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The Impact of Different Types of Soilless Media on Some Significant Biological Parameters of Cucumber (*Cucumis sativus* L.)

Irfan Ali[1], Tanveer Hussain[1*], Ijaz Ahmad[2], Adeel Anwar[3], Ayesha Manzoor[4], Muhammad Saqib Naveed[4],Imran Ali[1], Asfa Quddus[1], Laiba Satti[1], Waqas Naseem[5]

[1]Department of Horticulture, PMAS-Arid Agriculture University, Rawalpindi, Pakistan.
[2]Department of Botany, Govt. Post Graduate College Gujranwala, Pakistan.
[3]Department of Agronomy, PMAS-Arid Agriculture University, Rawalpindi, Pakistan.
[4]Soil and Water Conservation Research Institute Chakwal, Pakistan.
[5]Barani Agricultural Research Institute Chakwal, Pakistan.
Corresponding author's e-mail: dr.tanveer005@uaar.edu.pk,

Abstract

The cucumber (*Cucumis sativus* L.) is amongst the most vital crop species from the *Cucurbitaceae* family, originating within the Bay of Bengal and the Himalayas. Most of the cucumber varieties are cultivated in the tropics, subtropics and milder portions of the temperate zones of both hemispheres. The present research was carried out in the unheated greenhouse in the Department of Horticulture, PMAS-AAUR. The following growth media, Border soil as a control (2) Soil + sand (75:25), Soil + Peat (75:25) and Sand + Peat (50:50) were used in this study. Following physical and chemical parameters were studied during the experiment, i.e. plant height, stem thickness, area of leaf area and number of leaves per plant, length of individual fruit, diameter of individual fruit, fruit firmness, number of fruit/plant, weight of individual fruit, yield, leaf chlorophyll contents, pH of fruit juice and total soluble solids (TSS). The trial was conducted with a Randomized Complete Block Design (RCBD) with four treatments, and each treatment was replicated thrice. The analysis of variance technique was used to analyze the data, and the mean differences of the various parameters were compared by the least significant difference test at 5 % probability level. It is concluded that different growing soil mixes have shown effective responses to the growth, yield and quality of horticultural crops, especially cucumber (*Cucumis sativus* L.).

Key Words: Cucumber, growth media, Soil mixes

Highlights

- Identify optimal soilless media for cucumber cultivation, assessing factors such as plant development, crop yield, and overall produce quality.
- Valuable insights for enhancing cucumber cultivation practices,
- Potentially leading to improved agricultural productivity and sustainability, were recorded.

1.0. Introduction

Cucumber (*Cucumis sativus* L.) is among the most crucial crop species from the *Cucurbitaceae* family. It has been under cultivation for some 3000 years and is considered one of the oldest crops (Adedayo et al., 2023). The cucumber is assumed to have originated within the Bay of Bengal and the Himalayas. Most of the cucumber varieties are cultivated in the tropics, subtropics and milder portions of the temperate zones of both hemispheres. In Pakistan, cucumber is grown as a significant salad vegetable in an area of 900 hectares with a yield of 5500 tons annually (Islam, 2006). It is usually grown in Pakistan as a summer crop. Seeds are directly sown in a field on raised beds during March and April. To get a higher market price, farmers try to avoid the regular crop season; thus, preference is given to off-season crops. Cucumber plays a significant role in human nutrition. It has 95 % water content, higher than that of most other vegetables, and also contains 0.6 g per kilogram fiber (Hodges & Lester 2011). Cucumber has a cooling effect and is helpful in jaundice. It is believed that oil extracted from cucumber seeds is beneficial for the brain and body (Khan., et al., 2013). The nutritional value of cucumber per 100 g of edible portion in terms of energy is 15 cal. It contains 95 % water, 0.9 g protein, 0.1 g fat, 3.4 g carbohydrate, 25 mg Ca, 250 IU vitamin A, 0.03 mg thiamine, 0.04mg riboflavin and 0.2 mg niacin (Rubeiz,1990).

Cucumber is usually sown either in open fields (in which soil is only medium) or in the greenhouse. In order to grow greenhouse vegetables, different alternate medials like coconut fiber, pine bard, and peat with their mixes give better results in terms of yield and quality as compared to soil-based systems (Kareem, 2023). Soil-based problems related to vegetables in greenhouse border soils have given rise to the idea of focusing on the alternatives of soil-based systems in the world since 1980. Simultaneously, soilless culture has been a popular growing system during the era (Engindeniz, 2004) and containerized culture is one of the soilless growing systems; it has been used undercover in developed countries to grow most vegetables (Mazuela et al. 2012). Organic substrates are widely used in substrate culture for plant production at a commercial level, and this technique is named as eco-organic soilless culture (Montagne., et al., 2015). This system is reported to be low–cost compared to inorganic nutrient solution systems and is recommended for developing countries (Gul et al. 2007). Over the last few years, the demand for horticultural crops in the greenhouse through different organic growing media has increased for several reasons. Due to the high price and difficulty in availability of these organic substrates, either these are replaced with other substrates or used in different mixes (Sarwar et al. 2018).

The trend of combining different substrates (organic and inorganic) with the soil for containerized culture has developed significantly, especially in developing to underdeveloped countries, to get better results in terms of yield and quality of crops. Additionally, intensive cultivation in the greenhouse condition has gained momentum due to land degradation and the trend of industrialization and urbanization. Organically grown products are rapidly increasing in popularity due to significant concern for the environment and health. Hence, hydroponic products from different countries attempt to adopt organic practices as an option in soilless cultures. Nowadays, there is an excellent trend to use organic and inorganic hydroponic media in various combinations with or without soil that have the advantage of low cost and ease of use (Al-Mana et al., 1990). It is also a common practice to add a mixture of other materials, including sand, to organic substances to provide the desired texture in the form of increased porosity, water retention and drainage (Abuarab et al. 2017). The present study focused on the following objectives: a) to investigate the effect of different soil mixes on the growth, yield and quality of cucumber and b) to help the farming community decrease the input cost of cucumber cultivation.

2.0. Materials and methods

The present research was carried out in the unheated greenhouse in the Department of Horticulture, PMAS-AAUR. The seeds of cucumber (*Cucumus Sativus* L) cv. CM-59 were obtained from the seed band established by the Department of Horticulture, PMAS-AAUR.

The seeds were sown in a mixture of Soil, Sand and farmyard manure (FYM) (1:1:1) in the seed trays. The trays were kept in the incubators for the seed germination. The plants at 2-3 leaves stage were shifted to pots of volume 10 Kg, containing different soil and media in the form of mixes. Loamy Soil was taken as soil medium with sand, silt and clay in a ratio of 1:1:1. soil was sieved to remove the debris. The soil was kept in the form of a heap in the open area for a week with daily inversion for better aeration. In the sand mix medium, the sand used was coarse (river sand). The sand was also sieved to remove the debris and was washed with tap water to remove excessive salts. Peat with pH 5 was obtained from the local nursery. The combinations of the growing media in the form of treatments were: T1:Border soil, T2: Soil + Sand (75:25), T3:Soil + peat (75:25). T4 Sand + peat (50:50)

Before the transfer of the plants, the media were analyzed. In the greenhouse, the plants were planted in 10 Kg pots. The nutrients were provided through the Hoagland nutrient solution throughout the growing season.

2.1. Parameters and statistics.

The experiment was conducted following a Randomized Complete Block Design (RCBD) with four treatments, and each treatment was replicated thrice.Following physical and chemical parameters were studied during the experiment, i.e. plant height, stem thickness, Leaf area, number of leaves per plant, length of individual fruit, diameter of individual fruit, fruit firmness, number of fruit/plant, weight of individual fruit, yield, leaf chlorophyll contents, pH of fruit juice and total soluble solids (Afsharipour et al., 2023). Data was analyzed by using the analysis of variance technique, and the mean differences of the various parameters were compared by using the least significant difference test at 5 % probability level (Khademi et al., 2023).

3.0. Results and discussion

3.1. Plant Height (cm)

Plant height is an essential characteristic of the members of the family *Cucurbitaceae*. Plant height is a function of the combined effects of genetic makeup and the environment. An increase in plant height is the most apparent manifestation of vegetative growth. Data regarding the plant height showed a significant difference among the values (Table 1). It is clear that the peat-soil mixture gave the maximum plant height (326.4 cm), followed by border soil, Sand-Peat mixture and Soil-sand mixture. These results are in accordance with the findings of (Afsharipour et al., 2023), who found better plant height in peat base medium compared to control.

3.2. Stem diameter, number of leaves and leaf area

Stem thickness represents the growth, vigour and yield of the crop. The yield of the crop very much depends upon the thickness of the stem because the transport of the nutrients takes place through the stem. Stem thickness data showed statistically significant differences among the treatments (Table 1), with a nonsignificant effect on the number of leaves. These results are in line with the findings of (Sallam et al., 2021).

3.3. Length of individual fruit, Diameter of fruit and Number of fruit/Plant

The maximum fruit length (37.98 cm) was noted in the soil-peat-based mix, followed by the sand-peat and soil-sand-based mixture, respectively, while the minimum (17.80 cm) fruit length was observed in the border soil. The nonsignificant effect of the treatments on the number of fruits per plant is noted during the experiment (Table 1).A significant increase in the fruit diameter was observed in the soil peat-based mix followed by soil-sand and sand-peat, respectively. The lowest fruit weight (95.94 g) was observed in border soil. The current results are according to previous reports of Rashwan et al. (2021), who also reported the maximum fruit length and diameter of cucumber fruit in a peat-based mixture.

3.4. Fruit firmness, pH, TSS, and Chlorophyll

Highly significant data regarding days to fruit yield (Table 1) showed that the maximum (21.1 tons/acre) yield per hectare was recorded in peat-soil based mix followed by sand-peat and soil-sand, respectively. In contrast, the minimum (10.51 tons/acre) yield was recorded in control. Łaźny et al. (2022) also reported similar results that the total yield of cucumber was best in peat and peat-based mixture. Meanwhile, nonsignificant results in terms of fruit firmness, pH, and TSS were obtained during the experiment.

Table 1: Effect of different soil mixes on various plants attributes

Plant attributes	Border soil (Control)	Soil + Sand (75:25)	Soil + Peat (75:25)	Sand + Peat (50:50)
Plant Height (cm)	109.0 d	134.2 c	326.4 a	156.9 b
Stem diameter (mm)	10.29 d	10.33 c	10.96 a	10.82 b
Leaf area (cm^2)	100 c	195 b	255a	210 b
Number of leaves per plant	15.55 c	19.27 b	25.77 a	19b
Length of individual fruit (cm)	17.80 c	24.54 b	37.98 a	24.83 b
Fruit diameter (cm)	0.61 c	0.77 bc	1.44 a	0.86 b
Fruit firmness (kg/cm^2)	5.60 d	6.20 c	8.46 a	7.00 b
Number of fruit/Plant	10.99	10.05	10.38	10.99
Weight of individual fruit (g)	95.94 c	160.4 bc	424.4 a	175.9 b
Yield (t acre$^{-1)}$	10.51 d	18.38 c	21.1 a	20.82 b
pH	5.53 d	5.66 c	6.60 a	6.23 b
TSS (Brix)	0.11 d	0.20 c	0.48 a	0.36 b
Chlorophyll a	0.43	0.55	0.70	0.66
Chlorophyll b	0.23	0.31	0.47	0.48

The selection of substratum influences not only the vegetative characteristic but also yield (Łaźny et al., 2022) without affecting the quality of the fruit. According to Atzori et al. (2021), the mixing of peat substratum into perlite, vermiculite, and coco fibers influenced tomato development. Plants grown in peat-vermiculite and peat-perlite substratum had more considerable root weight, stem diameter, and leaf area (Atzori et al., 2021). The data of other scientists showed the highest vegetative characteristics under the mixture of peat substratum (Zapałowska et al., 2023). Pepper seedlings grown in peat substratum, enriched with 1/3 zeolite, were higher and had more leaves and dry matter (Prisa et al., 2023). According to the data of Güler & Buyuk (2004), tomato seedlings grown in peat-perlite and other substratum and grown only in peat were the same (Sharaf et al., 2023). Eltez et al. (1993) reported that the plants of aubergine and pepper grown in peat-perlite substratum didn't differ from seedlings grown in peat (Erdal et al., 2024). Meanwhile, according to Demirer et al. (2003), perlite positively influenced the growth and development of lettuce, cucumber, and tomato seedlings (Radhouani et al., 2021). The current investigation reveals that the soil mixed into peat substratum influenced the vegetative parameters of plants. Cucumber plants grown in border soil substratum were lower and had smaller leaf areas than the seedlings grown in peat-based mixes. Plants grown in peat-soil and peat-sand substratum had greater plant height, leaf area, fruit size, diameter and total yield.

3.5. Chlorophyll a and b

The amount of Chlorophyll in plant leaves is one of the potential productivity parameters. High Chlorophyll a and b contents support vegetative characteristics under given growing conditions (Table). It is often used to establish some method of growing and environmental conditions that influence the plant photosynthesis system. If growth conditions aren't suitable, chlorophyll concentration and the ratio of chlorophylls *a* and *b* decreases. Chlorophyll *a* is more critical to the photosynthesis process. It more quickly reacts to changing environmental conditions (Allakhverdiev et al., 2020). The addition of peat to the substratum also had some effects on the photosynthetic pigment contents photosynthetic parameters (Xie et al., 2023). According to the data of Güler et al. (2004), the amount of chlorophylls in the leaves of cucumber seedlings grown in peat was higher than that of the leaves of seedlings grown in others (Sharaf et al., 2023). The increase in the vegetative characteristics and yield by peat-based mixtures can be explained by the increasing effect of these substrates on the

Chlorophyll and photosynthetic activity of the plants. Peat-based substrates gave the best results. Their high cation exchange capacity is an important advantage of such material (Atzori et al., 2021). Adding peat to soil or sand gave higher yields compared with using these media alone. Mariyappillai & Arumugam (2021) report that soilless media may be helpful in improving the physical properties of the other substrates besides being used alone as a soilless medium.

In contrast, another study on decayed sawdust (Atzori et al., 2021) revealed that sawdust decreased yield. This may result from the use of uncomposted sawdust. Although it is reported that sawdust could be used for soilless cucumber or tomato production, the kind of tree should be taken into consideration to decide whether composting is necessary or not.

It is found that soilless media give better results with respect to yield compared with soil, confirming the results determined in our study. Contrast this with the results obtained in tomato production. Although the most marked effects of soilless media were observed in terms of total yield, it may also be increased in marginal land. In light of the results obtained, soilless media culture could be recommended for cucumber production in the non-acclimatized greenhouses in Pakistan.

Conclusion

It is concluded that different growing mixes have shown effective responses to the growth, yield and quality of horticultural crops, especially cucumber (*Cucumis sativus* L.). Soilless culture is a beneficial technique and is an alternative to soil in the modern era of agriculture production. The best growth and yield occurred in peat-based mixes, which may be because this substrate has a large capacity to retain water and contains more organic water than other substrates.

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