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RESEARCH ARTICLE

Effect of Grow Medium and Hydroponics Fertilizer on Iceberg Lettuce (*Lactuca sativa* var. *capitata*) Cultivation

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ABSTRACT

Iceberg lettuce (*Lactuca sativa* var. *capitata*), which belongs to the family Asteraceae, is a globally renowned vegetable, particularly in salads for its crisp texture, mild flavor and perceived health benefits. Iceberg lettuce remains relatively uncommon in Sri Lanka, and the cultivation is confined to cooler climates. However, there are gaps in the recommendations of fertigation protocols for hydroponics Iceberg lettuce cultivation. Therefore, this research was conducted to examine the influence of selected grow media and fertigation options on the vegetative growth and yield of Iceberg lettuce grown in the hydroponics system, "grow bag culture" in controlled environment agriculture. The research was carried out in a soft plastic-covered greenhouse under a mild climatic region in the higher attitudes (in Lindula), Sri Lanka. The experiment design was a single factor Completely Randomized Design (CRD) with six treatment combinations of grow media and fertigation options. Grow media compositions varied with different ratios of topsoil, coco-peat, rice hull charcoal, and compost. Vegetative growth was assessed during 1 to 7 weeks after transplanting (WAT). At the final vegetative stage, leaf area, chlorophyll concentration, leaf nitrogen content, plant fresh weight and dry weights were determined through destructive sampling. Percentage head formation was assessed at 9 – 11 WAT. At harvesting, yield parameters, head fresh weight, dry weight, head diameter and height were assessed. The results revealed significant variations in plant height, leaf parameters, and head characteristics among treatments, highlighting the effect of fertilizer mixtures and grow media on plant growth and head formation. Leaf color and chlorophyll content of Iceberg lettuce leaves indicated a lesser treatment effect. Substrate parameters, including pH, electrical conductivity, bulk density and water holding capacity, varied significantly among treatments and have a notable influence on the final yield. Treatment (T4) (which contained coco-peat: rice hull charcoal: topsoil at 1:1:2 ratio) and fed with half the strength of standard Alberts fertilizer dosage (F2) was the overall best combination for Iceberg lettuce cultivation. The information generated would be useful for revising the farmers' guide on hydroponics Iceberg lettuce with respect to the selection of grow media and management of fertigation.

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1. Introduction

With the continuous increase in the global population, food-crop supply is expected to increase intensely while other resources are gradually diminishing (Zhang et al., 2022). According to Jensen (2001) as cited in Sabir and Singh (2013) protected cultivation or controlled environment agriculture (CEA) is highly productive in terms of quality and quantity. In addition, it has a lesser environmental impact, compared to open-field cultivation (Chen et al., 2019).

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Lettuce (*Lactuca sativa*), is a leafy annual vegetable from the family Asteraceae. Iceberg lettuce, scientifically identified as *Lactuca sativa* var. *capitata*, Iceberg lettuce, or crisphead lettuce, is known for its tightly compacted head of crisp, pale green leaves with high water content. Nowadays Iceberg lettuce is being cultivated commercially worldwide as a salad crop (Meena & Kulakarni, 2022). In 2022, China ranked first in global lettuce and chicory production with 14.98 million metric tons, followed by the U.S. (3.30 million), Spain (0.97 million), Italy (0.64 million), Belgium (0.60 million), and Japan (0.56 million) (FAO, 2022). As a cool-season crop, lettuce is widely grown on all continents, primarily in temperate and subtropical regions. The growing cycle takes around 55 - 65 days depending on the climate of the production area (Ryder, 1999). The head weight of Iceberg lettuce ranges within 400 - 800 g, depending on the supermarket demand and season (Jenni & Bourgois, 2008; Kader, 2002).

Grow medium is a solid aggregate used in soilless culture systems to replace soil, providing anchorage for growing seedlings, and functioning as a source of plant nutrients, water and oxygen for the root system (Indriyani et al., 2011). An ideal grow medium should support seed germination, succeeding emergence, seedlings' growth, retaining moisture, draining excessive water, and providing sufficient plant nutrients for growth and development (Olaria et al., 2016). Grow media can include organic materials such as coir dust, rice hull charcoal, compost, biochar, and inorganic materials like sub-soil. This study aimed to develop a growing medium by mixing these substrates at different rates focusing on their physical characteristics, such as bulk density, and water-holding capacity.

Meanwhile, plants synthesize necessary carbohydrates through photosynthesis but require inorganic plant nutrients to diversify them structurally and functionally within the plant. Inadequate or unbalanced supply of these nutrients can negatively impact vegetable crop growth and productivity (El-Saady, 2016). However, excessive fertilizer supply may cause toxicity, nutrient uptake issues, reduced yields, environmental hazards, and increased costs. Proper balance of plant nutrients is essential to mitigate abiotic stresses such as low light, salinity, drought and heat (Söylemez, 2021).

Alberts hydroponics formula is the commonly used fully soluble fertilizer by Sri Lankan hydroponics growers but with the least adherence to recommended dosage (Weerakkody et al., 2007) or manufacturer's instructions. Due to its uncommon presence in Sri Lanka, there are no specific recommendations for fertilizer or suitable growing media. As a result, growers experience variable growth rates, yields and quality and due to issues in grow media and fertilizer management. Given the limited research on Iceberg lettuce in Sri Lanka, this study aimed to address the knowledge gap by exploring the effect of different grow media and fertilizer combinations on plant growth, yields, and head quality of Iceberg lettuce. It further aims to establishing proper fertigation protocols for grow-bag culture of Iceberg lettuce under semi-intensive climate control systems in the upcountry of Sri Lanka.

2. Materials and Methods

2.1. Experimental Setup

The experiment was conducted in a soft plastic-covered greenhouse in DIMO Agri Techno Park-Lindula located in the Agro-ecological region, WU1 (up country, wet zone) from November 2023 to February 2024. The mean day and night temperature was 23.4 °C and 18.0 °C. While the mean humidity was 76%. The percentage of fully sunny days during the season was 64%. The experiment was carried out as a grow bag culture (hydroponics) of Iceberg lettuce (*Lactuca sativa* var. *capitata*). Iceberg lettuce variety, Lettuce Tropical (Sakata Seed Corporation) was selected for the trial.

2.2. Experimental Design

The experimental design was single factor Completely Randomized Design (CRD) with six treatments (including the control) and three replicates. Each replicate was composed of five plants. Plants were grown individually in grow bags. The six treatment combinations made from four types of grow media and three fertilizer schedules (F1, F2 and F3) are given in Table 1. Plant density was maintained at 9 pots m^{-2}.

Table 1. Treatment combinations with grow media and fertilizer schedule.

Treatment	Grow media	Fertilizer schedule
T1 (Control)	Coco-peat: rice hull charcoal (1:1)	F1
T2	Coco-peat: rice hull charcoal: topsoil (1:1:2)	F1
T3	Coco-peat: rice hull charcoal: compost (1:1:2)	F1
T4	Coco-peat: rice hull charcoal: topsoil (1:1:2)	F2
T5	Coco-peat: rice hull charcoal: compost (1:1:2)	F2
T6	Coco-peat: topsoil (1:1)	F3

2.3. Media Preparation and Nursery Management

Coco peat was first subjected to excessive washing with water (super washing with adequate drainage), followed by calcium nitrate ($Ca(NO_3)_2$) treatment and excessive washing (Gbollie et al., 2021). This commodity treatment and repeated washing procedure ensured a low level of tannins and partial replacement of Na and Mg ions with Ca ions in coco peat, ensuring its readiness for attaining optimal plant growth. Subsequently, the ready-to-use media was utilized for filling the grow bags, creating a conducive environment for the cultivation of plants. Seedlings of Iceberg lettuce were raised in properly rehydrated jiffy pellets after. They were covered with paper for three days to facilitate seed germination. Then the seedlings were maintained under greenhouse conditions with proper water and plant nutrient management.

2.4. Transplanting and Fertigation

Transplanting was done at four true leaf stage (3 weeks after seeding). Grow bags were disinfected with Topsin (a.i. Thiophanate-methyl 70%) before transplanting, as a preventive measure against fungal infections (Usman et al., 2013). Seedlings were irrigated according to the manufacturer's instructions (Table 2) and the farm practice at daily basis and at a fixed time, manually. For Fertilizer schedule 2 (F2), half the dosage of F1 was applied.

Table 2. Fertilizer schedule 1 (F1).

Growth stage (WAT)	Alberts fertilizer (g/plant/day)	Water (ml/plant/day)	Approximate EC (mS/cm)
0 – 2/3	0.2	600	0.8
2/3 – 4/5	0.4	600-1000	1.2
4/5 – 7/8	0.6	1000-1500	1.5
7/8 – 10/12	0.8	1500-2000	1.9
After 10/12	0.4-0.6	1000-2000	1.5

Sources: CIC Colombo, Unipower, Colombo. WAT: Weeks after transplanting.

The fertilizer schedule 3 (F3) was the regular farm practice. In F3, the weekly fertigation started on the 1st day of the week with a dosage of 0.25 g of Alberts fertilizer per plant/day, dissolved in 300 ml. It was followed by applying the same dosage of NPK fertilizer (at the ratios of 10:52:10 and 30:10:10) and $Ca(NO_3)_2$ in subsequent days, respectively. Grow medium was subjected to excessive drainage (for removing accumulated salts) by irrigating without fertilizer application (with or without $MgSO_4$) two days a week. Meanwhile, EC of the supply solution was increased weekly by increasing the fertilizer dosage by 0.25 g/ plant increments at weekly basis up to the fourth week, keeping the same dilution rate. Fifth week onwards, the dosage was increased to 1.25 g/plant, dissolved in 600 ml of water.

Daily observations based pest and disease identification, followed by pesticide application were practiced, starting from the transplanting. Lettuce Drop, caused by *Sclerotinia sclerotiorum* was observed and controlled by applying Cabrio Top (a.i. Pyraclostrobin 5%+metiram) 55% (w/w) WG. Some lettuce heads were damaged by cabbage semilooper, *Tircihoplusia ni* (Lepidoptera; Noctuidae), and were controlled by applying Croagen (a.i. chlorantraniliprole) 200 g L^{-1} SC.

2.5. Data Collection and Analysis

Data collection on plant height and leaf number was done up to six weeks after transplanting (WAT). Counting leaves after 4 WAT was difficult due to their spiral arrangement in a dense rosette. Destructive sampling was done at peak vegetative growth (at 7 WAT) for dry weight and chlorophyll measurements. At harvesting, head formation, fresh weight, dry weight and dimensions of the head were determined using standard laboratory procedures. Leaf area was measured in destructive samples, using a leaf area meter (model AM350 ADC BioScientific Ltd.), and leaf chlorophyll content was measured using a SPAD meter (model 502Plus, Konica Minolta, Japan).

Meanwhile, leaf nitrogen content was determined using the Kjeldahl procedure (Martín et al., 2017). pH and electrical conductivity (EC) of the supply solutions and grow media were determined using a digital tabletop, pH- EC meter. The bulk density of the initial material and grow media were calculated by obtaining the weight of a known volume of air-dried and oven-dried samples (at 80 °C for 48 hours) by inserting them into moisture cans. Meanwhile, excessively moistened media samples were brought to field capacity (FC) by holding overnight. Subsequently, they were used to determine water holding capacity (WHC) using the following equation (Wilke, 2005).

$$WHC\ (\%) = \frac{Wsm - Wodm}{Wodm}\ x\ 100 \qquad (1)$$

Where, W_{sm}: Weight of saturated medium and W_{odm}: Weight of oven dried medium.

The parametric data of plant growth and yield parameters were analyzed using ANOVA of the statistical software, SAS (version 9.0). Mean separation was done using DnMRT to compare the treatment combinations. Non-parametric data were analyzed through chi-square test using Minitab.

3. Results and Discussion

3.1. Vegetative Growth

The effect of different grow media and fertilizer combinations on the vegetative growth of Iceberg lettuce is illustrated in Figure 1. The treatment effect was significant with respect to plant height ($p<0.0002$), except for the first week after transplanting (WAT). Plant height of T6 showed a significant increase at 3 WAT and continued to dominate throughout the vegetative phase, reaching 28.53±0.60 cm at 7 WAT, and was followed by T1 (25.5±1.6 cm) and T4 (21.8±1.2 cm), respectively. There was no significant difference ($p>0.05$) between T2 and T4 as well as T3 and T5 which were having the same grow media but different fertilizer schedules (Figure 1a). Farid et al. (2022) found that while variations in the composition of grow media significantly enhanced shallot growth, different dosages of NPK fertilizer did not yield significant changes. In here as the control treatment, coco-peat and rice hull charcoal were used to observe the direct effects of fertilizer treatments, as they are almost inert and have minimum nutrient content, compared to other treatments. The mixture of rice hull charcoal and compost provided superior results, may be due to better water retention and nutrient availability, and also aeration in charcoal, promoting healthier plant development. Meanwhile, lack of significant response to variable fertilizer dosages may be due to environmental factors and limited nutrient absorption during the growth phase. These findings emphasize that improving of the grow media plays a more crucial role in plant productivity than merely adjusting fertilizer levels.

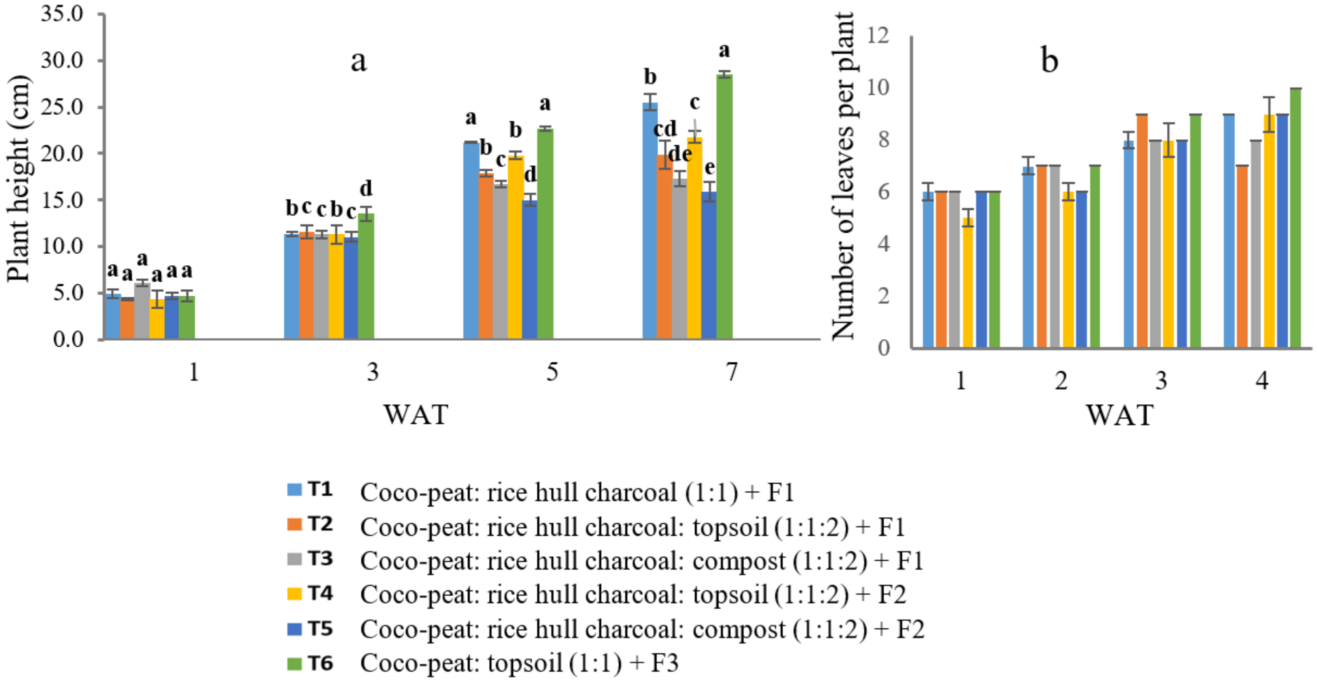

Figure 1. Effect of grow media and fertilizer treatments on plant height (a) and number of leaves (b) of Iceberg lettuce. Error bars indicate standard error (SE) of means, and the treatment means labeled with different letters are significantly different (at $p<0.05$); WAT: Weeks after transplanting.

The leaf number was not significantly different ($p>0.05$) among grow media and fertilizer treatments during 1- 4 WAT (Figure 1b). Generally, growth and development of leaves are affected by hormones, plant nutrition, environmental conditions (soil water content, incident light, and leaf temperature), and genetic factors (Cookson et al., 2005). However, in this experiment, the treatment effect was not evident in terms of leaf number but significantly evident with leaf area (Table 3). The highest total leaf area was shown by T6, followed by T1, reaching the upper range reported by Afton (2018) for Crisp head lettuce cultivars (3579.7 - 5449.7 cm^2 per plant).

Healthier and vigorous leaf growth is also reflected by leaf colour (SPAD reading). Media treatments, coco-peat and rice hull charcoal under F1 (higher fertilizer dosage) (T1) and the same medium with topsoil under F2 (lower fertilizer dosage) (T4) have shown a significantly lower SPAD reading (Table 3). Hence it reflects the incapability of the grow medium to sustain the supplied fertilizer, leading to a deficiency or imbalance of plant nutrients. This observation is supported by the fact that T5 has shown a higher SPAD reading among the treatments, under the lower fertilizer dosage (F2) where it contained an equal amount of compost to match with coco-peat and rice hull charcoal (1:1:2). This could be either due to higher N content in the compost supplement or its improved water and nutrient retention capacity. The first possibility is further supported by the results of leaf N analysis which indicates a similar treatment difference to SPAD reading (T6 and T3) (Table 3).

Table 3. Plant growth and physiological parameters of Iceberg lettuce at the final vegetative stage (7 WAT).

Trt.	**Leaf area (cm^2 $plant^{-1}$)**	**Chlorophyll concentration- SPAD reading**	**leaf N content (mg g^{-1})**	**Plant fresh weight (g)**	**plant dry weight (g)**
1	4728^{ab}	27.0^{b}	24.54^{b}	328^{ab}	13.16^{ab}
2	2377^{c}	38.6^{a}	24.36^{b}	131^{cd}	4.30^{c}
3	1413^{c}	45.8^{a}	29.12^{a}	87^{d}	4.85^{c}
4	3117^{bc}	26.1^{b}	24.45^{b}	227^{bc}	7.84^{bc}
5	1177^{c}	41.5^{a}	30.70^{a}	62^{d}	3.32^{c}
6	5664^{a}	38.0^{a}	28.98^{a}	370^{a}	13.61^{a}

Trt.: Media and fertilizer combinations. The means that do not share the same letter in superscripts are significantly different (DMRT/p<0.05).

Meanwhile, significantly higher leaf growth (indicated by leaf area) in T6 yielded the highest dry weight at the end of vegetative growth of Iceberg lettuce, and it was followed by T1 and T4, respectively (Table 3). The treatment effect on the plant fresh weight at that stage was also significant, following the same pattern of treatment differences. Both fresh and dry weights of T1 and T6 were significantly higher than the other media and fertilizer combinations (p=0.0010) (Table 3).

Based on the overall results, T6 (coco peat and topsoil with F3) has shown a dominant effect, indicating the superiority of the grow medium and fertilizer combination for maintaining the most favorable conditions for overall plant growth. This treatment also maintained a fairly high chlorophyll concentration and leaf nitrogen content, though it was not the highest for these parameters. T1 (coco peat and rice hull charcoal with F1) exhibited to be the closest competitor to T6. Even though T5 contributed to a relatively high level of leaf color (SPAD reading) and leaf nitrogen content, it has not been able to effectively convert these advancements into vegetative growth. Landis et al. (1989) (cited by Tripathi & Raghubanshi, 2014) reported decline in root: shoot ratio with accumulation of N in leaves under high nitrogen input. Hence, shoot growth retardation in T5 could be a negative influence of excessive plant uptake of nitrogen. This condition can damage the root tips, restricting root development and ultimately hindering the overall growth of the plant. The different stages of growth of Iceberg lettuce during the experiment are shown in Figure 2.

Figure 2. Iceberg lettuce plants at different growth stages: (A) three weeks after transplanting; (B) head formation stage; (C) harvested heads.

3.2. Head Formation

There was a statistically significant treatment effect on the time of head formation, which was assessed by the percentage of plants with a visible head formed at 9 WAT (P=0.03) but no significant difference was observed at 11 WAT (p = 0.981). Based on the results of both assessments the earliness of head formation was in the order of T1=T4>T2=T6>T3>T5. Meanwhile, the same results clearly indicate a greater uniformity of the time of head formation by T1, T2, T4 and T6, compared to T3 and T5 (Figure 3).

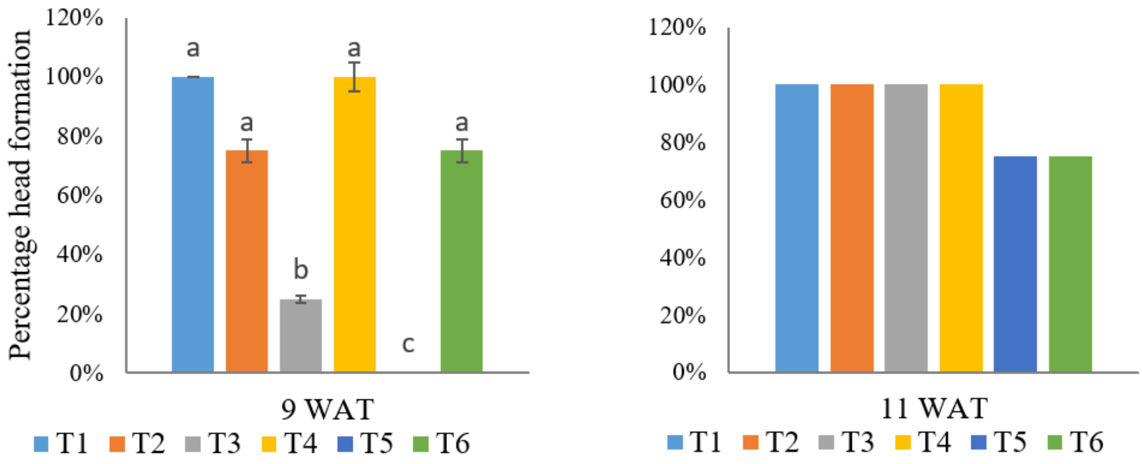

Figure 3. Effect of media and fertilizer combinations on the percentage head formation of Iceberg lettuce at 9 and 11 weeks after transplanting (WAT). Error bars indicate standard error (SE) of means, and the treatment means labeled with different letters are significantly different (at p<0.05).

The treatment effects on the head fresh weight (yield) at the harvesting stage were statistically significant (p = 0.028) where T1, T2, T4, and T6 gave higher yields (260 – 329 g per head) compared to the yields given by T3 and T5 (131 – 161.33 g per head) (Table 4). Meanwhile, the highest head dry weight among treatments was attained by T4 (14.8±1.54 g) which was significantly higher than all the other treatments (7.6 – 10.6 g head). Among the treatments having significantly higher head fresh weight, only T2, and T4 had the highest head height as well as head diameter, whereas the other treatments with higher head fresh weight (T1 and T6) had either higher head height or diameter (Table 4).

Table 4. Yield components and head dimensions of Iceberg lettuce treated with different media and fertilizer combinations, at harvesting.

Trt.	Head fresh weight (g/plant)	Head dry weight (g/plant)	Head diameter(cm)	Head height (cm)
1	271.67^{ab}	10.59^{b}	13.3^{a}	12.3^{b}
2	312.00^{a}	9.91^{b}	13.7^{a}	14.3^{a}
3	131.00^{c}	7.75^{b}	9.2^{c}	10^{c}
4	329.00^{a}	14.80^{a}	13.6^{a}	15.4^{a}
5	161.33^{bc}	7.55^{b}	9.8^{c}	10.4^{c}
6	260.33^{abc}	9.42^{b}	11.8^{b}	14.4^{a}

Trt.: Media and fertilizer combinations; The means that do not share the same letter in superscripts are significantly different (DMRT/p<0.05).

3.3. Substrate Parameters

The most used and optimal pH range in the grow medium or substrate for growing leafy greens is 5.5 - 6.6 (Kudirka et al., 2023). However, grow medium in T2 was in the acidic range while T3 and T5 were in the alkaline range (Table 5). Drifting pH out of the optimal range causes partial unavailability of plant nutrients, particularly micronutrients, in the grow medium (Nakano et al., 2006). The reason for lower plant fresh weight and dry weight in T2, T3, and T5 found at 7 WAT may be due to these unfavorable pH conditions which makes unavailability of some of the plant nutrients in the substrate. Meanwhile, EC of the supply solution when applying the recommended dosage of Alberts fertilizer (CIC Colombo, Unipower, Colombo) to crops at 2-7 WAT is 0.8-1.9 mS cm^{-1}. However, the substrate samples taken from T3 and T5 24 hours after fertigation show much higher EC values (1.651 – 4.681 mS cm^{-1}), indicating a lower rate of nutrient uptake, compared to the rate of water uptake by the root system. Unfavourable pH discussed above could be the root cause for a lower rate of nutrient uptake in these treatments, ultimately accumulating plant nutrients largely in the grow medium. Apart from this, higher EC itself reduces nutrient uptake rate by increasing osmotic pressure whereas lower EC may severely affect plant health and yield (Samarakoon et al., 2006). The reason for the lower plant fresh weight and dry weight in T3 and T5 at 7 WAT may be sub-optimal plant nutrient uptake under pH driven low availability of mineral ions.

Meanwhile, usual range of bulk density maintained in most grow media in solid media-based (aggregate type) hydroponics falls within the range of 0.1 - 0.7 g cm^{-3} (Khomami et al., 2019). All the grow media used in this experiment falls into this range. The highest bulk density was observed in T6 and the lowest bulk density was observed in T1 but their vegetative growth parameters and head parameters were satisfactory, when compared to the substrates having normal levels of bulk density (i.e. T3 and T5). Meanwhile, the influence of the grow media treatments on the WHC at the harvesting stage was significantly different (p=0.04). The differences among T2, T3, T4, and T6 were insignificant (p>0.05) but the WHC of T1 and T5 were significantly higher than the other treatments. The highest WHC was observed in T1 (0.75 ±0.07), and the lowest was observed in T6 (0.34 ± 0.02 gg-1) Meanwhile, the observations indicated a frequently dry substrate condition in T6, leading to rapid wilting of plants, compared to all other treatments. As shown in Table 3, the leaf area (per plant) of T6 was notably higher. Anticipated higher evapotranspiration (ET) through a relatively large leaf area while the WHC of grow media was low could have caused the plants in T6 to run into water stress conditions frequently. Eriksen et al. (2016) and Baslam and Goicoechea (2012) reported that under water stress, plants reduce growth and redirect developmental resources toward rapid maturation. At 11 WAT only T6 had begun to bolt in some replicates, probably due to this influence. Contrary to this, T6 has shown the highest plant dry weight during the vegetative stage at 7 WAT and achieved a relatively high head dry weight (9.42 g) at harvesting.

Table 5. pH, electrical conductivity (EC), bulk density (BD), water holding capacity (WHC) of different media and fertilizer combinations.

Trt.	pH	EC (mS cm^{-1})	Bulk density (g cm^{-3})	WHC (g g^{-1})
T1	6.82 ± 0.17^{a}	0.457 ± 0.157^{b}	0.18 ± 0.03^{c}	0.75 ± 0.07^{a}
T2	4.64 ± 0.14^{c}	0.302 ± 0.116^{b}	0.65 ± 0.01^{ab}	0.44 ± 0.03^{c}
T3	7.49 ± 0.11^{a}	2.157 ± 0.506^{a}	0.62 ± 0.07^{b}	0.42 ± 0.06^{c}
T4	6.04 ± 0.62^{b}	0.161 ± 0.053^{b}	0.68 ± 0.07^{ab}	0.4 ± 0.05^{c}
T5	7.28 ± 0.43^{a}	3.158 ± 1.523^{a}	0.67 ± 0.03^{ab}	0.56 ± 0.12^{b}
T6	5.49 ± 0.54^{b}	0.326 ± 0.018^{b}	0.74 ± 0.07^{a}	0.34 ± 0.02^{c}

Trt.: Media and fertilizer combinations; The means that do not share the same letter in superscripts are-significantly different (DMRT/p<0.05).

Overall results of this experiment indicate that the substrate parameters have significantly influenced the final yield of Iceberg lettuce. Treatments T2 and T4, with optimal pH, bulk density (BD), and water holding capacity (WHC), produced the highest head fresh weights. Conversely, T3 and T5, undesirable medium pH and higher nutrient accumulation in the medium (high EC), resulted in lower head weight and head size. T6 exhibited the highest BD and lowest WHC, leading to frequent wilting and reduced yields. T1, characterized by low BD and high WHC, yielded moderately. As a whole, optimal pH, moderate EC, suitable BD, and high WHC are critical for maintaining the plant growth and yield of Iceberg lettuce in solid media based hydroponics culture.

4. Conclusion

Grow media and fertilizer combinations significantly affect the vegetative growth and yield parameters of Iceberg lettuce grown in solid media based hydroponics under semi-intensive greenhouse conditions. Comparable vegetative growth parameters indicate the possible replacement of the grow media and fertigation schedules used in the industry (T6) where 1:1 ratio of coco peat and topsoil is applied with rather complicated (daily changing) fertigation schedule (F3) with equally effective grow media and less complicated fertigation schedules. Treatment combination, T1 (coco peat and rice hull charcoal at 1:1 with standard dosage of Albrets fertilizer; F1) was found the best contender in this regard. However, despite its moderate vegetative growth rate, T4 (coco peat, rice hull charcoal and topsoil at 1:1:2, with half the standard dosage of Albrets fertilizer; F2) was found to be resulting in superior head dry weight and comparable yield and head quality (dimensions) to T1 and T6. Therefore, with proper water management, coco peat, rice hull charcoal and topsoil at 1:1:2 can be recommended as the most effective grow medium or substrate, to be used with half of the standard dosage of hydroponics fertilizer (Alberts) for the grow bag culture of Iceberg lettuce under semi-intensive greenhouse conditions in the mild weather regions in the tropics. Upgrading the fertigation schedule up to full strength of the standard dosage (EC at 0.8 – 1.2 mS cm^{-1} and pH at 5.5 – 6.5) during 1-5 WAT might be a better option for enhancing vegetative growth furthermore. Meanwhile, based on the relationship between plant growth/ yield performance and physical properties of grow media, the bulk density at 0.64-0.81 g cm^{-3} and WHC at 0.32- 0.47g g^{-1} (found in T2, T4, and T6) could be used for selecting grow media for Iceberg lettuce cultivation in fertigated grow bag culture.

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Conflict of Interest

The authors declare no conflict of interest related to this research.

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