Sudan University of Science and Technology

College of Graduate Studies

Effect of compost amendment on growth and flowering of *Portulaca grandiflora* and *Portulaca pilosa*

تأثير اضافة الكمبوست على نمو وازهار نباتي رجلة الزهور وصباح الخير

By:

Salma Mustafa Elhessen Saad

B.Sc. Agric. (Landscape Art culture)

Omdurman Islamic University, 2009

A thesis submitted in partial fulfillment of the requirements for the M. Sc. Degree in Horticulture

Supervisor:

Prof. Mahmoud Ibrahim Yagi

March 2021

Dedication

To the soul of my father, my family, to all who taught me how to read or write.

Acknowledgements

Deep appreciation to my supervisor professor Mahmoud Ibrahim Yagi, for sincere effort and help coupled with smooth guidance to fulfill this study. Appreciation is also extended to Professor Tagelsir Ibrahim for support and help during the course of this study. To the Staff of the Department of horticulture, College of Agricultural Studies, and in particular the Staff of the tissue culture lab. Gratitude is also to my colleague Nabil Kassalawi Abdalla. Thanks, greeting and blessings are due to all study mates for their help and support.

Abstract

In this study, the effects of compost supplements to clay, sand and loam on the growth and flowering of *Portulaca grandiflora and Portulaca pilosa*) were tested in the nursery. Compost was added to the media at the ratio of 1:2. Treatments were: clay, loam, Sand, 2 clay + 1 compost, 2 loam + 1 compost and 2 sand + 1 compost. Treatments were arranged in a completely randomized design. Each treatment was replicated six times. The two grown genotypes responded differently to the various media. Improvement in the measured parameters was noticed in almost all treatments where compost was added to the basic soil types. The most pronounced improvement in growth and flowering of the two genotypes was obtained from clay plus compost. The superiority of clay plus compost over loam which is the principle growth substrate in most nurseries in Khartoum, indicates the possibility of using this mix instead of loam alone. Further confirmatory tests are needed.

المستخلص العربي

فى هذه الدراسة تم اختبار أثر اضافات المادة العضوية الى الطين والرمل والطمي فى نمو وإزهار نباتي رجلة الزهور وصباح الخير فى المشتل. اضيفت المادة العضوية بنسبة 2 : 1. المعاملات كانت كما يلى: طين، رمل، طمى، 2 طين: ا مادة عضوية، 2 طمى: 1 مادة عضوية، 2 رمل: 1 مادة عضوية. رتبت المعاملات في تصميم كامل العشوائية. كُررت كل معاملة ست مرات . تباينت استجابات النوعين المزروعين باختلاف أوساط النمو. تم الحصول على تحسين في مقاييس النمو المرصودة لمعظم الحالات التي تمت فيها إضافة المادة العضوية المتحللة لأنواع التربة الأساسية.تم الحصول على أفضل زيادات في النمو والأزهار في النباتين موضع الدراسة من مخلوط الطين والمادة العضوية المتحللة . وإن أفضلية الطين مع المادة العضوية على الطمي وهو وسط النمو الرئيسي في مشاتل ولاية الخرطوم. تشير إلى إمكانية استخدام هذا الخليط بدلاً عن الطمي . هنالك حاجة لمزيد من الاختبارات التأكيدية.

Table of contents

List of Tables

List of Figures

Chapter one

Introduction

Ornamentals are plants grown for decorative purposes in gardens and landscaping. They are usedas plants, outdoor houseplants orcut flowers. The cultivation of ornamental plants is called floriculture, which forms a major branch of horticulture. Commonly ornamentals are grown for the display of aesthetic features including: flowers, leaves and foliage texture and color, fruit, stem and bark. In some cases, unusual features may be of interest, such as the prominent thorns of *Rosa sericea* and cacti. In all cases, their purpose is for the enjoyment of humans especially gardeners, visitors, and interested public institutions. Ornamentals are either herbs including grasses, shrubs or trees. More-over, they can be indoor plants with different light requirements and such situation adds to the broad diversity of this group of plants (Amingad, and Lakshmipathy, 2014).

The history of ornamentals in Sudan dates back to the early years of the 20th century during the start of British colonization of Sudan. The activity started as component of architecture of official administrative buildings and British residential areas. The British introduced ornamentals to Sudan from their other tropical colonies. They trained the first Sudanese cadre of gardeners and technicians and started to establish public gardens in different towns and collected this group of genotypes in the botanical garden.

Horticultural awareness increased among the population in major cities, which led to an increase in the use of ornamental plants in designing home gardens,shade and flowering trees plantations along streets and roads and landscaping of governmental and private institutes. The biannual flower festivals in Khartoum have increased the public awareness and interest about ornamentals and floriculture to a large extent. The nursery business has been growing with time to meet the growing demand for ornamentals. The main growth substrate in ornamentals nurseries in Khartoum is 'Gureira'. Gureira is loamy soil resulting from the natural sediments of rivers. The use of clay or sand as basic growth substrate is rare. Clay is of poor drainage, while sand loose water quickly. No data is available in Sudan on the use of compost to improve the performance of clay and sand as substrates for growing ornamentals. Besides, scientific documentation on research or specialized references on ornamentals in Sudan is almost rare. Based on the above, this study aimed to test compost as a soil supplement for the improvement of growth and flowering of Moss Rose (*portulaca grandiflora*) and ornamental purslane (*portulaca polisa*), under the conditions of Shambat, Khartoum North, Sudan.

Chapter two

Literature review

2.1 Ground Cover plants:

Ground Cover plants are defined as plants planted to Ground Cover the ground surface (Sharma *etal.,* 2018). Ground Cover plants are vegetable crops, medicinal and aromatic plants or ornamentals. Ground Cover crops can be from any family such as grasses, legumes or forbs. However, to be effective, the Ground Cover crop must be quick and easy to establish, can form an early canopy Ground Cover. They should be aggressive enough to suppress weeds by a dense and deep root system (Morgan, 2005).

Ground Cover provides protection of the topsoil from erosion and drought. The Ground Cover forms the layer of vegetation below the shrub layer known as the herbaceous layer. Most Ground Covers are grasses of various types. In ecology, Ground Covers are known by several local names and are classified in several different ways. The term Ground Cover could also be referring to the herbaceous layer or the ground flora. In agriculture, Ground Cover refers to anything that lies on top of the soil and protects it from erosion and inhibits weeds. It can be a low layer of grasses or even a plastic material. The term Ground Cover can also specifically refer to an essential constituent in landscaping. In gardening, the term Ground Cover refers to plants that are used in place of weeds to improve the of soil surface appearance by concealing bare earth. (Gilliam, 2003).

2.1.1Advantages of Ground Cover plants:

- Improve the appearance of soil surface in landscaping horticulture.

- Improve soil conservation from erosion.

- Improve soil fertility.

- The use of Ground Cover plants also can improve the physical, chemical and biological properties of the soil (Haruna and Nkongolo, 2015; Ali *etal.*, 2018; Nascent and Stone, 2018).

- Improve soil water- holding capacity.

Lawns and flowering Ground Cover plants modify the coloring of open surfaces.

Ground Cover plants improve the environmental relative humidity and temperature and can absorb carbon dioxide and reduce the harmful effects of poisonous gases and Ground Cover is crucial to the survival of many environments (Gilliam, 2003).

The Ground Cover plants can be used as a weed management technique when establishing woody plantings (Balandier *etal.*, 2009; Willoughby *et al.*, 2009).

Ground Cover plants can produce a higher amount of biomass and increase soil organic matter (Laghlimi *etal.*, 2015; Whitaker *et al.*, 2018).

Ground Cover plants can be used to reduce the concentrations of heavy metals in soils (Ali *etal.*, 2013; Sumiahadi and Acar, 2018).

2.1.2 Ornamental Ground Cover plants:

2.1.2.1 Lawns:

Lawn plants are green Ground Cover plants of the grass type, belonging to Graminae, a mono cotyledon family. The lawn is an area of soil-Ground Covered land planted with grasses and other durable plants which are maintained at a short height with a lawnmower (or sometimes grazing animals) and used for aesthetic and recreational purposes. They are usually composed only of grass species and are subject to weed and pest infestations. Lawns are maintained in green color by watering, and fertilizers. They are regularly mowed to ensure an acceptable length. According to Ray (2010), lawns are used around houses, commercial buildings and offices. Most city parks have large lawn areas. In recreational contexts, the specialized names turf, pitch, field or green may be used depending on the sport and use. Lawns are useful as a playing surface both because they mitigate erosion and dust generated by intensive foot traffic and because they provide a cushion for players in sports (Susan, *etal.,* 2016). The three basic categories are cool season grasses, warm season grasses, and grass alternatives (Huxley, 1992).

2.1.2.2 Green Ground Cover plants:

Green Ground Cover plants are used in gardens as small patches of greenery. Among plants of this group are sweet potato and (*Hedera helix*).

2.1.2.3 Flowering Ground Cover plants:

Like the green Ground Cover plants, the flowering Ground Cover plants are used in small areas to conceal the structural defects in the garden. Among plants of this group are: *Lantana camara, Chrythanthemum spp., Portulaca grandiflora* and *Portulaca pilosa*.

2.1.3 Moss rose (Good morning) plant:

Portulacagrandiflora is a succulent flowering plant in the family Portulacaceae, native to Argentina, southern Brazil, and Uruguayand often cultivated in gardens (Huxley, 1992). It has many common names, including rose moss, ten o'clock, Mexican rose moss rose, Vietnam Rose, sun rose, rock rose, and moss-rose purslane. It is also seen in South Asia and widely spread in most of the cities with old 18th- and 19th-century architecture in the Balkans It is a small, but fast-growing annual plant growing to 30 cm tall, though usually less. However, if it is cultivated properly, it can easily reach this height. The leaves are thick and fleshy, up to 2.5 cm long, arranged alternately or in small clusters. The flowers are 2.5–3 cm diameter with five petals, variably red, orange, pink, white, and yellow. (Huxley, 1992). Their upright, or ascending, long shoots branch usually near the base. The spreading 20 to 25 millimeters long and 2 to 3 millimeters wide leaves are almost or completely stalk-shaped and taper towards the tip. The axillary have few to numerous, whitish, woolly hair, which are usually shorter than the sheets. The compressed inflorescences are surrounded by eight to ten leaves. The large flowers reach a diameter of up to 4 centimeters. The five bright magenta-colored petals are obviate and 15 to 26 millimeters long. Around the ovary with four to nine whitish scars are about 50 stamens. Capsules and seeds are not visible. (NRCS,2016).

Numerous cultivars have been selected for double flowers with additional petals, and for variation in flower colour, plain or variegated. (Huxley,1992).

It is widely grown in temperate climates as an ornamental plant for annual bedding or as a container plant. It requires ample sunlight and well-drained soils. It requires almost no attention and spreads itself very easily. In places with old architecture it can grow between the stones of the road or sidewalk. Seeds are often sold as mixtures, such as Double Flowering Mixture (see illustrations). It grows on sandy soils. In countries with a frost-free climate, it is wild. (Mitchell, 2003). Unlike *P. oleracea and P. umbraticola,* it is not edible because of its bitter taste. There are hybrids of *P. grandiflora* with *P. oleracea, umbraticola and villosa*. It is visited by honeybees for its pollen and nectar.

2.1.4 The flowering purslane (*Portulaca pilosa*):

Portulaca pilosa is a species of floweringsucculent plant in the purslane family, Portulacaceae, which is native to the Americas. Its common names include pink purslane, kiss-me-quick and hairy pigweed. Its range extends from the southern United States and the Caribbean as far south as Brazil. It is a succulent with linear leaves and pink flowers. (Lacerda*etal.,* 2002; Ocampo and Columbus, 2012). The name is derived from pilose, which means to be Ground Covered with long soft hairs. *Portulaca pilosa* is a highly variable species. It exhibits morphological variability during development with the immature plants having a wider, longer and flatter leaves than its mature counterparts. The mature leaves are narrower, shorter and more hemispheric in cross section. Physical differences may also occur due to the variable habitat that this species can be found in. Plants that grow in an arid environment tend to the greatest density of hairs. Plants that grow in a moister environment tend to have less hairs (Allred and Ivey 2012). Plants with very dense hair under a certain condition will produce growth with fewer hairs under a moist condition, showing its variability of growth. Habit is also governed by habitat. Plants growing in moist, warm environments tend to branch rather quickly into a spreading habit, with a secondary growth which is erect. Plants in dry and cool environment do the opposite in that they grow erect first and then branch more slowly. This type has a more compact habit. Specimens from Alabama, Arizona, Florida, Louisiana, Mississippi, Texas, and New Mexico exhibit all morphologic conditions. Those from Arkansas, Kansas, Missouri, and Oklahoma usually tend to occur in shallow, sandy soils, often on rocky outcrops, and are often highly branched, compact, short, and not very pilose (hairy) (Wunderlin and Hansen, 2003).

Portulaca pilosa is a pantropical species which according to some sources is native to the Americas, and according to others to Asia or even to both. In the Americas *P. pilosa* can be found in Mexico, West indies, Central America, and as far south in South America as Brazil. In the United States, they are typically concentrated in the southern parts such as Arkansas, Texas, New Mexico, Florida, and Mississippi (Allred and Ivey 2012).

2.2 Physical, chemical and biological characteristics of soil types:

Soil physical, chemical, and biological characteristics have significant bearing on crop production. Soil physical properties are extremely important in determining soil usage. Soil management practices like tillage, crop rotation, organic supplements and irrigation are of significant impacts on shoot and root growth and crop productivity per unit area. An improvement in soil structure would change the bulk density, relative proportion of macro and micro pore space, water infiltration in soil, soil water retention and air-water relation to the advantage of crop productivity ((Heenan *etal.*, 2004).

Availability of nutrients to plants is largely a function of soil chemical and biological characteristics. The reaction of soil solution is acidic, alkaline or neutral. Soil reaction is largely controlled by soil colloids and their associated exchangeable cations. Knowledge of soil chemical characters is essential to know how soil reaction is controlled, how it influences the supply and availability of plant nutrients and soil microbial activities (Jacqueline, 2019).

Biological activities are vital to the cycle of life on earth. Soil microbes digest plant and animal residues incorporated in the soil, release carbon dioxide in to the atmosphere for recycling through higher plants and would create humus vital to good physical and chemical soil conditions. During decomposition, soil organisms release essential plant nutrients in inorganic forms for plant absorption. Activities of some macro organisms such as earthworms, rodents, ants and snails have significant effect on soil physical properties (Jacqueline, 2019).

2.2.1 Clay:

Clay is a finely-grained natural rock or soil material that combines one or more clay minerals with possible traces of quartz (SiO_2), metal oxides (Al_2O_3 , MgO etc.) and organic matter. Geologic clay deposits are mostly composed of phyllosilicate minerals containing variable amounts of water trapped in the mineral structure (Guggenheim and Martin 1995).

Mixtures of sand, silt and less than 40% clay are called loam. Loam makes good soil and is used as a building material.

Depending on the academic source, there are three or four main groups of clays: kaolinite, montmorillonite-smectite, illite, and chlorite.

2.2.2 Loam:

Is soil composed mostly of sand (particle size> 63 micrometers (0.0025 in), silt (particle size > 2 micrometers (7.9×10^{-5} in)), and a smaller amount of clay (particle size < 2 micrometers (7.9×10^{-5} in)). By weight, its mineral composition is about 40–40–20% concentration of sand–silt–clay, respectively. These proportions can vary to a degree, however, and result in different types of loam soils: sandy loam, silty loam, clay loam, sandy clay loam, silty clay loam, and loam. (Kaufmann *etal.*, 2008). Loam is found in a majority of successful farms in regions around the world known for their fertile land. Loam soil feels soft and crumbly and is easy to work over a wide range of moisture conditions (Magdoff, and Van Es., 2009).

2.2.3 Sand:

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass (CDOF, 1976). The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropicalcoastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example, aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. For example, it is the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean. Sand is a non-renewable resource over human timescales, and sand suitable for making concrete is in high demand. (Ashraf *etal.*, 2011).

By definition, in terms of particle size as used by geologists, sand particles range in diameter from 0.0625 mm (or 1⁄16 mm) to 2 mm. An individual particle in this range size is termed a sand grain. Sand grains are between gravel (with particles ranging from 2 mm up to 64 mm by the latter system, and from 4.75 mm up to 75 mm in the former) and silt (particles smaller than 0.0625 mm down to 0.004 mm). Sands are defined as fine, medium, and coarse with ranges 0.063 mm to 0.2 mm to 0.63 mm to 2.0 mm. The most common constituent of sand, in inland continental settings and non-tropical coastal settings, is silica (silicon dioxide, or SiO2). Agriculture: Sandy soils are ideal for crops such as watermelons, peaches, and peanuts, and their excellent drainage characteristics make them suitable for intensive dairy farming (Krause *etall*., 2010).

2.3 Compost:

The compost is organic matter that has been decomposed in a process called composting. In composting, various wastes of organic materials which might be regarded as wastes are recycled in a product called compost used as soil conditioner. Compost is rich in nutrients and is usually used in gardens, landscaping and organic farming (Elisee *etal.*, 2001).

Composting can be aerobic or anaerobic. At the simplest level, the process of composting requires making a heap of wet organic matter (also called green waste), such as leaves, grass, and food scraps, and waiting for the materials to break down into humus after a period of months. However, composting also can take place as a multi-step, closely monitored process with measured inputs of water, air, and carbon- and nitrogen-rich materials. Microbes such as bacteria, fungi, actinomycetes, beside earth-worms are involved in the decomposing process. Composting requires the following three components: human management, aerobic conditions, development of internal biological heat. Certain ratios of carbon, nitrogen, oxygen and water are needed to provide the growth requirements of the microorganisms so they can work at a rate that will heat up the pile. Active management of the pile (e.g. turning) is needed to maintain sufficient supply of oxygen and the right moisture level. Alate *etal.,* (2019) proved the agronomic potential value of household urban solid wastes by composting. Studying composts, Agbede *etal.,* (2008) showed improvements in grain yield and soil physical and chemical characters by use of poultry manure. Composts from different sources are of different fertilizer value and trace elements contents (Meller *etal.,* 2015). The different wastes used for composting might be of different heavy metal content (Khan *etal.,* 2016). Yet, use of compost improves soil properties and crop productivity under low input agricultural system (Quedraogo *etal.,*2001).

Chapter three

Materials and methods

3.1 Experimental site:

Two experiments were conducted at the nursery of the Plant Tissue Culture Laboratory of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat, Khartoum North (latitudes 15 40'N, longitude 32 32'E, and altitude 375 meter above sea level).The climate of the site is tropical semi- dray, with summer rains. The average maximum temperature was 39.7C and the mean minimum temperature was 26.4C.

3.2 Experimental materials:

Moss rose (*Portulacagrandiflora*) and purslane (*Portulaca Pilosa)* were used in experiment (1) and experiment (2) respectively.

Three types of soil: clay, loam and sand were compared with or without compost as growth substrates for Moss Rose and ornamental purslane. The compost was a commercial formula named Abu Alkhaseeb made by the International Industrial and Trading Co. Ltd., Sudan. The chemical composition of the compost is compiled as appendix 1.

The plant materials for both tests were 10 cm stem cuttings from each plant planted directly in 20X30 cm plastic bags.

3.3 Treatments:

The following treatments were tested on each of Moss Rose and ornamental purslane:

1. Clay
2. Loam
3. Sand
4. Clay + Compost (2:1)
5. Loam + Compost(2:1)
6. Sand + Compost (2:1)

3.4 Experimental design and statistical analysis:

Treatments were laid in a completely randomized design with six replications. On bag (plant?) represented an experimental unit. Statistical analysis was carried out using MS tat- C computer program.

Mean separation was done by Dunlin's Multiple Range test at 5% level of significance.

3.5 The planting date:

The planting date for both plants was 12/9/2018, and the final data was recorded on 27/12/2018.

3.6 Measured parameters:

Data for both plants were recorded for the following parameters:

1. Plant height (m)
2. Number of main branches.
3. Number of secondary branches.

4. Number of tertiary branches.
5. Number of flowers.
6. Shoot fresh weight (g).
7. Shoot dry weight (g).
8. Root fresh weight (g).
9. Root dry weight (g).

Chapter four

Results

4.1. Experiment (1):

According to Table (1) and Figure (1-5), the basic growth substrates devoid of compost performed differently where clay ranked top for all parameters, followed by loam while the least values were recorded for sand. Upon addition of compost to the basic growth substrates, clay + compost resulted in best growth and flowering. In general the addition of compost to loam was enhancive for all measured growth parameters while improvements in number of branches, tertiary branches and number of flowers were also recorded in sand + compost.

Table (1). Effect of growth substrates on growth and flowering of moss rose (*Portulaca grandiflora*) 14 weeks after planting

Growth substrate	height plant (cm)	Number of main branches	No. of secondary branches	No. of Tertiary branches	Number of flowers
Clay	25.08b	32.17c	13.00b	20.50 b	22.50 b
Loam	20.90c	21.17e	11.67 b	13.83 c	14.33 d
Sand	19.42c	11.67f	5.833 c	5.833 d	13.00 d
Clay + Compost	28.48a	60.50a	18.33a	45.33 a	27.17 a
Loam + Compost	24.75b	28.17d	12.67 b	18.50 b	18.50 c
Sand + Compost	14.98d	38.17b	5.667 c	43.67 a	17.17 c
LSD	2.067	3.864	1.525	2.209	1.722
C.V%	7.87	10.25	11.55	7.61	7.078

*Means within column with the same letter(s) are not significantly different at P=0.05. acceding to Dunant's Multiple Range Test(DMRT)

4.1.1 Effect of growth substrate on plant height (cm):

Table (1) and Figure (1) shows the effect of growth substrates on plant height of moss rose (*Portulaca grandiflora)*. Clay + compost resulted in best heightfollowed by loam + compost or clay alone.

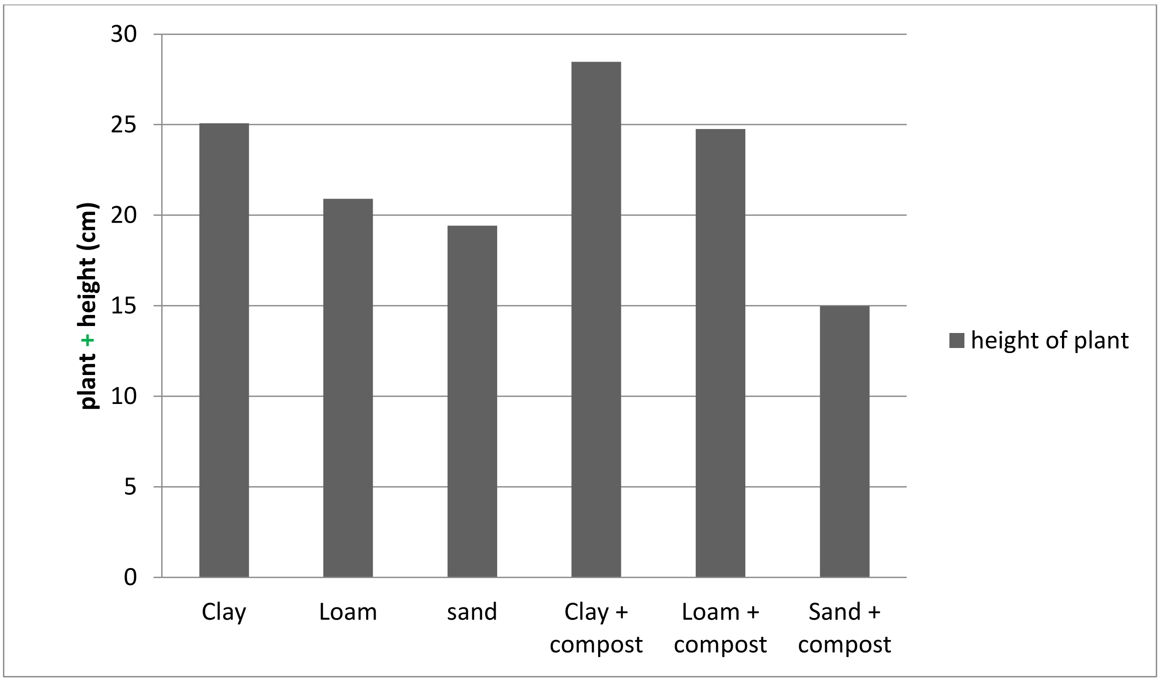

Figure (1). Effect of growth substrate on plant height of Moss Rose plant *Portulaca grndiflora*.

4.1.2 Effect of growth substrate on number of main branches

According to Figure (2), the highest number of branches in Moss Rose (*Portulaca grandiflora*) was recorded for clay + compost with significant difference from other treatments. The lowest number of branches was recorded for sand alone, but when compost was added to sand it increased the number of branches to the second rank.

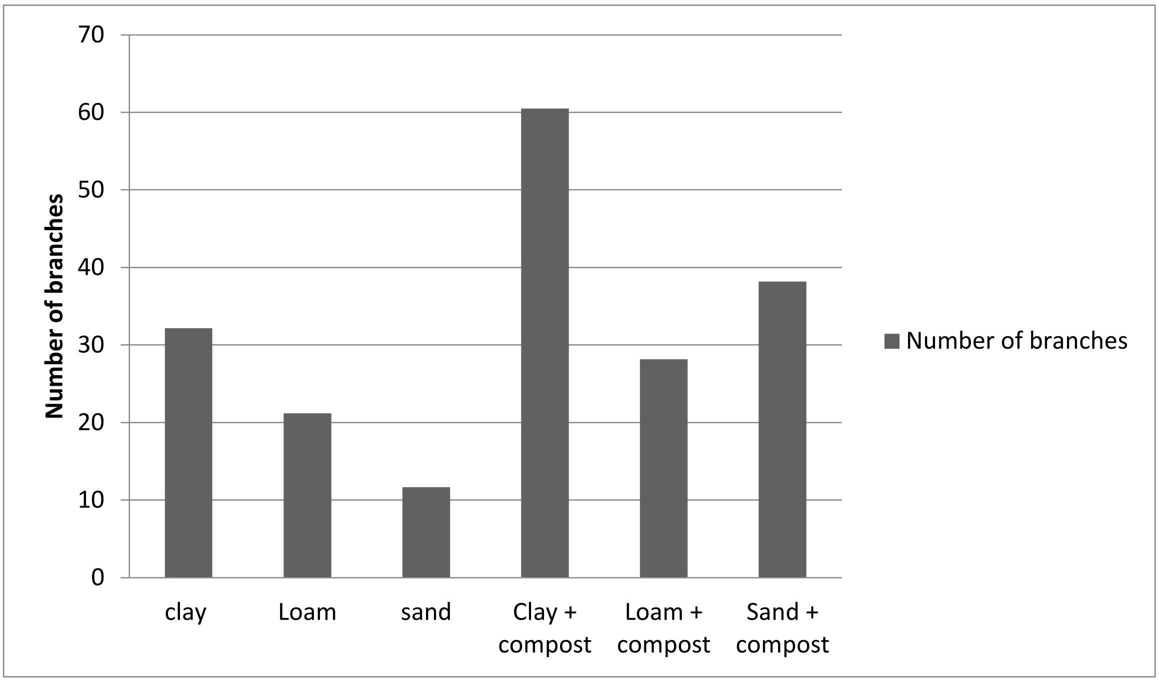

Figure (2). Effect of growth substrates on the number of main branches in Moss Rose plant *Portulaca grndiflora.*

4.1.3 Effect of growth substrate on the number of secondary branches:

Figure (3) shows the effect of growth substrates on the number of secondary branches in Moss Rose (*Portulaca grandiflora*). The highest number of secondary branches was achieved in clay + Compost. Compost did not improve this parameter in sand and loam.

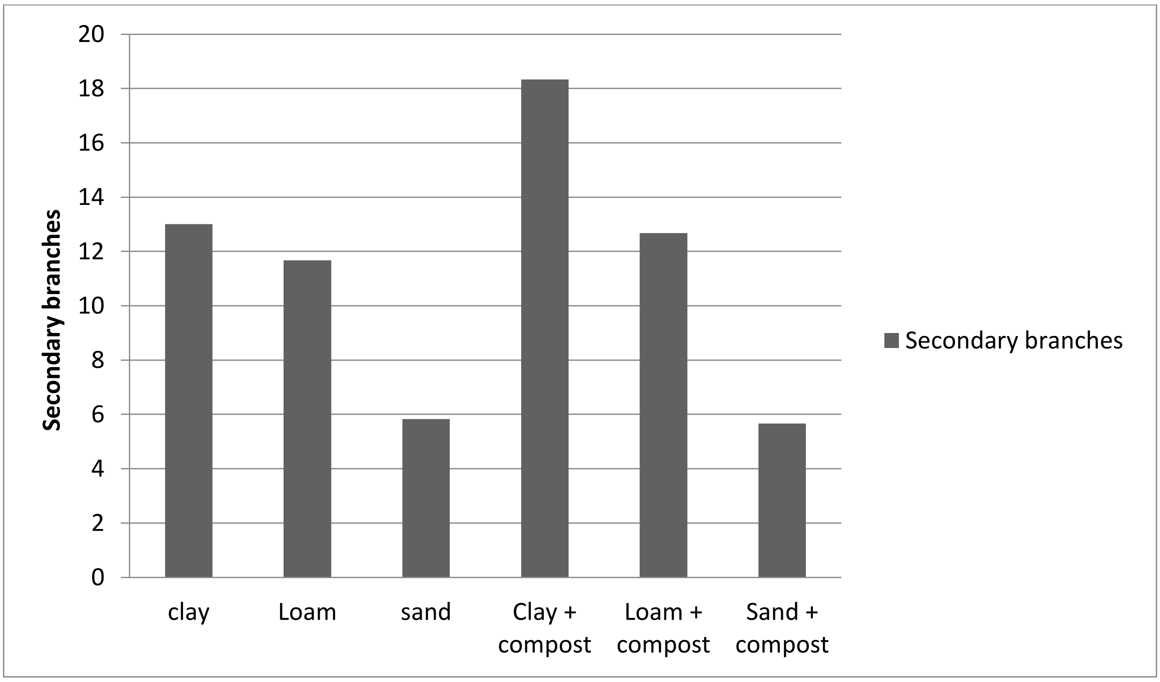

Figure (3). Effect of growth substrates on the number of secondary branches in Moss Rose plant *Portulaca grndiflora.*

4.1.4. Effect of growth substrate on the number of tertiary branches:

The highest number of tertiary branches was obtained from compost plus clay or sand. The least number of tertiary branches was recorded for sand alone (Figure 4).

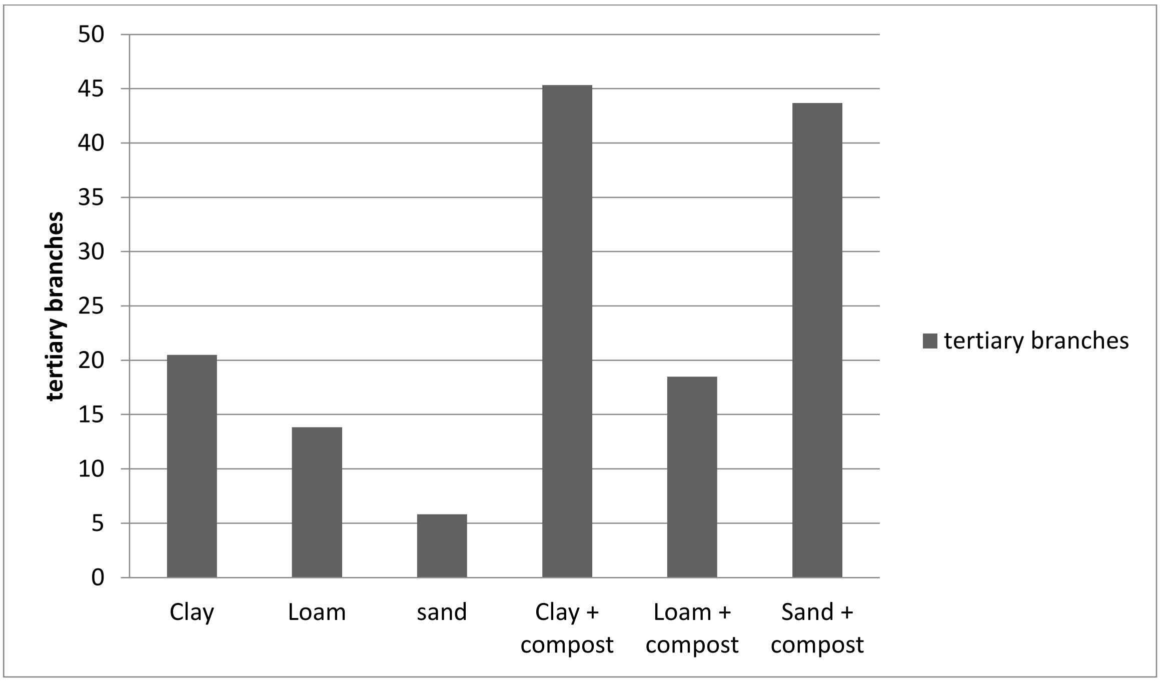

Figure (4). Effect of growth substrates on the number of tertiary branches in Moss Rose plant *Portulaca grndiflora.*

4.1.5 Effect of growth substrate on the number of flowers in Moss Rose plant (*Portulaca grandiflora*):

Figure (5) illustrates the effect of growth substrate on number of flowers in Moss Rose (*Portulaca grandiflora*). The highest number was obtained from clay + compost followed by clay alone. Compost also improved the number when added to either loam or sand.

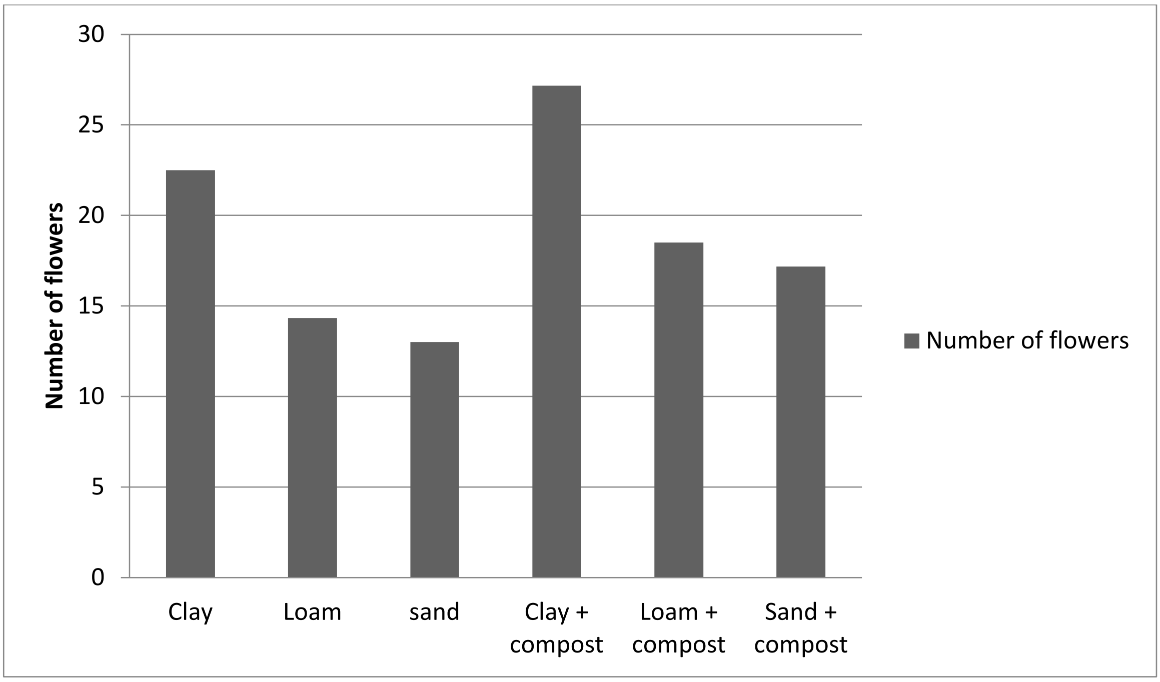

Figure (5) Effect of growth substrates on the number of flowers in Moss Rose plant *Portulaca grndiflora*

4.2 Effect of growth substrates on fresh and dry weights of shoots and roots of Moss Rose plant (*Portulaca grandiflora*):

The addition of compost to the basic substrates increased shoot fresh and dry weights significantly. Loam + compost was significantly higher than sand + compost, but was statistically equal to clay + compost. However, clay + compost resulted in best fresh and dry weights of roots (Table 2; Figures 6-9.

Table (2). Effect of growth substrates on fresh and dry weights of shoots and roots of Moss Rose plant (*Portulaca grandi flora*)

Growth substrate	**Shoot**		**Root**	
	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
Clay	46.00c	4.575c	10.43c	2.100 b
Loam	17.88d	1.375d	13.00b	2.525b
Sand	10.77d	0.775d	05.00d	1.100 c
Clay + compost	84.55ab	7.500ab	15.10 a	3.425a
Loam + compost	88.25a	8.575a	05.12d	1.475c
Sand + compost	74.28b	6.625b	02.73e	0.475d
LSD	10.63	1.227	1.762	0.4814
C.V%	13.34	16.84	13.85	17.52

*Means within column with the same letter(s) are not significantly different at P=0.05, according to DMRT

4.2.1 Effect of growth substrates on shoot fresh weight of Moss Roes plant(Portulaca grndiflora):

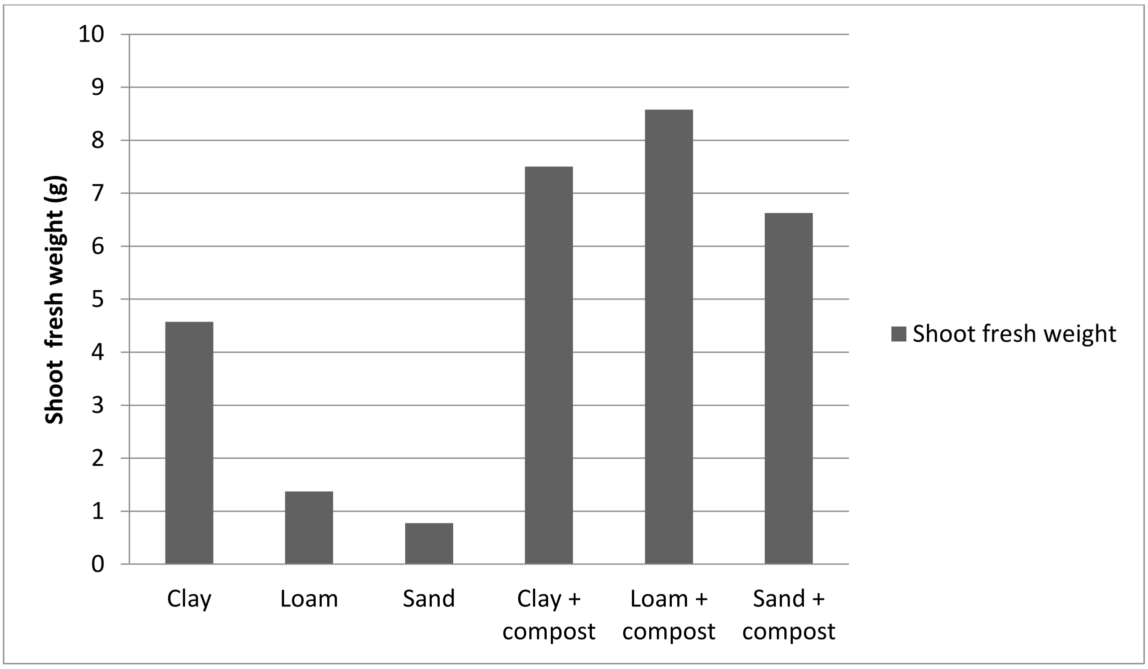

Figure (6). Effect of growth substrates on the shoot fresh weight in Moss Rose plant *Portulaca grndiflora*

4.2.2 Effect of growth substrates on shoot dry weight of Moss Roes plant (Portulaca grndiflora):

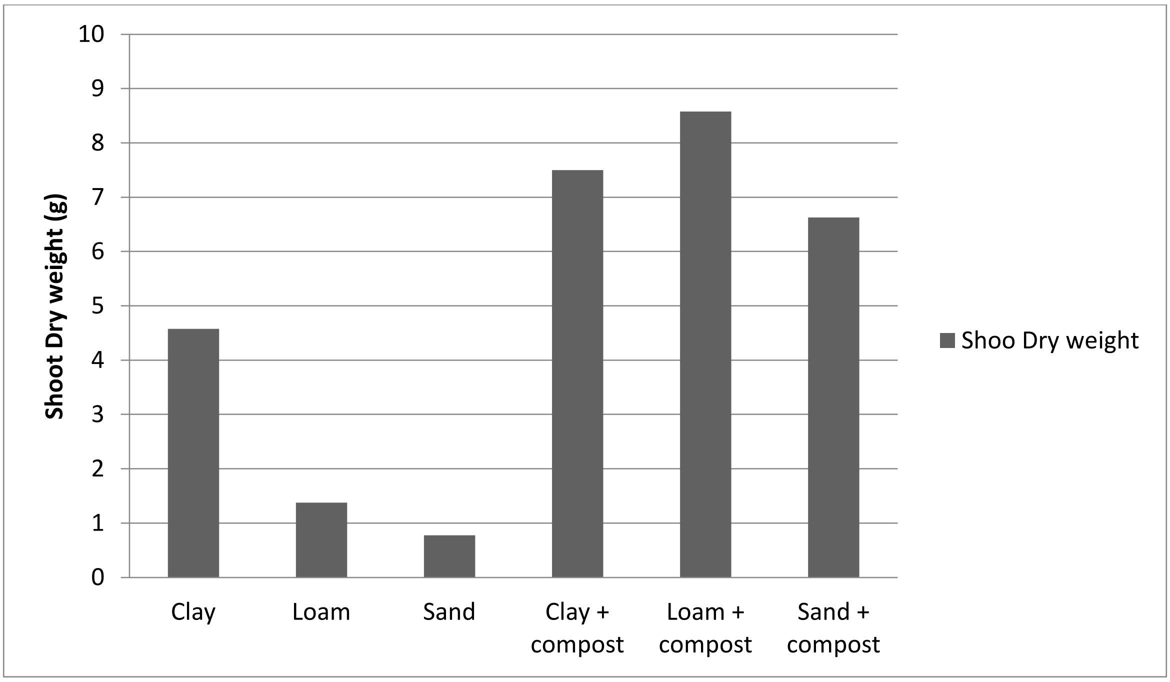

Figure (7) Effect of growth substrates on the shoot dry weight in Moss Rose plant *Portulaca grndiflora*

4.2.3 Effect of growth substrates on root fresh weight of Moss Roes plant(Portulaca grndiflora):

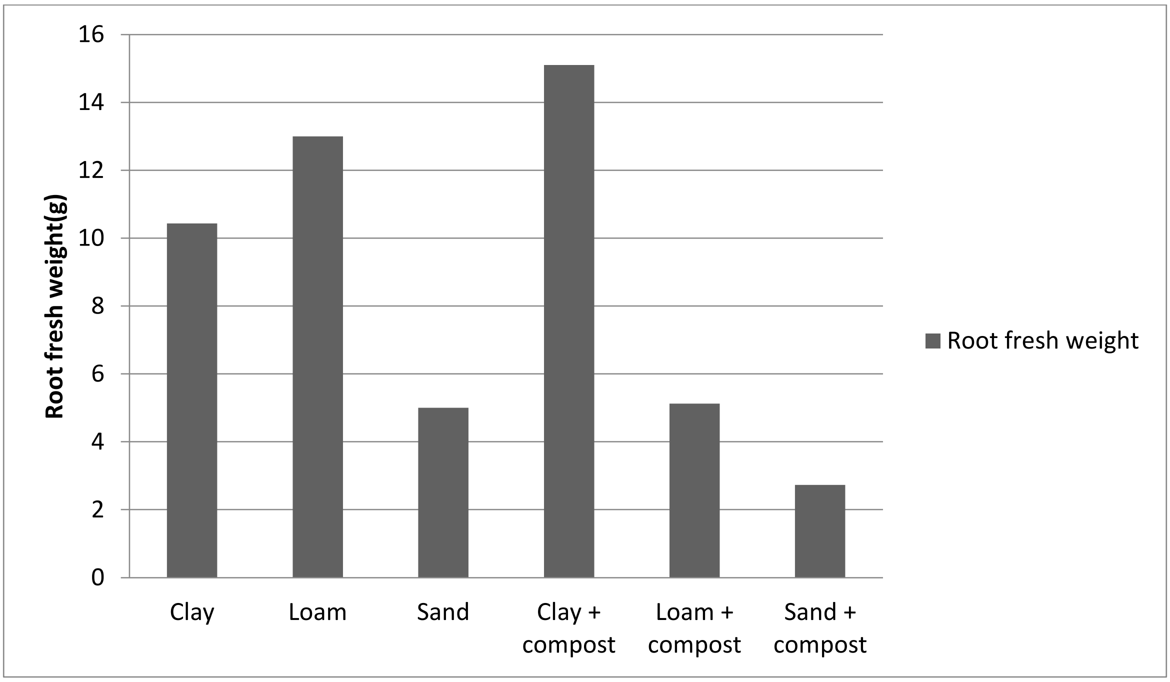

Figure (8). Effect of growth substrates on the root fresh weight in Moss Rose plant *Portulaca grndiflora.*

4.2.4 Effect of growth substrates on root dry weight of Moss Roes plant (Portulaca grndiflora).:

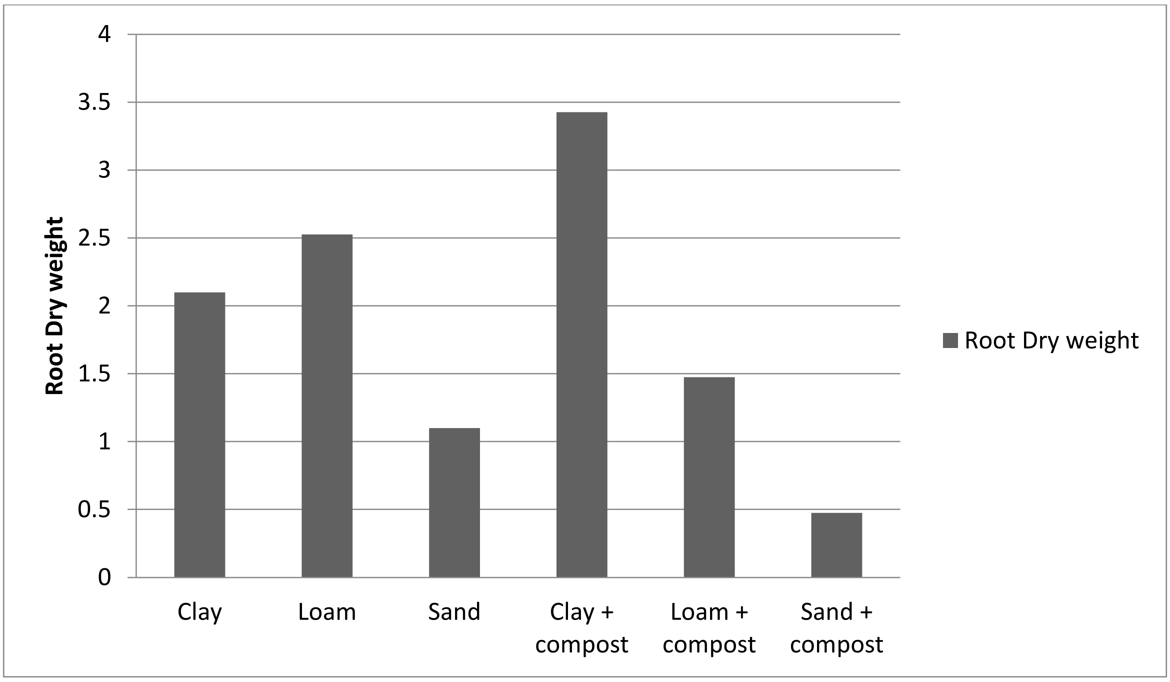

Figure (9). Effect of growth substrates on the root dry weight in Moss Rose plant *Portulaca grndiflora***.**

4.3 Experiment (2):

According to Table (3) and Figure (10-14), the performance of basic growth substrates was mostly improved when supplemented with compost. Generally loam + compost was the best enhancer of measured growth parameters including the number of flowers.

Table (3). Effect of growth substrates on growth and flowering of purslane (*Portulaca pilosa*)

Growth substrate	Plant height (cm)	Number of main branches	Number of secondary branches	Number. of Tertiary branches	Number of flowers
Clay	24.50 b	24.50 dd	12.83	23.33c	13.33d
Loam	20.47 c	36.00 cc	15.33c	22.17c	23.83b
Sand	17.80 d	16.33 ee	11.83d	6.500e	5.667e
Clay + compost	27.42a	70.17 bb	21.17a	33.50b	19.33c
Loam + compost	29.30 a	76.83 aa	17.50b	56.33a	29.67a
Sand + compost	18.67cd	23.33 dd	13.17d	13.67d	17.50c
LSD	2.241	4.006	1.854	2.855	2.290
C.V%	8.29	8.27	10.27	9.34	10.16

*Means within column with the same letter(s) are not significantly different at P=0.05, according to DMRT

4.3.1. Effect of growth substrate on plant height (cm):

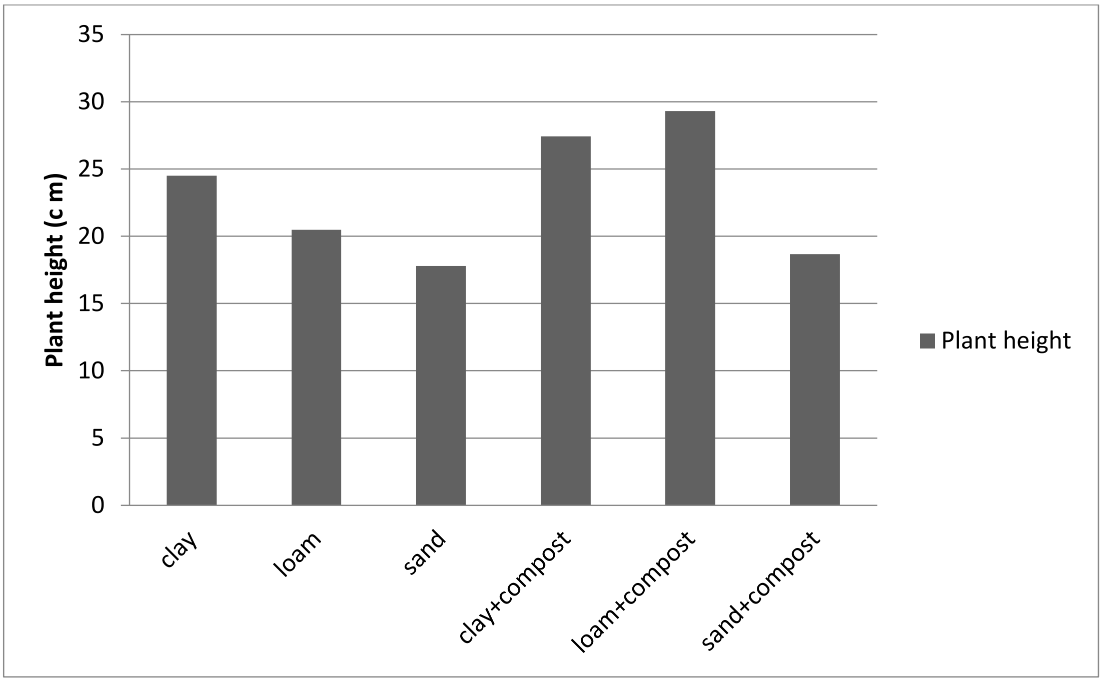

Figure (10) Effect of growth substrates on plant height *Portulaca pilosa*

4.3.2. Effect of growth substrate on number of branches:

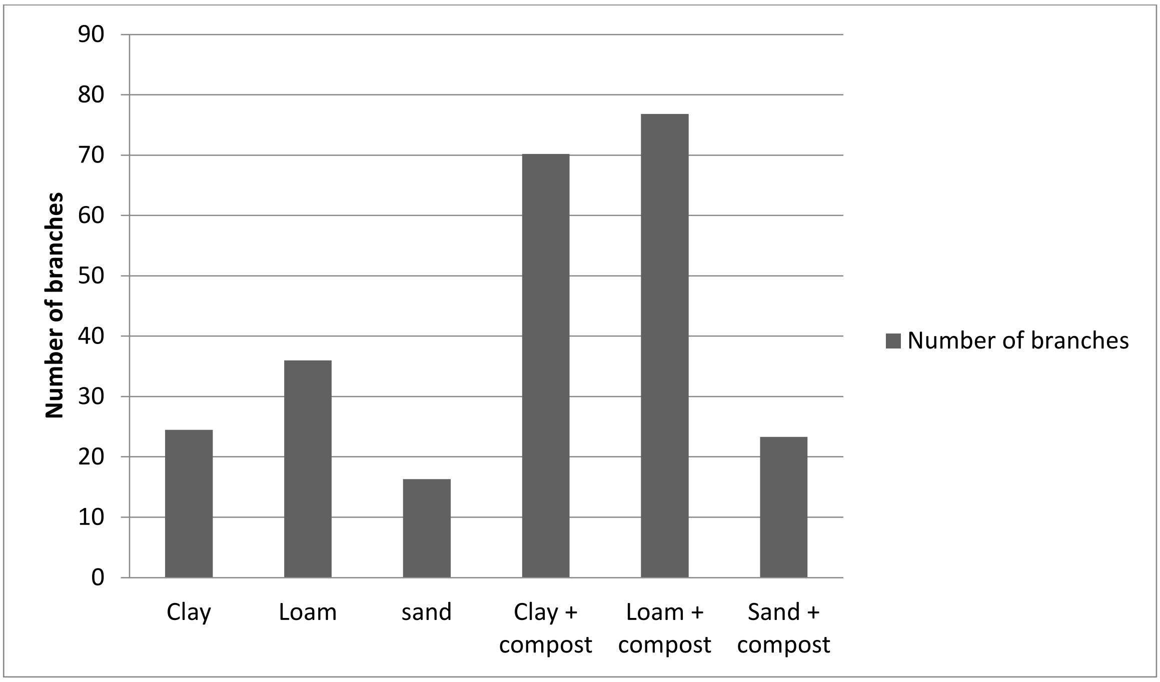

Figure (11) Effect of growth substrates on the number of branches in *Portulaca pilosa*

4.3.3 Effect of growth substrate on secondary branches:

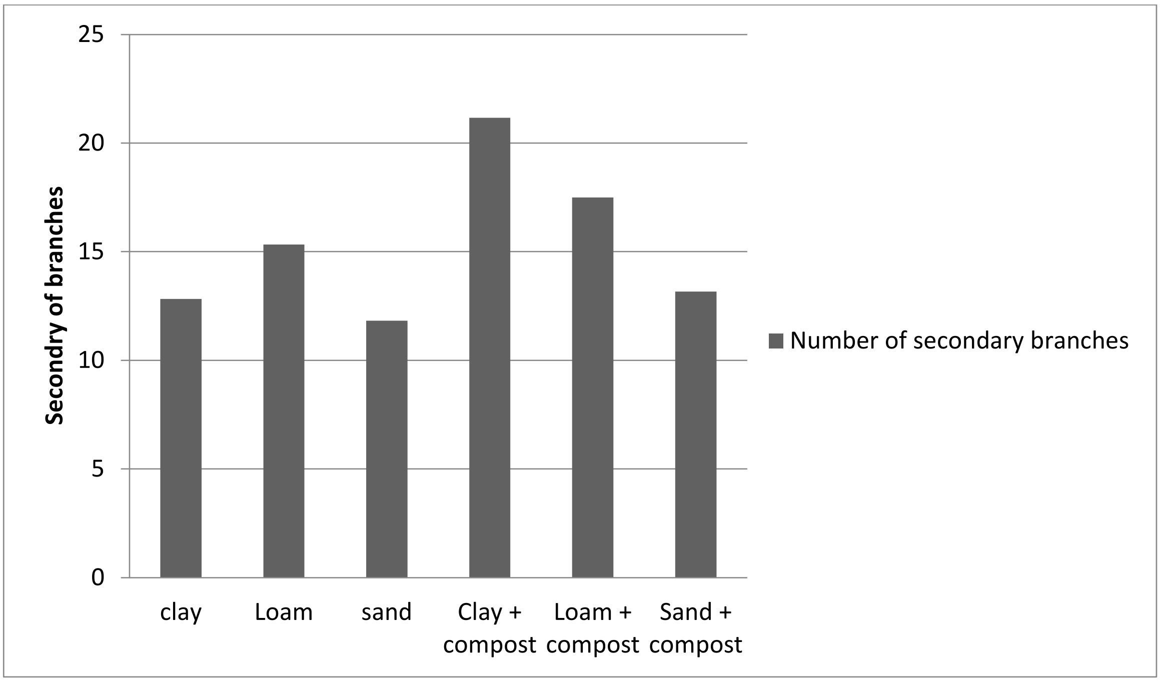

Figure (12) Effect of growth substrates on the number of secondary branches in *Portulaca pilosa*

4.3.4 Effect of growth substrate on Tertiary branches:

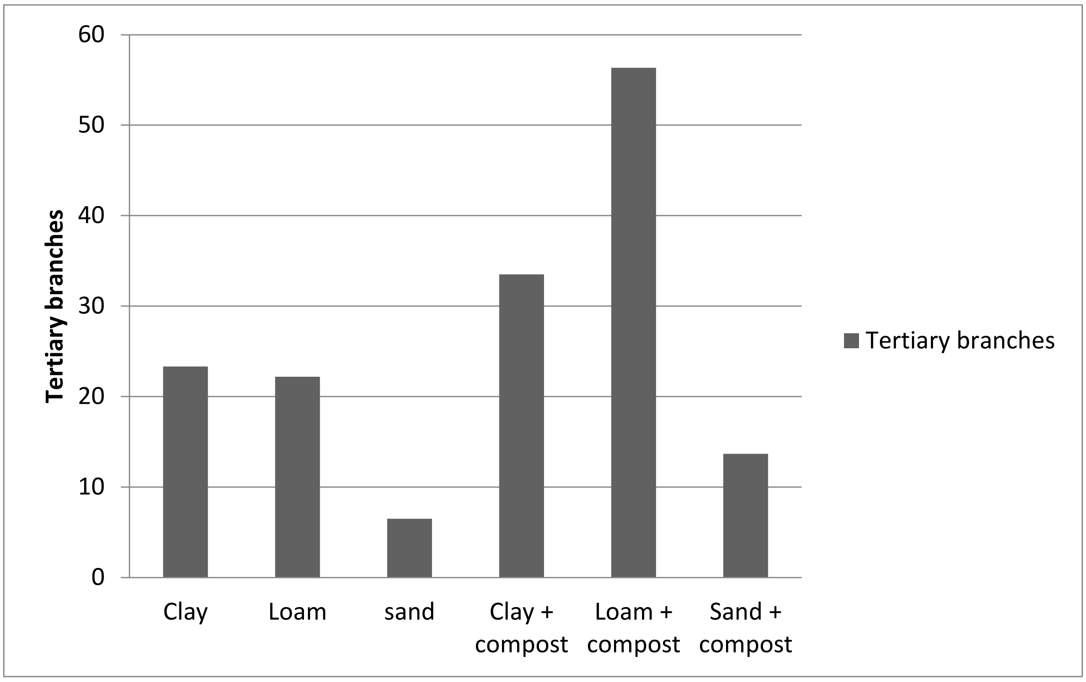

Figure (13) Effect of growth substrates on the number of Tertiary branches in *Portulaca pilosa*

4.3.5. Effect of growth substrate on number of flowers:

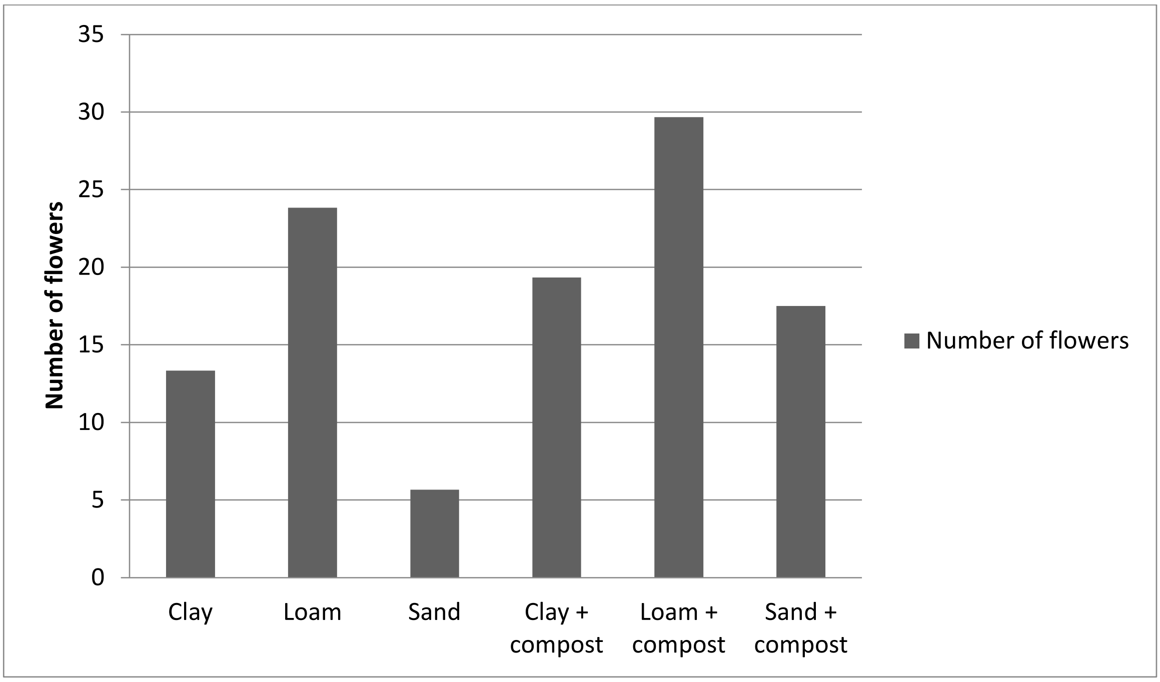

Figure (14). Effect of growth substrates on the number of flowers in *Portulaca pilosa*.

4.4 Effect of growth substrates on fresh and dry weights of shoots and roots of purslane*(Portulaca pilosa)*(g):

Table (4) and Figures (15-18) demonstrate the effect of growth substrates on fresh and dry weights of shoots and roots of *Portulaca pilosa*. The addition of compost to any of the three basic growth substrates resulted in improvement in both shoot and root fresh and dry weights. The highest shoot fresh weight was obtained from loam + compost, but clay + compost ranked top for shoot dry weight without significant difference from loam + compost. The root fresh weight was equally increased by clay + compost and loam + compost. However, clay + compost resulted in best root dry weight.

Table (4). Effect of growth substrates on fresh and dry weights of shoots and roots of purslane(*Portulaca pilosa*)(g)

Growth substrate	Shoot		Root	
	fresh weight(g)	Dry weight(g)	fresh weight(g)	Dry weight(g)
Clay	49.28c	4.000ab	3.575b	1.000c
Loam	20.13e	2.125c	1.625cd	0.625d
Sand	8.000f	2.000c	0.500d	0.375d
Clay + compost	58.88b	4.975a	5.625 a	2.250 a
Loam + compost	66.50a	4.375ab	6.875a	1.750 b
Sand + compost	43.38d	3.450b	2.725bc	0.475d
LSD	4.302	0.9787	1.335	0.2616
C.V%	7.06	18.89	25.77	16.38

*Means within column with the same letter(s) are not significantly different at P=0.05, according to DMRT.

4.4.1 Effect of growth substrates on shoot fresh weight of purslane(*Portulaca pilosa*):(g)

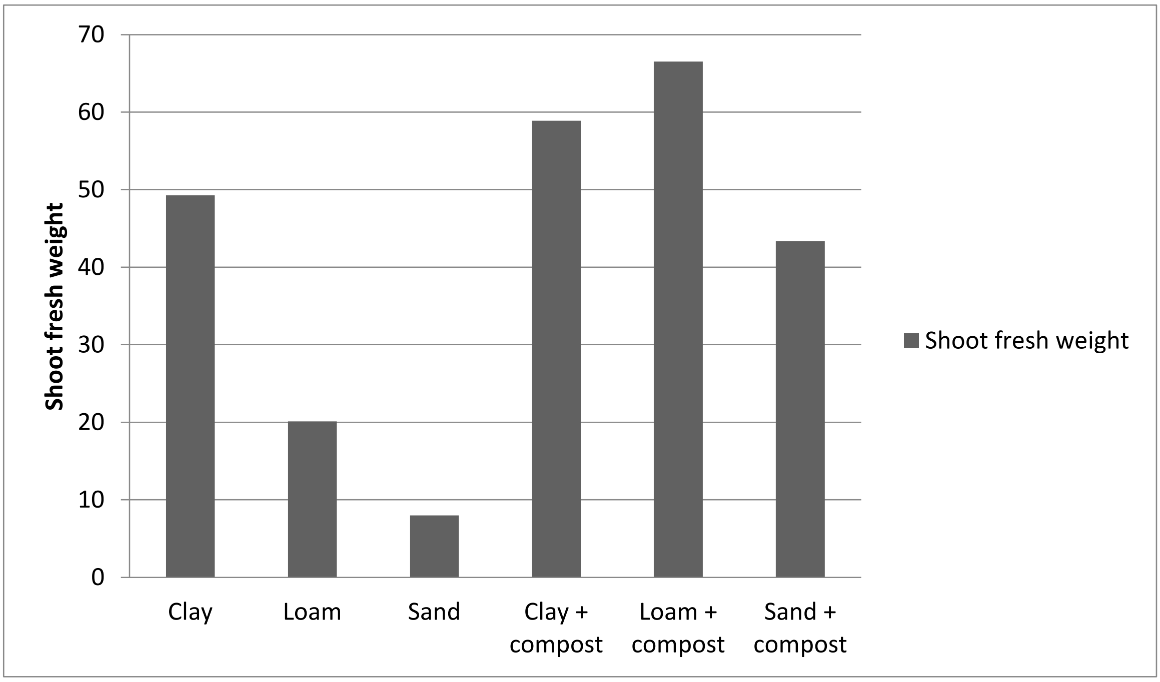

Figure (15). Effect of growth substrates on the shoot fresh weight in *Portulaca pilosa*.

4.4.2 Effect of growth substrates on shoot dry weight of purslane*(Portulaca pilosa)*:

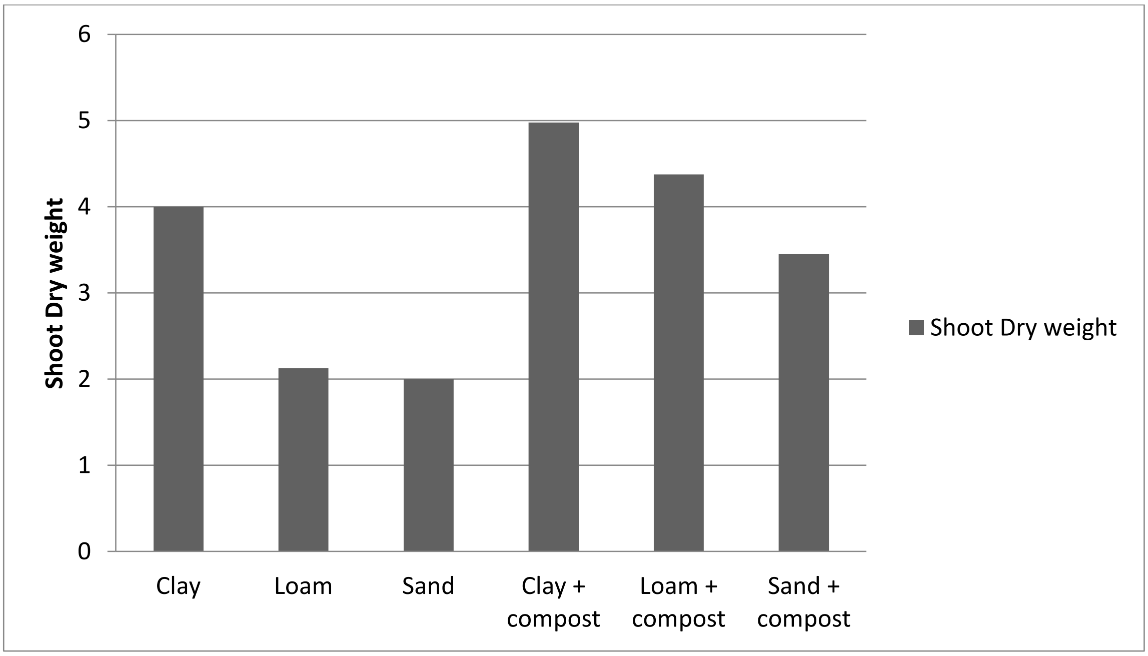

Figure (16).Effect of growth substrates on the shoot dry weight in *Portulaca pilosa*.

4.4.3 Effect of growth substrates on root fresh weight of purslane (*Portulaca pilosa*):

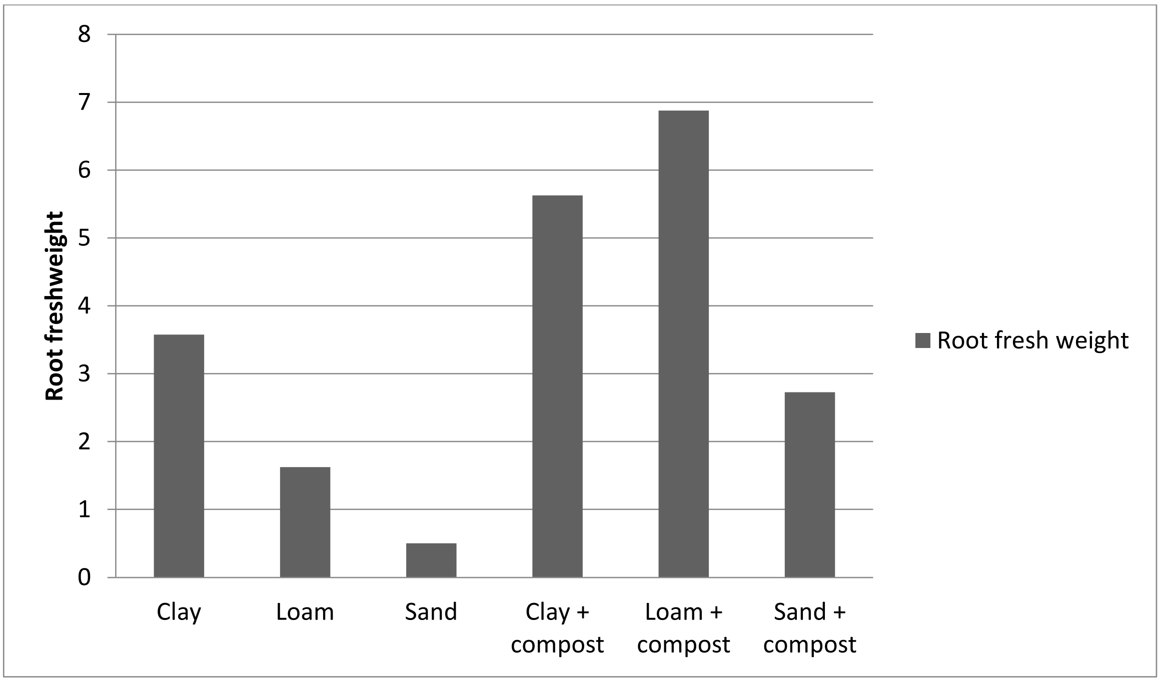

Figure (17). Effect of growth substrates on the root fresh weight in *Portulaca pilosa*,

4.4.4Effect of growth substrates on root dry weight of purslane (*Portulaca pilosa):*

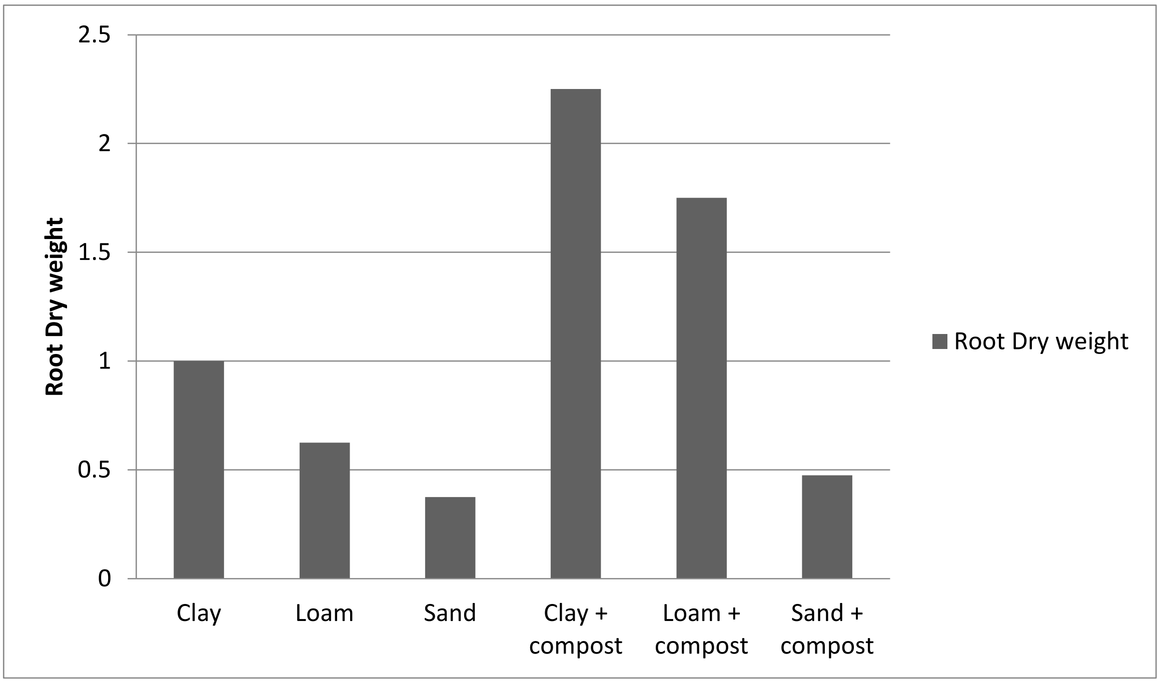

Figure (18). Effect of growth substrates on the root dry weight in *Portulaca pilosa.*

Chapter Five

Discussion

In this study, the benefit of compost addition to the different types of soils was tested. Significant growth and flowering increment was obtained in both (*Portulaca pilosa* and *Portulaca grandiflora*).

Compost is a digested organic matter readily available for uptake and absorption by the plant root system .It therefore adds to fertility of the growth substrate. Decomposed organic mattes almost of acidic reaction. It reduces soil PH and improves the uptake of micro –nutrient. Compost added to sand would improve fertility and water conservation. Compost added to clay would improve soil porosity, drainage and aeration,it also prevents compaction and helps roots extension within soil.Loam is the principle growth substrate in nurseries in Khartoum state.Compared to loam, the mix of claycompost (2:1)was found better as it increased the measured parameters significantly. The result indicates the possibility of using this mix as a replacement to loam. However, further confirmation tests are needed. Never the less, the compost industry in Sudan is limited and there may be other applications of compost in Sudan if the goal of organic farming is targeted.

References

1. Agbede, T.M.; Ojeniyi, S.O. and Adeyemo, A.J. (2008). Effects of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in Southwest, Nigeria. *American Eurasian J. Sust. Agric*. 1(2): 72 – 77.
2. Alate1, K.K.A.; Mawussi1, G.; Ayisah, K.D. and Sanda1, K. (2019). Agronomic potential value of household urban solid wastes by composting and composts quality assessment .*Int. J. Agril. Res. Innov. Tech.* 9(2): 1-8.
3. Ali, A.; Agung, I.; and Wijana, G. (2018). Effects of harvesting time and types of legume Ground Cover crop on soil quality in dryland farming. *Agrotop*, 6(2): 171-179.
4. Ali, H.; Khan, E. and Sajad, M A. (2013). Phytoremediation of heavy metals: concepts and applications. Chemosphere 91: 869-881.
5. Allred, K.W. and Ivey R.D. (2012). Flora Neomexicana III: an illustrated identification manual. Las Cruces, NM, USA: New Mexico State University, Range Science Herbarium, 719 pp.
6. Amingad, V. and Lakshmipathy, M. (2014).Ornamental plants and their role in human psychology, 2nd International Conference on Agricultural and Horticultural Sciences, Hyderabad, India February.
7. Ashraf, M.A.; Maah, M.J.; Yusoff, I.; Wajid, A. and Mahmood, K., (2011). Sand mining effects, causes and concerns: A case study from Bestari Jaya, Selangor, Peninsular Malaysia. *Scientific Research and Essays* 6(6), 1216-1231.
8. Balandier, P.; Frochot, H.; and Sourisseau, A. (2009). Improvement of direct tree seeding with Ground Cover crops in afforestation: Microclimate and resource availability induced by vegetation composition. *Forest Ecology and Management* 257:1716-1724.

9. Canada Department of Agriculture (CDOF), (1976). Glossary of terms in soil science, research branch Canada department of agriculture, minister of supply and services Canada. P.39.
10. Elisee, O.; Mando, A. and Zombre, N.P. (2001). Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. *Agriculture Ecosystems & Environment* 84(3):259-266.
11. Gilliam, Frank (2003). "The Dynamic Nature of the Herbaceous Layer". The Herbaceous Layer in Forests of North America .USA: Oxford University Press.
12. Guggenheim, S. and Martin, R. T. (1995). "Definition of clay and clay mineral: Journal report of the AIPEA nomenclature and CMS nomenclature committees", Clays and Clay Minerals, 43 (2): 255–256.
13. Haruna, S.I. and Nkongolo, N.V. (2015). Ground Cover crop management effects on soil physical and biological properties. Procedia Environmental Sciences 29: 13-14.
14. Heenan, D.P.; Chan, K.Y. and Knight, P.G. (2004) Long-term impact of rotation, tillage and stubble management on the loss of soil organic carbon and nitrogen from a Chromic Luvisol. *Soil Tillage Research* 76, 59-68.
15. Huxley, A. (1992). The new Royal Horticultural Society dictionary of gardening, London. 2:156.
16. Jacqueline, M. (2019). Ecosystem Consequences of Soil Warming. Microbes, Vegetation, Fauna and Soil Biogeochemistry. Elsevier, 1st Edition, Chapter 12, p 297-346.
17. Kaufmann, R.; Cutler, K. and Cleveland, J. (2008).Loam soil. *Environmental Science*. *McGraw-Hill*. pp. 318–319.

18. Khan, T.F., Ullah, M.W. and Huq, S.M.I. (2016). Heavy metal contents of different wastes used for compost. J. Minerals Materials Character. Eng. 4: 241 - 249.
19. Krause, C.; Diesing, M., and Arlt, G. (2010). The physical and biological impact of sand extraction: a case study of the western Baltic Sea. *Journal of Coastal Research* 51, 215-226.
20. Lacerda, L.D; Conde, J.E; Kjerfve, B; Alvarez-Leon, R; Alarcon, C. and Polania, J. (2002). American Mangroves. In: Lacerda LD, ed. Mangrove ecosystems: function and management. Berlin, Germany: Springer-Verlag, 1-62.
21. Laghlimi, M.; Baghdad, B.; El Hadi, H.; and Bouabdli, A. (2015). Phytoremediation mechanisms of heavy metal contaminated soil: a review. *Open Journal of Energy* 5: 375-388.
22. Magdoff, F., and Van Es, H. M. (2009). Building Soils for Better Crops. Beltsville, Md.: Sustainable Agriculture Research and Education Program.
23. Meller, E.; Niedzwiecki, E.; Rogalska, P.; Jarnuszewski, G. and Wilczynski, D. (2015). Fertilizer value and trace element content of composts produced from different wastes. *J. Ecol. Eng*. 16(4): 154 – 160.
24. Mitchell, H. (2003).The Essential Earthman: *Henry Mitchell on Gardening*. Indiana University Press. p. 113.
25. Morgan. R.P.C. (2005). Soil Erosion and Conservation 3rd Edition. *European Journal of Soil Science*, 56, 681-687.
26. Nascente, A.S.; and Stone, L.F. (2018). Ground Cover crops as affecting soil chemical and physical properties and development of upland rice and soybean cultivated in rotation. *Rice Science*, 25 (6): 340-349.

27. Natural Resources Conservation Service (NRCS)(2016)*"Portulacagrandiflora*".Plants Database. USDA. CS1 maint: discouraged parameter.
28. Ocampo, G. and Columbus J. (2012). Molecular phylogenetics, historical biogeography, and chromosome number evolution of Portulaca (Portulacaceae). *Molecular Phylogenetics and Evolution*, 63(1):97-112.
29. Ouedraogo, E.; Mando, A. and Zombre, N.P. (2001). Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. *Agric. Ecosyst. Environ*. 84: 259 - 266.
30. Ray Hutchison, (2010).Encyclopedia of Urban Studies, University of Wiscosin, Green Bay, SAGE Publication, Inc. V.1.
31. Sharma, P.; Singh, A.; Kahlon, CS.; Brar A.; Grover K.; Dia, M. and Steiner, RL. (2018). The role of Ground Cover crops towards sustainable soil health and agriculture. *American Journal of Plant Sciences* 9: 1935-1951.
32. Sumiahadi, A.; and Acar, R. (2018). A review of phytoremediation technology: heavy metals uptake by plants. IOP Conference Series: *Earth and Environmental Science*, 142:
33. Susan, M.Chawla, S.L. andRoshni, A. (2016). Recent Advances in Turf Management. *New India Publishing Agency*, New Delhi, Indi,pp 549-561.
34. Whitaker, J.; Field, J.; Bernacchi, C.; Cerri, C.; Ceulemans, R.; Davies, C.; DeLucia, E.; Donnison, I.; McCalmont, J.; Paustian, K.; Rowe, R.; Smith, P.; Thornley, P. and McNamara, N.(2018)."Consensus, uncertainties and challenges for perennial bioenergy crops and land use*"*. *GCB Bioenergy*. 10 (3): 150–164.

35. Willoughby, I.; Balandier, P.; Bentsen, N.S.; McCarthy, N.; and Claridge, J. (2009). Forest vegetation management in Europe: current practice and future requirements. COST Office, Brussels.
36. Wunderlin, R.P and Hansen, B.F. (2003). Guide to the vascular plants of Florida. Gainesville, Florida, USA: University Press of Florida, 812 pp.

Appendix 1

Plate (1) compost in tow experiments

Appendix 2

The layout of tow experiments

Plate (2) tow experiments

Appendix 3 and 4

Plate (3) caly in(*portuloca grandiflora) plant.*

Plate (4) caly + compost in *portuloca grandiflora*

Appendix 5 and 6

Plate (5) loam in(*portuloca grandiflora) plant..*

Plate (6) loam + compost in *portuloca grandiflora*

Appendix 7 and 8

Plate (7) sand in(*portuloca grandiflora) plant.*

Plate (8) sand + compost in(*portuloca grandiflora) plant.*

Appendix 9 and 10

Plate (9) loam in(*portuloca pilosa) plant.*

Plate (10) loam + compost in(*portuloca pilosa) plant.*

Appendix 11 and 12

Plate (11) caly in(*portuloca pilosa) plant.*

Plate (12) caly + compost in(*portuloca pilosa) plant.*

Appendix 13 - 14

Plate (13) sand in(***portuloca pilosa) plant.***

Plate (14) sand + compost(***portuloca pilosa) plant.***

Appendix 15

Plate (15) Mutation in (*portuloca pilosa) plant.*