EFFECT OF GROWING MEDIA AND WATERING FREQUENCIES ON GROWTH, YIELD AND QUALITY OF CARROT

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CERTIFICATE

*This is to certify that the thesis entitled "*__EFFECT OF GROWING MEDIA AND WATERING FREQUENCIES ON GROWTH, YIELD AND QUALITY OF CARROT__*" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE, embodies the result of a piece of bona fide research work carried out by* **SARMIN AKTER**, Registration No. **18-09306** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

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TO

MY BELOVED PARENTS

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ABSTRACT

A pot experiment was conducted at the central farm of the Sher-e-Bangla Agricultural University, Dhaka during December 2018 to March, 2019. This study aimed to evaluate the effect of growing media and watering frequencies on the growth, yield and quality attributes of carrot. The experiment consisted of two factors: Factor A: four growing media, viz., M_1-cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixture of cocopeat, sawdust and rice husk and Factor B: different watering frequencies viz., W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. There were 16 (4×4) treatments combination. The experiment was laid out in randomized complete block design with four replications. The experimental results showed maximum parameters were significantly influenced by different growing media and watering level. For growing media, the highest plant height (47.17 cm) at 100 DAS, number of leaves (12.31) at 100 DAS, length of root (12.25 cm), root diameter (20.25 mm), fresh weight of root (54.85 g), dry matter content of leaves (17.79 %), brix (10.57 %), β- carotene (9098.1 µg/100g) and moisture (86.01%) was obtained from M_1 and the lowest from M_4. For watering level, the maximum plant height (53.92 cm) at 100 DAS, number of leaves (12.98), at 100 DAS, length of root (12.06 cm), root diameter (21.50 mm), fresh weight of root (55.83 g), brix (10.20%), β- carotene (9347.9 µg/100g) and moisture (86.59%) was recorded from W_2 and the lowest from W3. For combined effect, the maximum plant height (56.51 cm) at 100 DAS, number of leaves (13.46) at 100 DAS, length of root (13.52 cm), root diameter (23.81 mm), fresh weight of root (67.42 g), brix (11.20%), β- carotene (9884.4 µg/100g) and moisture (87.11%) was obtained from M_1W_2 and the minimum from M_4W_3. So it might be concluded that the M_1W_2 was found the best performed for high growth, yield and quality of carrot.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATION

ACRONYMS	ELABORATIONS
@	At the rate
AEZ	Agro Ecological Zone
ANOVA	Analysis of variance
AOAC	Association of Analytical Communities
BARI	Bangladesh Agricultural Research Institute
cm	Centimeter
CV	Coefficient of variation
DAS	Days after sowing
d.f	Degrees of freedom
et al	And others
g	gram
μg	microgram
LSD	Least significant difference
ml	millilitre
mg	milligram
NS	Non-significant
SE	Standard error
SPSS	Statistical package for the social sciences
RCBD	Randomized complete block design
Viz	Namely

CHAPTER I

INTRODUCTION

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INTRODUCTION

Carrot (*Daucus carota* L.), is one of the world's most popular winter season root crop in Bangladesh. During the Rabi season, carrot grows successfully in Bangladesh, and from mid-November to early December it is the best time to grow satisfactorily.

It is rich in beta-carotene, an excellent source of iron, calcium, phosphorus, folic acid, vitamin B, content of sugar (Yawalker, 1992) and certain essential medicinal values (Sadhu, 1993). Carrot is one of the highly praised vegetables in Bangladesh, it is mainly used in our daily meal as a slicing carrot, in addition to being used in curry across the country.

To obtain quality root, it is essential to grow carrot under good rooting medium. Usually, plants are grown in mineral substrates such as rock wool, vermiculite, perlite, zeolite, and ceramsite culture media. Substrates come in a variety of forms, some are organic, while others are manufactured artificially. The growing medium provides mechanical support for plants and aids in the delivery of water, nutrients, and oxygen to the roots, enabling plants to grow and develop. As a result, substrate selection is one of the most important factors in soilless culture since it affects plant growth, development, and quality. The structure of the growing medium rather than soil must be sufficiently soft and porous to allow roots to penetrate widely into the substrate and to provide plants with food, anchorage and support (Utobo *et al*., 2015).

Most biodynamic substrates, such as peat moss, sawdust, pine bark, perlite, vermiculite, rice hulls, are used similarly to traditional crop production systems rather than soil, but one of the most prominent problems is lack of wettability in substrates based culture (Burnett *et al*., 2016). The addition of organic materials as a source of growth in potting media is essential since they are the main sources of organic matter needed by plants to supply essential nutrient elements (Khan *et al*., 2006). In some parts of Bangladesh, various natural substrates from our environment and have also been purchased from commercial suppliers have been used in various traditional ways. (Haq *et al*., 2002) namely baira, boor, dhap, gathua, gatoni, geto, kandi and vasoman chash (Islam and Atkins 2007; Irfanullah *et al*., 2007).

Rice husk can serve as a nutrient sorbent because of its high silica (94%), carbon (37%) and ash (20%) content (Tran *et al*., 1999). Sawdust is another waste product that has environmental benefits and is economically viable, so it can be used as a growing medium because it can hold moisture and nutrients (Hernández *et al.,* 2005). Cocopeat is accepted as a growing medium with acceptable chemical properties that can be used to produce a variety of high-quality crop species (Awang, Y. *et al.,* 2009). This research aimed to find a suitable organic substrate combination and assess its effectiveness as a growing media on carrot growth, yield and quality.

Water is a key requirement of a growing plant and plays an important role in the plant's metabolic activity (Osaigbovo and Orhue, 2012). They reported that when water is limited, a plant's growth is arrested. To avoid wasting water and to save watering costs especially during the winter season, it is important to determine the watering frequency for a plant raised in a pot. In addition, it is difficult to retain sufficient water in a growing medium dependent on substrates to reduce the frequency of watering.

While this technique is being practiced by some Bangladeshi scientists, the idea of using organic substrates is therefore new to farmers compared to conventional soil-based production. There is also a need for an evaluation of watering intensity in container cultivation during the dry season in the field area.

In Bangladesh, soilless vegetable cultivation is very important because there is a shortage of land for crop cultivation, and agricultural land is used for over-population accommodation. Also safe carrot cultivation can be encouraged using natural growing media with new innovation technologies focusing water use efficiency. Although soilless cultivation permits continuous vegetable development throughout the year and increases the yield.

It is necessary to identify the appropriate growing medium for growing and producing quality carrot rather than soil, to increase the production of carrot and its quality, and to introduce modern techniques to farmers. Using growing media in container carrot production with our local substrates can open up a new window for urban area. By making garden soil available as well as light weight as our traditional sole soil media, people could afford easily, and they will benefit. Therefore, this study was carried out with the following objectives:

Objectives:

- To optimize the growing media on the growth and yield of carrot.
- To investigate the level of water application on the growth and yield of carrot.
- To find out the nutritional profile and quality attributes of carrot.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Some of the research findings related to the growth, yield and quality of carrot as influenced by irrigation and aggregate hydroponic system, literature on other crops is also included in this chapter for a better understanding of the subject.

2.1. Impact of growing media to the growth, yield and quality attributes:

Sarkar *et al.* (2021) evaluate the effect of organic substrates on the growth yield, photosynthetic response, and nutritional profile of red leaf lettuce grown in different compositions of cocopeat (CP), sawdust (SD), and rice husk (RH). The result showed that the properties of substrates were influenced variably by their mixing ratios. The highest water holding capacity and moisture content were found in CP, and it provided the preferable pH, electrical conductivity, bulk density, and air-filled porosity in association with other categories of the substrate. Cocopeat-based media provides ample microclimate conditions in the root region of plants and increased their height, number of leaves, and fresh biomass components. The utmost dry biomass of plant parts also remarkably increased in CP; L*, a*, and b* chromaticity of leaves remained unchanged. The maximum chlorophyll content was attained in CP substrate, except for chlorophyll a/b, which was higher in RH. The net photosynthetic rate (PN), transpiration rate (E), and nitrate in leaves were enhanced substantially in CP, while it was lower in SD. Biochemical compositions and nutrients in leaves were likewise stimulated under the culture of cocopeat-based media. Results indicate that cocopeat, sawdust, and rice husk are a possible substrates mixture in a volume ratio of 3:1:1, which would be a better choice in the cultivation of red leaf lettuce.

Rahman *et al.* (2019) concluded that the maximum number of leaves per plant (21.44) and the highest fresh weight (92.49 g plant-1) were recorded from M_1 (60% rice husk + 30% coconut coir + 10% vermicompost). while the lowest in M_3 (60% sawdust + 30% brocken brick + 10% vermicompost) Therefore, the study revealed that the rice husked based growing substrates can be used for growing lettuce cv. ‘Legacy’ in aggregate soilless system in the tropics like Bangladesh.

Sudeshika *et al.* (2018) revealed that four rooting media treatments (Coir dust, leaf mould, compost and top soil) and two varieties (Kimona and New Kuroda) were used in this experiment. There was no significant difference in leaf number, leaf length, canopy diameter, root length, root circumference and yield in both carrot varieties. Growth and yield parameters were well performed in coir dust containing medium and top soil (control) gave the lowest performance of both growth and yield parameters, due to difference in root penetration and growth. But there was no significant difference between coir dust and compost containing medium. It can be concluded that coir dust containing medium can be recommended as a suitable medium for carrot growing based on the root penetration, growth and yield of the plant.

Rahman *et al.* (2018) experiment was conducted to specify the required amount of nutrient solution and ecofriendly mixtures of growing substrates of a hydroponic bitter gourd. Treatments consisted two factors, viz., four different types of growing substrate (M_1 = 60% rice husk + 30% coconut coir + 10% vermicompost, M_2 = 60% coconut coir + 30% khoa + 10% vermicompost, M_3 = 60% sawdust + 30% khoa + 10% vermicompost, and M_4 = 60% ash + 30% khoa + 10% vermicompost) and three different composition of nutrient solutions [N_1 = full strength Rahman and Inden (2012), N_2 = full strength Hoagland and Arnon (1940), and N_3 = ½ strength Rahman and Inden (2012). Photosynthetic responses and its related parameters, namely, stomatal conductance (gs), transpiration (E), and photo- synthetic rate (PN) were significantly affected by nutrient solution composition and growing substrate mixtures. Results revealed that the leaf gas exchange parameters, yield contributing characters, and biochemical parameters showed that full strength of Rahman and Inden (2012) nutrient solution application was better in a growing mixture of 60% rice husk + 30% coconut coir + 10% vermicompost in soilless culture for obtaining high yield and high quality of bitter gourd.

Quamruzzaman *et al.* (2017) studied Leaf gas exchange, physiological growth, yield and biochemical properties of groundnut as influenced by boron in soilless culture and conducted to identify the optimum dose of boron for groundnut plant. Six level of boron (B) application, B_0 (0 ppm), B_1 (0.5 ppm), B_2 (1 ppm), B_3 (2 ppm), B_4 (4 ppm) and B_5 (8 ppm) were evaluated. Photosynthetic rate, transpiration and stomatal conductance were increased for boron application but leaf vapor pressure deficit decreased. Physiological growth parameters, yield and yield contributing character, and shelling percentage was highest for B_3. The values of biochemical traits including protein, oil and vitamin E content were higher for B_4. Thus, leaf gas exchange showed that boron can be used to culture groundnut as it provides high yield and biochemical properties.

Rahman *et al.* (2017) studied Physical and chemical properties of different substrate mixtures and their effects on growth and yield of lettuce. The experiment aimed to assess the physicochemical properties of four growing substrate mixtures ((M_1 = 60% coconut coir + 30% khoa + 10% vermicompost, M2= 60% Carbonised rice husk+ 30% khoa + 10% vermicompost, M_3= 60% sawdust + 30% khoa + 10% vermicompost, and M_4= 60% coconut coir + 30% rice husk + 10% vermicompost) and their effects on growth and yield of lettuce. Results revealed that pH, electrical conductivity (EC) were higher in M_2, whereas bulk density was higher in M_1 and the lowest in M_3. Improved properties of M_3 and M_4 positively reflected in growth, dry weight, and yield of lettuce. Therefore, it can be concluded that incorporation of coarser materials improved physicochemical properties of coco peat based treatment (M_4) followed by sawdust based treatment (M_3) that positively influenced the growth and yield of lettuce.

Rahman *et al*. (2017) stated that the effects of irrigation timing on growth, yield, and physiological traits of hydroponic lettuce. The experiment was conducted to identify the optimum irrigation timings for hydroponic lettuce plants. Three nutrient solution timings, T_1 (once a day at 0900 hours), T_2 (once on alternative days at 0900 hours), and T_3 (once at two- day intervals), and three varieties, ‘Legacy’ (V_1), ‘Red fire’ (V_2), and ‘Green wave’ (V_3) were evaluated.

Growth and yield parameters, including number of leaves, leaf length, leaf diameter, and fresh weight of leaves, and growth parameters, including leaf area (LA), leaf area ratio (LAR), leaf mass ratio (LMR), root weight ratio (RWR), relative growth rate (RGR), and net assimilation rate (NAR) were determined. The values of growth parameters were the highest for T_1. The highest and lowest NAR and RGR values were obtained for T_1 and T_3, respectively. The values of most growth traits, including fresh weight, NAR, and RGR were higher for V_1 than other varieties. T_1 provides high yield with comparatively less irrigation water and nutrient solution so it can be used to culture lettuce using aggregate hydroponics as.

Barman *et al.* (2016) reported that soilless cultivation is disease free and eco-friendly as well as getting popularity all over the world, both the developed and the developing countries. It has a great prospect in Bangladesh along with high space research to fulfil the lack of arable land where proper cultivable land is not available. So, soilless cultivation would be a better technique to produce the different kinds of fruits and vegetables as well as meet the global nutrition demand with making advance future.

Jayawardana *et al.* (2016) concluded that the simplified hydroponics system consisting Si sources rice hull:sand (3:2 v/v) media was effective in reducing the anthracnose disease caused by Colletotrichum gloeosporioides by more than 83 % and enhancing shoot and root length, fruit fresh weight, fruit length and fruit firmness of *Capsicum annuum* L. 'Muria F_1' in comparison with non-circulating liquid hydroponic system supplied with either NF or Albert's nutrient solution. Therefore, it could be concluded that simplified hydroponics system with a natural silicon sources, rice hull in the media would be a low cost and environmental friendly method for growing capsicum to enhance anthracnose disease resistance and also shoot length, root length, fruit length, fruit weight and fruit firmness were also increased significantly.

Jayawardana *et al.* (2016) concluded that the simplified hydroponic system composed of rice hull, as a natural silicon supplement could be used as a low cost environmental friendly growing method of capsicum to enhance resistance against anthracnose disease, and to improve plant growth and fruit quality.

Utobo *et al.* (2015) found that the carrot varieties were significantly different in vegetative and yield parameters measured under both conditions regardless of potting media. Lunga rossa ottusa 2 (V_2) performed best, followed by Technisem (V_1) and the least was that of Royal Sluis (V_3). In terms of potting media, significant effects were also observed in growth and yield of the three carrot varieties evaluated under both screen house and field conditions respectively. Medium 6 (composted rice hull + composted sawdust + cured pig dung + top soil) performed best under both conditions, followed by media 5 (composted rice hull + cured pig dung + top soil), compared to the rest of the media.

Hell *et al.* (2013) reported that the temperature of the nutrient solution influenced the behavior of sweet pepper changing the electrical conductivity (EC). They found that the increased in EC did not reduce sweet pepper productivity when the maximum temperature of the nutrient solution was limited at 26°C. They also found that cooling of the nutrient solution provided greater accumulation of biomass and higher water content in plants, increasing the productivity of hydroponic sweet pepper in the tropics.

Ghehsareh (2013) reported some physicochemical properties of rice hull media such as porosity (73 %), water holding capacity (88 %), bulk density (0.09g/cm3), organic matter content (88.52 %), electrical conductivity (2.24 ds/m) and pH (6.2).

Jayawardana *et al.* (2014) reported that capsicum plants treated with rice hull leachate showed a significant increase in weight of fruits/plant (51 %), fruit weight (37 %), fruit length (32 %), shoot length (60 %), root length (100 %), no of leaves (55 %) and leaf area (44 %).

Malek *et al.* (2012) reported that the highest seed yield (1321.53 kg/ha) was recorded from Brasilia Agroflora and the quality of seed (germination 83.20% and seed vigour index 12.21) was produced from the same variety, while the lowest seed yield (1193.70 kg/ha) and germination (79.42%) were obtained from New Kuroda. The net covered stecklings were recorded the highest seed yield (1495.33 kg/ha) and the quality of seed (germination 86.93% and seed vigour index 13.17) was produced from the same condition, while the lowest seed yield (1047.14 kg/ha) and germination (75.77%) were obtained from polythene covered stecklings. In case of combined effect, the highest seed yield (1576.07 kg/ha) was recorded from Brasilia Agroflora with net covered stecklings and that of the lowest (1000.10 kg/ha) from New Kuroda with polythene covered stecklings.

Yield of cucumber grown in bags with composted pig manure alone or mixed with perlite (50:50) was higher when bag height was 10 cm than 20 cm (Naddaf *et al.,* 2011).

Vaughn *et al.* (2011) found that addition of inorganic substances to organic ones has resulted in a better plant growth and higher yield probably owing to increasing water-holding capacity and aeration of peat. Better aeration of peat promotes vigorous root growth, which allows better growth of foliage and therefore increases whole yield of plants.

The highest cucumber yield was obtained with a 1:1 mixture of peat and vermiculite. Plants grown in 3:1 peat-vermiculite, 3:1 peat-perlite, 3:1 peat-coal ash out yielded those grown in peat alone. Higher cucumber fruit quality was obtained by the mixture of peat to vermiculite 1:1 than in 3:1 peat/vermiculite, 3:1 peat/perlite, 3:1 peat/coal ash or peat (Gao *et al.,* 2010).

Okafor and Okonkwo (2009) reported that rice husk is an agricultural by product which is poorly utilized. More than 100 million tons of rice hull is generated annually in the world.

Yahya *et al.* (2009) concluded that, certain chemical and physical properties of cocopeat can be improved through incorporation of burnt rice hull. The positive effects of burnt rice hull were seen in the elevation of nutrient availability (as indicated by higher EC) increased bulk density, air-filled porosity and available water. Improvement in chemical and physical properties following incorporation of burnt rice hull into cocopeat was reflected in a better plant growth.

Gruda (2009) reported that the highest total as well as marketable yield was produced with a mixture of 80% pumice + 10% perlite + 10% peat medium, providing about 30% more product in comparison to the soil. A number of authors have reported that dry matter, sugar, soluble solids, vitamins and carotenoids content in tomatoes; acidity and taste have better marks when grown in soilless culture systems compared to soil.
Tomato plants grown in perlite produced higher total marketable yield than plants grown in either of the other media (pine bark and rockwool) (Hanna, 2009).

Saparamadu (2008), found that rice husk has useful properties as a growing media such as low in weight, inert with respect to adsorption and desorption of nutrients and also has good drainage, aeration and low rate of decomposition.

Saparamadu *et al.* (2008) reported that simplified hydroponics system which consisted rice hull: river sand (3:2 v/v ratio) medium enhanced growth of bush beans and tomato.

Michael and Lieth (2008) studied that total pore space for most growing media is 1.5 – 2.8 times higher than the values found for common soils (about 35 percent V/V) and increase in total pore space will often decrease the water retention, increase oxygen transport and increase root penetration. These, in turn, will influence plant growth.

Growing media based on peat and peat with cocos derivatives were tested against mineral wool for tomato. Results showed that plants grown in the pure peat rooted more easily than those grown in the peat-coco or mineral wool but the total yield was similar for all media. Flavour tests demonstrated that plants grown on peat substrate produced more tasty fruits compared to mineral wool and peat with cocos derivatives. Tomato plants grown in the pure peat or peat with cocos derivatives developed less BER than in mineral wool. Flavour tests demonstrated that plants grown on peat substrate produced more tasty fruits under certain conditions (Grunert *et al.,* 2008).

Tehranifar *et al.* (2007) reported that the vegetative growth of a number of strawberry cultivars were higher in media with peat and cocopeat compared with 100% sand and perlite and in cocopeat 40% + perlite 60% some cultivars produced the highest number of fruits and yield per plant. The yield in substrates with peat or cocopeat was higher than in substrates with without peat or cocopeat.

Common purslane (Common purslane) was taller and fresh weights of leaves and stems were higher, when plants were grown in peat compared to vermiculite, coir or perlite-grown plants (Cros *et al.,* 2007).

Fanasca *et al.* (2006) reported that Iron, copper, zinc, boron, and manganese, become unavailable at pH higher than 6.5 in nutrient solution of Hydroponic system.

The content of dry weight, ascorbic acid and sugars in fruit differed to a small extent between tomato plants grown on straw or rockwool. The content of dry weight, ascorbic acid and sugars in fruit differed to a small extent between tomato plants grown on straw or rockwool (Nurzynski, 2006).

Samarakoon *et al.* (2006) reported that the EC values for hydroponic systems range from 1.5 to 2.5 ds m-1. Higher EC hinders nutrient uptake by increasing osmotic pressure, whereas lower EC may severely affect plant health and yield.

Dufour and Guéri (2005) reported that when a nutrient solution is applied continuously, plants can uptake ions at very low concentrations. So, it has been reported than a high proportion of the nutrients are not used by plants or their uptake does not impact the production. It was determined that in anthurium, 60% of nutrients are lost in the leachate.

Different physiological disorders in broccoli include brown bud, bud deformation, bracting and hollow stem, which adversely affect the quality of the product. They are related to cultivar sensitiveness but also to nutritional disorders and/or to different stressing factors. Two growing media (perlite and coconut coir dust) were tested in plants grown in containers (San Bautista *et al.,* 2005).

Schnitzler *et al.* (2004) reported that, low-tech system suitable for long-term cultivation of bell pepper (*Capsicum annuum* L.) using wood fibre as substrate was further simplified. In a two years study, four different types of slow release fertilizers (SRF) in mixed or sole application in different container and closed irrigation systems (10 L plastic pots fitted with drips, troughs with continuous flow, troughs with drips and grow bags with drips) were investigated for 40 weeks in organic substrate. The low-tech systems with SRF were compared with re-circulating liquid feed (LF), PAR regulated irrigation, and EC dependent nutrient replenishment.Plant growth, fruit yield and quality parameters were better in the pot system fitted with drippers than in other container systems. High marketable yield of 12.80 kg m-2 was obtained in Mat 4 (mixture of 3 and 6 month types SRF) formulated fertilizer. The trend for other horticultural characters was also positive in Mat-4 combination.

Urrestarazu (2004), studied that the pH value determines the nutrient availability for plants. Accordingly, its adjustment must be done daily due to the lower buffering capacity of soilless systems.

Voogt (2002) studied that in closed systems of hydroponic nutrient solution, the loss of nutrients from the root environment is brought to a minimum.

Kobryń (2002) reported that higher yield (total, marketable and early) and lower weight per fruit of seven tomato cultivars were also obtained when grown on rockwool than on coir straw – Cocovita. Growing medium had no distinct effect on the content of sugars and ascorbic acid, but tomatoes grown on Cocovita contained fewer mineral elements. Fruits from plants grown on Cocovita contained more dry matter than those grown on rockwool.

2.2. Impact of watering on growth, yield and quality attributes

Putra and Yuliando (2015) reported that Soilless cultivation is intensively used in protected agriculture to improve control over the growing environment and to avoid uncertainties in the water and nutrient status of the soil. Recently the type of soilless culture transformed from open to close-loop system. This system is known for better result in water use efficiency, while maintaining the quality of the yield. Traditional techniques in protected agriculture may be highly productive but their relative use of water may be high due to run off and infiltration; thus, the water-use efficiency may be relatively low.

Water consumption for hydroponic and conventional production of lettuce in Arizona was comparable on an area basis, but when normalized by yield the average was 13 ± 2.7 times less water demand in hydroponic production compared to conventional production. Specifically, hydroponic lettuce production had an estimated water demand of 20 ± 3.8 L kg-1 per year, while conventional lettuce production had an estimated water demand of 250 ± 25 L kg-1 per year. This comparison also the difference between open field production (conventional) and greenhouse production (hydroponics) plays an important role. It is well-known that greenhouse cultivation improves water use efficiency compared to open field production (Barbosa *et al.*, 2015).

Where the water and nutrients are supplied as in conventional soil culture and the surplus (about 25%) nutrient and water is allowed to run to waste. The attraction of this technique (open system) is its similarity to soil as a growing medium and many similar techniques have been developed using a variety of inert media such as rockwool, sand, vermiculite, perlite and pumice. The two most important features relating to the substrate are that it is inert and that it has a great water-holding/release capacity. The maintenance of an appropriate water and nutrient level within the substrate is essential to prevent plant stress. Waste substrates can be used as a soil conditioner but its use is very limited. Rockwool can be recycled (re-used) for up to three years, after which it loses its water-holding capacity. A major disadvantage of open systems is that a proportion of the water and nutrients must be allowed to run to waste.

This lowers water-use efficiency and contaminates groundwater supplies with salts. There is also a pollution problem arising from the need to dispose of the substrate on an annual or biannual basis (Burrage, 2014).

Water use in soilless cultivation (substrates like mineral wool and NFT systems) is potentially much lower than in soil-based (conventional) systems. Whether this potential is realised depends on the irrigation strategy, the application of recirculation, and the quality of the irrigation water. Soilless cultivation systems can in principle obtain zero water losses, because the nutrient solutions can be recirculated (Beerling *et al.,* 2014).

The advantages of this system are: absence of soil-borne pathogens; safe alternative to soil disinfection; nutrients and water are applied more evenly to the plants, therefore reducing wastage and providing a situation closer to the ideal growing conditions; soilless cultivation has the capacity for increased yield. (Burrage,2014; Savvas *et al.,* 2013).

Nutrient film technique (NFT) maximizes water-use efficiency by recycling all the water and nutrients not used by the plants. The main requirement in changing from a soil-based system to NFT is the upgrade in management skills—the whole system reacts much faster than conventional (Burrage, 2014).

About 90% (8,500 ha) of the Dutch greenhouse horticulture consists of soilless cultivation. In these greenhouses collection and re-use of drain water is obligatory. That does not result in fully closed systems, as discharge of nutrient solution is sometimes needed (Beerling *et al.,* 2014).

The total water use of 6831 and 8632 m3 ha-1 for tomatoes grown on mineral wool either with or without re-use of drain water (closed-loop irrigation). Hence, re-use of drain water resulted in 21% water saving. Commercial yield and quality (Brix) were the same in both treatments (Stanghellini, 2014).
The fertilizers containing the nutrients to be supplied to the crop are dissolved in the appropriate concentration in the irrigation water and the resultant solution is referred to as "nutrient solution" (Savvas *et al.,* 2013).

In soilless crops, the plant roots may grow either in porous media (substrates), which are frequently irrigated with nutrient solution, or directly in nutrient solution without any solid phase. In recent decades, supplying nutrient solution to plants to optimize crop nutrition (fertigation or liquid fertilization) has become routine cultural practice, not only in soilless culture but also in soil-grown greenhouse crops. Hence, the drastically restricted volume of the rooting medium and its uniformity are the only characteristics of soilless cultivated crops differentiating them from crops grown in the soil (Savvas *et al.*, 2013).

Soilless cultivation systems can obtain zero water losses, because the nutrient solutions can be recirculated. In soil, precision irrigation can reduce water losses significantly but it will never be zero (Voogt *et al.*, 2012).

Because of a better control of the root environment, soilless cultivation commonly results in higher yields than soil-based cultivation. Soil-based cultivation is likely to use 50–100% more water as a result of water losses from overwatering the soil and evaporation from the soil surface. If we consider yield per unit of water applied, soilless systems may increase yield substantially over soil-based systems (Engindeniz and Gül, 2009).

Zucchini plants grown in a closed soilless system (cocofibre, perlite and pumice culture) exhibited higher yield (total marketable and fruit number), harvest index, and water-use efficiency compared with those grown in soil (Rouphael *et al.*, 2004).

Hydroponics technology with recirculation reduces water use for crops by 90% compared to conventional soilbased systems (Bradley and Marulana, 2001).

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The materials used and methods followed during entire period of the study are described in this chapter. A pot experiment was conducted at the central farm of the Sher-e-Bangla Agricultural University, Dhaka.

3.1 Description of the experimental site

3.1.1 Geographical location

The experimental site was 23º77′ N and 90º33′ E latitude and at an altitude of 8.6 m from the sea level.

3.1.2 Climate

The climate of the locality is subtropical which is characterized by high temperature and heavy rainfall during Kharif season (April-September) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature.

3.2 Details of the experiment

3.2.1 Experimental Period

The experiment was conducted during the period from December 2018 to March, 2019.

3.2.1 Treatments

The experiment comprised of two factors:

Factor A: Growing media

M_1- cocopeat
M_2- sawdust
M_3- rice husk
M_4- equal mixtures of cocopeat, sawdust and rice husk

Factor B: Watering frequencies

W_1- one day interval @ 200 ml
W_2- two days interval @ 300 ml
W_3- three days interval @ 400 ml
W_4- four days interval @ 500 ml

There were 16 (4×4) treatments combination such as

M_1W_1, M_1W_2, M_1W_3, M_1W_4, M_2W_1, M_2W_2, M_2W_3, M_2W_4, M_3W_1, M_3W_2, M_3W_3, M_3W_4, M_4W_1, M_4W_2, M_4W_3, M_4W_4.

The treatments were randomly assigned in experimental units/pots.

3.2.2 Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications.

3.3 Collection of seed and other organic substrates

The seeds of Carrot cv. 'NEW KURODA' were used in the experiment. The seeds were kept in a sealed packet, collected from Gulistan, Dhaka. The cowdung, cocopeat, sawdust, rice husk, pot etc were collected from Agargaon Nursery,Dhaka.

3.4 Growing media preparation

Cocopeat, Sawdust and Rice husk were soaked in a big bowl for 24 hours. It was washed well with water and spread in a polythene sheet for 3 hours. Then they were mixed well to prepare media mixture.

3.5 Pot preparation

The diameter of the pot was 25 cm top, 15 cm bottom diameter and 25 cm depth were collected from the local market and cleaned before use. 40% cowdung were added to each 8L plastic pot as a wetting agent for carrot growing. Each plastic pot which containing about 5 liters of substrates on a volume basis. The pot were prepared with as per treatment.

3.6 Seed soaking

Before sowing, the seed were soaked in water for 24 hours and then wrapped with a piece of thin cloth prior to planting. Then the moistened seeds were spread over polythene sheet for two hours to dry out the surface water, this operation was to facilitate for quick germination of seeds.

3.6.1 Sowing the seeds

Seeds were sown in each pot on December 2018. There were three holes in each pots and two seeds were placed in each hole at a depth of 1.5 cm. Three plants were allowed per pot others were removed by thinning.

3.7 Application of water:

As per treatments water spray applied at entire crop growth stage. The experiment was designed using surface watering system, directly at the base of the plant grown in organic media for up to 85 days of the entire growing season of 100 days after seed sowing.

3.8 Nutrient solution

Nutrient solution collected from Horticulture Research Center, BARI. Nutrient solution were applied at recommended doses.

3.9 Intercultural operations

3.9.1 Thinning

Emergence of seedlings started after 5 days from the date of sowing. Seedlings were thinned out two times. First thinning was done after 15 days of sowing (DAS).The second thinning was done after 10 days from first thinning. A plant was kept in each hill and others were removed by thinning.

3.9.2 Weeding

Hand weeding was done four to five times to remove the weeds and to keep the pots neat and clean.

3.9.3 Plant protection

Plants were infested with insect (cut worm) to some extent which was successfully controlled by applying Emitap @ 1 ml 2 L^{-1} of water.

3.10 Harvesting

The crop was harvested on March, 2019 after 100 days from seed sowing when the foliage turned pale yellow. It was done by uprooting the plants by hand carefully. The fibrous roots adhering to the conical roots were removed and cleaned.

3.11 Data Collection

Data were collected on plant growth, yield and quality attributes of carrot. The following parameters have been set for recording data and interpreting results. A brief outline of the data recording procedure followed during the study is given below:

3.11.1 Plant height (cm)

In order to measure the plant height, a centimeter (cm) by a meter scale at 30, 45, 60, 75 and 100 days after sowing (DAS) from the point of the attachment of the leaves to the root (ground level) up to the tip of the longest leaf.

3.11.2 Number of leaves

Number of leaves per plant were counted at 30, 45, 60, 75 and 100 days after sowing (DAS). All the leaves of the plants were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from the counting.

3.11.3 Fresh weight of leaves (g)

Leaves were detached by a sharp knife. The fresh weight of the leaves, which was collected at harvest time was taken and expressed in gram and the mean value for the unit plant was recorded. The weight was measured by a digital balance.

3.11.4 Length of root (cm)

The average length of the root was recorder in cm by a meter scale from the point of attachment of the leaves (proximal end) to the last point of the root (distal end) in each treatment combination.

3.11.5 Diameter of root (mm)

The average diameter of the root was measured at the upper, middle and lower portion of the root at harvest with the help of a slide caliper.

3.11.6 Fresh weight of root (g)

Roots were detached by knife from the attachment of leaves and after the cleaning the soil and thin roots, the fresh weight of every root was taken by a digital balance.

3.11.7 Dry matter content of leaves (%)

Fresh leaves of l00g as per treatment sample were weighted and cut into small pieces. After sun drying for 3 days the samples were oven dried at 72 hours. Then the samples were weighted by an electrical balance and the mean value was calculated.

The weight of dry leaves were calculated by using the following formula

% Dry matter of leaves= Constant dry weight of leaves (g) / Fresh weight of leaves (g) × 100

3.11.8 Dry matter content of roots (%)

Immediately after harvest, roots were cleaned thoroughly by washing with water and air dried. Then from several roots, a sample of 100g was taken and cut into small pieces were sun dried for 3 days and then oven dried for 72 hours at 70°-80°c temperature. After oven drying, the samples were weighted by an electrical balance and dry matter content was calculated by using the following formula—

% Dry matter of root = Constant dry weight of root / Fresh weight of root × 100

Quality attributes

Brix, Vit-C were determined in Dr. MA Wazed Miah Research Centre of Sher-e-Bangla Agricultural University, Dhaka. β-carotene, sugar, ash, protein, moisture, carbohydrate was analysed in Bangladesh Council of Scientific and Industrial Research (BCSIR),Dhaka. Mineral analysis (Nitrogen, phosphorus, potassium, calsium, magnesium) was done in Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur.

3.11.9 Determination of brix (%)

Juice extracted from sample of carrot each treatment was used to determine the Brix . Brix were determined by hand refractometer (ERMA, Tokyo, Japan) of 58-92 % range, at room temperature. By aiming the front end of the refractometer in the direction of a bright light, the adjusting ring of the diopter was adjusted until the reticle could be seen clearly. Adjustment of null was done by opening the cover plate and putting one or two drops of distilled water on the prism. The cover plate was closed and pressed lightly and then the correcting screw was adjusted to make the light/dark boundary coincide with the null line.

The cover plate was opened and the surface of the prism was cleaned with a piece of soft cotton flannel. 1 or 2 drops of the juice was placed on the prism surface. The cover plate was closed and pressed lightly and then the corresponding scale of light and dark boundary was read off. This reading was taken as the TSS Brix of the Carrot.

3.11.10 Determination of Vitamin C content (mg/100g)

The ascorbic acid content of carrot was determined by 2,6-dichlorophenol indophenol visual titration method (Ranganna, 1986) as detailed here under.

4 g of oxalic acid was placed in a beaker and dissolved in 100 ml of distilled water. In a beaker, 52 mg of 2, 6-dichlorophenol indophenol dye and 42 mg $NaHCO_3$ were dissolved and the volume made up to 200 ml using hot distilled water. 100 mg of ascorbic acid was dissolved in 100 ml of 4 percen toxalic acid.10 ml of stock standard solution was diluted to 100 ml using the acid (4 percent oxalicacid) mixture. Therefore the standard ascorbic acid contained 0.1 mg of ascorbic acid per ml solution. 1 ml of vitamin C solution containing 1 mg of vitamin C was added to 5 ml of 4 percent oxalic acid and titrated against dye solution taken in the burette.

The titre value was noted down and the titration repeated till identical values were obtained.

Calculation of Dye factor

Dye factor $= \frac{X}{\textbf{Titre (ml)}}$ Here, X= 0.5

Preparation of sample

A 10g of juice of carrot was taken in a 100 ml volumetric flask and thoroughly mixed with 50 ml of 4 percent oxalic acid. The mixture was filtered through a thin cloth, and the filtrate volume made up to 100 ml using 4 percent oxalic acid. 10 ml of this was pipetted out and titrated against 2, 6dichlorophenolindophenol dye solution.

Procedure

A 10 ml of filtered sample and 5 ml of 4 % oxalic acid were taken ina conical flask and titrated against the 2, 6 dichlorophenol indophenoldye solution in a burette. The endpoint was light pink colour that persisted for 5-10 seconds.

Calculation

$$\text{Ascorbic acid} = \frac{\text{Value titre(ml)} \times \text{ Dye factor (0.081)} \times \text{ Volume made up (100ml)} \times 100}{\text{Volume taken for titration (10ml)} \times \text{Weight of pulp sample(10g)}}$$

3.11.11 *β*- carotene (μg/100g)

Carotenoids are generally separated by chromatography (Herrero-Martinez *et al.,* 2006).

Reagents

1. Acetone
2. Petroleum ether (b.p. 65-70^0 C)
3. Anhydrous sodium sulphate (Na_2SO_4), granular
4. Adsorbent: mixintimately one part by weight of magnesium oxide (MgO) with three parts of Supercel
5. Eluent: 3% acetone in petroleum ether

Standard curve

Weigh accurately 25 mg of β-carotene (pure β- carotene ampoules are available). Dissolve in 2.5 ml of chloroform and make up to 250 ml with petroleum ether (1 ml = 0.1 mg or 100 mg). Dilute 10 ml of this solution to 100 ml with petroleum ether (1 ml = 10 mg). Pipette 5, 10, 15, 20, 25 and 30 ml of this solution to separate 100-ml volumetric flasks, each containing 3 ml of acetone. Dilute to mark with petroleum ether. The concentration will be 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mg per ml. Measure the color at 452 nm using 3% acetone in petroleum ether as blank. Plot absorbence against concentration.

Extraction

Weigh a representative sample (5 to 10 *g* or up to 25 *g)* containing 10 to 500 μg of carotene. If the sample contains too much of sugar, it may be washed with water on a fritted glass funnel under suction. Grind in a pestle and mortar with acetone. Use pure sand, if necessary, to assist grinding. On some occasions, after 2 or 3 extractions, the residue forms a resinous mass and cannot be ground. In such cases, addition of 1 or 2 ml of water enables further grinding. Filter through a wad of cotton into a conical flask. Continue extraction and filtration till the residue is colorless.

Transfer the filtrate to a separating funnel. Add 10 to 15 ml of petroleum ether. Transfer the pigments into the petroleum ether phase by diluting the acetone with water or water containing 5% sodium sulphate.

Filter the petroleum ether Extract, through anhydrous Na_2SO_4. Concentrate the petroleum ether extract, if necessary, and Make up to a known volume (25 ml). Saponification is essential for materials in which xanthophyll ester occur as in some varieties of peaches, apricots, mangoes etc. Saponify by blending the weighed sample with 150 ml of 12% alcoholic KOH for 5 min at room temperature in a blender. Add 10 to 15 ml of petroleum ether Shake the contents of the separating funnel gently for at least 30 sec and allow the layers to separate. If there is more than a slight yellow color in the alcohol water laver, acid water or water containing 5% Na_2SO_4 to aid the transfer of pigments to the petroleum ether. Repeat extraction with petroleum ether the alcohol-water layer is colorless.

Chromatographic separation

Preparation of column:

Attach the adsorption tube to a Buchner flask and place a plug of non-absorbent cotton or glass wool into the constriction. Apply vacuum and add enough adsorbent to make the column an in length. Add more adsorbent and repeat the steps until the column is approximately 10 cm in length. Place 1 cm of Na_2SO_4 over the top of the column.Adsorption and elution: Wet the column by washing with 25 to so ml of petroleum ether. While the last ml of the petroleum ether is still above the Na_2SO_4, disconnect the vacuum and transfer the adsorption column to a clean dry Buchner flask. Pipette out an aliquot (5 to 10 ml) of the extract to be chromatographed onto the column and apply suction. Continue the washings until the desired pigments have moved off the column and the eluent is colourless. Transfer the contents of flask to a volumetric flask and dilute to volume with eluent. (The concentration of carotene should be 1 to 3µg per ml.) Measure the intensity of the color at 452 nm using 3% acetone in petroleum ether as blank. Read the concentration of β-carotene in µg per ml in the solution from the standard curve. To measure total carotenes (carotenes, xanthophylls and xanthophyll esters), pipette an aliquot of the petroleum ether extract of the sample (unadsorbed) to a 100 ml volumetric flask containing 3 ml of acetone and dilute to mark with petroleum ether. Measure the color at 452 nm.

Calculation

µg of carotene per 100g =Concentration of carotene in solution as read from standard curve (µg/ml) x Final volume x Dilution x 100 / Wt of sample

3.11.12 Determination of Sugar Reagents (%)

Sugar reagents were estimated by the Fehling reagent method (AOAC, 1990).

1) Fehling A: Dissolve 69.28-g copper sulphate ($CuSO_4.5H_2O$) in distilled water. Dilute to 1000 ml. Filter and store in amber coloured bottle.

2) Fehling B: Dissolve 346 g Rochelle salt (potassium sodium tartrate) (K Na $C_4H_4O_6$. $4H_2O$) and 100 g NaOH in distilled water. Dilute to 1000 ml. Filter and store in amber coloured bottle.

Standardization of Fehling's solution:

Prepare standard dextrose solution into a 50ml. burette. Find the titre (volume of dextrose solution required to reduce all the copper in 10 ml. of Fehling solution) corresponding to the standard dextrose solution (Refer table below).Pipette 10 ml of Fehling's solution into a 300 ml of conical flask and run in from the burette almost the whole of the standard dextrose solution required to effect reduction of all the copper, so that more than one ml will be required later to complete the titration. Heat the flask containing mixture over wire gauze. Gently boil the contents of the flask for 2 minutes. At the end of two minutes of boiling add without interrupting boiling, one ml. of methylene blue indicator solution. While the contents of the flask begins to boil, begin to add standard dextrose solution (one or two drops at a time) from the burette till blue color of indicator disappears. The titration should be completed within one minute so that the contents of the flask boil together for 3 minutes without interpretation. Note the titre (that is total volume in ml. of std. dextrose solution used for the reduction of all the copper in 10 ml. of Fehling's solution). Multiply the titre (obtd. by direct titration) by the number of milligrams of anhydrous dextrose in one millilitre of standard dextrose solution to obtain the dextrose factor. Compare this factor with the dextrose factor and determine correction.Transfer test sample representing about 2- 2.5 gm sugar to 200 ml volumetric flask, dilute to about 100 ml and add excess of saturated neutral Lead acetate solution (about 2 ml is usually enough). Mix, dilute to volume and filter, discarding the first few ml filterate. Add dry Pot. or Sod. Oxalate to precipitate excess lead used in clarification, mix and filter, discarding the first few ml filterate. Take 25 ml filterate or aliquot containing (if possible) 50 – 200 mg reducing sugars and titrate with mixed Fehling A and B solution using Lane and Eynon Volumetric method.

For inversion at room temperature, transfer 50 ml aliquot clarified and deleaded solution to a 100 ml volumetric flask, add 10 ml HCl (1+ 1) and let stand at room temperature for 24 hours. (For inversion, the sample with HCl can be heated at 700 C for 1 hr. This saves time and makes the whole process shorter). Neutralise exactly with conc. NaOH solution using phenolphthalein and dilute to 100 ml.

Titrate against mixed Fehling A and B solution (25 ml of Fehling's Solution can be considered for the purpose) and determine total sugar as invert sugar (Calculate added sugar by deducting reducing sugars from total sugars). Reducing and total reducing sugar can be calculated as;

Reducing sugar (%) =

mg. of invert sugar x vol. made up x 100 / TR x Wt. of sample x 1000

Total reducing sugar (%) =

mg. of invert sugar x final vol. made up x original volume x 100/ TR x Wt. of sample x 1000

Total sugar (as sucrose) (%) = (Total reducing sugar – Reducing sugar) x 0.95

Added sugar = Total sugars – Reducing sugars

3.11.13 Determination of ash (%)

Ash was calculated as following the method of (Raghuramulu *et al.*, 2003).

10 gram of the sample was weighed accurately into a crucible. The crucible was placed on a clay pipe triangle and heated first over a low flame till all the material was completely charred, followed by heating in a muffle furnace for about 5-6 hours at 600°C. It was then cooled in a desiccator and weighed. To ensure completion of ashing, the crucible was then heated in the muffle furnace for 1h, cooled and weighed. This was repeated till two consecutive weights were the same and the ash was almost white or grayish white in color. Then total ash was calculated as following equation:

Ash content (g/l00 g sample) = Wt of ash × 100 / Wt of sample taken (Raghuramulu et al., 2003).

3.11.14 Determination of protein (%)

Protein content was estimated according to the procedure of modified Kjeldahl method (Yoshida *et al.*, 1976).Turned on digestion block and heated to appropriate temperature. Accurately weighted approximately 0.5 g tomato sample. Recorded the weight. Placed carrot sample in digestion tube. Repeated for two more samples.

Added one catalyst tablet and appropriate volume (e.g.7 ml) of concentrated sulfuric acid to each tube with tomato sample. Prepared duplicate blanks: one catalyst tablet + volume of sulfuric acid used in the sample + weigh paper (if weigh paper was added with the tomato sample). Placed rack of digestion tubes on digestion block. Covered digestion block with exhaust system turned on. Let samples digest until digestion is complete. The samples were clear with no charred material remaining. Took samples off the digestion block and allow to cool with the exhaust system still turned on. Carefully diluted digest with an appropriate volume of distilled water.

Distillation:

Followed appropriate procedure to start up distillation system. Dispensed appropriate volume of boric acid solution into the receiving flask. Placed receiving flask on distillation system. Make sure that the tube coming from the distillation of the sample is submerged in the boric acid solution. Put sample tube in place, making sure it is seated securely, and proceed with the distillation until completed. In this distillation process, a set volume of NaOH solution are delivered to the tube and a steam generator distilled the sample for a set period of time.

Upon completing distillation of one sample, proceed with a new sample tube and receiving flask. After completing distillation of all samples, shut down the distillation unit.

Titration:

Recorded the normality of the standardized HCl solution as determined. Put a magnetic stir bar in the receiver flask and place it on a stir plate. Kept the solution stirring briskly while titrating, but do not let the stir bar hit the electrode. Titrated each sample and blank to an endpoint pH of 4. Recorded volume of HCl titrant used. While using a colorimetric endpoint, put a magnetic stir bar in the receiver flask, placed it on a stir plate, and kept the solution stirring briskly while titrating.

Titrated each sample and blank with the standardized HCl solution to the first faint gray color. Recorded volume of HCl titrant used.

Calculation: Moles of HCl = moles of NH_3 = moles of N in the sample

A reagent blank was ran to subtract reagent nitrogen from the sample nitrogen.

% N = N HCl × Corrected acid volume g of sample ×14 g N mol ×100

A factor was used to convert percent N to percent crude protein. Most proteins contain 16% N, so the conversion factor is 6.25 (100/16 = 6.25).

% N/0.16 = % protein

3.11.16 Determination of Moisture (%)

The moisture content of the fruit is normally used as indicator of its shelf life. Experimental samples were subjected to moisture and dry matter analysis as per Association of Analytical Communities [AOAC] protocols. Here, 10 gm fruit was taken in crucible and placed in an ovent,he moisture content was determined by measuring weight loss of measured sample in a moisture box by desiccation in an oven maintained at 80°C for 72 hours until constant weight attained. The dry matter content was estimated as the difference of sample weight and moisture content.

$$\text{Moisture content (\%)} = \frac{(\text{Initial weight} - \text{Final weight}) \times 100}{\text{Initial weight}}$$

3.11.16 Determination of Carbohydrate (g/100g)

Carbohydrates are compounds made up of carbon hydrogen and oxygen, thus they are regarded as hydrates of carbon represented as C (H_2O). They are of special importance as they constitute more than 50% of the dry weight of most plants**.**

Carbohydrate = 100 – (Moisture + Ash + Protein)

3.11.17 Determination of Nitrogen (%)

Total nitrogen contents in plant samples collected at 15, 30, 45. 60. 75.90 DAE, at harvest and in grain were determined by Kjeldahl method following H_2SO_4- Salicylic acid digestion distillation and titration (Yoshida *et al*., 1976).

Digestion procedure

A Kjeldahl flask (100 ml) was taken. Then 0.1 g of oven-dried finely ground plant sample was placed in the Kjeldahl flask. Then 0.5 g of' catalyst made of K_2SO_4, CuSO4.5H-O and selenium powder in the ratio of 9:1:0.1 was put into the flask.

Then 5 ml cone. H_2SO_4-salicylic acid mixture was added to the flash. The Marsh was then swirled until the acid and catalyst mixed with the sample.

The task was heated cautious on a burner stand inside the fume hood.11 first heating was done son about 15 minutes. When trothing had ceased, the heat is increased until the digest was clear. The mixture was boiled and heating was continued so that H_2SO_4-Salicylic acid mixture condensed to about one-third of the way up the neck of the digestion flask. When the color of the mixture had turned green, it was boiled further for 30 minutes.The digest was cooled to room temperature. About 10 ml distilled water was added slowly with shaking. The solution was cooled and transferred into 100 ml volumetric flask. The Kjeldahl flask was rinsed three times with distilled water to complete the transfer. The solution was cooled and diluted up to the marked level. A blank (no, sample) was prepared in the same way as mentioned above.

Steam distillation:

From the stock solution 10 ml plant digest was taken out and poured into the distillation chamber through the funnel. The funnel was washed with small amount of distilled water. Then 5 ml 40% NaOH solution was added through the funnel to the distillation chamber and the funnel was washed with small amount of distilled water. The stopcock connecting the funnel and distillation chamber was closed. Then 5 ml of 4% H_3BO_3 solution was taken to a conical flask which was marked to indicate a volume of 50 ml. The flask was placed under the condenser of distillation apparatus so that the end of the condenser was about 4 cm above the surface of H_3BO_3. Distillation was commenced immediately. When the distillate reached 50 ml mark. distillation was stopped. The tip of condenser was rinsed with distilled water. The distillation of the blank was followed in the same manner as sample solution. Then the distillate was titrated against 0.02 N H_2SO_4 in a micro burette. The titration of the blank solution against 0.02 N H_2SO_4 was done.

Calculation:

% Nitrogen = 14.007 ×0.02 N H_2SO_4 × f × (T - B) x 100/X × 100/Y

Where, 1N H_2SO_4 standard solution (1 ml) = 14.007 mg NH_4-N

T =Sample titrated amount (ml)

B =Blank titrated amount (ml)

X =Amount of soil digest taken from 100 ml volumetric flask (10 ml)

Y =Plant sample weight (0.1 gm)

100 = Total digested volume (ml)

100 = Percent of nitrogen

3.11.18 Determination of phosphorus (%)

Dried plant materials were digested with concentrated HNO_3 and $HClO_4$ mixture as (Teh and Talib, 2006) for determination of total phosphorus content.

Digestion procedure:

Oven-dried plant sample of 0.5 g was taken in a 50 ml boiling flask. Then 5 ml of nitric per chloric acid solution was added to the boiling flask. The flask was placed on cool hot plate and the temperature was turned to 375°F F and the digestion was allowed for 2 hours. The flask was then removed and 15 mi distilled water was added to the lash. The flask was agitated and heated to dissolve the ash. The contents were filtered through a filter paper (Whatman No. 42) in a 100 ml volumetric flask and then distilled water was added to make the volume up to the mark (stock solution).

Dilution of sample solution:

An amount of 10 ml plant extract (stock solution) was taken in a 100 ml volumetric task and distilled water was added up to the mark.

Measurement of absorbance by AAS:

The instrument (Atomic Absorption Spectrophotometer. Model No. 170-30.HITACHI. Japan) was calibrated with standard solutions of K and a calibration curve was prepared by the series of standard solutions. Atomic absorption spectrophotometer readings of each standard solutions and plant extracts were recorded at wavelength of 766.5 nm.

Total P (%) = (S-B) × (100ml /10ml) × (50ml / 0.5g) × 1/10

3.11.19 Determination of potassium (%)

Oven dried plant materials were digested with concentrated HNO3 and HClO4 mixture (Teh and Talib, 2006) for determination of total potassium content.

Total K (%) = (S-B)×(100ml/10ml) ×(100ml/0.5g) × 1/102

3.11.20 Determination of Calcium (%)

Ca was determined by atomic absorption spectrophotometer conferring the procedure of (Miyazawa *et al*., 2008).

Dried plant materials were digested with concentrated HNO, and HCIO, mixture for determination of total calcium content.

Calculation

Total Ca (%) = (S-B) × (100ml/10ml) × (100ml /0.5g) × 1/10

3.11.21 Determination of Magnesium (%)

Mg was determined by atomic absorption spectrophotometer conferring the procedure of (Miyazawa *et al*., 2008).

Dried plant materials were digested with concentrated HINO; and HCIO mixture for determination of total magnesium content.

Calculation

Total Mg (%) = (S-B) × (100ml / 10ml) × (100ml/0.5g)×1/ 104

3.12. Statistical analysis

Analysis of variance was performed in order to assess growth, yield and nutritional quality of Carrot in response to growing media and water frequencies. LSD tests were used to determine variances between each treatment where $P<0.05$ was considered as significant. Statistical analysis were carried out using IBM SPSS Statistics version 20.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

This experiment was conducted in order to find out how different growing media and watering affects the growth, yield and quality of carrot. Different growing media and watering effects and their interactions with the growth, yield and quality attributes of carrot have been presented in different tables and figures and discussed in this chapter. The results of the experiment and possible interpretations were provided under the following headings.

Growth parameter

4.1 Plant height

The growing media is an essential factor considering plant height. In the present study, the height of the plant was significantly influenced by different growing media of carrot at different days after sowing (Figure 1 and appendix III). The highest plant height (18.01, 30.39, 41.60, 45.45 and 47.17 cm) was observed at 30, 45, 60, 75 and 100 DAS obtained from M_1. On the other hand, the shortest plant height (9.47, 18.59, 36.75 and 44.89 cm) was observed from M_4 at 30, 45, 60 and 100 DAS. At 75 DAS the shortest plant height (42.56 cm) was obtained from M_3 treatment.

Statistically significant variation was recorded in terms of plant height due to the different level of watering at different days after sowing (DAS) (Figure 2 and appendix III). The plant height was increased with increasing level of watering. The highest plant height (15.55, 26.46, 44.91, 51.79 and 53.92 cm) obtained from W_2 at 30, 45, 60, 75 and 100 DAS. On the other hand, however, the lower plant height (13.29, 23.20, 35.54, 39.75 and 42.36 cm) was obtained from the W_3 at 30, 45, 60, 75 and 100 DAS.

Significant variation was observed in the case of plant height with the combined effect of growing media with different levels of water (Table 1 and appendix III). Maximum plant height (19.48, 33.81, 49.89, 54.24 and 56.51 cm) was recorded from the M_1W_2 treatment combination at 30, 45, 60, 75 and 100 DAS.

On the other hand, the lowest plant height (7.85, 16.75, 34.06, 38.06 and 40.89 cm) was recorded from the treatment combination M_4W_3 at 30, 45, 60, 75 and 100 DAS.

The increased plant height observed in cocopeat based media with the application of water two days interval @ 300 ml (W_2). The increased plant height observed in the experiment is due to cocopeat having a high water holding capacity, aeration, EC with low bulk density association, and a strong nutrient supply with EC acceptance rate over the growing period. The highest plant height was recorded in cocopeat media. The reason could be the variation in nutrient contents in different types of rooting media. Bassiony (2006), stated that in onion, relatively high levels of nutrients are required for optimum growth and development at early stage and adequate moisture supply is most suitable during the early growth. Rahman *et al.* (2018) stated that, cocopeat has a maximum capacity for water retention, aeration, and EC, and provides a good nutrient source for growing bitter gourds. Moldes *et al*. (2007) they claimed that the application of mature compost at reasonable rates improved plant growth and soil physical properties, and increased the available soil nutrient levels.

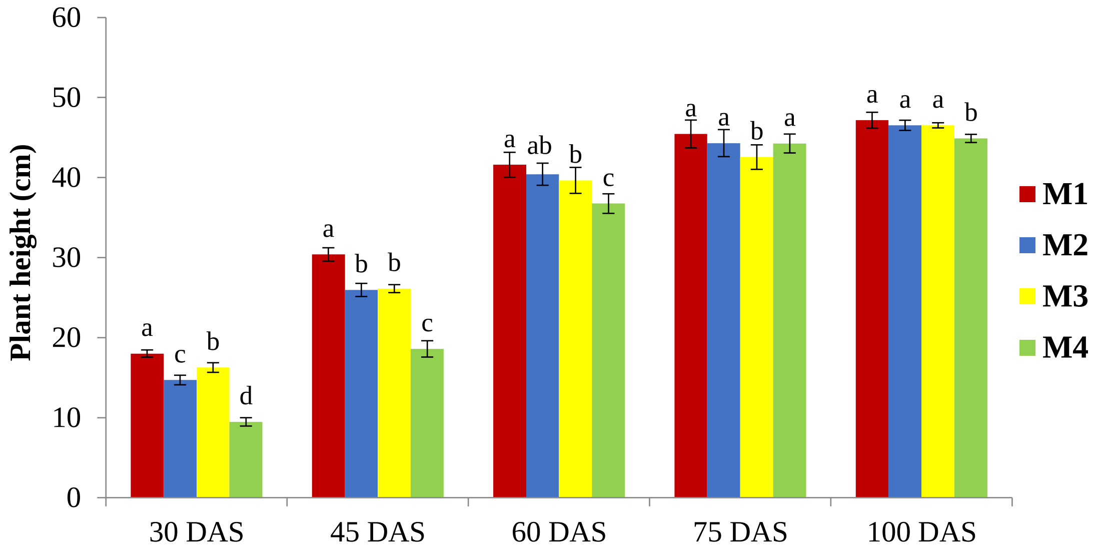

Figure 1. Effects of different growing media on the plant height of carrot at different days after sowing.

Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

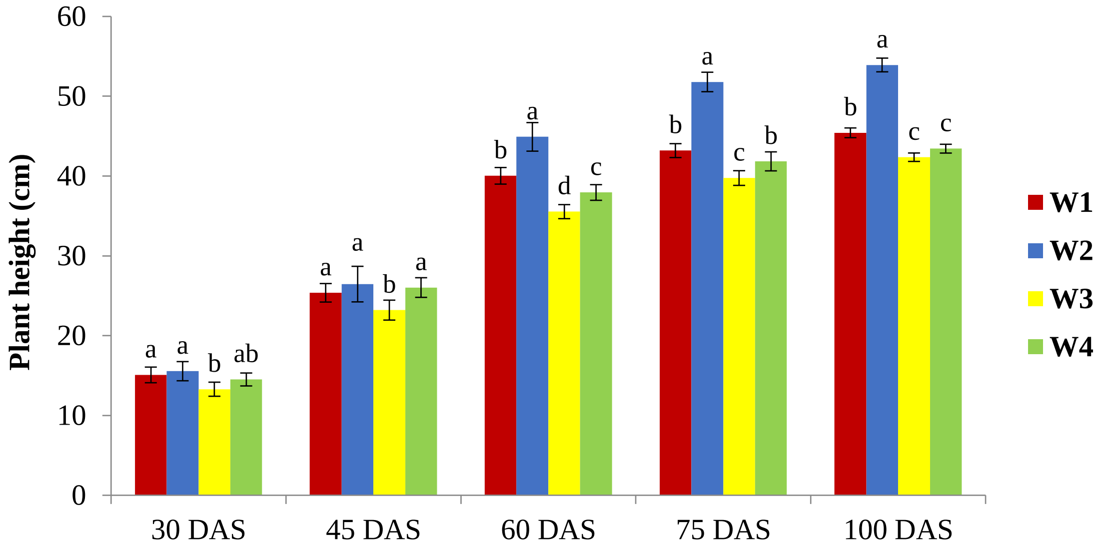

Figure 2. Effects of different level of water application on the plant height of carrot at different days after sowing.

Here, W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

Table 1. Combined effect of different growing media and watering frequencies on the plant height of carrot.

	Plant height (cm)				
Treatments	**30 DAS**	**45 DAS**	**60 DAS**	**75DAS**	**100 DAS**
M_1W_1	$17.81±1.13^{ab}$	$28.91±1.07^{bc}$	$40.54±2.15^{cd}$	$41.96±2.08^{ef}$	$44.52±2.25^{cd}$
M_1W_2	$19.48±0.85^{a}$	$33.81±0.83^{a}$	$49.89±1.47^{a}$	$54.24±0.97^{a}$	$56.51±0.80^{a}$
M_1W_3	$16.98±0.91^{b}$	$28.11±1.95^{bc}$	$36.99±1.93^{efgh}$	$40.05±2.71^{fgh}$	$42.55±2.02^{de}$
M_1W_4	$17.74±0.43^{ab}$	$30.75±1.51^{b}$	$38.99±2.40^{cde}$	$40.98±2.30^{fg}$	$42.56±2.38^{de}$
M_2W_1	$15.95±1.34^{bc}$	$27.77±1.40^{cd}$	$41.79±0.50^{c}$	$45.88±1.38^{d}$	$47.37±3.66^{c}$
M_2W_2	$15.89±1.78^{bc}$	$26.91±2.53^{cde}$	$45.93±2.57^{b}$	$53.96±1.28^{a}$	$55.25±2.89^{a}$
M_2W_3	$14.12±0.86^{cd}$	$24.12±0.94^{ef}$	$35.11±2.40^{ghi}$	$41.98±2.06^{ef}$	$44.54±1.39^{cd}$
M_2W_4	$12.82±0.21^{de}$	$25.03±1.17^{def}$	$38.85±1.58^{def}$	$39.97±1.33^{fgh}$	$41.55±3.60^{e}$
M_3W_1	$16.97±0.75^{b}$	$29.19±0.88^{bc}$	$39.77±2.78^{cde}$	$41.02±1.85^{fg}$	$43.39±1.26^{de}$
M_3W_2	$17.17±1.42^{ab}$	$23.69±5.64^{f}$	$47.85±2.41^{ab}$	$50.12±2.91^{b}$	$52.36±1.86^{b}$
M_3W_3	$14.20±1.21^{cd}$	$23.83±1.38^{f}$	$36.01±1.08^{fghi}$	$38.95±0.69^{gh}$	$40.88±0.47^{ef}$
M_3W_4	$16.68±0.91^{b}$	$27.75± 1.38^{cd}$	$34.96±1.81^{hi}$	$40.14±2.76^{fgh}$	$41.48± 1.79^{e}$
M_4W_1	$9.58 ±1.23^{fg}$	$19.97±2.20^{g}$	$38.01±2.68^{defg}$	$43.89±1.27^{de}$	$46.41±1.60^{c}$
M_4W_2	$9.65±0.52^{fg}$	$17.07±0.85^{h}$	$35.97±3.50^{fghi}$	$48.87±3.49^{bc}$	$51.54±2.57^{b}$
M_4W_3	$7.85 ±0.52^{g}$	$16.75±1.90^{h}$	$34.05±1.87^{i}$	$38.01±1.43^{h}$	$40.89±1.57^{e}$
M_4W_4	$10.79±1.21^{ef}$	$20.57±2.44^{g}$	$38.95±1.99^{cde}$	$46.26±2.08^{cd}$	$47.27±2.46^{c}$
$LSD_{(.05)}$	2.46	2.86	2.93	2.86	2.88
CV%	11.83	7.97	5.21	4.56	4.38
P-value	0.24	0.00	0.00	0.00	0.00

Different letters in the same column indicate significant differences between treatments ($P < 0.05$). Values are mean ± SE. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk and W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml,W_4- four days interval @ 500 ml.

4.2 Number of leaves

A good number of leaves indicated better growth and development of crop. The number of leaves per plant increased gradually with the period of time and continued up to harvest (DAS). A statistically significant variation was recorded in terms of number of leaves per plant due to the different growing media (Figure 3 and appendix IV). The highest number of leaves (4.83, 7.35, 8.90, 10.78 and 12.31) was recorded from M_1 treatment at 30, 45, 60, 75 and 100 DAS. The lowest number of leaves (3.44, 5.06, 7.91, 9.84 and 11.53) was recorded from M_4 treatment at 30, 45, 60, 75 and 100 DAS.

In case of watering, the highest number of leaves per plant (4.58) at 30DAS was recorded from W4 treatment. At 45, 60, 75 and 100 DAS the maximum number of leaves (6.56, 9.31, 11.66 and 12.97) was found in W_2 treatment. On the other hand, the lowest number of leaves (4.21, 6.12, 7.73, 9.65 and 11.36) at 30, 45, 60, 75 and 100 DAS was observed from W_3 treatment (Figure 4 and Appendix IV).

In case of number of leaves per plant with the combined effect of growing media with different levels of water was observed under the present study (Table 2 and Appendix IV). It was observed that the highest number of leaves (5, 8.08, 10.08, 12.60 and 13.46) was obtained at 30, 45, 60, 75 and 100 DAS from M_1W_2 treatment combination. On the other hand, the lowest number of leaves per plant (3.17, 7.33, 8.28 and 10.09) at 30, 60, 75 and 100 DAS from the M_4W_3 treatment combination. At 45 DAS the minimum number of leaves (5.00) was found in M_4W_4 treatment combination.

The variations in growth are most likely ascribed to growing media with proper moist condition. The increased number of leaves observed in cocopeat based media with the application of water two days interval @ 300 ml (W_2) that might has resulted suitable moist environment, aeration and a strong nutrient supply over the growing period. Cocopeat based media provides ample microclimate conditions in the root region of plants and increased plant numbers. The adequate water in growing media could be reason for better plant number performance. Bilderback *et al*. (2005) stated that organic components decompose during crop production and may change both the physical and chemical composition of the medium. This may in turn affect crop growth and development.

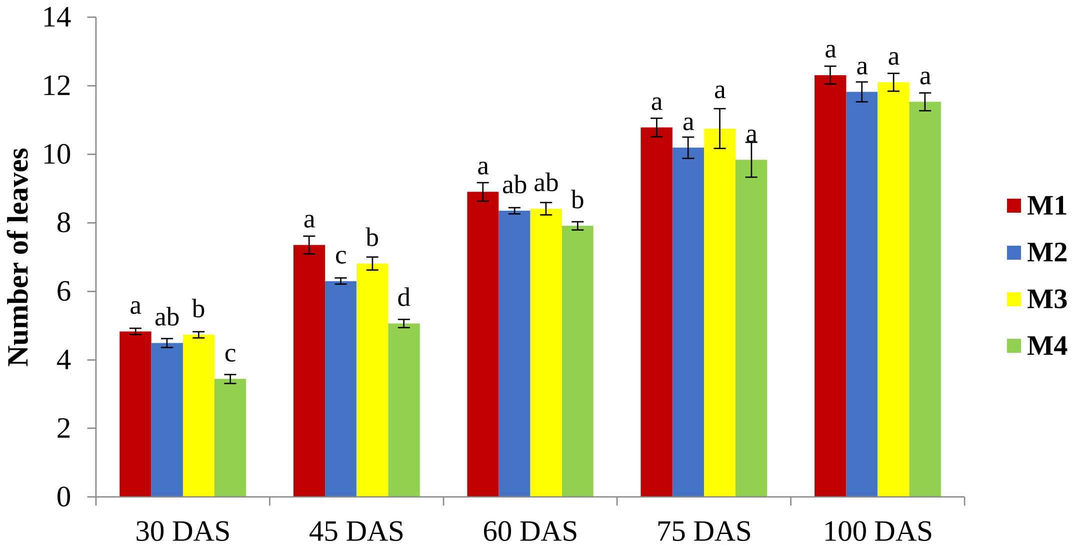

Figure 3. Effects of different growing media on the number of leaves of carrot at different days after sowing.

Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

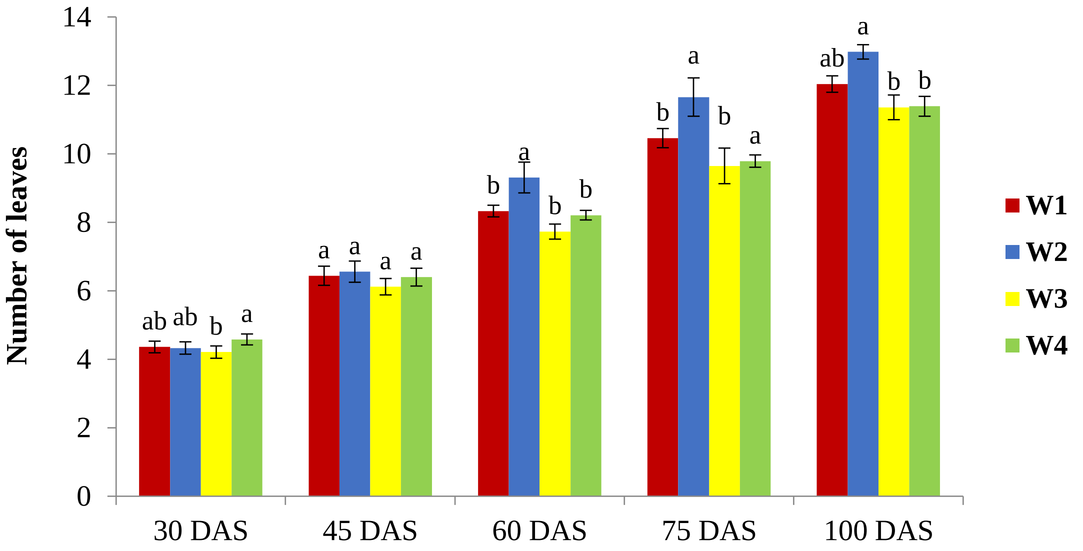

Figure 4. Effects of different level of water application on the number of leaves of carrot at different days after sowing.

Here, W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

Table 2. Combined effect of different growing media and watering frequencies on the number of leaves of carrot at different days after sowing (DAS).

	Number of leaves				
Treatments	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**100DAS**
M_1W_1	4.67±0.27^{ab}	7.25 ±0.76^{ab}	8.83±0.21^{abc}	10.74±0.52^{abc}	12.19±0.26^{ab}
M_1W_2	5.00 ±0.13^{a}	8.08 ±0.44^{a}	10.08±0.55^{a}	12.60±0.54^{a}	13.46±0.38^{a}
M_1W_3	4.83±0.17^{ab}	7.25 ±0.50^{ab}	8.42±0.61^{bc}	9.69± 0.61^{bcd}	11.24±0.68^{ab}
M_1W_4	4.83±0.17^{ab}	6.83±0.21^{bcd}	8.25±0.28 ^{c}	10.08± 0.43^{bcd}	11.53±0.71^{ab}
M_2W_1	4.42±0.25^{ab}	6.50±0.17^{bcd}	8.83±0.21^{abc}	10.54±0.61^{abcd}	12.09±0.65^{a}
M_2W_2	4.34±0.24^{bc}	6.08 ±0.16^{cd}	8.58±0.44^{abc}	10.69±0.29^{abc}	12.19±0.39^{ab}
M_2W_3	4.33±0.27^{bc}	6.17 ±0.10^{cd}	7.34±0.45^{c}	9.40± 0.56^{bcd}	11.08±0.87^{ab}
M_2W_4	4.84±0.29^{ab}	6.42±0.25^{bcd}	8.67±0.27^{abc}	10.14± 0.47^{bcd}	11.92±0.34^{ab}
M_3W_1	4.83±0.21^{ab}	6.92±0.25^{bcd}	7.92±0.34^{c}	10.43±0.66^{abcd}	12.02±0.39^{ab}
M_3W_2	4.67±0.24^{ab}	7.00 ±0.24b^{c}	9.92±1.08^{ab}	11.66±1.39^{ab}	13.08±0.55^{a}
M_3W_3	4.50±0.22^{ab}	6.00 ±0.13^{de}	7.83±0.17 ^{c}	11.24±1.83^{abc}	13.02± 0.75^{a}
M_3W_4	4.92±0.08^{ab}	7.33 ±0.49^{ab}	8.00±0.13^{c}	9.68± 0.23^{bcd}	11.13±0.44^{ab}
M_4W_1	3.50 ±0.22^{d}	5.09 ±0.31^{ef}	7.75±0.25^{c}	10.13± 0.74^{bcd}	11.86±0.61^{ab}
M_4W_2	3.33 ±0.24^{d}	5.08 ±0.16^{ef}	8.67±1.34^{abc}	11.68± 1.85^{ab}	13.21±0.42^{a}
M_4W_3	3.17 ±0.17^{d}	5.08 ±0.37^{ef}	7.33±0.24^{c}	8.28±0.55^{d}	10.09±0.58^{b}
M_4W_4	3.75±0.37^{cd}	5.00±0.24^{f}	7.92±0.29 ^{c}	9.27±0.44^{cd}	10.97±0.43^{ab}
LSD $_{(.05)}$	0.65	0.97	1.53	2.32	2.84
CV%	10.52	10.77	12.85	15.69	16.70
P-value	0.88	0.20	0.60	0.66	0.86

Different letters in the same column indicate significant differences between treatments ($P < 0.05$). Values are mean ± SE. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk and W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml.

4.3 Fresh weight of leaves

In the case of carrot, growing media showed significant effect in respect of fresh weight of leaves. The maximum fresh weight of leaves (21.54 g) was recorded from M_4 while the minimum fresh weight of leaves (18.54 g) was recorded from M_3 (Table 3 and Appendix V).

Fresh weight of leaves varied significantly due to different doses of water application. The maximum fresh weight of leaves (23.47g) was recorded from W_2 while the minimum fresh weight of leaves (18.51 g) was recorded from W_4 (Table 3 and Appendix V).

Significant variation was observed in the case of number of leaves per plant with the interaction effect of between growing media and different doses of watering. The maximum fresh weight of leaves per plant (27.70 g) was recorded in the treatment combination of M_4W_2 while the minimum (15.78 g) was recorded in the treatment combination of M_3W_4 (Table 4 and Appendix IV).

The fresh biomass is associated with food stored either in leaves, shoots, or roots. Higher capacity for holding water, better aeration with lower bulk density, and EC of growing media help to maintain a satisfactory atmosphere that resulted in vigorous plant growth, which ensures increased photosynthetic potential by leaves. Water retention ability, gaseous exchange, and root penetration depend on the amount of pore space in the media, which helps to improve plant growth (Rahman, M.J. *et al*., 2012 and Raviv, M. *et al.,* 2008). Utobo *et al.* (2015) stated that the potting media mixture significantly affected all the vegetative growth parameters in plants.

4.4 Dry matter content of leaves

Significant performance of growing media was observed on dry matter content of leaves. The highest dry weight (17.78 %) was found in M_1 and the lowest dry weight (15.53%) was found in M_2 (Table 3 and Appendix V).

Different level of watering effect on dry matter content of leaves. The maximum fresh weight of leaves (18.59 %) was recorded from W_1 while the minimum dry weight of leaves (15.79%) was recorded from W_3 (Table 3 and Appendix V).

Statistically significant variation was observed in case of dry matter content of leaves with combined effect of between growing media and different doses of watering. The maximum dry weight of leaves per plant (20.86 %) was recorded in the treatment combination of M_3W_1 while the minimum (14.57 %) was recorded in the treatment combination of M_4W_4 (Table 4 and Appendix V).

Riaz *et al.* (2008) reported that different growing media can be used to grow zinnia while the physical and chemical properties of media, like structure, texture, pH as well as nitrogen, phosphorus and potassium are the dominant factors for the growth and development of plant.

Yield parameter

4.5 Length of root

In the case of carrot, growing media showed significant performance in respect of length of root (Figure 5 and Appendix V). The root length was observed to be gradually increased. The highest root length (12.25 cm) was recorded from M_1 and the lowest (10.85 cm) was obtained from M_4.

The level of watering had significant effect on root length. It is evident that different levels of watering showed different length of root (Figure 6 and Appendix V). The highest root length (12.06 cm) was indicated with the treatment W_2 while the lowest root length (10.97 cm) was measured from W_3 treatment.

Statistically significant variation was observed in case of length of root with interaction effect of between different growing media and doses of watering under the present study (Table 4 and Appendix V). Different treatment combination showed different root length. The highest root length (13.52 cm) was recorded with M_1W_2 treatment combination. On the other hand, the lowest root length (10.08 cm) was recorded with M_4W_3 treatment combination.

The highest root length was observed in cocopeat based media with the application of water two days interval @ 300 ml (W_2). The proper media mixture, which promotes good aeration and fast root penetration. It could be concluded that the cocopeat media had the preferred texture for the root length of carrot. Cocopeat media had less compaction and it is easy for the penetration of the roots, easy to drain excess water.

Sudeshika *et al.* (2018) concluded that coir dust containing medium can be recommended as a suitable medium for carrot growing based on the root penetration, growth and yield of the plant.

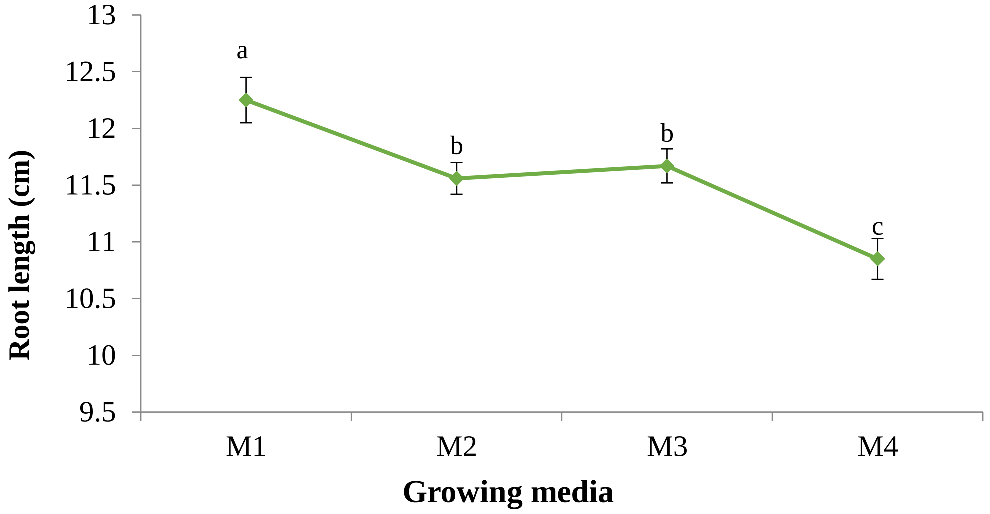

Figure 5. Effect of different growing media on the root length of carrot.

Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

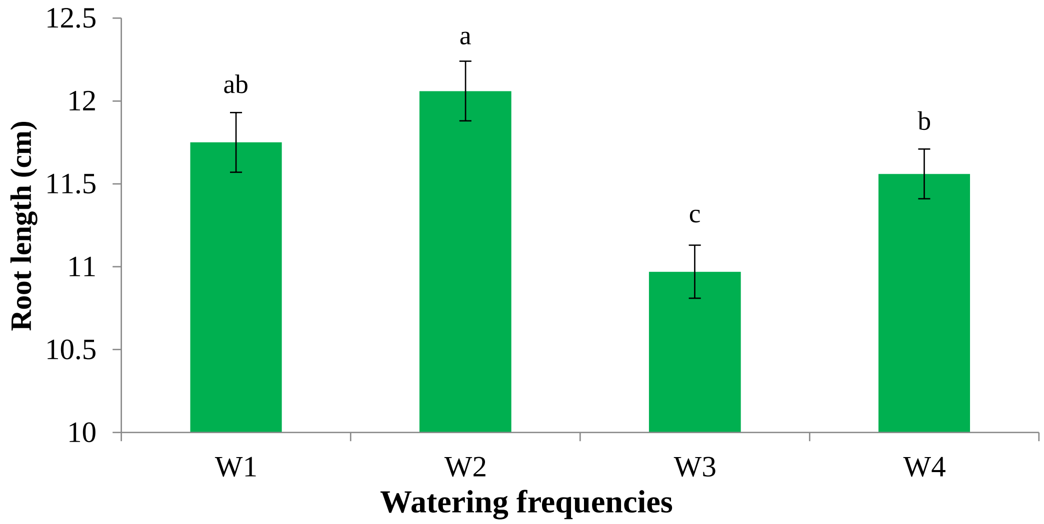

Figure 6. Effect of different level of water application on the root length of carrot.

Here, W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

4.6 Diameter of root

Statistically significant variation was observed in terms of root diameter due to the different growing media (Figure 7 and Appendix V). M_1 gave the maximum diameter of root (20.25 mm), while M_4 gave the minimum diameter of root (10.85 mm).

In case of root diameter a statistically significant variation was recorded due to different level of watering under the study (Figure 8 and Appendix V). It was recorded that the highest diameter of root (21.50 mm) was obtained with the treatment W_2. On the other hand, the lowest diameter of root (17.38 mm) was measured with W_4 treatment.

The combined effect of different growing media and doses of watering showed significant variation on diameter of root under the present study (Table 4 and Appendix V). Different treatment combination showed different diameter of root. It was observed that the highest diameter of root (23.81 mm) was recorded with M_1W_2 treatment combination. On the other hand the lowest diameter of root (16.41 mm) was obtained from M_4W_3 treatment combination.

Maximum root diameter value was observed in cocopeat media under the influence of watering @ 300 ml two days interval. This may be due to microclimatic condition of media which may be influenced in diameter of the roots. So, it is clear that the root diameter depends primarily on watering and growing media. Plant growth is aided by the growing medium, which may be attributed to the media's availability of nutrients. According to Trevisan *et al.* (2010); stated that organic media such as compost serves as a nutrient buffer, slowly releasing nutrients to plant roots. Peyvast *et al.* (2010); concluded that plant growth, leaf composition, total yield, and fruit quality are affected by the substrates in soilless culture. Bilderback *et al.* (2005), stated that growing media have three main functions: 1) provide aeration and water, 2) allow for maximum root growth and 3) physically support the plant. Growing media should have large particles with adequate pore spaces between the particles.

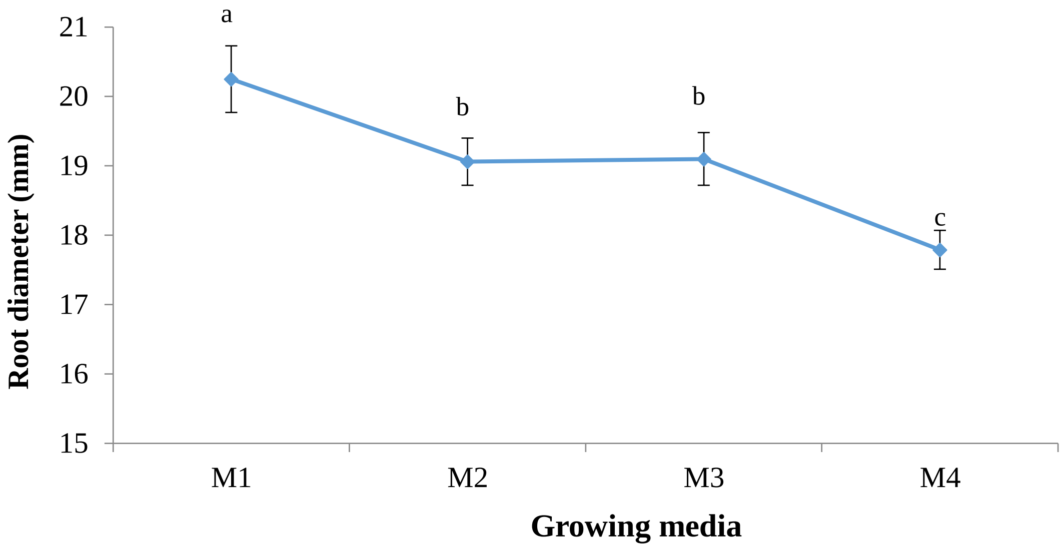

Figure 7. Effect of different growing media on the root diameter of carrot.

Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

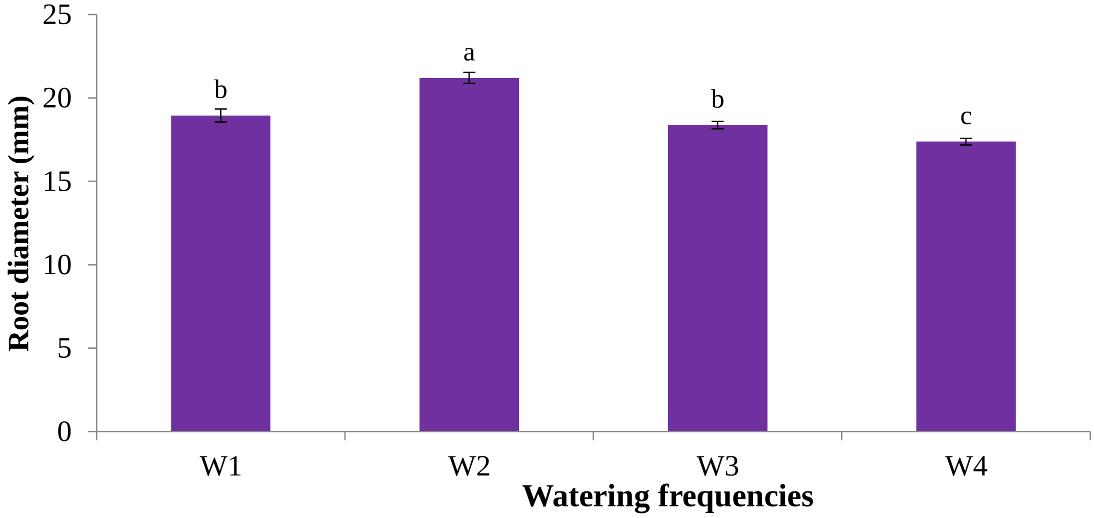

Figure 8. Effect of different level of water application on the root diameter of carrot.

Here, W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

4.7 Fresh weight of root

Significant performance of different growing media was observed on fresh root weight (Figure 9 and Appendix V).The maximum fresh weight of root (54.85 g) was observed in M_1 media and the minimum weight of root (44.64 g) was observed from cultivar M_4.

Different level of watering had several effect on fresh weight of root (Figure 10 and appendix VI). Maximum fresh weight of root (55.83 g) was recorded from W_2 treatment and minimum fresh weight of root (44.17 g) was recorded from W_3 treatment.

Statistically significant variation was observed in case of fresh weight of root with interaction effect of different growing media and doses of watering under the present study (Table 4 and appendix V). Different treatment combination showed different fresh weight of root. It was recorded that the maximum fresh weight of root (67.42 g) was recorded from M_1W_2 treatment combination, while M_4W_3 gave the minimum fresh weight of root (40.55 g)**.**

Root weight of carrot is an important parameter. Average size of carrot suitable for market. All growing media significantly affect the root biomass, although maximum plant height were found for cocopeat based organic substrates with the application of water two days interval @ 300 ml (W_2). The difference among the treatments would be due to the different compositions of growing media and level of watering. The highest water holding capacity and moisture content were found in cocopeat media and it provided the preferable pH, electrical conductivity, bulk density, and air-filled porosity in association with other categories of the substrate. Thus, the results showed that the frequency and volume of irrigation regulated the growth and root development of carrot. However, crop productivity in a soilless culture system depends heavily on the types of substrates (Grewal and Maheshwari, 2011). Higher capacity for holding water and better aerated growing media can help to maintain a satisfactory atmosphere that has resulted in vigorous root growth (Rahman *et al*., 2018; Raviv *et al*., 2019). Utobo *et al*. (2015) reported that rooting media also significantly affected the entire yield and yield parameters of carrot.

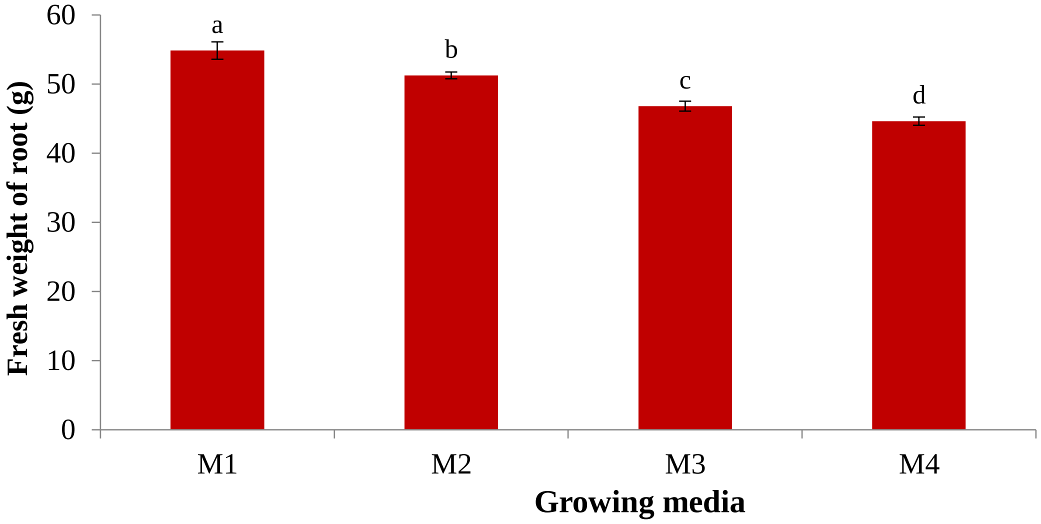

Figure 9. Effect of different growing media on the fresh root weight of carrot.

Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

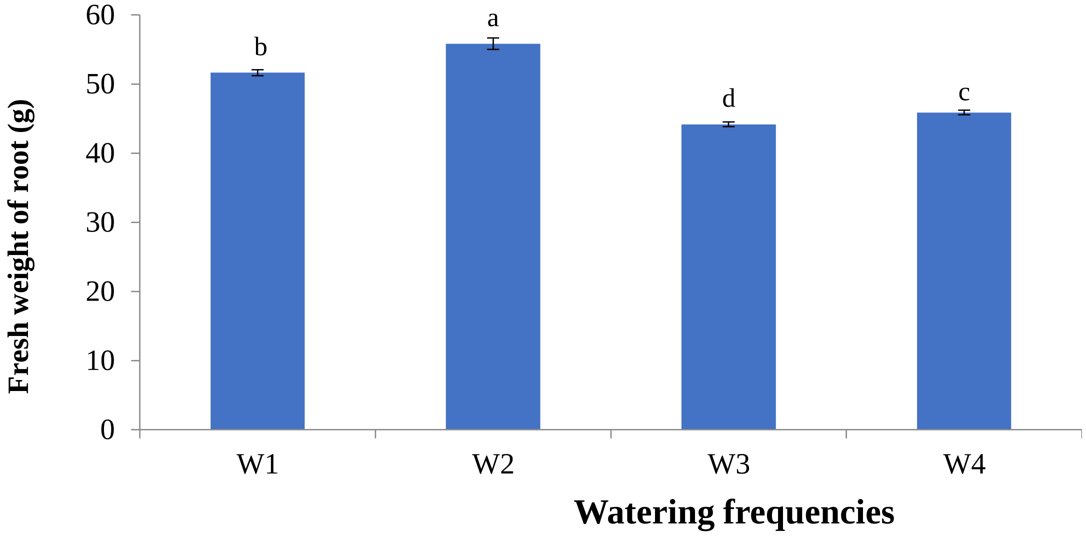

Figure 10. Effect of different level of water application on the fresh root weight of carrot.

Here, W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Vertical bar represent means ± standard error. Means with the same letter did not significantly differ from each other.

4.8 Dry matter content of root

Performance of growing media showed a significant variation in case of dry matter content of root (Table 3 and appendix V). The maximum dry matter content of root (12.67%) was observed in M_2 and the minimum dry matter content of root (8.81%) was recorded from M_1.

The different level of watering showed significant effect on the dry matter content of root (Table 3 and appendix V). The highest dry matter content of root (12.30%) was found in W_2 treatment while the minimum dry matter content of root (9.04%) was observed in W_3 treatment.

Significant variation was observed in case of dry matter content of root with interaction effect of different growing media mixture and doses of watering (Table 4 and appendix V). Different treatment combination showed different dry matter content of root. It was observed that the highest amount of dry matter content of root (14.58%) was achieved with M_4W_2 treatment combination. On the other hand the lowest dry matter content of root (3.90%) was obtained from M_3W_3 treatment combination.

Table 3. Effect of different growing media and watering frequencies on the fresh weight of leaves, dry matter content of leaves and dry matter content of root of carrot .

Treatments	Fresh weight of leaves (g)	Dry matter content of leaves (%)	Dry matter content of root (%)
M_1	19.37±1.67[bc]	17.786±0.84[a]	8.81± 0.36[d]
M_2	21.38 ±1.56[ab]	15.53±0.56[b]	12.67± 0.16[a]
M_3	18.54 ±1.03[c]	17.79 ±1.47[a]	9.24± 0.85[c]
M_4	21.54±1.84[a]	16.52 ±0.74[ab]	11.37 ±0.55[b]
LSD $_{(.05)}$	2.03	1.44	0.267
CV%	14.16	12.01	3.57
P-value	0.01	0.00	0.00
W_1	20.09±1.39[b]	18.59± 1.60[a]	10.89 ±0.63[b]
W_2	23.47 ±1.38[a]	17.05 ±0.70[b]	12.30±0.46[a]
W_3	18.77±1.66[b]	15.79± 0.48[b]	9.04± 0.85[d]
W_4	18.51 ±1.52[b]	16.28±0.60[b]	9.87 ±0.34[c]
LSD $_{(.05)}$	2.03	1.44	0.26
CV%	14.16	12.01	3.57
P-value	0.00	0.00	0.00

Different letters in the same column indicate significant differences between treatments ($P < 0.05$). Values are mean ± SE. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk and W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml.

Table 4. Combined effect of different growing media and watering frequencies on the fresh weight of leaves, dry matter content of leaves, length of root, diameter of root, fresh weight of root, dry matter content of root of carrot.

Treatments	Fresh weight of leaves (g)	Dry matter content of leaves (%)	Length of root (cm)	Diameter of root (mm)	Fresh weight of root (g)	Dry matter content of root (%)
M_1W_1	22.93±1.47^{bc}	19.89 ±1.91^{ab}	12.55± 22^{ab}	21.42±0.27^{bc}	56.58±0.57 ^{b}	6.77±0.13^{i}
M_1W_2	18.82±1.64^{defg}	18.97±1.80^{ab}	13.52±0.09^{a}	23.81±0.37 ^{a}	67.42±1.44^{a}	10.59±0.21^{f}
M_1W_3	15.84±4.23^{fg}	14.65±0.97^{e}	11.45±0.36^{cde}	18.13±0.32^{def}	49.35±0.48^{def}	8.71±0.18^{h}
M_1W_4	19.89±4.95^{cdef}	17.93±0.80^{bc}	11.47±0.10^{cde}	17.63±0.41^{efg}	46.03±0.37^{gh}	9.16±0.22g^{h}
M_2W_1	22.73±3.93^{bcd}	15.79±1.93^{cde}	11.45±.22^{cde}	19.33±0.37^{d}	56.12±0.56 ^{b}	12.59±0.23^{c}
M_2W_2	26.60±0.69^{ab}	15.79±1.20^{cde}	11.95±0.35^{bcd}	22.43±0.23^{ab}	55.30±0.89^{bc}	13.40±0.21^{b}
M_2W_3	17.59±3.11^{efg}	15.80±0.62^{cde}	11.12±0.22^{de}	18.05±0.27^{def}	43.46±0.68^{hi}	12.72±0.16^{c}
M_2W_4	18.60±2.35^{efg}	14.74±0.67^{de}	11.72±0.19^{bcde}	16.42±0.09^{g}	50.00±0.89^{de}	11.97±0.23^{d}
M_3W_1	16.84±3.08^{efg}	20.86±5.86^{a}	12.25±0.36^{bc}	16.52±0.58^{g}	47.44±0.64^{efg}	12.80 ±0.10^{c}
M_3W_2	20.81±1.51^{cde}	17.62±1.12^{bcd}	11.47±0.28^{cde}	20.82±0.54^{c}	52.27±0.73^{cd}	10.62±0.20^{f}
M_3W_3	20.71±0.95^{cde}	14.84±0.62^{de}	11.24±0.27^{de}	20.87±0.62^{c}	43.33±0.45^{hi}	3.90±0.05^{j}
M_3W_4	15.78±1.3^{g}	17.88±1.38^{bc}	11.74±0.27^{bcde}	18.21±0.39^{def}	44.21±0.36^{h}	9.66 ±0.17^{g}
M_4W_1	17.89±0.97^{efg}	17.81±2.20^{bc}	10.75±0.06^{ef}	18.52±0.49^{def}	46.39±0.88^{fgh}	11.38±0.20 ^{e}
M_4W_2	27.70±3.94^{a}	15.83±1.23^{cde}	11.28±0.41^{cde}	18.96±0.19^{de}	48.33±0.2^{efg}	14.58 ±0.21 ^{a}
M_4W_3	20.81±4.66^{cde}	17.85±1.15^{bc}	10.08 ±0.48^{f}	16.41±0.39^{g}	40.55±0.94^{i}	10.85 ±0.10^{ef}
M_4W_4	19.75±3.26^{cdefg}	14.57±0.77^{e}	11.30±0.37^{cde}	17.26±0.56^{fg}	43.29±0.37^{hi}	8.65 ±0.26 ^{h}
LSD $_{(.05)}$	4.06	2.89	0.99	1.47	3.16	0.53
CV%	14.16	12.01	6.00	5.41	4.50	3.57
P-value	0.00	0.01	0.0392	0.00	0.00	0.00

Different letters in the same column indicate significant differences between treatments ($P < 0.05$). Values are mean ± SE. Here M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk and W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml.

Quality attributes

4.9 Brix

Amount of brix was found to have significant variation among different growing media (Table 5 and appendix VI). In this experiment M_1 gave the maximum amount of brix (10.57%) and M_4 gave the minimum amount of brix (9.29%).

Significant variation was observed due to different level of watering (Table 6 and appendix VI). It was observed that the treatment W_2 gave the highest amount of brix (10.20%) whereas W_3 gave the lowest amount of birx (9.32%).

In case of combined effect the treatment combination M_1W_2 showed highest amount of brix (11.20%) and the treatment combination M_4W_3 was recorded the lowest amount of brix (7.62%) (Table 7 and appendix VI).

According to Jankauskien *et al.*, (2015), growing tomatoes in a coconut substrate changed the biochemical composition of the fruits, resulting in more sugar, less ascorbic acid, and less lycopene in the fruits.

4.10 Vitamin-C content

Amount of vit-C was found to have significant variation among different growing media (Table 5 and appendix VI). In this experiment M_3 gave the maximum amount of vit-C (18.05 mg/100g) and M_2 gave the minimum amount of Vit-C (16.65 mg/100g).

Significant variation was observed due to different level of watering (Table 6 and appendix VI). It was observed that the treatment W_1 gave the highest amount of vit-C (19.81 mg/100g) whereas W_3 gave the lowest amount of vit-C (15.56 mg/100g).

In case of combined effect the treatment combination M_3W_1 showed highest amount of vit-C (22.13 mg/100g) and the treatment combination M_1W_3 was recorded the lowest amount of vit-C (13.45 mg/100g) (Table 7 and appendix VI).

Gruda (2009), strongly suggested that changes in the quality parameter of many vegetables in response to the growing medium used.

4.11 β- Carotene

β- carotene was significantly influenced by growing media. Different level of growing media showed different range of β- carotene. The highest amount of β- carotene (9098.1 μg/100g) was obtained from M_1 and the lowest β- carotene (8847.5 μg/100g) was obtained from the treatment M_4.

Statistically significant variation was observed due to different level of watering (Table 6 and appendix VI). It was observed that the treatment W_2 gave the highest amount of β- carotene (9347.9 μg/100g) whereas W_3 gave the lowest amount of β- carotene (8605.5 μg/100g).

The combined effect of different growing media and doses of watering had significant variation on β- carotene of carrot (Table 7 and Appendix VI). Among the combinations of treatment the maximum β- carotene (9884.4 μg/100g) was observed in M_1W_2 treatment combinations and the minimum (8313.3 μg/100g) was obtained from the treatment combination of M_4W_3.

The organic substrates and frequency of irrigation had effect on the biochemical properties of the carrot root. The amount of chlorophyll and carotenoids in vegetables varies depending on the growing conditions (Kobayashi, K. *et al*., 1989; Kimura, M. 2003). Carotenoids and flavonoids are the main tomatoes antioxidants and both this antioxidant profile potentially influenced by water regime (Pernice *et al*., 2010).

4.12 Total sugar

The data on total sugar in roots of carrot was significantly influenced by growing substrate. The highest total sugar (35.85%) was obtained from M_3 treatment and the lowest (19.05%) was observed in M_1 treatment (Table 5 and Appendix VI).

Statistically significant variation was observed due to different level of watering (Table 6 and Appendix VI).The highest total sugar (27.40%) was recorded from W_2 and the lowest (24.53%) was obtained from W_1 treatment.

The combined effect of different growing media and doses of watering had significant variation on total sugar of carrot (Table 7 and Appendix VI). The highest total sugar (39.64%) was found from M_3W_2 and the lowest (19.01%) was recorded from M_1W_2.

The total sugar was high in rice husk media under the 300 ml water at two days interval. Padem & Alan (1994) reported that yield, fruit weight, ascorbic acid values, total soluble solid and composition of leaf of pepper were significantly influenced by cultivars and growing media.

4.13 Reducing sugar

In case of reducing sugar a statistically significant variation was observed among growing substrate (Table 5 and Appendix VI). In this experiment M_3 gave the highest reducing sugar (17.50%) and M_2 gave the lowest reducing sugar (9.75%).

Statistically significant variation was observed on reducing sugar due to different level of watering (Table 6 and appendix VI).The maximum reducing sugar (11.96%) was recorded in W_2 treatment. On the other hand the minimum reducing sugar (11.09%) was recorded in W_1 treatment.

In case of reducing sugar of carrot showed a significant variation with interaction effect of different growing media and doses of watering (Table 7 and Appendix VI). It was observed that the maximum reducing sugar (18.44%) was obtained with M_3W_2 treatment combination. On the other hand the lowest reducing sugar (7.55%) was obtained from M_2W_3 treatment combination.

Reducing sugar under the influence of watering @ 300 ml two days interval in rice husk based media was maximum. The physical properties of substrate are important factor in determining the plant development in soilless substrate that helped produce higher biochemical activities (Rahman *et al.,* 2017).

4.14 Non-reducing sugar

In case of non-reducing sugar a statistically significant variation was observed among growing substrate (Table 8 and Appendix VII). The highest non-reducing sugar (19.11%) was obtained from M_2 treatment and the lowest (9.38%) was observed in M_4 treatment.

Statistically significant variation was observed on non-reducing sugar due to different level of watering (Table 9 and appendix VII). The highest non-reducing sugar (14.69%) was recorded from W_2 and the lowest (12.76%) was obtained from W_1 treatment.

In case of non-reducing sugar of carrot showed a significant variation with interaction effect of different growing media and doses of watering (Table 10 and Appendix VII). The highest non-reducing sugar (20.48%) was found from M_2W_2 and the lowest (8.25%) was recorded from M_1W_2 (Table 10 and Appendix VII).

The type of substrate has an effect not only on plant yield, but also on quality profile (Hallman *et al.,* 2003).

4.15 CHO

There were actually no significant variation was observed among different growing substrate in case of CHO (Table 8 and Appendix VII). The maximum CHO (11.51 g/100g) was recorded from M_2 while the minimum (10.40 g/100g) was recorded from M_4.

Statistically significant variation was recorded in terms of CHO due to the different levels of watering (Table 9 and appendix VII). The highest CHO (11.43 g/100g) was found in W_1 treatment while the minimum CHO (10.09 g/100g) was observed in W_2 treatment.

Significant variation was observed in case of CHO of carrot with interaction effect of different growing media and doses of watering under the present study (Table 10 and Appendix VII). It was observed that the highest CHO (13.11g/100g) was found with M_2W_1 treatment combination while the lowest CHO (9.26 g/100g) was obtained from M_4W_2 treatment combination.

Table 5. Effect of different growing media on brix, vit-C, β- carotene, total sugar and reducing sugar of carrot.

Treatments	Brix %	Vit-C (mg/100g)	β- Carotene (µg/100g)	Total sugar (%)	Reducing sugar (%)
M_1	10.57± 0.33[a]	17.66±0.76[b]	9098.1±35.43[a]	19.05±0.18[d]	9.75±0.11[c]
M_2	9.55± 0.26[b]	16.65±0.47[d]	8962.4±45.05[c]	27.98±0.27[b]	7.85±0.10 [d]
M_3	9.49±0.22[b]	18.05±0.69[a]	8977.4±89.19[b]	35.85±0.72[a]	17.50±0.24[a]
M_4	9.29±0.15[c]	17.31±0.13[c]	8847.5±11.61[d]	19.95±0.23[c]	10.11±0.16[b]
LSD $_{(.05)}$	0.09	0.198	3.70	0.177	0.256
CV%	1.30	1.59	0.06	0.97	3.17
P-value	0.00	0.00	0.00	0.00	0.00

Means with the same letter did not significantly differ from each other at $p<0.05$. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Values are mean ± SE.

Table 6. Effect of different watering frequencies on brix, vit-C, β- carotene, total sugar and reducing sugar of carrot.

Treatments	Brix (%)	Vit-C (mg/100g)	β- Carotene (µg/100g)	Total sugar (%)	Reducing sugar (%)
W_1	9.98±0.17[b]	19.81±0.56[a]	9013.3 ±79.12[b]	24.53±1.38[d]	11.09±0.81b[c]
W_2	10.20±0.23[a]	16.93±0.34[c]	9347.9 ±69.97[a]	27.40±2.09[a]	11.96±1.01[a]
W_3	9.32 ±0.34[d]	15.56±0.54[d]	8605.5±141.48[d]	25.08±1.78[c]	10.93±0.96[c]
W_4	9.41±0.23[c]	17.37±0.14[b]	8918.6±52.65[c]	25.82±1.81[b]	11.23±1.04[b]
LSD $_{(.05)}$	0.09	0.19	3.70	0.18	0.26
CV%	1.30	1.59	0.06	0.97	3.17
P-value	0.00	0.00	0.00	0.00	0.00

Means with the same letter did not significantly differ from each other at $p<0.05$. Here, W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Values are mean ± SE

Table 7. Combined effect of different growing media and watering frequencies on brix, vit-C, β- carotene, total sugar and reducing sugar of carrot.

Treatments	Brix (%)	Vit-C (mg $100g^{-1}$)	β- Carotene (μg/100g)	Total sugar (%)	Reducing sugar (%)
M_1W_1	11.10 ± 0.09^{a}	21.73 ± 0.48^{b}	9052.0 ± 2.93^{g}	19.83 ± 0.21^{i}	9.83 ± 0.10^{ef}
M_1W_2	11.20 ± 0.05^{a}	17.75 ± 0.06^{c}	9884.4 ± 1.76^{a}	19.01 ± 0.00^{j}	10.33 ± 0.05^{e}
M_1W_3	10.80 ± 0.05^{b}	13.45 ± 0.06^{f}	8337.8 ± 2.63^{n}	18.03 ± 0.05^{k}	9.33 ± 0.09^{f}
M_1W_4	9.20 ± 0.09^{ef}	17.73 ± 0.05^{c}	8575.3 ± 1.90^{m}	19.33 ± 0.14^{j}	9.53 ± 0.14^{f}
M_2W_1	9.32 ± 0.05^{e}	17.75 ± 0.06^{c}	8891.5 ± 4.35^{k}	27.15 ± 0.10^{g}	8.00 ± 0.04^{g}
M_2W_2	10.32 ± 0.09^{c}	17.73 ± 0.09^{c}	9354.4 ± 1.93^{b}	29.61 ± 0.21^{e}	8.04 ± 0.01^{g}
M_2W_3	8.50 ± 0.04^{g}	13.48 ± 0.05^{f}	9151.2 ± 1.77^{d}	28.05 ± 0.06^{f}	7.55 ± 0.17^{g}
M_2W_4	10.08 ± 0.09^{d}	17.65 ± 0.06^{c}	8995.4 ± 1.97^{i}	27.10 ± 0.07^{g}	7.83 ± 0.36^{g}
M_3W_1	10.18 ± 0.09^{cd}	22.13 ± 0.05^{a}	9013.6 ± 4.77^{h}	32.00 ± 0.07^{d}	16.33 ± 0.15^{c}
M_3W_2	8.20 ± 0.08^{h}	14.66 ± 0.01^{e}	9165.3 ± 2.37^{c}	39.64 ± 0.18^{a}	18.44 ± 0.11^{a}
M_3W_3	10.35 ± 0.06^{c}	17.75 ± 0.06^{c}	8619.6 ± 2.05^{l}	34.95 ± 0.06^{c}	17.18 ± 0.08^{b}
M_3W_4	9.25 ± 0.10^{ef}	17.65 ± 0.12^{c}	9111.2 ± 2.25^{e}	36.83 ± 0.12^{b}	18.05 ± 0.47^{a}
M_4W_1	10.20 ± 0.07^{cd}	17.63 ± 0.06^{c}	9096.3 ± 1.60^{f}	19.13 ± 0.09^{j}	10.23 ± 0.08^{e}
M_4W_2	10.20 ± 0.09^{cd}	17.60 ± 0.11^{c}	8987.8 ± 3.17^{j}	21.33 ± 0.15^{h}	11.05 ± 0.01^{d}
M_4W_3	7.62 ± 0.06^{i}	17.58 ± 0.09^{c}	8313.3 ± 2.04^{o}	19.30 ± 0.18^{j}	9.65 ± 0.06^{f}
M_4W_4	9.13 ± 0.05^{f}	16.45 ± 0.06^{d}	8992.6 ± 1.13^{ij}	20.03 ± 0.05^{i}	9.53 ± 0.21^{f}
$LSD_{(.05)}$	0.18	0.39	7.41	0.35	0.51
CV%	1.30	1.59	0.06	0.97	3.17
P-value	0.00	0.00	0.00	0.00	0.00

Different letters in the same column indicate significant differences between treatments ($P < 0.05$). Values are mean ± SE. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk and W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml.

4.16 Moisture

Actually there were no significant variation was observed in case of moisture due to different growing substrate (Table 8 and Appendix VII).The highest amount of moisture (86.01%) was obtained from M_1 and the lowest (85.23%) was obtained from the treatment M_4.

Statistically significant variation was observed due to different level of watering (Table 9 and appendix VII). It was observed that the treatment W_2 gave the highest amount of moisture (86.59%) whereas W_3 gave the lowest amount of moisture (85.38%).

The combination effect of different growing media and doses of watering had significant variation on moisture of carrot (Table10 and Appendix VII). Among the combinations of treatment the maximum moisture (87.11%) was observed in M_1W_2 treatment combinations and the minimum (83.97%) was obtained from the treatment combination of M_4W_3.

4.17 Ash

Ash of carrot was significantly influenced by growing substrate. Among the treatments, the maximum ash (1.48%) was registered in M_4 and the minimum (1.41%) was recorded in M_3 (Table 8 and Appendix VII).

Actually there were no significant variation was observed in case of ash due to watering. The maximum ash (1.48%) was obtained from W_4 whereas the lowest amount of ash (1.44%) was recorded from W_1 treatment (Table 9 and Appendix VII).

Interaction effect between growing substrate with doses of water application was found to be non-significant of ash. Among the combination treatment the ash (1.52%) was maximum in M_4W_4 and the minimum (1.35%) in the treatment combination of M_3W_1 (Table 10 and Appendix VII).

4.18 Protein

Statistically significant variation was observed in terms of protein due to the different growing substrate (Table 8 & appendix VII). M_3 gave the maximum protein (2.20%), while M_2 gave the minimum protein (1.45%).

In case of protein a statistically significant variation was recorded due to different level of watering under the study (Table 9 and Appendix VII). It was recorded that the highest protein (16.24 cm) was obtained with the treatment W_1 (1.89%). On the other hand, the lowest (1.78%) was measured with W_3 treatment.

The interaction effect of different growing media with doses of watering showed significant variation under the present study (Table 10 and Appendix VII). Among the combination treatment the protein (2.53%) was maximum in M_4W_1 and the minimum (1.44%) in the treatment combination of M_2W_3.

Table 8. Effect of different growing media on non-reducing sugar, CHO, moisture, ash and protein of carrot.

Treatments	Non-reducing sugar (%)	CHO (g/100g)	Moisture (%)	Ash (%)	Protein (%)
M_1	8.83±0.17^{d}	11.05±0.34^{ab}	86.01±0.33^{a}	1.48±0.02^{a}	1.56±0.019^{b}
M_2	19.11±0.27^{a}	11.51±0.39^{a}	85.92±0.39^{ab}	1.46±0.02^{ab}	1.45±0.014^{c}
M_3	17.47±0.50^{b}	10.83±0.34^{ab}	85.62±0.33^{ab}	1.41±0.02^{b}	2.20±0.032^{a}
M_4	9.38±0.18^{c}	10.40±0.34^{b}	85.23±0.37^{b}	1.48±0.01^{a}	2.13±0.078^{a}
LSD $_{(.05)}$	0.32	0.83	0.77	0.06	0.09
CV%	3.24	10.65	1.26	5.66	6.70
P-value	0.00	0.06	0.17	0.04	0.00

Means with the same letter did not significantly differ from each other at $p<0.05$. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Values are mean ± SE.

Table 9. Effect of watering frequencies on non-reducing sugar, CHO, moisture, ash and protein of carrot.

Treatments	Non-reducing sugar (%)	CHO (g/100g)	Moisture (%)	Ash (%)	Protein (%)
W_1	12.76±1.03^{d}	11.43±0.42^{a}	85.38±0.36^{b}	1.44±0.026^{a}	1.89 ±0.12^{a}
W_2	14.69±1.46^{a}	10.09±0.35^{b}	86.59±0.35^{a}	1.46±0.021^{a}	1.86 ±0.09^{ab}
W_3	13.48±1.25^{c}	11.06±0.32^{a}	85.72±0.32^{b}	1.44±0.015^{a}	1.78± 0.09^{b}
W_4	13.86±1.10^{b}	11.21±0.26^{a}	85.43±0.28^{b}	1.48 ±0.02^{a}	1.81 ±0.08^{ab}
LSD $_{(.05)}$	0.32	0.83	0.77	0.06	0.09
CV%	3.24	10.65	1.43	5.66	6.70
P-value	0.00	0.01	0.00	0.55	0.05

Meanswith the same letter did not significantly differ from each other at $p<0.05$. Here W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml,W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Values are mean ± SE

Table 10. Combined effect of different growing media and watering frequencies on non-reducing sugar, CHO, moisture, ash and protein of carrot.

Treatments	Non reducing sugar (%)	CHO (g/100g)	Moisture (%)	Ash (%)	Protein (%)
M_1W_1	9.50±0.26^{fgh}	11.27±0.68^{bcdef}	85.70±0.66^{abcde}	1.51 ±0.07^{a}	1.53 ±0.04^{ef}
M_1W_2	8.25±0.04^{i}	10.20±0.50^{defg}	87.11±0.48^{a}	1.51± 0.04^{a}	1.58 ±0.03^{ef}
M_1W_3	8.27±0.04^{i}	12.42± 0.51^{ab}	84.64 ±0.50^{ef}	1.42±0.03^{abc}	1.518±0.01^{ef}
M_1W_4	9.31±0.19^{gh}	10.30±0.55^{cdefg}	86.63 ±0.63^{abcd}	1.48±0.05^{ab}	1.63 ±0.04^{e}
M_2W_1	18.19±0.08^{c}	13.11±0.71^{a}	85.32±0.68^{cdef}	1.47±0.06^{abc}	1.45 ±0.03^{f}
M_2W_2	20.48±0.19^{a}	10.93±0.62^{bcdef}	86.15±0.67^{abcde}	1.44±0.03^{abc}	1.47±0.04^{ef}
M_2W_3	19.47±0.19^{b}	10.12 ±0.48^{defg}	87.01 ±0.50^{ab}	1.45±0.03^{abc}	1.44± 0.03^{f}
M_2W_4	18.31±0.41^{c}	11.89 ±0.44^{abc}	85.19± 0.43^{cdef}	1.47 ±0.04^{ab}	1.45 ±0.03^{f}
M_3W_1	14.89±0.08^{e}	11.66± 0.66^{abcd}	84.93± 0.66^{def}	1.35±0.03^{c}	2.07 ±0.01^{cd}
M_3W_2	20.14±0.23^{a}	9.97 ±0.76^{efg}	86.41 ±0.84^{abcd}	1.38± 0.04^{bc}	2.25 ±0.05^{b}
M_3W_3	17.00±0.17^{d}	10.44±0.65^{cdefg}	85.88 ±0.67^{abcde}	1.44±0.04^{abc}	2.25± 0.06^{b}
M_3W_4	17.83±0.49^{c}	11.26±0.50^{bcdef}	85.25± 0.39^{cdef}	1.45±0.04^{abc}	2.25± 0.07^{b}
M_4W_1	8.45±0.14^{i}	9.69±0.32^{fg}	85.58±0.78^{abcdef}	1.45±0.02^{abc}	2.53± 0.19^{a}
M_4W_2	9.90 ±0.22f^{g}	9.26± 0.89^{g}	86.71 ±0.92^{abc}	1.49± 0.04^{ab}	2.14 ±0.03^{bc}
M_4W_3	9.17±0.13^{h}	11.27±0.29^{bcdef}	83.97 ±0.31^{f}	1.46±0.03^{abc}	1.90± 0.04^{d}
M_4W_4	9.98 ±0.16^{f}	11.37± 0.43^{bcde}	84.65± 0.32^{ef}	1.52±0.04^{a}	1.94 ±0.02^{d}
$LSD_{(.05)}$	0.63	1.66	1.53	0.12	0.17
CV%	3.24	10.65	1.26	5.66	6.70
P-value	0.00	0.00	0.01	0.64	0.00

Different letters in the same column indicate significant differences between treatments ($P < 0.05$). Values are mean ± SE. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk and W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml.

Mineral content

4.19 Nitrogen

Statistically significant variation was observed among different growing substrate in case of N (Table 11 and appendix VIII). The maximum amount of N (1.61%) was recorded from treatment M_4 and the minimum amount of N (1.48%) was recorded from treatment $M_{1.}$

In case of amount of N there were a statistically significant variation obtained due to different levels of watering (Table 12 and appendix VIII).The treatment W_4 gave the highest amount of N (1.65%) and the treatment W_1 gave the lowest amount of N (1.34%).

The interaction effect of different growing media and doses of watering had significant variation on N of carrot (Table13 and Appendix VIII). In case of interaction effect the treatment combination M_3W_4 showed highest amount of N (1.81%) and the treatment combination M_1W_1 was recorded the lowest amount of N (1.17%) (Table 13 and appendix VIII).

The nutrient balance in the leaves is influenced by textured rice husk and cocopeat, and is regulated by the nutrient solution by maintaining proper humidity and temperature levels (Rahman *et al.*, 2018).

4.20 Phosphorus

Actually there were no significant variation was observed in case of P due to growing substrate (Table 11 and appendix VIII). The maximum amount of P (0.15%) was recorded from treatment M_2 growing substrate mixtures and the minimum amount of P (0.14%). was recorded from treatment $M_{1.}$

In case of amount of P there were significant variation was obtained due to different levels of watering (Table 12 and appendix VIII).The treatment W_3 gave the highest amount of P (0.15%) and the treatment W_1 gave the lowest amount of P (0.13%).

In case of interaction effect the treatment combination M_3W_3showed highest amount of P (0.16%) and the treatment combination M_1W_1 was recorded the lowest amount of P (0.13%) (Table 13 and appendix VIII).

4.21 Potassium

In case of K, statistically significant variation was observed due to growing substrate (Table 11 and appendix VIII). In this experiment M_4 gave the highest K (0.98%) and M_1 gave the lowest K (0.90%).

Statistically significant variation was recorded in terms of K of carrot due to the different level of watering (Table 12 and Appendix VIII). The highest K (0.98%) was recorded from treatment W_2 and the lowest K (0.89%) was observed from treatment $W_{1.}$

The interaction effect of different growing media and doses of watering had significant effect on K (Table 13 and Appendix VIII). Among the treatment combinations K (1.05%) was obtained from M_4W_2 treatment combination and the minimum (0.85%) was obtained from the treatment combination of M_1W_1.

In a study it was found that, potassium concentration in plant parts may vary for growing seasons (spring or autumn) and also growing systems (Singer *et al.*, 2013)

4.22 Calcium

Statistically significant variation was observed in terms of protein due to the different growing substrate (Table 11 and appendix VIII). Among media the highest amount of Ca (1.43%) was recorded from M_4 treatment whereas the lowest amount of Ca (1.19%). was recorded from M_1 treatment.

Ca was significantly influenced by watering (Table 12 and Appendix VIII). The highest Ca (1.42%) was obtained from the treatment W_4 and the lowest amount of Ca (1.27%) was obtained from the W_2.

The interaction effect of growing substrate and doses of water application had significant Ca (Table 13 and Appendix VIII). Among the combinations of treatment the maximum Ca (1.61%) was observed in M_4W_3 treatment combinations and the minimum (1.04%) was obtained from the treatment combination of M_1W_3.

4.23 Magnesium

Actually there were no significant variation was observed in case of amount of Mg due to different media. Among the treatments, maximum Mg (0.43%) was registered in M_2 and the minimum (0.39%) was recorded in M_3 (Table 11 and Appendix VIII).

In case of amount of Mg there were significant variation was obtained due to different levels of watering (Table 12 and appendix VIII). The treatment W_3 gave the highest amount of Mg (0.43%) and the treatment W_2 gave the lowest amount of Mg (0.37%).

The interaction effect between growing substrate and doses of water application was found to be significant of Mg (Table 13 and Appendix VIII). Among the treatment combinations Mg (0.48%) was obtained from M_4W_3 treatment combination and the minimum (0.33%) was obtained from the treatment combination of M_4W_4.

Substrate culture found to be affected greatly increasing mineral contents in plants especially due to luxurious nutrient uptake during vegetative growth (El-Behairy, 1994).

Table 11. Effect of different growing media on mineral content of carrot.

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
M_1	1.48 ±.049^{c}	0.14±.004^{a}	0.90±0 .02^{d}	1.19± 0.03^{d}	0.41 ±0.01^{b}
M_2	1.57 ±.027^{b}	0.15±.004^{a}	0.94 ±0.02^{c}	1.42 ±0.04^{b}	0.43±0.01^{a}
M_3	1.57 ±.048^{b}	0.14±.004^{a}	0.97±.014^{b}	1.39±0.03^{c}	0.39±0.01^{c}
M_4	1.61 ±.025^{a}	0.14±.004^{a}	0.98± 0.02^{a}	1.43 ±.003^{a}	0.40±0.02^{c}
LSD $_{(.05)}$	0.03	0.02	0.02	0.03	0.02
CV%	3.70	9.95	5.05	3.94	11.17
P-value	0.00	0.25	0.00	0.00	0.27

Means with the same letter did not significantly differ from each other at $p<0.05$. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat, sawdust and rice husk. Values are mean ± SE.

Table 12. Effect of watering frequencies on mineral content of carrot.

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
W_1	1.34 ±.340^{d}	0.13±.004^{b}	0.89±.014^{c}	1.34 ±.035^{c}	0.42± .017^{b}
W_2	1.59 ±.018^{c}	0.14±.003^{ab}	0.98 ±.018^{a}	1.27 ±.036^{d}	0.37± .008^{c}
W_3	1.64 ±.013^{b}	0.15 ±.004^{a}	0.98 ±.019^{a}	1.40 ±.056^{b}	0.43± .010^{a}
W_4	1.65 ±.029^{a}	0.15± .003^{a}	0.94 ±.012^{b}	1.42 ±.020^{a}	0.42±.015^{b}
LSD $_{(.05)}$	0.03	0.02	0.02	0.03	0.02
CV%	3.70	9.95	5.05	3.94	11.17
P-value	0.00	0.05	0.00	0.00	0.00

Means with the same letter did not significantly differ from each other at $p<0.05$. Here, W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. Values are mean ± SE

Table 13. Combined effect of different growing media and watering frequencies on mineral content of carrot.

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
M_1W_1	1.17± 0.016^{k}	0.13± 0.009^{cd}	0.85±0.023^{g}	1.22 ±0.027^{j}	0.43±0.047^{cd}
M_1W_2	1.58±0.023^{f}	0.14± 0.006^{cd}	0.92±0.031^{e}	1.13±0.012^{k}	0.38± 0.015^{f}
M_1W_3	1.64±0.019^{d}	0.13 ±0.009^{d}	0.87± 0.027^{f}	1.04± 0.019^{l}	0.41± 0.023^{e}
M_1W_4	1.55± 0.021^{g}	0.15±0.004b^{cd}	0.95±0.023^{d}	1.37±0.029^{g}	0.45±0.013^{b}
M_2W_1	1.42±0..030^{i}	0.14 ±0.010^{bcd}	0.86±0.027^{fg}	1.56±0.021^{b}	0.45± 0.021^{b}
M_2W_2	1.54±0.024^{g}	0.15±0.005^{abcd}	0.96±0.037^{d}	1.21± 0.043^{j}	0.36±0.024 ^{g}
M_2W_3	1.66±0.022^{c}	0.16±0.005^{ab}	1.01± 0.017^{c}	1.51± 0.021^{c}	0.43±0.016^{e}
M_2W_4	1.64±0.019^{d}	0.15±0.009^{abcd}	0.92± 0.027^{e}	1.41± 0.039^{f}	0.47± 0.008^{a}
M_3W_1	1.31±0.029^{j}	0.14 ±0.009^{cd}	0.91 ±0.012^{e}	1.33±0.015^{h}	0.38± 0.033^{f}
M_3W_2	1.58±0.018^{f}	0.15±0.006^{abcd}	1.0± 0.023^{c}	1.28± 0.033^{i}	0.38±0.016^{f}
M_3W_3	1.60±0.041^{e}	0.16 ±0.004^{a}	1.03±0.017^{b}	1.44± 0.015^{e}	0.41±0.005 ^{e}
M_3W_4	1.81±0.045^{a}	0.14± 0.005^{cd}	0.94±0.016^{d}	1.51± 0.037^{c}	0.44±0.019^{bc}
M_4W_1	1.48±0.039^{h}	0.13±0.008^{cd}	0.92± 0.035^{e}	1.27 ±0.029^{i}	0.42±0.039^{de}
M_4W_2	1.69±0.024^{b}	0.14±0.007^{abcd}	1.05 ±0.021^{a}	1.47±0.033^{d}	0.38± 0.019^{f}
M_4W_3	1.66±0.019^{cd}	0.14±0.008^{abcd}	1.02± 0.012^{c}	1.61 ±0.008^{a}	0.48±0.0154^{a}
M_4W_4	1.61±0.045^{e}	0.15±0.006^{abc}	0.95±0.009^{d}	1.38±0.020^{g}	0.33± 0.007^{h}
LSD $_{(.05)}$	0.06	0.04	0.04	0.06	0.04
CV%	3.70	9.95	5.05	3.94	11.17
P-value	0.00	0.18	0.01	0.00	0.00

Different letters in the same column indicate significant differences between treatments ($P < 0.05$). Values are mean ± SE. Here, M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk and W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml.

CHAPTER V

SUMMARY AND CONCLUSION

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A pot experiment was conducted at the central farm of the Sher-e-Bangla Agricultural University, Dhaka during December 2018 to March, 2019 to evaluate the effect of growing media and watering frequencies on growth, productivity and quality attributes of carrot. The experiment comprised of two factors. Factor A: Four growing media viz., M_1- cocopeat, M_2- sawdust, M_3- rice husk, M_4- equal mixtures of cocopeat , sawdust and rice husk. Factor B: different level of watering viz., W_1- one day interval @ 200 ml, W_2- two days interval @ 300 ml, W_3- three days interval @ 400 ml, W_4- four days interval @ 500 ml. There were 16 (4×4) treatments combination. The experiment was laid out in Randomized complete block design with four replications. Data were taken on growth; yield and quality attributes. The collected data were statistically analyzed for evaluation of the treatment effects. The summary of the results has been described in this chapter.

The effect of growing substrate, the highest plant height (47.17 cm) at 100 DAS, number of leaves (12.31) at 100 DAS, length of root (12.25 cm), root diameter (20.25 mm), fresh weight of root (54.85 g), dry matter content of leaves (17.79 %), brix (10.57 %), β- carotene (9098.1 μg/100g) and moisture (86.01%) was obtained from M_1, the dry matter content of root (12.67%), non-reducing sugar (19.11%), CHO (11.51 g/100g), P (0.15%), Mg (0.43%) was found from M_2, the vitamin-C content (18.05 mg/100g), total sugar (35.85%), reducing sugar (17.50%) and protein (2.20%) was recorded from M_3, the fresh weight of leaves (21.54 g), ash (1.48%), amount of N (1.61%), K (0.98%) and Ca (1.43%) was observed from M_4.

The lowest plant height (44.89 cm) at 100 DAS, number of leaves (11.53) at 100 DAS, length of root (10.85 cm), root diameter (17.79 mm), fresh weight of root (44.64 g), brix (9.29%), β- carotene (8847.5 μg/100g), moisture (85.23%) and CHO (10.40g/100g) was obtained from M_4, the total sugar (19.05%), non-reducing sugar (8.83%), N (1.48%), P (0.14%) and Ca (1.19%) was observed from M_1, the dry matter content of leaves (15.53%), vitamin-C (16.65 mg/100g), reducing sugar (9.75%), protein (1.45%) and K (0.94%) was found from M_2, fresh weight of leaves (18.54 g), dry matter content of root (9.24%), ash (1.41%) and Mg (0.39%) was found from M_3.

The effect of different levels of watering, the maximum plant height (53.92 cm) at 100 DAS, number of leaves(12.98) at 100 DAS, length of root (12.06 cm), root diameter (21.50 mm), fresh weight of root (55.83 g), brix (10.20%), β- carotene (9347.9 μg/100g) and moisture (86.59%) was obtained from W_2 while the lowest from W_3. The maximum fresh weight of leaves (23.47 g), K (0.98%), dry matter content of root (12.30%), total sugar (27.40%), reducing sugar (11.96%), non-reducing sugar (11.96%) was found from W_2, the dry matter content of leaves (18.59%), vitamin-C (19.81mg/100g), CHO (11.43g/100g), protein (1.89%) was observed from W_1, the P (0.15%), Mg (0.43%) was recorded from W_3, the amount of N (1.65%), Ca (1.42%), ash (1.48%) was obtained from W_4.

The combination effect of the growing media and different levels of watering, the maximum plant height (56.51 cm) at 100 DAS, number of leaves (13.46) at 100 DAS, length of root (13.52 cm), root diameter (23.81 mm), fresh weight of root (67.42 g), brix (11.20%), β- carotene (9884.4 μg/100g) and moisture (87.11%) was obtained from M_1W_2, the fresh weight of leaves (27.70 g) from M_4W_2, the dry matter content of leaves (20.86%), vitamin-C (22.13mg/100g) from M_3W_1, dry matter content of root (14.58%) from M_4W_2, total sugar (39.64%), reducing sugar (18.44%) was found from M_3W_2, non-reducing sugar (20.48%) from M_2W_2, CHO (13.11g/100g) from M_2W_1, ash (1.52%) from M_4W_4, protein (2.53%) from M_4W_1, amount of N (1.81%) from M_3W_4, P (0.16%) from M_3W_3, K (1.05%) from M_4W_2, Ca (1.61%), Mg (0.48%) was observed from M_4W_3.

The minimum plant height (40.89 cm) at 100 DAS, number of leaves (10.09) at 100 DAS, length of root (10.08 cm), root diameter (16.41 mm), fresh weight of root (40.55 g), brix (7.62%), β- carotene (8313.3 μg/100g) and moisture (83.97%) was obtained from M_4W_3, the fresh weight of leaves (15.78 g) from M_3W_4, dry matter content of leaves (14.57%) from M_4W_4, dry matter content of root (3.90%) from M_3W_3, vitamin-C (13.45mg/100g) from M_1W_3, total sugar (19.01%) from M_1W_2, reducing sugar (7.55%) from M_2W_3, non-reducing sugar (8.25%) from M_1W_2, CHO (9.26g/100g) from M_4W_2, moisture (83.98%) from M_2W_1, ash (1.35%) from M_3W_1, protein (1.44%) from M_2W_3, amount of N (1.17%) from M_1W_1, P (0.13%) from M_1W_1, K (0.85%) from M_1W_1, Ca (1.04%) from M_1W_3 and Mg (0.33%) from M_4W_4 was recorded respectively.

CONCLUSION

It found that carrot needs ample moisture in the growing medium during its life cycle and the exact requirement of water rely on the irrigation frequencies, which showed a significant impact on root growth, development and nutrient balanced. Results indicate that cocoapeat-based in substrate based media with irrigation management like two days interval @ 300 ml could be a better choice in the cultivation of carrot.

RECOMMENDATION

Further similar studies are also required to determine a promising irrigation strategy for soilless carrot culture, with a view to ensuring a more efficient water management strategy.

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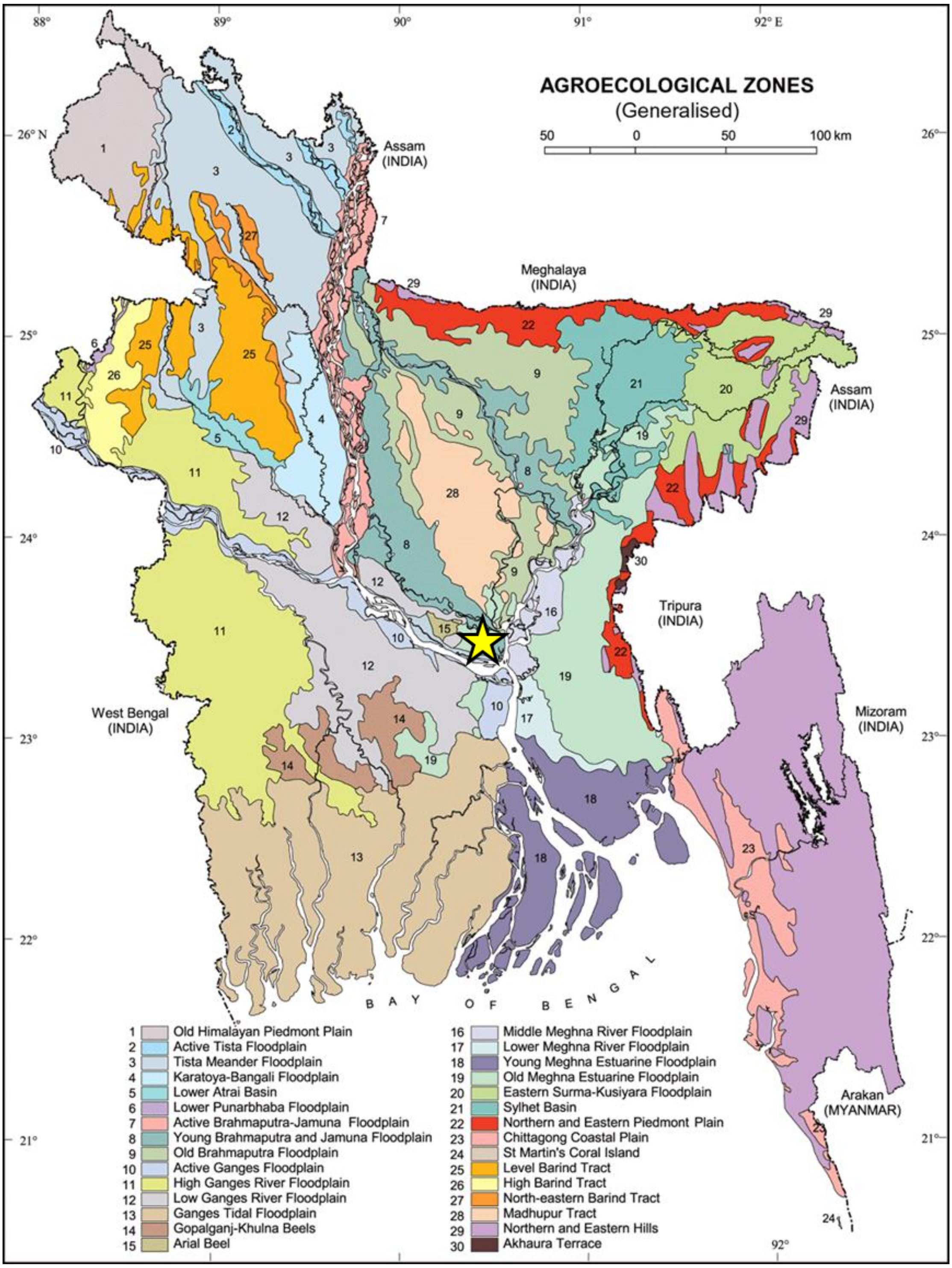
APPENDICES

APPENDICES

Appendix I. Map showing the experimental site under study



☆ The experimental site under study

Appendix II. Morphological characteristics of the experimental area

Morphological features	Characteristics
Location	central farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General soil type	Shallow red brown terrace soil
Soil series	Tejgaon
Flood level	Above flood level

Appendix II. Monthly record of air temperature, rainfall, relative humidity and sunshine hours during the period from November 2018 to March 2019

Year	Month	Average air temperature (^{0} C)		Total rainfall (mm)	Average humidity (%)	Total sunshine hours
		Max.	Min.			
2018	November	29.6	19.2	34.4	53	8
-	December	26.4	14.1	12.8	50	9
2019	January	25.4	12.7	7.7	46	9
-	February	28.1	15.5	28.9	37	8.1
-	March	32.5	20.4	65.8	38	7

Source: Dhaka meteorology center

Appendix IV. Analysis of variances on plant height at different days after sowing (DAS) of carrot.

		Mean square				
		Plant height				
Source	**Degrees of freedom**	**30 DAS**	**45 DAS**	**60 DAS**	**75DAS**	**100DAS**
M	3	217.01**	384.57**	68.42**	22.69**	15.17**
W	3	15.21**	33.44**	254.01**	448.83**	440.135**
M*W	9	3.98**	16.58**	38.73**	24.15**	19.05**
Error	48	2.98	4.05	4.25	4.05	4.10

**: at <0.01 level of probability, ns: non-significant, *: at <0.05 level of probability

Appendix V. Analysis of variances on leaf number at different days after sowing (DAS) of carrot.

		Mean square				
		Leaf Number				
Source	**Degrees of freedom**	**30 DAS**	**45DAS**	**60 DAS**	**75 DAS**	**100DAS**
M	3	6.54**	15.34**	2.57^{ns}	3.34^{ns}	1.86 ^{ns}
W	3	0.39^{ns}	0.542^{ns}	7.063**	13.41**	9.29^{ns}
M*W	9	0.09^{ns}	0.67^{ns}	0.95^{ns}	1.99^{ns}	2.05^{ns}
Error	48	0.21	0.47	1.16	2.66	3.98

**: at <0.01 level of probability, ns: non-significant, *: at <0.05 level of probability

Appendix VI. Analysis of variances on fresh weight of leaves, dry matter content of leaves, root length, root diameter, fresh weight of root and dry matter content of root of carrot .

		Mean square					
Source	**Degrees of freedom**	**Fresh weight of leaf/plant (g)**	**Dry matter content of leaf (%)**	**Root length (cm)**	**Root diameter (mm)**	**Fresh weight of root (g)**	**Dry matter content of root (%)**
M	3	35.48**	19.95**	5.26**	16.14**	332.42**	52.76**
W	3	84.37**	24.05**	3.32**	49.62**	458.83**	31.48**
M*W	9	39.55**	10.86**	1.07**	11.19**	49.51**	20.52**
Error	48	8.18	4.13	0.48	4.94	79.131	0.14

**: at <0.01 level of probability, ns: non-significant, *: at <0.05 level of probability

Appendix VII. Analysis of variances on brix, vit-C, β- carotene and total sugar and reducing sugar of carrot.

		Mean square				
Source	**Degrees of freedom**	**Brix (%)**	**Vit –C (%)**	**β- Carotene (µg/100g)**	**Total sugar (%)**	**Reducing sugar (%)**
M	3	5.31**	5.63**	168160**	990.275**	288.52**
W	3	2.95**	50.04**	1494657**	24.848**	3.35**
M*W	9	4.36**	17.55**	430786**	9.413**	1.03**
Error	48	0.02	0.0772	27	0.062	0.13

**: at <0.01 level of probability, ns: non-significant, *: at <0.05 level of probability

Appendix VIII: Analysis of variances on non-reducing sugar, CHO, moisture, ash and protein of carrot.

		Mean squqre				
Source	**Degrees of freedom**	**Non-reducing sugar (%)**	**CHO (g/100g)**	**Moisture (%)**	**Ash (%)**	**Protein (%)**
M	3	458.27^{**}	3.44^{ns}	2.03^{ns}	0.019^{**}	2.34^{**}
W	3	10.38^{**}	5.61^{**}	5.78^{**}	0.005^{ns}	0.04^{**}
M*W	9	5.64^{**}	4.11^{**}	3.06^{**}	0.005^{ns}	0.11^{**}
Error	48	0.197	1.36	1.16	0.007	0.015

**: at <0.01 level of probability, ns: non-significant, *: at <0.05 level of probability

Appendix IX: Analysis of variances on N, P, K, Ca and Mg of carrot

		Mean square				
Source	**Degrees of freedom**	**N (%)**	**P (%)**	**K (%)**	**Ca (%)**	**Mg (%)**
M	3	0.05^{**}	3.67^{ns}	0.023^{**}	0.20771^{**}	0.00278^{ns}
W	3	0.35^{**}	1.48^{*}	0.04^{**}	0.06830^{**}	0.01009^{**}
M*W	9	0.04^{**}	4.12^{ns}	0.00^{**}	0.07768^{**}	0.00699^{**}
Error	48	0.00	5.04	0.00	0.00287	0.00211

**: at <0.01 level of probability, ns: non-significant, *: at <0.05 level of probability