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Effects of Different Growing Media for Vegetables in Raised Beds for Future Green Roofs in Cities

Muhammad Adeel[1], Salih Gücel[2], Özge Özden[3*]

[1, 2, 3]Faculty of Agriculture, Near East University, North Cyprus, Nicosia

Email-[1]20206295@std.neu.edu.tr,[2]Salih.gucel@neu.edu.tr,[3]Ozge.ozden@neu.edu.tr

ABSTRACT:

Future food production will confront many difficulties. Global agriculture is under stress due to the projected 9.6 billion people on the planet by 2050, increasing urbanization, dwindling arable land, and weather extremes brought on by climate change. The percentage of people who reside in cities will increase to 70% by 2030 from the current level of over 50%. The importance of the food issue is growing as a result of the extraordinarily rapid population expansion, loss of arable land, dietary changes, rising bioenergy use, and climate change. Urban agriculture, urban farming, or urban gardening is the practice of cultivating, processing, and distributing food in or around urban areas. Raised bed systems with appropriate plant growing media improve productivity in urban farming. Urban agriculture offers the opportunity to provide fresh, local food to urban communities. However, urban agriculture can only be successfully embedded in urban areas if a good food production system is established. The purpose of this study was to examine the impact of various growing media for vegetables in raised beds. The experiment was conducted in 2022 at Near East University Nicosia, North Cyprus. Three different treatments were used in wooden raised beds with two replications each: S: control soil, SF: soil + farmyard manure [1:1], and SFPP: soil+ farmyard manure+ peat + perlite [1:1:1:0.5]. In each raised bed three vegetables: lettuce, onion and pepper seedlings were cultivated, various growth parameters such as height of the plant, no of leaves, weight of the plant and stem diameter for lettuce and onion while for peppers length of the plant, stem diameter, no of primary branches and mean yield of five harvestings of pepper fruit were used as parameters. Findings have justified that the usage of treatment SF and SFPP had significantly improved the plant growth and productivity of all three vegetables, treatment (SFPP) over all performed best in all parameters of three crops while treatment (SF) also performed really well. However, as compared to the other treatments, treatment (S) control soil did not exhibit significant growth. As a result, treatments SF and SFPP can be considered appropriate as growing media in raised beds for lettuce, onion, and pepper in urban farming. The results shown that the soil with farmyard manure is extremely valuable for healthy growing vegetables in raised beds.

Index Terms: Growing media, raised beds, urban farming, vegetable production.

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INTRODUCTION:

In mid-November 2022, the United Nations reported that there were 8 billion people on Earth [1]. By 2050, it is predicted that there will be 9.6 billion people on Earth, with Sub-Saharan African cities witnessing fast population expansion [2], [3]. Currently, about three billion people, or 55% of the World's population, live in cities; by 2050, 68% of the World's population is predicted to do the same [4]. For greater job prospects, education, and health-care services people are migrating from rural to urban locations. According to the United Nations, the population of Türkiye as of May 2021 is 85 million, with 75.7% of the population living in urban areas [5].

Increased food production and distribution are also necessary as a result of population growth, especially for those living in urban areas [6]. COVID-19, population migration triggered on by wars, and the impact of climate change all caused the problem of food insecurity [7]. Therefore, It indicates that 660 million people would experience hunger by 2030, and that figure will keep rising [8].

Currently, one of the biggest issues facing the World is food security due to the World's constantly expanding population [9], [10]. Food security, according to FAO is the availability of food for all people at all times, as well as its physical, social, and economic sufficiency, safety, and provision of all dietary needs for the consumer [11]. Since the 2007–2008 food crisis, availability, access, utilization, and stability have become the four main pillars upon which food security is now examined, but agency and sustainability are two additional essential pillars [12].

Due to the spread of urban areas, agricultural farmland is diminishing in terms of population supported per square kilometer of agricultural land [13]. Future climate change depicts extreme events like drought years and the uneven distribution of precipitation throughout the year will occur more frequently. Lower yields and greater production volatility could result from the potential increase of water scarcity and harsh weather occurrences [14].

Urban agriculture is the raising of plants and livestock in and around cities to produce, process, and distribute food and other goods that meet local requirements [15]. Moreover, urban farming delivers benefits like increased biodiversity, storm water management, recycling of organic waste and water to the urban population in addition to providing food [16]. Many urban areas in America were built near agricultural land in order to allow for easy supply of food items to cities without using many resources; however, with the invention of transportation networks, they began removing their food production areas from the cities [17].

Urban farmers and gardeners commonly employ raised bed production techniques to improve growing conditions and expose plants to less environmental toxins [18]. Raised-bed vegetable growing includes advantages such as simpler season extension through the use of covers,

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improved drainage, restoration of difficult sites, and higher yield per square foot [19]. For agricultural production, both temporary and permanent raised bed systems are commonly used, temporary raised beds are a less expensive option, but they are more prone to soil erosion over time due to the lack of a structure to keep the soil in place [20].

The primary initial step in any organic production operation is choosing an appropriate growing substrate because it has a substantial impact on production success and financial viability [21]. Because, growing media are substrates that give plants access to nutrients, water, air and physical support [22], [23]. Peat, bark, coir, composted green waste, loam, rockwool, wood waste, perlite, and foam are the main types of growing media utilized in the horticulture industry [24]. Therefore, raised beds frequently contain soil, compost, soilless media (such perlite or sand), or a mixture of media. Raised beds with compost in them offer improved soil conditions for water drainage [16]. Likewise, utilizing natural organic media has advantages over using inorganic or manufactured substrates, including natural sourcing, relatively lower purchase costs, and increased nutrient provision to the crop [25].

Reference [26] investigated the effects of various concentrations of farm yard waste and discovered that adding 60-80% farmyard waste increased plant growth and yield of pepper and cucumber crops. Also, [27] studied the impact of several growing substrates on the growth and production of cucumbers for kitchen gardening in pots and found that the application of leaf compost, perlite, and silt at (1:1:1) improved all parameters. Likewise, [28] compared peat compost and conventional practice media for tomato seedlings and resulted that maximum growth could be achieved by mixing peat, compost, and traditional practice media including soil, sand and farmyard manure in equal proportions. Similarly, [29] evaluated the effect of several organic wastes as growing media for lettuce and found that PM (peat moss) media provided the most significant values of growth parameters.

Considering the significance of urban farming, a study was designed to assess the impact of various plant growing media in raised beds on the growth and yield of lettuce, onion, and pepper plants.

MATERIAL AND METHODS:

A. Experimental Site Description

Experiment was conducted during 2022 at Near East University main campus near kinder garden school Nicosia, North Cyprus. The experiment site was located at 35º13'34" North latitude 33º19'19" East longitude and altitude about 158m above sea level. The mean minimum and maximum temperatures from July to September were 19.75ºC and 34.75ºC respectively.

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B. Experimental Materials

The plant material used in this study was lettuce (*Lactuca sativa* L. var. *longifolia*), onion (*Allium cepa* L.) and pepper (*Capsicum annuum* L. *Var*. *Charleston*), seedlings were in good health and free of disease. As experimental material soil, farmyard manure, peat moss and perlite were brought and mixed in right proportions before being placed in raised beds.

C. Experimental Design and Treatments

Experimental treatments were arranged in CRD (completely randomized design). T1= (S) control soil, T2= (SF) (soil + farmyard manure) [1:1], T3= (SFPP) (soil+ farmyard manure + peat + perlite) [1:1:1:0.5] each treatment was replicated twice in raised beds. In this study 6 wooden raised beds with dimensions (length=228.60cm, width=137.1cm and height= 60.96cm) were used, all raised beds were placed equally distant from each other as shown in Fig. 1. Weeds and existing media present in raised beds were removed and cleaning was done. To prevent the loss of water and media, all the damaged pieces of raised beds were fixed.

D. Sowing of Seedlings and Cultural Practices

Different mixtures were made and placed in clean raised beds according to the treatments. Each raised bed had three rows; soil between two rows was used to create ridges. 8 seedlings of lettuce, 20 seedlings of onion and 6 seedlings of pepper plants were transplanted in each raised bed on the ridges at proper distance as shown in Fig. 2, to promote intercropping. All the seedlings were planted in the morning time. Plants were irrigated periodically and equally. Water was given twice a day for the first week, then once a day depending on the soil condition.

E. Laboratory Analysis of Growing Media

Five random samples were taken from the top 20cm soil in various locations of the raised bed. These small samples were thoroughly combined together to form a composite sample weighing approximately 1kg. This practice was repeated for each raised bed, and six samples were prepared from six raised beds and sent for laboratory analysis.

F. Data Collection

Three plants were randomly selected from each replication, and data was collected in accordance with the requirements. Height of the plant (cm), number of leaves, weight of the plant (grams) and stem diameter (mm) for lettuce and onion while for pepper plant length of the plant (cm), stem diameter (mm), number of primary branches and mean yield of 5 harvestings of pepper plant were used as parameters. Plant data was obtained in the field as well as in the laboratory.

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G. Data Analysis

All of the data for this research were calculated using the means of the two replicates. The statistical software Statistix-10 was used to examine the data and to perform the analysis of variance. In order to confirm the significance, difference their means were compared by using Tukey's honest significance difference (HSD) at 5% probability level.

Fig. 1. Equally distant placement of wooden raised beds with proper tags.

Fig. 2. Plantation of lettuce, onion and pepper plants on ridges.

RESULS AND DISCUSSIONS:

The difference between the three treatments was obvious and significant; the effect of these treatments indicated a significant increase in all the parameters of the three crops lettuce, onion, and pepper when compared to the control one. The mean results of all the parameters are shown in various graphs with an ANOVA table ($P < 0.05$) at the top and a capital letter above each bar indicating the significance differences among treatments at 5% probability level after Tukey's HSD test.

I. Laboratory Analysis

Laboratory analysis results are shown in Table. 1,for all treatments. There was no significant difference in pH and $CaCO_3$ levels across the three treatments: (1) S: control soil, (2) SF: soil + farmyard manure [1:1], and (3) SFPP: soil+ farmyard manure+ peat +perlite [1:1:1:0.5]. While the saturation percentage in treatment (SFPP) was highest 75.5%, it was the lowest in control soil (S) at 58.5%. The concentration of soil organic carbon (SOC) preserves soil quality and promotes high and constant soil productivity [30], [31]. Whereas organic matter in the soil provides plant available water capacity and plant available nutrients, both of which are important for crop productivity [32]. Treatment SFPP (soil+ farmyard manure+ peat +perlite) had a greater percentage of organic carbon and organic matter than treatment SF

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(soil+ farmyard manure). Similarly, both potassium and phosphorus are key macro nutrients for crop production, the treatment SF (soil + farmyard manure) had the greatest P_2O_5% and K_2O%, followed by SFPP, and both were lowest in control soil.

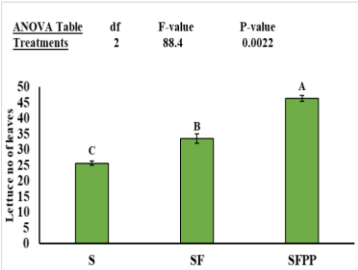
Table. 1: Results showing mean values of laboratory analysis of soil samples. T: Treatments, S: simple soil, SF: soil+ farmyard manure [1:1] and SFPP: soil+ farmyard manure+ peat +perlite [1:1:1:0.5].

T	pH	(Saturation%)	$CaCO_3$ %	Salt %	Organic carbon %	Organic matter %	P_2O_5 %	K_2O %
S	7.55	58.5	12.5	0.20	0.55	3.85	23	213
SF	7.55	60.5	12.5	0.34	0.77	4.2	68	780
SFPP	7.65	75.50	12.5	0.22	1.39	5.15	60	311

II. Lettuce Results

A. Lettuce number of leaves

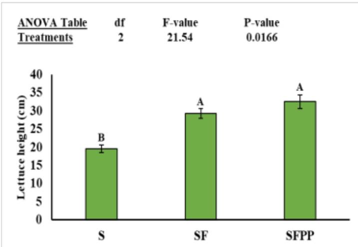
Number of leaves of lettuce were counted after harvesting, Fig. 1A, shows the significant (P<0.05) difference between the treatments on lettuce number of leaves, treatment (SFPP) (soil+ farmyard manure+ peat+ perlite) [1:1:1:0.5] gave the highest number of leaves that were 49 leaves per plant followed by treatment SF (soil + FYM) [1:1] while the control soil gave the lowest number of leaves 23 per plant.



(Fig. 1A)

B. Lettuce plant height

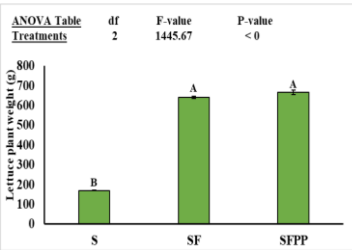
Fig. 1B, indicates that the treatments SFPP (soil+ farmyard manure+ peat+ perlite) [1:1:1:0.5] and SF (soil+ FYM) [1:1] are not significantly different from each other but both of them were significantly different from S (control soil). Plant height was highest with the treatment SFPP (35.5 cm), whereas it was lowest in control soil (18 cm).



(Fig. 1B)

C. Lettuce plant weight

As shown in Fig. 1C, the highest fresh lettuce plant weight was obtained by treatment SFPP (soil+ farmyard manure+ peat+ perlite) (685 grams), followed by treatment SF (soil + FYM) and the lowest was obtained by treatment S (control soil) (165 grams). According to Tukey's honest significance test (HSD), the treatments SFPP and SF were not significantly different.



(Fig. 1C)

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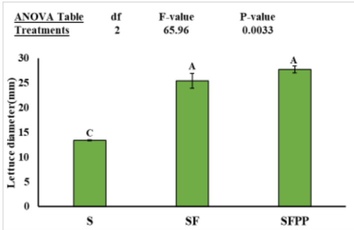
D. Lettuce stem diameter

The findings of this study show that the treatments SFPP and SF did not differ significantly from one another, but both performed significantly better than treatment S (control soil) as shown in Fig. 1D. The largest stem diameter measured for lettuce was 31.3 mm when grown in the SFPP treatment (P< 0.05). However, the lowest stem diameter measured in control soil was 12.2 mm.

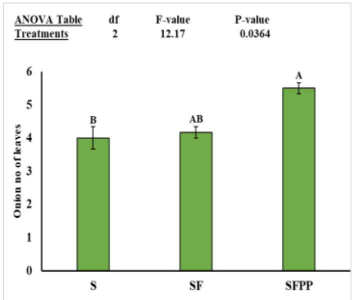


(Fig. 1D)

III. Onion Results

A. Onion plant number of leaves

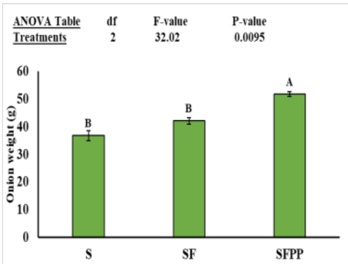
The onion number of leaves as influenced by the different growing media for vegetables in raised beds is shown in Fig. 2A. The onion number of leaves was highest with SFPP (soil+ farmyard manure+ peat+ perlite) and followed by SF (soil+ farmyard manure). Highest number of onion leaves was 6 leaves per plant it was grown in treatment SFPP (P<0.05). However, the lowest number of leaves was recorded in control soil that was 3 leaves per plant.



(Fig. 2A)

B. Onion plant weight

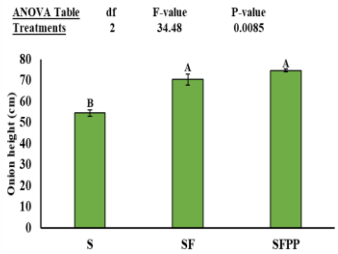
Quantitatively, treatment SFPP (soil+ farmyard manure+ peat+ perlite) produced a higher fresh weight of the onion plant (63 grams) followed by treatment SF (soil + FYM), while treatment S (control soil) produced the lowest (32 grams). Treatment SFPP differed significantly from both treatments SF (soil+ farmyard manure) and control soil Fig. 2B.



(Fig. 2B)

C. Onion plant height

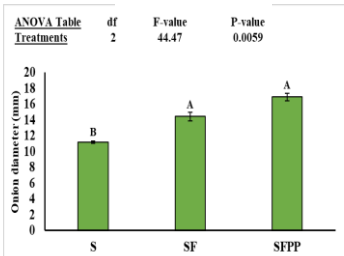
Among the treatments tested, SFPP (soil+ farmyard manure+ peat+ perlite) increased plant height (79 cm) followed by treatment SF (soil+ FYM). Treatment S (control soil) had the lowest (51 cm), as illustrated in Fig. 2C. However, the treatments SFPP and SF were not significantly different from one another but both of them different from control soil.



(Fig. 2C)

D. Onion plant diameter

Fig. 2D, reveals that the treatments SFPP (soil+ farmyard manure+ peat+ perlite) and SF (soil + FYM) were not significantly different from one another (P< 0.05) but were distinct from treatment S (control soil). The plants grown in treatment SFPP had the largest



(Fig. 2D)

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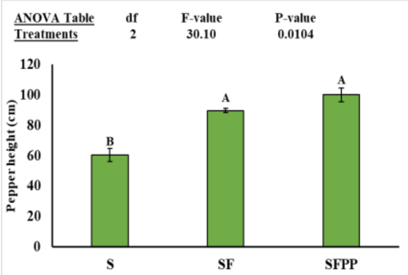
onion stem diameter (18.1mm), followed by treatment SF, and the smallest (10.6mm) in treatment S (control soil).

IV. Pepper Results

A. Pepper plant height

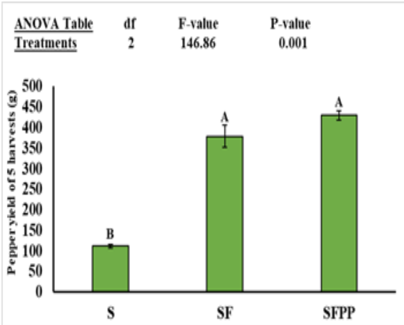
The treatment SFPP (soil+ farmyard manure+ peat+ perlite) achieved the highest plant height (114 cm), followed by treatment SF (soil + FYM), and the lowest (53 cm) was recorded in treatment S (control soil), as indicated in Fig. 3A. Treatments SFPP and SF were not substantially different from one other; however, they were distinct from treatment S (control soil).



(Fig. 3A)

B. Pepper fruit yield

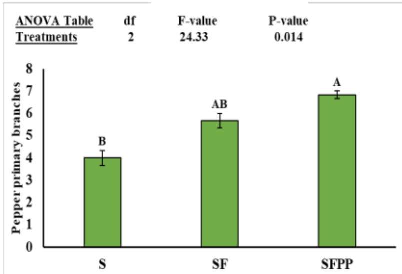
Fig. 3B, depicts the Pepper mean yield of 5 harvestings as impacted by the different growing media for vegetables in raised beds. Pepper yield was measured by taking the average of five harvestings. SFPP (soil+ farmyard manure+ peat+ perlite) had the highest pepper fruit production, followed by SF (soil+ farmyard manure). The maximum pepper mean yield obtained for a pepper plant was (593 grams) when grown in the SFPP treatment ($P<0.05$). The lowest value however, was (130 grams) in treatment S (control soil).



(Fig. 3B)

C. Pepper number of primary branches

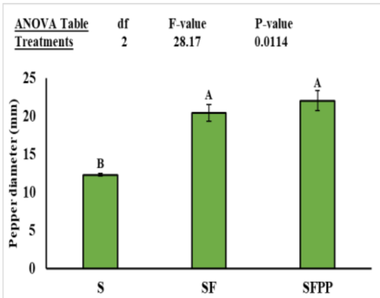
The treatment SFPP (soil+ farmyard manure+ peat+ perlite) had the highest number of primary branches (8 branches per plant) ($P< 0.05$), followed by treatment SF (soil+ FYM), but the lowest was recorded in S (control soil), which had 3 branches per plant, as shown in Fig. 3C.



(Fig. 3C)

D. Pepper stem diameter

The treatment SFPP (soil+ farmyard manure+ peat+ perlite) and SF (soil+ FYM) altered pepper stem diameter. The largest stem diameter (23.9 mm) was recorded for plants grown in treatment SFPP, followed by treatment SF, and the lowest (11.1mm) was recorded in control soil ($P<0.05$), as depicted in Fig. 3D. Both treatments SFPP and SF were not significantly different from one other, however they were different than S (control soil).



(Fig. 3D)

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DISCUSSIONS:

In order to meet the need for food from an ever-increasing population, urban farming is crucial since it helps to ensure food security. The use of high-quality growing substrates promotes greater plant growth and development, resulting in higher yield and quality.

Data from our experiment revealed that the treatment SFPP (soil+ farmyard manure+ peat+ perlite) performed best followed the treatment SF (soil+ farmyard manure) in all parameters. This could be due to the presence of farmyard manure in both treatments, which provides nutrients to plants, as well as the presence of peat and perlite in treat SFPP, which improve water and nutrient holding capacity.

Reference [21] discovered that substrates including vermi compost, coco peat, perlite, and sphagnum peat moss (2:1:1:1 or 1:1:1:1 v/v) provided considerably superior growth, yield, and quality in tomato, cucumber, and pepper. Likewise, [33] who discovered a rise in the number of pepper leaves as a result of the implementation of a high rate of chicken manure. Therefore, we may believe that the rise in pepper growth parameters is due to farmyard manure, peat, and perlite.

Previous research on lettuce indicated that the medium comprising green manure and farmyard manure produced the greatest significant values of growth parameters [29], and the maximum yield [34]. In our experiment, the media SFPP, containing soil, farmyard manure, peat, and perlite, yielded the greatest lettuce parameters, followed by the treatment SF (soil + farmyard manure).

Both of our treatments, SFPP and SF, produced the best outcomes for onion, which could be attributed to the presence of farmyard manure. Application of farmyard manure together with nitrogen doses boosted onion growth parameters while the plain soil remains quite low [35].

CONCLUSION:

Different combinations of growing media, such as farmyard manure, peat, and perlite, have been demonstrated to be an excellent tool for raised bed organic vegetable production. We discovered that treatment (3) SFPP: soil+ farmyard manure+ peat+ perlite [1:1:1:0.5] performed best in all parameters and influenced plant growth and yield in all three vegetables lettuce, onion and pepper ($P < 0.05$). Treatment (2) SF: soil + farmyard manure [1:1] likewise performed effectively. Because the outcomes of treatments SF and SFPP were so close, we concluded that they were not statistically different from each other in most of the parameters recorded. However, they were both significantly different from treatment 1 (S) control soil.

Hence, the urban farmers can use both of the treatment SF: soil + farmyard manure [1:1] and SFPP: soil+ farmyard manure+ peat+ perlite [1:1:1:0.5] according to their availability and choice which will help the urban farmers to get more success in farming.

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