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Performance Test of Three Supporting Media during Outdoor Hydroponic Farming of Onion

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ABSTRACT: This study used different supporting media (polystyrene sheet, sand, and gravel) during outdoor hydroponic farming of onion within a natural environment setup. Domestic onion variety Taherpuri was taken as a model onion plant. As for performance parameters, plant height, number and length of leaf, length of root, bulb weight, number of bulblet, and chlorophyll contents were recorded. The number of produced leaves was almost same, although the length of leaf and root was found to have variations in these three supporting media. The yield (weight of bulb and number of bulblet) performance was slightly higher in polystyrene sheets (7.74 g and 3 bulblets per plant) than in the others. Chlorophyll-a, Chlorophyll-b, and total chlorophylls were comparatively higher in polystyrene sheets, 0.530, 0.764, and 1.294 mg/g respectively. Other growth parameters also showed better results in the case of polystyrene sheets. Finally, the results suggested that the polystyrene sheet as a hydroponic floating bed is suitable for outdoor hydroponics for onion cultivation.

Keywords: Onion, Hydroponics, Alternative farming, Taherpuri

Onion, *Allium cepa* L., is one of the most important spices in the world. It has been cultivated in many parts of the world for at least 5000 years for trading and consuming purposes. Turkey and Afghanistan mark the primary centers of origin for this genus. Another center of origin is located in Western North America, however (1). It has been considered for a long time as a member of the Liliaceae family (2,3). According to current taxonomic schemes, the genus presently belongs to the family Amaryllidaceae (4). There are many local varieties of the onion found in Bangladesh, among them Taherpuri is less disease affected as compared to the others (5). Onions are considered an integral part of our daily life because almost all local foods need onions. Although the bulb is the main edible portion, the flower, and green leaf are also edible. There also found many reports on its uses as home remedies against many diseases (6,7).

It is considered as one of the most important winter season, monocotyledonous, biennial, or perennial vegetable crops in the world (8). The leaves are hollow with longitudinal symmetry and at bulbing time, newly formed leaves become smaller (9). The leaves contain more chlorophyll than bulbs and absorb light energy during the photosynthesis process (10). According to Sarkar et al. (2019), the chlorophyll content of leaves in onion was influenced by different cultivation methods (11). The stem-like structure of the onion leaf is called the pseudo-stem, and roots usually do not branch, except few roots

hairs. Additionally, onion has a shallow roots system and rarely grows more than 50 cm below the soil surface (12). The primary organ of an onion is a bulb which is an aggregate of swollen leaf base, which is also regarded as onion yield. Skin variations of the bulbs are scored by their different colored skin white, yellow, brown, red, or purple (9,13). In Bangladesh, it's ranked first in respect of production among the spices crops grown in this country. The yield of onion varies from 370 to 500 kg/ha, which is very low as compared to the yield of 1,000-1,200 kg/ha in other countries. There is an acute shortage of onion in relation to its requirement in this country (14-16). To meet up its demand, every year Bangladesh has to import a big amount of onion from other countries (17). The lack of high-yielding varieties and the follow-up of improper production practices are the reasons behind such low yield (16,18).

Alternative farming, like hydroponics and other soilless cultures could be used to mitigate the present crisis in Bangladesh. These farming practices have been gaining much popularity worldwide (19,20). Hydroponics can be defined as the method of growing plants on different kinds of chemically inert substrates, such as sand, gravel, or liquid, in which nutrients are added without using soil (21-23). This farming method is mostly preferable for lettuce, strawberries, and some herbs cultivation nowadays (20). Outdoor hydroponics means the production of crops hydroponically but mainly providing natural environmental conditions. This farming system was first applied during the 2nd World War to produce lettuce (24). However, this system did not gain popularity worldwide due to its many limitations (25). Later on, this type of hydroponics was replaced by modern indoor hydroponic farming systems in many advanced countries.

In the case of Bangladesh, no previous reports on successful onion farming using any alternative farming techniques was found, except some recent attempts (26,27). To establish an outdoor hydroponics for onion cultivation in this country, supporting media selection is a crucial stage. As supporting media, pure sands, polystyrene sheets, and gravels are the most common materials used in hydroponic farming systems. Therefore, the main aim of the study was to check the performances of the three supporting media during onion cultivation in outdoor hydroponics in Bangladesh.

MATERIALS AND METHODS

Model crop

This experiment used a local variety of onions (*Allium cepa* L.) named Taherpuri as a model crop species. Seeds were collected in November 2018 from an authentic seed shop located in Barishal City. Seeds were used to produce seedlings and the 60 days of mature seedlings were used in this experiment.

Experimental set up

The basic procedures for the custom-made outdoor hydroponics installation and agronomic practices were followed by the mentioned methodology of Irani et al. (2021) (27). The hydroponic unit comprises a 5-liter capacity plastic container (18 cm×18cm×20cm). Three types of supporting media (Polystyrene bed floating on the water; 0.2 to 2.0 mm pure sands and 3-20 mm chemically inert gravels) were used. Six healthy, 60 days old seedlings were transferred to the prepared hydroponic units (Figure 1). For the performance test of these three supporting media, all types of agronomic practices and management were performed similarly for all units to maintain research homogeneity. Four replications were done and the placement of hydroponic units followed a randomized block design (RBD). The bulbs were harvested after four months of planting; the entire experiment lasted for one natural growing season of onion cultivation in Bangladesh (November 2019 to February 2020).

Chlorophyll content measurement

A single mature leaf was collected from each plant. Then 0.05 g of leaf from each sample was cut into fine pieces and then ground with a mortar and pestle. Later, 5 ml of 80% acetone was added with further ground, following an established method (28). Then the mixture was centrifuged (1000 rpm, 5 min) and the supernatant was transferred carefully to a 10 ml volumetric flask. The volume was made up to 10 ml with the addition of 80% acetone to estimate the chlorophyll content. The absorbance of the solution was measured at 645nm and 663nm in a T-60 UV-Vis spectrophotometer using the 80% acetone solution as blank. The reading was taken in a triplicate sample and the average was considered for calculation of chlorophyll content following the formulae of Gu et al. (2016) (29).

Data collection and analysis

The number and length of leaves, length of roots of selected plants were counted at 30, 60, 90 DAT (days after transplanting) and during harvesting time.

Weight of bulb, number of bulblet was counted during harvesting time only. Onions were harvested when half of the leaves turned yellowish-brown. All weight was calculated with the help of an electronic balance and expressed in grams. The length was measured by a meter scale and expressed as centimeters. Plant health also was examined with naked eyes. All data was primarily processed by MS Excel-10 version. All statistical analysis was done by Microsoft Excel 2010 software.

RESULTS AND DISCUSSION

Number and length of leaves, and length of roots

Number of leaves per plant was recorded at 30, 60, and 90 days after transplanting and at harvesting (Figure 2). The number of leaves per plant in different media has been given in Table 1. Comparatively highest number of leaves was produced in gravel during 90 days and during their harvesting time (10 and 5 leaves/plant respectively). However, the difference in leaf number of the three supporting media from beginning to harvest was statistically non-significant. As a strong and hard media, gravel showed the highest number of leaves, whereas the minimum number was possessed in polystyrene and sand. As an indication of successful growth in these supporting media, leaves number was increasing significantly with time.

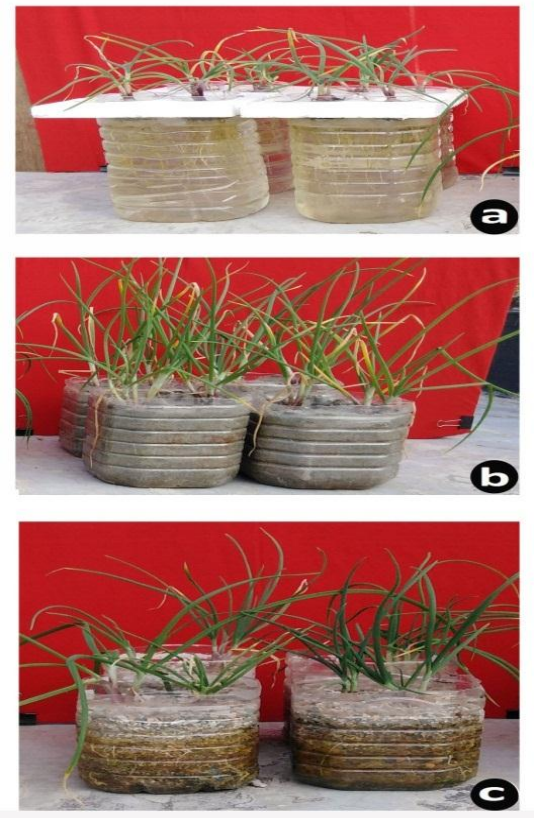

Figure 1. Growing onions in outdoor hydroponics using different supporting media. Here, (a) Growth in polystyrene bed, (b) in sands, and (c) in gravels.

Figure 2. Onion plants growth morphology with close view of leaves and roots in outdoor hydroponics using different supporting media. Here, (a) growth in polystyrene bed, (b) in sands, and (c) in gravels.

Figure 3. Produced onion bulb in outdoor hydroponics using different supporting media. Here, (a) Onions grown in polystyrene bed, (b) in sands, and (c) in gravels.

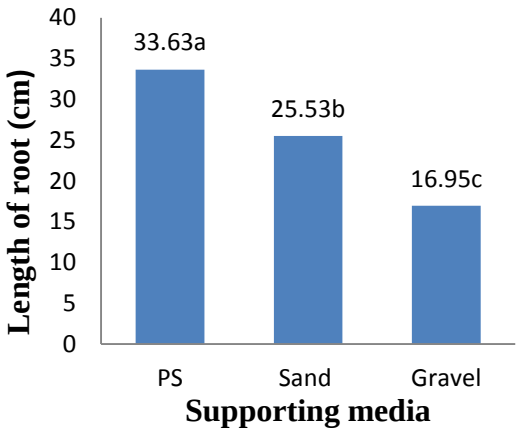

Figure 4. Graphical presentation of onion roots length growing in outdoor hydroponics using different supporting media. Values with different letters are significantly different at 5% probability level.

The three supporting media gave almost same results in the case of leaves number. The small

changes observed in produced leaves number but the changes were statistically non-significant among the three supporting media.

Table 1. Number of onion leaves in different supporting media of hydroponics at different growth stages.

Med	Number of leaves				Length of leaves (cm)			
	30 DAT	60 DAT	90 DAT	HT	30 DAT	60 DAT	90 DAT	HT
PS	6.6z	7.5z	8z	4.0z	12c	19c	21c	19c
Sand	6.6z	6.8z	9z	4.2z	21b	23b	31b	23b
Grav	6.0z	8.2z	10z	5.3z	23a	26a	32a	27a
F	0.87	3.29	3.0	1.97	129.7	28.7	112	63.9

Note: PS= Polystyrene Sheet; HT= Harvesting Time, and different letters are significantly different at P<5% by LSD test.

In case of leaf length, 30 days plant showed significantly maximum length in gravel (23.37 cm), which gave same pattern in 60, 90 days and harvesting time onion plant, 25.87, 32.13 and 27.46 cm respectively. Leaf length was lowest in the polystyrene sheet (12.14, 19.34, 21.03 and 18.18 cm) and it was moderate in sand medium comparatively during the calculated time. The differences was significant at 5% probability level that means the type of supporting media is responsible for onion leaves length than leaf number. As the length of leaf is also linked with the growing media type (liquid, soft and hard, and so on) in plant; here it is clear that gravel is comparatively hard medium than sand and polystyrene and thus possessed longest leaves than the other two media. Finally, the results confirm that these supporting media could be successfully used in hydroponic onion cultivation. Root lengths were measure after harvesting only. The mean values at harvesting time indicated significant differences among root length, and the result were recorded treatment wise (Figure 2), and presented graphically in Figure 4. Significantly the mean longest root length was recorded at polystyrene sheet (33.63 cm) comparatively than sand (16.95 cm) and gravel (25.53 cm). The result showed that the average length of root pattern was opposite of leaf length. The hard media can make barrier for root development and polystyrene media is floating over water in this experiment. As a result, produced roots can easily pass through the water without any obstacles. Thus, their length was conspicuously longer than sand and gravel media. However, for leaf purposes the gravel is better than the other two supporting media according to the observed leaf length data.

Bulb weight, bulblet number and Chlorophylls

The data on mean bulb yield per plant were presented in the table (Table 2). In polystyrene sheet the mean bulb weight per plant was 7.74 g, for sand the mean bulb weight per plant was 6.77 g and for gravel the mean bulb weight was 6.63 g per plant. Although it seemed the weight of produced bulb was higher in sand, but these were almost same in significant test. The size, shape, color and physical condition of produced onion was also almost same (Figure 3). The analysis of variance showed that the produced onion bulblet per plant in different supporting media was not significantly different. In polystyrene sheet, the mean number of bulblet per plant was 3.13, while it was 2.88 for sand and 2.69 for gravel media. Besides, Irani et al. (2021) reported that outdoor hydroponics for onion cultivation is possible in Bangladesh using polystyrene sheet as floating bed on water (27). These data support the idea that alternative farming using polystyrene sheet could be effectively used without affecting the yield of the local onion.

Table 2. Weight and bulblet number, and chlorophyll contents of leaf of onion in the different supporting media.

Media	Bulb-Wieght (g)	Bulblet number	Ch-a (mg/g)	Ch-b (mg/g)	Total Chl. (mg/g)
PS	7.74z	3.13z	0.530a	0.764a	1.294a
Sand	6.77z	2.88z	0.341b	0.533b	0.874b
Gravel	6.63z	2.69z	0.266c	0.477c	0.744c
F test	2.60	0.73	40.46	227.9	90.97

Note: Ch= Chlorophylls; Wt= Weight, and different letters are significantly different at P<5% by LSD test.

It was clear that chlorophyll contents of onions leaf was significantly affected due to different supporting media in outdoor hydroponic cultivation system. The polystyrene sheet possessed highest amount of Chl. a (0.530 mg/g), Chl. b (0.764 mg/g), and total chlorophyll (1.294 mg/g). In case of sand, it showed 0.341, 0.533 and 0.874 mg/g respectively which were moderate in range in the analysis. On the other hand, it was gravel which provided the minimum level of chlorophyll contents (Chl. a, Chl. b and total chlorophyll). The result indicated that, the produced

onion using only polystyrene as floating bed in this experiment gave outstanding results on its primary production capabilities using solar energy. While the other media gravels and sands were lower productive comparatively. The quantitative variation of chlorophyll contents in three media might be due to the structure and nature of the supporting media, and here polystyrene sheet showed the promising level of chlorophylls which meant this system is more appropriate for maximum primary production (photosynthesis). This might due to the availability of water in the vicinity of roots, when grown in polystyrene floating beds, and previously scientists said lack of water is one of the main reasons for low level chlorophyll contents in leaves (30). Although we found significant variations in produced leaf and root length and chlorophyll content, the produced onion yield indicated that all three supporting media would be considerable during outdoor hydroponic system. The authors preferred the polystyrene sheet as a supporting media because of its higher amount of chlorophyll contents. Finally, the authors suggested that much more research is needed including more parameters to confirm the performance of these three supporting media during outdoor hydroponic onion farming in Bangladesh.

CONFLICT OF INTEREST

This article has no conflict of interest.

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Author's contributions
Irani Khatun performed this research. Subroto Kumer Das supervised the thesis. Ishita Haider participated during data analysis and manuscript preparation. Riyad Hossen planed and designed the work, and prepared the maximum portion of the manuscript.

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