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Effect of soil and soilless media on biochemical composition of lettuce (*Lactuca sativa*) cultivars under open condition

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Abstract

A study was carried out at the Centre for Protected Cultivation and Technology (CPCT), ICAR- IARI, New Delhi, during 2022-23 to find out the effect of soil and soilless media on agro-morphological characters, yield, and economics of lettuce (*Lactuca sativa* L.) varieties in open conditions. The experiment was set up in a factorial randomized block design with 3 replications. Various biochemical traits including total soluble solids (5.31 ^{0}Brix), antioxidant activities (40.99 DPPH inhibition %), respiration rate (2.88 ml CO_2/kg/h), moisture content (83.98 %), chlorophyll content (3.05 mg/g FW), total carotenoid content (1.10 mg/g FW) and ascorbic acid content (16.55 mg/100g) of different lettuce genotypes were higher in soil media compared to soilless media (cocopeat). Thus, it can be inferred that soil serves as a suitable medium for cultivation of lettuce varieties.

Key words: Soil, Lettuce, Open condition, Biochemical composition, Moisture content, Respiration rate

Lettuce (*Lactuca sativa* L.) is one of the most consumed vegetables across the world. It is an annual crop belonging to the family Asteraceae with chromosome number 2n=18. World production of lettuce is 27 million tonnes and China leads with 53% of production (FAO, 2023). In India, lettuce is widely grown in the northern part of the country, especially in Jammu and Kashmir, Himachal Pradesh, and Uttarakhand. The growing medium is a substrate or potting soil or any substance other than soil used to cultivate its plants. Numerous materials can be used to make a growing medium, such as sawdust, peat, rice husk, perlite, cocopeat and vermiculite (Douglass *et al.*, 2009; Rahman *et al.*, 2019). Lettuce can be grown in soil (traditional system) and soilless media. Soil-based techniques may be highly productive but the relative use of water may be high due to runoff and infiltration. As a result, the relative water-use efficiency will be lower. Soilless techniques offer a way of improving water-use efficiency and obtaining better water management in its production.

Hence, an attempt was made to compare the effect of soil and soilless media on agro-morphological, yield, and economics of lettuce production under open cultivation.

MATERIALS AND METHODS

The experiment was conducted at CPCT, ICAR-IARI, New Delhi from November 2022 to March 2023. The region has a sub tropical climate, with an average maximum temperature of 17.9^0 C, an average minimum temperature of 9.9^0 C and annual rainfall is around 33.70 mm. A total of 16 genotypes were obtained from ICAR-NBPGR, New Delhi and private sector. The seeds were initially sown in 98-cell trays and later transplanted to the main field after one month. The experiment was designed according to the factorial randomised block layout, with three replications at 50 cm × 20 cm spacing. The plot size was 2.0 m × 2.0 m.

The total soluble solids (TSS) (^{0} Brix), antioxidant activity (DPPH inhibition %), respiration rate (ml CO_2/kg/h), moisture content (%), chlorophyll content (mg/g FW), total carotenoid content (mg/g FW), and ascorbic acid content (mg/100g) were measured.

The refractometer was used to estimate the TSS by dripping the extract onto the detector, and the readings were duly recorded. The antioxidant activity was determined through the DPPH assay described by Blois in 1958 and Desmerchelier *et al.* in 1997. The DPPH assay involved dissolving 2,2-diphenyl-1-picrylhydrazyl (DPPH) in 100% ethanol to a concentration of 200µM, followed by sonication for 5 minutes to stabilize the free radical DPPH. The test compound was then diluted in a 1:1 ratio with the DPPH solution in a 96-well microplate, with appropriate controls in each series.

Fresh DPPH solution was prepared daily. Leaf samples weighing 0.5g were crushed with 5 ml of 70% ethanol, and centrifuged for 20 minutes, and 0.1 ml of the sample extract was mixed with 3.9 ml of DPPH solution, followed by a 30-minute incubation in the dark. The absorbance was measured after 25 minutes using a microplate spectrophotometer at 517 nm.

Inhibitor ratio = (AC-AS/AC) ×100,
where AC is the OD of DPPH, AS is the OD of the sample

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The moisture content of samples was assessed utilizing the procedure outlined by Ranganna (2007). About 5g samples were extracted and weighed together with the container, with the initial weight being documented. Subsequently, samples were subjected to drying at 65°C until reaching a consistent weight, and the final weight was recorded. The moisture content was then computed using the subsequent formula:

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

The 40g leaf samples were finely chopped and placed in a plastic container. Subsequently, top lid was securely sealed with paraffin film to prevent any air from escaping. The CO_2 and O_2 levels were then measured for each sample, and the respiration rate was determined using a specific formula:

$$\text{Respiration Rate (ml } CO_2\text{/kg/h)} = \frac{CO_2 \times \text{head space}}{\text{Fresh weight}}$$

The levels of chlorophyll and total carotenoids were determined post-harvest through the utilization of dimethyl sulfoxide (DMSO) technique. About 100 mg of leaf fragments were ground with 20 ml of DMSO. Subsequently, samples were placed in an oven at 65°C for 4 hours in the dark until the cap exhibited a white colour. Following this, centrifugation at 16000xg for 15 minutes was conducted to obtain the supernatant. The optical density of extract was then gauged at 645, 663, and 470 nm with DMSO serving as the blank. The quantification of chlorophyll and total carotenoids was carried out using a specific formula:

Chlorophyll a = $(12.7 \times OD_{663}) - (2.69 \times OD_{645})$ V×1/1000×W

Chlorophyll b = $(22.9 \times OD_{645}) - (4.68 \times OD_{663})$ V ×1/1000×W

Total chlorophyll= $(20.2 \times OD_{645}) - (8.02 \times OD_{663})$ V ×1/1000×W

Total carotenoids = $(1000 \times OD_{470}) - (3.29 \times$ Chl. a) - (104× Chl. b)/198

The concentration of ascorbic acid was determined through a titrimetric technique employing 2, 6-dichlorophenol indophenol dye. A 5 g leaf sample was blended in 50 ml of HPO_3. The mixture was then filtered using Whatmann No.1 filter paper. Subsequently, a 10 ml portion was transferred to a conical flask and titrated with the dye until a pink colour emerged. The findings were denoted as milligrams of ascorbic acid per 100 grams of the sample.

Ascorbic acid content =

$$\frac{\text{Titration value} \times \text{dye factor} \times \text{Volume made up (ml)}}{\text{Aliquot (ml)} \times \text{weight or volume of sample (g)}} \times 100$$

The statistical analysis of data was performed using R 3.4.1 software (InQuest Data Analytics, Bengaluru). Significance was determined by calculating F values and P values ≤0.05.

RESULTS AND DISCUSSION

All the biochemical compositions of lettuce genotypes grown under open conditions showed better performance in soil than in soilless media (Table 1). The soil-grown lettuce exhibited slightly higher levels of TSS (5.31 ^{0} Brix), antioxidant activity (40.99 DPPH inhibition %), respiration rate (2.88 ml CO2/kg/h), moisture content (83.98 %), chlorophyll content (3.05 mg/g FW), total carotenoid content (1.10 mg/g FW), and ascorbic acid content (16.55 mg/100g) compared to that lettuce grown in soilless media. This can be attributed to soil that provides more nutrients, resulting in a greater biochemical composition in plants. These findings align with those of Pace *et al.* (2018). However, our results contradict the findings of Majid *et al.* (2021) regarding TSS and chlorophyll, as well as the research conducted by Gonnella *et al.* (2020) on chlorophyll and total carotenoid content, and Buchanan and Omaye (2013) on ascorbic acid content.

Within leafy-type cultivars, Romaine II exhibited the highest TSS, moisture content, and chlorophyll content; Lollo Rossa showed the highest level of ascorbic acid, aligning with the research conducted by Selma *et al.* (2012) but specifically in soilless growing conditions. Red Romaine exhibited the greatest antioxidant activity. Red Salad showed a higher respiration rate, while Oak Leaf Red had the lowest TSS. Tango had the lowest antioxidant activity and ascorbic acid content. Oak Leaf Green had the lowest respiration rate. New Red Fire had lowest moisture content. Red Rose had a lower chlorophyll content. Romaine I and Harit Baigani had the lowest total carotenoid content among leafy types. Among head types, Butterhead Green had the highest TSS, antioxidant activity, and ascorbic acid contents.

Great Lakes had highest chlorophyll and total carotenoid content. Iceberg Salista had highest respiration rate, while lowest TSS was found in Great Lakes. Iceberg Salista had lowest antioxidant activity. Butterhead Green had the lowest respiration rate, moisture content, chlorophyll content, and total carotenoid content. Iceberg Crispiano had the lowest ascorbic acid content. Parikh *et al.* (2023) also recorded excellent quality parameter in turmeric crop when grown under soil conditions along with spray of organic liquids. Poonia *et al.* (2024) also recorded excellent

Table 1 Effect of growing media on biochemical composition of lettuce genotypes

Treatment	Total soluble solids/TSS (^{0} brix)			Antioxidant activity (DPPH inhibition %)			Respiration rate (ml CO_2/kg/h)			Moisture content (%)			Chlorophyll content (mg/g FW)			Total carotenoid content (mg/g FW)			Ascorbic acid content (mg/100g)		
	M_1 (Soil)	M_2 (Soilless)	Mean	M_1 (Soil)	M_2 (Soilless)	Mean	M_1 (Soil)	M_2 (Soilless)	Mean	M_1 (Soil)	M_2 (Soilless)	Mean	M_1 (Soil)	M_2 (Soilless)	Mean	M_1 (Soil)	M_2 (Soilless)	Mean	M_1 (Soil)	M_2 (Soilless)	Mean
V_1– Romaine I	4.33	4.15	4.24	24.16	24.01	24.09	2.22	2.04	2.13	82.32	82.13	82.06	2.17	2.12	2.15	0.39	0.34	0.37	12.37	12.22	11.35
V_2 – Romaine II	7.82	7.64	7.73	23.07	22.92	22.99	2.77	2.59	1.56	88.07	87.88	87.98	4.34	4.29	4.32	1.13	1.08	1.11	16.34	16.19	14.42
V_3 – Tango	4.60	4.42	4.51	23.03	22.88	22.96	2.87	2.69	2.78	86.53	86.34	86.44	4.26	4.21	4.24	0.88	0.83	0.86	11.22	11.07	11.15
V_4– Oak Leaf Green	5.13	4.95	5.04	26.01	25.86	25.94	2.21	2.03	1.11	84.86	84.67	82.72	4.16	4.11	4.14	0.79	0.74	0.77	20.17	20.02	19.99
V_5 – Grand Rapids	6.53	6.35	6.44	33.21	33.06	33.14	3.64	3.46	3.55	84.13	83.94	83.55	3.18	3.13	3.16	0.57	0.52	0.55	16.24	16.09	13.79
V_6– Harit Baigani	6.13	5.95	6.04	34.56	34.41	34.49	3.24	3.06	3.15	83.38	83.19	83.29	2.28	2.23	2.26	0.44	0.40	0.42	11.51	11.36	10.94
V_7 – Oak Leaf Red	3.23	3.05	3.14	52.39	52.24	52.32	2.73	2.55	2.64	83.44	83.25	83.35	3.02	2.97	2.99	1.39	1.34	1.37	16.43	16.28	13.55
V_8– Red Romaine	4.07	3.89	3.98	62.89	62.74	62.82	2.72	2.54	2.63	83.17	82.98	83.08	2.23	2.18	2.21	1.28	1.23	1.26	11.99	11.84	11.26
V_9– Lollo Rossa	4.53	4.35	4.44	61.29	61.14	61.22	3.51	3.33	3.42	93.22	93.03	91.64	4.24	4.19	4.22	1.25	1.19	1.22	26.46	26.31	23.34
V_{10}– New Red Fire	6.53	6.35	6.44	29.66	29.51	29.59	3.11	2.93	1.64	81.86	81.67	81.77	2.12	2.07	2.10	1.18	1.15	1.16	21.93	21.78	20.23
V_{11} – Red Salad	4.73	4.55	4.64	62.16	62.01	62.09	3.67	3.49	3.58	81.82	81.63	81.23	2.11	2.06	2.09	2.27	2.22	2.25	16.43	16.28	16.36
V_{12} – Red Rose	5.33	5.15	5.24	63.06	62.91	62.99	2.25	2.07	2.16	81.02	80.83	81.16	2.02	1.97	1.99	2.11	2.06	2.09	21.99	21.84	19.31
V_{13}– Iceberg Salista	5.33	5.15	5.24	33.99	33.84	33.92	3.43	3.25	3.34	83.25	83.06	82.19	3.16	3.11	3.14	0.98	0.93	0.96	12.89	12.74	12.82
V_{14}– Iceberg Crispiano	5.73	5.55	5.64	35.42	35.27	35.35	2.74	2.56	1.63	81.73	81.54	81.64	3.11	3.06	3.09	0.96	0.91	0.94	15.27	15.12	13.76
V_{15}– Butterhead Green	6.27	6.09	6.18	56.16	56.01	56.09	2.27	2.09	2.18	81.48	81.29	80.81	2.88	2.83	2.86	0.86	0.81	0.84	16.76	16.61	15.59
V_{16} – Great Lakes	4.66	4.48	4.57	34.72	34.57	34.65	2.71	2.53	2.62	83.48	83.29	83.39	3.56	3.51	3.54	0.99	0.94	0.97	16.74	16.59	15.09
Mean	5.31	5.14	5.22	40.99	40.84	40.91	2.88	2.70	2.79	83.98	83.79	83.51	3.05	3.00	3.03	1.10	1.00	1.10	16.55	16.40	15.18

quality parameters in tomato crop using the plant growth regulators.

CONCLUSION

The biochemical composition of lettuce genotypes grown in soil were rich in total soluble solids, antioxidant activity, moisture content, chlorophyll, total carotenoid, ascorbic acid and other essential nutrients, due to presence of nitrogen, phosphorus, potassium, and other micronutrients in soil that are crucial for the growth and development of the plant. Additionally, soil provides a stable and supportive structure for the roots of lettuce plants, allowing them to access water and nutrients efficiently. Overall, the findings of this research highlight the importance of soil as a key factor in successful lettuce cultivation, and emphasize the benefits of utilizing soil as the primary medium for growing lettuce.

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