Evaluation of Spinach and Lettuce Production (Growth, Morphological Characteristics, Biomass Yield, and Nutritional Quality) in NFT Hydroponic System in Greenhouse, Room, and Open Environment at Leh, India.

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ABSTRACTS

Advanced crop production systems that combine grove design, size limiting space, irrigation and nutrient management, and mechanical harvesting have the potential to make crops more efficient and economically competitive. Experiments conducted on a comparative study of vegetables (spinach and lettuce) growth pattern, yield and nutritional quality in NFT hydroponic systems with greenhouse, Room Conditions and Open Environment growing conditions. Experiments result in crop spinach var. *Delta* shown in green house NFT system crop morphology data viz. plant height, number of leaf, leaf area, fresh weight and yield was higher achieved as compared to other condition and lettuce var. *Grand rapid* number of leaf, leaf area, fresh weight and yield was maximum compared to other condition, plant height higher in room conditions. Results indicated spinach & lettuce grown in green house NFT is best for hydroponic system in green house for getting maximum yield. Plant Sugar profiling and pigment contents of spinach & lettuce crop highest TSI, fructose, glucose and sucrose content was observed in green house NFT system compared to other condition. Spinach and lettuce growing in green house condition found macro and micro nutrients higher contain. The most immediate agricultural challenge for the 21st century is to increase the yield of crops per surface unit while increasing water use efficiency and nutrient use efficiency to meet global food demand.

Key words: Spinach, lettuce, hydroponic, Nutritional Quality and Ladakh

1. Introduction

The global food production system generates significant negative effects on the environment and consumes tremendous amounts of resources. Agriculture accounts for 60–70% of global water demand (FAO, 2019). Pesticides and fertilisers used in agriculture are a major source of pollution that poses a hazard to the environment due to leaching and deposition. Leh-Ladakh is a high-altitude, cold desert region of India that has very harsh climatic conditions, a short agriculture season, and is landlocked for about six months during the winter months. The high radiation level, low humidity, low soil fertility, and only one cropping season in a year (May to October) are typical characteristics of this region (Kumar et al. 2022). In order to meet the basic human requirements, hydroponic techniques have been implemented to get fresh leafy vegetables in extreme high-altitude conditions. However, this region faces major challenges in fresh vegetable production throughout the year. The major problems with fresh leafy vegetable cultivation in cold desert areas are less cultivated land, saline water, low fertility, and barren topography. Thus, obtaining quality production is one of the main challenges for fresh leafy vegetable crops. Lettuce (Lactuca sativa) is a commonly used leafy vegetable that can be grown in a commercial hydroponic system and is mostly grown using the nutrient film technique (NFT). Hydroponic vertical farming helps increase per-unit area production (Touliatos et al., 2016). Lettuce is an important source of vitamin K and A, with higher concentrations of pro-vitamin A and beta-carotene, as well as an excellent source of folate and iron. Lettuce is mostly consumed with burgers and is extremely demanded in hotels and restaurants as a fresh salad. Spinach (Spinacia oleracea) is an edible leafy vegetable that has leaves that can be eaten fresh, frozen, canned, diced, or dehydrated. When spinach is used fresh, frozen, steamed, or briefly boiled, it has a high nutritional value. It is a good source of iron, folate, magnesium, manganese, and vitamins A, C, and K. Spinach is an excellent source of riboflavin and pyridoxine, vitamin E, calcium, potassium, and dietary fibre (source: Food and Agriculture Organisation of the United Nations). This general outline remains today as the basis for our present understanding of plant functions. We now know that 16 elements (C, H, O, S, N, P, K, Ca, Mg, B, Cl, Cu, Fe, Mn, Mo, Ni, and Zn) are essential for normal plant growth. Jones (2014) defines hydroponics as "the practise of growing plants in liquid nutrient cultures rather than in soil". To gather relevant data that can aid in understanding the operation of hydroponic crops and the effective control of fertigation, it is important to close this research gap. In earlier research on the subject, only the nutrient solution, leachates, and plant absorption were taken into account, and the nutrient and water balance were calculated from these fluxes. Due to its effective use of natural resources, especially in regions where soil and water are limiting factors for plant development, hydroponic agriculture is currently becoming more and more popular around the world. It also helps to address climate change concerns and produce high-quality food.

2. Materials and Methods

2.1 Experimental Site- The experiment trial was conducted at Vegetable Research Unit, Defence Institute of High-Altitude Research, DRDO, Leh, UT- Ladakh (latitude, longitude, 34°08'23"N, 77°34'21"E and Altitude 3333 meter) year of 2021. The day length average approximately 9-14 h; temperature, 5-34^{o}C and relative humidity 30-85% during experimental trial. The experiment was level and largely uniform open window double layer polycarbonate greenhouse, open environment and room conditions with window north fessing. . The type of nutrient film technique (NFT) hydroponics system used for research.

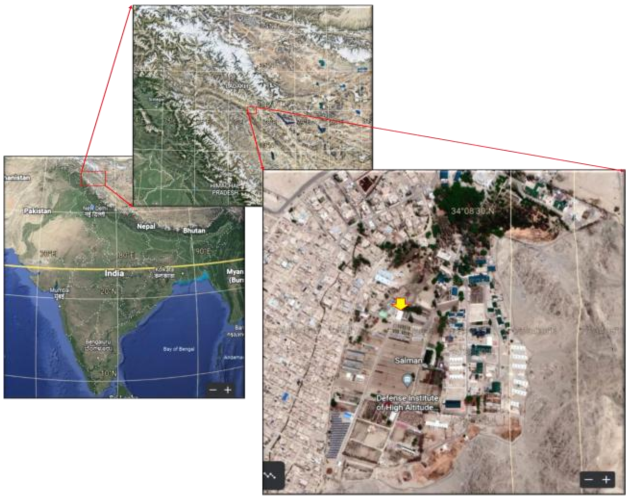

Fig. 1. Experimental site (India, Ladakh and Leh)

2.2 Nutrient film technique (NFT) circulating method- The NFT systems maintain a continuous coating of water and nutrients down a channel's bottom. In essence, some of the roots grow below the water line and receive nutrients, while other parts of the roots grow above the water line and receive oxygen. Vertical NFT circulated system dimension L×W×H (160×90×150cm) with 48 net pot & reservoir of 20 lit capacity. It is can increase the depending open where is place on structural area. The Nutrient film technique system used for electricity18 hrs. for running.

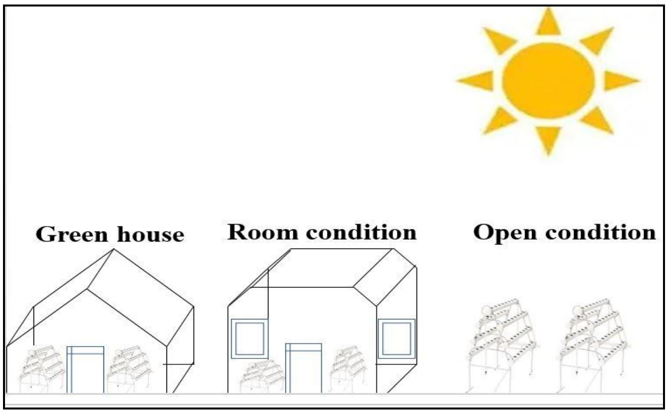

Fig.2 Experimental site diagrammatic

Preparation of Nutrient Solution- Plant nutrients used in hydroponics are dissolved in water and are mostly in inorganic and ionic forms. 17 critical components that plants need for growth were given using various chemical combinations. For the hydroponic production of leafy crops, modified Hoagland nutrient solution (DIHAR-I and DIHAR-II) was utilised (Table-1). The nutrient solution preparation for leafy vegetable lettuce and spinach 2 ml of each DIHAR-I and DIHAR-II nutrient solution was mixed with 1 liter of tube well of nutrient solution was mixed with 1 liter of water. Using a pH and EC metre, the hydroponics nutrient solution's pH and EC values were regularly assessed (Hach, USA). For the best plant growth, the hydroponics solution pH ranges from 6.0 to 6.5. To bring the pH of the nutrition solution within the ideal range, NaOH and HCl were added.

Table 1. Modified Hoagland Nutrient Solution composition

Component	**Stock Solution (g/L)**
DIHAR-I	
$Ca(NO_3)_2*4H_2O$	202
Iron EDDHA (Iron Chelate)	5.6
DIHAR-II	
KH_2PO_4	136
KNO_3	133
$MgSO_4*7H_2O$	58.1
H_3BO_3	2.89
$ZnSO_4*7H_2O$	0.22
$MnCl_2*4H_2O$	0.20
$CuSO_4*5H_2O$	0.08
$NaMoO_4*2H_2O$	0.12

2.3 Crop management- The seed sown in a mixture of cocopeat, vermiculite and perlite (5:2:1) media in pro-trays. Seed sown at optimum depth with maintain moisture proper level seed germination up to seedling transplant. The seedling are ready for transplanting in hydroponic units in two- three leaf stage 25 days old. The seedlings were placed into net pots in growing channels in hydroponic systems. The net pots were filled with clay balls for supporting seedlings. The nutrient solutions were added approximately at 10-12 days interval in hydroponic systems. Crops were harvested35 days after marketable size gain.

2.4 Crop Sampling & Analysis - From each experimental site, nine plants were taken at random. The plants had tags when they were transplanted. Each growing condition's growth and quality parameters are recorded. Utilising SPSS 22, conventional statistical techniques were used to analyse experimental data. (SPSS Corporation, Chicago, Illinois, USA) and MS excel 2019.

2.5 Chlorophyll and anthocyanin content and leaf area analysis: A portable handheld chlorophyll and anthocyanin metre (CCM-200 plus and ACM-200 plus, both from ADC Bioscientific, UK) was used to measure the chlorophyll and anthocyanin content of lettuce and spinach, respectively. Each plant's physiologically active leaves were collected, and a scanner-based leaf area metre (Biovis PSM - L2000) was used to quantify the size of each leaf

2.6 Anions analysis and sugar profiling: Anions (nitrate, sulphate, and phosphate) and Sugar (glucose, fructose, and sucrose) standards were bought from Sigma Aldrich (St. Louis, MO, USA) for the purpose of determining the anions and sugar profiles of lettuce and spinach. Using ultrapure Type 1 water from Direct-Q (Millipore Waters, USA) with a resistivity of 18.2 M.cm, all aqueous solutions were created. Using an ion chromatography (IC) system (930 compact IC Flex, Metrohm, Switzerland), nitrate, phosphate, sulphate, and sugar profile (glucose, fructose, and sucrose) were measured (Acharya et al., 2020).Magwaza and Opara (2015) used the equation to construct the total sweetness index (TSI), which was based on each soluble sugar's content and sweetness coefficient

$$TSI = 1.50 \times \text{fructose} + 0.76 \times \text{glucose} + 1.00 \times \text{sucrose}.$$

2.7 Mineral nutrients analysis: Using the AOAC (1990) techniques, the mineral content of the lettuce and spinach samples was ascertained. Atomic absorption spectroscopy (ZEEnit 700P, Analytik Jena, Germany) and inductively coupled plasma optical emission spectroscopy (ICPE-9000, Shimadzu, Japan) were used to determine the concentrations of calcium (Ca), magnesium (Mg), manganese (Mn), iron (Fe), copper (Cu), boron (B), nickel (Ni), and zinc (Zn). The mineral contents in samples of fresh spinach and lettuce were expressed in mg per 100gm

3. Results and Discussion

3.1 Plant growth and yield attributes of Spinach and Lettuce:

Table 2 compares the growth, morphology, and yield-related traits of spinach and lettuce grown in hydroponic NFT systems under various environmental growing conditions, including plant height, number of leaves, leaf area, fresh weight, and yield. The crops exhibited significant differences in the above attributes when grown in the NFT system under different environmental conditions. It was observed that the plant height of spinach grown in green house (25.0±2.0 cm) was found maximum while followed by open condition (21.33±2.08 cm) minimum plant height was found in room condition in both conditions (19.0±1.0 cm).The highest number of leaves per plant was recorded in green house gown circulated NFT system (15.0±1.0) and the lowest number of leaves per plant was recorded in room condition (10.7±1.5 b). The leaf area of green house with grown in NFT system (76.4±3.7 cm^2) was significantly higher ($P<0.05$) than open condition (68.9±4.06 cm^2) and room condition (64.1±9.4cm^2) grown crop. Because more leaves result in a greater photosynthetic response and more photosynthetic product, it might be achievable. Green house grown in NFT circulated system (52.1±3.4g and 3.23±0.21 kg) exhibited maximum values for fresh weight gram per plant and yield kg.m^{-2} followed by Open condition grown in NFT circulated system (31.4±2.5 g and 1.94±0.15 kg) and lowest value of Room condition (28.5±2.5 g and 1.77±0.16 kg) at $P<0.05$ in spinach crop.

The plant height of lettuce observed in room condition (25.3±1.5cm) was found maximum while followed by green house (21.3±1.5cm) and minimum plant height was found in open condition

(15.0±1.0cm).The highest number of leaves per plant was recorded in green house gown circulated NFT system (25.3±1.5) and the lowest number of leaves per plant was recorded in room condition (9.7±0.6a). The leaf area of green house (68.4±2 cm^2) with grown in NFT system was significantly higher ($P<0.05$) than open condition (63.3±7.4 cm^2) and room condition (45.6±5.7 cm^2) grown crop. It might be possible because higher number of leaves causes higher photosynthetic reaction leading to more photosynthetic product. Green house grown in NFT circulated system (38.3±3.5g and 2.38±0.22kg) exhibited maximum values for fresh weight gram per plant and yield $kg.m^{-2}$ followed by Open condition grown in NFT circulated system (29.7±2.1g and 1.84±0.13kg) and lowest value of room condition (15.3±2.5g and 0.95±0.16 kg) at $P<0.05$. Green House grown in NFT system showed significant ($P<0.05$) difference in lettuce plant yield.

Table 2. Growth and yield attributing characters of lettuce and spinach grown in different environmental condition, at harvest.

Growing Conditions	Green House	Open condition	Room condition
Spinach			
Plant Height (cm)	25.0±2.0b	21.33±2.08ab	19.0±1.0b
Leaf number $plant^{-1}$	15.0±1.0b	12.0±1.0ab	10.7±1.5b
Leaf Area(cm^2)	76.4±3.7a	68.9±4.06a	64.1±9.4a
Fresh Weight (g. $plant^{-1}$)	52.1±3.4b	31.4±2.5a	28.5±2.5a
Yield ($Kg.m^{-2)}$	3.23±0.21b	1.94±0.15a	1.77±0.16a
Lettuce			
Plant Height (cm)	21.3±1.5b	15.0±1.0a	25.3±1.5c
Leaf number $plant^{-1}$	13.3±0.6b	12.3±1.2b	9.7±0.6a
Leaf Area(cm^2)	68.4±2b	63.3±7.4b	45.6±5.7a
Fresh Weight (g. $plant^{-1}$)	38.3±3.5c	29.7±2.1b	15.3±2.5a
Yield ($Kg.m^{-2)}$	2.38±0.22c	1.84±0.13b	0.95±0.16a

Data were shown in mean ± standard deviation (n = 9). The values with the different letter within same column are statistically significant by Duncan's test at $p \leq 0.05$.

This distinction is made because of the exceptional surroundings in the case of hydroponic greenhouse cultivation under different conditions. Crops want appropriate surroundings for their growth. The handiest circumstance to attain appropriate surroundings for higher crop production is the hydroponic greenhouse cultivation. It is feasible to develop cereals, vegetables, fruits, fodder, flowers, condiments, and medicinal plant in hydroponic greenhouses (Khan, 2018). The initial assessments of the hydroponic in inexperienced residence manipulate approach display that it is ideal opportunity to the presently to be had strategies used for nutrient deliver and environmental circumstance with top best manufacturing of crops. (Saraswathi, et al., 2018). Hydroponic greenhouse cultivation is higher choice with inside the feel of usage of inputs and progressed crop production and similar results show (Khan, 2018).

3.2 Sugar profiling and pigment contents of spinach & lettuce:

Plant Sugar profiling and total sweetness index of spinach as influenced by different growing condition like green house, open condition and room condition in NFT hydroponic system are described in Fig 3. In spinach, significant highest TSI (6708.95), fructose (3091.80 mg100g^{-1}), glucose (2517.43 mg100g^{-1}) and sucrose (158.0 mg100g^{-1}) content was observed in green house NFT system followed by TSI (6264.76), fructose (6264.76 mg100g^{-1}), glucose (2199.83 mg100g^{-1}) and sucrose (148.7 mg100g^{-1}) contain in open condition. Whereas, lowest TSI (5912.6), fructose (2853.8 mg100g^{-1}), glucose (1951.6 mg100g^{-1}) and sucrose (148.6 mg100g^{-1}) content was recorded in room condition.

The lettuce crop grown in different growing condition like green house, open condition and room condition in NFT hydroponic system are described in Fig.4. In lettuce, significant highest TSI (2928.05), fructose (1320.33 mg100g^{-1}), glucose (1123.97 mg100g^{-1}) and sucrose (93.33mg100g^{-1}) content was observed in green house NFT system followed by TSI (2756.17), fructose (1247.60 mg100g^{-1}), glucose (1048.47 mg100g^{-1}) and sucrose (87.93 mg100g^{-1}) contain in open condition. Whereas, lowest TSI (2426.31), fructose (1079.70 mg100g^{-1}), glucose (950.73 mg100g^{-1}) and sucrose (84.20 mg100g^{-1}) content was recorded in room condition. Somen et al. (2020) found comparable leafy viewable each lowering and general sugar content material turned into determined substantially better in NFT gadget than soil grown spinach. Total sugar content material of lettuce varies from 480 to 1970 mg.100g^{-1} relying upon range and type (Mou. 2008). The carbohydrates production through plant is an important factor affected by CO_2, water and light. Our results are in agreement with reviews of Fillion and Kilcast (2002) who confirmed effective correlation among soluble sugar content material and first-class of veggies and d described that that soluble sugar .

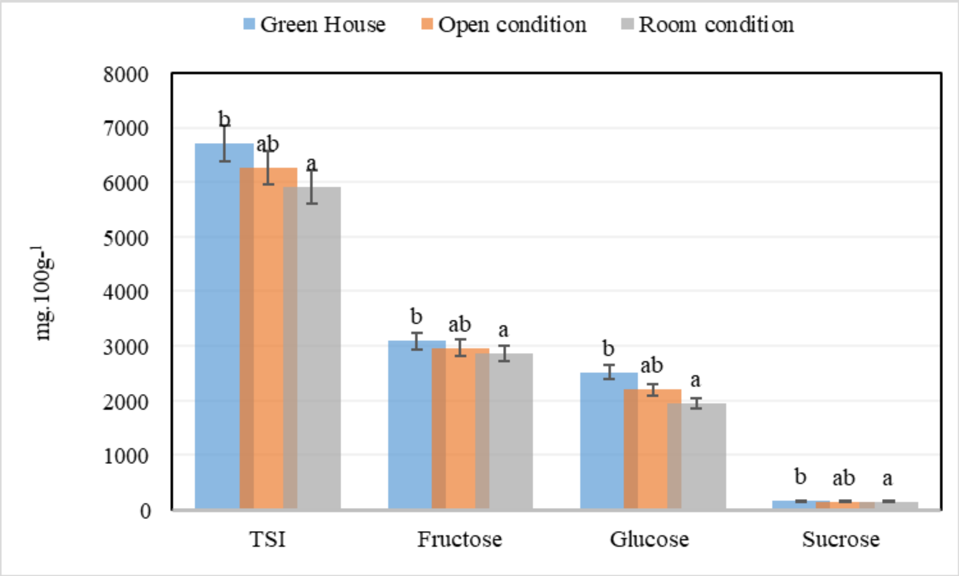

Fig. 3 Glucose, Fructose, Sucrose and Total sweetness Index of spinach grown in Different environmental condition, at harvest.

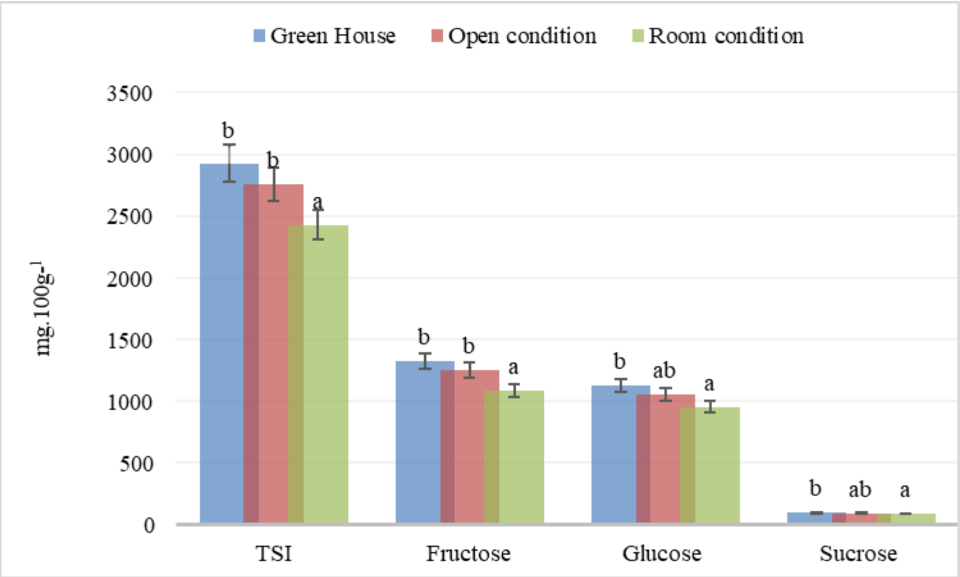

Fig. 4 Glucose, Fructose, Sucrose and Total sweetness Index of lettuce grown in Different environmental condition, at harvest.

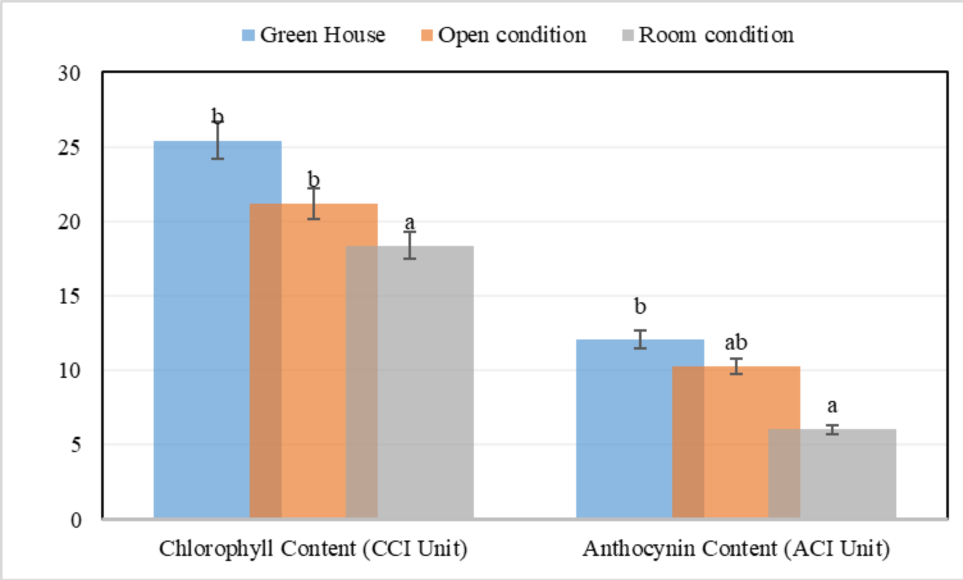

Fig.5 Plant leaf pigment anthocyanin and chlorophyll contents of spinach grown in Different environmental condition, at harvest.

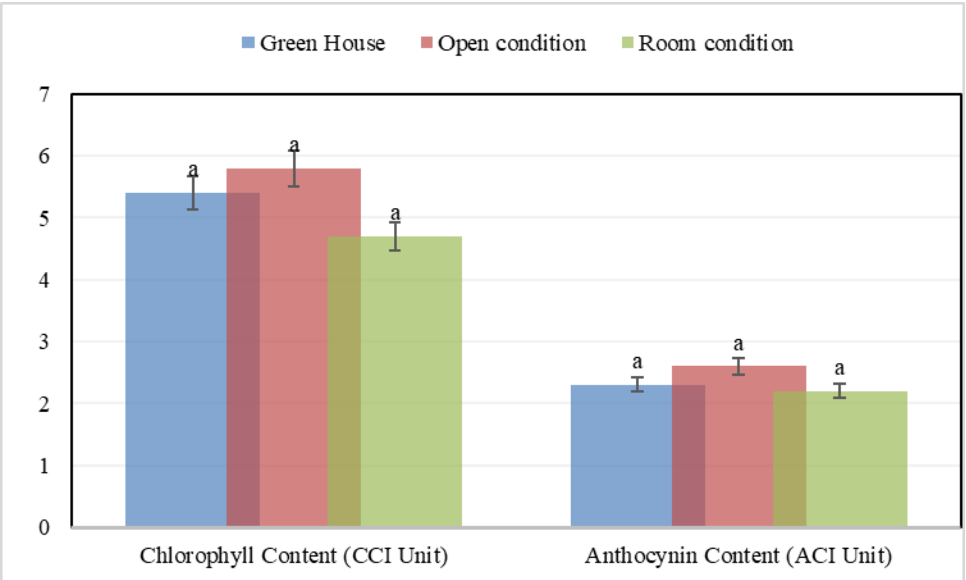

Fig. 6 Plant leaf pigment anthocyanin and chlorophyll contents of lettuce grown in Different environmental condition, at harvest.

and crude fiber are carbohydrates that have an effect on the beauty and crispness of leafy vegetables Plant leaf pigment anthocyanin and chlorophyll contents of spinach as influenced by various growing condition NFT hydroponic system described in fig 5. The green house NFT circulated system exhibited significantly highest chlorophyll content (25.4 CCI) and anthocyanin content (12.1 ACI) followed by open condition (21.2 CCI) and (10.3 ACI) with NFT system. The spinach in room condition showed lowest chlorophyll content and anthocyanin content (18.4 CCI) and (6.0

ACI).

The present in spinach anthocyanin and chlorophyll contents grow in various condition in verticality NFT hydroponic system of lettuce described in fig 6. The open condition NFT circulated system exhibited non-significantly highest chlorophyll content (5.8 CCI) and anthocyanin content (2.6 ACI) followed by green house (5.4 CCI) and (2.3 ACI). The room condition showed lowest chlorophyll content and anthocyanin content (4.7 CCI) and (2.2 ACI). Significant difference in quality of yield between different grown condition of lettuces and spinach was also observed by Matthew et al. (2011), somen, et al. (2021) with agree results.

3.3 Macro and Micro nutrients of spinach & lettuce:

Spinach grown in different growing condition NFT hydroponic systems showed significant effects ($P<0.05$) on plant quality parameters viz. nitrate, phosphate, sulphate calcium and magnesium content of leaves (Fig. 7). Macro primary and secondary nutrient content was significantly affected by the growth and production of plant system. When examining the qualitative characteristics of leafy spinach grown in a greenhouse, the NFT system showed the maximum nitrate (997.09 $mg.kg^{-1}$), phosphate (904.92 $mg.kg^{-1}$), sulphate (311.04 $mg.kg^{-1}$) calcium (83.34 $mg.kg^{-1}$) and magnesium (97.65 $mg.kg^{-1}$) content followed by open condition with NFT system exhibited the maximum nitrate (964.44 $mg.kg^{-1}$), phosphate (828.17 $mg.kg^{-1}$), sulphate (295.05 $mg.kg^{-1}$) calcium (78.43 $mg.kg^{-1}$), and magnesium (93.31 $mg.kg^{-1}$) content. Minimum nitrate (895.30 $mg.kg^{-1}$), phosphate (775.17 $mg.kg^{-1}$), sulphate (276.80 $mg.kg^{-1}$), calcium (67.20 $mg.kg^{-1}$) and magnesium (89.04 $mg.kg^{-1}$) content of spinach was recorded in room condition.

Lettuce cultivated under various conditions on plant quality measures, such as the nitrate, phosphate, sulphate, calcium, and magnesium content of leaves (Figs. 8), NFT hydroponic systems demonstrated significant effects ($P<0.05$). The production and expansion of the plant system had a major impact on the macro primary and secondary nutrient content. While analysing the quality attributes of leafy lettuce greenhouse with NFT system exhibited the maximum nitrate (521.1 $mg.kg^{-1}$), phosphate (965.9 $mg.kg^{-1}$), sulphate (578.2 $mg.kg^{-1}$) calcium (78.6 $mg.kg^{-1}$) and magnesium (64.4 $mg.kg^{-1}$) content followed by open condition with NFT system exhibited the maximum nitrate (495.0 $mg.kg^{-1}$), phosphate (925.1 $mg.kg^{-1}$), sulphate (506.7 $mg.kg^{-1}$) calcium (69.2 $mg.kg^{-1}$), and magnesium (53.1 $mg.kg^{-1}$) content. Minimum nitrate.

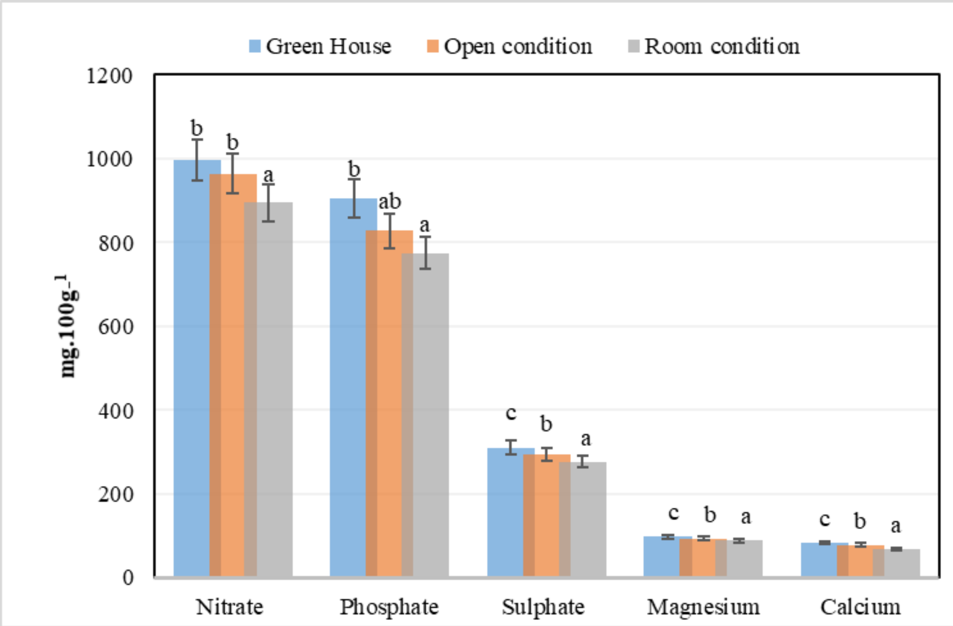

Fig. 7 Macro (nitrate, phosphate, sulphate calcium and magnesium) content and Micro nutrient contents of spinach grown in Different environmental condition, at harvest.

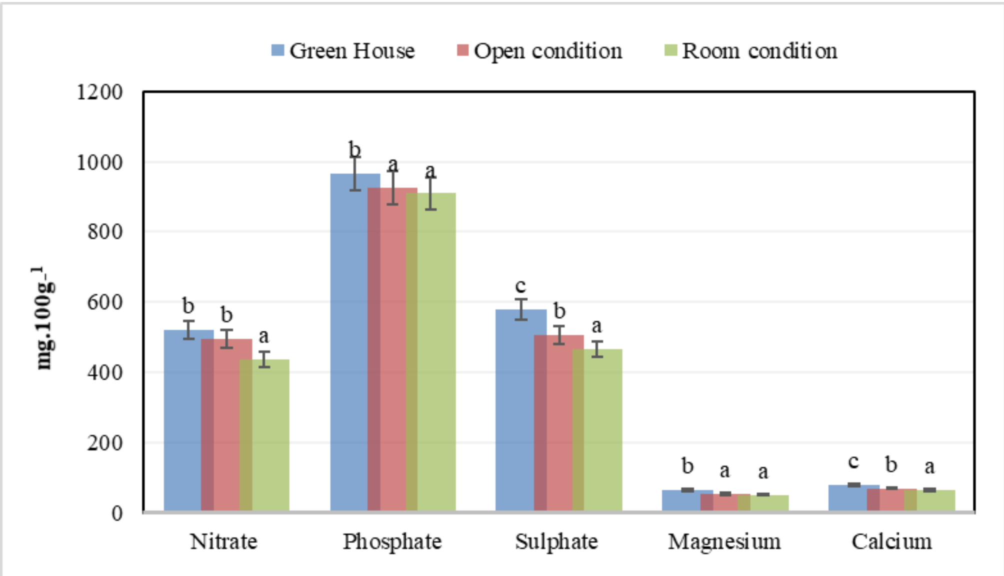

Fig.8 Macro (nitrate, phosphate, sulphate calcium and magnesium) content and Micro nutrient contents of lettuce grown in Different environmental condition, at harvest

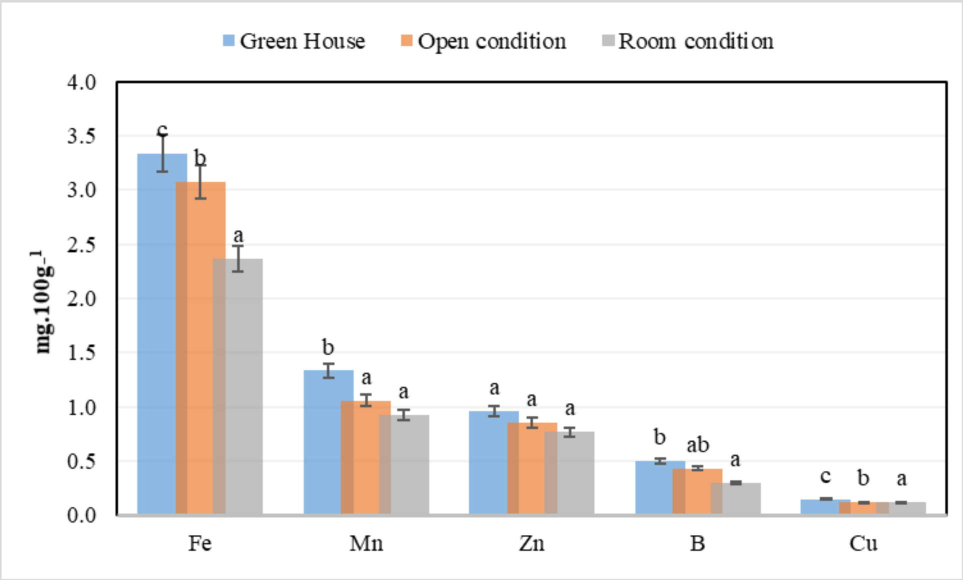

Fig. 9 Micro nutrient (Fe Mn, Zn, B and Cu) contents of spinach grown in Different environmental condition, at harvest

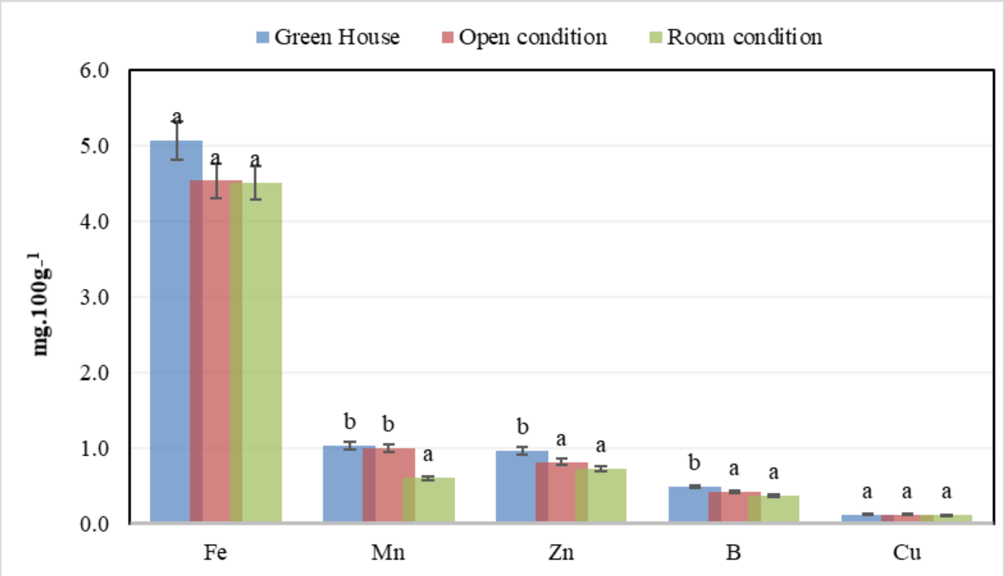

Fig. 10 Micro nutrient (Fe Mn, Zn, B and Cu) contents of lettuce grown in Different environmental condition, at harvest

(435.1 mg.kg-1), phosphate (909.2 mg.kg-1), sulphate (465.8 mg.kg-1), calcium (64.2 mg.kg-1) and magnesium (50.2 mg.kg-1) content of spinach was recorded in room condition.

This assessment confirmed that there may be distinction among developing conditions. This distinction is because of favourable environment in case of hydroponic greenhouse cultivation compare to other cultivation condition. To attain the best quality, its miles essential to deliver main nitrate, phosphate, sulphate calcium and magnesium ions for plant boom with better attention in produces yield. (Lee et al. 2017, Kwon et al. 2021 & Khan, 2018)

Spinach crops growing different conditions Fe Mn, Zn, B and Cu mineral concentration ($mg.100g^{-1}$

fresh weight of fruit) of are shown in Fig 9. Spinach grown in different growing condition NFT hydroponic systems showed significant effects ($P<0.05$) on plant quality parameters viz. Fe, Mn, B and Cu content and non-significant in Zn content in spinach leaves. Micronutrient content was significantly affected by the reproduction system of plant. While analysing the quality attributes of leafy spinach greenhouse with NFT system exhibited the maximum Fe (3.34 $mg.kg^{-1}$), Mn (1.33 $mg.kg^{-1}$), Zn (0.96 $mg.kg^{-1}$), B (0.50$mg.kg^{-1}$) and Cu (0.15 $mg.kg^{-1}$) content followed by open condition with NFT system exhibited the Fe (3.08 $mg.kg^{-1}$), Mn (1.06 $mg.kg^{-1}$), Zn (0.85 $mg.kg^{-1}$), B (0.43 $mg.kg^{-1}$) and Cu (0.12 $mg.kg^{-1}$) content while minimum content was recorded in plants harvested from room condition Fe (2.36 $mg.kg^{-1}$), Mn (0.93 $mg.kg^{-1}$), Zn (0.77 $mg.kg^{-1}$), B (0.30 $mg.kg^{-1}$) and Cu (0.12 $mg.kg^{-1}$) in spinach crop.

In Fig. 10, lettuce cultivated under various conditions is depicted, together with their Fe, Mn, Zn, B, and Cu mineral concentrations (mg.100g-1 fresh weight of fruit). lettuce cultivated under various conditions On plant quality measures, such as Mn, B, and Zn content, NFT hydroponic systems shown substantial effects ($P<0.05$), while the effects on Fe and Cu content in spinach leaves were not significant. The plant's reproductive system has a substantial impact on micronutrient content. While analysing the quality attributes of leafy spinach greenhouse with NFT system exhibited the maximum Fe (5.07 $mg.kg^{-1}$), Mn (1.04 $mg.kg^{-1}$), Zn (0.96 $mg.kg^{-1}$), B (0.49 $mg.kg^{-1}$) and Cu (0.12 $mg.kg^{-1}$) content followed by open condition with NFT system exhibited the Fe (4.54 $mg.kg^{-1}$), Mn (1.00 $mg.kg^{-1}$), Zn (0.82 $mg.kg^{-1}$), B (0.42 $mg.kg^{-1}$) and Cu (0.12 $mg.kg^{-1}$) content while minimum content was recorded in plants harvested from room condition Fe (4.51 $mg.kg^{-1}$), Mn (0.60 $mg.kg^{-1}$), Zn (0.72 $mg.kg^{-1}$), B (0.38 $mg.kg^{-1}$) and Cu (0.11 $mg.kg^{-1}$). Optimising the usage of nutrients in hydroponic vegetation is key, on account that plant nutrient intake has come to be one of the most significant environmental factors in greenhouse situations with better mineral nutrition uptake in plant yield. Sanjuan, (2017). Green house technique, in particular with inside the creation of mineral vitamins and better yield manufacturing with rich, exceptional mineral nutritional Martin et al. (2019) and Cumo et al. (2018).

4. Conclusion

Results of the study revealed growth and yield-attributing parameters of spinach grown under circulating hydroponic techniques under greenhouse, open environment, and room conditions. The crops grown Spinach and lettuce exhibited significant improvements in leaf area, plant height, root length, number of leaves per plant, fresh weight, and yield in the NFT system with a greenhouse compared to other conditions. The higher content of calcium, magnesium, nitrate, phosphorus, and sulphur (B, Cu, Mn, Ni, Zn, and Fe elements), glucose, fructose, sucrose, and total sweetness index was observed in hydroponically grown spinach and lettuce, especially in the NFT system with greenhouse, compared to other conditions

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