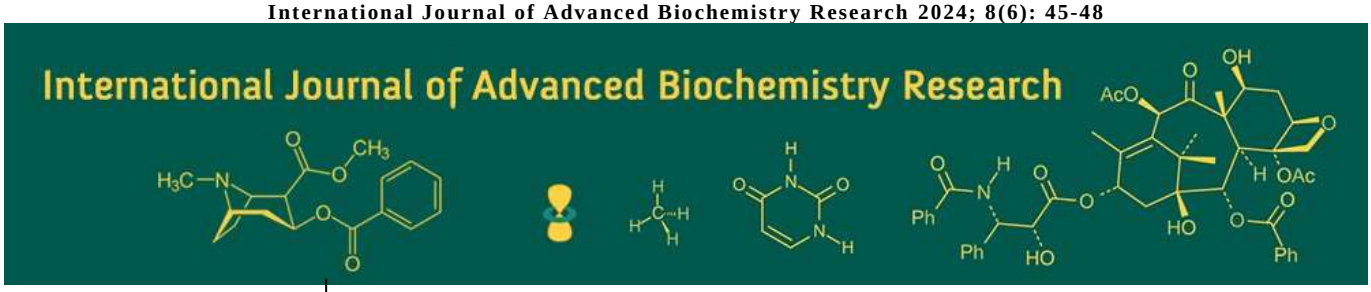

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Evaluation of solar operated aeroponic system on plant growth parameter over the conventional method of cultivation of lettuce (*Lactuca sativa*)

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Abstract
Global food consumption of the increasing world population is expected to increase significantly in the next decades. However, as the world's natural resource base (land, water, and air) is put under greater demand to raise food production, all of the main resources for modern agriculture are becoming less available. Increased food production can be obtained through increasing crop fields and improving cultivation. The hydroponic system is one of today's most advanced crop production methods. A hydroponic system's basic components include nutrient film technique (NFT), deep water culture (DWC), wick hydroponic, flood and drain system, drip hydroponic, and aeroponics. This study compared the solar-powered Aeroponic technology to the standard lettuce growth approach. The plant growth parameter *viz*. plant height (7.6, 12.9 and 20.1 cm, and 5.6, 10.4 and 16.6 cm), number of leaves (9.6, 14.0 and 17.2, and 5.0, 9.6 and 13.4) and leaf length (8.5, 10.4, 12.5 cm, and 7.3, 9.1 and 10.9 cm) at 15, 30 and 45 DAT for aeroponic system and conventional method of cultivation, respectively.

Keywords: Hydroponic system, aeroponic system, nutrient film technique, conventional method of cultivation and SPAD reading

Introduction
Global food demand has been estimated to increase significantly in the future centuries as the world's population continues to grow. Every day, around 200,000 people are added to the global population. The population is estimated to grow to 9.2 billion by 2050. One of the greatest challenges is eliminating hunger and poverty while making agriculture and food systems sustainable, and supplying clean and fresh food for the next generation is our primary importance, especially with a growing world population. (Alexandratos and Bruinsma, 2012) [1]. However, all major components of modern agriculture are becoming less available as the world's natural resource base (land, water, and air) is under pressure to increase food production.

Despite high yielding cultivars and an effective collection of practices, farmers cannot to take advantage of production potential when plants are not properly irrigated. Also, India is already water-stressed and on its way to becoming water limited, and water has become an essential component in Indian agriculture. The ultimate pressure for optimal utilization of highly prohibited water resources consequently increases significantly. It is very essential to use every drop of freshwater efficiently. Aeroponics is a method in which roots are suspended in the air and saturated with water at specific times. The benefit of this form of growing is that it uses less water than traditional soil farming. Aeroponics allows farmers to produce some types of food crops faster and larger with less water. The multiple water use method can create additional economic benefits and reduce susceptibility by allowing for greater variety of life alternates and improving ecosystem sustainability. (Dhawan, 2017) [3]. Aeroponic culture is an optional method of soilless cultivation in growth-controlled situations such as greenhouses. This method involves keeping the root system in a dark chamber while providing a nutritional solution through a mist device. This was commonly employed in horticultural plants like lettuce. (Cho *et al*., 1996) [2].

Lettuce (*Lactuca sativa* L.) belongs to the Compositae family and is one of the world's most important vegetable crops. It is produced mostly in open fields as well as under greenhouse settings. It is popular for its delicate, crunchy texture, slightly bitter taste, and milky juice when fresh. It is the most popular of all salad vegetable harvests. (Squire *et al*., 1987) [8]. Based on Stevens' (1974) [9] research in the United States, lettuce ranks 26th among vegetables and fruits in terms of nutritional value and 4th in terms of consumption rate, indicating the crop's growing importance. The deeper green outer leaves have the maximum nutritious content and are low in calories. Each head has 65-70 kilocalories. in, carbohydrate and Vitamin C and in 100 g of edible portion of lettuce contains 93.4 g moisture, 2.1 g protein, 0.3 g fat, 1.2 g minerals, 0.5 g fibre, 2.5 g carbohydrates, 310 mg calcium, 80 mg phosphorus, 2.6 mg iron, 1650 I.U. vitamin A, 0.09 mg thiamine, 0.13 mg riboflavin and about 10.0 mg vitamin C (Gopalan and Balaraman, 1966) [4]. The objective of this study is to compare the effect of a solar-powered aeroponic system with conventional lettuce farming in terms of growth characteristics.

Materials and Methods

Location

The experiment was carried out in the Department of Soil and Water Engineering, College of Agricultural Engineering, University of Agricultural Sciences Raichur in Karnataka. Raichur is located in latitude 16˚15′ N and longitude 77º 21 ′ E, with an elevation of 389 m above Mean Sea Level (MSL) with an average annual rainfall of around 650 mm. It is considered the North Eastern Dry Zone of Karnataka. As per the state's agroclimatic zones.

General description of solar powered aeroponic system

The solar powered aeroponic system comprised of an aluminum rectangular section frame with a diameter of 2.0 m × 1.0 m × 0.6 m (L × W × H). The growth chamber was elevated at a height of 0.4 m above the ground and longitudinal gradient was applied to it. The growing chamber was covered with an acrylic sheet, while the inside was covered with a 300 micron black polythene sheet, with a drain exit at the edge finding any excess spray. To accommodate the seedlings, the growth chamber had been covered with a polystyrene sheet.

Misters with 6.5 to 7.5 lph were placed in the bottom of the growth chamber to provide the water that is required and nutrients to the seedlings that were placed on a polystyrene sheet. A rectangular loft tank was used for holding the fertilizer solution while additionally collecting drained solution from the growing chamber by gravity. The design specification of growth chamber as shown Fig. 1.

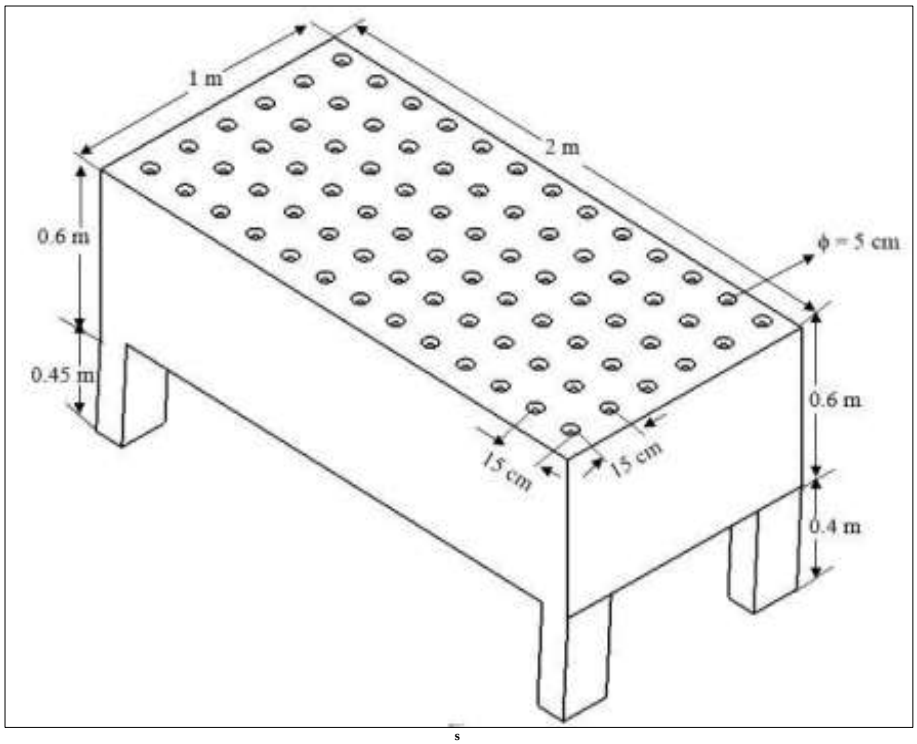

Fig 1: Design specification of growth chamber

Preparation of nutrient stock solution in aeroponic system

Two bottles were selected: bottle A and bottle B. Bottle A was added with calcium nitrate, potassium nitrate, manganese sulphate, EDTA iron, zinc sulphate and copper sulphate and bottle B was added with potassium nitrate, potassium dihydrogen phosphate, boric acid and ammonium molybedate (Hassan *et al*., 2018) [6]. The 6 ml of concentrated stock solution from each bottles was combined and diluted in 1 litre of normal water. The EC and pH were maintained before to delivery to the crop.

Irrigation scheduling in aeroponic system

The irrigation duration and interval were 10 seconds on and 5 minutes off. Because of the misting interval, the temperature in the plant's root zone chamber is constantly monitored, which saves energy.

Biometric parameters of lettuce under aeroponic and conventional system

The biometric parameters of lettuce were measured and recorded at intervals of 15, 30, and 45 days after transplanting (DAT) from five randomly labeled

competitive plants from each aeroponic and conventional system in order to study various characteristics such as plant height, number of leaves, and SPAD readings.

Plant height
The plant height was measured from observational plants at 15, 30, and 45 DAT using a meter scale and recorded in centimeters (cm). The plant height was measured from the net pot's attachment to the tip of the growing point, and the average plant height was determined.

Number of leaves
The total number of leaves per plant was counted from the observational plants between 15 and 45 DAT at 15-day intervals, and the mean number of leaves was determined.

Leaf length
The leaf length was measured using a meter scale. The measurement was taken from the base to the tip of the leaf. The average leaf length was determined from five selected plants. Data were collected at 15-day intervals, from 15 to 45 DAT. The mean leaf length was given in centimeters (cm).

SPAD reading
SPAD readings of green leaves from each of the five tagged plants were recorded. For this estimation, SPAD reading (Model, SPAD-502) was applied and the average values obtained were represented in percentages.

Statistical analysis
The data were analyzed and interpreted using the paired-two sample t-test, as defined by Gomez and Gomez (1976) [5]. Wherever the results are significant, the crucial difference at the 5% level was calculated and shown. The data were examined by utilizing 'MS Excel' program.

Result and Discussion
Biometric parameters of lettuce under aeroponic and conventional system
The aeroponic system was compared to the conventional method in terms of lettuce vegetative parameters, including plant height, number of leaves, leaf length, and SPAD reading. The information on growth parameters is presented below.

Plant height
The Table 1 and Figure 2 show the statistics on plant height as influenced by the aeroponic and conventional systems at 15, 30, and 45 DAT. The results showed that the plant height was 7.6, 12.9, and 20.1 cm at 15, 30, and 45 DAT in the aeroponic system. Similarly, with conventional method the plant height was determined to be 5.6, 10.4 and 16.6 cm at 15, 30 and 45 DAT correspondingly. The data clearly indicate that the plant height in the aeroponic system was higher, with percentages of 26.3, 19.37, and 17.41 at 15, 30, and 45 DAT, respectively. However, because the tcal values were 4.9, 8.3, and 4.5, which are greater than the ttab value of 2.7, there is a considerable difference in mean plant height between the aeroponic and conventional systems. So the aeroponic system was shown to have higher plant height or vegetative development than the conventional system, which is due to the constant supply of nitrogen in the aeroponic system. Additionally, in room conditions, plant hormones such as gibberellins, auxin, and cytokinins were synthesized. According to Lakkireddy *et al*. (2012) [7], the increased root exposure to air allows the plants to receive more oxygen, resulting in faster metabolism and growth rates.

Number of leaves
The Table 1 shows the number of leaves recorded from aeroponic and conventional farming systems at DATs of 15, 30, and 45. The results revealed that the number of leaves was observed to be 9.6, 14 and 17.2 at 15, 30 and 45 DAT for aeroponic system. Similarly, the number of leaves in the conventional system was determined to be 5, 9.6, and 13.4 at 15, 30, and 45 DAT, respectively. The data clearly show that the quantity of leaves in the aeroponic system was larger, with percentages of 47, 45, and 22. Table 1 shows the tcal and ttab values derived using paired t-tests to compare the number of leaves in the aeroponic and conventional systems. However, because the tcal values were 4.6, 6.4, and 4.7, which are greater than the ttab value of 2.7, there is a considerable difference in the mean number of leaves between the aeroponic and conventional systems. As a result, the aeroponic system produced more leaves than the conventional system due to mister performance, increased plant proliferation, and direct nitrogen supply to plant roots, as nitrogen promotes lettuce development. The number of leaves aeroponic and conventional system at 15, 30 and 45 DAT is depicted graphically in Fig. 2.

Leaf length
The Table 1 shows the data for leaf length (cm) acquired from different growing methods at 15, 30, and 45 at DAT. The results showed that the leaf length was 8.5, 10.48, and 12.58 cm at 15, 30, and 45 DAT for the aeroponic system. Similarly, for the conventional technique, the leaf lengths were 7.32, 9.12, and 10.96 cm at 15, 30, and 45 DAT, respectively. The results clearly show that the leaf length of the aeroponic system was larger, with percentages of 13.88, 12.97, and 12.87. Table 18 shows the tcal and ttab values derived using paired t-tests to compare the leaf length of plants in aeroponic and conventional systems. However, it was discovered that as the tcal values were 4.61, 4.42 and 8.86 which are larger than the ttab value 2.7, therefore there is a considerable difference between the mean values of leaf length of aeroponic and conventional system. As a result, aeroponic systems have longer leaf lengths than traditional systems. The optimum vegetative development happened owing to the provision of potassium nitrate, which leads to lettuce growth and the ultimate consequence is the longest leaf. Figure 2 depicts the leaf lengths of aeroponic and conventional systems at 15, 30, and 45 DAT.

Table 1: Effect of aeroponic and conventional system on plant height (cm), number of leaves, leaf length and SPAD reading at different crop growth stages

Plant growth parameter	Plant height (cm)			Number of leaves			Leaf length			SPAD reading		
	DAT			DAT			DAT			DAT		
Growing method	15	30	45	15	30	45	15	30	45	15	30	45
Aeroponic metho	7.6	12.9	20.1	9.6	14.0	17.2	8.5	10.4	12.5	31.0	34.2	36.8
Conventional method	5.6	10.4	16.6	5.0	9.6	14.4	7.3	9.1	10.9	35.6	37.4	41.0
t_{cal}	4.9	8.3	4.5	4.6	6.4	4.7	4.6	4.4	8.8	-4.0	-2.4	-3.4
t_{tab}	2.7			2.7			2.7			2.7		

SPAD reading

The findings on SPAD reading (%) as influenced by aeroponic and conventional system at 15, 30 and 45 DAT are reported in Table 1 and showed graphically in Fig. 2. The SPAD value observed to be 31.04, 34.28 and 36.8% at 15, 30 and 45 DAT for aeroponic system. Similarly, using the conventional approach, the SPAD readings were 35.68, 37.46, and 41.04% at 15, 30, and 45 DAT, respectively. Thus, the SPAD reading of the aeroponic system was found to be lower than that of the conventional system. Table 1 shows the tcal and ttab values derived when comparing SPAD readings of plants in aeroponic and conventional systems using the paired t-test. However, because the tcalvalues were -4.01, -2.46, and -3.46, which were less than the ttab value of 2.7, there was no significant difference in the mean SPAD readings of the aeroponic and conventional systems. As a result, the aeroponic system had a lower SPAD reading than the conventional system, which might be attributed to the aeroponic system's lower light intensity compared to the conventional system's light level.

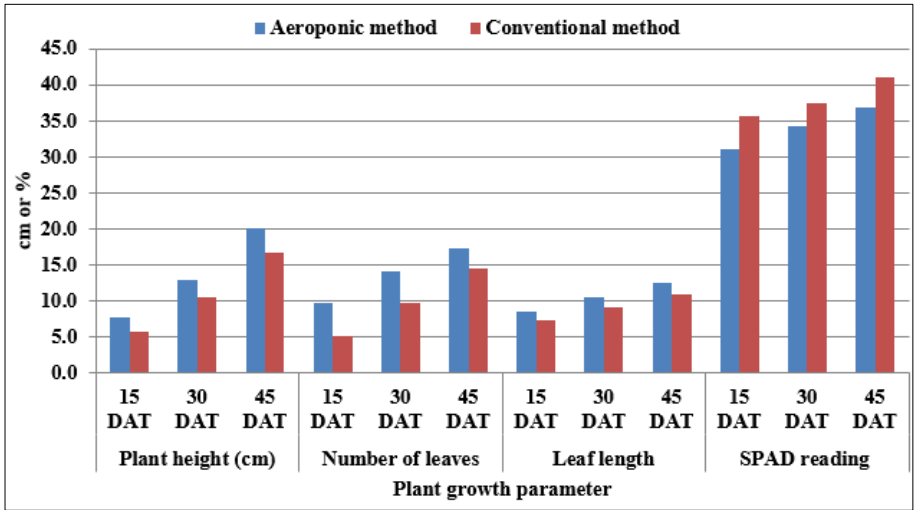

Fig 2: Effect of aeroponic and conventional system on plant height (cm), number of leaves, leaf length and SPAD reading at different crop growth stages

Conclusion

The amount of water consumed by lettuce crop under aeroponic system was minimum compared to conventional system.The response of lettuce crop under aeroponic system in terms of plant height, number of leaves, leaf length was significantly higher in aeroponic system but SPAD reading was lower in aeroponic system.

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