NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF LANDSCAPE ARCHITECTURE

EFFECTS OF DIFFERENT GROWING MEDIA FOR VEGETABLES IN RAISED BEDS FOR FUTURE GREEN ROOFS IN CITIES

M.Sc. THESIS

Muhammad ADEEL

Nicosia

January, 2023

MUHAMMAD ADEEL

EFFECTS OF DIFFERENT GROWING MEDIA FOR VEGETABLES IN RAISED BEDS FOR FUTURE GREEN ROOFS IN CITIES

MASTER THESIS

2023

NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF LANDSCAPE ARCHITECTURE

EFFECTS OF DIFFERENT GROWING MEDIA FOR VEGETABLES IN RAISED BEDS FOR FUTURE GREEN ROOFS IN CITIES

M.Sc. THESIS

Muhammad ADEEL

Supervisor

Prof. Dr. Özge ÖZDEN

Nicosia

January, 2023

Approval

We certify that we have read the thesis submitted by **Muhammad Adeel**, titled **"Effects of different growing media for vegetables in raised beds for future green roofs in cities"** and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master.

Examining committee	Name-Surname	Signature
Supervisor	Prof. Dr. Özge Özden	
Co- supervisor	Prof. Dr. Salih Gucel	
Committee member	Assoc. Prof. Dr Buket Asilsoy	
Committee member	Assist. Prof. Dr. Perihan Adun	
Committee member	Assist. Prof. Dr. Huseyin Ok	

Approved by the Head of the Department

.1/.3./2023

……………………………

Prof. Dr. Özge Özden

Head of Department

Approved by the Institute of Graduate Studies

…../…../2023

Prof. Dr. Kemal Hüsnü Can Başer

Head of the Institute

Scanned with CamScanner

Declaration

I hereby declare that all information, documents, analysis, and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of institute of graduate studies, near east university. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

Muhammad Adeel

…../…../…..

Acknowledgements

I would like to express my deepest appreciation to my Supervisor Prof. Dr. Özge ÖZDEN for her guidance and without her supervision my thesis work could not have been possible and for shaping my colloquial opinionated writing into something that resembles academic research writing.

My special thanks to my co-supervisor Prof. Dr. Salih Gucel, for his support and encouragement as i wrote my thesis and for shining a bright light on it. His support inspired me to work hard and enthusiastically finish my thesis. All thanks to the Near East University and department of Landscape Architecture.

Special thanks to my family and my friends for providing moral and emotional support without them this thesis couldn't have been complete.

Muhammad Adeel

Abstract

Effects of different growing media for vegetables in raised beds for future green roofs in cities

Adeel, Muhammad
Masters, Department of Landscape Architecture
January 2023, 80 pages

In search of better employment opportunities, education, and health-care services people are moving from rural areas to cities. Food production units are rapidly turning to industrial zones and housing societies. World's population reached 8 billion in November 2022; it will be impossible to feed the world's rapidly growing population in the future. Urban farming is the simplest way to deliver fresh food commodities to urban residents at reasonable prices. Raised bed systems with appropriate plant growing media improves productivity in urban farming. The purpose of this study was to examine the impact of various growing media for vegetables in raised beds. The first chapter of this framework covers the statement of problem, significance of the study and purpose of study. In second chapter the literature has been reviewed regarding the thesis topic. In third chapter the methodology of the research has been discussed and findings are presented in chapter four. This experiment was conducted in 2022 at Near East University Lefkosa, TRNC. 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.

Key Words**:** urban farming; raised beds; growing media; vegetable production.

Özet

Şehirlerin gelecekteki yeşil çatıları için yükseltilmiş yataklarda sebzeler için farklı yetiştirme ortamlarının etkileri

Adeel, Muhammad
Yüksek Lisans, Peyzaj Mimarlığı Bölümü
Ocak 2023, 80 Sayfalar

Insanlar, daha iyi istihdam fırsatları, eğitim ve sağlık hizmetleri arayışında kırsal alanlardan şehirlere taşınıyor. Gıda üretim birimleri hızla sanayi bölgelerine ve toplu konutlara dönüşüyor. Kasım 2022'de dünya nüfusu 8 milyara ulaştı; gelecekte hızla artan dünya nüfusunu beslemek imkansız olacaktır. Şehir çiftçiliği, taze gıda ürünlerini şehir sakinlerine makul fiyatlarla ulaştırmanın en basit yoludur. Uygun bitki yetiştirme ortamına sahip yükseltilmiş yatak sistemleri, kentsel tarımda verimliliği artırır. Bu çalışmanın amacı, yükseltilmiş yataklarda sebzeler için çeşitli yetiştirme ortamlarının etkisini incelemektir. Bu çalışmanın ilk bölümü problemin ifadesini, çalışmanın önemini ve çalışmanın amacını içermektedir. İkinci bölümde tez konusu ile ilgili literatür taraması yapılmıştır. Üçüncü bölümde araştırmanın metodolojisi tartışılmış ve dördüncü bölümde bulgular sunulmuştur. Bu deney 2022 yılında Yakın Doğu Üniversitesi Lefkoşa, KKTC'de yapılmıştır. Yükseltilmiş ahşap yataklarda her biri iki tekerrürlü olmak üzere üç farklı işlem kullanılmıştır: S: Kontrol toprağı, SF: Toprak + Çiftlik gübresi [1:1] ve SFPP: Toprak+ Çiftlik gübresi+ Turba+ Perlit [1:1:1:0.5].Yükseltilmiş her yatakta üç sebze: marul, soğan ve biber fideleri yetiştirilmiş, marul ve soğan için, bitkinin boyu, yaprak sayısı, bitki ağırlığı ve sap çapı gibi çeşitli büyüme parametreleri, biber için bitkinin uzunluğu, sap çapı, birincil dal sayısı ve Biber meyvesinin beş hasadın ortalama verimi parametre olarak kullanılmıştır. Bulgular, SF ve SFPP uygulamalarının üç sebzenin de bitki büyümesini ve üretkenliğini önemli ölçüde iyileştirdiğini, uygulamanın (SFPP) üç ürünün tüm parametrelerinde hepsinden daha iyi performans gösterdiğini ve aynı zamanda uygulamanın (SF) gerçekten iyi performans gösterdiğini doğrulamıştır. Ancak, diğer uygulamalarla karşılaştırıldığında, işlem (S) kontrol toprağı önemli bir büyüme göstermemiştir. Sonuç olarak, kentsel tarımda marul, soğan ve biber için yükseltilmiş yataklarda yetiştirme ortamı olarak SF ve SFPP uygulamaları uygun kabul edilebilir.

***Anahtar Kelimeler*:** kentsel tarım; yükseltilmiş yataklar; yetiştirme ortamı; sebze üretimi

Table of Contents

CHAPTER III

CHAPTER IV

List of Figures

List of Tables

List of Abbreviations

TRNC	Turkish Republic of Northern Cyprus
NEU	Near East University
S	Control soil
SF	Soil + Farmyard manure
SFPP	Soil + Farmyard manure+ Peat moss+ Perlite
RB	Raised beds
USDA	United States Department of Agriculture
UN	United Nations

CHAPTER I

Introduction

Background of the Study

According to United Nations the World population reached 8 billion in mid-November-2022 (UN, 2022) that number is expected to increase to 9.6 billion, this indicates that in order to fulfill the increasing demand, we must improve our current way of food production (Xi et al., 2022). One of the main concerns of the modern era is the rise in urbanization and food security (FAO, 2011). According to Vasylieva and Harvey (2021) it is expected that 66% of the world population will be living in cities by 2050. Urban areas provide easier access to jobs, education, healthcare, commodities, and services, as well as intellectual and cultural advances however, the rate of urbanization is surpassing many municipal government's capacity to fulfill rising demands (Bryld, 2003)

Food insecurity is defined by the US Department of Agriculture (USDA) as "a household level economic and social condition of limited or uncertain access to adequate food" (USDA, 2022). According to FAO (2017) the food security means that the food should be available for all the people at all the time and that food should be physically, socially and economically sufficient, safe and it should provide all the dietary requirement of the consumer. The problem of food insecurity was made worse by climate change, population migration brought by wars, and COVID-19 (Laborde et al., 2020). The COVID-19 pandemic enhanced already high rates of food poverty by disrupting household incomes and supply networks. Gundersen et al. (2021) stated that food is becoming less affordable for people because of rising grocery prices that started during the pandemic's peak and are still present now.

Rapid climate change challenges will have a significant impact on agriculture over the next 50 years. According to estimates, 10% of the land where we currently cultivate food crops will be lost with every increase of 1ºC in atmospheric temperature and it will be difficult to supply food and water to population (Despommier, 2011). Urban farming can be explained as a localized food system in which the crops are produced within the city, consumed with in the city and also recycled with in the urban area (Wijaya et al., 2020). According to Brown et al., (2016) many urban places in America were built nearby the agricultural land it was planned for the easy supply of food items to cities without using many resources, with the invention of transport networks they started taking away their food production areas from the cities.

Significance of the Study

Urban farming not only provide food for urban population it also provides benefits such as increase in biodiversity, storm water management, recycling of organic waste and water (Taylor & Wortman, 2018). Contrary to traditional agriculture, indoor farming in the urban areas has numerous benefits: whole year crop harvest, no crop losses because of weathers, no need for fossil fuels for harvest and transportation, no need for pesticides or herbicides, multiple employment opportunities for urban residents and 70% less water consumption than traditional outdoor farming (Molden, 2007). Another strategy proposes that cities should serve as the new crop fields. creating gardens on roof tops and cultivating and harvesting vegetables on vacant lots (Despommier, 2011). Three types of urban farming that were identified are vertical farming, rooftop farming, and community farming. Each farm follows similar procedures and has comparable goals but differs in certain ways due to space arrangements and boundaries. (Yusoff et al., 2017). Kitchen gardens (or home-based gardens) can significantly contribute to resolving the issues of hunger and malnutrition in urban areas (Mohsin et al., 2017).

Raised bed production methods are frequently used by urban farmers and gardeners to enhance growing conditions and less exposure to environmental contaminants (Sullivan et al., 2015). Raised-bed vegetable farming has benefits such as, easier season extension by utilizing covers, increased drainage, remediation of tough sites, and higher yield per square foot (Starbuck, 2003). Both temporary and permanent raised bed systems are frequently utilized for crop cultivation. Temporary raised beds are a less expensive choice, but they are more vulnerable to soil erosion over time because they lack a structure to keep the soil in place (Cudnik, 2014).

Soil, compost, soilless media (such perlite or sand), or a combination of media are frequently used in raised beds. Compost-filled raised beds provide better soil conditions for water drainage (Taylor & Wortman, 2018). The primary types of growing medium used in the horticulture sector are peat, bark, coir, composted green waste, loam, rockwool, wood wastes, perlite, and foam (Drakes et al., 2001). Schmilewski (2008) stated that different growing media can be mixed together some of the materials that could be used as mixtures are peat, recyclable compost, wood fiber, perlite, vermiculate and coir. Currently, soilless culture methods and glasshouses are used to raise vegetables. These methods prevent soil borne diseases while ensuring uninterrupted production and a high yield of good quality products from an area. In order to support the growth of plants, growing media are used, and they perform four major functions, supply roots enough support, nutrients, water and air. Good quality media also provide maximum root growth and physical support to plants (Grunert et al., 2016).

Purpose of the Research

Urban framing is important in reducing food security issues in urban areas caused by urbanization, as well as the negative impacts of global warming. By using a proper growth substrate in raised beds, urban farmers can obtain high quality and yields; thus, this research was conducted to evaluate the best performance of plant growing media in raised beds for available climatic conditions. The objectives of this research are given below:

- ✓ To study the effect of different growing media in raised beds
- ✓ To develop a better combination of growing media for raised beds
- ✓ To increase the productivity of vegetables in raised beds

Limitations of the Research

This study was only limited to three treatments each having two replications for three vegetables lettuce, onion and pepper.

CHAPTER II

Literature Review

Urbanization

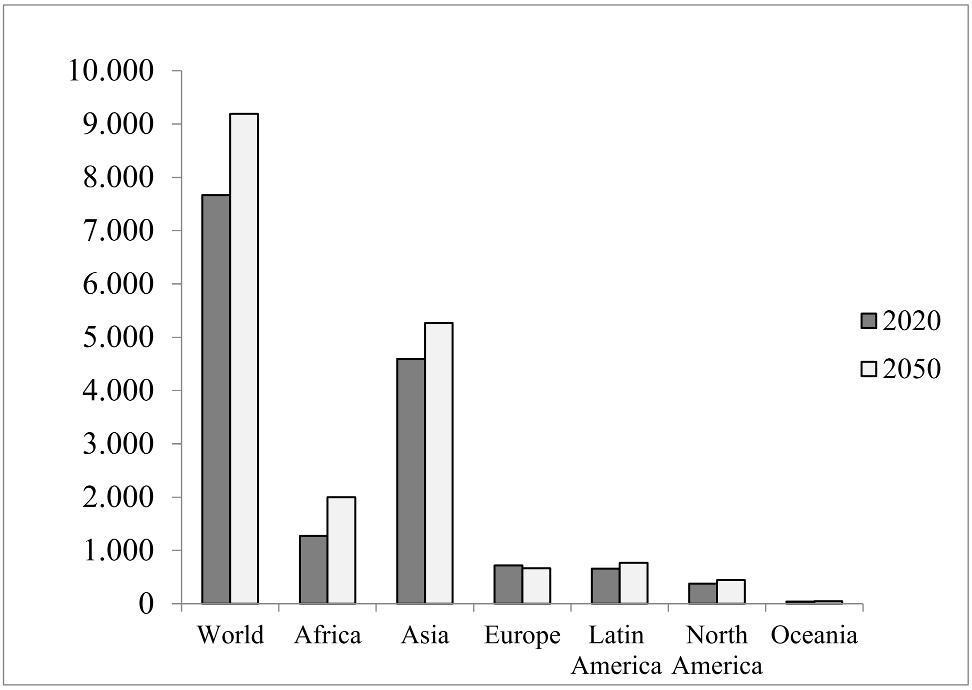
A study conducted by Europe investment Bank (EIB) stated that the world has enter a century which is metropolitan where from 1980 to 2080 human growth is trailing off and will trek to cities which will leads towards increase in 90% of human population in urban population. During this age of urbanization, population from core rural areas will prefer moving to urban and suburbs regions to access smarter technologies to live a quality life, to avail superior access to convenient infrastructure and to avail better opportunities. Although, urbanization is associated with positive socio-economic development however, rapid metropolitan population if fails to absorb will cause disruption all dimensions in global insecurity, outstretch the urban regions capacity to accommodate, food insecurity, planetary warming, and arrest climatic changes (EIB, 2019). Every year large number of people pours into urban region and majority of times the rural-urban migration is due to pull factors (higher rate of employment and wages) and push factors for instance displacement due to natural disaster or social sigma in villages (Overman & Venables, 2005; Cohen, 2006).

According to a report by UNDESA conducted in 2020 around 56.2% of total world's population inhibit in cities and the rate of urbanization is increasing with an alarming rate especially in Annex II countries (developed countries having financial responsibility for instance Sub Sahara Africa) and due to increase in urban population prime agricultural lands are converted either into industrial or residential areas leading towards irreversible damage to biodiversity. United Nation is addressing this rapid urbanization in these countries through project which will plunge the urban population by the year 2050 (shown in figure 2.1 and 2.2). Both, the good quality of life and well-being of living organism is dependent on plenty of services offered by rural and urban ecosystem and one of the paramount impacts of increasing urban growth rate is destruction in natural ecosystem in both urban and rural landscapes (Puplampu et al., 2021).

Over last decades a noticeable increase in rapid urbanization is observed in Turkey especially in secondary cities, urban growth rate which was only 25 % and it escalated up to 75% today. If urban regions do not adapt to the real realities the expected boost in urban population growth could worsen the urban dwellers to shock in markets associated with agriculture. Problem associated with urbanization is inevitable thus, raising the well-being of city life will be the biggest challenge in upcoming years and putting effort to address this challenge for instance, instructing the concept of relatively sustainable cities, clean transportation and building more green space demands great planning. In urbanization age, almost half of the world's population is living in urban region which is causing implications on shift in global food system, local systems of food, food security, malnutrition, and food nutrition. Thus, both public and private organizations are required to work hand to hand to overcome the upcoming challenges due to urbanization (IFC, 2022).

Figure 2.1

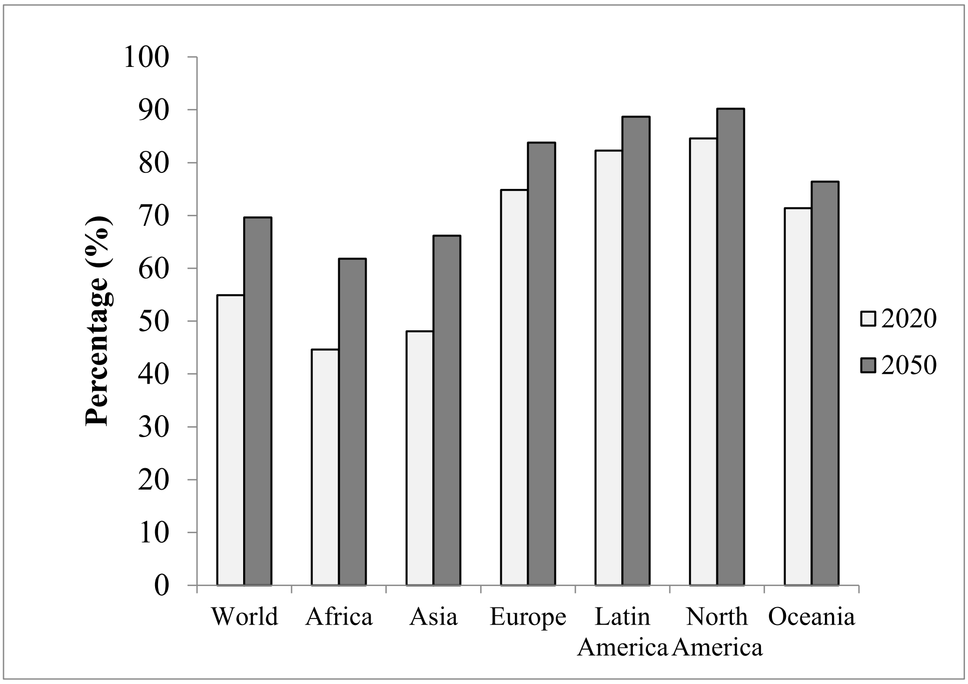
Showing increase in urban population (million) from 2020 to 2050



(UNDESA, 2007; Orsini et al., 2013)

Figure 2.2

Showing percentage increase in urban population in 2020 and 2050



(UNDESA, 2007; Orsini et al., 2013)

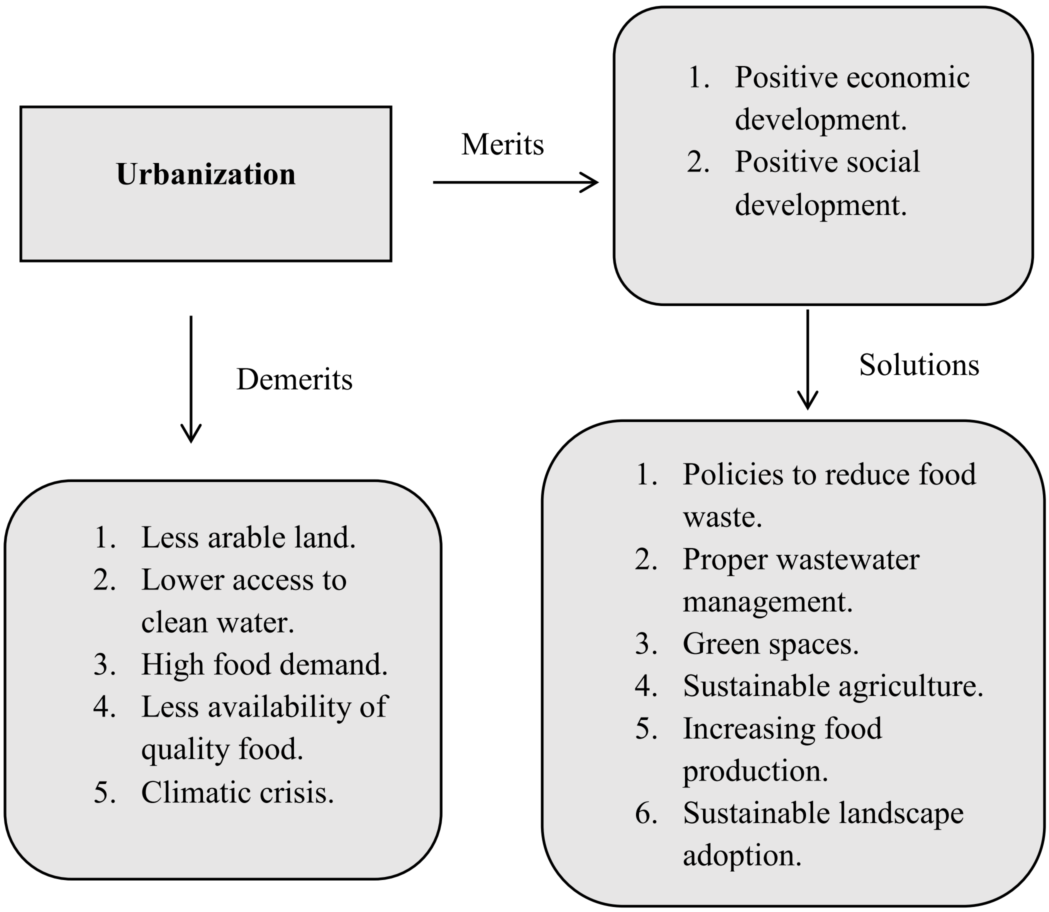
Food Security

Food security refers to state in which "people at all times have access to food which is safe and nutritious to consume to meet the dietary needs to live an active life" (FAO, 2001). There are four dimensions of food security including food availability, food stability, food safety and access to nutritious food (figure 2.3). Here, city expansion is causing inevitable damage to availability of sufficient food (first dimension), quality of food available to people should be consumable without causing any health risks (second dimension), resources someone possess to obtain food to full fill their dietary needs (final dimension) (Schmidhuber & Tubiello, 2007).

Due to issues related to huge population, rapid urbanization and limited amount of arable farmland areas, food security for a long time has gained wide attention in worldwide. The challenges because of huge population mostly in urban and suburb regions has alter the food scenario too causing challenges to meet the ends for massive population. China, which is the most populous country with highest population constitutes of 20% of World's population have inadequate water, incapable agricultural land and lack of food resources to full the requirement of its citizens however Chinese government is committed to combat this issue by adopting policy measures to address food insecurity, adoption of sustainable agricultural practices, more investment towards agriculture sector and more institutional innovation in rural areas. Additionally, to ensure food security in China it adopted the policy "four reductions and four subsidies" to encourage the agricultural production (Huang & Yang, 2017). A recent study conducted in China reported that an increase of urbanization rate from 17.91% to 57.35% was observed from year 1978 to 2016 and the major reason behind this shift of rural labour towards urban regions was because of attraction of rural residents to access better public services, better opportunities, and better cultural facilities. This unprecedented urbanization lead towards the disparity between less inland in China urbanized regions and high urbanized east. Expansion of cities imply irreversible loss to prime agricultural lands and the expanding cities challenged agricultural production due to substantial thirst for water (Wang, 2019).

Figure 2.3

Showing demerits, merits, and possible solution to mitigate effects of urbanization



(FAO, 2000)

Urban Farming

Urban farming constitutes of cultivating vegetables and fruits to promote localized food system where food processing, its production and access of produce to locals and market is done in or around the urban region. By 2050 the level of urbanization in world will increase to 69%, the developing countries will account about 86% urban dwellers while the under developing countries urban dwellers will account 66% causing compact cityscape. Thus, increase in urban heat island, heavy toll on demand for sources and decrease in green space is inevitable. Due to this, majority of countries are adopting the concept of urban farming in urban and peri-urban regions to increase the urban green spaces which will mitigate environmental problems, sufficient availability of food, economic sustainability, air quality problems, increasing the biodiversity and decreasing urban heat island (Hui, 2011). Additionally urban agriculture provides wide range of advantages from access of food having high dietary quality to the people living in cities (food security) to improving sustainability (Grebitus et al., 2022). "Food and Agriculture Organization" in 2007 reported that urban agriculture is contributing to Millennium Development Goals and targets by ensuring the eradication of poverty (Millennium Development Goals-1) and by contributing to sustainable environment (Millennium Development Goals-7). The concept of adaptation urban farming is growing very rapidly on agenda related to international development and policy recognition. Following are some of the organizations established to introduce the concept of urban agriculture:

1. (UNDP) established the "Urban Agriculture Advisory Committee" (UAAC) established by United Nations Development Program.
2. "Support Group on Urban Agriculture" (SGUA).

"Urban Agriculture Advisory Committee" was established in 1991 by United Nation Development Program while SGUA was established in 1992 which have ten participants (given in figure 2.4).

Figure 2.4

Showing participants of Support Group on Urban Agriculture

(FAO, 2007)

Concept of Green Roofs

Abbas et al. (2020) reported that economic development on this globe is leading towards increase in construction of buildings and according to estimation in 2030 the number of mega cities will plunge too which ultimately will cause greenhouse gas emission. Additionally, an increase in utility of global energy consumption due to human activity will be noticed consisting of 40% energy consumption by building sectors. Thus, it is crucial to use sustainable ways demanding less energy utility, especially techniques which requires less fossil fuel utilization and propose it to both private and government sector, so energy is used in ways to mitigate energy depletion. Roof garden is an ancient technique, and it was used by ancient people for insulating properties and to mitigate the effect of urbanization. Furthermore, "Hanging Gardens of Babylon" is the oldest roof garden and was built in 500 BC and majority of people covered their roof with sod however modern roof garden are more efficient. In early 1900's when Germans faced energy crises, they adopted the modern roof gardens to reduce energy consumption thus, they are known as world leader of green roofs, and it was further introduced to market in 1980. Along with this, in modern early Germany is on top having buildings with green roof and research in Germany is increasing at approximately 13.5 million m^2 every year (Zhang et al., 2011).

Increasing problems related to urban population can be tackle through urban greening which is further divided into urban forestry, urban agriculture, and growing parks however, to implement this concept demands area to make this space green and increase of high density in urban population is making it impossible. Thus, it necessities using a new innovative form of urban greening which can be use as alternative for instance utilizing exterior surfaces of buildings including green roofs and greening of facades (Fernandez-Cañero et al., 2013). Furthermore, urbanization can be address by introducing the concept of developmental strategies associated with urban region for instance growing different vegetation on different growth substrates also called green roofs (eco roofs), rain gardens, bio-retention practices and growing vertical greenery through upright structure called rain gardens. The sustainable design of eco roofs is practice worldwide to get the multiple benefits including economic, environmental, and societal (Shafique et al., 2018).

Roof surfaces in urban areas covers about 25% of area which can be used to decline the temperature of air in cities, and it is an effective way to decrease environmental problems in areas having high temperatures through horizontal living systems. So, the concept of intensive or extensive roofs through vegetation is called eco-roof or green roof (Abbas et al., 2020). Urbanization effect on air quality and the increasing of the average urban temperature are inevitable. Here, increase in average urban temperature is mainly due to higher percentage of air temperature is being entrapped causing an increase in average temperature which is called urban heat island effect. Thus, it is pre-requisite to decrease “Urban Heat Island effect”, and which could be done through increasing the vegetation on building roofs in urban areas which will mitigate the heat flux ultimately causing decrease in thermal flux (Lazzarin et al., 2005). Benefits of green roof are enormous, and this green technology is spanning the economy and environment sector. Moreover, in context of sustainability it is contributing to environment, economy, and social sustainability. In terms of environmental sustainability this strategy is reducing transportation of food, reducing the quantity of waste by generating less packaging concept, through the concept of compositing it is reducing waste, ameliorating air quality, and improving urban storm water management. Additionally, it is providing social inclusiveness, providing job opportunities, increase aesthetic value of urban buildings and providing an amenity space for exercise thus it is contributing towards social sustainability too. Likewise, green roofs are contributing towards economic sustainability by making biofuel available, increasing production and sell of organic horticultural produce, improving food security and reduce energy cost and cooling load of urban buildings (Hui, 2011). To achieve multiple benefits developing as well as non-developing countries are adopting strong initiative to install green roof on old and new buildings (Table 2.1). Since 1980's roof gardens were known and constructed in Turkey and certain improvements are introduced to practice this concept on both commercial and residential buildings. In Turkey, the vegetative material used most of the times are different Sedum species and foreign guidelines are being followed to install this technique (Eksi et al., 2020).

Table 2.1

Depicts countries who adopted green roof initiative and strategies to introduce as green concept.

Countries adopting green roofs	**Strategies to adopt Green roofs**	**Citation**
Canada	In Toronto if roof area is ≥ 2000 m^2 installation of green roof is mandatory.	(Chen, 2013).
USA	New buildings must have 70% covered by green roofs.	(Derek, 2007)
Japan	If private building is larger than 1000m^2 must have total 20% roof area green or will be charged fine.	(Badescu & Sicre, 2003)
South Korea	Government is appreciating public to adopt sustainable agricultural ways to avoid depletion of our planet.	(Ji et al., 2022)
China	Government is appreciating public to apply green practices.	(Zhang et al., 2012)

Growing Media and Effects

A green roof contains multi-layers and before installing this it is important to understand how rainfall passes through these multi-layers and its structure. It contains multi-layers of vegetative roof which is composed of vegetative portion, drainage layer, growth media and root barrier layer which is usually waterproof. The production of vegetation solely depends on growth media on which it is grown and drainage system which has been installed (She & Pang, 2010).

Based on type of vegetative cover used, depth and function green roof is divided into following:

a. Extensive green roof
b. Semi-intensive green roof
c. Intensive green roof

Extensive roofs require less maintenance, and these green roofs are suitable for lower growing plants like Sedum which grow on shallow soils. These green roofs act as filter for storm water and are usually 3-5 inch high and are not irrigated so often. Additionally, extensive green roofs are considered less expensive. On the other hand, intensive green roof is expensive, have variety of vegetation and require high maintenance and it is usually installed on roof which have high bearing capacity. Moreover, green roof which contains small shrubs and ornamental plants is called semi-intensive green roof (Anonymous, 2017).

Success rate of green roof solely depends on selection of proper growing media because this is not only vital to provide support to plant but is also a crucial source of water and nutrient. Therefore, before selecting media its water holding capacity, aeration capacity, cation exchange capacity, durability, source either it is organic or inorganic and bulk density should be evaluated. Some of the growing substrate which can be used are perlite (water holding capacity is 3-4 times higher as compared to its weight), compost, coconut peat, volcanic tuff (it can be used for many years), Leca clay (have high porosity) and peat (Raviv et al., 2019; Wilkinson et al., 2014). Table 2.2 depicts all the previous work which was done on growing substrate used for growing vegetation in green roof and their effect on growth parameters.

Table 2.2

Showing different media which can be used for growing plants on greenroofs.

Growing media or blends used	Effect on growth and major findings	References
Compost Soil Bricks	This growing media blend is usually used in hot-semi arid zone and this blend has poor water holding capacity thus, if not timely irrigated plants will die.	(Ondono et al., 2016)
Blend of compost with composited bark	Successful growth of succulent plants was noticed. This substrate blend is usually used in semi-arid zones.	(Schneider et al., 2014)
Leca clay + cocopeat	This blend is use in Mediterranean regions and this blend has less weight, proper aeration and water holding capacity thus we can obtain optimal growth of plants.	(Tala et al., 2020)
Peat moss (Organic material)	Peat moss is natural soil conditioner having proper water holding capacity and has good aeration property.	(Shukla et al., 2021)
Peat with sandy loam soil and perlite	If this blend is used in plant, it promotes growth and flowering. Also, adding perlite and peat in sandy loam soil decreases the weight load of substrate.	(Eksi et al., 2020; Panayiotis et al.,2003)
Compost	It has good potential for holding water, good source of nutrient and high microbial activity.	(Shukla et al., 2021)

Use of Raised beds in Urban Farming

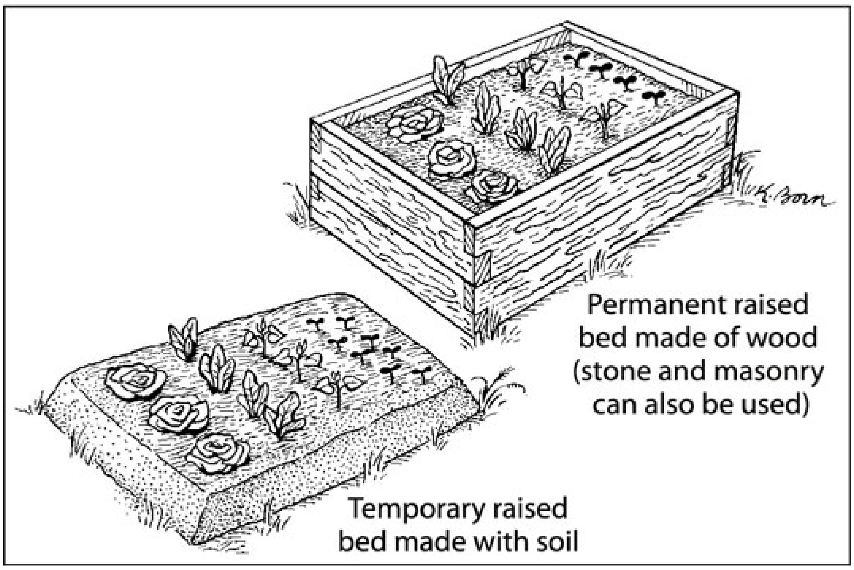
According to research conducted by Starbuck (2003) Raise bed involves growing plants in soil that is little higher than the ground level and raised beds are more appealing in landscape. If the soil used by farmers is compact, then growing plants on raised bed is a better option because it permits plants to grow its root in soil which is higher than the compact soil which provides an optimal soil environment for plant root growth. Moreover, better root development promotes growth and higher yield. If plants are grown on raised bed intensive farming can be done and it will provide better drainage and water holding capacity. Raised bed can be categorized into temporary raised bed and permanent raised beds (Figure 2.5). Temporary raised beds are simple to build and are generally used in backyards for vegetable growing. After one growing season, they can be flattened and rebuilt, whereas permanent raised beds are built with various materials such as wood, metal, stones, and bricks, among many others, and are used for a longer period of time. The initial investment is higher, but it can last for a long time. Some of major benefits of raised beds are given below:

- ✓ Raised beds have good water drainage therefore, they can be used in water logging soil it promotes the better root development for healthier plant growth.
- ✓ Raised beds provide better root growth which leads to higher yields as compared to flatbed planting methods.
- ✓ Because of the better drainage of the soil raised beds increases soil temperature of growing media which helps in speedy germination and better growth in spring season.
- ✓ Raised beds require less maintenance, weeding and watering requirements.
- ✓ Raised beds can be used in sites where gardening is not possible because of the soil conditions.

Bakker et al. (2005) discussed that waterlogging in Australia is due to perched water tables mostly in duplex soil which cause decrease in water holding capacity and lower the drainage rate. Thus, raised bedding system is used in Australia to grow plants on duplex soils but before making raised bed it is important to undergo deep cultivation which lowers the bulk density ultimately increasing growth parameters in plants. Zhang et al. (2012) stated that raised bed production system decreases the morality rates of seed, helps in the easy uptake of water and nitrogen and increases soil condition also less labor requirements as compared to flatbed planting methods.

Figure 2. 5

Difference between the permanent and temporary raised bed.



(Born, 2016)

Intercropping of Vegetables

With rapidly expanding population the demand for fresh vegetable is increasing too and it is a necessity to use a method which will increase the production of vegetable though sustainable ways which ensures food security. Furthermore, these practices should offer ecological and socioeconomic sustainability and intercropping is a method which concerns both ecological and socioeconomic sustainability. Intercropping can be defined as growing two or more species of crop in a way that these crops interact agronomically. Also, it is a promising technology which reduce disease incidence, increase production, more than one crop on same land at same time and reduce insect population. The effect of mixed cropping in Brassica on pest level has been reported previously and intercropping of white cabbage, Brussels sprouts, broccoli, and Chinese cabbage reduces cabbage aphids and different caterpillars. Thus, intercropping of vegetable is an approach towards sustainable agriculture (Theunissen, 1997).

Previous Studies

Eksi et al. (2015) investigated the effect of six increasing amount of municipal yard waste “0, 20, 40, 60, 80, and 100%” combined with a heat-expanded shale and sand base on raised green roof platforms and it was compared with normal garden plot for cucumber and peppers different growth parameters were recorded to compare their effects and it resulted that the highest plant growth and fruit harvests were achieved by adding 60 or 80 percent compost, while compost had a greater impact on peppers' growth and yield than on cucumbers. It also resulted that that ground plot performance was poor as compared to the green roof platforms because of the growing media that helps the plants to grow more efficiently.

Goutam et al. (2011) carried out a field experiment to check the effect of six different composts and nutrients on tomato plant in this study six treatments T1 control, (T2-Chemical fertilizers, T3-Farm Yard Manure (FYM), T4-Vermicompost, T5 and T6- FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively), by comparing the growth parameters of tomatoes the result was conducted that the T6 FYM supplemented with chemical fertilizers and vermicompost gave 73% better fruit yield of tomatoes as compared to other treatments.

Alhrout et al. (2018) conducted a study in 2014 in which he evaluated the effect of NPK and farmyard manure (mixture of chicken, cow, and sheep manures) for growth parameters of tomato plants. Three parameters control, farmyard manure (8 t/ha) and NPK (250 kg/ha) were used in this study, tomato growth parameters used for this study ware “plant height, leaf number/plant, fruit number/plant and fruit yield”. The farmyard manure showed the significant growth in all parameters while the control showed the lowest. The highest yield given by the farmyard manure was (9.57 t/ha), NPK gave (7.15 t/ha) and lowest yield was recorded by control (5.98 t/ha).

Atif et al. (2016) compared the peat, compost and traditional practicing media for tomato seedlings, the experiment was conducted in 2013-14 at NARC Pakistan. Peat, compost and traditional practicing media was studied alone and in mixtures, different seedling quality variables were studied like “days to emergence, shoot length, height, vigour index, dry matter accumulation and benefit cost ratio”, and it was resulted that the optimum growth of tomato seedling can be obtained by using peat, compost and traditional practicing media (soil+ sand+ farmyard manure in 1:1:1) in equal proportions.

Sarwar et al. (2016) evaluated effects of different growing substrates for growth and productivity of cucumber plants in pot culture for kitchen gardening. Eight treatments of leaf compost, compost, perlite, and coconut compost were used alone and in combinations. Cucumber parameters used for this study were “maximum germination, plant growth, emergence percentage, gas exchange attributes, shoot/root length, shoot fresh and dry biomass, root fresh and dry biomass, no. of leaves, leaf mineral contents, and chlorophyll concentration” and cucumber yield and it was resulted that all the treatments positively increase the growth parameters of cucumber but leaf compost+ perlite+ silt (1:1:1) showed the best results.

CHAPTER III

Material and Methods

Site Information

Experiment was conducted during 2022 at Near East University in front of Kinder garden school Lefkosa (Figure 3.1), TRNC. North Cyprus is a small island in Mediterranean sea it is semi-arid region and total area is 3355 km^2 (Katircioglu, 2006). The experiment site is located at 35º13'34" North latitude 33º19'19" East longitude and altitude about 158m above sea level. Site visits were made to see and observe the research area, as well as to ensure that the research materials were available. Before beginning of work, meetings with school staff were held to obtain permission to use the research area. Mean minimum and maximum temperature for the four months from July to September was 19.75ºC and 34.75ºC respectively, sunlight available for 8 hours a day, during the experimental period there was no rainfall (0mm).

Figure 3.1

Site location of an experimental area

Experimental Design and Factors

In total, three treatments with two replications (6 raised beds) were used in the experiment. The treatments were arranged in a completely randomized design (CRD) with two factors. Factors used in this study were following:

Factors A: Soil types

S: (Control soil)

SF: (Soil + Farmyard manure) [1:1]

SFPP: (Soil + Farmyard manure + Peat + Perlite) [1:1:1:0.5]

Factor B: Vegetables grown

L: Lettuce

O: Onion

P: Pepper

Materials

Materials available at research site

6 wooden raised beds with dimensions (Length=228.60cm, Width=137.1cm and Height= 60.96cm) were available at research area, a freshwater tap was available for irrigation purpose, as well as some storage boxes for tools (Figure 3.2). Several market visits were done for purchasing of tools required for conducting research.

Figure 3.2

Materials available at research area

Plant material

Plant material used for this research was lettuce (*Lactuca sativa* L. var. *longifolia*) commonly known as "Marul", onion (*Allium cepa* L.) "Soğan" and peppers (*Capsicum annuum* L. *Var*. *charleston*) "Charli biber". All of these vegetables were chosen based on their climatic conditions, growth habits, and local consumption. Seedlings of lettuce, onion and pepper were brought from well-known nursery present in Lefkosa, all the seedlings were good in condition and free from all kinds of diseases (Figure 3.3).

Figure 3.3

Seedlings of lettuce, onion, and pepper plant

Media used for research

The substrates chosen for this study are locally available, inexpensive, and commonly used in the nursery or greenhouse industry. To check the availability of required organic and inorganic media in the market several visits were conducted to different shopping malls, plant nurseries and stores. Some readymade media mixtures were also available in the market (Figure 3.4), however the prices were high, hence all of the necessary media (peat, perlite, farmyard manure) was purchased from a reputable nursery and mixed in proper proportions according to the study plan (Figure 3.5).

Figure 3.4

Readymade mixtures of media available at different stores

Figure 3.5

Media purchased from the market (Peat, Perlite, FYM & Soil)

Preparation of Raised Beds

First, unwanted plants and weeds were removed from the raised beds to clean the surface (Figure 3.6). Soil in the raised beds was so hard and difficult to remove. The raised beds were filled with water to soften the soil, then compacted soil was removed next day and broken down into smaller pieces in order to reuse the soil in the proper proportions in treatments (Figure 3.7). Soil from all the raised beds was removed and raised beds were cleaned after cleaning to prevent the loss of water and media, all the damaged pieces of raised beds were fixed. The removed soil was than sieved by a metal net to make it more refined (Figure 3.8), after that the refined soil was mixed with peat farmyard manure and perlite to make different mixtures according to the study plan (Figure 3.9). All the mixtures were prepared by mixing proper proportions and then these mixtures were filled into the raised beds. All raised beds were filled uniformly, media in raised beds was leveled with the help of the tools to make it better for equal distribution of water three ridges in each raised bed were made for lettuce, onion, and pepper.

Figure 3.6

Cleaning of weeds from raised beds

Figure 3.7

Removal of soil from raised beds

Figure 3.8

Sieving of soil removed from raised beds to refined form

Figure 3.9

Preparation of mixtures for treatments

Figure 3.10

Filling of media and ridges for plantation

Sowing of Vegetable Seedlings

On 27th May 2022, vegetable seedlings were received from a reliable nursery for sowing. Early morning transplanting allows seedlings to establish firm roots in the soil, and the soil temperature is not too high in the early morning, so there is less possibility of wilting. Each seedling was carefully taken out from the tray to avoid root damage before being placed into the soil, for each raised beds 8 seedlings of lettuce, 20 seedlings of onion and 6 seedlings of pepper plants were transplanted in each row (Figure 3.11). Lettuce and pepper were planted on one side of the ridge, while onions were planted on both sides; all seedlings were planted with appropriate spacing, Water was distributed between the ridges immediately after transplanting to ensure that water reached each plant equally and the water level was kept low from the plant stem to limit the risks of fungus attack. Plants showed wilting symptoms with single irrigation therefore, during the first week irrigation was done twice a day in the morning and evening, after the first week, irrigation was done once a day in the morning. Each raised bed was tagged with the planting date, vegetable grown, treatment information, and replication details (Figure 3.12)

Figure 3.11

First day after sowing of seedlings

Figure 3.12

Tagging of raised beds

Cultural Practices

Irrigation

Fresh water source was available in research area there was a water tap and a long plastic pipe which was enough to irrigate all raised beds. Fresh water was accessible from 7 am to 5 pm, though occasionally it was unavailable due to public holidays or technical problems. When there was no water available, water was carried in bottles from the school building to irrigate plants. Due to the late sowing of seedlings irrigation was the biggest challenge, because of the high temperature the water requirement of crops was also high. In initial days the seedlings showed the wilting symptoms, so irrigation was increased and for the first week irrigation was done twice a day, after one week the irrigation was reduced to single time a day in morning that it showed the good response with single irrigation. Irrigation was done between the ridges (Figure 3.13) and the level of soil between the ridges was kept equal to made irrigation water available for every seedling. There was no rainfall during the growing season so therefore daily irrigation was done to maintain the moisture level of the soil for better growth of the plants.

Figure 3.13

Irrigation of seedlings

Hoeing and weeding

The first hoeing and weeding was done on June 11, 2022, and it was repeated every two weeks to ensure there were no unwanted plants and to make the soil soft for optimum aeration of the roots. The majority of weeds develop in the plant's root zones; all unwanted plants were carefully eliminated during weeding without damaging the main plants (Figure 3.14). Similarly, while hoeing, the hard clots of soil were broken into smaller pieces to soften the soil, and this was done carefully to avoid injuring the roots of seedlings (Figure 3.15). No fertilizers were applied to plants during the research all vegetables were grown organically.

Figure 3.14

Weeds in raised beds

Figure 3.15

Hoeing between the ridges to improve aeration

Insect pest and diseases

From the beginning to the end of the trial, there were numerous insect, pest, and disease attacks, at the start of the experiment, snails attacked the lettuce, damaged the leaves that had been cured by the snails and slug pallets by placing it in the corners of the raised beds, because the snails were climbing to the raised beds, they fed on the pallets and died, this saved the lettuce from the snails (Figure 3.16)

Figure 3.16

Lettuce leaves attacked by the snails and their treatment

Pepper seedlings were attacked by the disease called "Leaf curl virus" during the vegetative growth by which the leaf of pepper plants started curling and growth of the plant become dormant biological remediation was done to cure pepper plants from this disease all the damaged leaves were cut and buried away from the experimental area (Figure 3.17) to resist the spreading of the disease to more plants this practice was revised 3 times and all the plants were cured from leaf curl virus.

Figure 3.17

Diseased leaves were cut and buried away from experimental site

During the flowering and fruiting stages, the pepper plants were attacked by aphids (Figure 3.18), which are small insects that suck the cell sap and cause the leaves to curl, The same treatment was used this time since the attack was greater than the leaf curl virus and it spread quickly. All of the branches and leaves with aphids were removed (Figure 3.19) and taken away from the field area before being buried under the ground. this practice was revised 4 times and plants were cured from this attack. No insecticide was used to cure the plants.

Figure 3.18

Aphids attack on leaves of pepper plant

Figure 3.19

Pruning of pepper branches and leaves to cure from Aphids attack

The trial location was in an open area, some lettuce plants, onion plants, and peppers were also harmed by people who pluck them for eating purposes. To mitigate this issue, notes were printed on paper and pasted to discourage people from plucking the vegetables.

Laboratory Analysis of Growing Media

On the 28th of July 2022, samples for laboratory examination were collected in the morning before irrigation, when the soil moisture level was low. Raised bed samples were collected using a random sampling technique. Five random samples were obtained from the top 20cm soil from different locations of the raised bed, After taking these small samples, they were thoroughly combined together to form composite sample weighing approximately 1 kg, this practice was done for each raised bed and 6 samples were prepared from 6 raised beds (Figure 3.20). After collecting the samples, each sample was appropriately labeled to avoid sample mixing. Each label provided information about the sampling date, sampling time, treatment details, and replication numbers (Figure 3.21). When this procedure was completed, the samples were sent to Guzelyurt soil laboratory, Ministry of Agriculture KKTC for analysis. The analysis required for soil were pH, Saturation percentage, $CaCO_3$ percentage, Salt percentage, Organic carbon percentage, Organic matter percentage, P_2O_5 percentage, and K_2O percentage.

Figure 3.20

Collection of samples from raised beds

Figure 3.21

Packing of samples treatment vise

Plant Parameters

Three plants from each replication were chosen randomly and mean was calculated, height of the plant (cm), number of leaves, weight of the plant (grams) and stem diameter (mm) for lettuce and onion while for peppers 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. Peppers were harvested 5 times at different time intervals and mean was calculated, plants were harvested when they reached to their required growth level and brought to laboratory for analysis. Plants were harvested early in the morning and kept in separate bags with proper tags to avoid mixing of samples. For lettuce and onion roots were removed in filed area and then plants were transported to laboratory for parameter recording while for peppers only fruits were plucked and brought to laboratory rest of the parameters were recorded in field. Measuring tape, measuring scale, digital weighing machine, vernier caliper, paper cutter, scissor and marker were used for measuring plant parameters (Figure 3.22).

Plant height: Measuring tape was used to measure the height of randomly selected plants from base of plant to the tip of shoot.

Number of leaves: Plants were selected, and their number of leaves were counted for both onion and lettuce.

Weight of plant: For lettuce and onion weight of the whole plant in grams was calculated by using digital weighing balance**,** for peppers their fruits were harvested five times from their selected plants and then the mean of each plant was calculated.

Stem diameter: Stem diameter for all three vegetables lettuce, onion and pepper was calculated by using vernier caliper in (mm).

Number of primary branches: For pepper plants no of primary branches attached to the main stem were calculated from selected random plants.

Figure 3.22

Tools used for measuring parameters of plants

Figure 3.23

Plants were harvested and kept in labelled bags

Figure 3.24

Height of plants were measured by measuring tape

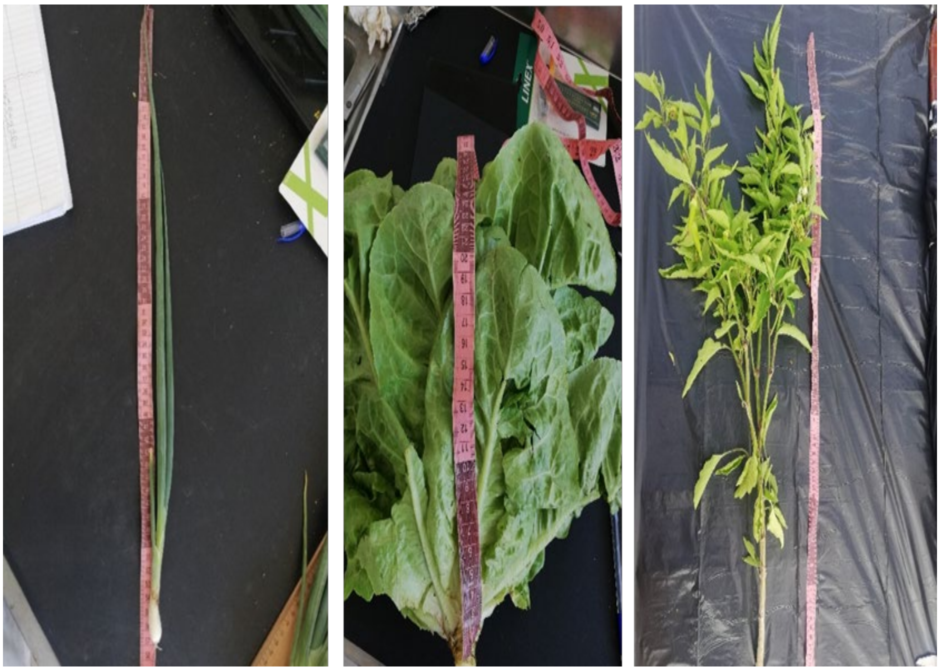


Figure 3.25

Measuring of stem diameter by vernier caliper

Figure 3.26

Weighing by using digital weight balance

Statistical Analysis

The means of the two replicates were used to calculate all the data that were recorded for this study. Data were evaluated and their analysis of variance was done using the statistical software Statistix-10 in order to confirm the significant difference in various parameters. Their means were compared by using Tukey's honest significance difference (HSD) at 5% probability level to see whether there was a significant difference between treatments.

CHAPTER IV

Results and Discussions

Both the treatments SF: Soil + Farmyard manure [1:1] and SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5] performed really good as compared to the control soil (S) as shown in Figure 4.1 (Lettuce), Figure 4.2 (Onion), and Figure 4.3 (Pepper). Different parameters of lettuce, onion and pepper were recorded at their maturity level, and the mean of recorded data was subjected to statistical software statistics 8.10 for analysis of variance (ANOVA) and significance test Tukey's (HSD) test at 5% probability level.

Figure 4.1

Effect of different growing media on growth of lettuce plant

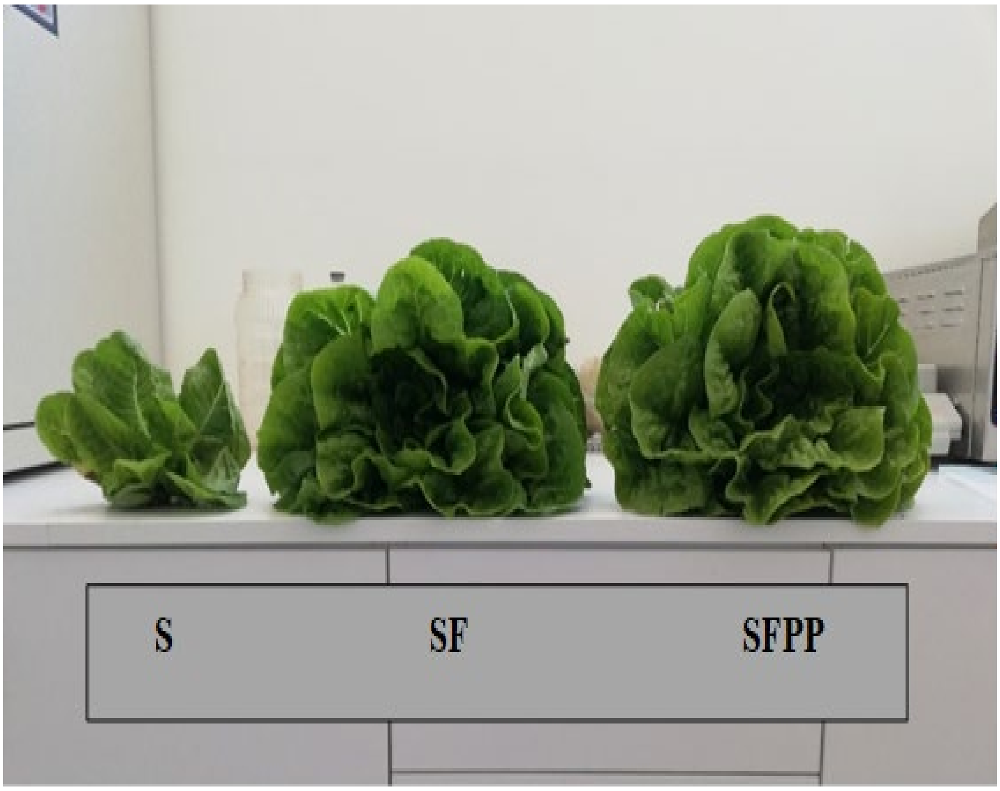


Figure 4.2

Effect of different growing media on growth of onion plant

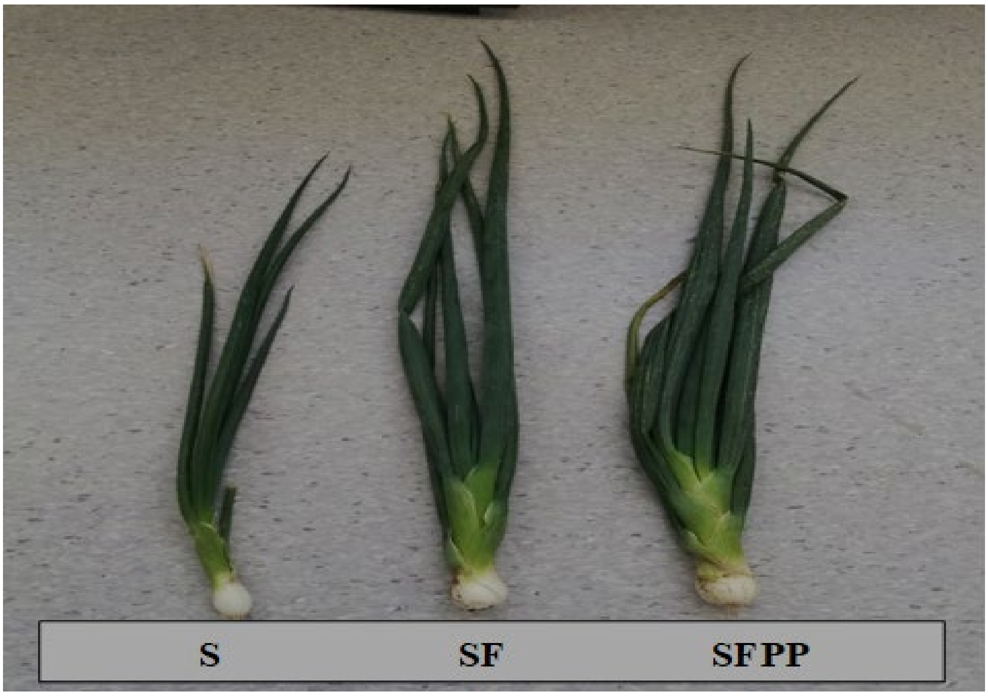


Figure 4.3

Effect of different growing media on growth of pepper plant

Soil Analysis Results

The laboratory analysis results were received on August 17, 2022. Table 4.1 displays the results for all treatments. There was no significant difference in pH or $CaCO_3$ 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 75.5%, it was the lowest in control soil (S) at 58.5%. Treatment SFPP (Soil+ Farmyard manure+ Peat +Perlite) had a greater percentage of organic carbon and organic matter than treatment SF (Soil + Farmyard manure). However, 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 4.1

Results showing mean values of laboratory analysis of soil samples. T: 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].

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

Lettuce Results

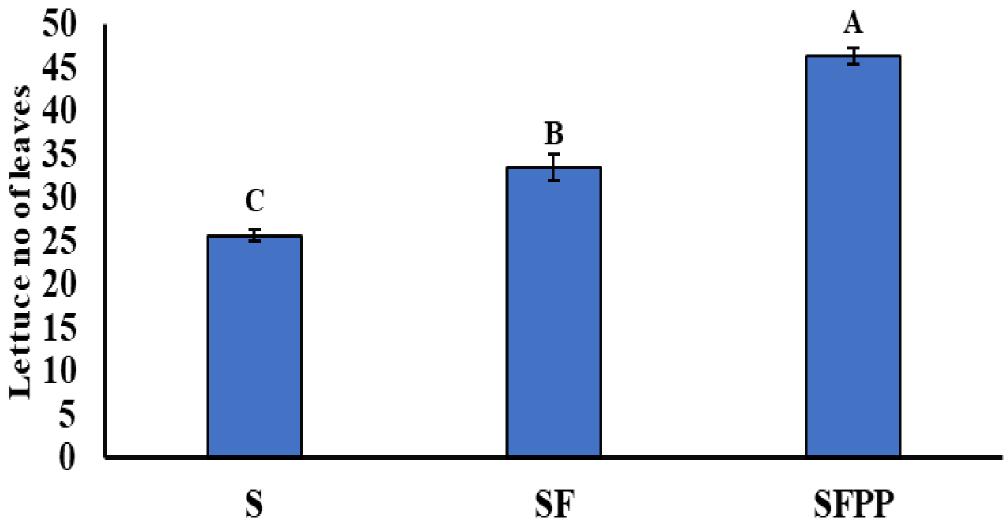
Lettuce number of leaves

The number of lettuce leaves as effected by the different growing media for vegetables in raised beds is shown in Figure 4.4. the number of leaves was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). The highest number of leaves recorded for lettuce was 49 leaves per lettuce plant, it was grown in treatment SFPP ($P < 0.05$). however, the lowest number of leaves were recorded in S (control soil) that was 23 leaves per plant. Both the media SF and SFPP enhanced the number of leaves for lettuce plants, The capital letters above the data bars are showing that all three treatments were significantly different from each other as compared by honestly significant test at 5% probability level.

Figure 4.4

Lettuce no of leaves as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).

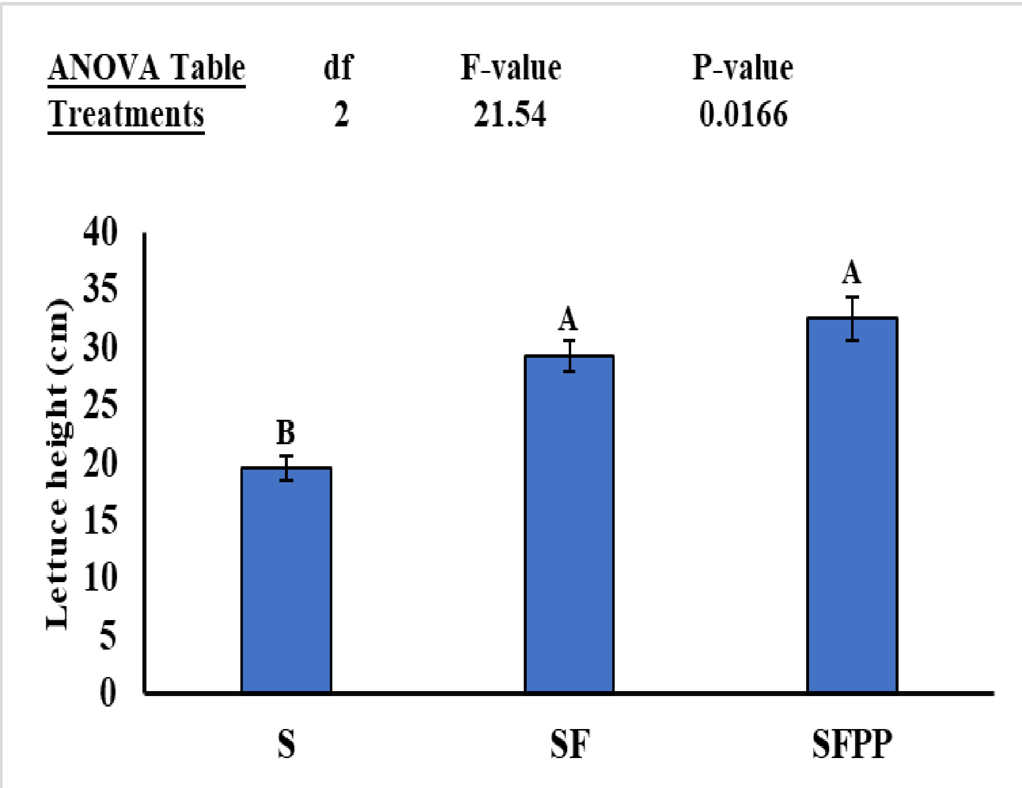
ANOVA Table	df	F-value	P-value
Treatments	2	88.4	0.0022



Lettuce plant height

The lettuce plant height (cm) as influenced by the different growing media for vegetables in raised beds is shown in Figure 4.5. the plant height was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). The highest plant height was recorded for lettuce was 35.5 cm it was grown in treatment SFPP (P < 0.05). however, the lowest plant height was recorded in control soil that was 18 cm. Both the media SF and SFPP enhanced the lettuce plant height, The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other, but they performed better than the treatment (S) Control soil. Both of them were significantly different from treatment S (control soil) as compared by honestly significant test at 5% probability level.

Figure 4. 5
Lettuce plant height as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).



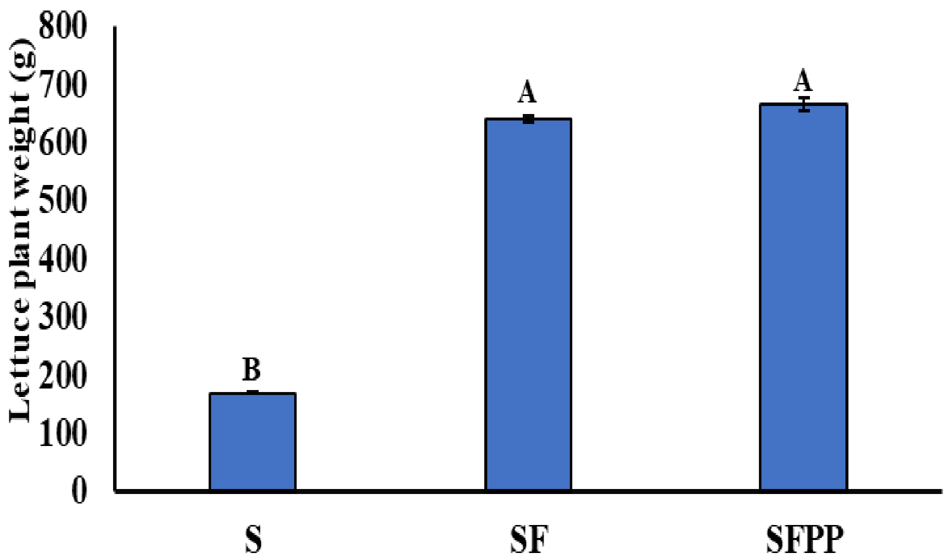
Lettuce plant weight

The lettuce plant weight as influenced by the different growing media for vegetables in raised beds is shown in Figure 4.6. The fresh lettuce plant weight was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest plant weight was recorded for lettuce was 685g it was grown in treatment SFPP ($P < 0.05$). however, the lowest plant weight was recorded in control soil that was 165g. Both the media SF and SFPP enhanced the fresh plant weight, The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other but both of them were significantly different from treatment S (Control soil) as compared by honestly significant test at 5% probability level.

Figure 4.6

Lettuce plant weight as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).

ANOVA Table	df	F-value	P-value
Treatments	2	1445.67	< 0

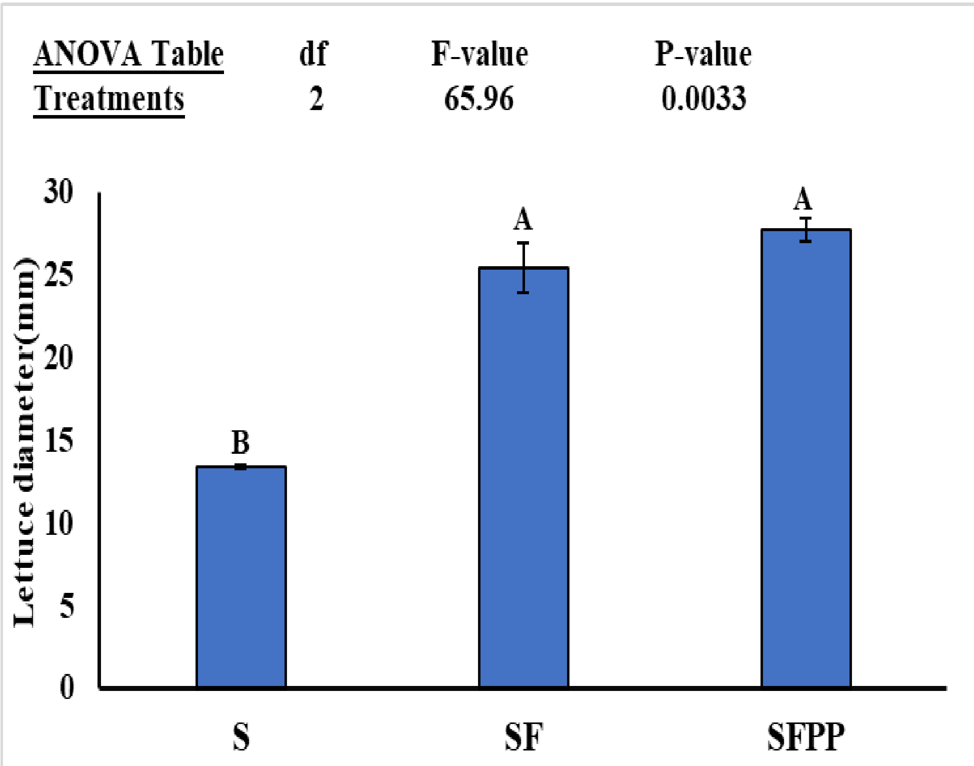


Lettuce stem diameter

The lettuce stem diameter as effected by the different growing media for vegetables in raised beds is shown in Figure 4.7. the stem diameter was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest stem diameter was recorded for lettuce was 31.3 mm it was grown in treatment SFPP ($P < 0.05$). however, the lowest stem diameter was recorded in control soil that was 12.2 mm. Both the media SF and SFPP enhanced the stem diameter, The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other but both of them were significantly different from treatment S (control soil) as compared by honestly significant test at 5% probability level.

Figure 4.7

Lettuce stem diameter as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).



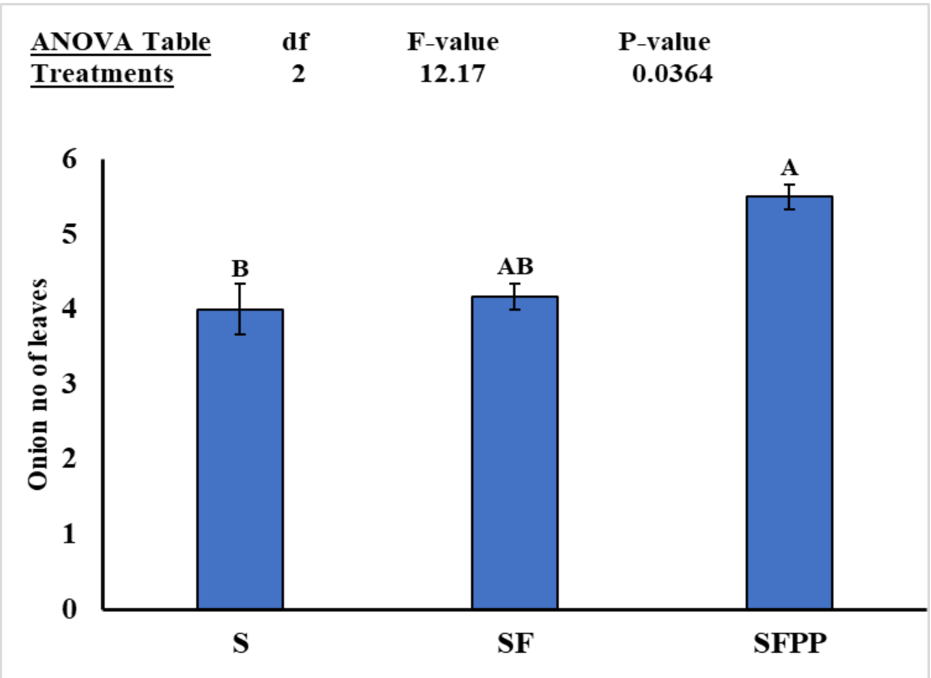
Onion Results

Number of leaves of onion plant

The onion number of leaves as influenced by the different growing media for vegetables in raised beds is shown in Figure 4.8. the onion number of leaves were highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest number of onion leaves was recorded for onion 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. Both the media SF and SFPP enhanced the onion number of leaves, the capital letters above the data bars are showing that the treatment S, SF and SFPP they were significantly different from each other as compared by honestly significant test at 5% probability level.

Figure 4.8

Onion no of leaves as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).



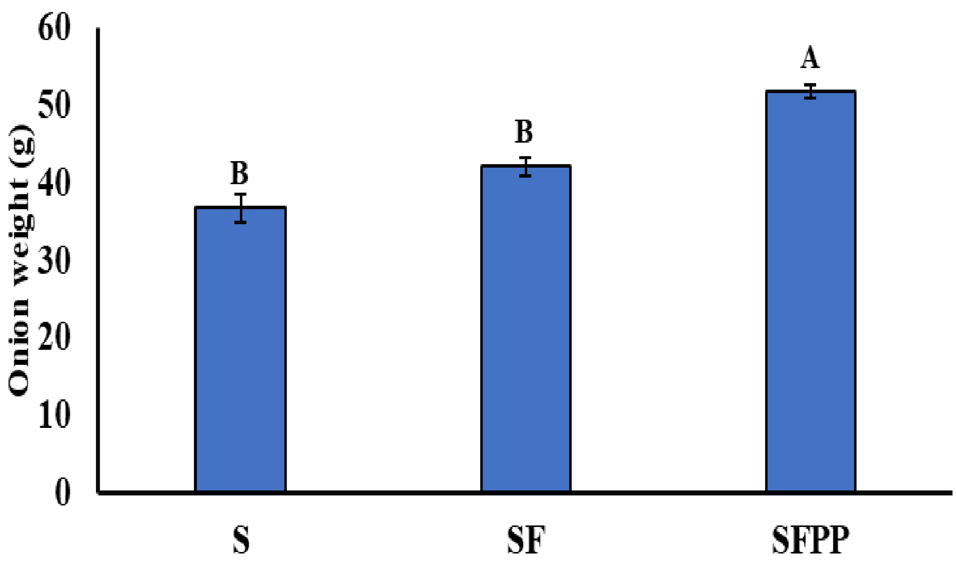
Onion plant weight

The onion fresh plant weight as effected by the different growing media for vegetables in raised beds is shown in Figure 4.9. the onion fresh plant weight was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest onion plant weight was recorded was 63g it was grown in treatment SFPP ($P < 0.05$). however, the lowest was recorded in control soil (S) that was 32g, both the media SF and SFPP enhanced the onion fresh plant weight, The capital letters above the data bars are showing that the treatment SF and SFPP they were significantly different from each other, but treatment S and SF are not significantly different as compared by honestly significant test at 5% probability level.

Figure 4.9

Onion fresh plant weight as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).

ANOVA Table	df	F-value	P-value
Treatments	2	32.02	0.0095



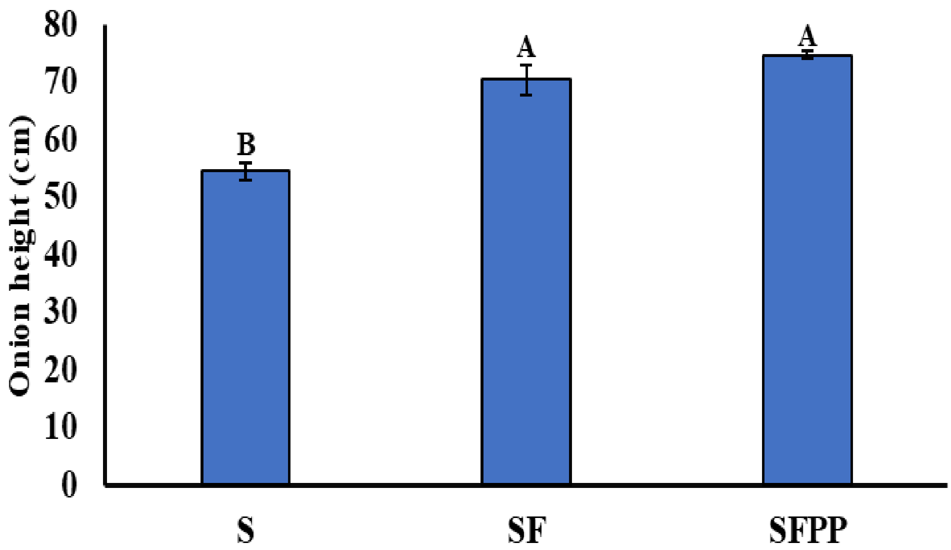
Onion plant height

The onion plant height as effected by the different growing media for vegetables in raised beds is shown in Figure 4.10. the onion plant height was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest onion plant height was recorded 79cm it was grown in treatment SFPP ($P < 0.05$). however, the lowest was recorded in control soil that was 51cm. Both the media SF and SFPP enhanced the height of the onion plant. The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other but both of them were significantly different from treatment S (Control soil) as compared by honestly significant test at 5% probability level.

Figure 4.10

Onion plant height as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).

ANOVA Table	df	F-value	P-value
Treatments	2	34.48	0.0085



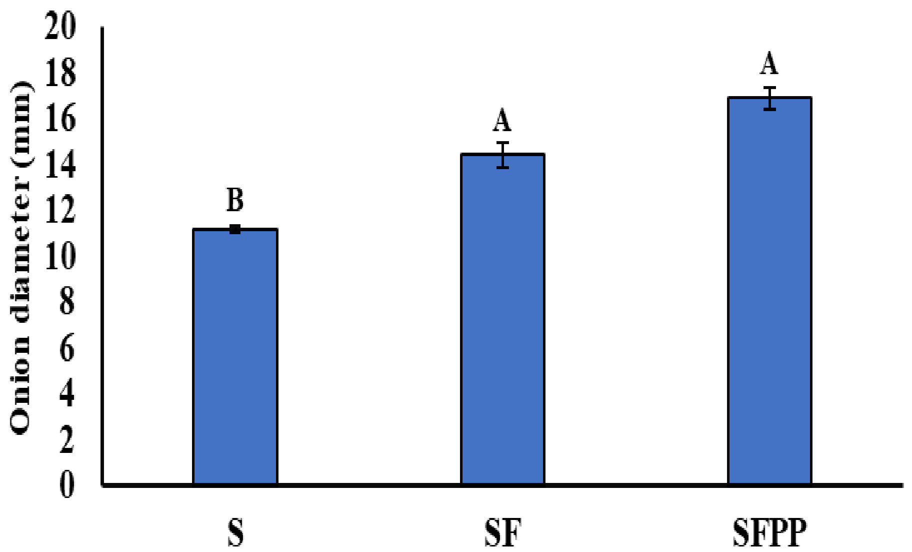
Onion diameter

The onion stem diameter as effected by the different growing media for vegetables in raised beds is shown in Figure 4.11. the onion stem diameter was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest stem diameter for onion was recorded 18.1mm it was grown in treatment SFPP ($P < 0.05$). however, the lowest was recorded in control soil that was 10.6mm. Both the media SF and SFPP enhanced the stem diameter of onion plant. The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other but both of them were significantly different from treatment S (control soil) as compared by honestly significant test at 5% probability level.

Figure 4.11

Onion stem diameter as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA)

ANOVA Table	df	F-value	P-value
Treatments	2	44.47	0.0059



Pepper Results

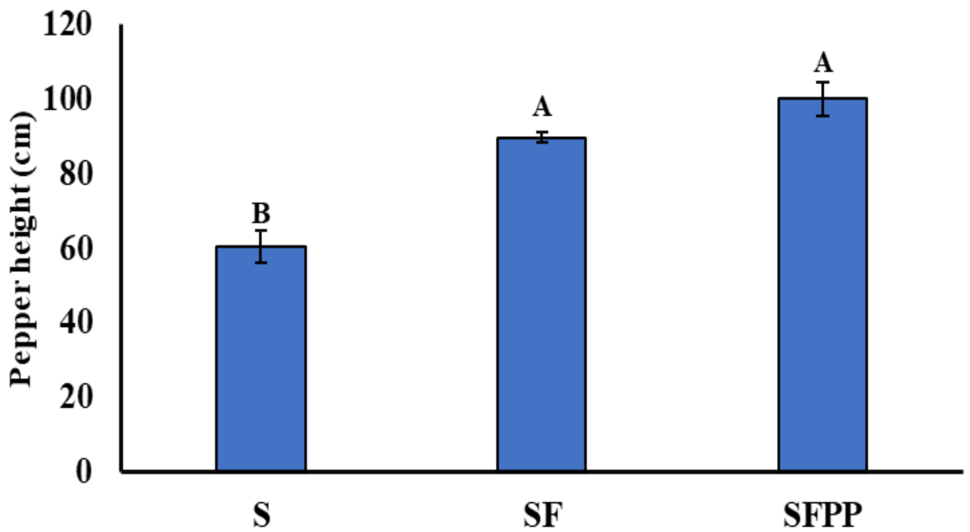
Pepper plant height

The pepper plant height as effected by the different growing media for vegetables in raised beds is shown in Figure 4.12. the pepper plant height was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest plant height for Pepper was recorded 114cm it was grown in treatment SFPP ($P < 0.05$). however, the lowest was recorded in control soil that was 53cm. Both the media SF and SFPP enhanced the pepper plant height. The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other but both of them were significantly different from treatment S (Control soil) as compared by honestly significant test at 5% probability level.

Figure 4.12

Pepper plant height as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).

ANOVA Table	df	F-value	P-value
Treatments	2	30.10	0.0104



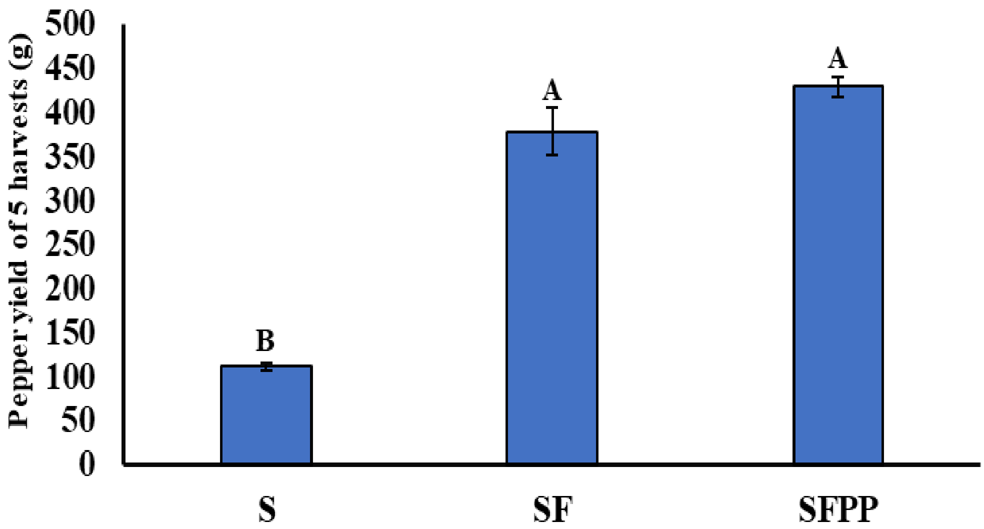
Pepper fruit yield

The Pepper mean yield of 5 harvestings per plant as effected by the different growing media for vegetables in raised beds is shown in Figure 4.13. Pepper yield was calculated by measuring the mean of 5 harvestings the pepper fruit yield was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest pepper mean yield recorded for Pepper plant was recorded 593 g it was grown in treatment SFPP ($P < 0.05$). however, the lowest was recorded in control soil that was130 g. Both the media SF and SFPP enhanced the pepper fruit yield. The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other but both of them were significantly different from treatment S (Control soil) as compared by honestly significant test at 5% probability level.

Figure 4.13

Pepper means yield of 5 harvestings per plant as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).

ANOVA Table	df	F-value	P-value
Treatments	2	146.86	0.001



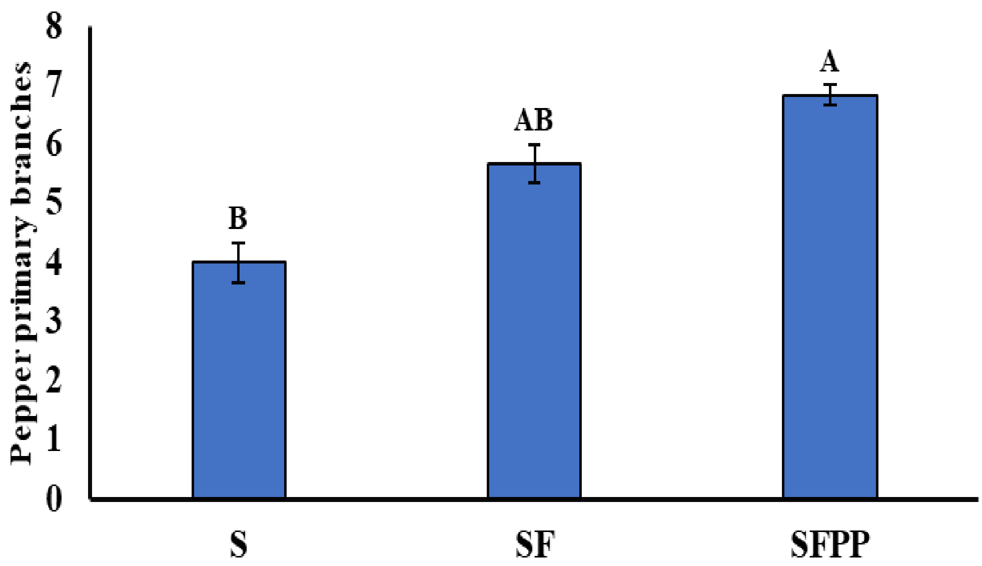
Pepper no of primary branches

The pepper number of primary branches effected by the different growing media for vegetables in raised beds is shown in Figure 4.14. the pepper number of primary branches per plant was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest number of primary branches for Pepper was recorded 8. it was grown in treatment SFPP ($P < 0.05$). however, the lowest was recorded in control soil that was 3 pepper branches per plant. Both the media SF and SFPP enhanced the number of primary branches. The capital letters above the data bars are showing that the treatment SF and SFPP they were not highly significantly different from each other but both of them were significantly different from treatment S (control soil) as compared by honestly significant test at 5% probability level.

Figure 4.14

Pepper no of primary branches as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).

ANOVA Table	df	F-value	P-value
Treatments	2	24.33	0.014

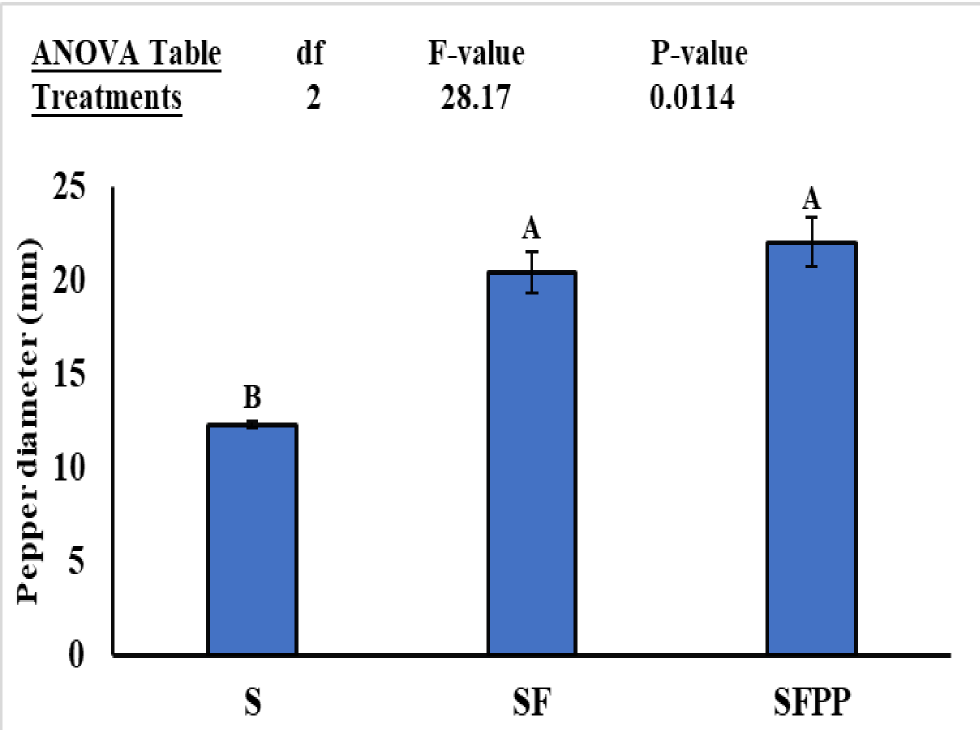


Pepper stem diameter

The pepper stem diameter as effected by the different growing media for vegetables in raised beds is shown in Figure 4.15. the pepper stem diameter was highest with SFPP (Soil+ Farmyard manure+ Peat + Perlite) and followed by SF (Soil+ Farmyard manure). the highest stem diameter for Pepper was recorded 23.9mm it was grown in treatment SFPP ($P < 0.05$). however, the lowest was recorded in control soil that was 11.1mm. Both the media SF and SFPP enhanced the stem diameter of pepper plant. The capital letters above the data bars are showing that the treatment SF and SFPP they were not significantly different from each other but both of them were significantly different from treatment S (control soil) as compared by honestly significant test at 5% probability level

Figure 4.15

Pepper stem diameter (mm) as affected by application of different growing media (1) S: Control soil, (2) SF: Soil + Farmyard manure [1:1] and (3) SFPP: Soil+ Farmyard manure+ Peat +Perlite [1:1:1:0.5]. Error bars depicted standard errors (±) of the mean, capital letters above each bar showed significant differences among treatments at 5% probability level after Tukey's HSD test. Table above represented results of the analysis of variance (ANOVA).



Discussions

Urban farmers mostly use raised bed production methods to make farming easier and more productive. Raised beds provide a number of advantages, including increased drainage and the potential to be used in situations where farming is impossible due to contaminated soil or a lack of cultivable soil (Starbuck, 2003). Proper organic and inorganic media mixtures facilitate rapid plant growth and development. Because it provides adequate nutrients, a pathogen-free environment, and ideal water holding capacity, good quality media is essential to the establishment of a successful crop (Manenoi et al., 2009). According to our soil analysis results the soil organic matter and soil organic carbons were found higher in treatment SFPP which contains the mixture of soil, farmyard manure, peat and perlite media having higher organic matter increases crop production by making the water and nutrients available to the crops. According to Lal, (2020) Most agricultural soils have low levels of soil organic matter. Excessive soil organic matter loss may damage soil functionality and its ability to support important ecosystems. Organic matter improves the soil's ability to hold water and makes nutrients more readily available to plants. Similarly, the soil organic carbon (SOC) plays important role in enhancing physical, chemical, and biological qualities of the soil, many areas of the world have seen improvements in agricultural productivity (Dhaliwal et al., 2019). In accordance with our research results we observed that treatment SFPP: Soil+ Farmyard manure+ Peat+ Perlite [1:1:1:0.5] performed best in all the parameters of lettuce, onion and peppers after that treatment SF (Soil & Farmyard manure) also performed really well while the treatment S (Control soil) gave the least results and it was according to our expectations because in previous studies researches have shown that the 60-80% of farmyard manure can increase the yield of pepper plants (Eksi et al., 2015). Similarly, the mixture of peat, compost and soil mixtures had improved the tomato growth (Atif et al., 2016).

CHAPTER V

Conclusion and Recommendations

More people are relocating to urban areas as time goes on in search of facilities and a better way of life. In order to feed 9.6 billion people in the future, we immediately need to enhance our food production units. Our current agricultural system won't be able to achieve this, so municipalities are concentrating on increasing urban farming in cities through kitchen, terrace, and roof gardening in order to lower production costs and transportation costs so that food will be accessible to people inside of cities, it will help to solve the problem of food insecurity.

Urban farmers use raised beds to grow crops in contaminated soil or in areas without access to other farming equipment's, such as roof gardens, terraces, and mountainous terrains. Raised beds also help plants to grow more quickly by raising the temperature of the growing medium and enhancing easy root development. Similarly choosing the right growing medium in raised beds boosts crop production performance, each growing medium has unique characteristics, therefore picking the right one is important for improved yield and plant growth.

This study was conducted to check the effect of different growing media in raised beds for future green roofs in cities. In this study, three different treatments were used in 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]. To evaluate the impact of media on these crops, lettuce, onions, and peppers were grown. If we talk about the evaluation factors plant growth and yield shows the success of the growing media. After analyzing the data, 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 worked really well. Because the outcomes of treatments 2 and 3 were so close, we concluded that they were not statistically different from each other in most of the parameters recorded for lettuce, onion and pepper. However, they were both significantly different from treatment 1 (S) control soil. All vegetables in Treatment 1 (S) control soil stayed low. So, we can recommend that control soil should be enriched with farmyard manure, peat and perlite to improve plant growth and yield in lettuce, onion and pepper.

Treatment (2) SF: Soil + Farmyard manure [1:1] only contains soil and farmyard manure, both of which are inexpensive and easy to get while under treatment (3) SFPP: Soil+ Farmyard manure+ Peat+ Perlite [1:1:1:0.5] peat and perlite are expensive growing media that are not widely available; thus, based on our findings, we recommend the treatment (2) SF: Soil + Farmyard manure [1:1] to be used in raised beds for vegetable production because it produced results comparable to the best performing treatment and is inexpensive and widely available. 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.

Recommendations for future studies

For future studies researchers can work on the following fields related to study:

- ✓ Different compositions of growing media including (soil, farmyard manure, peat and perlite) in raised beds for vegetable production.
- ✓ Comparative study of different growing media between raised beds and open field for different vegetables.
- ✓ Production of vegetables by using different growing media in raised beds at roof gardens.

REFERENCES

Abbas, F., Ismail, L. H., Wahab, I. A., & Elgadi, A. A. (2020). A review of green roof: definition, history, evolution, and functions. *Materials Science and Engineering, 713*(1), 12048.

Alhrout, H. H., Akash, M. W., & Hejazin, R. K. (2018). Effect of farmyard manure and NPK on the yield and some growth components of tomato (Lycopersicum esculentum). *Research on Crops*, 655-658.

Anonymous. (2017). *Intensive, Semi-Intensive, and Extensive. Archtool box.* From Green Roof Systems: https://www.archtoolbox.com/green-roof-systems/

Atif, M. J., Jellani, G., Malik, M. A., Saleem, N., Ullah, H., Khan, M. Z., & Ikram, S. (2016). Different growth media effect the germination and growth of tomato seedlings. *Science, Technology and Development*, 123-127.

Badescu, V., & Sicre, B. (2003). Renewable energy for passive house heating: II. Model. *Energy and buildings*, 1085-1096.

Bakker, D. M., Hamilton, G. J., Houlbrooke, D. J., & Spann, C. (2005). The effect of raised beds on soil structure, waterlogging, and productivity on duplex soils in Western Australia. *Soil Research, 43*(5), 575-585.

Born, K. (2016). *Farming with Raised Beds in an Urban Environment*. From Dummies:https://www.dummies.com/article/home-auto-hobbies/garden-green-living/gardening/urban/farming-with-raised-beds-in-an-urban-environment-167950/

Brown, S. L., Chaney, R. L., & Hettiarachchi, G. M. (2016). Lead in urban soils: a real or perceived concern for urban agriculture? *Journal of environmental quality*, 26-36.

Bryld, E. (2003). Potentials, problems, and policy implications for urban agriculture in developing countries. *Agriculture and human values*, 79-86.

Chen, C. F. (2013). Performance evaluation and development strategies for green roofs in Taiwan: A review. *Ecological engineering*, 51-58.

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society, 28*, 63-80.

Cudnik, J. L. (2014). *Evaluation of substrates in constructed, raised-beds for vegetable culture.* University of Georgia.

Derek, T. (2007). Study on green roof application in Hong Kong. *Final Report*, 77-81.

Despommier, D. (2011). The vertical farm: controlled environment agriculture carried out in tall buildings would create greater food safety and security for large urban populations. *Journal fur Verbraucherschutz und Lebensmittelsicherheit, 6*(2), 233-236.

Dhaliwal, S. S., Naresh, R. K., Mandal, A., Singh, R., & Dhaliwal, M. K. (2019). Dynamics and transformations of micronutrients in agricultural soils as influenced by organic matter build-up: A review. *Environmental and Sustainability Indicators*, *1*, 100007.

Drakes, D., Briercliffe, T., Lightfoot-brown, S., Arnold, D., & Mackay, N. (2001). The use and disposal of growing media. *ADAS Horticulture Park Farm Ditton, Aylesford, Kent ME20 6PE.*

EIB. (2019). *Europe and its Urban Development, 1970 to 2020*. From Europe Investment Bank: https://www.eib.org/en/essays/the-story-of-your-city

Eksi, M., Rowe, D. B., Fernandez-Canero, R., & Cregg, B. M. (2015). Effect of substrate compost percentage on green roof vegetable production. *Urban Forestry & Urban Greening, 2*, 315-322.

Eksi, M., Sevgi, O., Akburak, S., Yurtseven, H., & Esin, I. (2020). Assessment of recycled or locally available materials as green roof substrates. *Ecological Engineering, 156*, 105966.

FAO. (2001). *The State of Food Insecurity in the World 2001.* From Food and agriculture.organization:https://www.fao.org/agrifood-economics/publications/detail/en/c/122100/

FAO. (2007). *Profitability and sustainability of urban and peri-urban agriculture*.

FAO. (2011). *Food, Agriculture and Cities-Challenges of food and nutrition security,* . From agriculture and ecosystem management in an urbanizing world: www.fao.org

FAO. (2017). From Food and Agriculture Organization of the United Nations: http://www.fao.org

Fernandez-Canero, R., Emilsson, T., Fernandez-Barba, C., & Machuca, M. H. (2013). Green roof systems: A study of public attitudes and preferences in southern Spain. *Journal of environmental management, 128*, 106-115.

Goutam, K. C., Goutam, B., & Susanta, K. C. (2011). The effect of vermicompost and other fertilizers on cultivation of tomato plants. *Journal of Horticulture and Forestry, 3*(2), 42-45.

Grebitus, C., Chenarides, L., Muenich, R., & Mahalov, A. (2020). Consumers' perception of urban farming—An exploratory study. *Frontiers in Sustainable Food Systems, 4*, 79.

Grunert, O., Raheul, D., Van labeke, M.-C., Perneel, M., Hernandez-Sanabria, E., Vlaeminck, S. E., & Boon, N. (2016). Growing media constituents determine the microbial nitrogen conversions in organic growing media for horticulture. *Microbial biotechnology, 9*(3), 389-399.

Gundersen, C., Hake, M., Dewey, A., & Engelhard, E. (2021). Food insecurity during COVID-19. *Applied economic perspectives and policy, 43*(1), 153-161.

Huang, J. K., & Yang, G. L. (2017). Understanding recent challenges and new food policy in China. *Global Food Security*, 119–126.

Hui, S. C. (2011). Green roof urban farming for buildings in high-density urban cities. *Hainan China World Green Roof Conference.*

IFC. (2022). *Addressing the challenges of urbanization.* From International finance corporation: https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/turkey+urbanization

Ji, Q., Lee, H. J., & Huh, S. Y. (2022). Measuring the economic value of green roofing in South Korea: A contingent valuation approach. *Energy and Buildings, 261*, 111975.

Katircioglu, S. T. (2006). Causality between agriculture and economic growth in a small nation under political isolation: A case from North Cyprus. *international Journal of Social Economics*.

Laborde, D., Martin, W., Swinnen, J., & Vos, R. (2020). COVID-19 risks to global food security. *Science, 369*(6503), 500-502.

Lal, R. (2020). Soil organic matter content and crop yield. *Journal of Soil and Water Conservation*, *75*(2), 27A-32A.

Lazzarin, R. M., Castelloti, F., & Busato, F. (2005). Experimental measurements and numerical modelling of a green roof. *Energy and Buildings, 37*(12), 1260-1267.

Manenoi, A., Tamala, W., Tunsungnern, A., & Amassa, P. (2009). Evaluation of an on-farm organic growing media on the growth and development of pepper seedlings. *Asian J Food Agro-Ind*, 575-580.

Mohsin, M., Anwar, M. M., Jamal, F., Ajmal, F., & Breuste, J. (2017). Assessing the role and effectiveness of kitchen gardening toward food security in Punjab, Pakistan: a case of district Bahawalpur. *International Journal of Urban Sustainable Development, 9*(1), 64-78.

Molden, D. (2007). *Water for food water for life: A comprehensive assessment of water management in agriculture.* Routledge.

Ondono, S., Martinez-Sanchez, J. J., & Moreno, J. L. (2016). The composition and depth of green roof substrates affect the growth of Silene vulgaris and Lagurus ovatus species and the C and N sequestration under two irrigation conditions. *Journal of Environmental Management*, 330-340.

Orsini, F., Kahane, R., Nono-Womdim, R., & Gianquinto, G. (2013). Urban agriculture in the developing world: a review. *Agronomy for sustainable development, 33*(4), 695-720.

Overman, H. G., & Venables, A. (2005). *Cities in the developing world. Unpublished Manuscript.* London School of Economics.

Panayiotis, N., Panayiota, T., & Ioannis, C. (2003). Soil amendments reduce roof garden weight and influence the growth rate of Lantana. *Horticultural Science, 38*(4), 618-622.

Puplampu, D. A., & Boafo, Y. A. (2021). Exploring the impacts of urban expansion on green spaces availability and delivery of ecosystem services in the Accra metropolis. *Environmental Challenges*, 100283.

Raviv, M., Lieth, H., & Bar-Tal, A. (2019). *Soilless culture: Theory and practice.* Elsevier.

Sarwar, M., Anjum, S., Khan, M. A., Haider, M. S., Ali, S., & M, K. (2018). Assessment of sustainable and biodegradable agricultural substrates for eminence production of cucumber for kitchen gardening. *International Journal of Recycling of Organic Waste in Agriculture, 7*(4), 365-374.

Schmidhuber, J., & Tubiello, F. (2007). Climate change and global food security: Socio- economic dimensions of vulnerability. *Proceedings of the National Academy of Sciences, 104*(50), 1973-19708.

Schmilewski, G. (2008). The role of peat in assuring the quality of growing media. *Mires & Peat, 3*.

Schneider, A., Fusco, M., Bousselot, J., & Horticulturist, D. G. (2014). Observations on the survival of 112 plant taxa on a green roof in a semi-arid climate. *Journal of Living Architecture*, 10-30.

Shafique, M., Kim, R., & Rafiq, M. (2018). Green roof benefits, opportunities and challenges–A review. *Renewable and Sustainable Energy Reviews, 90*, 757-773.

She, N., & Pang, J. (2010). Physically based green roof model. *Journal of hydrologic engineering, 15*(6), 458-464.

Shukla, K., Mishra, R., & Sarkar, P. (2021). . Understanding soilless engineered soil as a sustainable growing material for food production in a green roof. *Materials Today: Proceedings, 43*, 3054-3060.

Starbuck, C. J. (2003). Raised-bed gardening. *MU Guide, University of Missouri—Columbia, MO*, 4.

Sullivan, C., Hallaran, T., Sogorka, G., & Weinkle, K. (2015). An evaluation of conventional and subirrigated planters for urban agriculture: Supporting evidence. *Renewable Agriculture and Food Systems, 30*(1), 55-63.

Tala, S., Al-Ajlouni, M. G., Ayad, J. Y., Othman, Y. A., & Hilaire, R. S. (2020). Performance of six different soilless green roof substrates for the Mediterranean region. *Science of the Total Environment, 730*, 139182.

Taylor, L. S., & Wortman, S. E. (2018). Raised beds for vegetable production in urban agriculture. *Urban Agriculture & Regional Food Systems*, 1-10.

Theunissen, J. (1997). Intercropping in field vegetables as an approach to sustainable horticulture. *Outlook on Agriculture, 26*(2), 95-99.

UN. (2022). *Global issues population*. From United Nations : https://www.un.org/en/global-issues/population

USDA.(2022).*Definitions of food security*. From https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-theu-s/defnitions-of-food-security/

Vasylieva, N., & Harvey, J. J. (2021). The effect of urbanization on food security and agricultural sustainability. *Economics & Sociology*, 76-88.

Wang, Y. S. (2019). The Challenges and Strategies of Food Security under Rapid Urbanization in China. *Sustainability, 11*(2), 542.

Wijaya, K. P. (2020). Pemanfaatan Urban Farming Melalui Konsep Eco-Village Di Kampung Paralon Bojongsoang Kabupaten Bandung. *Jurnal Arsitektur ARCADE, 4*(1), 16-22.

Wilkinson, K., Landis, T. D., Haase, D. L., Daley, B. F., & Dumroese, R. K. (2014). Tropical nursery manual: a guide to starting and operating a nursery for native and traditional plants. *Agriculture Handbook 732. Washington, DC:US Department of Agriculture, Forest Service, 732*, 376.

Xi, L., Zhang, M., Zhang, L., Lew, T. T., & Lam, Y. M. (2022). Novel materials for urban farming. *Advanced Materials, 34*(25), 2105009.

Yusoff, N. H., Hussain, M. R., & Tukiman, I. (2017). Roles of community towards urban farming activities. *Planning Malaysia, 15*.

Zhang, X., Ma, L., Gilliam, F. S., Wang, Q., & Li, C. (2012). Effects of raised-bed planting for enhanced summer maize yield on rhizosphere soil microbial functional groups and enzyme activity in Henan Province, China. *Field Crops Research, 130*, 28-37.

Zhang, X., Shen, L., & Wu, Y. (2011). Green strategy for gaining competitive advantage in housing development: a China study. *Journal of cleaner production, 19*(2-3), 157-167.

Zhang, X., Shen, L., Tam, V. W., & Lee, W. Y. (2012). Barriers to implement extensive green roof systems: A Hong Kong study. *Renewable and sustainable energy reviews, 16*(1), 314-319.

APPENDIX

Similarity Report