

Original Research Article

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Modification and Performance Evaluation of Hydroponic Structure with Nutrient Film Technique for Spinach

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ABSTRACT

A field experiment was conducted to study the growth and quality of spinach under controlled atmosphere of hydroponic structure at Instructional Farm Department of Farm Structure, Dr. PDKV, Akola during February, 2019 – April, 2019. The experiment was laid out in randomized block design. The structure was 1400 mm long and 970 mm wide and at a height of 1800 mm, OPI STAT statistical software was used for analyzes biometric characteristics and quality parameters respectively. The study indicated that the temperature, relative humidity, light intensity and CO₂ inside the green hydroponic structure were favorable for the growth of spinach in the summer season. Green hydroponic structure showed better results followed by white and uv-polyethylene hydroponic structure. However, temperature inside the white and uv-polyethylene hydroponic structure was 1-3⁰C greater and also light intensity found maximum. Biometric characteristics of spinach like plant height, number of leaves and stem diameter was found maximum in green, white and uv-polyethylene hydroponic structure than open field. The yield was found maximum inside the green hydroponic structure. Yield on the open field was found 2 times less as compare to the green, white and uv-polyethylene hydroponic structure.

Keywords

Hydroponic Structure, spinach, biometric characteristics, uv-polyethylene

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Introduction

Agriculture has been crucial for sustaining life and regularly improving technology to increase food production.

Technological advances in food production have been ample all over the world. Different methods of farming have strayed from the traditional system of soil based farming to the hydroponic techniques.

Soil less culture mainly refers to the techniques of Hydroponics and Aeroponic. The term Hydroponics was derived from the Greek words 'hydro' meaning water and 'ponos' meaning labour. It is a method of growing plants in soil less condition with their roots immersed in nutrient solution without soil. Soilless culture system using artificial substrates would result in efficient and effective use of water and fertilizers and minimize the use of chemicals for pest and disease control. Plants grown in soil less

culture have consistently superior quality, high yield, rapid harvest, and high nutrient content.

Polyhouse farming as well as other modes of controlled environment cultivation has been evolved to create favorable micro-climates, conducive for crop production, making cultivation possible throughout the year or part of the year as required. Adopting soilless culture in protected cultivation with technical practices like integrated plant protection, fertigation, drip irrigation and climate control ensures better yield and water use efficiency. Therefore, studies over the last few decades have mainly focused on the development and rehabilitation of new or readily available systems especially aiming to provide more water and nutrient saving, increased yield and decreased waste of nutrients.

Materials and Methods

A field experiment on “Modification and Performance Evaluation of Hydroponic Structure with Nutrient Film Technique for Spinach” was conducted during 2018-19. This chapter gives the details of parameters considered for the experimental design and recording of data for the experimental study, procedure and instrumentation considered for conducting experiments and the methodology adopted for data analysis.

The experiments were conducted at Instructional Farm, Department of Farm Structures, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the month of Feb - April of 2018-19. The topography of the field was fairly uniform and leveled.

Hydroponic Structure

The easy to build modular hydroponic structure was used for conducting the experiment. Three hydroponic structures having different covering material were

fabricated for the cultivation of spinach by nutrient film technique. The different covering material used were green, white and uv polyethylene. The structure was light weight and movable so that it can be move from one place to another place as per the convenience of crop environment. The structure was made up of un-plasticized polyvinyl chloride (UPVC) pipes of size 32 mm attached together to form an even pan type structure.

Treatment details

The field experiment was laid out in RBD with 8 replications and 4 treatments.

Experimental details

The details of experiments are given in Table.

Nutrient Film Technique (NFT) system process

Nutrient solution was pumped up from the tank to 2 cm diameter PVC pipe delivered to the top of the PVC pipe, the solution discharge in 75 mm PVC pipe was at the rate of 2 l/min.

One side PVC pipe water slowly runs down the other end of PVC pipes.

The pipe was positioned at an angle to water flow at approximately 20-30 mm of depth inside PVC pipe.

The plants start to consume the nutrient rich water from bottom of PVC pipe, they begin to develop root systems inside the PVC pipes.

Water at the bottom of each pipe that the roots receive large amounts of oxygen at the root zone with water and nutrient.

This system supplied constant exchange of the water, nutrient and air to the plant.

The PVC pipes connected to the end cap

excess water from the structures was returned into the tank and recirculated. The Structure was designed so that all the net cups got equal amount of water, nutrient and air

Results and Discussion

Environmental parameters

Temperature

During the experiment, the temperature was recorded at 8, 11, 14 and 17 hours from 15th February, 2019 to 30th March, 2019 after the sowing of seeds. Table 3.1 and Table 3.2 showed average temperature in February and March green and white colour, and uv-polyethylene hydroponic structures and also average temperature on open field. Due to the controlled atmosphere system, temperature inside the green and white and uv-polyethylene hydroponic structure has great influence on crop growth. Temperature inside the green and white colour hydroponic structure was found 5-6⁰C less than the outside temperature. This difference was found due to the installation of floggers and exhaust fans, which helps in controlling the temperature. But as compared green and white structure, temperature inside the uv-polyethylene structure was greater by 3-2⁰C than green colour hydroponic structure. The results i obtained during the research work are represented graphically as shown in Fig 3.1 and Fig 3.2. Similar results have been reported for temperature (Meena *et al.*, 2012) and (Meena *et al.*, 2014).

Relative humidity

During the experiment, the relative humidity was recorded at 8, 11, 14 and 17 hours. Table 3.3 and Table 3.4 shows average relative humidity in green and white colour and uv-polyethylene hydroponic structure and in the open field condition. The relative humidity

inside the green and white colour and uv-polyethylene hydroponic structures was found to have great influenced on crop growth. In open field relative humidity was found minimum as compare to the green and white colour hydroponic structures during the growth stages of crop. The relative humidity inside the green and white colour and polyethylene hydroponic structure was observed in between 50-60% as on the open field relative humidity was found between 30-40%. The relative humidity inside green and white colour and uv-polyethylene hydroponic structure was found 19-20% more as compared to open field. But comparing green and white colour hydroponic structures, relative humidity inside the green colour hydroponic structure was found 3-4% more than white and uv-polyethylene hydroponic structure. This difference was observed due to the controlled atmosphere management inside the hydroponic structure. Results obtained during the research work are shown graphically as shown in Fig 3.3 and Fig 3.4. Similar results have been reported for relative humidity (Meena *et al.*, 2012) and (Meena *et al.*, 2014)

Light intensity

During the experiment, the light intensity was recorded at 8, 11, 14 and 17 from hours 15th February, 2019 to 30th March, 2019. Table 3.5 and Table 3.6 shows average light intensity in February and March green and white colour and uv-polyethylene hydroponic structure and on the open field condition. The light intensity inside the green and white colour and polyethylene hydroponic structures was found to have great influence on crop growth. In open field hydroponic structure light intensity was found maximum as compare to the green and white colour and uv-polyethylene hydroponic structures during the growing stages of crop. The light intensity inside the green and white colour hydroponic structure

was observed in between 50-60% less as compare to open field and polyethylene. But as compare green white and uv-polyethylene hydroponic structure light intensity inside the green colour hydroponic structure was found 2-3 % less than white colour and polyethylene hydroponic structure. Results obtained during the research work are graphically as shown in Fig 3.5 and Fig 3.6. Similar results have been reported for light intensity (Meena *et al.*, 2012) and (Meena *et al.*, 2014).

Effect of carbon dioxide (CO₂) on the growth of Spinach

The CO₂ concentration in the uv-polyethylene hydroponic structure was recorded higher in between 334.23 – 599.17 ppm as compared to the white and green hydroponic structure and open field at all crop growth stages. This might be due to green and white colour decreases the crop temperature and vapour pressure deficit which leads to increase stomatal conductance and CO₂ assimilate.

Among the covering material uv-polyethylene sheet reported highest CO₂ concentration at all the crop growth stages. The open field conditions showed lowest CO₂ concentration because of less photosynthetic rate and high temperature. The highest production of spinach was found in green hydroponic structure and lowest production was found in open field. Results obtained during the research work are graphically presented as shown in Fig 3.7.

Biometric Characteristic

Height of the plant

The plant height of spinach was influenced significantly due to different hydroponic structures and at all crop growth stages. Table 3.8 shown mean plant height influenced by different hydroponic structure at four days interval and the graphical representation of data is shown in Fig 3.8.

Treatment details

Treatments	Specification
T ₁	Green hydroponic structure with nutrient film technique
T ₂	White hydroponic structure with nutrient film technique
T ₃	UV-polyethylene hydroponic structure with nutrient film technique
T ₄	Open field condition hydroponic structure with nutrient film technique

Experimental details

Sr. No.	Particulars	Specification
1.	Name of the crop	Spinach
2.	Scientific name	<i>Spinaciaoleracea</i>
3.	Variety	<i>Savoy spinach</i>
4.	Planting time	Summer season
5.	Design	Randomized block design
6.	Number of treatment	4
7.	Number of replication	8
8.	Total no of racks	4
9.	No of PVC pipe (Inside)	8
10.	No of plants (Inside)	56
11.	No of plants per pipe	7
12.	Duration of crop	45 days

Table.1 Average temperature in month of February in GHS, WHS, PHS and OF

Time (Hrs)	Temperature (⁰ C)			
	GHS	WHS	PHS	OF
8:00	19.10	21.09	22.12	24.50
11:00	24.23	26.28	27.19	29.74
14:00	32.22	34.24	35.26	37.33
17:00	26.25	28.36	29.40	31.55

Table.2 Average Temperature in month of March in GHS, WHS, PHS and OF

Time (Hrs)	Temperature (⁰ C)			
	GHS	WHS	PHS	OF
8:00	23.15	25.10	26.12	28.12
11:00	29.14	32.17	33.10	34.56
14:00	32.41	34.19	35.41	38.57
17:00	26.10	28.49	29.10	31.42

Table.3 Average relative humidity in month of February in GHS, WHS, PHS and OF

Time (Hrs)	Relative Humidity (%)			
	GHS	WHS	PHS	OF
8:00	59.62	57.87	55.21	39.16
11:00	57.11	55.44	52.12	36.24
14:00	53.22	51.21	48.54	32.20
17:00	55.16	53.44	50.11	34.10

Table.4 Average relative humidity in the month of March in GHS, WHS, PHS and OF

Time (Hrs)	Relative Humidity (%)			
	GHS	WHS	PHS	OF
8:00	56.32	54.21	52.54	36.32
11:00	53.12	52.12	50.21	33.12
14:00	51.26	49.44	47.21	30.26
17:00	52.17	50.12	48.22	31.20

Table.5 Average light intensity in the month of February in GHS, WHS, PHS and OF

Time (Hrs)	Light intensity (Lux × 10 ³)			
	GHS	WHS	PHS	OF
8:00	205.13	225.27	240.19	408.33
11:00	260.41	280.11	295.87	512.12
14:00	317.01	337.21	352.19	630.25
17:00	230.25	250.31	265.41	456.21

Table.6 Average light intensity in the month of March in GHS, WHS, PHS and OF

Time (Hrs)	Light intensity (Lux × 10 ³)			
	GHS	WHS	PHS	OF
8:00	260.27	280.12	295.25	512.54
11:00	320.09	340.12	355.16	634.18
14:00	360.21	380.71	395.75	712.42
17:00	295.54	315.54	330.54	587.09

Table.7 CO₂ concentration in GHS, WHS and OF at five days interval

Days/interval	CO ₂ concentration (ppm)			
	GHS	WHS	PHS	OF
5	300.12	330.2	334.23	280.11
10	325.74	346.14	350.56	299.1
15	410.29	400.1	456.63	300.14
20	468.42	450.25	497.28	325.24
25	489.58	460.63	525.69	350.12
30	499.89	480.87	555.74	365.87
35	510.69	490.86	599.36	371.74
40	525.23	500.1	603.17	385.45
45	515.26	505.57	599.25	395.56

Table.8 Mean plant height as influenced by different hydroponic structure at four days interval

Treatment/days interval	4	8	12	16	20	24	28	32	36	40
GHS	2.13	2.78	3.32	3.8	4.03	4.8	5.26	5.71	6.26	6.86
WHS	1.93	2.56	2.92	3.47	3.87	3.97	4.17	4.26	5.03	5.97
PHS	1.15	2.42	2.91	3.25	3.48	3.88	4.07	4.15	4.82	5.57
OF	0.92	1.43	1.67	1.91	2.18	2.73	2.95	3.65	4.43	4.38
C.D	0.18	0.18	0.14	0.16	0.33	0.15	0.10	0.23	0.32	0.33
S.E(m)	0.06	0.06	0.04	0.05	0.11	0.05	0.03	0.08	0.10	0.11
C.V.	10.30	7.52	5.17	5.00	9.45	3.84	2.33	5.10	5.99	5.59

Table.9 Mean of no. of leaves as influenced by different hydroponic structure at four-day interval

Treatment /days interval	4	8	12	16	20	24	28	32	36	40
GHS	3.75	5.12	5.50	7.25	8.00	8.75	10.00	11.12	13.62	15.25
WHS	3.50	4.25	4.50	4.37	6.65	7.37	8.25	8.87	9.87	9.87
PHS	3.00	3.75	3.75	3.75	6.45	7.00	7.25	8.00	9.12	8.87
OF	2.12	2.75	2.62	3.50	3.62	4.12	4.62	4.87	4.87	5.00
C.D	0.83	0.76	0.88	0.98	0.44	0.68	0.61	0.62	0.91	0.83
S.E(m)	0.28	0.25	0.29	0.33	0.14	0.23	0.20	0.21	0.30	0.28
C.V.	25.82	18.36	20.58	19.97	6.89	9.54	7.75	7.24	9.31	8.14

Table.10 Mean stem diameter as influenced by different hydroponics structure at four days interval

Treatment/days interval	4	8	12	16	20	24	28	32	36	40
GHS	0.088	0.141	0.221	0.286	0.349	0.434	0.493	0.573	0.634	0.833
WHS	0.051	0.103	0.174	0.253	0.323	0.409	0.439	0.528	0.6	0.59
PHS	0.043	0.093	0.16	0.241	0.313	0.394	0.423	0.489	0.523	0.579
OF	0.026	0.069	0.114	0.198	0.275	0.336	0.37	0.404	0.433	0.466
C.D	0.016	0.017	0.021	0.032	0.031	0.044	0.044	0.036	0.047	0.021
S.E(m)	0.005	0.006	0.007	0.011	0.01	0.015	0.015	0.012	0.016	0.007
C.V.	28.95 4	16.02	12.062	12.59 3	9.321	10.68 6	9.831	6.734	8.257	3.307

Fig.1 Average temperature in month of February

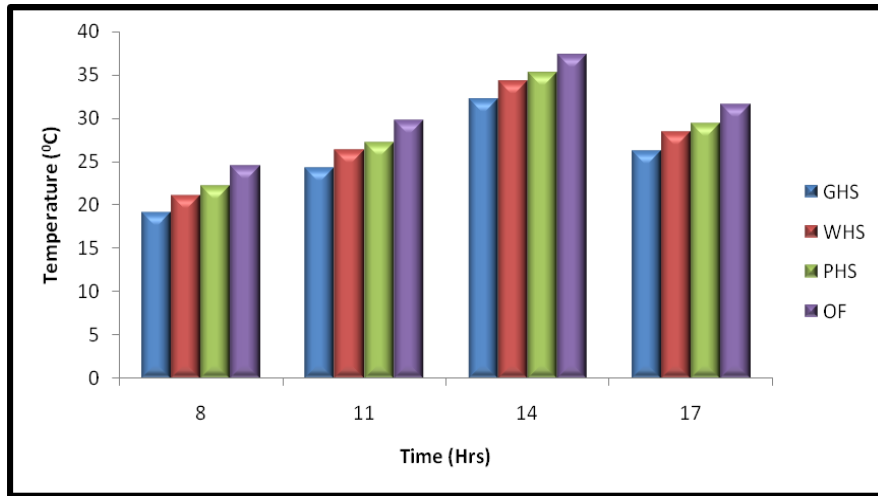


Fig.2 Average temperature in month of March

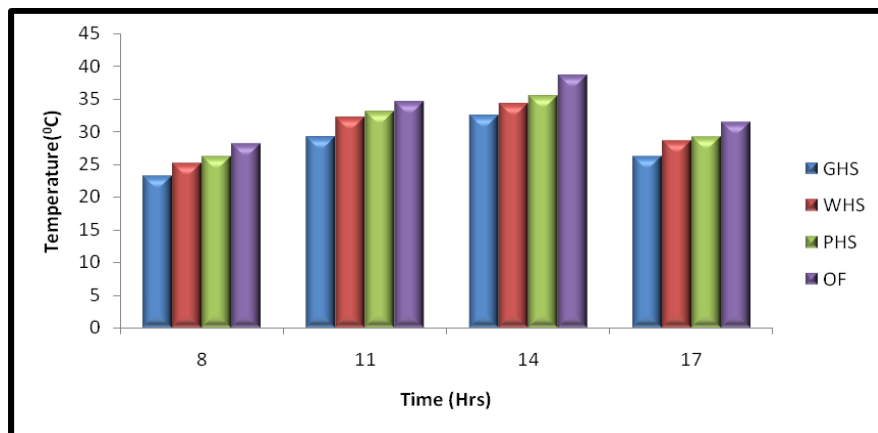


Fig.3 Average relative humidity in the month of February

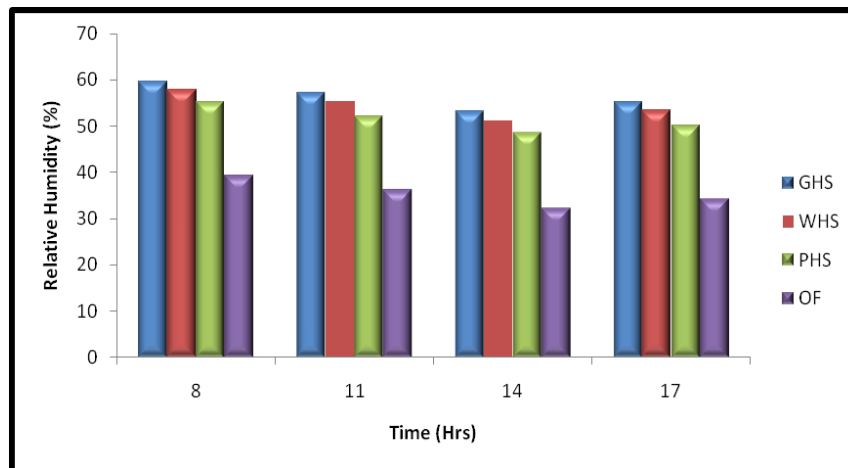


Fig.4 Average relative humidity in the month of March

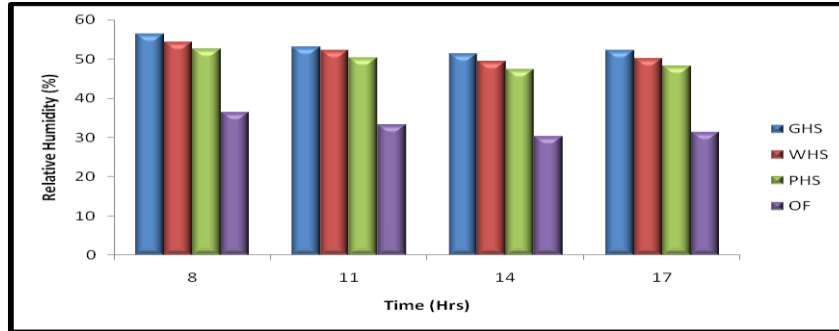


Fig.5 Average light intensity in the month of February

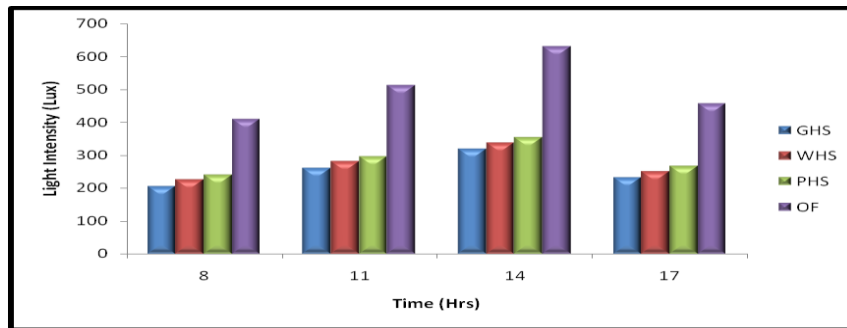


Fig.6 Average light intensity in the month of March

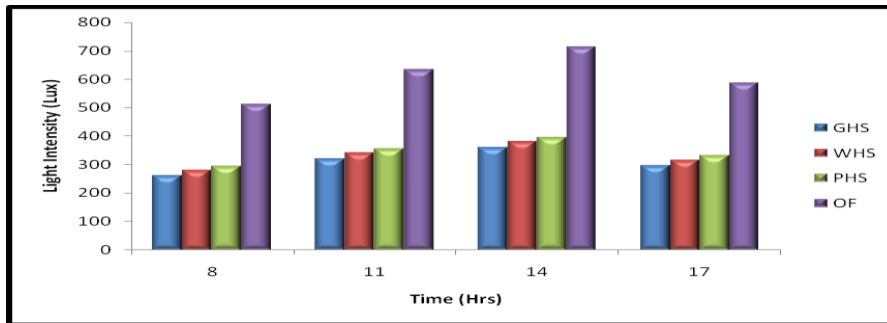


Fig.7 CO₂ concentration at five days interval

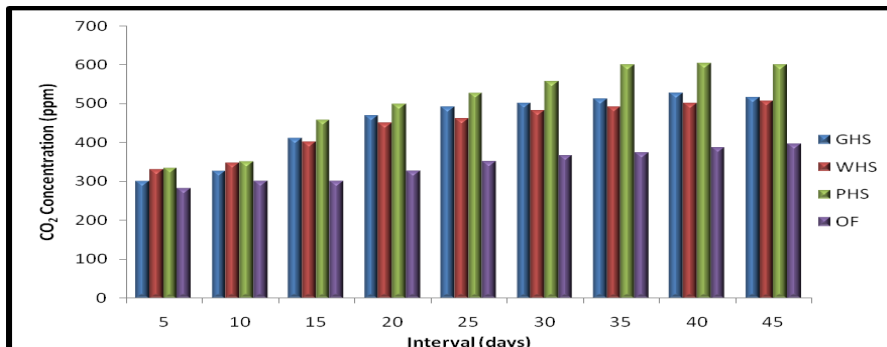


Fig.8 Average plant height of spinach at four days interval

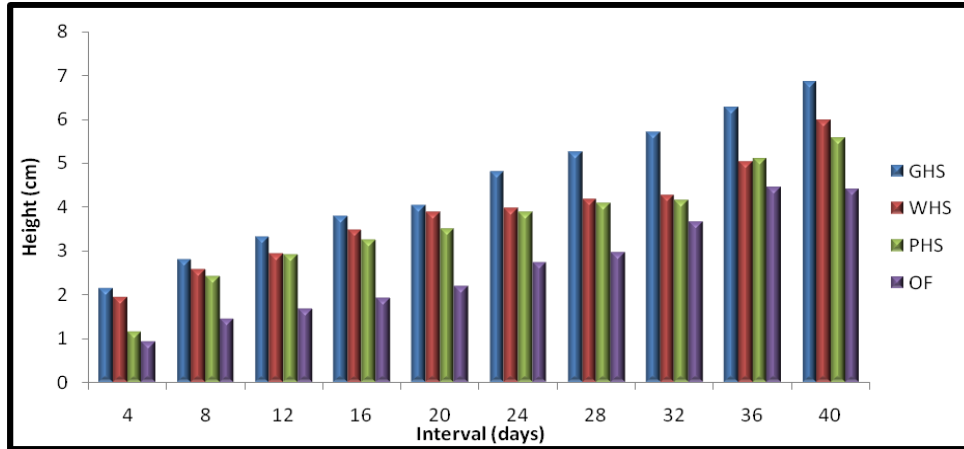


Fig.9 Average no. of leaves of spinach at four days interval

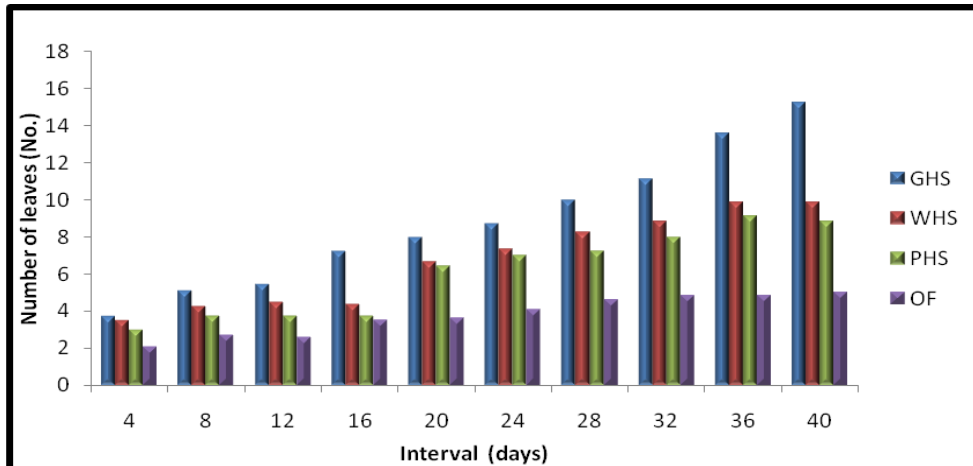
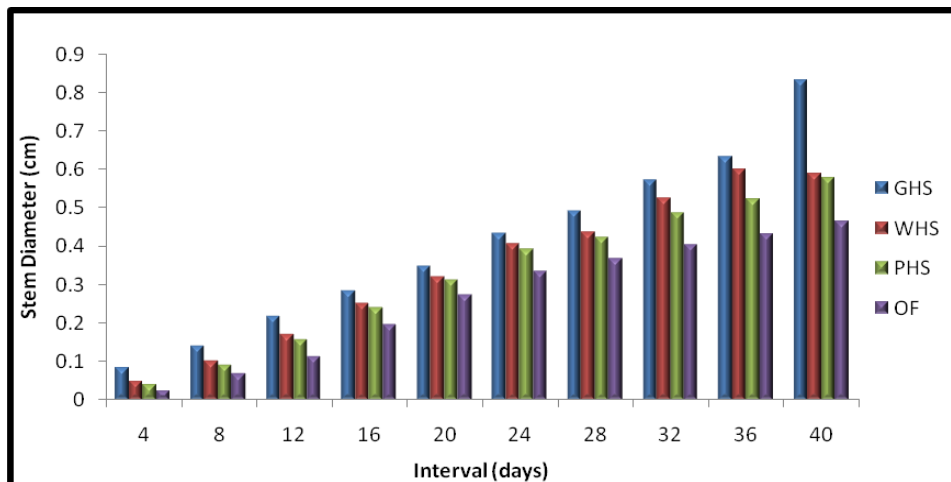


Fig.10 Average stem diameter of spinach at four days interval



From Table 3.8, it was observed that during initial growth stage, at 8 and 12 days interval, height of plant was found at par. and the highest value of plant height were found in green hydroponic structure. It was found significantly lower in open field. At 16, 20, 24, 28, 32, 36, 40 day interval the height of plant was found at par. The highest value of plant height was found for the green hydroponic structure followed by white hydroponic structure followed by uv-polyethylene hydroponic structure.

Green hydroponic structure showed the better results compared to remaining three structures. It was found significantly lower in open field in all eight replications, height of spinach was found maximum (6.86 cm) inside green hydroponic structure at the time of harvest i.e at the end of 40 days.

Number of leaves

The number of leaves of spinach was found to be influenced significantly due to different hydroponic structures. Table 4.9 shows the mean number of leaves influenced by different hydroponic structures at four days interval and graphical representation of data is shown in Fig 4.9. The number of leaves measured at four days interval is given in Appendix VI.

From Table 3.9, it was observed that during initial growth stage, at 10th day interval no. of leaves of plant was found at par. The highest value was found for green hydroponic structure. It was found significantly lower in open field. At 16, 20, 24, 28 32, 36, 40 day interval, no. of leaves of plant was found at par. The highest value was found for the green, followed by white hydroponic structure followed by uv- polyethylene hydroponic structure. it was found significantly lower in open field in all eight replications. The number of leaves of spinach was found

maximum (15 Nos) inside the green hydroponic structure at the time of harvest.

Stem Diameter

The stem diameter of spinach was found to be influenced significantly due to different hydroponic structures at all crop growth stages. Table 3.10 shows mean stem diameter influenced by different hydroponic structure at four days interval and graphical represented as shown in Fig 3.10.

From Table 3.10, it was observed that during all growth stages at 8, 12, 16, 20, 24, 28, 32, 36, 40 days interval, stem diameter of plant was found at par. The highest value was observed for green hydroponic structure followed by white followed by uv-polyethylene hydroponic structure and open field. It was found significantly lower in open field. Stem diameter of spinach was found maximum (8.83 mm) inside the green hydroponic structure at the time of harvest.

References

- Asker H S (2015) Hydroponic technology for lily flowers and bulbs production using rainwater and some common nutrient solutions. *Afr J Biotechnol* 14: 2307-13.
- Avalhaes C C, Prado R M, Rozane D E, Romualdo L M and Correia M R (2009) Macronutrients omission and the growth and nutritional status of elephant grass (cv. Mott) growing in nutrient solution. *SciAgrar* 10: 215-22.
- Barrett D.M., J.C. Beaulieu and S.T. Rob (2010). Color, flavor, texture, and nutritional quality of fresh-cut fruits and vegetables: desirable levels, instrumental and sensory measurement, and the effects of processing.
- Behera B.P, R.R. Pattnaik, M. Das and J. Jena (2016). International journal of applied

- and pure science and agriculture (ijapsa). 2(8): 47-54.
- Castillo F S, Perez E C, Pineda P J, Osuna J M, Perez J R and Encino T O (2014) Hydroponic tomato production with and without recirculation of nutrient solution. *Agrociencia* 48: 185-97.
- Hochmuth G. and R. Hochmuth (2008) Design suggestions and greenhouse management for vegetable production in perlite and rockwool media in Florida. Horticultural Sciences Department. uf/ifas Extension, Bulletin 327.

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