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Hydroponic strawberry production - A soil free water saving technique for quality produce

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Abstract
Hydroponics is the technique of growing plants in a water-based, nutrient-rich medium, without the use of soil. This method essentially cuts down the amount of water being used compared to the method in which plants are grown in soil. Strawberry (*Fragaria x ananassa* Duch.) is one of the most popular fruits around the world due to its highly desirable taste and flavour. The increased demand for strawberries throughout the year is met through Hydroponic cultivation. In some cases, up to 90 percent less water is used in the hydroponics method compared to the traditional soil-based agriculture. Hydroponics is the technique of growing plants in a water-based, nutrient-rich medium, without the use of soil. Terrestrial plants may be grown with their roots in the mineral nutrient solution only or in an inert medium, such as perlite, gravel, or mineral wool. Hydroponics is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution. Keeping all these benefits and constraints in view a comparative study was conducted with objectives to compare Hydroponic v/s open field strawberry cultivation in Satpura Plateau region of Madhya Pradesh at dist. Chhindwara, during the year 2019-20. The average rainfall in the region is 1144.7 mm, and maximum temperature range in the summer is 42- 45°C and minimum is 5.0- 6.0°C. These zones were strategically chosen because of their agroclimatic potential, which promotes better plant growth, fruit development. The dist. Chhindwara has conditions which are favourable to strawberry production in relation to precocity and production. However there is a need to adopt new technique like as hydroponic (NFT, Verti-Gro, etc) to improve the cultivation techniques with an aim to producing larger-sized qualitative fruits. In general, the yield and other physic-chemical parameters (fruit length, width, average fruit weight, TSS, etc.) of the strawberry were higher in hydroponics technique. This techniques helps to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition.

Keywords: hydroponics**,** growth, strawberry, fruit quality, vertical, yield

Introduction

Soilless (Hydroponic) fruits grown in greenhouses are gaining popularity and potentially represent a compliment toward sustainable food sources. Only a few studies have looked at the nutrient quality of strawberries (*Fragaria* × *ananassa*) grown in soilless systems. Strawberries (*Fragaria x ananassa* Duch.) are cultivated in nearly all countries of the world, have a unique, highly desirable taste and flavor, and are one of the most popular winter fruit in India. Strawberries consist of 95% water and 5% dry matter that contains varied percentages of proteins, lipids, sugars, vitamins and minerals. This composition changes according to the variety, the handling carried out in the production, the climate and the production region as well as sampling time and the degree of ripeness.

Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, etc. for successful plant growth. However, Presence of disease causing organisms and nematodes, unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion etc. are serious limitations for plant growth. In addition, conventional crop growing in soil (Open Field Agriculture) is somewhat difficult as it involves large space, lot of labour and large volume of water. Moreover, some places like metropolitan areas, soil is not available for crop growing at all, or in some areas, we find scarcity of fertile cultivable arable lands due to their unfavorable geographical or topographical conditions. Under such circumstances, soil-less culture can be introduced successfully.

Soil-less culture mainly refers to the techniques of Hydroponics. The term Hydroponics was derived from the Greek words *hydro'* means water and *ponos'* means labour. It is a method of growing plants using mineral nutrient solutions, without soil. Terrestrial plants may be grown with their roots in the mineral nutrient solution only or in an inert medium, such as perlite, gravel, or mineral wool.

Hydroponics is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution.

This system helps to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition.

Hydroponic systems for crop production are nowadays essential to maximize yields. Sometimes, the benefits of hydroponics have been questioned by the researchers as compared to growing of crops in other soilless culture. The growers raised the crops through hydroponics system get yields more compared to conventional practices as hydroponically grown plants dip their roots directly into nutrient-rich solutions. Hydroponics is the emerging sector of horticulture that deals with growing of plants in a soilless nutrient solution. NFT is a hydroponic technique wherein a very shallow stream of water containing all the dissolved nutrients required for plant growth is re-circulated past the roots of plants in a watertight gully, also known as channels. According to the pre-requisite to achieve a nutrient film situation more effectively is described as (i) ensuring the gradient down where water flows is uniform and not subject to localized depressions, (ii) rapid inlet flow rate that a considerable depth of water flows down to the gradient, (iii) adequate width of the channels to avoid any damming up of the nutrients, and (iv) flat channel base but not curved due to which otherwise will be a considerable depth of liquid along the center of a channel with a curved base. N.F.T. system is fairly a simple design.

In India the fruit especially strawberry is produced with high-technology, but there is little research on the productivity of strawberry under hydroponic systems. The present investigation was conducted to compare soil based with hydroponic systems for the strawberry production (*Fragaria* × *ananassa* Duch.). In strawberries, NFT is the most commercially practiced method. In this method, the runners of strawberry are placed in net pots in which the roots are covered with clay medium in the root zone, which help in increasing the strength of plant. They can also be placed with plugs into the net pots which are framed in the NFT channels. It must be placed such that there is continuous contact with the flow of nutrient solution in the initial weeks of root development. The optimum amount of oxygen must also be maintained during the operation of system with 14–16 hours of daylight. The nutrient discharge should be 1–2 liters/minute with circulation pump running all the time. In NFT, it must be grown in low humidity conditions and care should be taken as it is susceptible to root rot.

Advantages of Soil-Less Culture

- Here nutrients are fed directly to the roots, as a result plants grow faster with smaller roots, and plants may be grown closer.
- There is no chance of soil-borne insect pest, disease attack or weed infestation too.
- Overall soil-less culture provides efficient nutrient regulation, higher density planting, and leading to increased yield per unit area along with better quality of the produce.
- It is also effective for the regions of the World having scarcity of arable or fertile land for agriculture.

Limitations of soil-less culture

Despite of many advantages, soil–less culture has some limitations.

- Application on commercial scale requires technical knowledge and high initial investment, though returns are high.
- Considering the high cost, the soil-less culture is limited to high value crops.
- Great care is required with respect to plant health control.
- Finally energy inputs are necessary to run the system.

Material and Methods

This comparative study was conducted in two different places in District Chhindwara M.P. during the year 2019-20. First study done in the farmer's field under soilless with greenhouse and second is another farmer's field under soil based without greenhouse. The average rainfall in the region is 1144.7 mm, and maximum temperature range in the summer is 42- 45°C and minimum is 5.0- 6.0°C. These zones were strategically chosen because of their agroclimatic potential, which promotes better plant growth, fruit development. The objective was to assess which production system of the strawberry plants develop better and reach higher yield and quality. To compare Hydroponic to open field strawberry cultivation in Satpura Plateau region of Chhindwara District, Madhya Pradesh and to study the growth, yield and quality of strawberry cultivated hydroponic with soilless medium in a vertical hydroponic system. The strawberry cv. Chandler planted under raised bed planting system at 60 cm × 30 cm spacing under farmer's field. All necessary cultural practices and plant protection measures were followed uniformly during the study. Three plants were selected randomly for taking observations on growth and physico-chemical parameter of fruits. As the yield of strawberry plants is closely related to vegetative growing parameters such as crown height, petiole length, number of leaves/plant, plant weight and spread, root weight and volume and number of roots per plant, was investigated in different growing environments. The plant growth parameters like crown (aerial portion of the plant) height, petiole length (cm) of the leaves of the randomly selected plants were measured in each replication at final harvest with the help of meter scale. Total number of leaves (per plant) was counted from tagged plants in each replication after completion of harvesting period. The spread (cm) of the plants was recorded in east-west and north-south direction with the help of a meter scale. After completion of harvesting, tagged plants were uprooted and cleaned properly. They were then dried in oven at 70°C and the plant (Fresh and dry) weight (g) was recorded.

Fruit length and width (mm) of 10 fruits from each site was taken with the help of digital vernier caliper and fruit length: diameter ratio of the same 10 fruits was used to record length and width. The weight of fruits (g) from each tagged plants was taken on each date of harvest with the help of electronic top pan balance and dry weight (g) of the fruit was recorded by drying the fruits in oven at 70°C till the constant weight up to 2 days. The number of fruits/plant was recorded by counting the fruits reaching harvestable maturity. The yield/plant (g) was recorded by adding yield of all the harvests obtained from selected plant.

Total soluble solids (TSS) (°Brix) were recorded with the help of hand refractometer. The titratable acidity (%) was determined by titrating the juice against standard alkali solution (0.1 N NaOH). TSS: acid ratio was calculated by dividing the value of total soluble solids content by per cent acidity. For estimation of juice percentage, the ripe fruits of strawberry were taken in muslin cloth and crushed. It was squeezed firmly to get juice. The juice was weighed with the help of balance and the percentage of juice was worked out on the basis of total weight of fruit taken for juice extraction. For estimation of sensory score, a panel of five judges conducted organoleptic test of the fruits immediately after

harvest. The observation were recorded on the basis of flavour, colour, taste and general appearance of fruit and rated on 10.0 scale as Excellent (9.1 to 10.0), Very Good (8.1to 9.0), Good (6.1 to 8.0), Acceptable (5.1 to 6.0), Nonacceptable (0.0 -5.0).

Results and Discussion

Plant growth parameters like crown height (cm), petiole length (cm), number of leaves/plant, plant spread (E-W and N-S) (cm), plant fresh weight and dry weight (g) were significantly influenced by different growing environments (Table 1).

Table 1: Effect of growing environment on morphological characteristics of strawberry

Parameters		Hydroponics	Open condition
Crown Height (cm)		26.46	20.12
Petiole length (cm)		14.87	10.42
No. of leaves/plant		62.55	59.22
Plant spread (cm.)	E-W	43.02	34.04
	N-S	41.03	37.30
Plant weight (g)	Fresh weight	97.66	90.33
	Dry weight	23.72	38.84

The crop grown in hydroponics under greenhouse recorded maximum crown height (26.46 cm), whereas the minimum crown height (20.12 cm) recorded due open condition with soil based medium. The maximum plant spread (E-W: 43.02 cm; N-S: 41.03 cm) was recorded in the plants grown in hydroponics under greenhouse, whereas minimum plant spread was observed in open condition. The present findings are in accordance with those as reported by Pires *et al*. (2006). These findings may be attributed to favourable environment and better moisture conservation vis-a-vis suppression of weeds resulted in better plant growth parameters (Qureshi *et al*. 2012).

The Strawberry plants grown in hydroponics under greenhouse recorded the maximum petiole length (14.87 cm), while minimum (10.42 cm) plant spread was observed in open condition. The Strawberry plants grown in hydroponics under greenhouse has highest number of leaves (62.55) per plant due to better exploration of nutrients and water (Sturm *et al*. 2003) and once it is grown under open condition, number of leaves/plant reduced to 59.22. The plant weight was maximum on fresh weight (97.66 g) if grown under hydroponics but on dry weight basis open field conditions improved plant weight (23.72 g). Plant grown under open condition had reduced plant weight (Table 1).

It is evident from the data that fruit length (44.23 mm), fruit width (33.93 mm), length: diameter ratio (1.30), fruit weight (on fresh weight and dry weight basis) (26.24 g, 2.03g) was recorded maximum in plants grown under hydroponics conditions than growing environment while minimum fruit length (38.30), width (30.73) length: diameter ratio (1.25) was observed in open condition (Table 2).

Table 2: Effect of growing environments on fruit yield and quality characteristics of strawberry

Parameters		Hydroponics	Open condition
Fruit length (mm)		44.23	38.30
Fruit width (mm)		33.93	30.73
L:B ratio		1.30	1.25
Fruit weight (g)	Fresh	26.24	15.31
	Final	0.94	2.10
No. of fruits/plant		28.20	24.23
Fruit yield/plant (g)		232.22	202.74

There was a significant difference in term of yield between the Hydroponic greenhouse and open field condition (Table 2).

The higher fruit yield recorded in the plants grown under hydroponic condition (28.20 number of fruits/plant). Favourable and integrated effect of moderation in hydrothermal regime that possibly enhanced the root growth for better uptake of water and nutrients might lead to better yield. Singh *et al*. (2009) also found enhanced fruiting, i.e. fruit yield increased by 27% and advanced flowering by two weeks through using plastic tunnels during night (5 pm to 9 am) in northern India.

It was observed that there was no significant effect of hydroponic greenhouse and open field condition on fruit TSS and acidity of strawberry fruits (Table 3). Strawberry growing in hydroponics was better with respect to fruit juice (96.30 %) and sensory scores (8.55). Such differential in sensory score may be due to differences in physico-chemical properties of strawberry under various degree of light reflectance (Decoteau *et al*. 1988) under various growing conditions.

Table 3: Effect of different growing environments on fruit bio-chemicals parameters of strawberry

Parameters	Hydroponics	Open condition
TSS (°B)	7.30	7.20
Titratable Acidity %	1.40	1.60
Juice %	96.30	93.40
Sensory score	8.55	7.40

Conclusion

This system helps to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition. Plant growth parameters like crown height (cm), petiole length (cm), number of leaves/plant, plant spread (E-W and N-S) (cm), plant fresh weight and dry weight (g) were significantly influenced in hydroponic. The Chhindwara region has conditions which are favourable to strawberry production in relation to precocity and production continues throughout the year; however there is a need to test new cultivars and to improve the cultivation techniques with an aim to producing larger-sized qualitative fruits. In general, the yield and other physical parameters (fruit length, width, average fruit weight) of the strawberry were higher in hydroponics under greenhouse than the fruits grown in open field condition.

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