AATCC Review

24 October 2024: Received
27 December 2024: Revised
21 January 2025: Accepted
28 January 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article

Open Access

Influence of different growing conditions and substrates for growth, yield and quality of *Sukhsagar* cultivar of onion

Sanjita Marandi[1], Chandan Karak[1]*, Satadal Chakraborty[1], Puspita Das[1], Pradeep Bhutia[1], Biswajit Chakraborty[1], Partha Choudhuri[1], Pran Krishna Thakur[2]

[1]*Department of Vegetable Science, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741252, India*

[2]*Department of Post Harvest Technology, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741252, India*

ABSTRACT

Present experiments were carried out with the aim to study the influence of different growing conditions and substrates for vegetative growth of plants, initiation of root, development of bulbs, and quality attributes of Sukhsagar cultivar of onion as it is being an indigenous popular local cultivar in West Bengal and there is no information available in the hydroponic and sand-based production of bulbs. Hence, Hydroponic and sand-based growing were experimented under the open roof condition of direct sunlight and a field experiment was undertaken at Horticulture Research Station Mondouri following Completely Randomized Design with three replications during the Rabi season of 2023-2024. The results revealed that the custom low-cost hydroponic system outperformed all other growing conditions of sand and soil in terms of vegetative growth of the plants, initiation of root and bulb, bulb development, and quality of bulbs. The floating bed of the hydroponic system revealed the early bulb initiation faster rate of bulb development and higher pungency of bulbs followed by sand and soil-based growing conditions. The production of onion bulbs in the low-cost hydroponic system even curtails the total time span for growing the crops and might be a better option for future bulb growers to get extra early bulbs with the least input cost and management.

Keywords: *Growing conditions, Substrates, Low cost hydroponic, Sand, Soil, Growth, Yield, Quality, Sukhsagar, Onion*

Introduction

Onion is one of the oldest cultivated and extensively used bulbous vegetables after tomato (1). The crop has a great contribution to both economic and health issues (2). Onions are preferred for their rich characteristic flavor and aroma due to the presence of sugars and organic acids which contributed to the organoleptic test. The Pungency level and total soluble solids are important quality attributes of any onion bulbs though the lower pungency is more popular than the higher pungency for handling. The sweetness of onion mainly depends upon the higher levels of soluble solids. The quality parameters of onion influence the export and processing quality (3). Onions are one of the few versatile vegetable crops that can be stored for an extended period of time for future use and can withstand rough handling and long-distance transport (4). Different governments and agencies have taken the initiative for the expansion of onion areas through various schemes in traditional ways and techniques by providing inputs even though this is not enough to mitigate the day-to-day demand. Some of the costly aeroponic, nutrient film techniques, floating and aggregate techniques for the production of onion bulb under glasshouse conditions are not feasible in some contexts. Presently, the production of leafy vegetables in Nutrient Film Technique and in Floating systems through hydroponically using artificial light and Styrofoam, Polysterene foam as rafts is very common under vertical farming systems in urban and periurban areas and in some plant factories which is sometimes technology and skill dependent to manage the whole system irrespective huge installation and maintenance charges. Production of other vegetable crops under nutrient film technique, hydroponic, aeroponic, or soilless substrates is sometimes not feasible to the general growers though advantageous in climate-smart farming. The rapid expansion of urban horticulture through roof gardens, varanda garden, and vertical gardens under soilless media or artificial media might be possible but very scanty information are available in regard to the growing of red bulbs of onions under different substrate systems including floating systems as well as the standardized package of practices for production of onion in a hydroponics system.

Keeping in view of the research gap of bulb production under hydroponic conditions as well as the cost-effective production of onion under different substrates and to increase the production of onion within a short span of time hence, the present experiment was framed to study the production possibility of onion bulbs under different substrates and growing conditions and their influences as well by using minimum inputs.

Materials and Methods

Polythene sheets and polystyrene foam as floating rafts without seedling holders were used to accommodate more plants under a hydroponic system and while fine-grade sand was considered for sand-based growing conditions.

*Corresponding Author: ***Chandan Karak***

DOI: https://doi.org/10.21276/AATCCReview.2025.13.01.131

Floating and sand bed were carried out under the open roof condition at Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya while field experiment was undertaken at the Horticulture Research Station of Mondouri during the winter season of 2023-2024 following a Complete Randomized Design with three replications with the aim to study the effects of different substrates and influence of different growing conditions on vegetative growth of plants, roots and bulb development, yield and quality of *Sukhsagar* cultivar of onion. Black polythene sheets of 100-micron thickness was used to make a container of 1.5 m x 1.1 m x 0.15 m for holding the water and polystyrene foam of 45cm x 100 cm x 4 cm was used as a floating raft along with prefilled plug trays with sand were used for the experiment. A popular local red ellipsoid variety (5) of West Bengal namely '*Sukhsagar'* is employed for the study. The 40 days old onion seedlings were transplanted in the polystyrene foam bed of the hydroponic system along with sand and soil-based growing conditions. The commercial grade fertilizer (19:19:19) @2g per litre of was applied at 11 days after transplanting (DAT) and 32 days after transplanting (DAT), 45 days after transplanting (DAT). Sulphur(60%) @ 2g per liter of water was applied twice at 15 days after transplanting (DAT) and 35 days after transplanting (DAT). Micronutrient @ 25g was applied at 11 days after transplanting (DAT) as supplements of micronutrients. The observations on various growth stages of plants, roots, initiation of the bulb, bulb development, changes in bulb geometry, and bulb quality parameters were studied from ten randomly selected plants of each replication, and the data were analyzed statistically(6). Total Soluble Solid (TSS) in ^{0}Brix was estimated by hand refractometer and total sugar (%) was estimated as per standard biochemical methods (7) while the pungency of onion was estimated by the organoleptic test.

Results and Discussion

The observations on various growth, yield and quality parameters of onion plants under the three different growing conditions were recorded and presented in the Table 1, 2, 3 and illustrated in the Figure [1 to 6]. The mean performance of growth, yield and quality parameters of onion along with the effects of different substrates or growing conditions for changes in bulb geometry presented and discussed hereunder.

Vegetative growth of plants

The significant influence of different substrates on the vegetative growth of plants was observed with the advancement of the growth stages.

Plant height (cm)

A significant average highest plant height of 41.33 cm was recorded at 30 Days After Transplanting (DAT) in the polystyrene foam bed of the hydroponic system followed by open field condition (40.57cm) and lowest plant height of 25.33 cm recorded in the sand bed system although plant height in the field was statistically at par with the thermocol bed of hydroponic system slightly higher than the field indicated the significant influences of the water-based growing condition for better growth of plant than the other growing conditions of sand and soil.

The initial growth rate of onion plants in the hydroponic system was quite faster due to the readily available nutrients dissolved in water which increases the uptake efficiency of plants through roots revealing the significant influences of the substrate while the comparatively slower growth rate in sand bed might be due to the texture and structural properties of substrate however, the residual fertility of soil might have a positive effect for vegetative growth of the plants. Higher plant height of 25.2cm in hydroponic conditions than 22.3cm for traditional soil grown of spring onions at 21 days of planting and revealed that onion plants grew more efficiently in hydroponic conditions than in soil-based traditional conditions (8) however, significantly taller plants of sweet onion at 31 DAT both in aggregate and floating system than NFT and aeroponics system was reported (9). However, the average highest plant height of 43.79 cm was recorded in open fields followed by hydroponic-grown onion (41.77cm) 45 days after transplanting although both are statistically *at par* means there are no significant differences whereas, the average lowest plant height of 29.50cm was recorded in sand grown onion. All the substrates and growing conditions system influence the increased rate of vegetative growth, however, the soil bed system recorded slightly higher plant height than the hydroponic system of floating bed might be due to the steady support of soil based growing conditions and adoption of the plant-however favorable growing conditions irrespective of substrates also recorded phenomenal changes (Figure 1 & 2) in plant growth. Top length of 49.57 cm of the Sukhsagar cultivar of onion plants in November planting exhibited the highest in soil based field conditions (5) while upto 60cm height in the same cultivar of onion under field conditions was recorded (10).

Number of leaves per plant

The significantly highest average number of leaves per plant (5.73) was recorded in hydroponically grown plants following open field conditions (4.8) whereas, the lowest number of leaves per plant was found in sand-grown onions. The number of leaves per plant exhibited significant differences among the different substrates indicating the better influence of the hydroponic system over the other growing conditions and substrates. In earlier, 12 numbers of leaves in hydroponic grown onions after 56 days of monitoring of different sensors to provide a better environment (11) however, better performance in leaf number in specified nutrient solutions in hydroponic grown green onion was found (12) even polystyrene floating bed was suggested better than the sand and gravel grown onion (13) however, November planted of Sukhsagar cultivar in field produces 8.16 number of leaves (5) while 5.3 number of leaves also recorded in Sukhsagar cultivar of onion in open field condition (10).

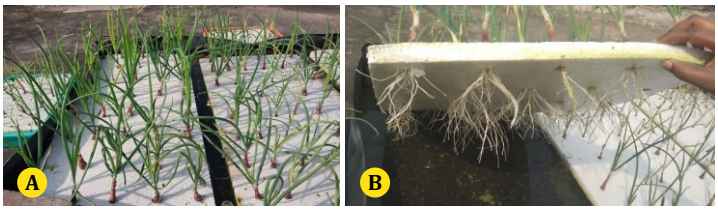

Fig. 1: Onion plant growth and root development in hydroponic condition (A) and (B) at 30 days after transplanting

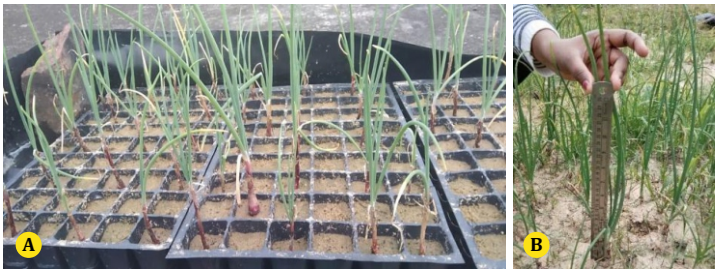

Fig. 2: growth and development in (A) sand and (B) soil condition at 30 days after transplanting Root length (cm)

The influence of different substrates or growing conditions on root growth, development and quality at different stages of plant growth is presented in the Table 1 and depicted in Figure 3. The significant maximum average root length of 18.7 cm was recorded in the floating bed of hydroponically grown plants followed by sand-grown plants whereas a minimum average root length of 7 cm was recorded from field-grown plants. It indicated that the root growth and proliferation are greatly influenced by the different substrates. The water-grown plants exhibited three times higher root length than field even much higher than the sand might be due to the texture and structural properties of substrates which inhibited the root growth by creating a physical hindrance. The floating system exhibited white color healthy root in the early growth stages of the onion plant while the creamy white color or brownish color root indicated the aging of plants might be due to the water quality however, healthy root was observed in the sand and field grown onion even after harvesting. Hence, the quality of roots is largely influenced by the substrates and aging of plants.

However, the significantly highest average root length of 20.13cm was recorded in the floating bed of a hydroponic system followed by sand (13.17cm) grown onion plants while field-grown onion plants recorded up to 7. 81 cm of average root length at 65 days after transplanting which indicated the significant influenced of the substrates and growing conditions for the root length of onion plants. Root length of hydroponically grown onion exhibited much lengthier roots than the other system might be due to the structural properties of the substrates which create physical hindrances for root proliferation in the sand and field though onion is a shallow-rooted crop and root growth is restricted within the 15 cm of the upper portion of soil layers however, the results clearly indicated the significant influenced of substrate could restrict the root growth. On the other hand in a hydroponic system plant able to grow roots easily which increases the uptake efficiency of the nutrients for its better growth and development as the growth of the plants have a direct relation with its root. The higher the roots of the plant may have contributory effects on the growth, yield and quality of the crops as the root is one of the major receptive organs that can easily adsorb the nutrients from the growing media for better growth and development of the plants. Earlier reports of variation in root length of onion plants in three supporting media of water (33.63 cm) sand (25.53 cm) and gravels (16.95 cm) and suggested that the hard media makes many obstacles than the other media to pass the root easily (14). Aeroponic and Floating plants developed the largest roots while aggregate plants developed the smallest root system in sweet onions and white colour root marked the most functional with brown being the most aged. Aggregates appeared to be the healthiest followed by Aeroponic and NFT systems while the least healthy root system was observed in the floating plants (9).

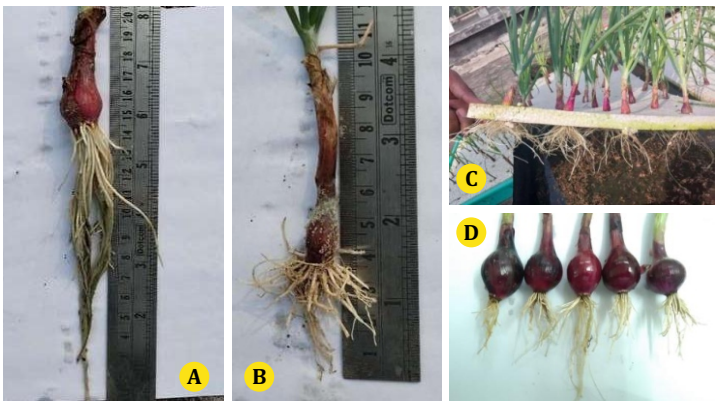

Fig. 3 Root length and root quality of the onion plants grown under different growing conditions of (A & C) water at 35 days after transplanting, (B) sand at 45 days after transplanting and (D) soil at 60 days after transplanting.

Neck girth (mm)

A significant maximum average neck girth of 10.66 mm was recorded in hydroponic-grown plants at 35 DAT followed by field-grown onions while a minimum average neck girth of 7.60 mm was recorded in sand-grown onions which indicated the influence of different substrates for the character. However, neck girth recorded at 45 DAT exhibited no significant influence by the different substrates. Aggregates and floating recorded higher neck girth than NFT although floating did not differ from aggregate plants but neck diameter exceeded in NFT plants at 59 DAT (9). However, 13.2 mm neck girth was also recorded in *Sukhsagar* cultivar of onion in the field condition (10).

Table 1 Mean performances of different vegetative growth and root parameters of onion cultivar Sukhsagar under different growing conditions of water, sand and soil

Characters	Plant height(cm)		Number of leaves	Root length (cm)		Neck girth(mm)	
	30 DAT	45 DAT	30 DAT	35 DAT	45 DAT	35 DAT	45 DAT
Hydroponic	41.33	41.77	5.73	18.70	20.13	10.66	12.95
Sand bed	25.43	29.50	3.93	12.00	13.17	7.60	10.93
Open field	40.57	43.79	4.80	7.00	7.81	9.13	11.58
SEm(±)	1.88	1.25	0.13	0.61	0.90	0.55	0.48
SEd	2.66	1.77	0.18	0.87	1.28	0.77	0.67
CD at 1%	6.50	4.33	0.44	2.12	3.13	NS	1.65
CV (%)	9.10	5.65	4.59	8.46	11.42	10.34	6.99

DAT-Days After Transplanting, NS-Non-Significant

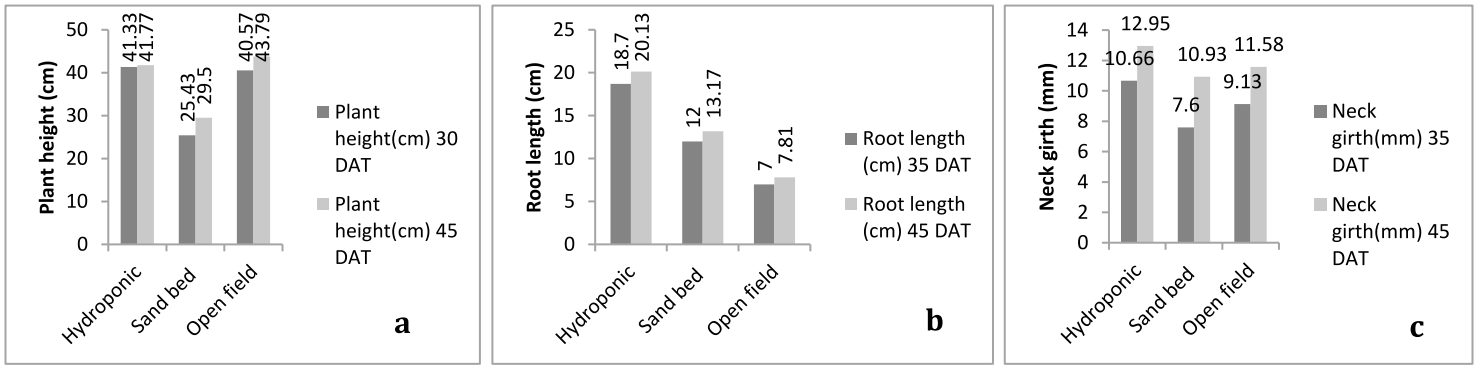

Fig. 4 Influence of different growing conditions of water, sand and soil on (a) plant height (cm) at 30DAT and 45 DAT (b) Root length (cm) and (c) Neck girth (mm) at 35DAT and 45 DAT of Sukhsagar cultivar of onion plants.

Bulb development parameters

The results related to the initiation of bulb and bulb development are presented in the Table 2 and illustrated in Figure 5 & 6 and its contributory effects to the total bulb yield. The shape and size of the bulbs mainly depend on the equatorial and polar diameter of bulb which influences the bulb geometry.

Equatorial diameter (mm)

Significantly highest average equatorial diameter of bulb (24.99 mm) was recorded at 35 days after transplanting (DAT) followed by field-grown onion bulb (17.60 mm) whereas the lowest equatorial diameter of bulb (16.42 mm) was recorded in sand bed system indicating the significant influenced of the substrates and growing conditions. The increased rate of bulb equatorial diameter quite higher in hydroponic system over the field and sand-grown systems might be due to the higher growth rate of plant-stimulating bulbing in the particular substrate. Early bulb development is an important and positive sign in respect to early harvest of bulb which shortens the crop cycle and has commercial value and economically viable option for the growers.

However, the steady increase of the equatorial diameter of the bulb is recorded at 45 days after transplanting (DAT). A significant maximum average equatorial diameter of 31.65 mm was recorded in the field followed by a hydroponic system (30 mm) though both are statically *at par* whereas, the minimum average diameter of the bulb (24.01 mm) was recorded in sand-grown onion indicating the significant influence of the substrates might be due to the better vegetative growth of plants which translocate the photosynthates to bulbing. The adaptability of onion plants in the growing conditions or substrates especially in the field and residual nutrient availability etc. might have a positive influence on the bulbing of onion. Generally, Sukhsagar cultivar of onion takes 90-100 days to reach maturity for harvesting of bulb in traditional growing conditions (5) which is quite a lengthier period for the growers. The results indicated that the faster bulb development in the floating system of polystyrene foam bed might be a better option for the growers to get early bulbs to fetch higher market price. In earlier, the equatorial diameter of bulb up to 3.56 cm in the Sukhsagar cultivar of onion was recorded from November planting from field (5) however, a higher equatorial diameter (55.6 mm) of Sukhsagar cultivar of onion also recorded at 120 days after transplanting in the field condition (10).

Polar diameter (mm)

Significant highest average polar diameter of bulb was recorded in the hydroponic system of polysterene foam bed (21.20 mm) followed by the open field (16.05 mm) while the lowest average polar diameter (14.69 mm) was recorded in sand-grown onion bulb at 35 days after transplanting (DAT) which indicated the positive influenced of the substrates. The water grown bulb exhibited much higher polar diameter than the other growing conditions of sand and soil.

However, in the contrary the significantly highest polar diameter of the bulb (38.76 mm) was recorded in the soil-grown plants followed by the plants grown in a polystyrene foam bed of a hydroponic system (34.95 mm) whereas the lowest polar diameter of bulb was recorded in the sand bed system (25.15 mm) at 45 days after transplanting (DAT) indicated the significant influenced of thermocouple or polystyrene foam bed for changes in the polar diameter of bulb of onion. The polar diameter of bulb was much higher in the field-grown onion than the floating bed of the hydroponic system and sand bed system. The sharp increase of polar diameter to the equatorial affected in the shape and size of the bulb which formed the globular-shaped bulb while the floating bed of polystyrene foam bed exhibited a somewhat round-shaped bulb indicating the changes in bulb geometry towards sphericity. In contrast, no effects for the shape index of bulb in the floating system were found which might be due to the use of Styrofoam board as a bedding material not even in another system (9). The growth rate of polar diameter of bulb might be restricted due to the stiffness of the thermocouple while in the field polar diameter of the bulb exhibited as usual as per characters laid for the Sukhsagar cultivar of onion. In earlier, higher polar diameter of bulb of 5.32 cm than the equatorial diameter (3.58cm) of Sukhsagar cultivar of onion during the November planting time in the field was reported (14) however, in contrast the lesser polar diameter of bulb (49.8mm) than equatorial diameter of bulb (55.6 mm) of Sukhsagar cultivar of onion was revealed from the field (10).

Individual bulb weight (g)

The individual bulb weight was recorded at 60 days after transplanting presented in Table 2. The growth of onion plants in the hydroponic system was adversely affected due to some unavoidable circumstances forced to harvest the bulbs early stages of maturity. The significantly highest individual weight of the bulb (21.86g) was recorded from the hydroponic system followed by field (20.72g) whereas, the lowest individual bulb weight (20.59g) indicated the positive influence of different substrates for bulb yield.

The floating bed of the hydroponic system performed better in terms of bulb weight might be due to the overall vegetative growth of the plants and faster rate of nutrient uptake efficiency than the other system. In earlier, the polystyrene foam of the hydroponic system exhibited slightly higher bulb weight of 7.74g and 3 bulblets per plants than the sand and gravel system by using the natural environment set up and the harvesting of

the bulb was done at 120 days after planting (12) whereas, bulb yield of 7.87 kg/m^2 in floating system followed by AG (7.57 kg/m^2) and AER (6.22 kg/m^2), while the NFT (5.20 kg/m^2) showed lowest bulb yield of sweet onion and harvesting was done at 244 DAS/104 DAT (9). The average bulb weight of Sukhsagar cultivar of onion is 58.74 g was recorded from the field-grown plants (5) while bulb weight upto 62.00g when planted in November in the field condition found better results than the earlier planting time of September and October (15) however, the bulb weight (80.6g at 130 days after harvesting) of Sukhsagar cultivar in the field condition (10).

Here in the present investigation, quite impressive bulb weight was recorded even at early harvesting of bulbs. The hydroponic system of floating bed will be very helpful for the onion growers to get higher yield subject to face any adversity during the growth stages of plants.

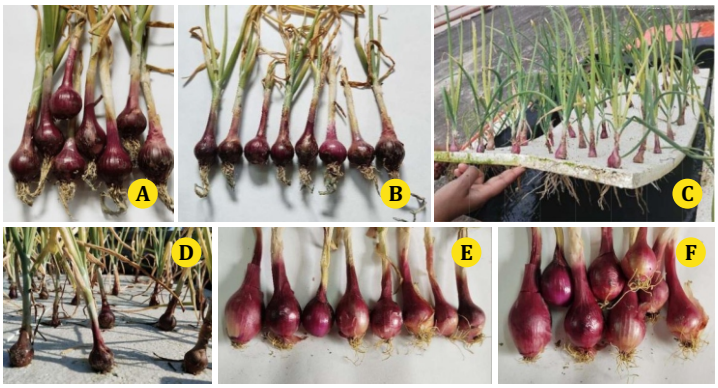

Fig. 5 Bulb development in different growing conditions of water (A) crop stand at 30 days after transplanting (B) & (C) bulbs harvested from hydroponic condition (D) crop stand at 45 days after transplanting in hydroponic condition and (E) & (F) bulbs harvested from field under soil condition

Number of scales

The average highest number of scales per bulb was recorded in the floating system (7.73) while the other two system recorded same number of scales per bulb (7.53) and no variations was recorded between the substrates of sand and soil-grown bulbs even not much varied with the hydroponic system indicated least influenced by the growing conditions. Although, bulb diameter is mainly dependent on the thickness of the scales which might be differed in the substrates due to variations recorded in the bulb diameter though the number of scales is same which can be compensated by the thickness of the scales. Thickness of the scales might be due to the accumulation of higher photosynthates in the bulb. In earlier, the number of scales up to 8.1 for Sukhsagar cultivar of onion in field conditions was also reported (10).

Table 2 Influence of different growing conditions of water, sand and soil on various bulb parameters of onion cultivar Sukhsagar

Characters	Equatorial diameter (mm)		Polar diameter (mm)		Individual bulb weight (g)	Number of scales
	35 DAT	45 DAT	35 DAT	45 DAT		
Hydroponic	24.99	31.65	21.20	34.95	21.86	7.73
Sand bed	16.42	24.01	14.69	25.15	20.59	7.53
Open field	17.60	30.00	16.05	38.76	20.72	7.53
SEm(±)	1.11	0.93	0.97	1.05	0.24	0.13
SEd	1.56	1.32	1.37	1.48	0.34	0.18
CD at 1%	3.83	3.23	3.36	3.63	0.84	0.45
CV (%)	9.74	5.66	9.71	5.52	2.00	2.94

DAT-Days After Transplanting

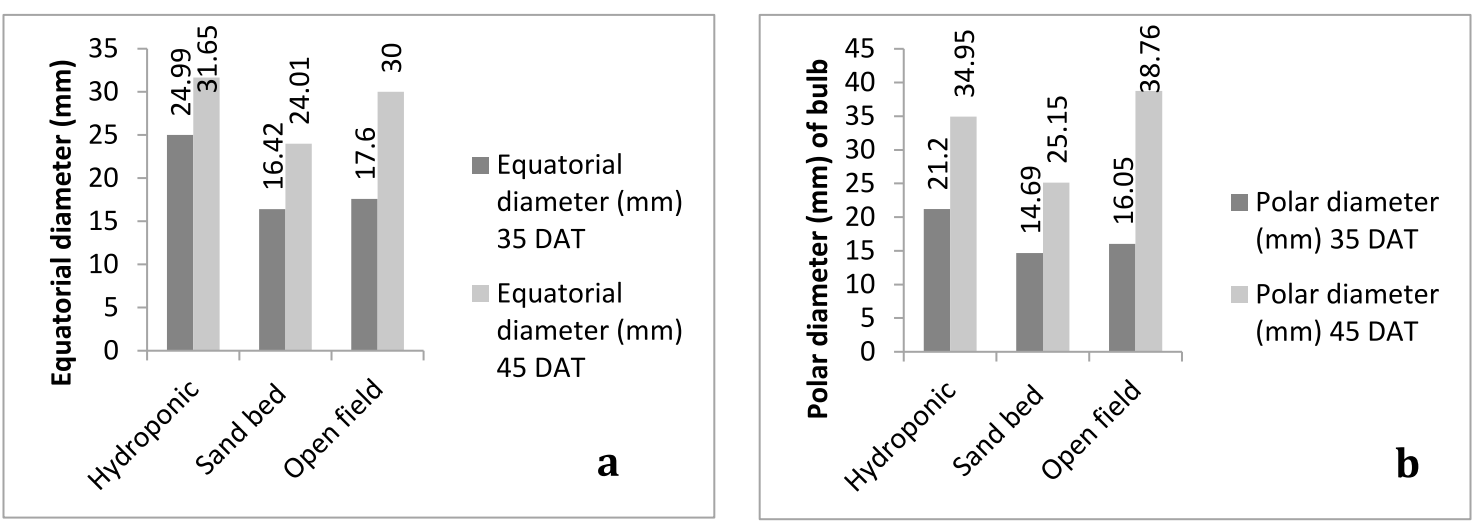

Fig. 6 Influence of different growing conditions of water, sand and soil on (a) Equatorial diameter (mm) at 35DAT and 45 DAT (b) Polar diameter (mm) of bulbs at 35DAT and 45 DAT of Sukhsagar cultivar of onion.

Bulb quality parameters

The three important quality parameters were estimated and presented in the Table 3 while pungency of onion was estimated by the organoleptic test.

Total Soluble Solid (TSS) (^{0}Brix)

A significant maximum TSS of 11.61^{0}Brix was recorded in the bulbs harvested from the field at 60 days after transplanting, followed by sand-grown bulbs (8.31^{0}Brix) whereas, a minimum TSS of 8.23^{0}Brix was recorded in bulbs harvested from the hydroponic system and both showed statistically at par each other. However, water and sand-grown bulbs did not vary much while much higher amount of TSS was exhibited by the bulbs harvested from the field indicating the influence of the growing conditions. Previously, TSS up to 7.05^{0}Brix in NFT-grown bulbs (16) however TSS of Agrifound Dark Red variety of onion ranges from 10.5 to 11^{0}Brix in sand bed system with the various organic treatments (17) while TSS up to 13.4^{0}Brix for the Sukhsagar cultivar of onion was recorded from field grown bulbs (10).

Total Sugar (%)

The significant highest total sugar percentage was recorded 6.45% followed by 5.25% while lowest total sugar (5.11 %) was estimated from the bulbs harvested in hydroponic grown bulbs. Total sugar value was slightly higher in the bulbs harvested from field indicating the influenced of the soil-based growing conditions however total sugar did not vary much in the bulbs harvested from sand and water-based growing conditions. In earlier, the total sugar percentage of Agrifound Dark Red variety of onion ranges from 5.98 to 7.19 in sand bed system with the organic treatments (17).

The quality parameters of bulbs are important for fresh, processing and storing. The higher level of sugar and soluble carbohydrates contributed sweetness of bulbs which influenced the export and processing quality (3). Sweetness of onion mainly depends upon the higher levels of sugar and soluble solids.

Table 3 Effects of different growing conditions on quality parameters of Sukhsagar bulbs

Characters	TSS (^{0}Brix)	Total sugar (%)	Pungency of bulbs
Low cost hydroponic system	8.23	5.11	Strong
Sand bed system	8.31	5.25	Medium
Open field system	11.61	6.45	Medium
SEm(±)	0.09	0.07	
SEd	0.13	0.10	
CD at 1%	0.32	0.25	
Grand mean	9.38	5.60	
CV (%)	1.70	2.20	

Pungency of bulbs

The pungency levels of bulbs were evaluated through organoleptic test and presented in the Table 3. The bulbs harvested from hydroponic growing conditions showed strong pungency followed by sand and soil-grown bulbs. It was also observed that the higher level of pungency is inversely correlated with the total soluble solids and total sugar content of bulbs. The Pungency level and total soluble solids are important quality attributes of any onion bulbs though the lower pungency is more popular than the higher pungency for handling.

Conclusion

The floating bed of hydroponic based growing conditions performed better in terms of highest plant height, highest root length, higher neck girth, maximum equatorial diameter, highest bulb weight and a maximum number of scales per bulb. Hence, overall vegetative growth of the plants, root development, early bulb initiation and faster rate of bulb development and better establishment of plants, higher level of pungency and lesser sweetness in terms of quality attributes in the floating bed of hydroponic system over the sand and soil based growing conditions. The floating bed of hydroponic system is easy to handle with minimum inputs may be a low cost viable option for onion growers as it can easily be accommodated in a roof garden, verandah garden, and balcony garden etc even in a vertical farming system and more importantly which could give extra early bulbs than the traditional growing system to fetch a better market price. Hence, the polysterene floating bed of hydroponic system outperformed all other growing conditions and substrates might be a better option for future growers to increase the onion production as a whole to meet the demand after several trials in different locations subjected to fulfill the conditions that emerged from the experiment.

Future scope of the study

There are lot of scope for future studies by using these growing conditions and substrates in different growing season of the crop and locations considering different varieties of onion in replicated manner in both indoor and outdoor vertical farming system to standardize the agro-techniques for management of the crops. Different types of organic and inorganic nutrient solutions may be included for production of bulbs. Cost analysis should be done by using comparative statements of the different substrates and growing conditions.

Declaration

All the authors have declared that there is no conflict of interest.

Acknowledgment

Authors are thankful to Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India for extending support for carrying out the research work.

References

1. Sidhu JS, Ali M, Al-Rashdan A, Ahmed N (2019) Onion (*Allium cepa* L.) is potentially a good source of important antioxidants. *J Food Sci & Technol,* 56(4):1811-1819. https://doi.org/10.1007/s13197-019-03625-9.

2. Yeshiwas Y, Alemayehu M, Adgo E (2023) The rise and fall of onion production; its multiple constraints on pre-harvest and post-harvest management issues along the supply chain in northwest Ethiopia, *Heliyon,* 9(5): e15905. https://doi.org/10.1016/j.heliyon.2023.e15905.

3. 3. Dhumal, K., Datir, S. & Pandey, R. (2007). Assessment of bulb pungency level in different Indian cultivars of onion (*Allium cepa* L.). *Food Chem*, 100(4):1328-1330. https://doi.org/10.1016/j.foodchem.2005.11.044

4. Tripathi PC, Lawande KE (2019) Onion storage in tropical region : A review. *Curr Hort*, 7(2):15-27. http://dx.doi.org/10.5958/2455-7560.2019.00014.1

5. Karak C, Hazra P (2014) Influence of environment on growth and bulbing of onion (*Allium cepa* L.) under Gangetic alluvial plain of West Bengal. *Ind J Agril Sci*, 84(4): 492-497. https://doi.org/10.56093/ijas.v84i4.39464

6. Bhattacharya D, Dhakre DS (2024) CRD analysis with equal number of replications by using D x D Statfield. https://psbvb.ac.in

7. Ranganna S (1977) Handbook of analysis and quality control for fruits and vegetable products (2nd ed.). Tata McGraw-Hill Publishing Company Limited.

8. Bhandari K (2023) Evaluating the Efficiency of Hydroponic Farming. *Int Res J Modern Engg Technol Sci*, 5(4): 2415-2421. https://www.doi.org/10.56726/IRJMETS35988

9. Mouroutoglou C, Kotsiras A, Ntatsi G, Savvas D (2021) Impact of the Hydroponic Cropping System on Growth, Yield, and Nutrition of a Greek Sweet Onion (*Allium Cepa* L.) Landrace. *Horticulturae,* 7: 432. https://doi.org/10.3390/horticulturae7110432

10. Mandal J, Ajgalley R, Saha D, Mohanta S (2019) Growth, yield and quality of onion cultivars under laterite belt of Eastern India. *Veg Sci*, 46 (1&2): 129-131. https://doi.org/10.61180/dp37nv09

11. Rahmat RF, Adnan S, Anugrahwaty R, Alami EPS, Siregar B (2019) Red onion growth monitoring system in hydroponics environment. *J Phys: Conf Ser*, 1235**:** 012117. https://doi.org/10.1088/1742-6596/1235/1/012117

12. Santos JE, Luz JMQ, Oliveira RC, Almeida RF, Silva JR, Lana RMQ (2021) Cultivation of green onion (*Allium fistulosum* L.) with support channels and nutrient solution in hydroponic. *Communicata Scientiae,* 12:3775. https://doi.org/10.14295/CS.v12.3775.

13. Khatun I, Haider I, Das SK, Hossen R (2021) Performance test of three supporting media during outdoor hydroponic farming of onion. *Plants and Eco*, 1:3-8. http://dx.doi.org/10.54479/pae.v1i01.6663

14. Khatun I, Karim S, Das SK, Hossen R (2021) Onion cultivation approach by custom-made outdoor hydroponics: A very first attempt in Bangladesh. *J Aridland Agri*, 7: 48-51. https://doi.org/10.25081/jaa.2021.v7.6518

15. Halder A, Karak C, Naik A, Samanta MK, Hazra P (2009) Identification of suitable early rabi onion varieties under West Bengal conditions. *J Crop Weed*, 5 (1): 131-134. https://www.cwss.in/Journal/Complete_jurnal/Vol5_1__25.pdf

16. Singh A, Bahadur V, Topno SE, Prasad VM, Kerketta A (2023) Effect of Different Levels of NPK and Micronutrients for Plant Growth, Bulb and Quality of Onion (Allium cepa) in NFT System of Hydroponics. *Int J Environ Climate Change*, 13(9): 2261-2272. http://dx.doi.org/10.9734/ijecc/2023/v13i92459

17. Nag D, Dutta AK (2017) Yield and quality of Sand Mulched Onion with the Application of Different Liquid Organic Manures. *Environ Ecol*, 35 (2B): 1050—1054. (https://environmentandecology.com/ CABI).