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Effect of growing systems on yield and quality of lettuce (*Lactuca sativa*) under subtropical climatic condition

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Abstract

The study was carried out to indentify suitable growing system for higher yield of lettuce (*Lactuca sativa* L.) at ICAR-CISH, Lucknow during 2021-22. The experiment was conducted with two growing, aeroponic and geoponic systems. Five lettuce varieties were sown in portray by using mixture combination of coco peat, vermiculite, and perlite in a 3:1:1 ratio. After 30 days, plants were transplanted in both aeroponic and geoponic systems. The maximum yield (181.90 q/ha) was found in aeroponic system followed by geoponic system (144.73 q/ha). However, vitamin C content and total carotenoid content were non significantly highest (12.09mg/100g) and (6.13) in geoponic system respectively. Chlorophyll 'a' (0.70 mg/g FW) was observed in geoponic system, while chlorophyll 'b' (0.119 mg/g FW) under aeroponic system.

Key words: Growing system, Growth, Yield, Quality, Subtropical climate

Lettuce (*Lactuca sativa* L.), of Asteraceae family and chromosome (2n=2x=18), is most significant leafy vegetable crops worldwide. Recently, greenhouses have broadened its cultivation methods to encompass soilless techniques like aeroponics, alongside traditional soil-based methods (Koukounaras, 2021). In recent decades, there has been a notable shift from soil cultivation to soilless systems for lettuce production, offering various benefits. These include shortened growth cycles, enabling multiple harvests per year, precise control over nutrient solutions to reduce nitrates in the final product, the capability to incorporate essential trace elements crucial for human nutrition, and the potential for shelf-life extension (Gordana *et al.*, 2022). Additionally, the system shows promise in nutrient and water recycling, mitigating climate change effects, enhancing production, and decreasing pest and soil disease incidences (Gashgari *et al.*, 2018). The main differences between conventional cultivation and hydroponics growing system are water and nutritional supply availability (De Souza *et al.*, 2019). Hence an experiment was conducted.

MATERIALS AND METHODS

The experiment was conducted at ICAR-CISH, Rehmankhera, Lucknow, during winter season to see the performance of aeroponic and geoponic systems. Lettuce crop was grown under both system during 2021-22. During first week of October 2021, seeds of lettuce cultivars, Tango, Summer Star, Grand Rapid, Bingo, and Black Rose, were sown in portray by using mixture consisting of coco peat, vermiculite, and perlite in a (3:1:1) ratio, which was sterilized using hydrogen peroxide (0.02%). The seedlings with 4-5 leaves were transplanted in both aeroponics unit and open field conditions. The aeroponics unit was set up in an automatically controlled polyhouse environment, featuring green shade netting on exterior, silver shade netting inside, along with fans, pads, and a misting system.

The aeroponic units were constructed in an A-frame configuration, measuring 1.4 m wide, 1.4 m high, and 6 m long. The planting density was upheld at 25 plants m^2 with a spacing of 20cm x 20 cm. The plants were treated with nutrient solutions CISH A and B having 3x strength (one litter each) under aeroponic system. Nutrient solution misting occurred at 30-minute intervals, with each misting session lasting for one minute.

In the auto hydroponic system, electrical conductivity (EC) of the nutrient solution was kept at 1.0 - 1.2 (mS/cm) by supplementing the tank with additional solution, while the pH of nutrient solution was 5.5 - 6.5 and 15 - 18 ^{0}C during the growing season. Flat beds measuring 2.0 m x 2.4 m were prepared for transplanting seedlings in open field conditions, with a spacing of 40cm x 40cm. Ten fully grown seedlings at of each treatment were selected randomly in each replication, to record the data.

Observations were recorded on plant height (cm), plant weight (g), plant stem diameter (mm). root length (cm), no. of leaves / plant, plant shoot weight (g), leaf length (cm), leaf width (cm), leaf weight (g), root weight(g), leaf index, yield (q/ha). For quality parameter, dry - matter content, 25g of leaf samples were dried

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in an oven at 60°C until reaching a constant weight (AOAC, 2005). The determination of ascorbic acid was conducted using 2,6-dichlorophenol titration method and expressed as mg/100g (AOAC, 1996). The carotenoid content was determined as per Kemmerer and Frap, (1943). Chlorophyll a, Chlorophyll b, and total chlorophyll were assessed utilizing the standard spectrophotometric method recommended by Ameel and Axler, (1998); Gowthami *et al.* (2022). The mean values of all parameters were noted. The results underwent a two-way analysis of variance (ANOVA) utilizing SPSS Statistics 19.0 to analyze the effects of cultivation systems, cultivars, and their interaction.

RESULTS AND DISCUSSION

Growth parameters

The maximum plant height (27.11 cm) was recorded under aeroponic system as compared to geoponics system (22.52cm) this might be due to better aeration in root zone and better growing conditions in aeroponics. These findings are inconformity with those of Sapkota *et al.* (2019); Helaly and Darwish, (2019); Margaret *et al.* (2021). The highest weight was observed in geoponics system(325.31 g) as compared to aeroponic systems (181.80 g) due to crops growing in soil benefit from soil nutrient mineralization and microbial activity, whereas aeroponic plants depend exclusively on fertilizer addition to solution (Djidonou and Leskovar, 2019). However, non-significant difference in plant weight of hydroponic and soil grown system was observed.

It supports to those findings of Goddek and Vermeulen (2018). The highest plant stem diameter (14.66 mm) was observed in geoponics system compared to aeroponic systems due to continuous supply of nutrients in geoponics system conditions to shoot growth. These results are conformity with the findings of Qiansheng *et al.* (2018); Sarkhel *et al.* (2022). Root length (56.07 cm) was observed significantly under aeroponic system as compared with geoponics system (11.60 cm) .

This might be due to congenial environment for root growth under aeroponic owning to its high aeration. This result corroborates with findings of Qiansheng *et al.* (2018); Helaly and Darwish (2019); Agarwal *et al.* (2019). Number of leaves/plants (22.97) were found to be non - significant and geoponics system produced a more number of leaves / plants as compared to aeroponics (22.77). This might be due regular nutrient availability in soil in contrary to aeroponics intermittent misting of nutrient. The similar results had been reported by Helaly and Darwish, (2019).

Shoot weight (19.67 g) was observed significantly highest under geoponics system as compared to aeroponic system (15.00 g). growing to constant and regular availability of nutrients and water under geoponics system. Leaf length was influenced significantly with different treatment combinations and highest leaf length was recorded under aeroponic system (21.12 cm) as compared to geoponics system (19.71 cm) due to control environment under polyhouse of aeroponic system resulted for larger leaf length. The findings are in conformity with findings of Lie and Engeseth (2021). Leaf width which determines the yield of lettuce has influenced by different treatment.

The highest leaf width (18.31cm) was recorded under geoponics as compared to aeroponic (16.87cm) due to open environment of soil growing which received high light intensity more or less similar result has also been reported by Lie and Engeseth (2021). Leaf weight (290.67g) was recorded significantly maximum under geoponics system as compared aeroponic system (139.17g) due to condense environment and regular regular nutrient supply to plant under soil condition and the results corroborates with findings Sahil *et al.* (2023); Lie and Engeseth, (2021). They reported higher fresh weight of leaf soil grown lettuce as compared to aeroponics.

Significant differences on root weight in different growing system were observed and same condense environment might have played positive role for better growth and development of root Lie and Engeseth (2021); Ali *et al.* (2015); Qiansheng *et al.* (2018); Sayad and Khater, (2016). Leaf index showed significant differences in different growing system and highest leaf index was recorded under aeroponic (0.89) as compared to geoponics system (0.76) when might be due to proper maintenance of environment under polyhouse in aeroponic system. Similar findings have been reported by Kim *et al.* (1995). The total yield was observed significant differences in different growing system and the highest total yield was recorded under aeroponic system (181.90 q/ha) as compared to geoponics system (144.73 q/ha) it might be due higher plant population /unit area and proper control environment and condensive controlled environment plant population/ unit area light have played important role in yield under aeroponics similar results had been reported by Majid *et al.* (2021).

Quality parameters

The highest dry-matter content was recorded under geoponics system as compared to aeroponic system. It might be due to better assimilation of nutrient and high light intensity contribution in open conditions, Similar findings had been reported by Helaly and Darwish, (2019). The highest Vitamin C content (12.09 mg/100g)

was recorded under geoponics system as compared to aeroponic system. Available of better light intensity and nutrient assimilation under soil might have enhanced then value calculated get support with findings of Lie and Engeseth, (2021). Carotenoid was observed statistically non-significant and highest total carotenoids content (6.13mg/100g) was recorded under geoponics as compared to aeroponic system (6.01 mg/100g) due to environmental effect, more or less similar findings had been reported by Lie and Engeseth (2021).

The highest chlorophyll 'a'content was recorded non-significant under geoponics (0.70 mg/g) as compared to aeroponic system (0.32 mg/g). It might be due to higher light intensity and favourable plant growth due to contant and reuse nutrient availability in soil. These findings are corroborating with findings of Lie and Engeseth (2021). There was highest chlorophyll 'b' content (0.119 mg/g) under aeroponic system as compared to geoponics system (0.083 mg/g) (Table 2). The total chlorophyll was observed statically non-significant and highest total chlorophyll was recorded under aeroponic system as compare to geoponics systems and these result in consonance with the finding or reported by Helaly and Darwish (2019).

CONCLUSION

The aeroponic system produced the highest yield of 181.90 q/ha under subtropical climatic conditions, making it the most effective method for growing lettuce and an excellent option for farmers during the *kharif* season.

Table 1: Effect of growing system on yield and yield - attributing traits of lettuce

Growing system	Plant weight(g)	Leaf length(cm)	Leaf width(cm)	Leaf weight(g)	Stem diameter(mm)	Average shoot weight(g)	Average root weight(g)	Root length(cm)	Plant height (cm)	Number of leaves	Area leaf index	Yield (q/ha)
Aeroponics	181.80	21.13	16.87	139.17	11.61	15.00	23.60	56.07	27.11	22.77	0.89	181.90
Geoponics	325.31	19.71	18.31	290.67	14.66	19.67	8.57	11.60	22.52	22.97	0.76	144.73
C D @5 %	7.07	1.00	0.83	3.00	0.57	0.83	1.32	0.79	1.13	N.S	0.05	1.64
S E(d)	3.34	0.47	0.39	1.42	0.27	0.39	0.62	0.37	0.54	0.53	0.02	0.77
S E(m)	2.36	0.33	0.28	1.00	0.19	0.28	0.44	0.27	0.38	0.38	0.02	0.55

*N.S. = non-significant

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Table 2: Effect of growing systems on quality attribute of lettuce

Component	Vit. C(mg/100g)	Total carotenoids (mg/100g)	Chlorophyll 'a' (mg/g fresh weight)	Chlorophyll 'b' (mg/g fresh weight)	total chlorophyll (mg/g fresh weight)	Dry -matter content (%)
Aeroponics	12.08	6.01	0.32	0.119	0.42	6.56
Geoponics	12.09	6.13	0.70	0.083	0.40	6.82
C D @5 %	N.S*	N. S	N/S	0.009	N/S	N.S
S E(d)	0.33	0.06	0.35	0.004	0.02	0.28
S E(m)	0.23	0.04	0.25	0.003	0.01	0.19

*N.S. = Non- significant

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