNAP nutrient solution	75	mL	.70	52.5
• Coconut water	1800	mL	.025	45
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**219.27**
Net Income				**-219.27**
ROI%				**(100)**

Appendix 21. Cost and Return Analysis of Spinach Grown under Hydroponic System with Fresh Coconut Water-Enhanced Fermented Fruit Juice

Items	Quantity	Unit	Value	Total Cost
Income				0
Sales				0
Expenses				
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	1	kilo	20	20
• Muscovado Sugar	1.5	kilo	50	75
• Banana	.5	kilo	20	10
• Papaya	.5	kilo	15	7.5
• Squash	.5	kilo	20	10
• Coconut water	1800	mL	.025	45
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**269.27**
Net Income				**-269.27**
ROI%				**(100)**

Appendix 22. Cost and Return Analysis of Spinach Grown under Hydroponic System with Fresh Coconut Water-Enhanced Fermented Plant Juice

Items	Quantity	Unit	Value	Total Cost
Sales				0
Expenses				
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	0.5	kilo	20	20
• Muscovado Sugar	1.5	Kilos	50	75
• *Arachis pintoi shoots*	1.5	kilos	10	15
• Coconut water	1800	mL	.025	45
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**256.77**
Net Income				**-256.77**
ROI%				**(100)**

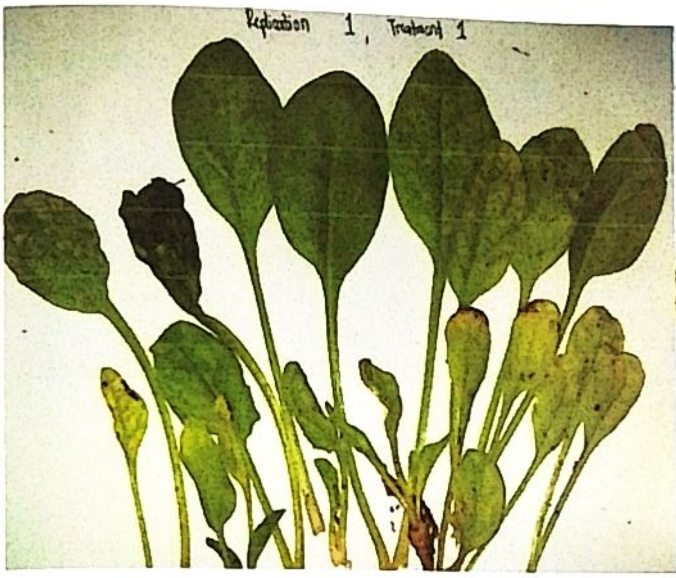
Appendix Table 23 Cost and Return Analysis of Spinach Grown under Hydroponic System with Fresh Coconut Water-Enhanced Fermented Fruit and Plant Juice

Items	Quantity	Unit	Value	Total Cost
Income				0
Sales				0
Variable Cost				
Labor				
• Seedling Preparation	0.06	hour	37.5	2.34
• Preparation (Hydroponics Set-up)	0.13	hour	37.5	4.69
• Initial Treatment Application	0.03	hour	37.5	1.17
• Weeding	0.13	hour	37.5	4.69
• Application of Treatment	0.25	hour	37.5	9.38
• Harvesting	0.13	hour	37.5	4.69
Materials				
• Coco Peat	1	kilo	20	20
• Muscovado Sugar	1.5	kilo	50	75
• Banana	.5	kilo	20	10
• Papaya	.5	kilo	15	7.5
• Squash	.5	kilo	20	10
• *Arachis pintoi shoots*	1.5	kilos	10	15
• Coconut water	1800	mL	.025	45
• Seeds	0.5	mg	60	30
Fixed Cost (Non- cash)				
• Styro Boxes	3	piece	65	3.25
• Styro Cups	24	piece	1.50	36
• Pail	1	piece	50	1.39
• Seedling Tray	1	piece	50	4.17
Total Expenses				**284.27**
Net Income				**-284.27**
ROI%				**(100)**

Appendix 24. Summary of Cost and Return Analysis of Hydroponically Grown Spinach Applied with Different Nutrient Solution

	Without coconut water				With coconut water				Total
Items	T1	T2	T3	T4	T1	T2	T3	T4	
Income	29.76	0	0	0	0	0	0	0	29.76
Sales	29.76	0	0	0	0	0	0	0	29.76
Expenses									
Variable Cost									
Labor									
• Seedling Preparation	2.34	2.34	2.34	2.34	2.34	2.34	2.34	2.34	18.72
• Preparation (Hydroponics Set-up)	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69	37.52
• Initial Treatment Application	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	9.36
• Weeding	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69	37.52
• Application of Treatment	9.38	9.38	9.38	9.38	9.38	9.38	9.38	9.38	75.04
• Harvesting	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69	37.52
Materials									0
• Coco Peat	20	20	20	20	20	20	20	20	160
• SNAP nutrient solution	52.5	-	-	-	52.5	-	-	-	105
• Banana	-	10	-	10	-	10	-	10	40
• Papaya	-	7.5	-	7.5	-	7.5	-	7.5	30
• Squash	-	10	-	10	-	10	-	10	40
• *Arachis pintoi shoots*	-		15	15			15	15	60
• Coconut water	-	-	-	-	45	45	45	45	180
• Seeds	30	30	30	30	30	30	30	30	240
Fixed Cost (Non- cash)									0
• Styro Boxes	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	26
• Styro Cups	36	36	36	36	36	36	36	36	288
• Pail	1.39	1.39	1.39	1.39	1.39	1.39	1.39	1.39	11.12
• Seedling Tray	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	33.36
Total Expenses	174.27	224.27	211.77	239.27	219.27	269.27	256.77	284.27	1429.16
Net Income	(159.99)	(224.27)	(211.77)	(239.27)	(219.27)	(269.27)	(256.77)	(284.27)	(233.11)
ROI%	(91.87)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(98.98)

Fig. 1. Yellowing and tip burn (A), Curling (B), Wilting (C), Root rot of spinach grown hydroponically with and without fresh coconut water supplementation



T1 – SNAP A&B

T2- Fermented Fruit Juice (FFJ)

T3 - Fermented Plant Juice (FPJ)

T4- FFJ + FPJ

Fig. 2. Harvested spinach plants applied with fresh coconut water-enhance nutrient solution.

T1 – SNAP A&B

T2- Fermented Fruit Juice (FFJ)

T3 - Fermented Plant Juice (FPJ)

T4- FFJ + FPJ

Fig. 3 Harvested spinach plants applied with different nutrient solutions without coco water supplementation.

Fig. 4 Marketable (A&B), Non- marketable (C) and Healthy roots (D) of Spinach Plants applied with SNAP A&B