Original Article

A Comparative Growth Wise, Biochemical And Anti-Nutrient Properties Study On Green Leafy Vegetables Solanum Nigrum And Alternanthera Sessilis Cultivated By Hydroponic And Conventional Method

B.V.Febiyola Justine[1]

[1] Research Scholar, Department of Biochemistry, St.Peter's Institute of Higher Education and Research, Chennai, Tamil Nadu, India.
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Abstract

Soilless or liquid culture may serve as an alternative to conventional soil-based cultivation systems. The goal of the current research was to examine several hydroponic growing methods and assess their potential for usage in conjunction with traditional farming for the development of certain vegetable crops, including *Solanum nigrum* and *Alternanthera sessilis*. Standard protocol has been followed for growing both the species and also in evaluating biochemical and anti-oxidant contents. In this experiment the growth rate of both species found to be higher in plants grown in hydroponic condition. Similarly, biochemical and anti-oxidant contents are higher in plants grown in hydroponic condition. This study concludes that plants grown in hydroponic condition when supplemented with several components could give higher and nutrient rich yield compared to plants grown in conventional soil method.

Keywords:*Alternanthera sessilis*, Hydroponic method, Proximate analysis, *Solanum nigrum*.

INTRODUCTION

The availability of land per person is declining, which is the most important problem facing conventional soil-based agriculture. Other problems include poor soil fertility caused by years of continuous cultivation, depleted soil productivity in cultivable areas, and depleted soil productivity overall. In addition to these, climate change poses threats in the form of rising temperatures, frequent dry spells, the unpredictability of weather patterns, poor management of water resources within the watershed due to excessive irrigation use and water waste, unchecked pollution of water bodies, and a decline in groundwater levels(Cyaria *et al.*,2019). These challenges are a serious threat to conventional soil-based agriculture systems due to which producing food nowadays is becoming a real challenge. In order to overcome this challenge, soil less method has to be employed. Hydroponics or liquid culture is one such specialized technique that involves the growth of plants without soil. Although artificial, it is based upon the same principles that nature has set up as the pattern of life and therefore is not an unnatural crop production method.

Hydroponic food production, also known as the production of food without the need of soil, is increasing all over the world. This trend seems to be advantageous as consumers become more aware of the environmental benefits associated with hydroponic food production. Hydroponics has the advantage of being able to be grown everywhere, regardless of the condition of the soil, whether it be a desert or an urban environment. Although minimal research has been done on the topic, hydroponic *Solanum nigrum* and*Alternanthera sessilis* has been thought to have potential.

Hydroponics may be perceived as an engineered way of growing plants that utilizes a soil-less growing medium and a nutrient solution that is optimized to deliver the calculated resources essential for plant growth and development. With regard to water management, it can be viewed as the art of managing water, infusing it with the nutrition vital to plants, and delivering it to their thirsty roots on an as-needed basis so that the highest yields can be achieved in the same sized space while using much less water and labor. Plants grown hydroponically receive a well-balanced diet due to which these plants are healthier than their soil-grown counterparts (Benton, 1982). Hydroponics, unlike conventional agriculture, facilitates complete control over the nutrition of the crop thus using no more than the amount of nutrients and water required by each crop leading to more efficient nutrient regulation and better water management. Due to the reasons aforementioned, hydroponics is usually considered a superior form of agriculture in virtually all the countries of the world. Hydroponic studies aimed at improving crop productivity of hydroponic systems and resolving their limitations have increased exponentially over the past several decades in the developed nations. The technology is being increasingly implemented in the developed world and hydroponic cultivation of several crops, including lettuce, cucumbers, tomatoes, etc. has been studied. However, the technique is still in its juvenile phase in the developing nations and demands extensive research on various aspects before its adoption in crop production. In India particularly, the continued population growth has rendered a market that is willing to purchase locally grown hydroponic produce. But the technique is far from enactment due to lack of evidence and research on the various aspects of the technology that would address the concerns of the growers while providing an insight into the production technique (Ahn *et al.,*2021). Therefore, this study aimed to provide detail insight on the growth, biochemical and anti-oxidant values of two green leafy vegetable *Solanum nigrum*and *Alternanthera sessilis.*

MATERIALS AND METHOD

Plant Collection

From Hosur, two different kinds of green vegetables*Solanum nigrum* (Manathakkali) and *Alternanthera sessilis* (Ponnankanni) were procured and transported to the research location in an aseptic manner. By measuring the height of the plants during the course of the research, the growth of the plants was documented for 21 days.These two plants received authentication fromChennai-based plant anatomy research center.

Chemicals Used

The elements with higher concentrations were iron, ammonium phosphate, calcium citrate, and potassium nitrate. The nutritious solution in each bottle has a total capacity of 100 milliliters (ml). Thirty liters of water were already in the container, so we added ten milliliters of each nutrient to it.

METHODOLOGY

Traditional system

Experiment was conducted at the St. Peter's College, Chennai. Seedlings of *Solanum nigrum* (ManathakkaliKeerai) and *Alternanthera sessilis* (Ponnanganni)were grown in a sterile plastic container with the dimensions of 12 inches by 12 inches and holes measuring 3 millimeters in diameter were placed at the bottom of the container. The remaining three quarters of the container were filled with farming soil. One centimeter below the surface of the soil was each sample's distinct planting location for a little piece of the sample's stem. Daily irrigation was provided for the plants. Every week, the growth rate of every plant was measured and recorded.

Hydroponic system

The roots of the plants are submerged in a nutritional solution while they are cultivated using this technique, which eliminates the need for soil (Maharana and Koul, 2011).In order to carry out this approach, a PVC pipe with a diameter of 4 inches was used, and a hole with a diameter of 2 inches was drilled into it. A net pot with a diameter of 2 inches was selected, and then it was filled with coco peat. A hole was cut in the PVC pipe, and the little pot was placed inside of it. The water filled up about one-half of the PVC pipe. The water flow was kept going thanks to the installation of a portable pump inside the container, which included both an intake and an output. The oxygen supply to the plants that are developing was improved by using a portable aerator that was purchased from Amazon and linked to a pipe made of PVC. In order to promote healthy development in the plants, supplemental nutrients were applied to them twice each week. Once every seven days, measurements were taken to determine the height of the plants that were growing (Fig 1).

Fig 1 Hydroponic Method

Drip Method

One of the hydroponic methods of plant growth is known as the drip system.The plants are cultivated in a media that does not include dirt. The coco peat was purchased from Amazon.com and used to fill the pot that measured 10 inches across and 10 inches tall. A very little piece of a stem was inserted into the container and planted. Water for irrigation and other mineral supplements were stored in a reservoir, and the pump was also supplied with them (Maharana and Koul, 2011).

When the pump is turned on, the drip system will provide water to each plant once a day for a predetermined amount of time of 20 minutes. The water will be delivered individually via nozzles of a pinpoint size. A weekly application of fertiliser solution was likewise performed on the plant in the same manner. The amount of water required for this technique of propagation is rather low. (Fig 2).

Fig 2 Hydroponic Drip Method

Wick Method

The cultivation of plants using the wick technique is simple and does not need the use of any instruments. The plants that were chosen for the experiment were planted in an absorbent media such as coco peat, and each plant has a wick that extends from its roots to a reservoir that holds water and nutrients. Capillary action provided by the wick allows for the transfer of water and nutrients from the reservoir to the plant roots. (Fig 3).

Biochemical analysis:

Protein, carbohydrate, Fat, Ash, Moisture, Amino acid, Fatty acids, EPA and DHA, Vitamins and Minerals were estimated using following methods Jiang *et al.*,2014, Munson and Walker, 1906, AOAC, 1995, Dry ash, Thermogravimetric, Shimadzu HPLC, Gas chromatography, Teng and Gowda, 1993, Wills,1977, Heckman, 1967 respectively.

Fig 3 Hydroponic Wick Method

RESULTS

Growth of these two plants in hydroponic condition is found to be higher than the conventional soil method. In case of *Solanum nigrum*, growth rate was increasing rapidly from 0^{th} week to 3^{rd} week with increase height of 3cms to 41 cms whereas in conventional soil method growth rate was found to be 18 cms in 3^{rd} week of the growth. Similarly, in *Alternanthera sessilis*, growth rate was increasing rapidly from 0^{th} week to 3^{rd} week with increase height of 3cms to 24 cms whereas in conventional soil method growth rate was found to be 15 cms in 3^{rd} week of the growth. In this study, compared to soil method, hydroponic method yielded 2.5 times higher growth rate in both the species. (Table 1-2; Fig 4-5).

Biochemical analysis deals with Proximate analysis, vitamin, minerals and anti-oxidant profiles of these two species. In this current study, plants grown in hydroponic method showed higher proximate concentration in both the species compared to conventional soil method. Among proximate concentration, protein is found to be in higher concentration in both *Solanum nigrum*(22.37mg/g) and *Alternanthera sessilis*(31.42mg/g) respectively.

Similarly, vitamin and mineral profiles of both the species grown in hydroponic condition is found to higher than the conventional soil type. Comparatively, Vitamin A is found to be in higher concentration in *Solanum nigrum*whereas in *A. sessilis* vitamin C is found to be in higher concentration. Also, in mineral profile, Calcium is found to be in higher concentration in both the species.

Anti-oxidants derived from these plants are generally classified under secondary anti-oxidants and in this study, plants grown under hydroponic condition showed higher anti-oxidant content than soil type and found in minimal amount (Table 3-10; Fig 6-9).

Table 1: Growth of *Solanum nigrum* in different concentrations at different time interval

Method	0^{th} week (in cms)	1^{st} week (in cms)	2^{nd} week (in cms)	3^{rd} week (in cms)
Drip method	3±0.18	17±0.28	32±0.28	38±0.28
Wick method	3±0.26	10±0.44	12±0.44	19±0.18
Hydroponic method	3±0.16	12±0.44	28±0.17	41±0.18
Soil method	3±0.1	5±0.44	11±0.15	18±0.21

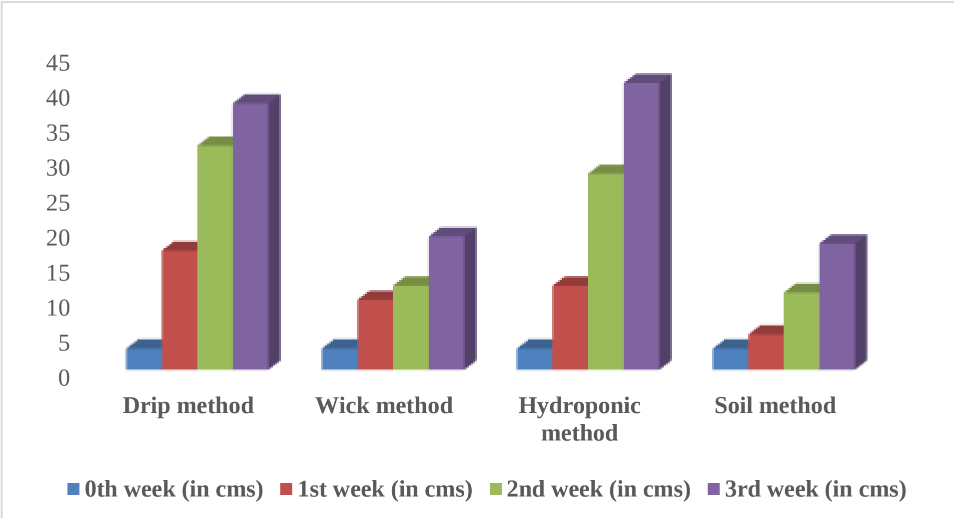

Figure 4: Comparison of growth of *Solanum nigrum* in different method

Table 2: Growth of *Alternanthera sessilis* in different concentrations at different time interval

Method	0^{th} week (in cms)	1^{st} week (in cms)	2^{nd} week (in cms)	3^{rd} week (in cms)
Drip method	4±0.15	9±0.14	14±0.08	16±0.08
Wick method	3±0.12	18±0.08	22±0.08	21±0.05
Hydroponic method	3±0.20	12±0.14	18±0.08	24±0.23
Soil method	3±0.20	6±0.14	12±0.11	15±0.08

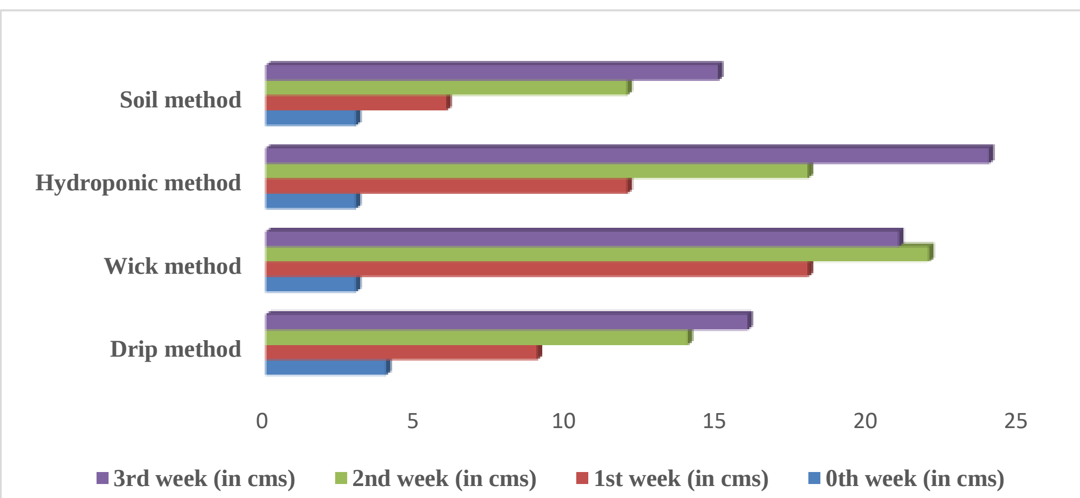

Figure 5: Comparison of growth of *Solanum nigrum* in different method

Table 3: Proximate analysis of *Alternanthera sessilis* (in gms)

Proximate	Soil	Hydroponic	Drip	Wick
Carbohydrates	14.33±0.14	11.42±0.03	18.49±0.008	13.44±0.01
Protein	20.93±0.12	22.37±0.008	25.94±0.01	20.59±0.008
Fat	0.60±0.05	0.40±0.01	0.39±0.008	0.50±0.11
Ash	14.55±0.07	19.02±0.01	25.01±0.02	19.22±0.014
Moisture	9.34±0.01	7.84±0.01	8.60±0.11	8.03±0.11

Table 4: Vitamin analysis of *Alternanthera sessilis* (in mg)

Vitamin content	Soil	Hydroponic	Drip	Wick
Vitamin B1	0.204±0.0008	0.612±0.001	0.0045±0.0001	0.102±0.001
Vitamin B2	3.25±0.011	10±0.08	0.018±0.0008	0.053±0.001
Vitamin B3	12.34±0.008	49.36±0.21	7.33±0.01	2.03±0.01
Vitamin B6	0.102±0.001	0.502±0.001	0.030±0.01	0.021±0.01
Vitamin C	59.34±0.01	72.34±0.01	25.33±0.01	90.56±0.14
Folic acid	0.102±0.001	1.25±0.005	0.41±0.01	0.13±0.01
Vitamin A	12.56±0.01	60.82±0.01	0.025±0.001	23.5±0.11
Vitamin E	1.48±0.01	21.75±0.01	1.5±0.11	7.25±0.01
Vitamin B5	1.23±0.008	3.69±0.008	0.72±0.01	0.593±0.004

Table 5: Mineral analysis of *Alternanthera sessilis* (in mg)

Mineral content	Soil	Hydroponic	Drip	Wick
Calcium	78.43±0.01	656.7±0.002	32.14±0.01	25.98±0.01
Potassium	34.5±0.008	232.33±0.02	16.93±0.01	78.33±0.004
Zinc	5.35±0.01	8.91±0.01	9.19±0.001	23.5±0.001
Magnesium	20.91±0.02	64.69±0.02	46.94±0.11	47.24±0.11
Iron	10.55±0.001	18.10±0.01	19.25±0.004	62.5±0.1
Sodium	150.3±0.001	180.5±0.01	125.6±0.01	210.5±0.01

Table 6: Anti-oxidant content of *Alternanthera sessilis* (in mg)

Anti-oxidant	Soil	Hydroponic	Drip	Wick
Tannins	0.034±0.0005	0.684±0.05	0.04±0.0005	0.304±0.0005
Oxalate	0.18±0.005	0.22±0.025	0.069±0.005	4.24±0.005
Saponin	0.0045±0.0001	0.53±0.015	0.42±0.0005	0.102±0.05

Table 7: Proximate analysis of *Solanum nigrum* (in gms)

Proximate	Soil	Hydroponic	Drip	Wick
Carbohydrates	9.22±0.01	15.19±0.005	12.74±0.01	11.12±0.01
Protein	5.45±0.01	31.42±0.01	22.46±0.01	19.34±0.01
Fat	0.204±0.001	0.30±0.04	0.10±0.02	0.203±0.001
Ash	22.4±0.11	10.33±0.01	13.56±0.14	11.23±0.01
Moisture	5.33±0.01	17.44±0.01	8.26±0.24	9.45±0.01

Table 8: Vitamin analysis of *Solanum nigrum* (in mg)

Vitamin content	Soil	Hydroponic	Drip	Wick
Vitamin B1	14.21±0.01	42.63±0.01	4.12±0.01	0.14±0.005
Vitamin B2	5.33±0.01	15.9±0.05	1.77±0.008	0.83±0.008
Vitamin B3	20.47±0.17	24.3±0.11	17.52±0.011	22.14±0.01
Vitamin B6	4.98±0.06	14.9±0.05	3.25±0.01	3.24±0.01
Vitamin C	17.22±0.01	52.22±0.01	15.34±0.01	22.34±0.01
Folic acid	0.44±0.01	1.2±0.05	0.5±0.02	0.29±0.005
Vitamin A	125.8±0.11	133.5±0.11	100±0.08	89±0.05
Vitamin E	10.25±0.01	12.25±0.01	4.23±0.005	3.24±0.005
Vitamin B5	2.33±0.01	6.82±0.01	3.56±0.01	2.45±0.005

Table 9: Mineral analysis of *Solanum nigrum* (in mg)

Mineral content	Soil	Hydroponic	Drip	Wick
Calcium	65.23±0.002	200.13±0.05	45.63±0.002	38.48±0.001
Potassium	45.3±0.03	136.4±0.01	34.23±0.01	85.23±0.11
Zinc	15.45±0.01	16.23±0.01	10.47±0.01	6.32±0.001
Magnesium	21.82±0.01	29.85±0.01	14.78±0.01	14.23±0.002
Iron	8.56±0.013	16.35±0.002	5.34±0.01	8.79±0.001
Sodium	140.23±0.015	152.36±0.01	100.23±0.02	98.36±0.001

Table 10: Anti-oxidant properties of *Solanum nigrum* (in mg)

Anti-oxidant	Soil	Hydroponic	Drip	Wick
Tannins	0.20±0.005	0.30±0.005	0.04±0.0001	0.14±0.002
Oxalate	0.13±0.002	0.21±0.001	0.03±0.0002	0.03±0.001
Saponin	0.04±0.0001	0.12±0.0002	0.1±0.0005	0.08±0.001
Lectins	0.02±0.0001	0.05±0.001	0.01±0.0001	0.01±0.0001
Phytate	6.23±0.02	10.34±0.02	2.33±0.001	3.22±0.001

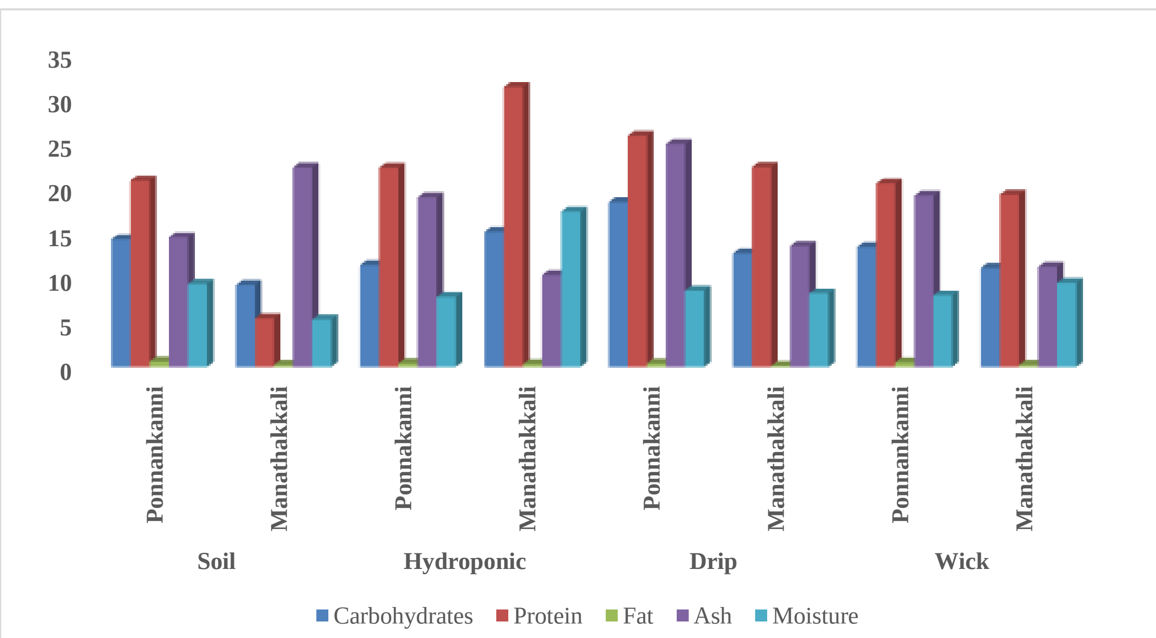

Figure 6: Comparative analysis of proximate values of *Solanum nigrum* and *Alternanthera sessilis*

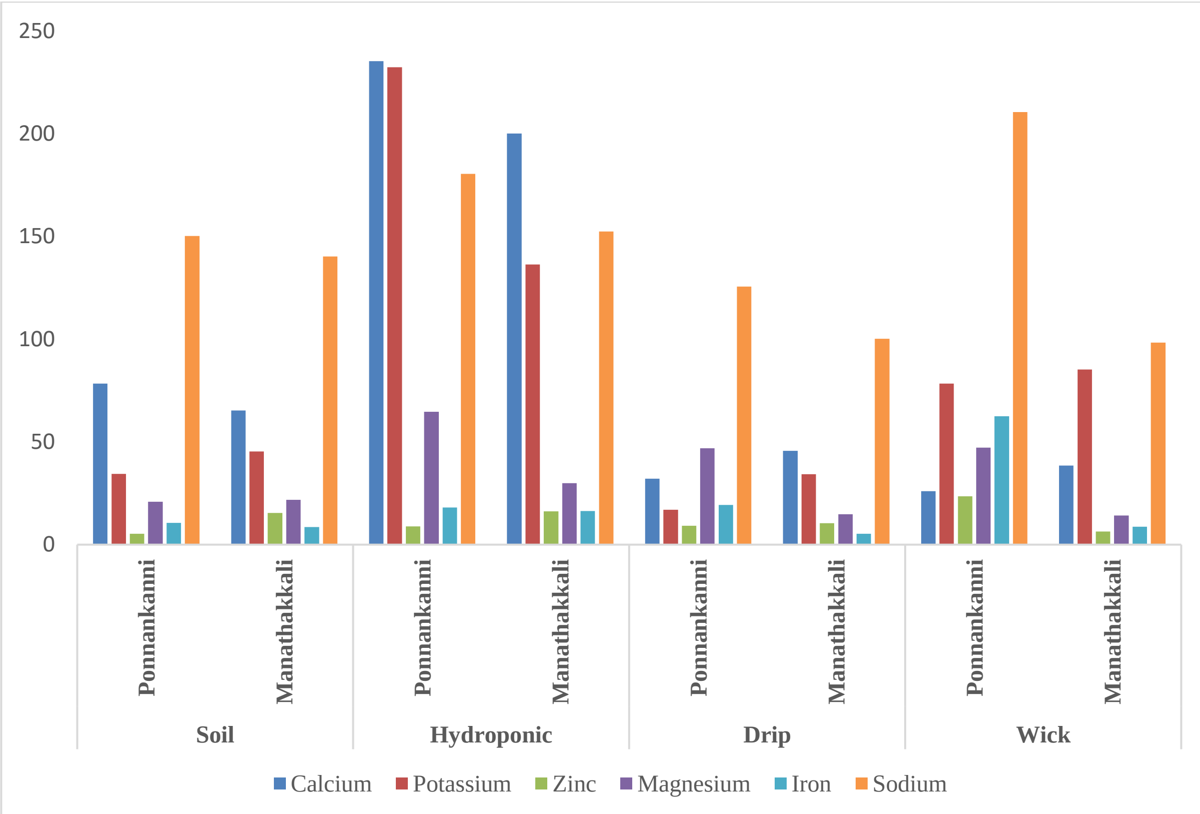

Figure 7: Comparative analysis of vitamin values of *Solanum nigrum* and *Alternanthera sessilis*

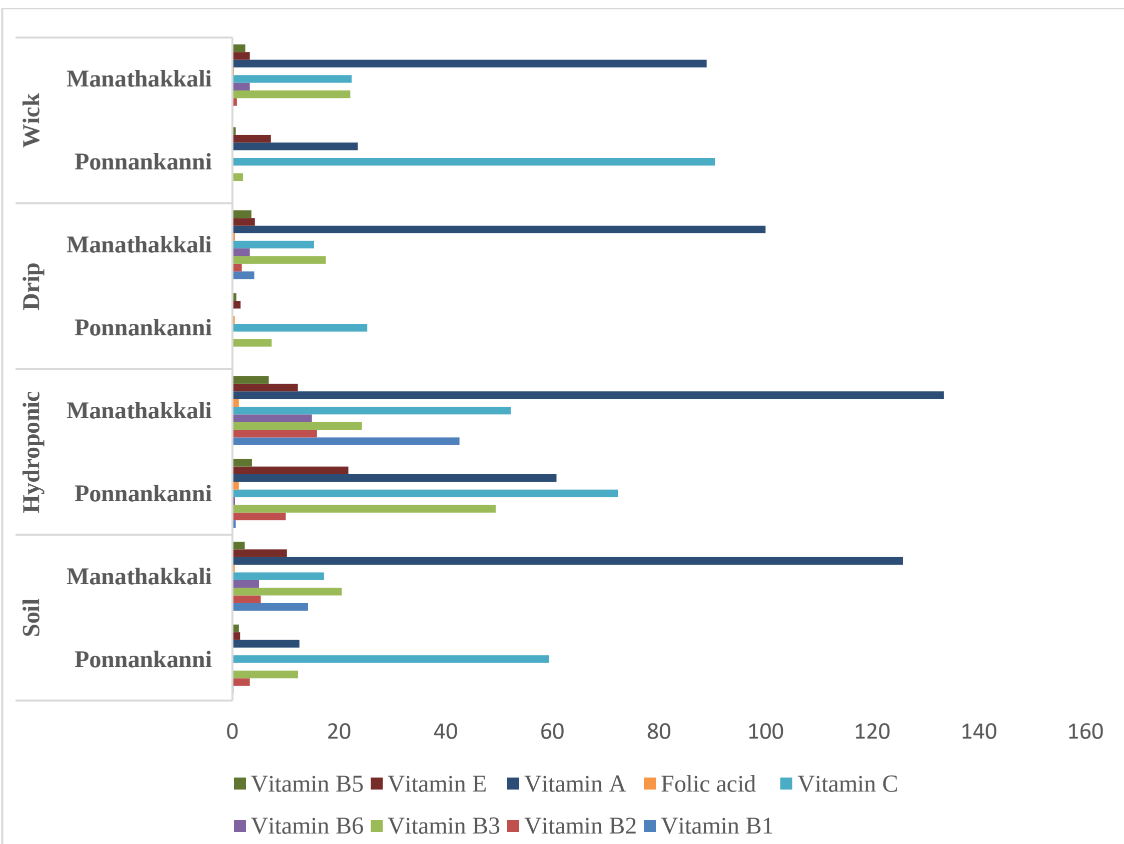

Figure 8: Comparative analysis of mineral values of *Solanum nigrum* and *Alternanthera sessilis*

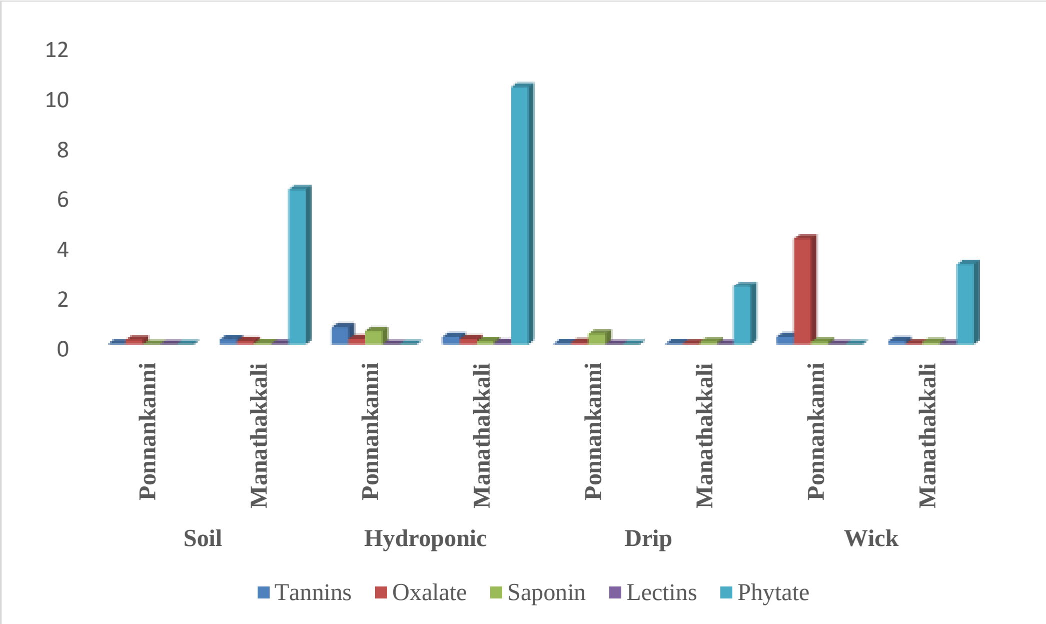

Figure 9: Comparative analysis of mineral values of *Solanum nigrum* and *Alternanthera sessilis*

DISCUSSION

Modern agricultural methods that are more productive and environmentally responsible must be used in conjunction with the conventional soil-based farming practices. These contemporary agricultural practices should include the current issues of decreased soil productivity, low soil nutrient stores, restricted water availability for irrigation, as well as help address the issues of climate change. Promoting soil-free farming techniques is one way to address these contemporary difficulties. While limiting the dangers connected with soil-based cultivation systems, soilless or liquid culture techniques can be used as supplementary cultivation systems to offer a feasible answer to the existing challenges of shortage of fertile arable lands and water (Manjula and Raja, 2019).

By adopting a hydroponic system, water may be saved, production can take place throughout the whole year, yields can be raised, and less pesticides can be used. It has been shown that the nutritional value of fruits and vegetables grown in hydroponic systems is superior to that of its soil-grown equivalents, as is the sensory appeal of the hydroponically cultivated products. Studies on hydroponics have largely focused plants like lettuce, peppers, and tomatoes (Murphy *et al.*,2011).

In his research, Millspaugh(1887) found the height of the *Solanum nigrum* plant to be between 30.9cm, which was lower than the findings of our current study. Based on the findings of this research, it is plausible to assume that as the height of the drip technique, there would inevitably be an increase in the amount of vegetative growth represented by the leaves. Additionally, the leaf yield that was generated by the liquid fertiliser and coco peat medium was the greatest across the whole trail.

In this current study, plants grown in hydroponic method yield higher growth compared to soil, similar result was observed in Armenian cucumber plant where the plant grown in hydroponic condition has higher growth (177cms) than soil method (70cms) (Gashgari *et al.,* 2018).

Biochemical analysis is one of the important parameter which determines the nutrient quotient of any species in detail. In this study, two varities of lettuce (*Keerai)* has been used. Experimentally, it was shown that both species specifically grown in hydroponics has higher nutrient content than soil type lettuce. Similar result was observed in experimenting various types of lettuce grown in conventional method and found that lettuce is highly nutrient. Also, lipid content is found to be only 30% in plants grown in conventional method (Settaluri *et al.*,2015) which is comparatively less to the lipid observed in this experiment.

Anti-oxidant properties have greater part as anti-microbial and anti-cancer agents. Numerous pathogenic conditions, including both communicable and non-communicable illnesses, have been linked to oxidative stress. As a result, it becomes imperative that we consume powerful antioxidants in our diet and as dietary supplements (Hussein *et al.,* 2017; Kadhim *et al.,* 2017; Ahmed *et al.,* 2017; Fakir *et al.*,2017; Mekhlef *et al.,* 2017).

CONCLUSION

The purpose of this study was to investigate a variety of hydroponic growth techniques and evaluate their viability for use in combination with conventional agricultural practices in the production of particular vegetable crops, such as *Solanum nigrum* and *Alternanthera sessilis*, amongst others. The discovery that the efficacy of hydroponics is greatly dependent on the nutrient absorption, which has been demonstrated to be significantly influenced by the pH of the medium, was made. The height of the plants that were grown in soil and the plants that were produced in hydroponic systems were noticeably different from one another. Plants that were grown in hydroponic conditions had a yield that was two times more than that of soil-grown plants, as well as a more lush and quick development rate than plants produced in soil. Additionally, the plants that were grown in hydroponic environments began blooming and fruiting sooner. On the basis of these hopeful results, hydroponics may be recommended as an alternative to growing techniques based on soil, and it may be investigated further for the aim of assuring sustainable agricultural production and the safety of food across the globe.

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