EFFECT OF CHICKEN MANURE, SOIL TYPE AND SALINITY ON GROWTH AND YIELD OF SPEARMINT

By

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Dedication

To my parents,

Husband and

Kids

Acknowledgement

I am most grateful to my academic supervisor Dr. Awatif Ahmed for her excellent assistance, devotion and valuable guidance during this work.

My thanks go to the staff of the Department of Horticulture, University of Khartoum and to the staff Medicinal and Aromatic Plants Research Institute.

I am indebted for the courtesy and help accorded to me by the Staff of the Laboratory in Medicinal and Aromatic Plant Research Institute during the laboratory analysis.

It is a pleasure to have this opportunity to thank all the staff of Documentation and Information Centre (NCR) for their cooperation throughout this work.

I am further indebted to my husband for his tolerance, support and time he always has generously given to me.

To all upon whose support I conducted this work. None are mentioned by name, my gratitude goes to them.

Before all my thanks to God who gave me the health and strength to finish this work.

ABSTRACT

The experiment was carried out at Medicinal and Aromatic Plants Research Institute Farm for the growing seasons 2001 - 2002. The planting date was the 15/11/2001. The objective of this experiment is to study the effect of chicken manure, soil type and salinity on herbage yield and oil content of spearmint "Baladi Nanaa".

The experiment comprised two chicken manure rates [0.0 ton/fed and 16 ton/fed], two soil types [Shambat and Soba] and two salinity levels [Tap water EC = 0.26 dsm^{-1} and saline water EC = 1.0 dsm^{-1}].

The treatments were arranged in a split-split-plot design with three replicates where salinity levels assigned to the main plots, soil types assigned to the sub-plots and chicken manure assigned to the sub-sub plots.

The plants harvested two times, the first cut made in the 18/3/2002 and the second cut five weeks after the first cut.

Parameters measured include, plant height, number of branches/stem, fresh and dry herbage yield, roots fresh and dry weight and oil content.

Shambat soil out yielded Soba soil and salinity found to reduce all measured parameter significantly.

Chicken manure found to increase all measured parameters significantly where as a positive effect of chicken manure in alleviating salinity effect was proved. Hence reclamation of marginal lands with chicken manure found to improve both growth and yield attributes of spearmint.

Arabic Abstract

خلاصة الأطروحة

أجريت هذه التجربة في معهد أبحاث النباتات الطبية والعطرية في خلال الموسـم 2001 - 2002م تاريخ الزراعة 2001/11/15م.

الهدف من البحث هو معرفة اثر التسميد العضوي بمخلفات الدواجن في ظـروف الري بالمياه المالحة في نوعين من التربة وهي شمبات وسوبا علي الإنتاج العشبي وكمية الزيت للنعناع البلادي spearmint.

احتوت التجربة علي معدلين للتسميد بمخلفات الدواجن (0ر0 طن للفدان، 16 طن للفدان) ودرجتين للملوحة [saline Ec= 1,0 dsm^{-1}, Ec= 0.26 dsm^{-1} (Tap water)] ونوعين من التربة (شمبات وسوبا). التصميم الذي استخدم في التجربة هو Split-split plot design

تم حصد النباتات مرتين،القطع الأول بتاريخ 2002/3/18م والثاني بعـد خمسـة أسابيع من القطعة الأولي. شملت البيانات التي جمعت طول النبات، عدد الأفرع في الساق الواحد، إنتاج العشب الطازج والجاف والوزن الطازج والجاف للجذور وكمية الزيت.

أوضحت التجارب الاستجابة المعنوية لإضافة مخلفات الدواجن والتأثير العكسـي للملوحة علي كل المعايير التي قيست.

تربة شمبات أدت إلى اكثف نمو خضري وجزري إلى أطول النباتـات واعلـي إنتاج من العشب الطازج والجاف وكمية الزيت. كان لإضافة مخلفات الـدواجن للتربـة الأثر الواضح في تقليل اثر الملوحة علي النمو والإنتاج العشبي خاصة علي تربة سوبا.

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CHAPTER ONE

INTRODUCTION

1.1. Importance of medicinal and Aromatic plants:

The use of plants for the treatment of a variety of diseases in an old civilization which has been developed during the succession of civilizations and generations as a result of discovery of new plants and isolation of new active compounds and this practice has continue even to day both in developed and developing countries.

The Islamic and Arabic cultures have a remarkable contribution in this field for example Mohamed - Elrazi and Abu Ali Ebn Sina, they published famous books dealing with medicine and herbal medicine.

Due to the side effects of many drugs of synthetic origin many companies directed to produce drugs of plant origin, in addition to the increase in the use of folkloric medicine, therefore, there is increase in demand for medicinal are aromatic plants.

Moreover, herbal preparations can provide food, vitamins, minerals and other micronutrients, which can not be supplied by a single synthetic drug, in addition to all this the use of medicinal and aromatic plants has extended to the field of food industry such as beverages, confectioneries and aromatics.

1.2. Potentiality of Sudan:

Sudan has a diversity in climatalogical condition and soil type which allow growing of a large variety of medicinal and aromatic plants of economic values, this will meet the demand of drugs, save a lot of expenses and can be a source of foreign currency through exporting of semi finished products.

1.3. *Mentha viridis*:

It hold different English names, e.g.= common mint, spear mint, whorled mint (Grieve, 1931). It is locally named "Na Naa", used as flavouring agent in tea. Generally it is used as antispasmodic and carminative (Walt, 1962). The plant contains essential oil, which can be obtained by water distillation of plant top.

In the Sudan spear mint was grown in a limited area of about 25 fed in Khartoum North (Hilat Kuku) for local market and at a very small scale around towns all over the country. The crop is cultivated traditionally and may last for 3-5 years in the land.

The increase in demand for spearmint both locally and internationally may inforce the farmers to move to lands away from the river bank and utilization of marginal land of saline water so as to expand in the cultivation area, so our objective from this study is, the utilization of two soil types for mint production (Shambat and Soba soils) through reclamation of these soils using chicken manure as fertilizer and soil amendment and also to show the effect of salinity and chicken manure on growth and oil content of spear mint grown in these soils, as the expanding poultry industry in and around big towns encourage us to use chicken manure which will insure minimum damage to the environment and reduce the production costs.

CHAPTER TWO

LITERATURE REVIEW

Mentha viridis namely spearmint is originally native to Mediterranean region and then introduced to Britain by the Romans (Grieve, 1931). Most of the world's output of mint oil produced by the United States. The characteristic odour and flavour of spearmint are caused by its Volatile oil (Guenther, 1949).

2.1. Family characteristics:

Mentha viridis belong to the family labiatae (lamiaceae). It is dicotyledones, herbaceous or rarely woody, often odiferous, leaves opposite or whorled, simple, unstipulated, inflorescence are varied, flowers are hermaphrodite (Hutchinson, 1973).

This family contains about 200 genera and 3300 species which are annual, perennial herbs or shrubs, many members of this family are used as culinary or medicinal herbs (Heywood, 1985).

2.1.1. Genus mentha:

This genus is one of the most important genera that belong to the family labiatae. It contains about 25 species with 2000 - 3000 varieties being obtained by hybridization

(Foster, 1984). The species are herbaceous perennial, evergreen plants, the plant height reach 25 - 50 cm in length.

2.1.2. Plant description:

Mentha viridis carried different names, eg. The Arabic name "Na Naa", the English name common mint, spearmint or whorled mint (Loutfy Boulos, 1983).

It has erect stems which arise from creeping root-stocks to a height of about two feet, bearing very short-stalked, acute pointed, lance-shaped, wrinkled, bright green leaves with toothed edges and smooth surfaces. The flowering spikes are sharply pointed (Guenther, 1949). The small flowers are densely arranged in whorls or rings in the axil of the upper leaves-pinkish or lilac in colour which followed by very few, roundish , minute brown seeds. The taste and odour of the plant is very characteristic (Grieve, 1931).

2.2. Essential oil:

The characteristic odour and flavour of spearmint are caused by its volatile or essential oil which is normally extracted via steam distillation (Guenther, 1949).

2.2.1. Oil constituents:

The chief constituent of spear mint oil is carvone C_{10}. H_{14}. 0 (60-65%) (Guenther, 1949). Phellandrine, limonene, dihydro-carveol acetate and esters of acetic, butyric and carproic or caprytic acid are also present (Grieve, 1931).

Carvone was found to be dominant in young plants, which converted to dihydrocarvone in older plants (Walt, 1962).

2.2.2. Physiochemical properties of spearmint oil:

The specific gravity of spearmint oil at 25^{o}C is 0.902 - 0.933, optical rotation -50^{o} 15' - 60^{o} 10', refractive index at 20^{o}C is 1.4851 - 1.4899. It is soluble in 1 volume of 80% alcohol (Guenther, 1949).

2.2.3. Medicinal action and uses:

Spearmint oil is chiefly used for culinary purposes. It has a wide application especially in flavouring of chewing gums and lately in tooth pastes (Guenther, 1949). The properties of spearmint oil resemble those of peppermint, being stimulant, carminative and antispasmodic, but its effect is less powerful. Hence spearmint taste is pleasant and less strong than peppermint oil, it is better adapted for children's maladies (Grieve, 1931).

The sweetened infusion is an excellent remedy in fever, inflammatory diseases and relieve of cough, it is also used in allaying nausea and vomiting, relieve of colic pain, strangury and gravels (Grieve, 1931).

2.3. Cultivation:

Mint succeed in almost all soil types once it started growth, but a moist situation is preferable. In dry sandy soil where it is difficult to grow, it should be planted in coolest and dampest situation. Heavy soil should be lightened by organic fertilizer such as leaf mold, manure and similar materials, which will increase the moisture absorbing power of the soil (Grieve, 1931). The most suitable soil for mint growth is loamy up land soil or various types of muck soils (Guenther, 1949). Soil types affected mainly herbage and stolon production where herbage yield was highest in forest soil since it is rich in organic matter and stolon production was the best in sandy soils. Essential oil content found to be the highest in peaty soil, (Zambory, *et al*., 1986).

2.4. Salt affected soils:

Salt-affected soils, is one of the major constrains of crop production in arid and semi-arid regions of the world, which result in yield reduction and in severe cases complete failure of the crop (Sanchez, 1976 and Allison, 1964).

2.4.1. Salt-affected soils in Sudan:

About 250 thousand hectares in Northern Sudan found to be affected to some degree by sodicity and/or salinity (Ali and Fadul, 1977). The largest areas are mostly found to the North of Khartoum along both banks of the main Nile. About 49% around Khartoum province were classified as salt-affected soils, of which 38%, 7% and 4% are saline, saline-sodic and sodic soils respectively. There are areas which are potentially saline and would easily be damaged by secondary salinization through irrigation with bore hole waters (Mustafa, 1973).

In addition to soils in Khartoum province large areas of the Gezira clay soil were found to be salt affected soil (Fink, 1961), later report of soil survey (1976) revealed that salinity affected most of the areas along the Nile.

2.4.2. Reclamation of salt-affected soils:

Reclamation of saline soil involves the removal of excessive soluble salts from the root zone by leaching or addition of chemical amendment such as gypsum ($CaSO_4.2H_2O$) or elemental sulfur (S) if the soil contains an excessive amount of sodium (Amundson and Lund 1985) these remedies, however, are relatively expensive and may be not available in many developing countries, an alternative must be sought.

2.4.3. Organic manure as amendment:

The uses of manure on agriculture has been a traditional practice, hence it supply nutrients and improve soil physical properties (Loehr, 1977). Nowadays emphasis on pollution control has encouraged the use of manure on crop production (Abot and Tucker, 1973).

2.4.4. Chicken manure as a fertilizer and amendment:

Chicken manure is an agricultural waste that could be of great importance as an organic fertilizer (Perkin and Parker, 1964). Since poultry production has become one of the most important industries, chicken manure disposal is a major problem. The progressive accumulation of this material represent an environmental hazard, leading to significant pollution of water ways (Liebhardt, *et al*., 1979), therefore, to prevent damage to the environment the use of chicken manure as organic fertilizer offer a promising alternative to this problem.

2.4.5. Salinity effects on plant growth:

Salinity is a major problem that decrease soil productivity and damaged numbers of crops (Ayoub, 1970). Increasing salinity level found to reduce dry matter production, yield characters and oil content, this salinity effect could be reduced or alleviated by increasing fertility level of the soil (Singh, 1994).

Abou El Fadl, *et al* (1986) showed that increasing salinity of irrigation water decreased the vegetative growth and seed yield of both Dill and Black cumin.

Crop salt tolerance defined as the ability of the plant to survive and produce economic yield under high salt concentration. The sensitivity of plant to salinity varies with plant growth stage (Mass and Hoffman, 1977).

2.5. Fertilization:

To have a really good mint the plantation should be renewed every three years or it is essential that a good top-dressing of rich soil should be added. A top dressing of short decayed manure after the first and second cutting will ensure luxuriant growth (Grieve, 1931).

Chattopadhyay and Gupta (1999) found that addition of mint residue fertilizer ensure recycling of other secondary and micro-nutrients along with organic carbon and maintain soil productivity.

On the other hand Imliaz-ul-Hag (1999) reported that higher moisture content was observed in organic types of soil. Mulch found to increase both herbage and oil yield (Saxena and Singh, 1996)..

In order to get higher herbage and oil yield of spear mint on low fertile, clay, loam soil 160 kg N/ha found to be effective (Chinnabbai, 1992). Kothari (1995) mentioned that the green herbage yield and oil yield increased significantly up to an application of 200 kg N/ha at 45 - 60 cm row spacing.

Court (1993), had found that in loamy sand-soil, oil yield increased with N-fertilization up to 180 kg N/ha and after that increases in N-fertilization had no influence on yield, also many of the chemical constituents of the oil were not influence by N. fertilization.

2.6. Mint diseases:

The most serious disease is the Rust disease which caused by a fungus *Puccinia mentha* which may completely destroy the crop (Grieve, 1931). The main pests of spearmint in Sudan are the *Termites*. Other disease which attack the crop are wilt disease, mint stolon decay, mint *Anthraenose* and root lesion caused by *Nematodes*. Also insects such as the *Flea beetle*, *Variegated cut worm*, *Aphid* and *Spidermite* found to cause a considerable loss in the crop (Anonymous 1).

CHAPTER THREE
MATERIAL AND METHODS

3.1. Description of the experimental site:

The experiment was carried out for one growing season 2001-2002 in the farm of Medicinal and Aromatic Plant Research Institute (Latitude 15^{o} 40'N, longitude 32^{o} 32').

3.2. Experimentation:

Split-split-plot design with three replicates was used for pot experiment. Salinity levels assigned to the main plots, soil type to the sub plots and fertilization treatment with chicken manure to the sub-sub plots.

The two salinity levels consisted of a control receiving tap water only (Ec= 0.26 dsm^{-1}), the other treatment was saline water (EC= 1.0 dsm^{-1}) which prepared by salinization of tap water using calcium and sodium chloride. (Department of Soil Chemistry, Faculty of Agriculture, University of Khartoum).

Two types of soils were investigated, Shambat and Soba soils (9 kg soil/Pot). The physiochemical properties of the soils were presented in Appendix I.

Referring to the results of a previous experiment carried on the effect of addition of chicken manure on yield of mint, it was decided that to add chicken manure in two levels, control (0.0) and receiving 16 ton/fed chicken manure which equivalent to 200 gm/pot. The chemical analysis of chicken manure used in the experiment shown in Appendix II.

The replicate comprise two pots/treatment so as to increase the plant material, therefore the total number of pots used in the experiment was 48 pots. The average pot diameter is 24cm.

The appropriate amount of chicken manure was added and mixed with the soil in pots and then irrigated with tap water before planting.

3.3. Propagation and planting:

Spearmint was propagated by means of soft rhizomes. The plant material was obtained from fully mature plants grown in the experimental farm of Medicinal and Aromatic Plant Research Institute. Planting was done in 15/11/2001 and resowing was done two weeks after planting.

Irrigation with tap water continued for six weeks until the crop was established and thereafter irrigation with saline water was started.

Irrigation was done day after day or every two days whenever the plant needed. Hand weeding was done continuously.

3.4. Data collection:

The plant height and number of branches were recorded three months after planting (11/2/2002), the fresh and oven dry weight were determined, then the moisture content was calculated:

$$Moisture\% = \frac{Fresh\,wt - over\,dry\,wt}{Fresh\,wt}\ X\ 100$$

The oven dry weight was taken by drying the samples in an oven at 65°C for 48 hrs.

The plants harvested two times, harvesting was done in the morning as recommended (Grieve, 1931). The first cut was made in after four months from planting and the second cut was five weeks after the first cut. The plant was cut 5 cm above the soil surface and the fresh herbage yield was determined in gm/pot.

The plant material was air dried in shade for about six days and then the air dry weight was recorded.

3.5. Distillation:

Using Clevenger apparatus, the air-dried material was weighted, and then transferred into a 5 litre, three-necked, round bottom flask, then distilled water was added. The apparatus had an efficient cooling system consisting of two doubled-surface condensers, the receiver was inform of bent graduated tube, which work by syphoning. The distillation allowed for four successive hours. After distillation was completed, the oil permitted to stand undisturbed so as to obtain good separation, then the volume of oil was measured and the percentage of oil was determined expressed as a volume/weight percentage.

$$\% of\ Oil = \frac{Volume\ of\ oil}{Air\ dry\ weight(gm)} X\, 100$$

After that the percentage of oil from oven dry weight was calculated.

3.6. Analysis of data:

The data was analysed using Duncan Multiple Range Test at 5% and 1% level of significance.

CHAPTER FOUR
RESULTS

4.1. Effect of chicken manure, soil type and salinity on growth attributes:

4.1.1. Effect on plant height:

Table (1) and Figure (1) show that differences in plant height among fertilizer treatment is highly significant at (P= 0.01), where chicken manure score higher plant height, (Plate 1). No significant difference were noted in plant height among soil types and salinity levels, yet, the highest values of plant height were associated with Shambat soil with chicken manure and tap water irrigation where as the lowest values are associated with Soba soil and saline water without chicken manure addition, (Plate 2).

4.1.2. Effect on branching:

Effect of fertilization treatments on branching was highly significant (P= 0.01). Chicken manure score higher number of branches, (Plate 1). There were no significant differences detected in number of branches among other factors, but the highest values were associated with Shambat soil with chicken manure and tap water irrigation, (Table 2, Figure 2).

Table 1: Effect of chicken manure, soil type and salinity on plant height (cm)

M.P. / S.P. / S.S.P	Tap		Saline		Mean (S.S.P) S.E.± 0.905
	Sh	So	Sh	So	
Control	17.5	16.5	16.6	15.8	16.6[b]
+Chicken manure	26.3	20.0	25.6	24.1	24.04[a]
Mean (M.P) S.E.± 0.89	20.08[a]		20.58[a]		
Mean (S.P) S.E.± 1.19	Sh 21.54[a]		So 19.12[a]		

Note:

M.P. = Main plot
S.P. = Sub plot
S.P.P.= Sub-Sub plot

Sh = Shambat soil
So = Soba soil
S.E. = Standard error

Means carrying the same letter are not significantly different at 0.05 level of significance according to Duncan's Multiple range test (DMRT).

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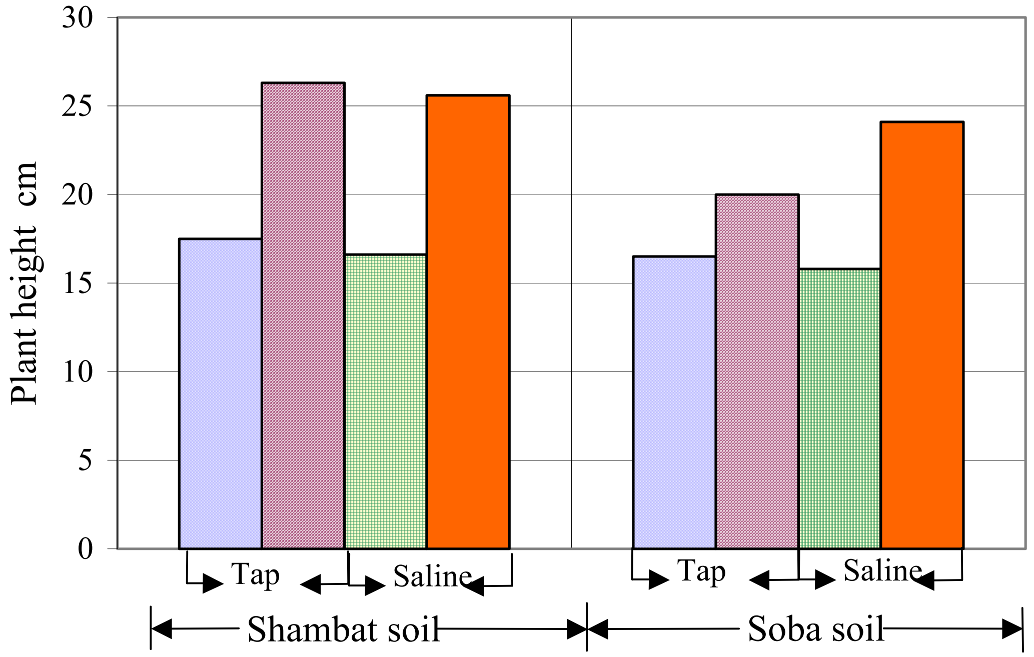

Figure 1: Effect of chicken manure, soil type and salinity on plant height

Table 2: Effect of chicken manure, soil type and salinity on branching (No. of branches/stem)

M. Plot	Tap		Saline		Mean (S.S.P) S.E.± 0.66
S.P. / S.S.P	Sh	So	Sh	So	
Control	13.66	13.33	12.00	11.00	12.50[b]
+Chicken manure	19.00	17.33	17.66	17.66	17.91[a]
Mean (M.P) S.E.± 0.53	15.83[a]		14.58[a]		
Mean (S.P) S.E.± 0.35	Sh 15.58[a]		So 14.83[a]		

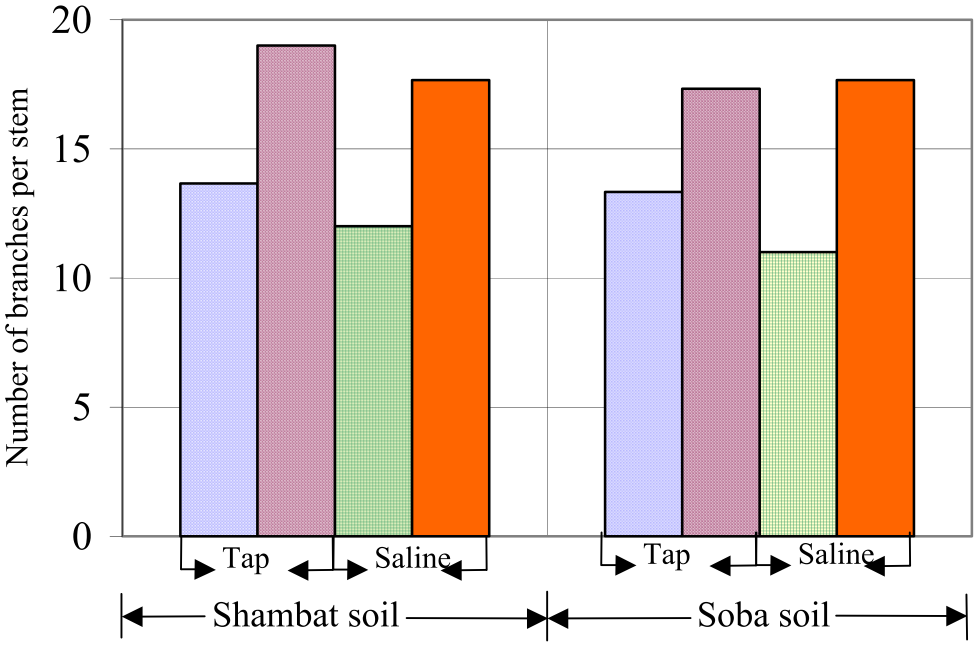

Figure 2: Effect of chicken manure, soil type and salinity on branching

- Branching without chicken manure using tap water
- Branching with chicken manure using tap water
- Branching without chicken manure using saline water
- Branching with chicken manure using saline water

Plate 1: Effect of chicken manure on plant height and branching

Note:

T = Tap water

ch = + chicken manure

N = without chicken manure

So = Soba soil

Sh = Shambat soil

Plate 2: Effect of soil type and Salinity on plant height

S.N.sh

S.N.So

Note:

S = Saline water

N = No –Chicken manure (Nil)

4.1.3. Effect on root fresh weight:

The effect of chicken manure on root fresh weight was highly significant (P= 0.01). Chicken manure score higher values. With respect to soil type and salinity, their effect was significant (P= 0.05). Shambat soil with chicken manure and tap water irrigation produce higher root fresh weight but Soba soil with tap water without chicken manure addition produce higher root fresh weight than Shambat soil with the same treatment. The interactions between the factors were highly significant (Tables 3, 4 and 5),   (Figures 3, 4 and 4).

4.1.4. Effect on root dry weight:

Effect of chicken manure and salinity on root dry weight were significant at (P= 0.05). Chicken manure and tap water score higher root dry weight. Although the effect of soil type on root dry weight was non-significant but Soba soil with tap water without chicken manure addition produce higher root dry weight than Shambat soil with the same treatment. The interaction between all three factors was significant (Table 6, Figure 6), also the interaction between soil types and fertilizer treatment was significant (P= 0.05), (Table 7, Figure 7). Although the highest root dry weight is associated with Shambat soil with chicken manure addition, the lowest root dry weight was produced by the same soil without chicken manure addition (Table 7, Figure 7). Soba soil and tap water without addition of chicken manure produced higher root dry weight than Shambat soil with the same treatment.

Table 3: Effect of chicken manure, soil type and salinity on root fresh weight (gm/pot)

M.P / S.S.P \ S.P.	Tap		Saline		Mean (S.S.P) S.E.± 7.08
	Sh	So	Sh	So	
Control	312.5[c]	350.5[c]	264.04[d]	262.33[d]	297.33[b]
+Chicken manure	647.5[a]	444.83[b]	451.66[b]	359.50[e]	475.89[a]
Mean (M.P) S.E.± 9.31	438.85[a]		334.37[b]		
Mean (S.P) S.E.± 15.67	Sh 418.93[a]		So 354.29[b]		

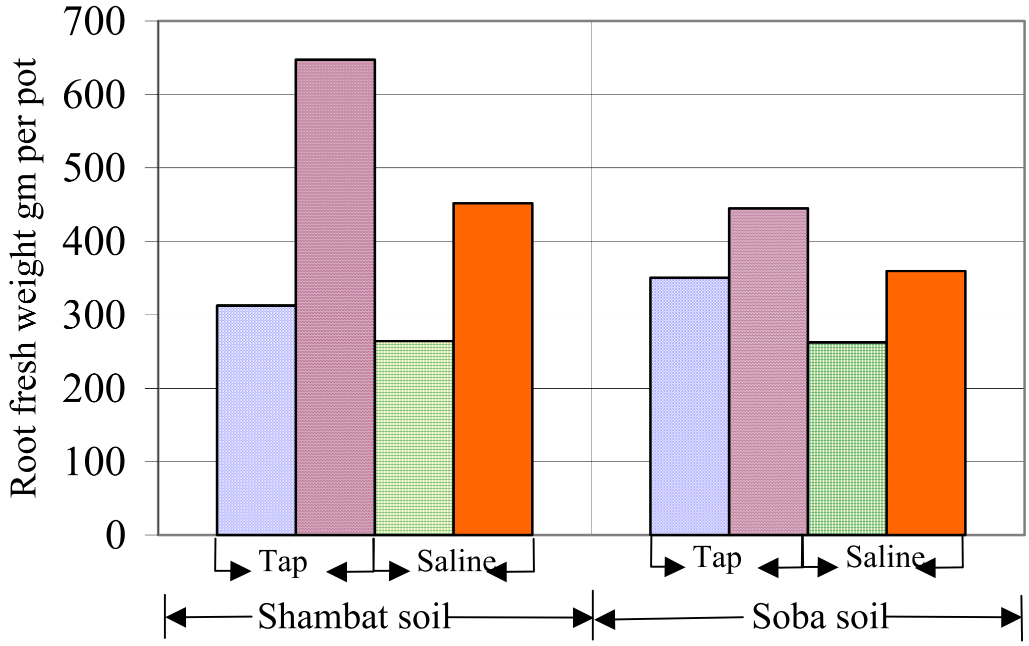

Figure 3: Effect of chicken manure, soil type and salinity on root fresh weight

- Root fresh weight without chicken manure using tap water
- Root fresh weight with chicken manure using tap water"
- Root fresh weight without chicken manure using saline water
- Root fresh weight with chicken manure using saline water

Table 4: Effect of chicken manure and salinity on root fresh weight (gm/pot).

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Salinity (M.P) / Fertilizer S.S.P	Tap water	Saline water	Mean (S.S.P) SE± 7.08
Control	331.5[c]	263.7[d]	297.33[b]
+chicken manure	546.2[a]	405.5[b]	475.89[a]
Mean (M.P.) S.E. ± 9.31	438.85[a]	334.37[b]	M.P. X S.P. S.E.± 10.02

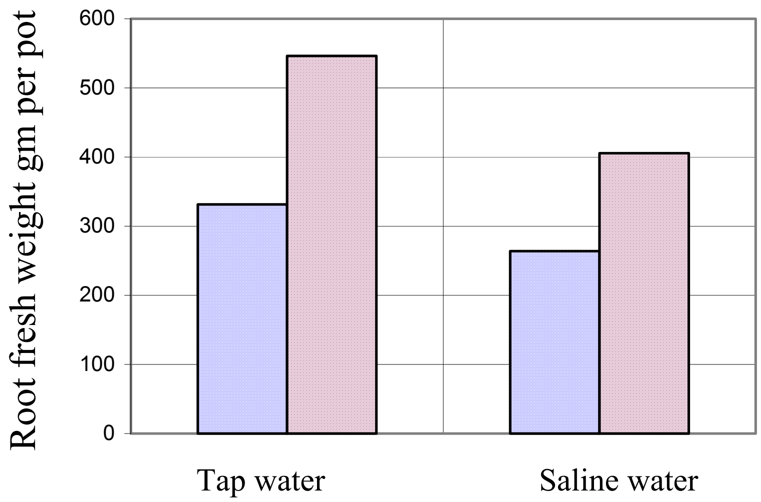

Figure 4: Effect of chicken manure and salinity on root fresh weight

Table 5: Effect of chicken manure and soil type on root fresh weight (gm/pot).

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S.P / S.S.P	Shambat	Soba	Mean (S.S..P) SE± 7.08
Control	288.2^{c}	306.4^{c}	297.33^{b}
+chicken manure	549.2^{a}	402.1^{b}	475.89^{a}
Mean (S.P.) S.E. ± 15.67	418.93^{a}	354.29^{b}	S.S.P. X S.P. S.E.± 10.02

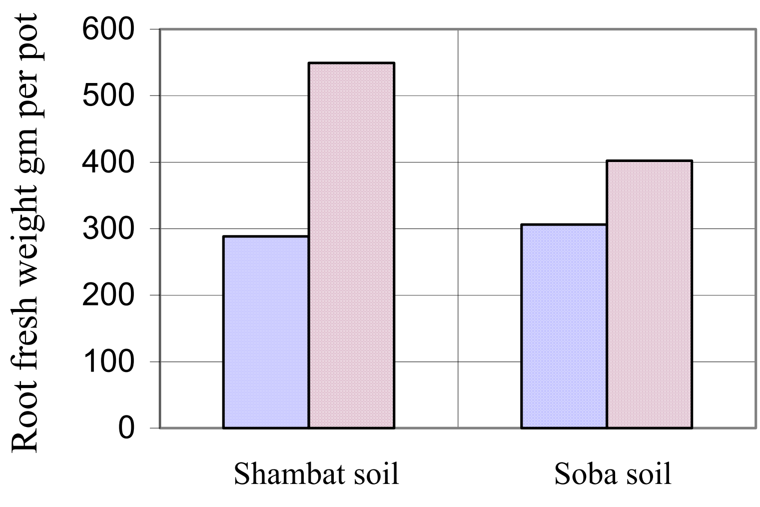

Figure 5: Effect of chicken manure and soil type on root fresh weight

Table 6: Effect of chicken manure, soil type and salinity on roots dry weight (gm/pot).

M.P	Tap		Saline		Mean (S.S.P) S.E.+ 0.97
S.P. / S.S.P	Sh	So	Sh	So	
Control	58.2[c]	71.1[b]	41.6[d]	39.7[d]	52.69[b]
+Chicken manure	101.3[a]	76.8[b]	76.2[b]	61.5[c]	78.96[a]
Mean (M.P) S.E.+ 0.78	76.89[a]		54.76[b]		
Mean (S.P) S.E.+ 3.02	Sh 69.35[a]		So 62.30[b]		

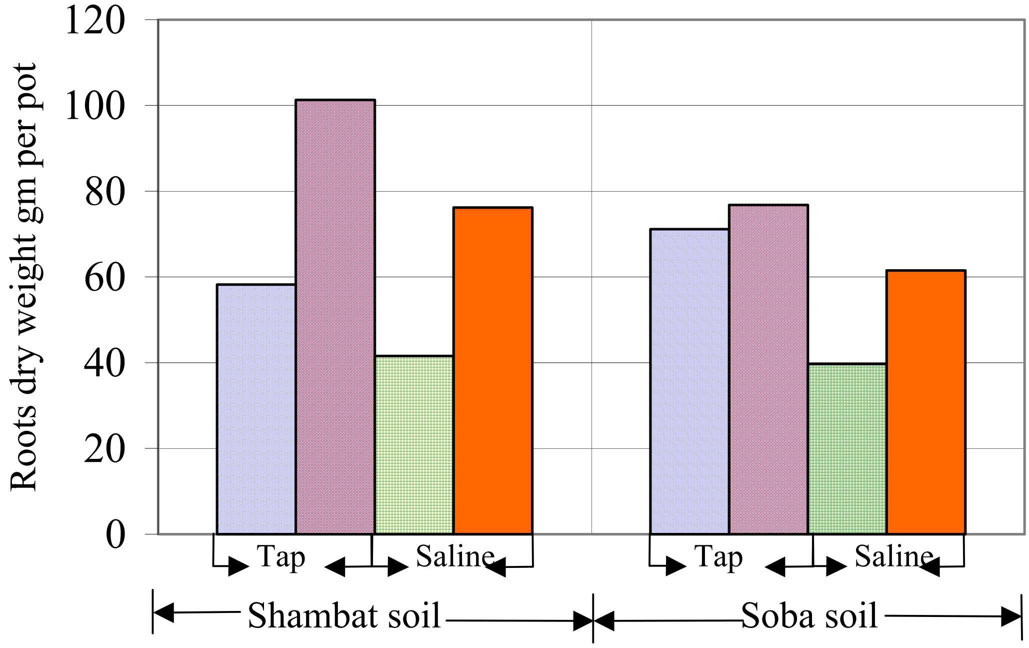

Figure 6: Effect of chicken manure, soil type and salinity on roots dry weight

Table 7: Effect of chicken manure and soil type on root dry weight (gm/pot).

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Soil (S.P) / Fertilizer S.S.P	Shambat	Soba	Mean (S.S.P) SE± 0.97
Control	49.9[d]	55.45[c]	52.6[b]
+chicken manure	88.7[a]	69.1[b]	78.9[a]
Mean (S.P.) S.E. ± 3.02	69.35[a]	62.30[a]	S.P. X S.S.P. S.E.±

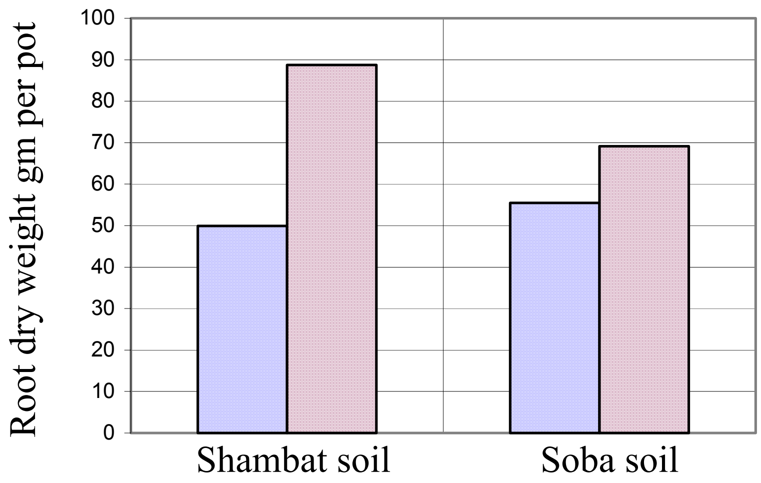


Figure 7: Effect of chicken manure and soil type on root dry weight

4.2. Effect of chicken manure, soil types and salinity on yield attributes:

4.2.1. First cut:

4.2.1.1. Effect on fresh herbage yield (gm/pot):

Statistical analysis revealed that the differences in fresh herbage yield among fertilization treatment and soil types was highly significant at (P= 0.01). Chicken manure addition and Shambat soil produced the highest fresh herbage yield values. The effect of salinity was significant (P= 0.05). Tap water irrigation gave higher fresh herbage yield than saline water (Table 8, Figure 8), and the interaction between soil type and salinity was significant (P=0.05), (Table 9, Figure 9).

4.2.1.2. Effect on dry herbage yield (gm/pot):

Differences in dry herbage yield were highly significant (P= 0.01) among fertilization treatment and soil types. Chicken manure and Shambat soil score higher values. The effect of salinity on dry herbage yield was significant (P= 0.05). Tap water irrigation produced higher dry herbage yield (Table 10, Figure 10). There was an interaction between soil type and salinity, which is highly significant (Table 11, Figure 11).

4.2.1.3. Effect on oil content:

Statistical analysis of extracted oil from different fertilization treatments was highly significant the highest value was obtained from chicken manure, soil type effect on oil content was significant, where high value produced by Shambat soil. The effect of salinity on oil content was non-significant (Table 12, Figure 12).

Table 8: Effect of chicken manure, soil type and salinity on fresh herbage yield (gm/pot) (1^{st} cut).

M. Plot	Tap		Saline		Mean (S.S.P) S.E.$\pm$ 5.15
S.P. / S.S.P	Sh	So	Sh	So	
Control	165.15^{c}	62.10^{f}	90.13^{e}	59.70^{f}	94.27^{b}
+Chicken manure	263.23^{a}	143.48^{c}	198.99^{b}	127.14^{d}	183.21^{a}
Mean (M.P) S.E.$\pm$ 6.49	158.49^{a}		118.99^{b}		
Mean (S.P) S.E.$\pm$ 5.21	Sh 179.37^{a}		So 98.10^{b}		

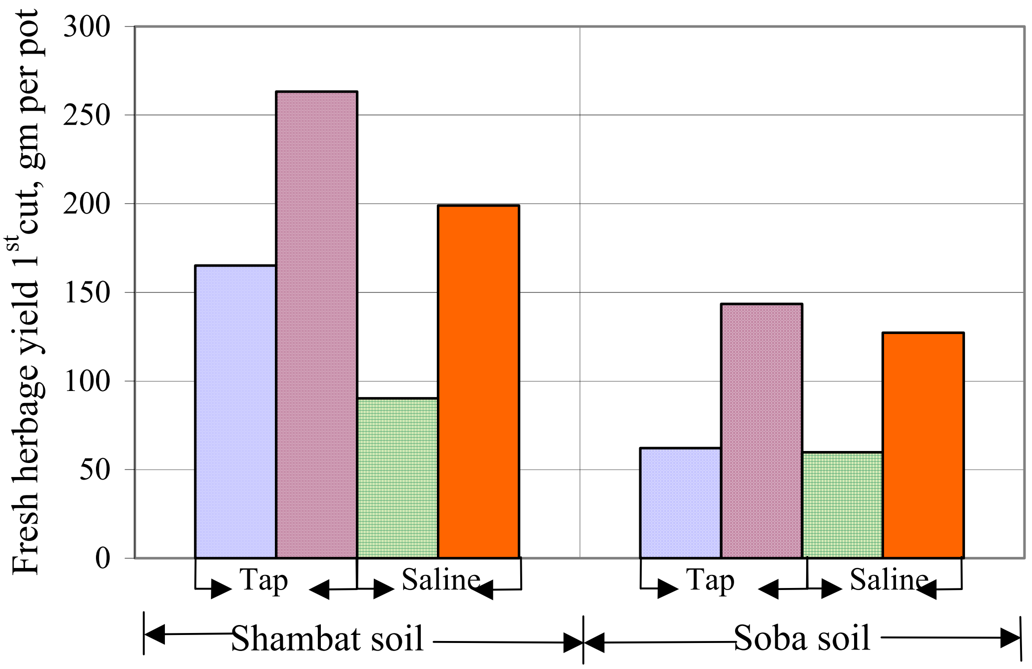


Figure 8: Effect of chicken manure, soil type and salinity on fresh herbage yield (1^{st} cut)

- Fresh herbage yield without chicken manure using tap water
- Fresh herbage yield with chicken manure using tap water
- Fresh herbage yield without chicken manure using saline water
- Fresh herbage yield with chicken manure using saline water

Table 9: Effect of soil type and salinity on fresh herbage yield (gm/pot) (1st cut).

Salinity (M.P) / Soil (S.P)	Tap water	Saline water	Mean (S.P) SE± 5.27
Shambat	214.19[a]	144.56[b]	179.37[a]
Soba	102.79[c]	93.42[c]	98.10[b]
Mean (M.P.) SE± 6.49	158.49[a]	118.99[b]	M.P. X S.P. S.E.± 7.38

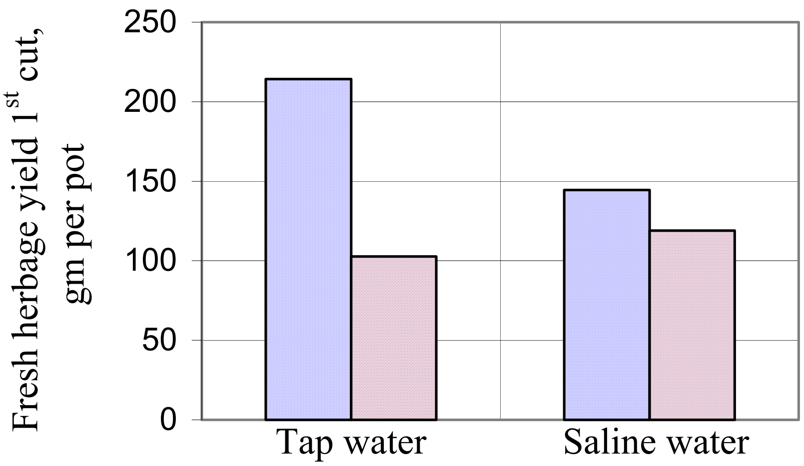


Figure 9: Effect of soil type and salinity on fresh herbage yield (1st cut)

Table 10: Effect of chicken manure, soil type and salinity on dry herbage yield (gm/pot) (1st cut).

M.P / S.P. / S.S.P	Tap		Saline		Mean (S.S.P) S.E.± 1.97
	Sh	So	Sh	So	
Control	33.47	12.46	19.40	13.31	19.66[b]
+Chicken manure	62.91	31.01	44.26	29.37	41.89[a]
Mean (M.P) S.E.± 0.70	34.96[a]		26.58[b]		
Mean (S.P) S.E.± 0.93	Sh 40.01[a]		So 21.53[b]		

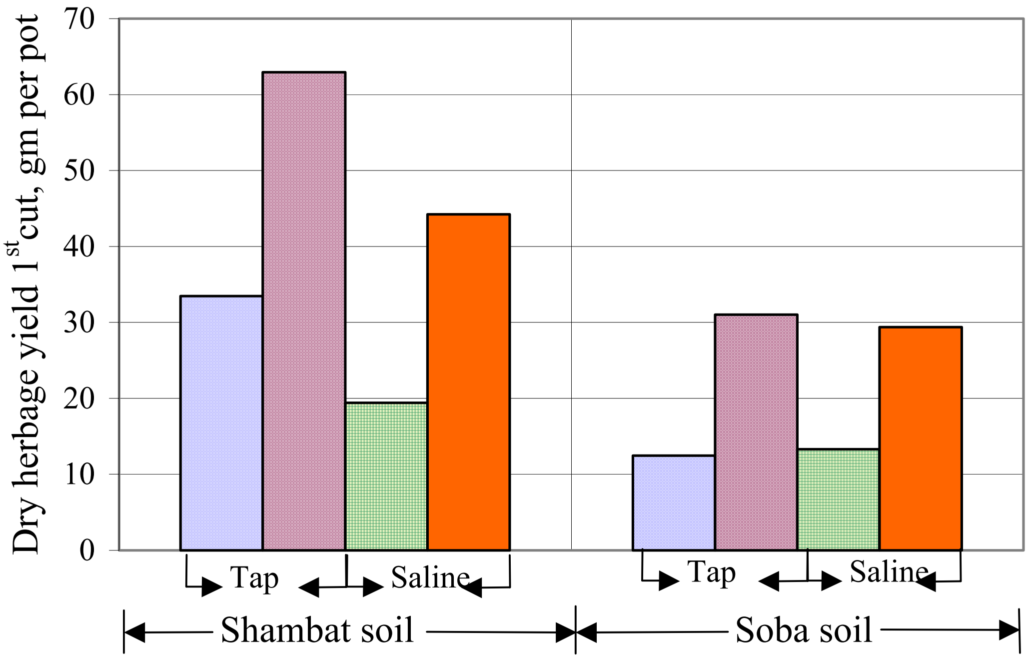


Figure 10: Effect of chicken manure, soil type and salinity on dry herbage yield (1st cut)

Table 11: Effect of soil type and salinity on dry herbage yield (gm/pot) (1st cut).

Salinity (M.P) / Soil (S.P)	Tap water	Saline water	Mean (S.P) SE± 0.93
Shambat	48.19[a]	37.83[b]	40.01[a]
Soba	27.73[c]	21.34[c]	27.53[b]
Mean (M.P.) S.E. ± 0.70	34.96[a]	26.58[b]	M.P. X S.P. S.E.± 1.32

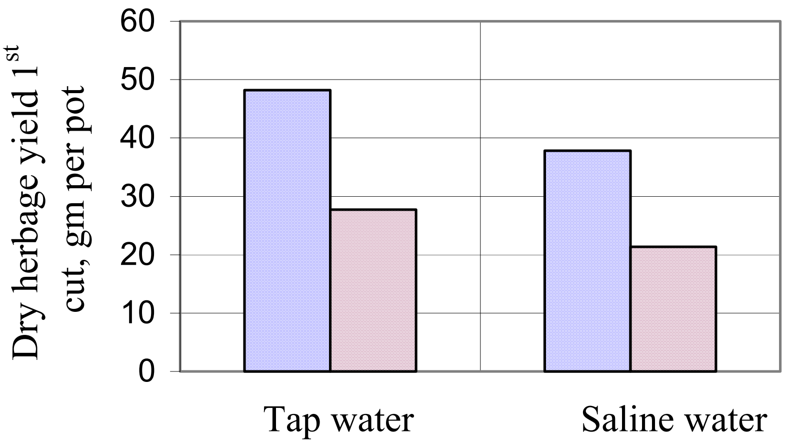


Figure 11: Effect of soil type and salinity on dry herbage yield (1st cut)

Table 12: Effect of chicken manure, soil type and salinity on percentage of oil (1^{st} cut).

M.P / S.P. / S.S.P	Tap		Saline		Mean (S.S.P) S.E.± 0.01
	Sh	So	Sh	So	
Control	1.4^{d}	1.3^{e}	1.5^{c}	1.3^{e}	1.40^{b}
+Chicken manure	1.7^{a}	1.4^{d}	1.6^{b}	1.5^{c}	1.58^{a}
Mean (M.P) S.E.± 0.01	1.48^{a}		1.50^{a}		
Mean (S.P) S.E.± 0.03	Sh 1.58^{a}		So 1.40^{b}		

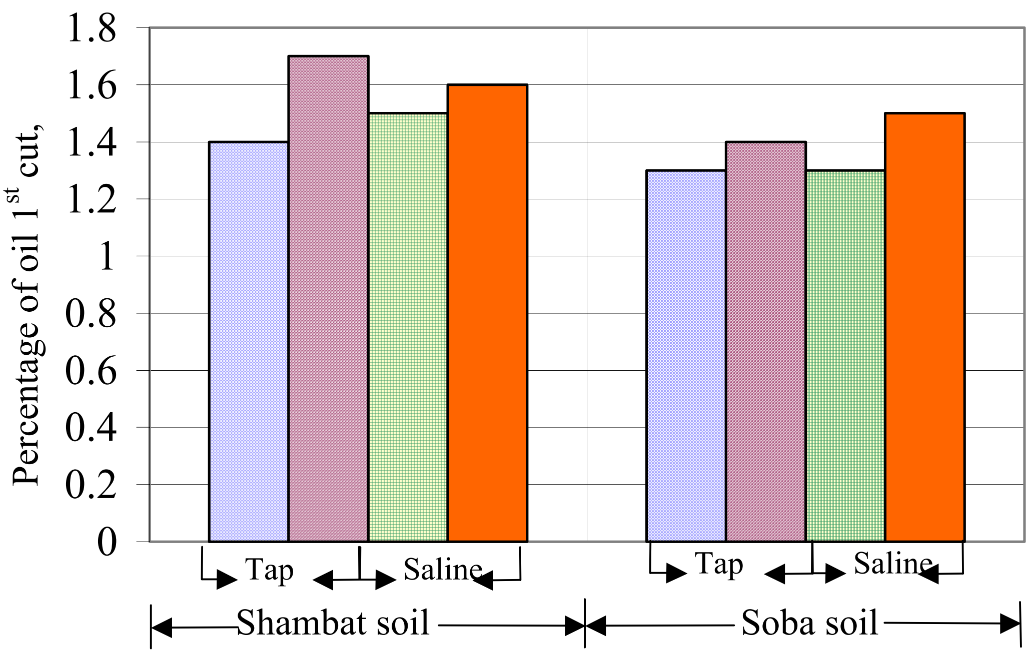


Figure 12: Effect of chicken manure, soil type and salinity on percentage of oil (1^{st} cut)

4.2.2. Second cut:

4.2.2.1. Effect of chicken manure, soil types and salinity on fresh herbage yield:

Data in Table (13) and Figure (13) show that differences in fresh herbage yield among fertilization treatment and soil type were highly significant (P= 0.01). Chicken manure and Shambat soil with tap water score the highest fresh herbage yield. Regarding salinity levels, the effect was non-significant, however, slight decrease in fresh herbage yield was observed in saline treatments. The interactions between salinity and soil type was significant at (P= 0.05), (Table 14, Figure 14).

4.2.2.2. Effect on dry herbage yield:

Differences in dry herbage yield regarding fertilization treatments was highly significant (P= 0.01). Chicken manure recorded the highest value. The effect of soil types on dry herbage yield was significant (P= 0.05). Shambat soil score higher dry herbage yield values. Salinity effect was non-significant, but tap irrigation produced slight increase in dry herbage yield (Table 15, Figure 15), the interaction between salinity and soil types was significant (Table 16, Figure 16).

4.2.2.3. Effect on oil content:

Fertilization treatment effect on extracted oil was highly significant at (P= 0.01), chicken manure score higher oil content. The effect of soil type and salinity on oil content was non-significant (Table 17, Figure 17).

Table 13: Effect of chicken manure, soil type and salinity on fresh herbage yield (2nd cut).

M.P / S.P. / S.S.P	Tap		Saline		Mean (S.S.P) S.E.± 7.08
	Sh	So	Sh	So	
Control	138.53	90.60	126.50	96.00	112.90[b]
+Chicken manure	216.75	192.33	169.33	180.66	189.77[a]
Mean (M.P) S.E.± 10.03	156.63[a]		146.04[b]		
Mean (S.P) S.E.± 1.25	Sh 162.77[a]		So 139.90[b]		

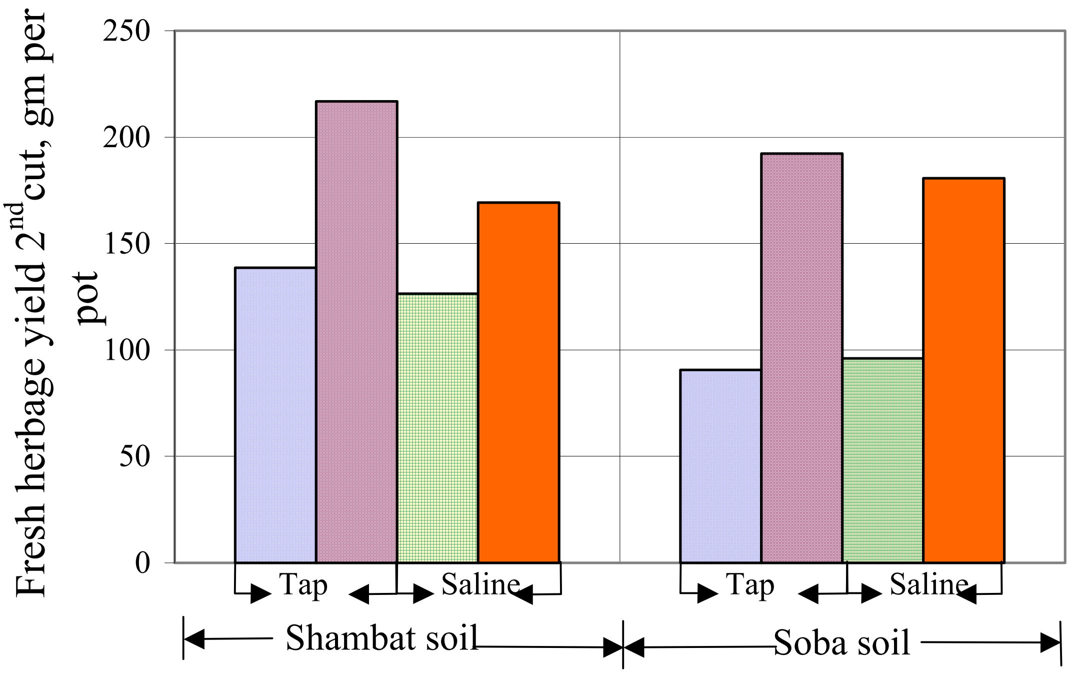


Figure 13: Effect of chicken manure, soil type and salinity on fresh herbage yield (2nd cut)

Fresh herbage yield without chicken manure using tap water
Fresh herbage yield with chicken manure using tap water
Fresh herbage yield without chicken manure using saline water
Fresh herbage yield with chicken manure using saline water

Table 14: Effect of soil type and salinity on fresh herbage yield (gm/pot) (2nd cut).

Salinity (M.P) / Soil (S.P)	Tap water	Saline water	Mean (S.P) SE$\pm$ 1.25
Shambat	177.6^{a}	147.9^{b}	162.7^{a}
Soba	144.1^{b}	135.6^{c}	139.9^{b}
Mean (M.P.) S.E. $\pm$ 10.03	156.63^{a}	146.9^{a}	M.P. X S.P. S.E.$\pm$ 1.77

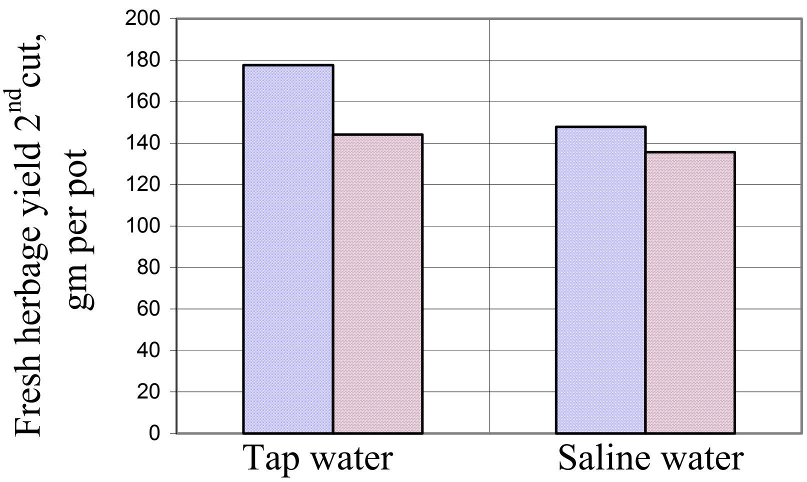


Figure 14: Effect of soil type and salinity on fresh herbage yield (2nd cut)

Table 15: Effect of chicken manure, soil type and salinity on dry herbage yield (gm/pot) (2^{nd} cut).

M.P / S.P. / S.S.P	Tap		Saline		Mean (S.S.P) S.E.± 1.59
	Sh	So	Sh	So	
Control	33.2	19.7	24.8	20.0	24.44^{b}
+Chicken manure	46.3	45.4	40.0	39.3	42.75^{a}
Mean (M.P) S.E.± 1.76	34.63^{a}		32.56^{a}		
Mean (S.P) S.E.± 0.89	Sh 36.07^{a}		So 31.72^{b}		

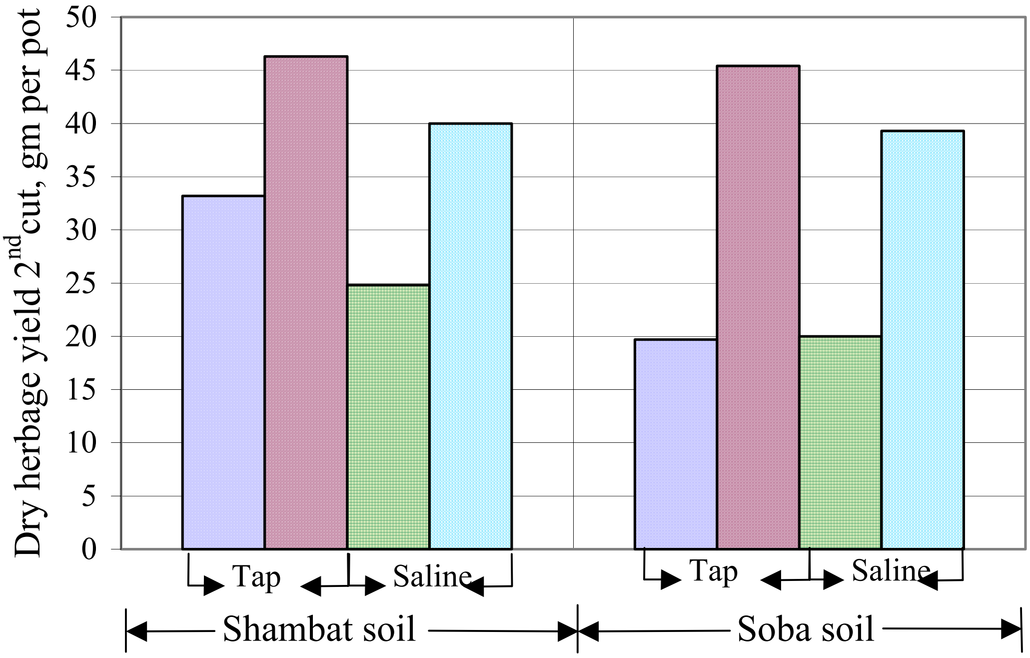


Figure 15: Effect of chicken manure, soil type and salinity on dry herbage yield (2^{nd} cut)

Table 16: Effect of soil type and salinity on dry herbage yield (gm/pot) (2^{nd} cut).

Salinity (M.P) / Soil (S.P)	Tap water	Saline water	Mean (S.P) SE± 0.89
Shambat	39.7[a]	32.4[b]	36.07[a]
Soba	32.7[b]	29.5[b]	31.12[b]
Mean (M.P.) S.E. ± 1.76	34.63[a]	32.56[a]	M.P. X S.P. S.E.± 1.26

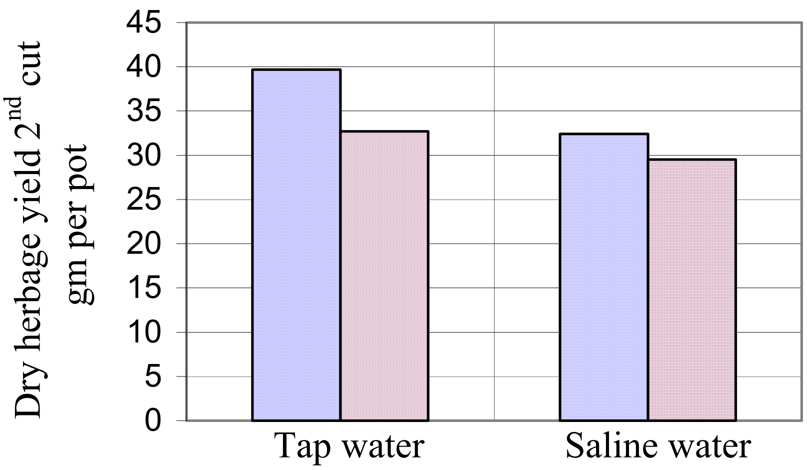


Figure 16: Effect of soil type and salinity on dry herbage yield (2^{nd} cut)

Table 17: Effect of chicken manure, soil type and salinity on percentage of oil (2^{nd} cut).

M.P / S.P. / S.S.P	Tap		Saline		Mean (S.S.P) S.E.± 0.05
	Sh	So	Sh	So	
Control	1.8	1.8	1.4	1.6	1.66^{b}
+Chicken manure	2.2	2.2	2.03	1.9	2.17^{a}
Mean (M.P) S.E.± 0.07	2.00^{a}		1.76^{a}		
Mean (S.P) S.E.± 0.04	Sh 1.86^{a}		So 1.97^{a}		

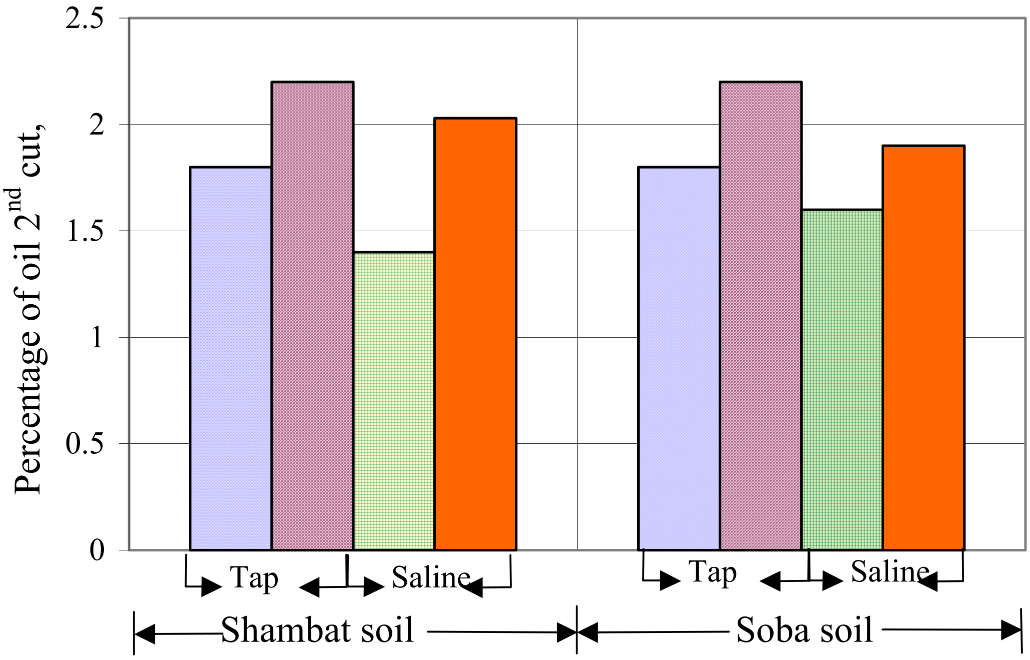


Figure 17: Effect of chicken manure, soil type and salinity on percentage of oil (2^{nd} cut)

CHAPTER FIVE
DISCUSSION

5.1. Effect of treatments on plant height:

The effect of chicken manure on plant height was very highly significant, however, the other treatment have no significant effects on plant height, but Shambat soil with chicken manure and tap water irrigation score higher plant height.

The positive effect of the added manure was attributed to the beneficial effects of manure on soil structure (William and Cooke, 1967; Sharma, 1971 and Malik, 1983), increase in permeability and diffusivity of water and root penetration (Kova and Vanderpeng, 1973) and their complexing properties which prevent precipitation and fixation of many plants nutrient and improve soil fertility status (Bandel, *et al*., 1972).

The higher plant height recorded from plants grown on Shambat soil can be attributed to the higher organic matter content of Shambat soil that indicated more available nitrogen compared with Soba soil (Mubarak, 1989).

The slight effect of salinity on plant height in early stages of plant development was attributed to the fact that plant roots are so tender and after three months it became more strong and efficient in utilization of nutrients as the growing season proceeded, hence the salinity effect was much reduced or alleviated (Bandel, et al., 1972 and Morgan, 1966). This was online with finding of Mass and Hoffman (1977) who found that the sensitivity of plants to salinity varies with plant growth stage. Also Horst Marschner (1986) shows that the sensitivity to salinity of a given species or cultivars may change during ontogeny and it may increase or decrease depending on plant species, cultivars or environmental factors, and most sensitive cultivars at seedling stage, were rather tolerant at maturity stage.

5.2. Effect on herbage yield:

The increase in herbage yield which correlated with plant height could be possible explained in the same way as plant height.

The positive effects of chicken manure on soil physical and chemical properties as explained before expected to increase plant nutrient absorption and therefore plant growth was much increased, hence the superiority and merits of chicken manure was evident, also the application of chicken manure for vegetable production in the Sudanese Egyptian Agricultural Co-operation Farm at Soba found to improve yield (Gabir, 1984 and Nour, 1988).

The decrease in dry weight with salinity was in consistent with Samani (1980) who reported a decline in dry weight with increasing salinity level which may be attributed to the decrease in nitrogen uptake with increase in salinity (Hassan et al., 1970).

The interactive effect of manure and salinity, and the alleviation of the adverse effect of salinity with fertilization is a practice of wide spread (Karouri, 1977, Gabir, 1984 and Mohamed Ahmed, 1988). Also Eltilib (1993) found that chicken manure was very effective in counteracting salinity effect and the value of chicken manure as soil amendment and fertilizer was well documented. (Plate 3).

5.3. Effect of treatments on root growth:

All treatments affect root growth significantly salinity found to reduce root growth as reported by Schwarz and Gale (1981) and Eltilib (1993) this could be attributed to the fact that phosphorus uptake was reduced or retarded in saline soil (Hassan, *et al*., 1969). As phosphorus is very important in the growth and metabolism of plant, its deficiency lead to a general reduction of the most metabolic processes such as cell division and expansion, also the root hydraulic conductance is decreased (Horst Marshner, 1986).

The detrimental effect of salinity are amplified by poor soil aeration, this could explain the lower root fresh and dry weight obtained from Shambat soil due to the higher clay content of this soil which hinder root growth compared with higher root fresh and dry weight obtained from Soba soil which is light soil (contain more sand) that facilitate root growth and penetration.

As addition of chicken manure improve soil structure, increase permeability of water and enhance root penetration and growth, the highest root fresh and dry weight was obtained from Shambat soil with chicken manure addition followed by Soba soil with the same treatment.

The interactive effect between salinity and chicken manure more evident on root growth, which indicated the superiority and merits of chicken manure in reducing the salinity effect, since the composting process decrease the pH due to production of H^+ during mineralization and nitrification, hence increase phosphorus availability which promote root growth (Miguel, *et al*., 1990).

5.4. Effect on Oil Content:

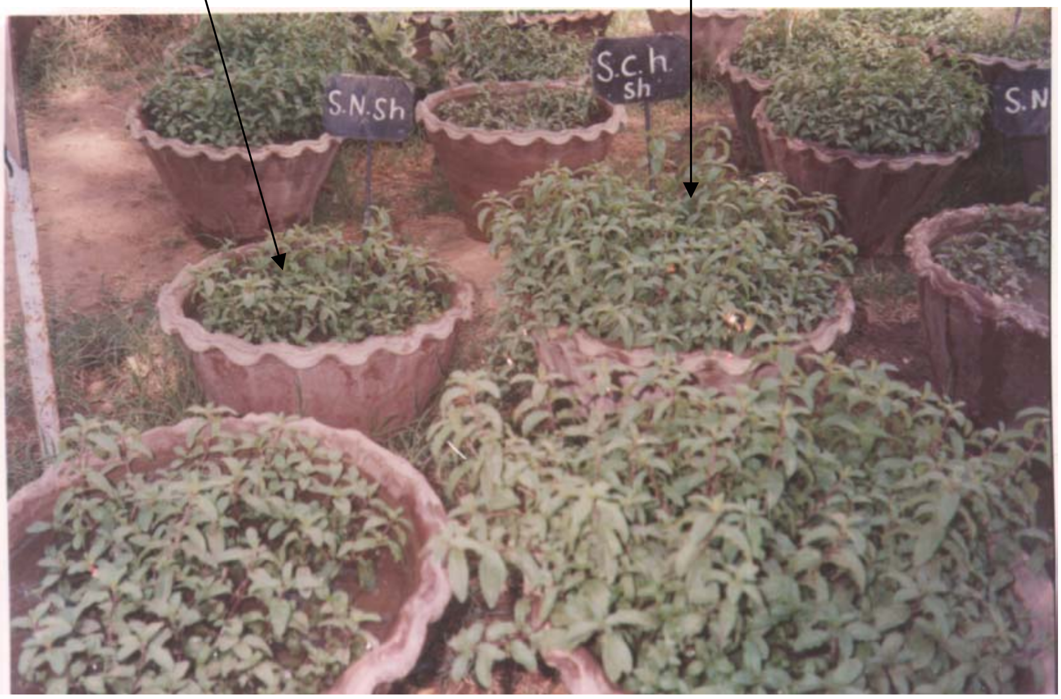
In the first cut chicken manure and soil type found to affect oil content, this may indicate that the fertility status of the soil affect oil content this was in agreement with the findings of Ghosh and Chatterjee, (1993) who reported that the increasing NPK is the most effective treatment for increasing essential oil content of mint. Also

Chinnabbai, (1992), Kothari, (1995) and Court, (1993) reported that increasing in the fertility status of the soil found to increase both herbage and oil yield. This could explain the higher oil content obtained from Shambat soil with chicken manure addition, compared with Soba soil with the same treatment.

In the second cut only chicken manure found to affect oil content significantly. Due to slow decomposition rate of chicken manure, also the growth of plant and its strength may minimize the adverse effect of soil salinity.

Plate 3: The interactive effect between chicken manure and salinity and the alleviation of the adverse effect of salinity by chicken manure addition.

S.N.sh S.ch.sh



Note:

S = Saline water

N = without chicken manure

ch = with chicken manure

CHAPTER SIX

CONCLUSION

Large areas of Sudan are affected by salinity and sodicity problems according to reports of soil survey (1976). Example of these soil is Soba soil in the northern part of Khartoum. The salinity problem of these soil reflected in poor physical and chemical properties which cause serious limitation in the productivity of land, therefore reclamation for such soil is a must before any serious agricultural developments so as to increase the productivity and the economic yield.

Chicken manure found to increase both herbage and oil yield of spearmint in both Shambat and Soba soil examined in this work.

This study confirms that chicken manure is very effective in counteracting salinity effect and facilitates root growth.

Shambat soil out yielded Soba soil, hence addition of chicken manure to Soba soil is highly recommended to counteract the effect of poor type of soil and salinity in that area.

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