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RESPONSE OF FOUR GRAFTED EGGPLANTS TO NaCl SALINITY

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The biochemistry and physiology of different hybrid and grafted eggplants in response to NaCL salinity in soil and hydroponic systems.

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Abstract

The major problem of salinity n regions of intensive cultivations such as Ierapetra, has started to affect the crop production. This project was designed to study the effects of salinity on several biochemical and physiological parameters in two hybrids of eggplant as grafted and non-grafted. The two hybrids were the *Solanum melongena* L hybrid Habana and *Solanum melongena* L hybrid Vernina.

The concentrations that were chosen (12.5 25, 50, 100, 150 and 200mM) represent a scale of salt concentration and were cultivated as self rooted plants in soil, hydroponically and hydroponically as grafted. Grafting also seems to play an important role for salinity tolerance. To corroborate the different parameters were used as indicators of salinity affection and quantified.

Plant height and number of leaves were affected in all three experiments and for all plant types whether grafted or not. Similar were the results for the dry and fresh weight of stem leaves and fruits. For the physiological function of the plants factors such as chlorophyll fluorescence and photosynthetic rate were affected especially at higher concentrations of NaCL. The chlorophyll content in the leaves, which was also measured, was negatively affected in all hybrids.

Biochemical measurements the K and Na concentrations in dry leaves and the enzyme activity of APX, GPX and SOD were also made. The K and Na ion concentrations were similar with other studies presenting a reduction of K and raise of Na as the concentration of salt was rising.

Unfortunately the enzyme activity was not affected at the specific experiment so it was not able to find exactly how the salinity affects this factor.

Overall the results of grafted plants were better than as self rooted and the *Solano torvum* plant used as rootstock is more tolerant than the Tomato Resistar also used as rootstock.

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I would like to express my deepest appreciation and gratitude to my supervisors Assistant Professor Dragasaki Magdalene for her help, guidance, and support and to Dr. Aldred David for his help, throughout of this thesis.

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Notacion

%	per cent
^oC	degrees Calcius
APX	Ascorbate Peroxidase
ANOVA	analysis of variance
C	Carbon
Ca^{+2}	Calcium
$CaCl_2$	Calcium Chloride
Cl^-	Chlorium
CO_2	Carbon Dioxide
Cu	Copper
D.W.	dry weight
E.C.	Electrical Conductivity
et al.	and others
Fe	Iron
Fm	Maximum Fluorescence
Fo	Basal Fluorescence
Fv	Variable Fluorescence
F.W.	Fresh Weight
g.	grammar
GPX	Glutathione Peroxidase
Ci	Intercellular CO_2 Concentration
K^+	Potassium
m^2	square meter
Mg^{+2}	Magnessium
mg/ l	milligram/liter
mg/ml	milligram/mole
$MgCl_2$	Magnessium Chloride
min	minutes
mm	milimeters
mM	milimole
Mn	Manganese

Mo	Lead
Na^+	Sodium
NaCl	Sodium Chloride
nm	nanometer
PSII	Photosnthetic System II
POD	peroxidase
pH	Power of Hydrogen (measure of the activity or basicity of a solution)
Po	Photosynthetic rate
ROS	Reactive Oxygen Species
sec	seconds
sig.	significance
gs	Stomatal Conductance
SOD	Superoxide Dismutase
w/v	weight/volume
v/v	volume/volume

CHAPTER 1. INTRODUCTION

1.1 General Introduction

The city of Ierapetra it is located on the south-east coast of the island of Crete on the Libyan Sea. It has approximately 20,000 residents with the main occupation being the culture of greenhouse food products. The climate in Ierapetra is quite warm. Temperature ranges from 5^0 to 40^0C with on average 20^0C. Average hours of sunshine per month are 265 h. The summertime is dry and the winter is mild.

Because of these particular climatic conditions Ierapetra and Messara – also in South Crete, were the first regions where the all year- greenhouse food production of vegetables and flowers was developed.

The 13,000 acres of greenhouses are mainly cultivated with tomato (the higher percentage) and the remaining with eggplant, pepper, cucumber and courgette, in metal framed passively ventilated greenhouses covered with polyethylene. However the increased and intensive culture of these products has resulted in an important problem. The excessive consumption of water has led to the draining of the groundwater horizon.

The locals tried to solve the problem by assembling water from adjacent rivers and springs with the construction of a dam and an artificial lake, which was initially attended to the irrigation shortages of the region. However in the dry years, the water of the lake is not enough so water from a large seafloor spring is directed into the dam. Although the water from the spring is of good quality, during the pumping it is mixed with seawater and becomes marginally suitable for irrigation for olive groves and other tolerant plants. When mixed with the water of the artificial lake, the quality of the resulting water is better but not without problems particularly in the summer months.

Thus this increase in salinity in the irrigation water is causing various problems in the greenhouse culture of most vegetables, mainly causing the decreased quality of products and a reduction in production Yield.

This project was designed to study the effects of salinity on several biochemical and physiological parameters in two hybrids of eggplant. The two hybrids were the *Solanum melongena* L hybrid Habana and *Solanum melongena* L hybrid Vernina.

1.2 THESIS STRUCTURE.

The thesis is composed in six chapters.

- Chapter 1. Introduction and thesis structure. This chapter contains a small description of the region of Ierapetra, the eggplant and the cultivation of the eggplant and the thesis structure.

- Chapter 2: Literature review. This chapter is a literature review of the salinity and the problems that occur in cultivated plants. The affect of salinity on eggplant plants, plant growth, photosynthetic rate, antioxidant enzyme activity, macro and micro nutrients etc. Also the importance of grafting in eggplant and in plants generally.

- Chapter 3. Materials and methods. A thesis structure and details for each experiment and the methods that was used.

- Chapter 4. This Chapter presents Experiment 1. Self rooted plants of *Solanum melongena* L hybrid Habana and *Solanum melongena* L hybrid Vernina, *Solanum torvum* and *Solanum lycopersicum L* hybrid Resistar in soil, treated with the concentrations of 12.5 25, 50, 100, 150 and 200mM.

- Chapter 5. Self rooted plants of *Solanum melongena* L hybrid Habana and *Solanum melongena* L hybrid Vernina, *Solanum torvum* and *Solanum lycopersicum L* hybrid Resistar in perlite, treated with the concentrations of 12.5 25, 50, 100, 150 and 200mM.

- Chapter 6. Grafted plants of *Solanum melongena* L hybrid Habana and *Solanum melongena* L hybrid Vernina as scions and *Solanum torvum* and *Solanum lycopersicum L* hybrid Resistar as rootstocks, in perlite, treated with the concentrations of 12.5 25, 50, 100, 150 and 200mM.

- Chapter 7. This presents the general conclusions from the experiments and suggested future work.

2. LITERATUREREVIEW

2.1 *Solanum melongena* L.

The eggplant (*Solanum melongena*) belongs in the family of Solanaceae; it originated in India and was transported into Europe by the Arabs. It is cultivated for its fruit which is one of the basic components of the Mediterranean diet. The Agricultural Research Service of the USDA, reports that eggplants contain high percentages of phenolic antioxidants. Most important of these is chlorogenic acid, which according to researchers can block the creation of carcinogenic nitrosaminates and decrease the danger of certain types of cancer such as liver and intestinal.

2.2 EGGPLANT CULTIVATIONS

It is an herbaceous plant with vertical growth habit with a burgeoning top. Its leaves are big, alternately on the stem. The flowers have all the male and female reproductive parts and they grow solitarily on the shoot. The fruit of eggplant is oval or cylindrical and varies in size depending on the variety. The colour of the fruit can be purple, deep purple, purple with white lines, deep or light blue, white or even yellow in some varieties. The flesh of the fruit is spongy and contains many seeds when overripe.

The eggplant is a thermophilic plant and the cultivation requires a large amount of water. It is cultivated outdoors from May to October. It can also be cultivated ‘off season’ in heated greenhouses with night temperatures of 18-20^{0}C and day temperatures of 21-22^{0}C. 15^{0}C and higher temperatures in the soil helps in the improvement of colour of the fruits.

In greenhouse culture, single stem or double stem cutting is usually applied to fit more plants per acre because the plants need to occupy less space in the greenhouse. The plants in the greenhouse need support with strings because of the height that they can reach during cultivation. They also need defoliation for better aeration and more light.

The local varieties in Greece are the Lagkada with oval, dark purple, long fruits weighing roughly 150 grams, the Tsakoniki,(Leonidioy) (Protected Name of Origin from 1996) (Plate 2.1), with long purple fruits of 120-150 grams, and Syrou, a off season variety with the bigger, round or pear shaped, dark purple fruits of typically 300 grams.

Plate 2.1Tsakoniki eggplant, (Leonidiou)

The cultivation in greenhouses is mostly preferred because it can achieve higher temperatures in the winter months so the fruits of eggplant can be sold all year round with a good price. However, this also causes some problems as cultivators are encouraged to grow the plants intensively with a high demand for water, fertilizers and other chemicals.

2.3 Salinity.

Salinity is the existence of ions in high concentrations, mostly Na^+ and Cl^- in the soil and water. Those ions occur from mineral rocks, salty lakes and oceans, bad draining of the soil and small amounts of annual rain (Therios 1996).

For the soil, the problem of salinity is mainly in areas near the sea, which are in the lower point of the landscape (valleys etc) or in places with low water penetrability into sub layers. It occurs generally in areas with a dry or semi dry climate where the evapotranspiration is high but the amount of fresh water, for example from rain, is not enough to wash the salts from the soil. Another reason for the development of high salinity is the use of water with high concentration of salts for irrigation, as in the case of Crete (Missinopoulos 1991). According to the U.S Salinity Laboratory, a soil is characterized as ‘salty’ when the electrical conductivity (EC), the resistivity of a material to the movement of an electric charge, of the saturated extract is more than 4 $dS.m^{-1}$ (deciSiemens in meter), good quality water for cultivation is one with < $2dS.m^{-1}$,when the sea water has EC 44-55 $dS.m^{-1}$.

To understand the scale of the problem of salinity in cultivation, the area with salinity problems worldwide is about 8 billion acres, > 6% of the world total land area (FAO, 2009). So in the future, if we consider the large demand from countries with fast development and higher demand for fresh water and new land for food cultivation, there must be further research for salt tolerant cultivation and new methods for cultivation in areas with salinity problems.

2.4 Effects of salinity on plants.

The salinity of soil plays an important role in the growth of plants (Zhu, 2001) and in many of the vital process such as photosynthesis, (Parida and Dass 2005), The plants are stressed in conditions of high salinity and this happens mainly because of the high concentrations of Na^+ and Cl^- ions in the soil water. (Hasegawa et al., 2000). This generally disturbs the osmotic potential (the ability of water to move from a hypotonic to a hypertonic solution) of the roots.

When the concentration of Na^+ ions exceeds the 1500ppm (1 EC= 500ppm), most plants are under stress conditions. So they have developed some defense mechanisms (Munns et al. 2002).

These are:

a) Decreasing the reception of the chemical ions from the roots.

b) Decreasing the transport of the ions inside the plant and at the same time increasing the transport of others, like K^+, to decrease the osmotic potential.

c) Accumulating the ions in the higher parts of the root, shoot and leaves.

d) Decreasing the transport of ions among the developing tissues.

e) Discarding the salt through the leaves.

Halophytes (plants that can grow in high salt conditions) are the only plants that use all of the above mechanisms to protect themselves from salt. Other plant species that are not adapted to withstand high salt conditions mostly use the first three mechanisms. On the other hand, glycophytes (plants that grow in non saline soils) behave in a completely different manner when Na^+ and Cl^- ions in the ground solution are at a low level. These acts like a lack of water and these plants reduce their growth and lose some of their leaves. Growth is only resumed when the ions are replaced in the soil, until they begin to reach toxic levels in the tissues (Yeo et al.., 1991).

2.5 Effects of salinity on the growth of plants.

The most common effects of high salinity on plants are the direct reduction of the growth and development of a condition of high stress which can lead to total leaf fall. The reason is the increased difficulty of the plant to obtain water from the soil, because of the osmotic and the ionic effect, to other ions, of salt. That is to say movement of ions into tissues will be reduced, which results in the decreased function of cells (Munns, 2005). The reduction of growth occurs before the symptoms of the salinity stress begin, due to the reduction of the osmotic difference and then to the toxicity of the ions in higher concentrations to the cells. Another important change is in the integrity of cellular membranes and in the activity of enzymes.

The high salinity also results in smaller leaves, reduction in the intercellular spaces (empty and non empty spaces among the cells) and also reduction in the number of the chloroplasts. The leaves are thicker and have liquefied mass Weisel 1991, Shannon 1994). In tomato in particular, a reduction of the leaf surface and lower stomatal conductance has been observed (Romeroaranda et al. 2001).

The biggest effect occurs in the leaves because in these structures, all the vital operations of the plant take place. The Cl^- ions accumulation leads to chlorosis and premature ageing of leaves and leaf abscission. This results in the reduction of photosynthetic ability of the plant and the reduction of stem growth (Zekri 1991).

A consequence of these effects is also the reduction of the fresh as well as dry weight of plants (Chartzoulakis and Klapaki 2000; Navaro et al. 2003; Lykoskoufis et al. 2005).This also affects the fruits because of the smaller capacity of the plants to produce metabolites and results generally in decreased production and quality.

2.6 EFFECTS OF SALINITY ON THE PHYSIOLOGY OF THE PLANTS

2.6.1 Photosynthetic rate.

The influence of salinity on the photosynthetic ability of plants is concerned mainly with the toxic effect of salts but also with the reduction of water potential. In the first few hours of the exposure to salinity, there is a total interruption of the carbon (C) absorbance by the older leaves and in the next few days to the new developed leaves due to the toxicity of the concentration of salts.

Also salinity reduces the stomatal conductivity and respiration. The rise in water potential causes absorption of water from the cells, reducing the inter-cell space and stops the transport of the electrons, which are products of photosynthesis. With the increase of osmotic potential there is entry of Na^+ ions into the cytoplasm which causes further dysfunction of the photosynthetic and respiratory transport of electrons (Parida and Das 2005).The ionic imbalance that is created leads to the degradation of the photosynthetic system II (PSII) (Ashraf 2004.). Also the closure of the stomata under salinity stress reduces respiration, so the concentration of CO_2 in the inter-cell space is raised which hinders the photosynthetic procedure (Schulze 1986).

Some other non-stomatal factors that reduce the photosynthetic rate are the dehydration of the cell membrane, tissues that mature faster than normal, changes in the inter-cell enzyme activity and the toxicity of the salt ions themselves (Ziska et al. 1990.).

Although most researches report a reduction in the photosynthetic rate, in some studies it is reported that photosynthesis is raised in low concentrations of salinity (Parida and Das. 2005.) Differences are also reported between different species and varieties of a single species.

2.6.2 Chlorophyll content.

Another factor that salinity affects is the chlorophyll content. The result is general chlorosis of the leaves, which leads to premature death and leaf fall. Netodo et al. (2009) reported a significant reduction in chlorophyll content in sorghum under salinity stress. Reduction in chlorophyll concentrations is probably due to the inhibitory effect of the ions of salts on the biosynthesis of the different chlorophyll factors.

Salinity affects the production of the pigment protein complex in the chloroplast structure. As the chloroplast is membrane-bound its stability is dependent on the membrane stability itself, which under high salinity conditions seldom remains intact. (Y. Ali, Z. Aslam, M. Y. Ashraf and G. R. Tahir 2009.).

2.6.3 Chlorophyll fluorescence.

Chlorophyll fluorescence is another indicator of plant stress. The value of chlorophyll fluorescence is used in many studies to indicate salinity stress conditions (Yamada et al. 1996; Meyer and Gently. 1998; Maxwell and Johnson. 2000.). The reason is that light as stimulator of photosynthetic system II (PSII) can also be used as fluorescence in the chlorophyll molecules (chlorophyll fluorescence). By this procedure chlorophyll fluorescence can be measured as a factor of chlorophyll activity. Measuring the amount of chlorophyll fluorescence under stress conditions we can detect any changes in photosynthesis before almost any other symptom appears (Maxwell and Johnson 2000.).

In order to measure this parameter in plants we have to measure the maximum fluorescence (Fm) and the basal fluorescence yield (Fo). The basal florescence is measured when the pulsed light for photosynthesis is very low and the Fm is measured by exposing the chlorophyll to a specific wave length of light that can activate chlorophyll (actinic light), about 10,000 μmol photons $m^{-2}s^{-1}$.The Fm (fluorescence maximum) minus the Fo (fluorescence minimum) equals the Fv which is the fluorescence variable and (Fm-Fo)/Fv is the the efficiency of photon yield (the number of times that a chemmical raction occurs per photon) by PSII. Normally this value is from 0.75 to 0.85.

2.6.4 Effects of salinity on ion levels.

There seems to be an interaction between the ions in plant cells caused by high salinity conditions. For example, in high salinity conditions the plant increases the concentration of Ca^{+2} and K^{+} in the cellular solution during the process of conditioning to these conditions (Knight et al 1997, Zhu 2001). Also salinity influences the absorption of nutrients from the ground because the competition that is created between the ions.

Finding the concentrations of specific ions through tissue analysis is a reliable method to study salt tolerance. A characteristic example is potassium (K). The K^+ in the plants is related with the ratio of Na^+/K^+ in the substrate (Devitt et al. 1981). In many studies it has been found that the concentration of K^+ in the plant is decreased when the concentration Na^+ increases in the substrate (Okusanya and Ungar 1984; Cramer et al 1985; Subbarao et al 1990). Under high salinity condition adding potassium in the nutrient solution is reported to increase the dry weight of the stem and the roots in cotton (Silverbush. 1987.) and it may be important to add essential ions such as K^+ to the growth substrate.

2.6.5 Effects of salinity on antioxidant enzyme activity.

Also an important affect of salinity to plant tissues is the production of reactive oxygen species which are functioning by-products of metabolism due to abiotic stresses, as well as important signal transduction molecules (Jithesh et al 2006). Consequently the detoxification of these molecules makes the plants more tolerant to increased salinity (Xiong and Zhu 2002). In order to detoxify, the reactive oxygen species plants use certain antioxidative enzymes in antioxidative mechanisms.

The non-enzymatic antioxidant mechanism uses various compounds or molecules such as a-cetoferole, (a substance which is produced by chlorophyll during the process of photosynthesis) (Konstantinidou 2003), ascorbic acid and various soluble proteins (Jithesh et al. 2006) such as osmotin which is a protein that is produced in conditions of stress (Ashraf and Harris 2004).

The enzymatic mechanism includes the production of enzymes such as superoxidedismutase (SOD), catalase (CAT), guaiacolperoxidase (GPX), ascorbateperoxidase (APX), glutamatedehydrogenase (GDH) and peroxidase (POD) (Scandalios 1997; Jithesh et al 2006). Each one of these enzymes is active in different parts of the cell. For example, the peroxides are detoxified by CAT in the cytoplasm and also from APX in the plasmodia (Konstantinidou 2003). The hyper-production of SOD and CAT helps plants to tolerate stress factors such as salinity, cold and general external oxidant factors. Many researchers report that although the expression of the different enzymes at the same time helps during stress conditions, each one is regulated independently (Levine 1999).

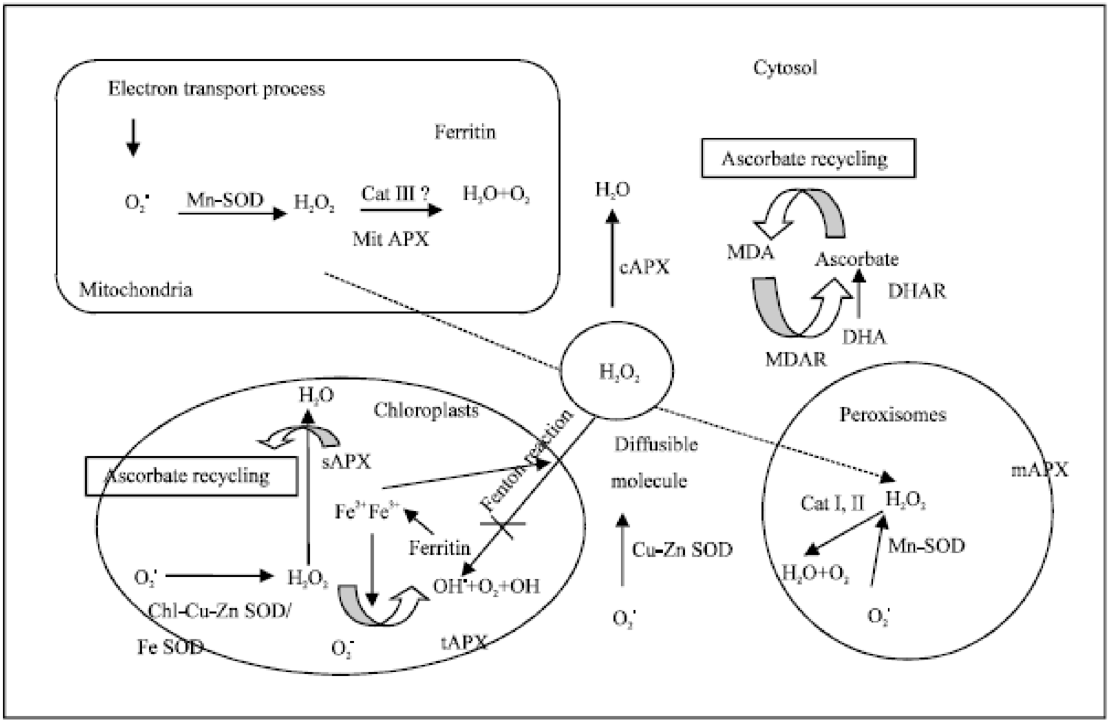


Fig.2.2. Antioxidant network in different organelles of the plant cell. (Jithesh et al. 2006).

The cells also produce high quantities of many osmoregulating substances such as sugars and polyols (Saira and Tyagi 2004). These substances protect some cellular structures in interaction with other proteins and enzymes (Rhodes et al 2002).

2.6.7 Water relations.

The water and osmotic potential, the minimum force that it is needed to stop osmosis, becomes more negative as salt concentration increased. On the other hand turgor pressure (the presure of plasma membran to the cell wall of plant cells) increases (Parida and Dass, 2005). When the plants are under high osmotic stress (e.g. salinity), due to high osmotic potential, they turn to osmotic regulation. This regulation happens through ions or organic compound entry in to the plants. Under this osmotic stress there is reported growth reduction (Ashraf, 2004)

2.7 Effect of salinity on eggplants.

Eggplant is usually considered to be a plant which is sensitive to salinity (Heuer et al. 1986; Savvas and Lenz 1996). However it is capable of maintaining a more favorable water balance than other vegetables (Behboudian, 1977). However, in high concentrations of salt the results are similar to those in other vegetable plants.

Greenway and Munns (1980) came to the conclusion that the seedlings of eggplant are more sensitive at the beginning of their growth than in later stages, probably because of the osmotic stress caused by the sudden change of the solution concentrate.

Observations in plants of eggplant show that in hydroponic cultures the growth and production of fruits differ depending on of salinity levels (Savvas, Lenz 1996). In lower concentrations of salt there is a reduction of the dry weight of the fruits and also a relative reduction of the number of the fruits per plant (Chartzoulakis and Loupassaki 1996). In higher concentrations plants ultimately show poor and may lose biomass (Ashraf 1994).

This clearly affects the relative yield of fruit. Mass and Hoffman (1977) found that the relative yield is decreased by 23%, 41%, 69% and 88% at 25 mmol, 50mmol, 100 mmol and 150 mmol NaCl, respectively.

2.8 Grafting and the role of grafting to improve salt tolerance.

Grafting is an environment-friendly technique combining two different plant types (usually the same species) the upper part (stem leaves fruits etc.) of the one to the lower part (stem and roots) of the other. This technique is based on the vascular tissues from two plants (rootstock and scion) join together to become one. In figure 2.2 it is shown the same technique of grafting used in the experiments.

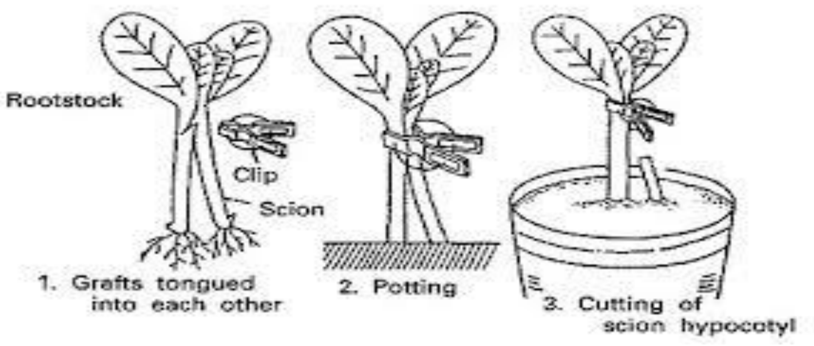


Fig.2.3. Tongue approach grafting.

Grafting losses in crop production from many factors such as pest and soil diseases and also to improve tolerance to many stress conditions like salinity. It is concerned with developing a combination of desired shoot characteristics and desired root characteristics (Pardo et al 1998). Grafting is a very common method for solving the problems of salinity in *Curcubitaceae* and *Solanaceae* families and it is been studied by many researchers. (Santa-Cruz et al, 2002; Colla et al. 2005; Zhu et al. 2008; Yetisir and Uyrur 2010.).

Grafting can provide

a) Higher accumulation of proline and sugar in the leaves (Ruiz et al. 2005)
b) Higher antioxidant capacity in the leaves (Lopez-Gomez et al. 2007)
c) Lower accumulation of Na^+ and Cl^- in the leaves (Fernandez-Garcia et al, 2004; Goreta et al, 2008).

Many studies report that an important technique in some crop species has been the grafting of varieties with saline resistant rootstocks onto other varieties of the same species making them resistant to soil-borne diseases (such as *Verticilium dahliae*) , low temperatures and salinity (Zhang 2002, Yang et al 2006). However in eggplant up until now there have been very few reports of the use of this technique.

In these reports it has been found that grafting of eggplant affects the polyamines metabolism and the antioxidant enzymes activity at the cells (Zhang et al 2008). Also an increased activity of SOD was found (Dhindsa et al 1981) and also Peroxidace (POD) activity was assayed (Kochba et al 1977) under salinity stress.

The table 2.8.1 below shows the Na^+ and Cl^- exclusion and inclusion in some grafted species as rootstocks and scions.

Table 2.1. Na^{+} and Cl^{-} exclusion and inclusion in grafted vegetables under saline conditions.

Scion species	Rootstock species.	Ion exclusion in the scion.	Ion inclusion in the rootstock.	Reference.
Cucumis sativus L.	*Cucurbita moscata Duch.*	Na^{+} exclusion.		Chen and Wand. (2003)
Cucumis sativus L.	*Langenaria siceraria Standl.*	Na^{+} and Cl^{-} exclusion.	Similar Na+ and Cl-.	Huang et al.(2009)
Cucumismelo L.	*Cucurbita maxima Duch. x C. MoshataDuch.*	Na^{+} exclusion, similar Cl^{-}.		Edelstein et al.(2005)
Solanum melongena L.	*Solanum torvum Swartz.*	Na^{+} and Cl^{-} exclusion.	Na+ inclusion.	Wei et al.(2007)
Solanum lycopersicum L.	*Solanum lycopersicum L.*	Na^{+} and Cl^{-} exclusion.		Estan et al.(2005)

The salt tolerance in grafted plants is due mainly to the choice of the rootstock. He et al (.2009) observed that in non-grafted tomato a decrease in root dry mass at 100 and 150 mM NaCl concentration was observed but in the case of grafted tomato the reduction was smaller. Using tomato as rootstock, the growth performance was improved under saline conditions when it was grafted to *Solanum torvum* plants (Wei et.al 2007).

Wei et.al (2009) also observed that grafted eggplants had an improved antioxidant enzyme activity compared to self rooted seedlings. Similar results have also been noted with other plant species as shown in the tablet 2.2 below.

Table 2. 2. Antioxidant as markers of salinity tolerance in grafted vegetables.

Scion species.	Rootstock species.	Antioxidant.	Reference.
Cucumis sativus L	*Cucurbita maxima Duch x C. MoshataDuch*	SOD, POD, CAT, APX.	Yang et al.(2006)
Cucumis sativus L	*Curcubita ficifolia Bouche*	SOD, Cu/Zn-SOD, Mn-SOD, CAT.	Gao et al.(2008)
Citrus lanatus	*Langenaria sicerariaStandl*	SOD, POD, CAT, APX.	Zhu et al.(2008)
Solanum lycopersicum L	*Solanum lycopersicum L*	SOD, POD, APX, AsA.	Chen et al.(2005)
Solanum melongena L	*Solanum torvum* Swartz	SOD, POD, APX, GR.	Wei et al.(2009)

2.9. Aim and objectives of the present work

2.9.1 Aim

The effect of salinity on the eggplant production is a major problem which reduction in cropyield and quality. The aim of this PhD project is to examine the effect of NaCl in the irrigation water of two greenhouse eggplant hybrids and two rootstocks, by studying the effects of salinity on different physiological and biochemical parameters of their growth and development. Two eggplant hybrids (Vernina and Habana) and two rootstocks (*Solanum torvum*, a bushy, erect and spiny perennial plant used horticultural as a rootstock for eggplant and tomato (*Lycopersicon esculentum*) were used, all of them as self rooted and as grafted plants.

2.9.2 Objectives

- To study the effect of NaCl on the growth and development of two popular eggplant hybrids and two rootstocks.
- To assess the impact of salinity on major physiological and biochemical parameters of the growth and development of each hybrid and rootstock.
- To collect evidence on the tolerance or sensitivity of the two eggplant hybrids by evaluating the symptoms and comparing the results of salinity on the measured parameters. To make recommendations on the most effective varieties of eggplant that can be grown in greenhouses under saline conditions.

3. MATERIALS AND METHODS

The follow experiments were designed to study the tolerance of two eggplants hybrids (*Solanum melongena* L hybrid Habana and *Solanum melongena* L hybrid Vernina) and two commonly used rootstocks (*Solanum torvum* and *Solanum lycopersicum L* hybrid Resistar) both as grafted and self-rooted plants in seven different concentrations of NaCl 12,5, 25, 50, 100, 150 and 200 mM. The first experiment tested the plants at a soil sub-layer, and the two other experiments in perlite, simulating a hydroponic culture system.

3.1 Description of the experimental work.

The above plant types, as scions (the upper part of a grafted plant) and rootstocks were chosen because of their good characteristics and fruit production in the greenhouses of Ierapetra, and because they are commonly used by the local eggplant producers. . The plant types were studied in three different experiments located in the same place but in three different periods. The experiments were as follows:

Experiment 1.

In this experiment the four plant types, future rootstocks and scions, were studied as self rooted plants in pots using commercial compost as the substrate. The plants were fed with nutrients using a common soluble fertilizer containing the main nutrients that a plant needs. The NaCl was added at 12.5, 25, 50, 100, 150 and 200mM.

Experiment 2.

In this experiment the four plant types were planted as self rooted plants, in pots with perlite simulating a hydroponic system. All the nutrients and NaCl were added in a solution that irrigated the pots in regular time at the duration of the experiment. The NaCl treatment was the same as in experiment 1.

Experiment 3.

In this experiment the four plant types were planted as grafted plants in pots with perlite and the solution was the same as in experiment 2. The NaCl treatments were the same as experiment 1.

3.1.1 Experiment of self rooted scions and rootstocks in soil.

In this experiment the eggplant hybrids Habana and Vernina as self rooted and the rootstocks tomato and torvum plants were used. The plants were obtained from a commercial nursery in Ierapetra, in the developmental stage of two fully developed leaves. They were transplanted into plastic flowerpots (5L), using commercial compost as a substrate.

Every second day the plants received 150 ml water, containing a certain amount of fertilizer [(full-soluble fertilizer which includes N (nitrogen), P (phosphorous) and K (potassium) micronutrients, and salt (it was used a common salt used also in cooking), in amounts depending on the concentration.

Salt was added into the irrigation water at the following concentrations: 12.5, 25, 50, 100, 150, 200 mM NaCl. Along with the salt, for the nutrition of plants, a water soluble fertilizer was used. The fertilizer contained the following macronutrients (mM): NO_3 , 14 ; H_2PO_4, 1.5; SO_2 4,1; $Ca2^+$, 4; K^+, 7.5; $Mg2^+$, 1. The micronutrient concentrations were (mg/L): Fe, 1.0; Mn, 0.5; B, 0.25; Cu 0.02; Mo, 0.01. The pH was adjusted to 5, 6.

The concentrations of salt in the irrigation water were increased progressively during the first week in order to avoid the creation of a strong osmotic shock from the salt. Thus the first day the plants were irrigated with water and fertilizer and in the following days 25 mM increments were added (apart from the 12, 5 mM, treatment) until the desired concentration were reached.

After the 5^{th} week and until the end of the experiment the irrigation was increased to 200 ml because of the bigger needs of the plants. It was used 12 plants per species at each concentration totally randomized. The experiment was conducted in a heated greenhouse of the farm of Technological Education Institute of Crete. It began in December 2009 and lasted three months.

3.1.2 Experiment of self rooted scions and rootstocks in perlite.

The second experiment took place at the same greenhouse. The plants were self rooted in flowerpots of 5L, filled with perlite. They were obtained in the stage of two fully developed leaves. Then the roots were washed from soil and planted in the pots with perlite. The pots were irrigated from an automatic irrigation system using barrels of 150L and pumps. The nutrient solution in each barrel consisted by two stock concentrated solutions (700 ml from each concentrated stock solution for 160 L of nutrient solution), salt (the amount was different for each concentration) and water.

The pH was adjusted at 5.9-60 using Nitric acid. The salt was added at the following concentrations: 12.5, 25, 50, 100, 150, and 200 mM NaCl.

Nutrient solution used for open hydroponic systems for vegetable cultivations in greenhouses as shown in Table 3.1. In this experiment it was used 10 plants from each species at each concentration randomly planted. The concentrations of salt in the irrigation water were increased progressively during the first week as in the Experiment 1.

Table 3.1. Nutrient solution used for irrigation.

Stock solution A	Amount for 30L concentrated solution (1:100).
Calcium nitrate.	1,865 Kg.
Potassium nitrate.	1,175 Kg.
Ammonium nitrate.	0,042 Kg.
Fe-chelate.	0,042 Kg.
Stock solution B	Amount for 30L concentrated solution (1:100).
Potassium nitrate.	1,175 Kg.
Magnesium sulphate.	0,845 Kg.
Magnesium nitrate.	0,421 Kg.
Phosphoric acid.	0,307 L.
Manganese sulphate.	5, 07 grams.
Zinc sulphate.	3, 34 grams.
Copper sulphate.	0, 55 grams.
Boric acid.	4, 64 grams.
Ammonium heptamolybdate.	0, 26 grams.

3.1.3 Experiment with grafted eggplants in perlite.

In this experiment the method was the same as for experiment 2.with the only difference that the plants were grafted as in shown in the Tablet 3.2.

Tablet 3.2. Scions and roots stocks of the third experiment.

Scions.	Root stocks.
Solanum melongena L hybrid Habana	*Solanum torvum*
Solanum melongena L hybrid Vernina	
Solanum melongena L hybrid Habana	*Solanum lycopersicum L* hybrid Resistar
Solanum melongena L hybrid Vernina	

3.2 Measured parameters

After the start of each experiment, measurements were taken every second week. The measurements concerned the height of the plants in cm and the number of fully developed leaves. At the end of each experiment it was kept a specific amount of fresh leaves in deep freezer for the antioxidant enzyme analysis but unfortunately it was saved tissue only from the last experiment. Also the fresh weight of leaves, stem and fruits of each plant was measured and then the dry weight of them.

Chlorophyl measurements.

The chlorophyll content was measured using the Konica Minolta Sensing, Inc, Chlorophyll Meter SPAD-502Plus, the chlorophyll fluorescence using the OPTI-SCIENCE, OS-30p and photosynthesis, stomatal conductance, transpiration , intracellular CO^2 (using the LI-COR, Li-6400, Plate 3.1).

Plate 3.1. The LI-6400XT_md measures the rate of photosynthesis in the leaves of plants.

The measurements of the chlorophyll content, chlorophyll fluorescence and photosynthesis were taken from the last real leaves of each plant.

At the end of the experiment, the plants were separated into leaves, shoots, fruits and flowers, their fresh weight was measured, were dried in ovens at 80^0Cand reweighed in order to measure the dry weight. Also 3 grams of plant tissue from one leaf were kept in a refrigerator at – 70 ^{0}C in order to be used for further enzyme and protein analyses in the laboratory.

Tablet 3.3. Measurements for each experiment.

	Num. Leaves.	Height.	K and Na	Fresh and dry weight.	Photo. Rate	Chloro. Cont.	Chloro. Fluore.	Enzyme. Act.
Exp.1	✓	✓	✓	✓	✓	✓	✓	✓
Exp.2	✓	✓	✓	✓	✓	✓	✓	x
Exp.3	✓	✓	✓	✓	✓	✓	✓	x

Enzyme Measurements.

For the activity of ascorbate peroxidase (APX), glutathione peroxidase (GPX), peroxidase (POD) was determined in fresh leaf (0.2 g) which was homogenized with a mortar and pestle in 1.6 ml of ice-cold 50 mM NaH_2PO_4 extraction buffer pH=6.5, containing 1% (w/v) Polyvinilpolypyrrolydon PVPP and 1M NaCl. The homogenate was centrifuged at 20000 rpm for 20 min and the supernatant was used for the enzyme assays. All steps were carried out at 0-4^{o}C with the use of liquid nitrogen.

The reaction mixture for each enzyme was:

a) For the APX 50μl of the enzyme extract in 0.5 mM ascorbate and 0.1 mM H_2O_2 in 50 mM phosphate buffer (KH_2PO_4) (pH 7). The activity was determined by following the rate of the decrease of absorbance at 290 nm using UV spectrophotometer every 20 sec from 0 to 280 (Pinhero et al. 1997).

b) For the GPX, 100μl of the enzyme extract in 0.024 mM guaicol and 327 mM H_2O_2 in 50 mM phosphate buffer (KH_2PO_4) (pH 6). The activity was determined by following the rate of the increase of absorbance at 470 nm. Every 20 sec from 0 to 140 . (Pinhero et al. 1997)

c) For the POD, 10μl of the enzyme extract in 0.5% (w/v) pyrogallol and 0.027% (w/w) H_2O_2 in 14 mM phosphate buffer (KH_2PO_4) (pH 6). The activity was determined by following the increase of absorbance at 420 nm every 20 sec from 0 to 180 (Chance et al. 1995).

Ion Measurements.

For the K and Na determinations it was used the method of flame photometer. Three sample of dryed leaves from each concentration was separeted and crushed by hand to make them into small crumbs in a plastic container, this operation is to the homogenization of the sample. Then the leaves are crushed by means of an electric grinder so as to obtain a very fine grind. After grinding of each sample, the vegetable stock powder was put in a pill box and from this powder it was weighted 1 gram. The powder was put in a conical flask (**Erlenmeyer flask)** and dried once more in an oven to avoid any moisture.

Then the samples were heated in high temperature with 20 ml of a specific mix of acids. The ratio of the acids was: 1 H_2O_4S (Sulfuric acid) : 2 $HCLO_4$

(Perchloric acid): 5 HNO_3 (Nitric acid) (Tsikalas 2003). This procedure it is call wet oxidation and we use it to destroy the organic matter. At the end of this procedure a 3-5ml of the mixture is left in the flask. Distilled water is added to 100 ml. this solution is called stock. The determination of potassium and sodium in the flame photometer it is done by using stock solutions and samples corresponding to a known concentration. For the determination we need sometimes to make a dilution of 10 times by placing 5 ml of stock solution in vials of 50 ml numbered and add distilled water to the mark.

Sample of K calculation in 1gramm of dry plant tissue:

- Dry weight plant tissue: 1.2154 gramms
- Stock solution- 100ml
- Stock dilution 1:5
- Standards used : 0,10,25,50,75,100ppm
- Standards indication: 1,18,38,64,84,100
- Stock indication: 57

The standar concentrations (X axel) and indication (Y axel) creat a calibration graph form wich we can find the concetration of our sample. Hypothecally it is 38.

So:

38x5(times of dilution)=190ppm

The 1000000 mg (1000 ml) contain 190mg of K

The 100000 mg (100ml stock solution) contain X of K

X=19 mg.

The 1.2154 grams (1215.4 mg stock) of plant tissue contain 19 mg of K

The 100 mg of dry plant tissue contain X mg of K

X= 1.563.

So the % concetration of plant tissue is 1.563%

The same method it is used for the Na determination.

3.3 Statistical Analysis.

For the statistical analysis of the results it was used the SPSS STATISTICS program and more specific the ANOVA one way type of analysis. It is a completely randomized experiment using one factor each time. Finding the significant differences of the results the Duncan's test was used from the same program. It is a multiple range test using multiple comparison methods.

4. RESULTS

4.1. Cultivation in soil.

4.1.1. Plant height.

The plant height of the hybrid Habana was affected by salinity. The plant height at 150 and 200mM concentrations of NaCl was progressively decreased (figure 4.1.) showing a reduction of growth. The effect on the height of the plants started after the fifth week of the experiment. The plants of the self rooted hybrid Vernina were significantly affected by salinity.

The average height of the plants (Fig 4.1) was affected. The highest concentration of 200 mM caused higher reduction of growth compared to the other concentrations from the fifth week. At the ninth week three of the eleven plants at the concentration of the 150mM NaCl were dead.

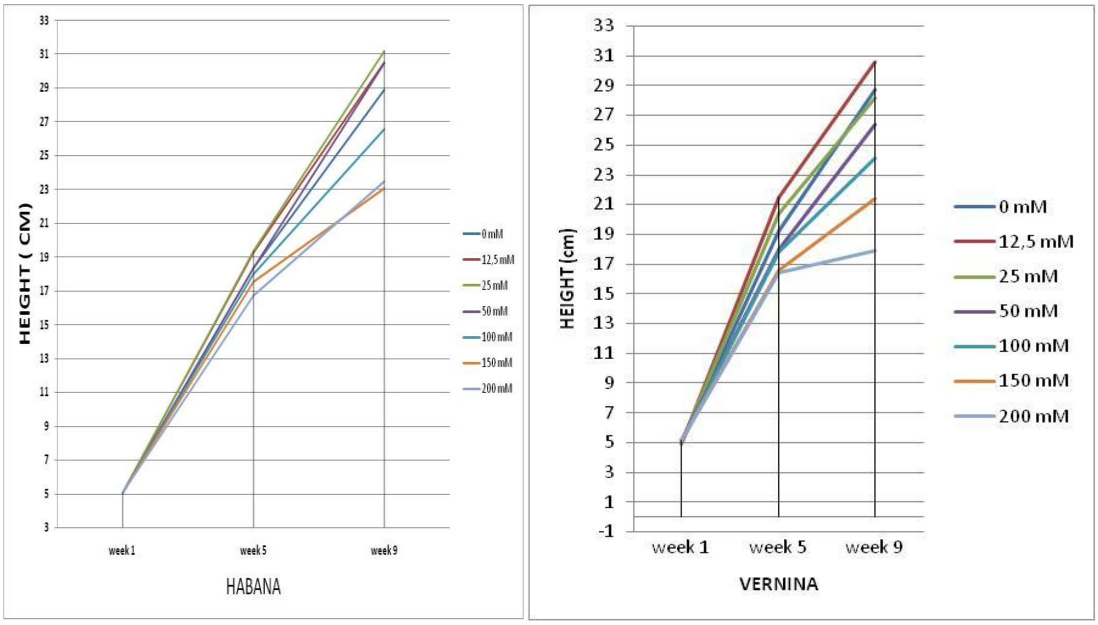


Fig 4.1. Mean effect of the irrigation water salinity on the average height (cm) of self rooted Habana and Vernina plants after culture in soil for nine weeks at different concentrations of NaCl.

The height of *Solanum torvum* plants was not affected except from the 150mM concentration that stayed stable for the last week. Tomato in this experiment was cultured in soil without been grafted, for nine weeks irrigated with water containing

NaCl at different concentrations. Figure 4.2 Shows plant heights over the experimental period. The height was not affected at the lower concentrations. In the higher concentrations (100, 150 and 200mM) the height of the plants was negatively affected, showing a significantly smaller growth than the other concentrations.

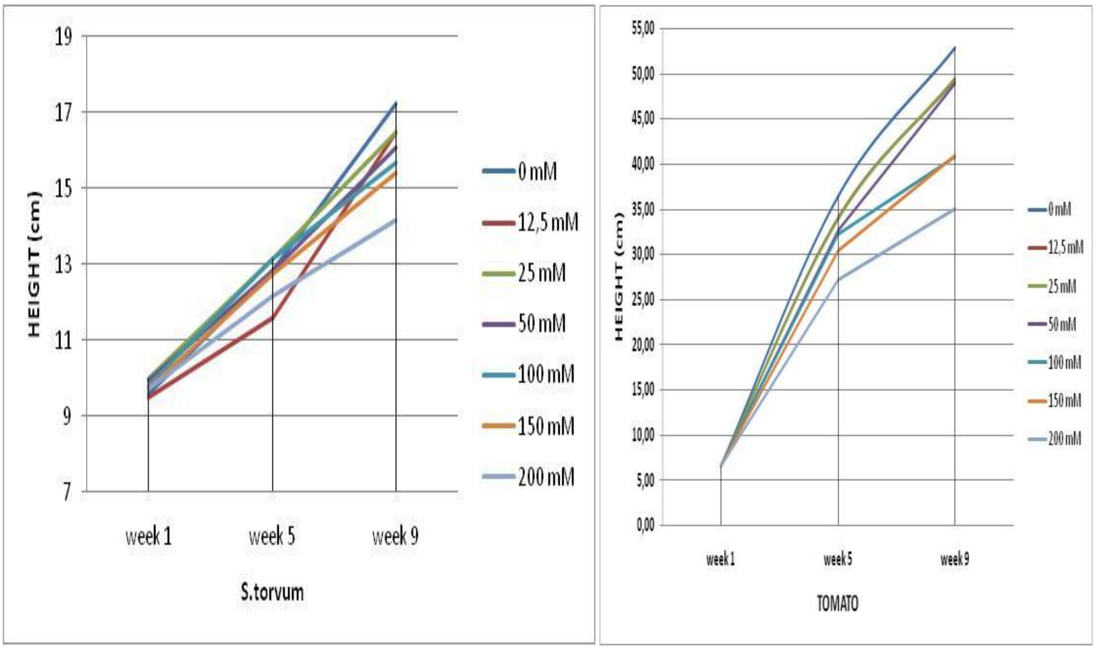


Fig 4.2. Effect of the irrigation water salinity on the average height (cm) of *Solanum torvum* and Tomato plants cultured in soil for nine weeks at different concentrations of NaCl.

At figure 4.3. The differences were at the two last higher concentrations of S. *torvum* plants. The Habana plants did not have any statistical differences at all concentrations.

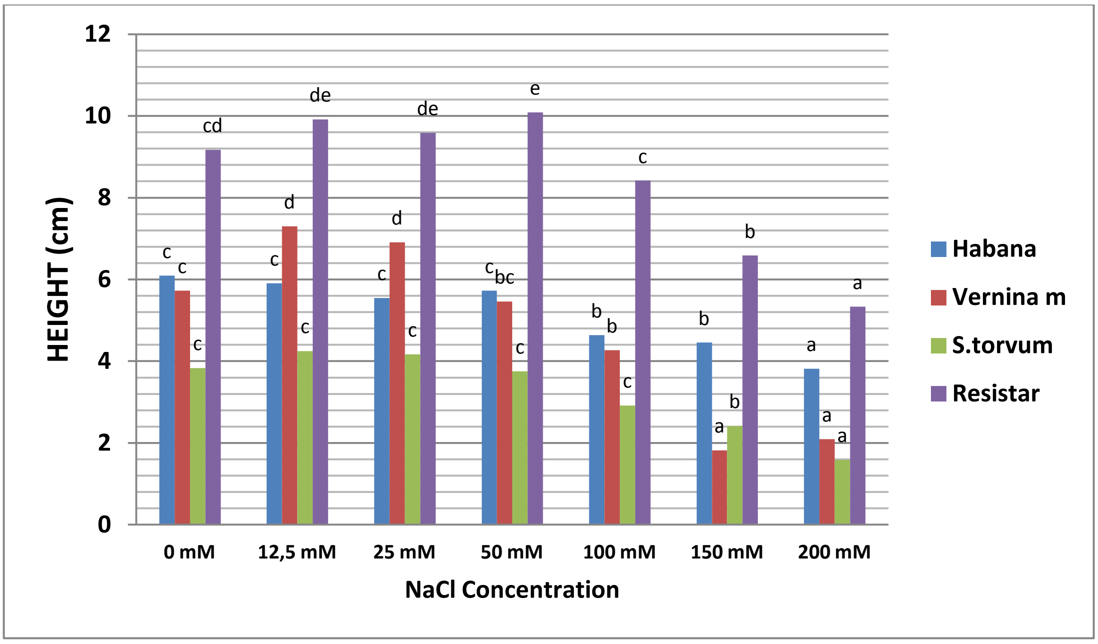


Figure 4.3. Comparison of different NaCl concentrations in the irrigation water on the height of self rooted eggplant (*Solanum melongena*) hybrids Habana,and Vernina and two commonly used rootstocks *Solanum lycopersicon*, hybrid Resistar and *Solanum torvum*, cultured in soil for nine weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.1.2 Effect of Nacl treatments on at number of leaves.

The number of fully developed leaves per plant of the hybrid Habana was affected by irrigation salinity from the fifth week (200mM NaCl) or seventh week (150 and 100 mM NaCl concentrations). Compared to control plants lower number of leaves per plant was measured at the concentrations of 100, 150 and 200mM. Figure 4.4 below shows a major loss of the leaves of Vernina plants after the 5th week. The concentrations of 100, 150 and 200mM had the higher leave loss compared to other NaCl treatments.

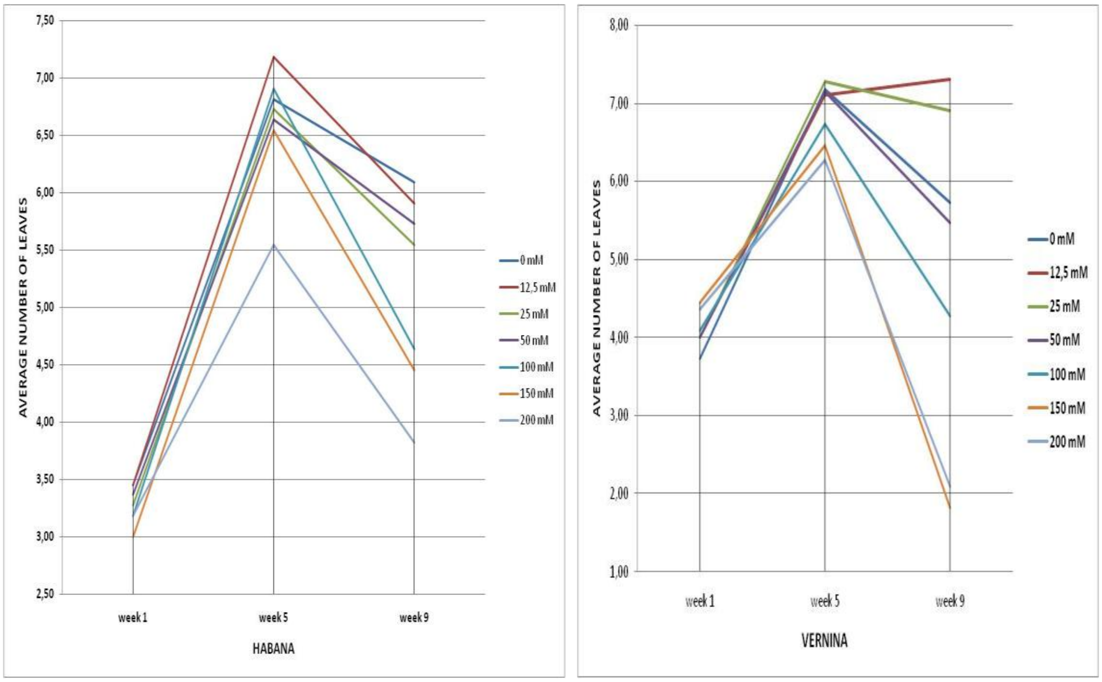


Fig.4.4 Effect of salinity on the average number of fully developed leaves of Habana and Vernina eggplants during culture in soil for nine weeks, irrigated with NaCl at different concentrations.

Fig 4.5 below shows the effect of salinity on leaf number of *Solanum torvum*. The leaves started falling off after the 6th week. The higher loss of leaves was at the concentrations of 100, 150 and 200mM NaCl. In Figure 4.5, plants irrigated with the two higher concentrations of NaCl (150 and 200mM) had the lowest number of the leaves per plant, mainly due to early leaf drop, but also because of delayed growth.

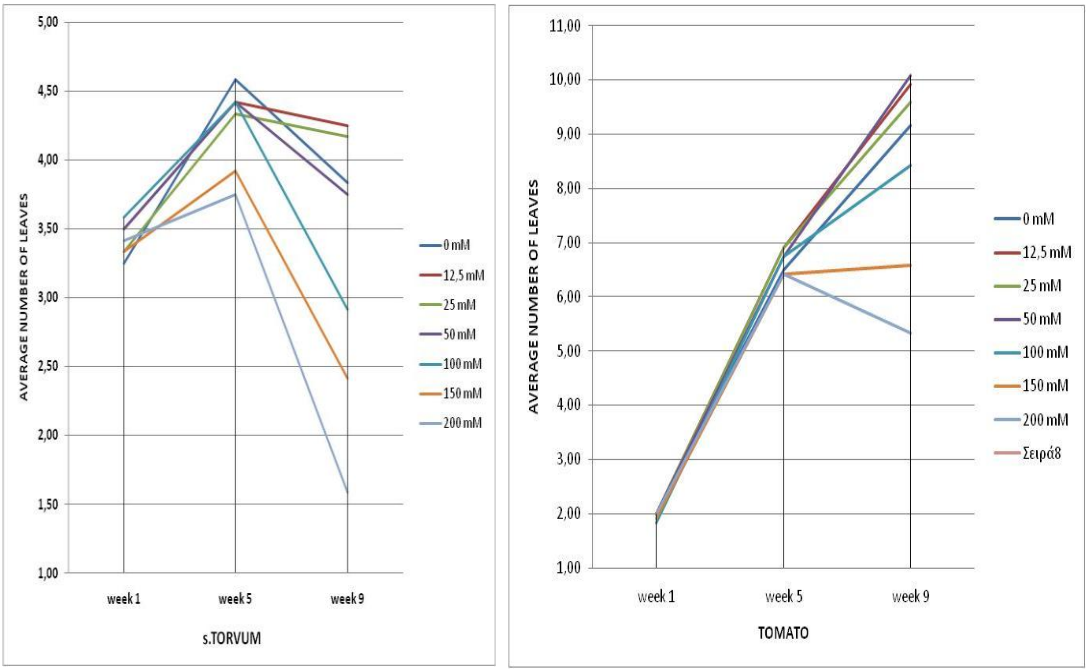


Fig 4.5 Effect of salinity on the average number of fully developed leaves of *Solanum torvum* eggplants cultured in soil for nine weeks, irrigated with NaCl at different concentrations.

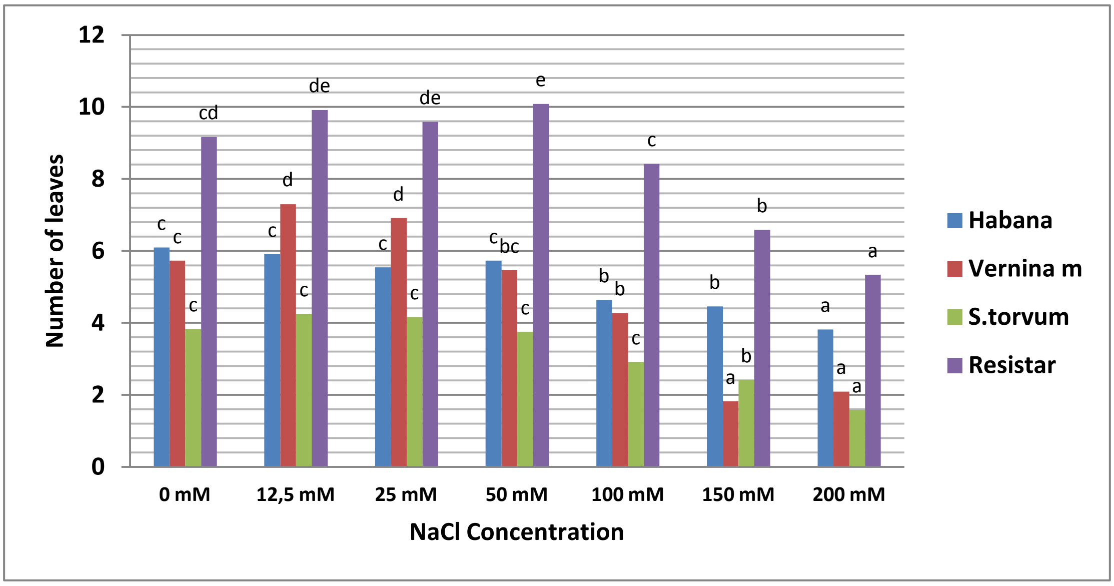


Figure 4.6 Comparison of different NaCl concentrations on the number of leaves of eggplants hybrids (Habana , Vernina) and two (not grafted) rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.1.3. Effect of NaCl treatments on Chlorophyll content.

The chlorophyll content of the first fully developed leaves of Habana eggplants was reduced dramatically at the higher concentrations of NaCl (Fig 4.7) after the fifth week of the experiment. A reduction after nine week was also evident at the control. Figure 4.7 shows the effect of salinity on the chlorophyll content of the Vernina leaves. The chlorophyll content was affected at all concentrations after the third week of the start of NaCl irrigation. There was a very marked difference in chlorophyll content between the control leaves and the leaves of all plants of NaCl treatments in this experiment.

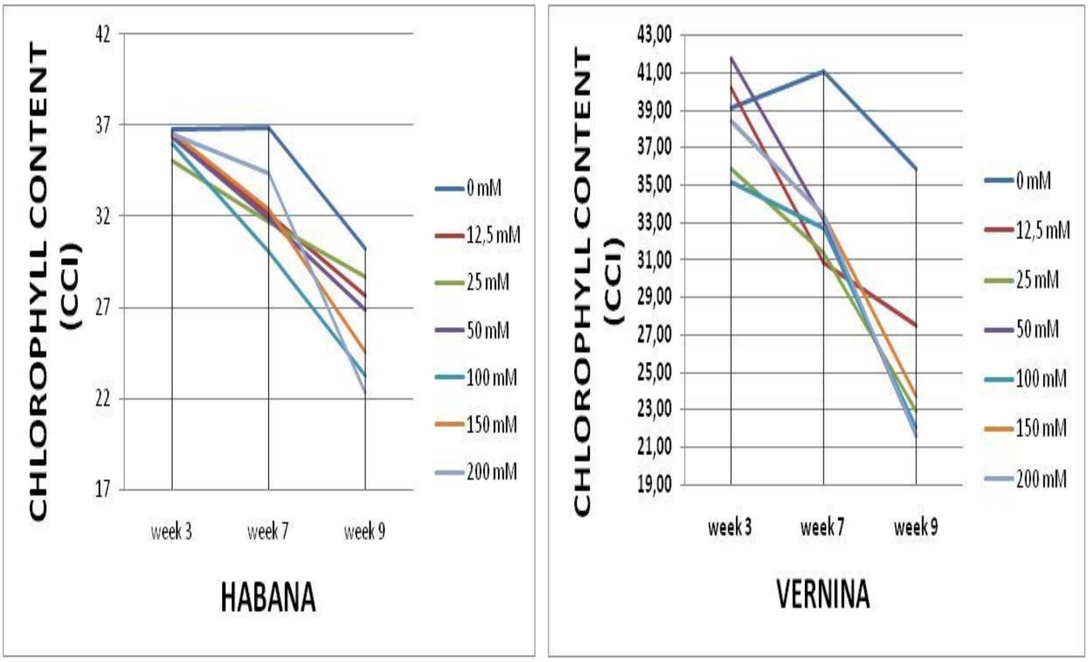


Fig 4.7 Effect of salinity on the average chlorophyll content of leaves Habana and Vernina eggplants cultured in soil for nine weeks irrigated with NaCl at different concentrations.

The chlorophyll content of the first fully developed leaves of *Solanum torvum* eggplants, (Fig 4.8) was affected in all concentrations compared to control leaves. After the fifth week the chlorophyll content was reduced even more, especially at the higher concentrations (150 and 200mM). The effect of salinity on the chlorophyll content of leaves of tomato plants is shown in Fig 4.8. Chlorophyll content was affected in all concentrations even at 12.5 NaCl. The concentrations of 150 and 200mM showed a marked decline after the fifth week.

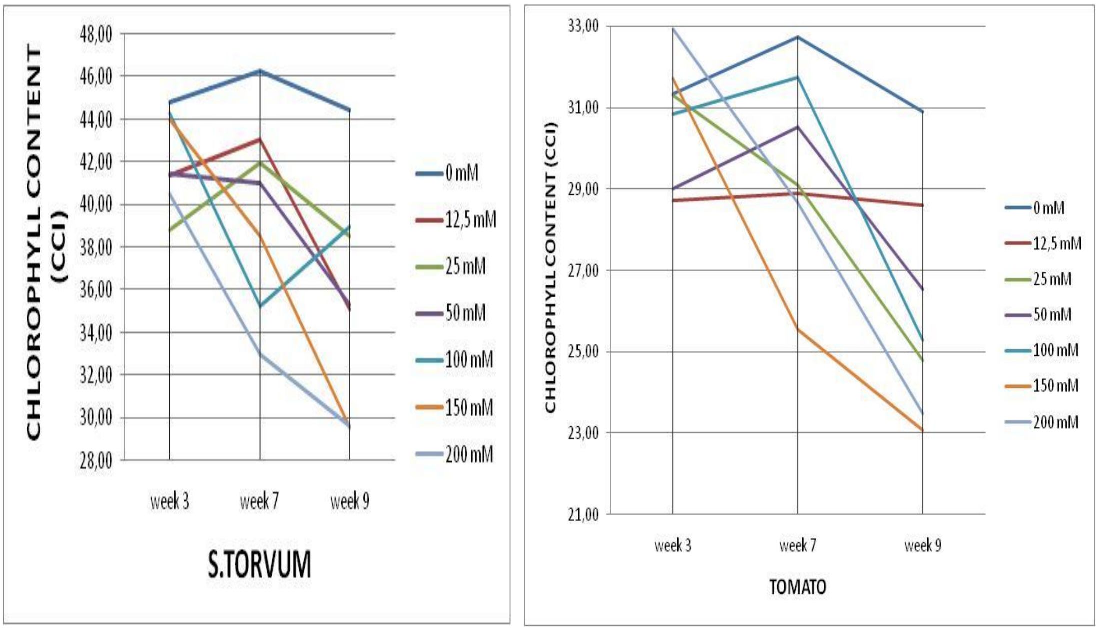


Fig 4.8 Effect of salinity in the average chlorophyll content of *Solanum torvum* and tomato leaves cultured in soil for nine weeks with NaCl irrigated with NaCl at different concentrations.

The statistical analysis of the last measurements shows that the higher concentrations had no big differences for each plant type, compared to the lowest.

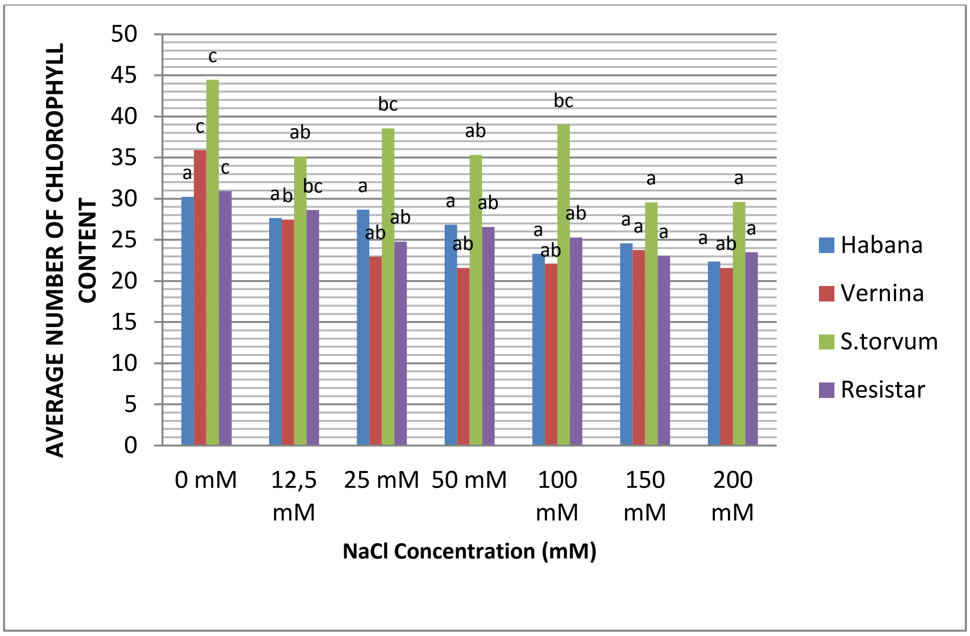


Figure 4.9 Comparison of different NaCl concentrations on the chlorophyl content of the youngest fully developed leave of eggplant hybrids (Habana and Vernina) and two comon rootstocks cultured self rooted and non grafted (Tomato hybrid Resistar and *Solanum torvum*) after cultured in soil for 9 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.1.4. Effect of NaCl concentrations on the chlorophyll fluorescence.

On average, the chlorophyll fluorescence in the youngest fully developed leaves of Habana eggplants was reduced in all treatments, even the control plants (0mM NaCl), as shown in Fig 4.10. The highest reduction was observed at the concentrations of 12.5 and 100mM NaCl after nine week. The chlorophyll fluorescence of the youngest fully developed leaves of Vernina eggplants (Fig 4.10) was affected mainly by time as it was reduced in all salinity treatments after the third week. At the ninth week the reduction of chlorophyll fluorescence treatment, was higher in 12.5 and 200mM NaCl and control.

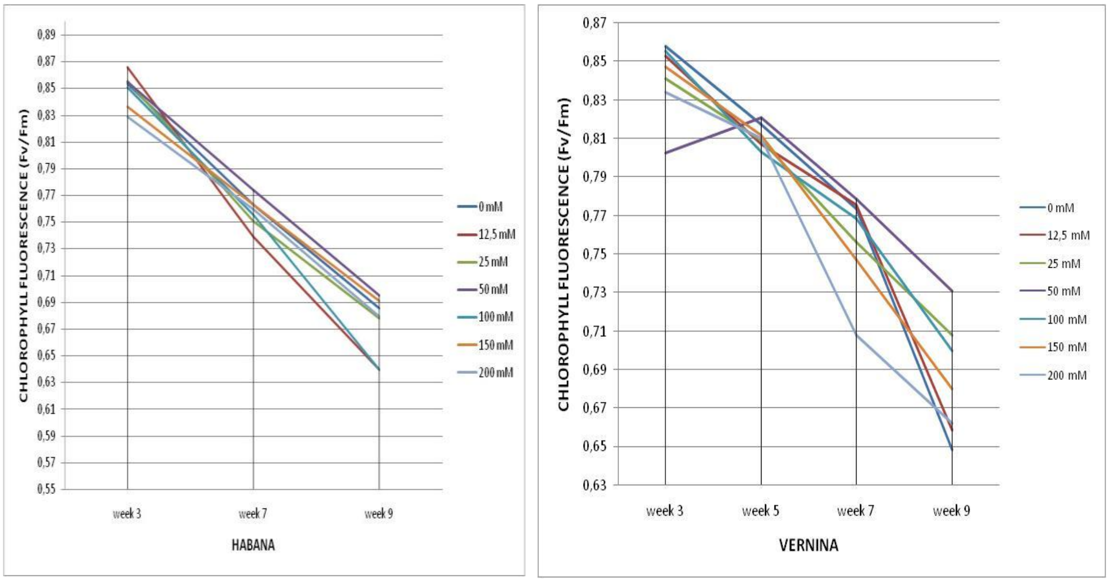


Fig 4.10 Effect of salinity on the average chlorophyll fluorescence in leaves of Habana and Vernina eggplants cultured in soil for nine weeks with NaCl irrigated with NaCl at different concentrations.

Chlorophyll fluorescence in the leaves of the *Solanum torvum* eggplants declined with time, but negative salinity effects were clear after the 7th week and are more pronounced at the higher NaCl treatments. The effect of the salinity on the chlorophyll fluorescence in leaves of Resistar tomato plants (Figure 4.11) was similar in all treatments up to the seventh week but at nine week there were some differences among the treatments.

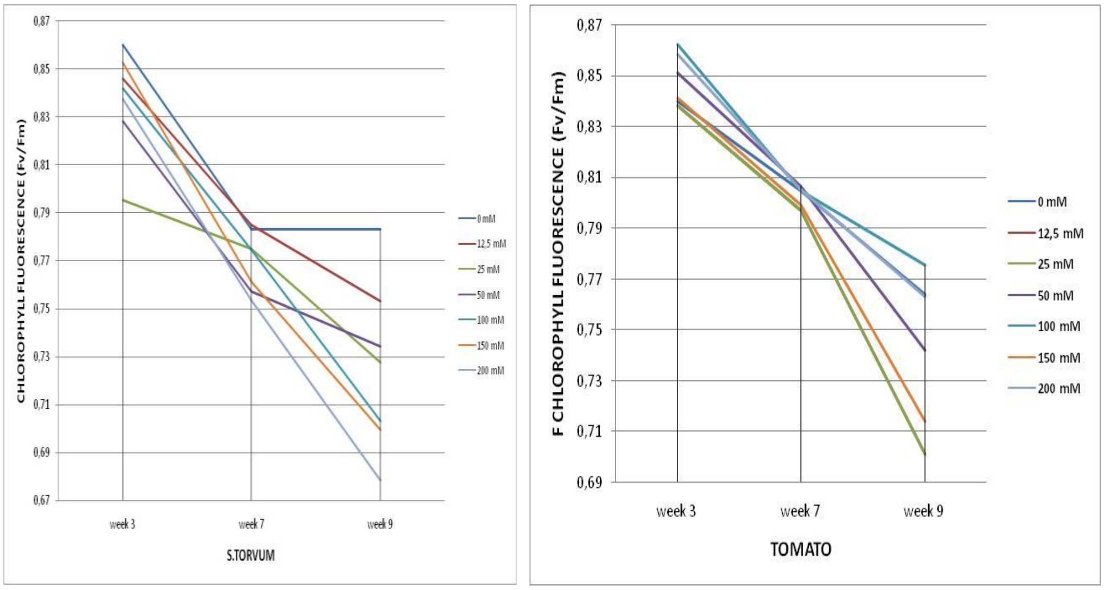


Fig 4.11 Effect of salinity on the average chlorophyll fluorescence in leaves of *Solanum torvum* and tomato eggplants cultured in soil for nine weeks irrigated with NaCl at different concentrations.

Fig.4.12 compares statistically the effect if NaCl treatments at chlorophyll fluorescence. Overall, there are no significant differences except the *S.torvum* results for control and higher concentrations.

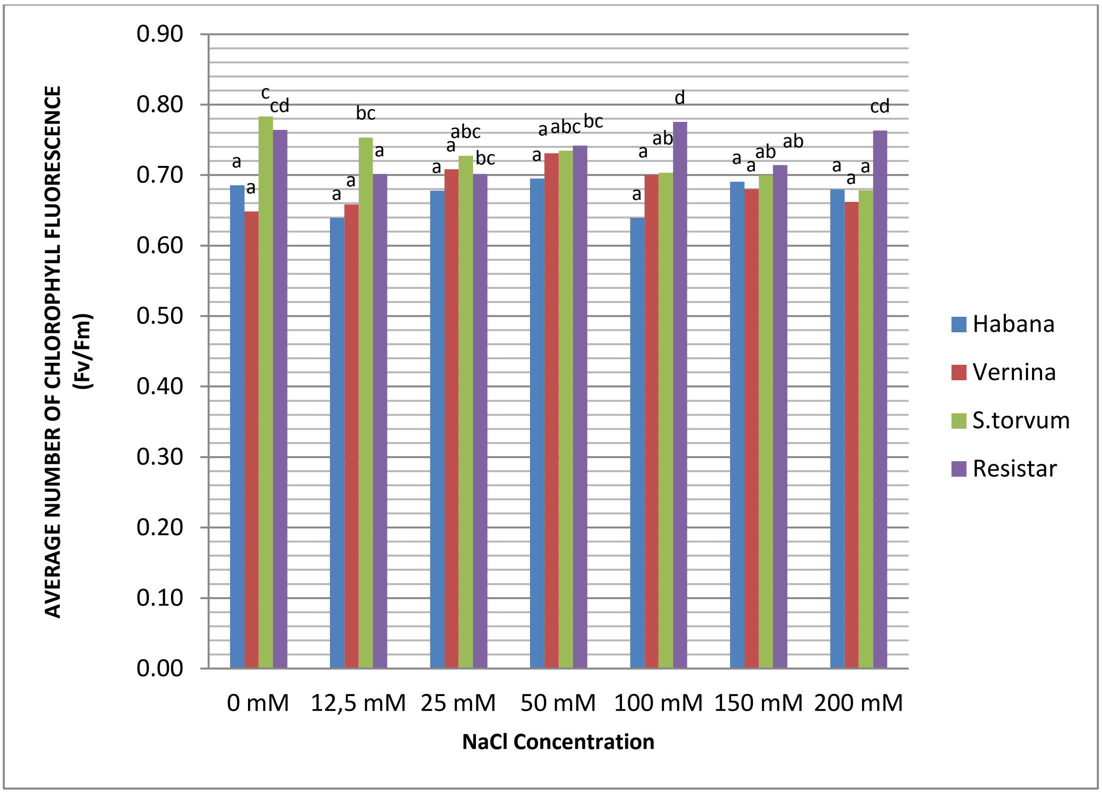
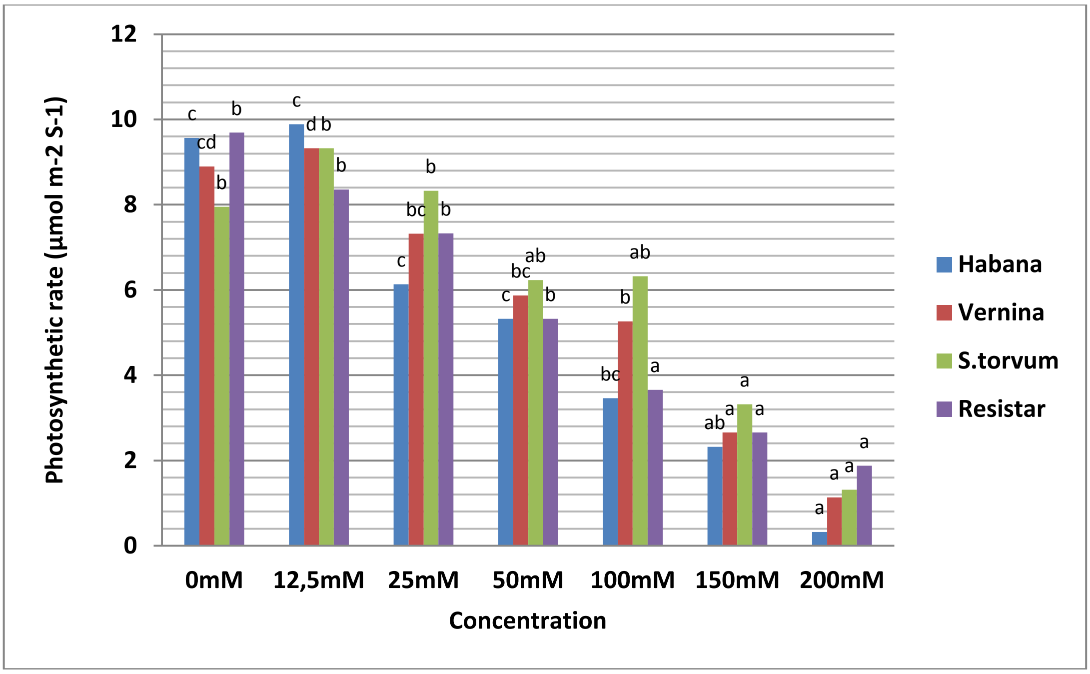


Figure 4.12 Comparison of different NaCl concentrations on the chlorophyl fluorescence in leaves of eggplant hybrids (Habana , Vernina) and two (non grafted) rootstocks (Tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.1.5. Effect of NaCl treatments on Photosynthetic rate.

Fig.4.13 compares the effect on photosynthetic rate for the cultivated plants at week nine. It affected all types of plants and there was a reduction in higher concentrations. The statistic differences were not



4.13 . Comparison of different NaCl concentrations on the photosynthetic rate in leaves of eggplant hybrids (Habana , Vernina) and two (non grafted) rootstocks (Tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks. **Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.1.6 Fresh and dry weight.

In the following figures the fresh and dry weight of different parts of the plants is presented. In figure 4.14 the fresh weight of the leaves was significantly increased when Vernina, Habana and tomato Resistar plants were irrigated with NaCl at low concentrations (12,5 and 25 mM) while at concentrations 100 to 200 mM it was significantly redused, compared to control plants. In the case of S.torvum the fresh weight of leaves was significantly reduced in all treatments, more severily in the higher concentrations of 100 to 200 NaCl. . The difference in the the two rootstocks was large due to the different plant type.

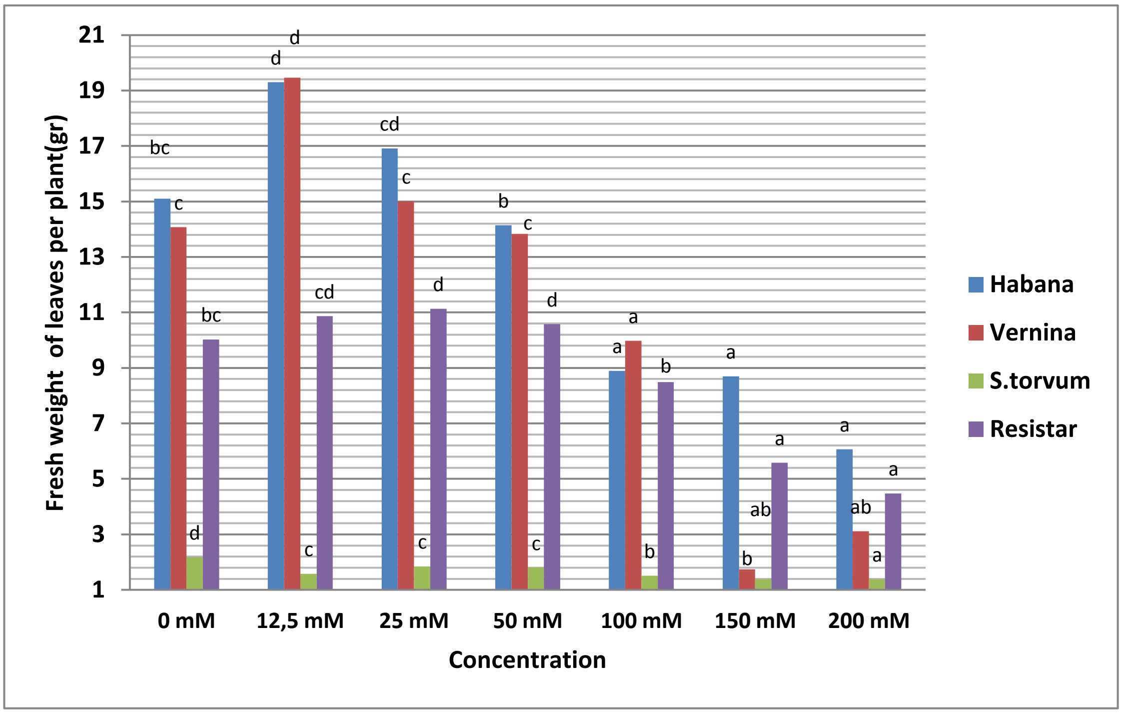


Figure 4.14 Effect of NaCl irrigated on the fresh weight of leaves of eggplant hybrids (Habana , Vernina) and (non grafted) rootstocks (Tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.15 shows the dry weight of the leaves. The Habana plants had more dry weight than the Vernina plants in all treatments. The two rootstocks have much lower dry weight. The dry weight was affected in all treatments in the same way as the fresh weight.

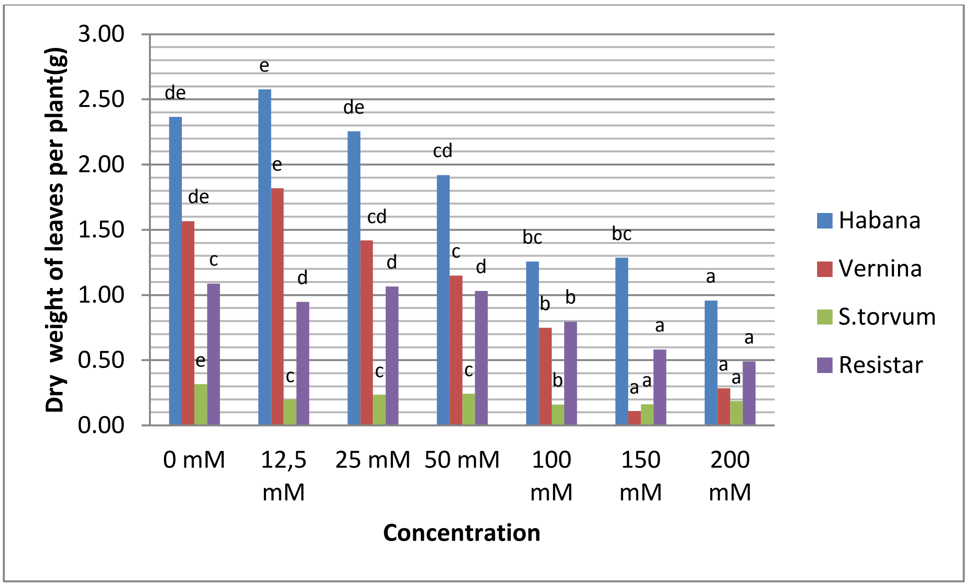


Figure 4.15 Effect of irrigated NaCl on the dry weight of leaves of eggplant hybrids (Habana , Vernina) and two (non grafted) rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.16 shows the differences in the fresh weight of fruits of the two hybrids. There is a big decrease in fruit fresh weight at the treatments of 50 mM NaCl and higher in both egplant hybrids.. The rootstock *S.torvum* did not produce any fruits during the experiment period.

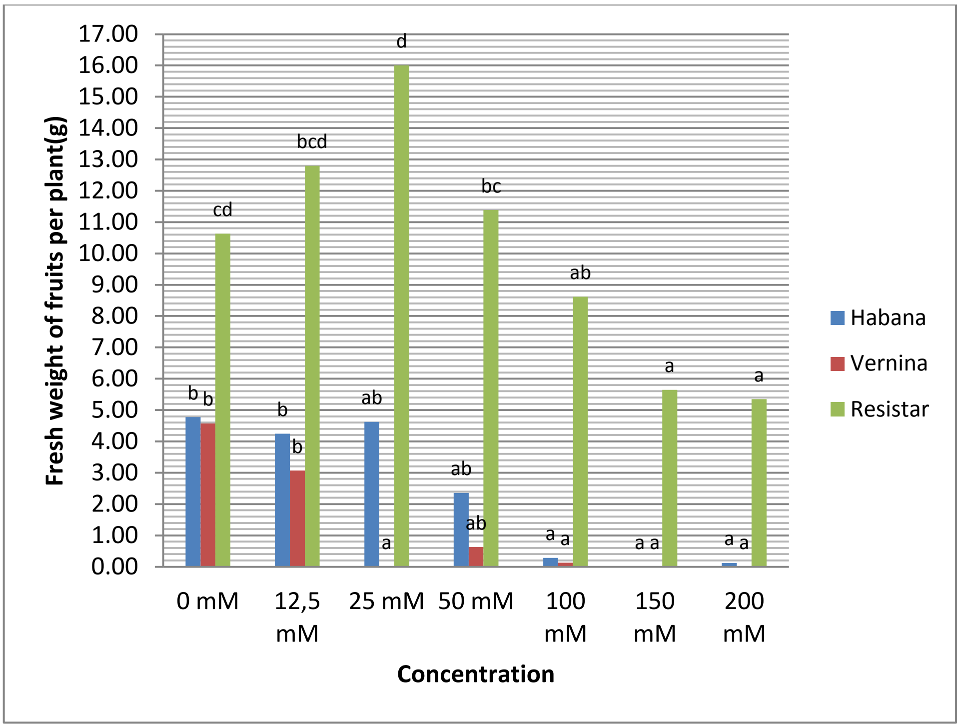


Figure 4.16 Effect of NaCl on the fresh weight of fruits of eggplant hybrids (Habana , Vernina) and two (non grafted) rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At figure 4.17 the dry weight of fruits of the rootstock Resistar was not significantly affected by salinity, while rootstock *S. torvum* did not produce any fruits. The fruit dry weight of Vernina was generally lower than that of Habana.

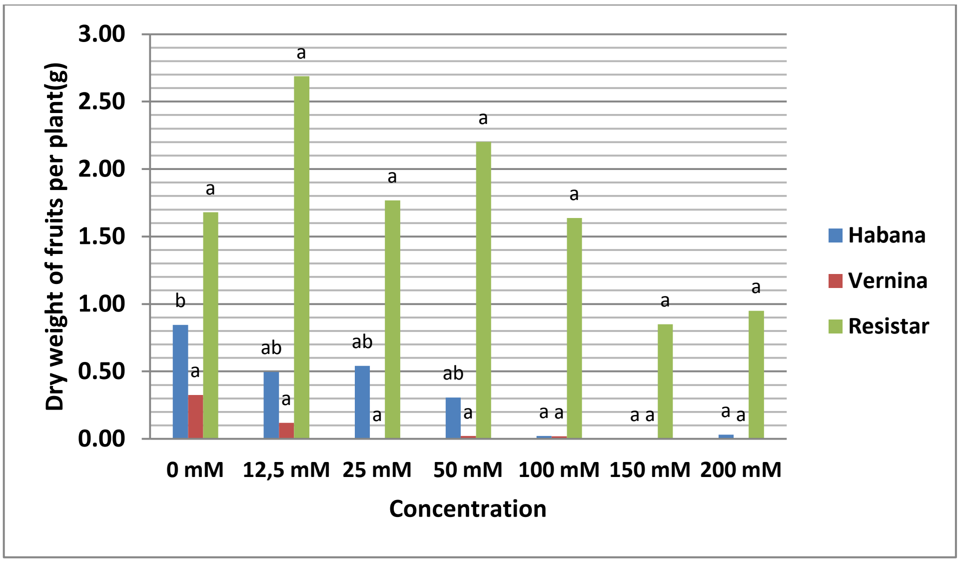


Figure 4.17 Effect of irrigated NaCl on the dry weight of fruits of eggplant hybrids (Habana , Vernina) and two(non grafted) rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At figure 4.18 compares the stem's fresh weight of Habana and Vernina and seems to be affected by NaCl in a similar way. Up to 50 mM concentration the stem fresh weight was not significantly affected, while in higher concentrations the reduction was significant but not sharp.

Stem fresh weight in tomato was not significantly affected up to 100mM NaCl, but in 150 and 200 mM the reduction was significantly further at eggplants hybrids. In *S.torvum* fresh weight was negatively affected at 12, 5 mM NaCl.

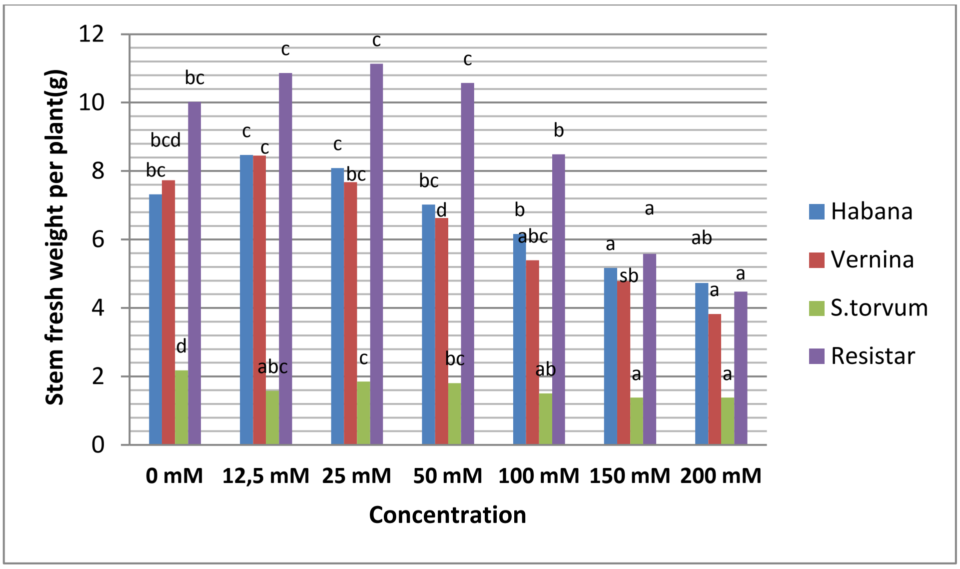


Figure 4.18 Effect of irrigated NaCl on stem fresh weight of eggplant hybrids (Habana , Vernina) and two rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.19 shows the stem dry weights. In Vernina there were no significant differences among the measured dry weight of the stems. In Habana stem dry weight was not affected in 12,5 mM, and although there were reductions in NaCl concentrations at 50 to 200 mM, there were no significant differences. Rootstock Resistar was not affected up to 50 mM NaCl, while S. torvum was negatively affected at 12,5 mM NaCl.

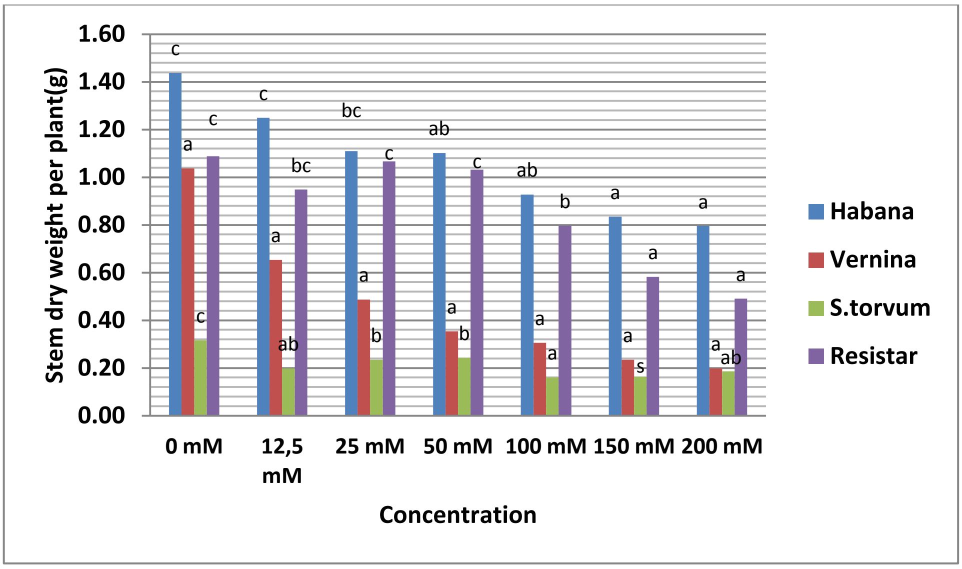


Figure 4.19 Effect of irrigated NaCl on the dry weight of stem of eggplants hybrids (Habana , Vernina) and two rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.1.7 K and Cl concentration.

Figure 4.20 shows the concentration of K / gram dry tissue at all treatments. 200mM NaCl treatment of Habana hybrid has the biggest difference among the other plants types. *S.torvum* plants also had statistical differences in the concentrations of 0 and 12.5mM.

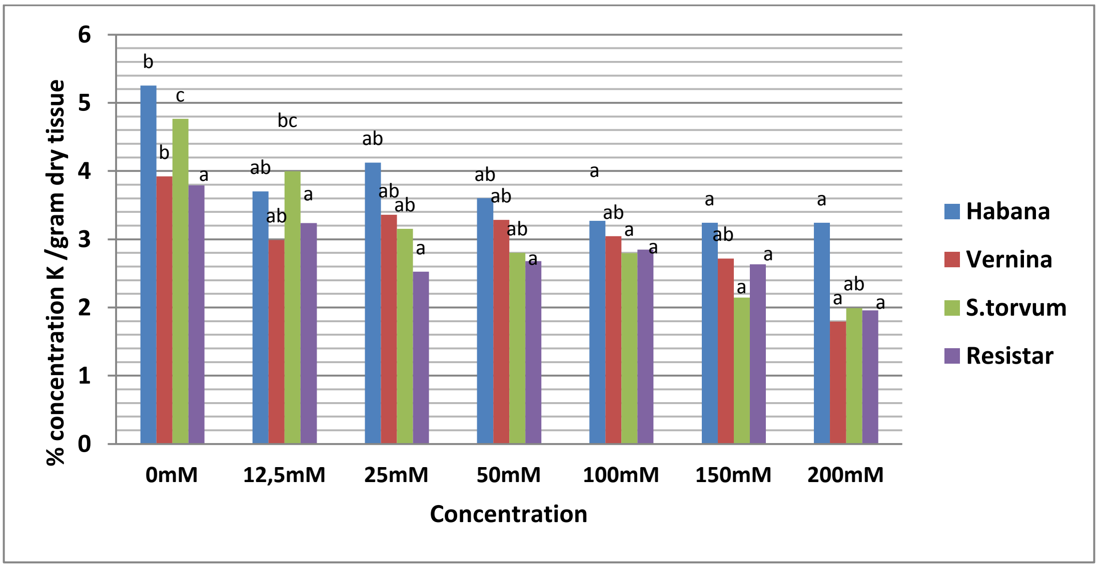


Figure 4.20 Effect of irrigatted NaCl on the K^+ concentration of tissue of eggplant hybrids (Habana , Vernina) and rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.21 is shown the concentration of Na / gram dry tissue. *S.torvum* has bigger differences in all concentrations except the 0mM.

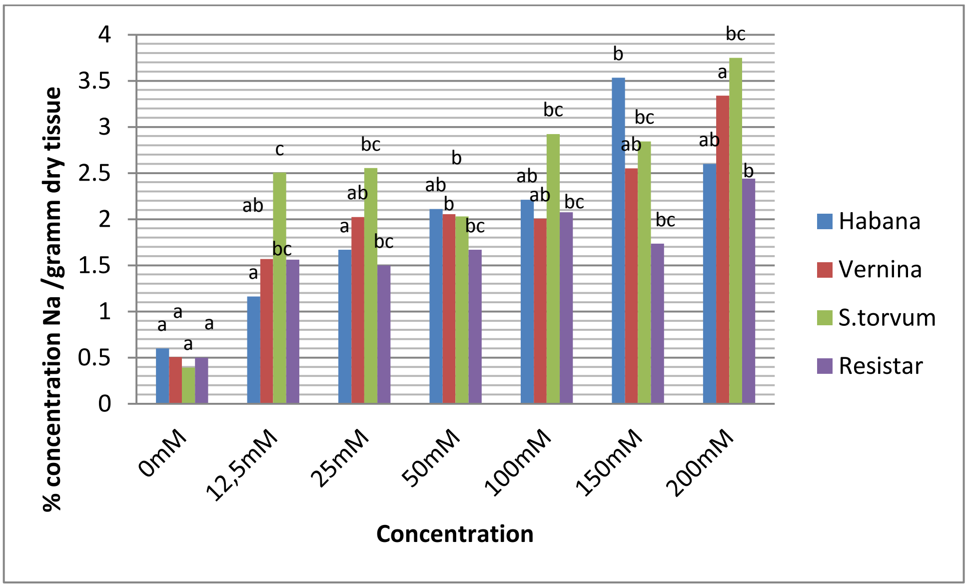


Figure 4.21 Effect of NaCl Effect of irrigatted NaCl on the Na concentration of tissue of eggplant hybrids (Habana , Vernina) and rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in soil for 9 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.2 HYDROPONIC CULTURE IN PERLITE.

The measurements were taken for eight weeks. After the seventh week the temperatures inside the greenhouse were rather high causing additional stress to the plants which resulted in losing almost all their leaves especially at the higher concentrations of NaCl. Even the control plants started losing their leaves at this period of time.

In the sections below the results for each species and hybrid are shown regarding the height (cm), the number of fully developed leaves, the chlorophyll fluorescence the chlorophyll content and the photosynthetic rate.

At the end of the experiment as in the previous one, the fresh and dry weight of each part of the plant was measured. The roots were not measured. Also it was measured the K^+ and Na^+ content of the plant tissues.

The average temperatures for the months of the experiment as shown at table 4.2:

Table 4.2

Month	DAY	NIGHT
May	24	15
June	27	19
July	29	21

The averages were calculated from the data which were taken from the data logger inside the greenhouse when the experiment took place.

4.2.1 Plant height.

The plants of the hybrid Habana were affected by the salinity. The number of leaves is clearly affected after the third week. Although there are not pronounced differences among the treatments with 12,5, 25 and 50 mM compared to control, the loss of leaves at 100, 150 and 200 mM NaCl is clearly higher than that of the control. Plant number of leaves at the control plants and at the concentrations of 12.5mM and 25mM were similar (figure 4.22). The effect of NaCl on the number of the plants started after the third week of the experiment. The average height of the Vernina plants (Fig 4.22) was slightly affected by salinity. At the concentrations of 150 and 200 mM was recorded the smaller plant height at the fifth week. At the seventh week of the experiment the height of the plants in all treatments was similar with small differences.

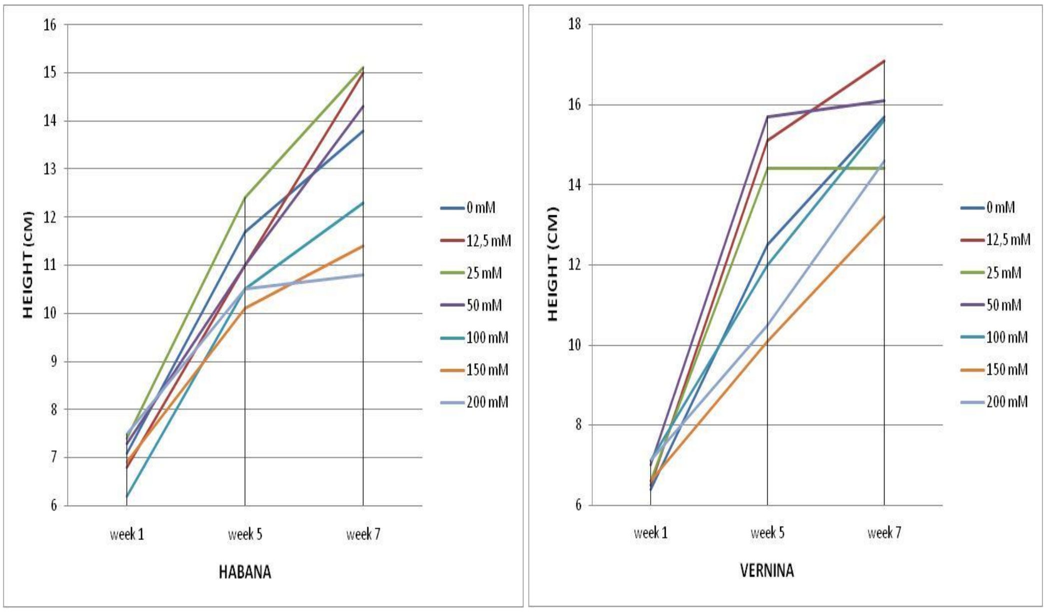


Fig 4.22 Effect on the average height (cm) of Habana and Vernina eggplants after culture in perlite for seven weeks irrigated with NaCl at different concentrations.

In this experiment *Solanum torvum* is cultured without been grafted but will be used as rootstock in future experiments. The plants show a slower growth at the concentrations of 200 and 150mM (Fig 4.23). The plants at the almost all concentrations after the fifth week had only a small raise of their height.

The tomato hybrid Resistar will be also used as a root stock in future experiments. Figure 4.23 shows plant heights over the experimental period. The height was not affected at the lower concentrations and only after the fifth week they had a reduced growth. In the concentrations of 150, and 200mM the height of the plants was affected, showing a clearly smaller growth than the other concentrations.

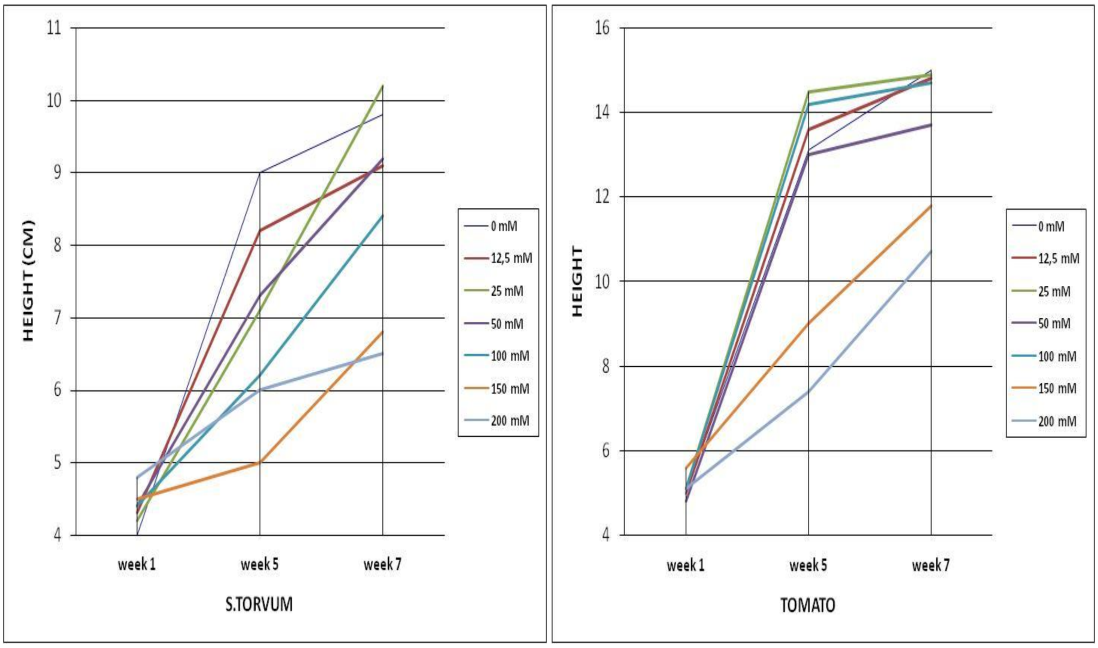


Fig 4.23 Effect of the irrigation water salinity on the average height (cm) of *Solanum torvum* and tomato after culture in perlite for seven weeks irrigated with NaCl at different concentrations.

The Habana plants have statistical differences at the higher concentrations and also the torvum plants.

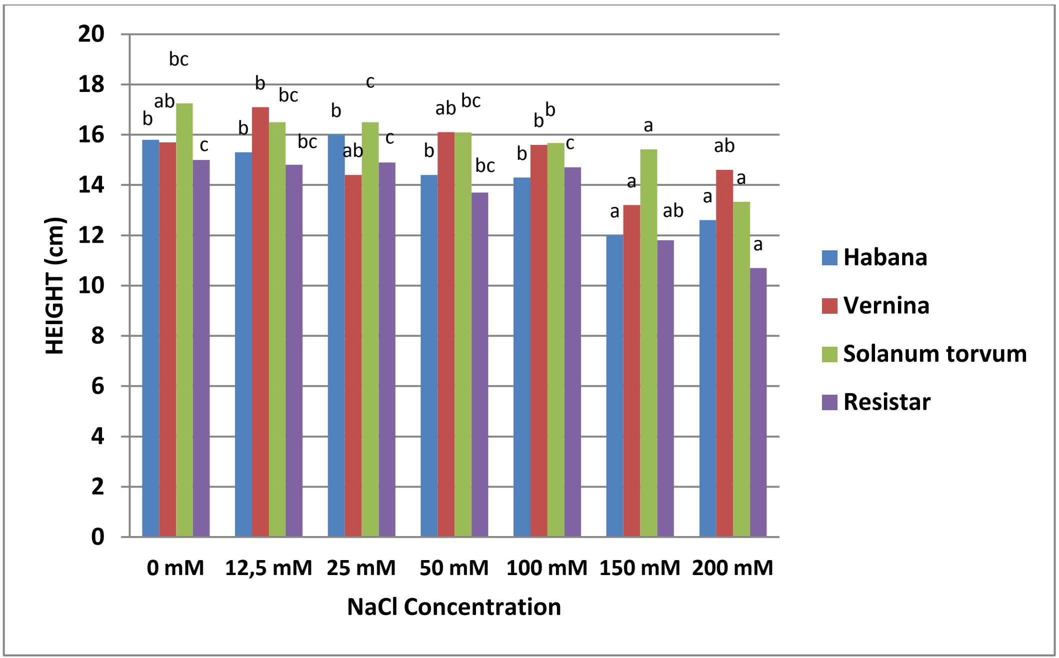


Figure 4.24 Comparison of different NaCl concentrations on the height of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.2.2. Effect of Nacl treatments in number of leaves.

The number of fully developed leaves was affected by salinity from the fifth week. The lowest numbers of leaves were measured at the high concentrations of 100, 150 and 200mM NaCl. After week five the control plants started also to losing leaves. Figure 4.25 of Vernina plants below shows a major loss of the leaves after the fifth week. Plants treated with the concentrations of 150 and 200mM NaCl lost more leaves compared to plants of other concentrations. The control plants started losing their leaves as well.

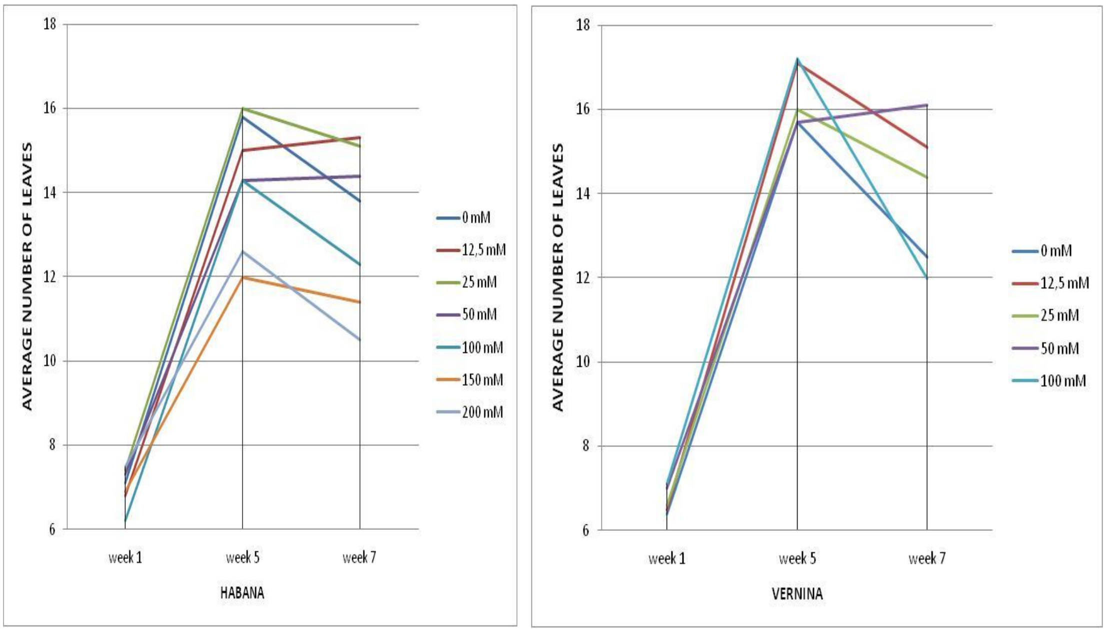


Fig.4.25 Effect of salinity on the average number of fully developed leaves of Habana and Vernina eggplants after culture in perlite for 7 weeks irrigated with NaCl at different concentrations.

The numbers of the leaves of tomato are shown in Figure 4.26 The two higher concentrations (150 and 200mM NaCl) had the lowest number of the leaves; the rest of the concentrations had similar results. Similar results in *S.torvum* with higher rate of leave loss.

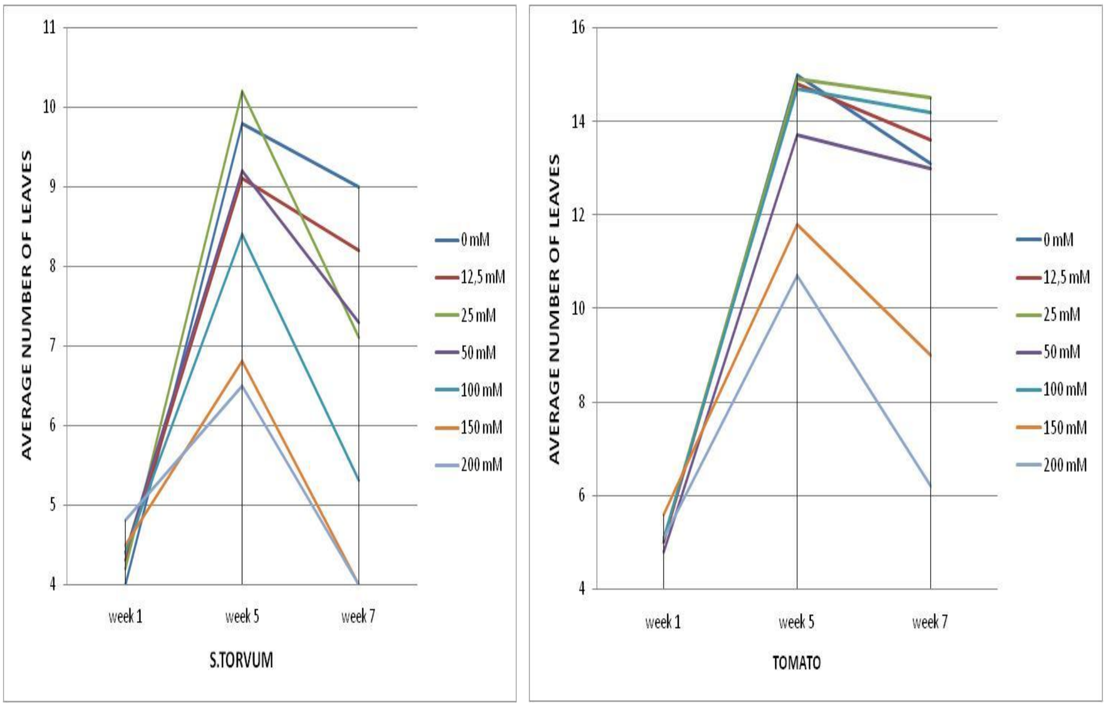


Fig 4.26 Effect of salinity on the average number of fully developed leaves of *Solanum torvum* and tomato after culture in perlite in a period of seven weeks irrigated with NaCl at different concentrations.

The biggest statistic differences were at *S.torvum* plants and Habana. As shown in Fig.4.27 S.torvum had a significant leaf fall compare to other plants.

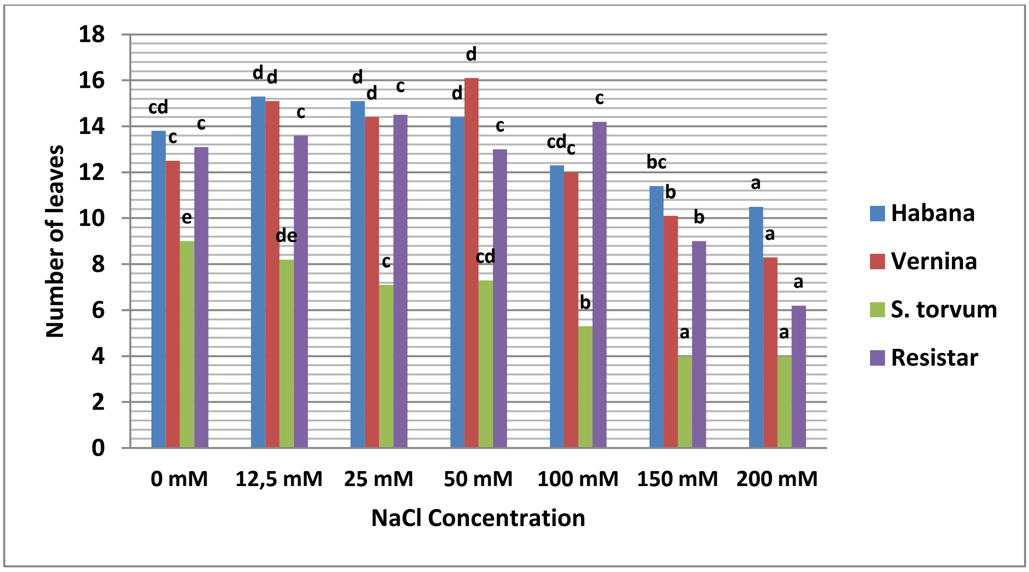


Fig 4.27 Comparison of different NaCl concentrations on the average number of fully developed leaves of hybrids (Habana , Vernina) and rootstocks (tomato hybrid Resistar and *Solanum torvum*) after seven weeks culture in perlite. **<u>Bars with the same color</u>**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.2.3 Effect of NaCl treatments on Chlorophyll content.

The chlorophyll content in leaves of Habana eggplants was reduced dramatically at the higher concentrations of NaCl (Fig 4.28) after the third week of the experiment. The effect of salinity on the chlorophyll content of Vernina leaves (Figure 4.28) is very strong. The chlorophyll content was affected dramatically at all concentrations of NaCl without major differences among treatments.

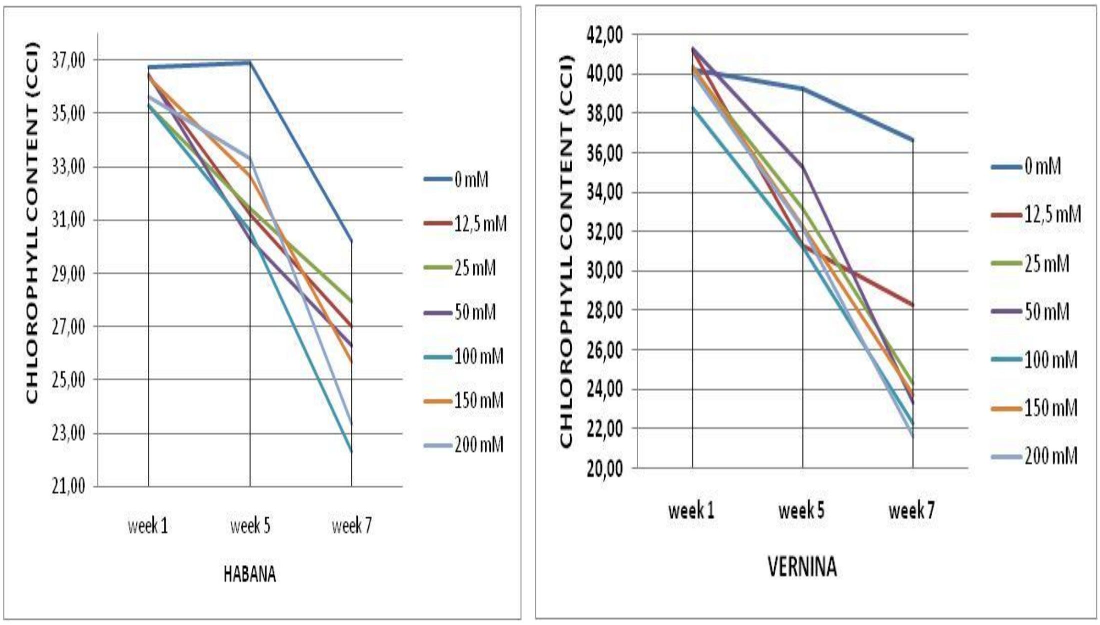


Fig 4.28 Effect of salinity in the average chlorophyll content of Habana leaves in a period of seven weeks in perlite, irrigated with NaCl at different concentrations.

The chlorophyll content of leaves of *Solanum torvum*, (Fig 4.28) was negatively affected by NaCl in all concentration compared to the control, where chlorophyll content of the leaves was only slightly reduced. The reduction is higher at week five, especially at the higher concentration (200mM NaCl). The effect of salinity on the chlorophyll content of hybrid Resistar tomato plants as shown in Fig 4.28 was affected at all the concentrations even at the lowest concentration of 12.5mM compared to the control specially after the fifth week.

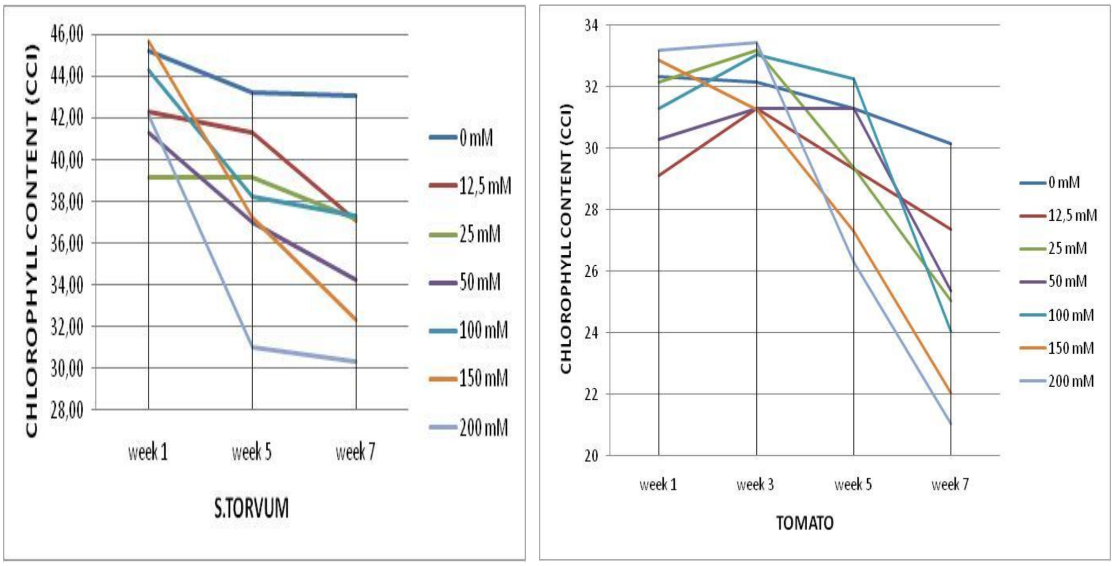


Fig 4.28 Effect of salinity in the average chlorophyll content of *Solanum torvum* and tomato cultured in soil for nine weeks, irrigated with NaCl at different concentrations.

At Fig 4.29 the Vernina plants do not have statistical differences at all concentrations except the 12.5 mM. The S.torvum had significant better results at the end of the experiment than the tomato plants.

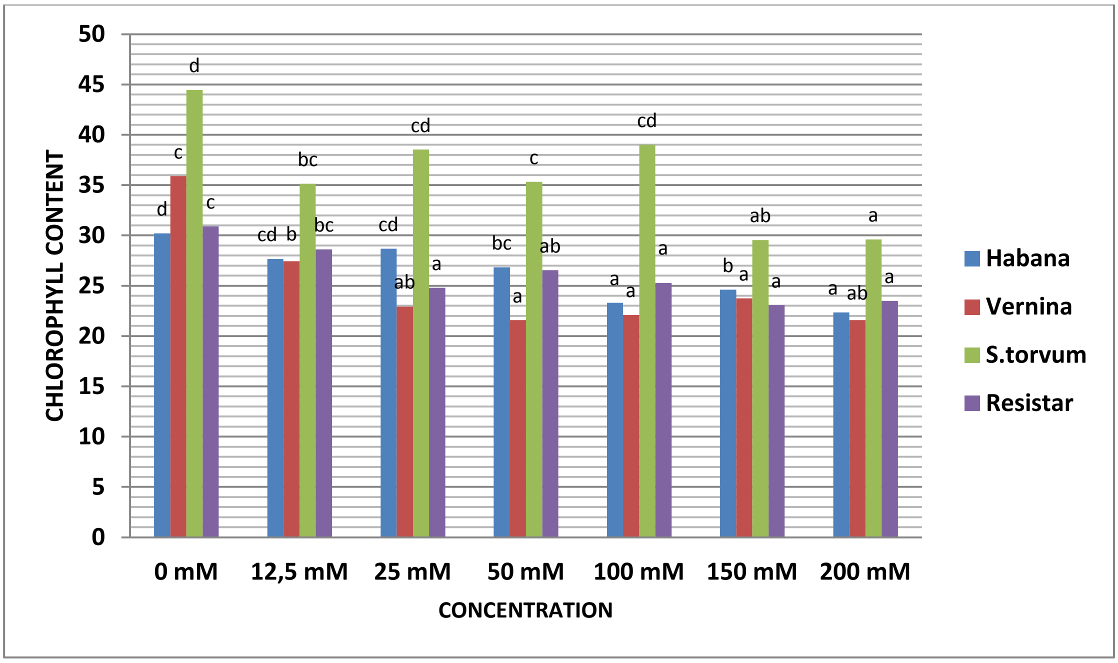


Figure 4.29 Comparison of different NaCl concentrations on the chlorophyl content of leaves of eggplant hybrids (Habana , Vernina) and two non crafted rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.2.4 **Effect of NaCl concentrations on the chlorophyll fluorescence.**

The average chlorophyll fluorescence in leaves of Habana eggplants was reduced at all the concentrations of NaCl compared to the control plants (12.5, 25, 50, 100, 150 and 200mM) as shown in Fig 4.30, specially at week five although reduction started earlier, with the biggest reduction at the concentration of 200mM at the seventh week. The chlorophyll fluorescence in leaves of Vernina eggplants (Fig 4.30) was not affected by NaCl at concentrations up to 50 mM while big reduction is recorded at week five at the concentration of 200 and 150mM and at the seventh week at 100, 150 and 200mM NaCl.

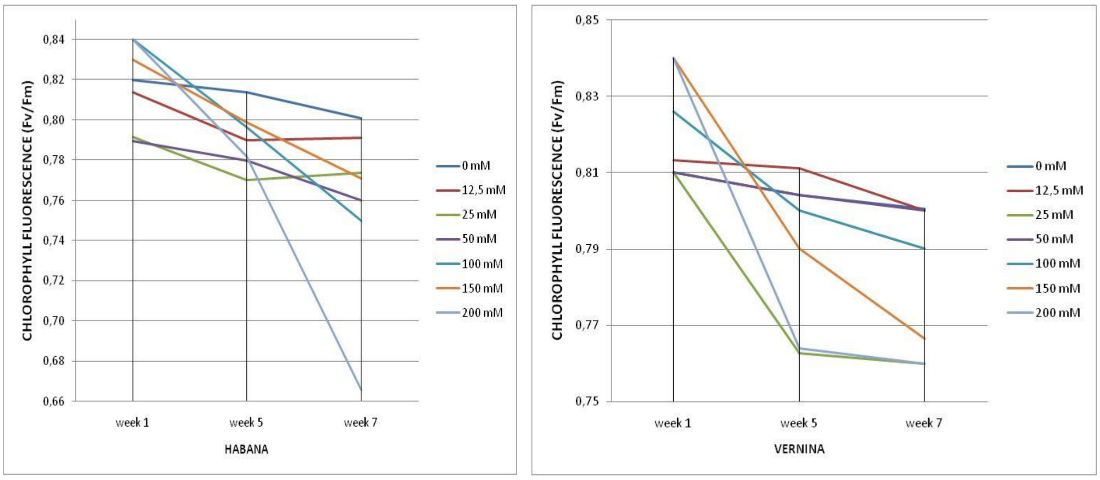


Fig 4.30 Effect of salinity on the average chlorophyll fluorescence in leaves of Habana and Vernina eggplants for seven weeks in perlite, irrigated with NaCl at different concentrations.

Salinity affected the chlorophyll fluorescence of the leaves of the Solanum torvum at all concentrations except of the control plants and 12.5mM which had only a small decline. The effect of the salinity on the chlorophyll fluorescence of leaves of Resistar tomato plants (Figure 4.31.) was apparent in all concentrations of NaCl compared to the control plants. After the third week the decrease was bigger in higher concentrations.

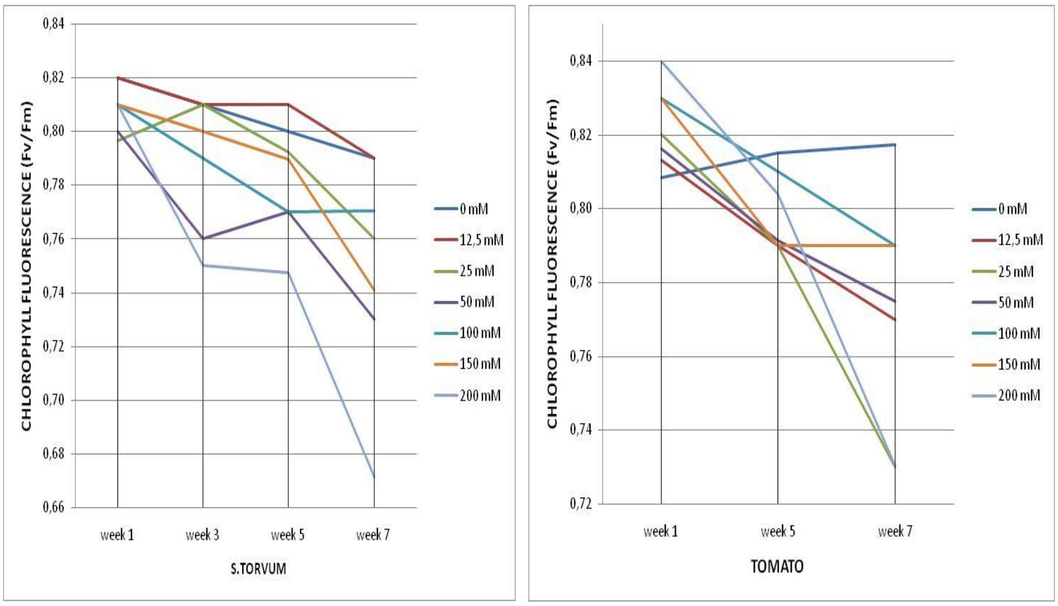


Fig 4.31 Effect of salinity on the average number of chlorophyll fluorescence of Solanum torvum and tomato irrigated for seven weeks in perlite.

All the plant type did not have any important statistical differences at all concentrations for the last measurements.

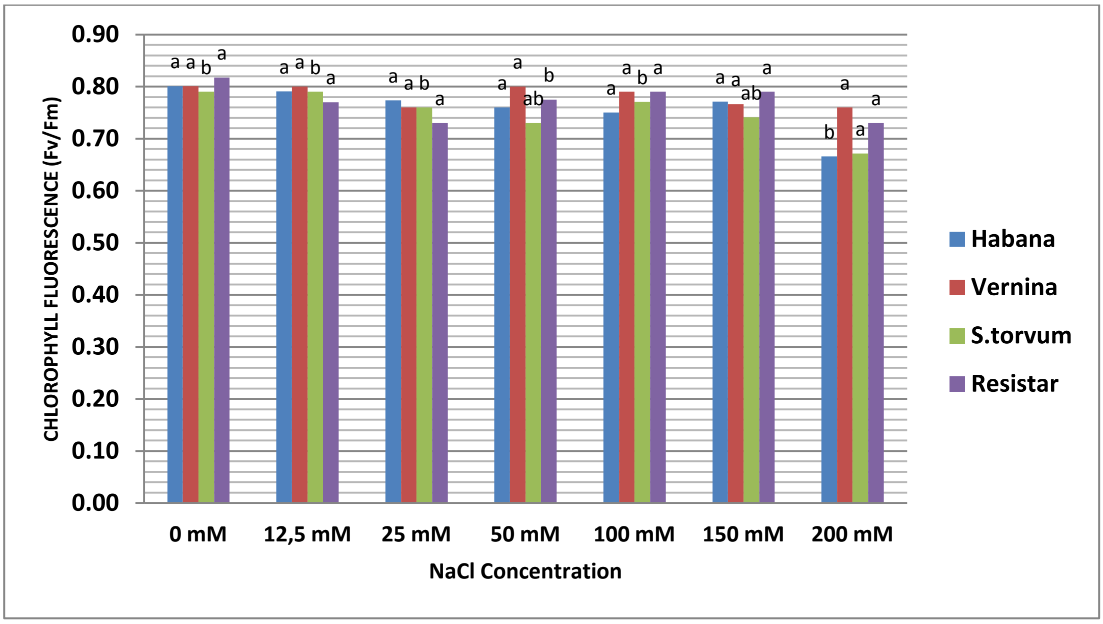


Figure 4.32 Comparison of different NaCl concentrations on the chlorophyl fluorescence of leaves of eggplant hybrids (Habana , Vernina) and two rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**<u>Bars with the same color</u>,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.2.5 Effect of NaCl treatments on Photosynthetic rate.

According to Fig.4.33 Habana plants were affected less than the other plants on the photosynthetic rate, as reduction is significant at after 50 mM. Resistar and *S. torvum* were affected at 25 mM NaCl, while Vernina was affected at 12,5 mM. The differences in the first two concentrations are not significant among the plant types.

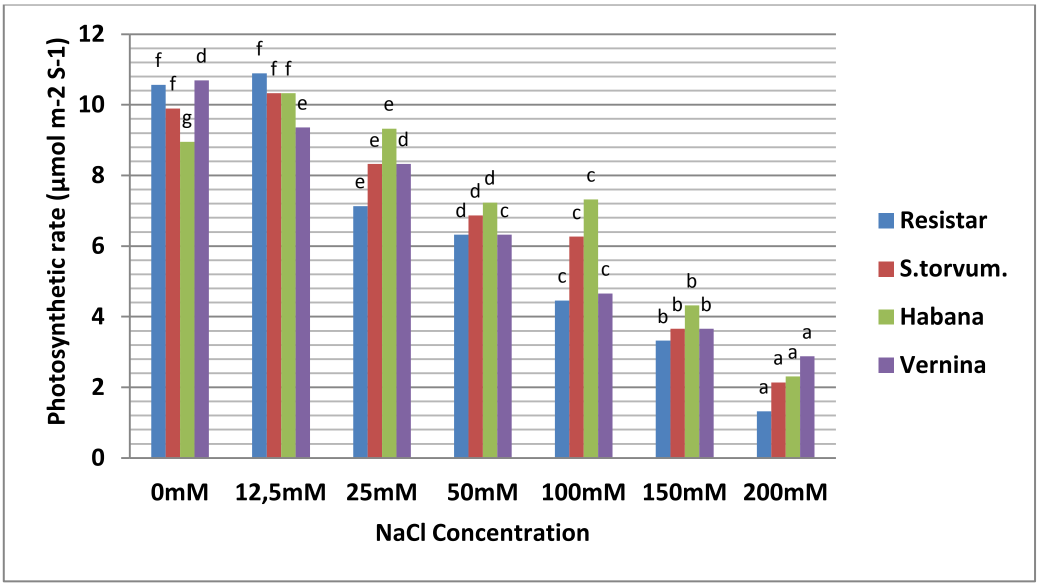


Figure 4.33 Comparison of different NaCl concentrations on the photosynthetic rate of leaves of eggplant hybrids (Habana , Vernina) and two rootstocks (tomato hybrid Resistar and *Solanum torvum*) cultured in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.2.6 Fresh and dry weight.

At the following figures the fresh and dry weight of different parts of the plants is presented.

In figure 4.34 the fresh weight of the leaves show a bigger reduction in the two hybrids in almost all concentrations. The difference between the two rootstocks is not siqnificant .

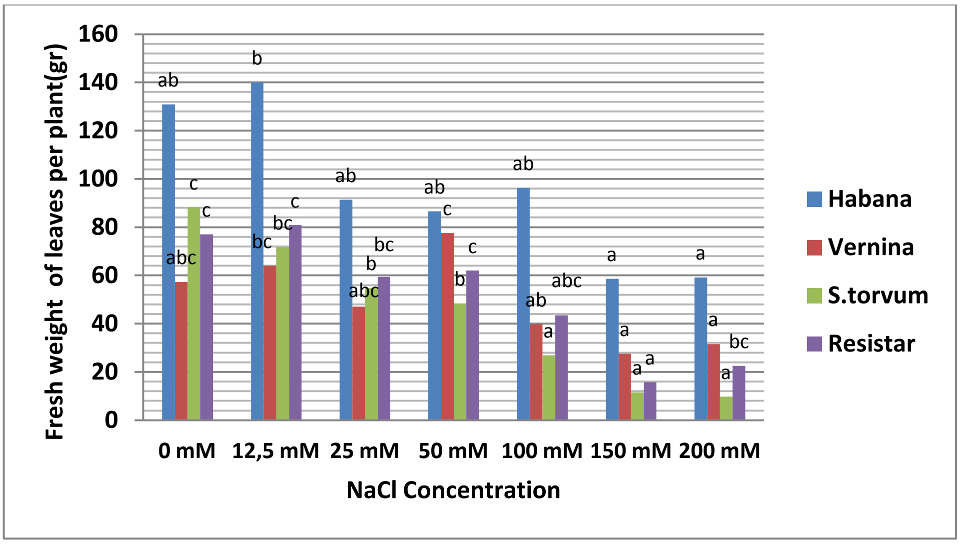


Figure 4.35 Effect of irrigated NaCl on the fresh weight of leaves of eggplant hybrids (Habana , Vernina) and two rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**<u>Bars with the same color</u>,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.36 shows the dry weight of the leaves. Habana leaves' dry weight was not significantly affected up to 100 mM Vernina's leaves dry weight was not significantly affected up to 50mM NaCl, while the two rootstocks had no significant differences up to 100 mM NaCl.

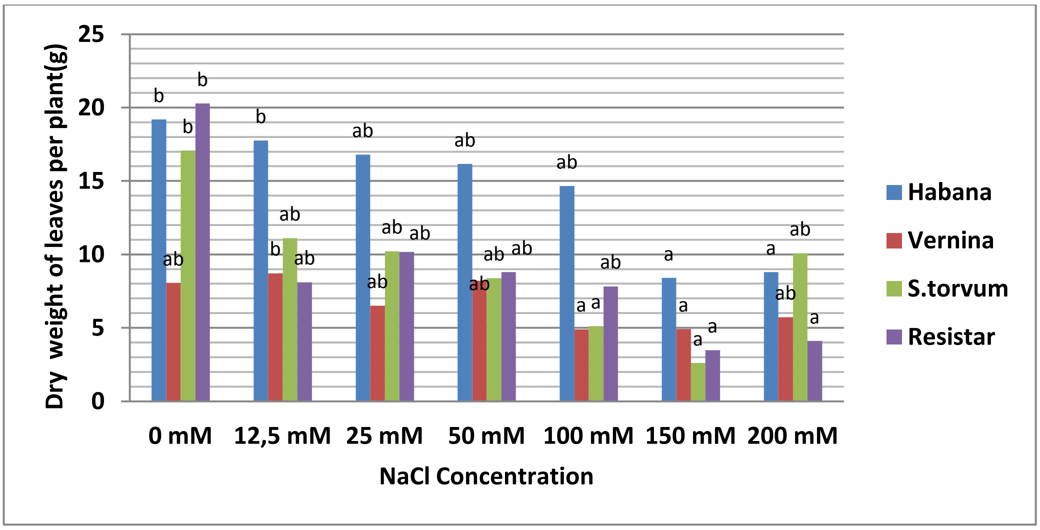


Figure 4.36 Effect of NaCl on the dry weight of leaves of eggplant hybrids (Habana , Vernina) and two rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**<u>Bars with the same color</u>,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.37 shows the differences in the fruits fresh weight of the two hybrids and the tomato rootstock. The differences between the two hybrids are not siqnificant. The tomato fruts had differences in fresh weight at all concentrations but only at 100, 150 and 200mM NaCl the differences were statistically significant, . The *S. torvum* plants did not produce any fruits.

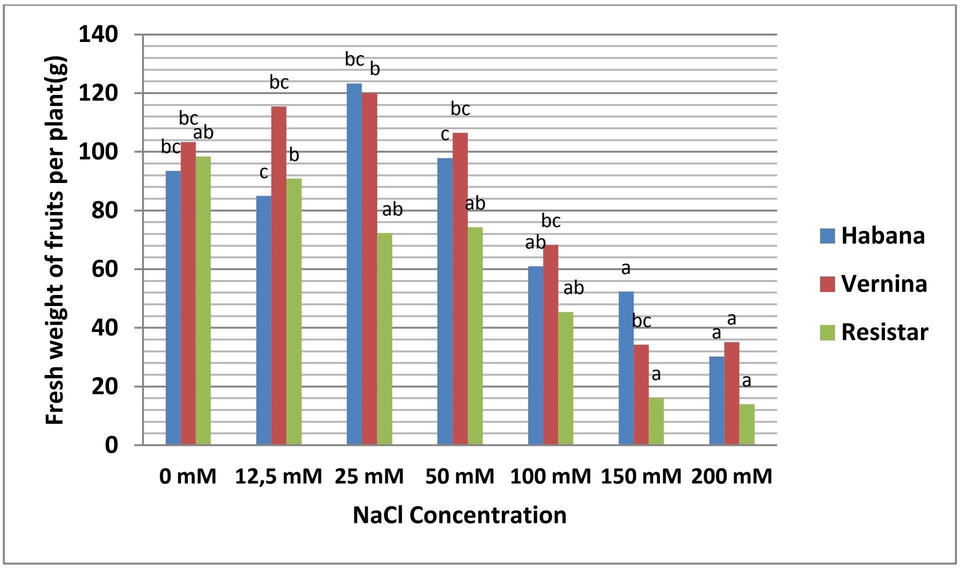


Figure 4.37 Effect of NaCl on the fresh weight of fruits of eggplant hybrids (Habana , Vernina) and two rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At Figure 4.38 the dry weight of the fruits of the Habana plants was bigger than the Vernina plants at the concentrations of 25, 50 and 100mM.

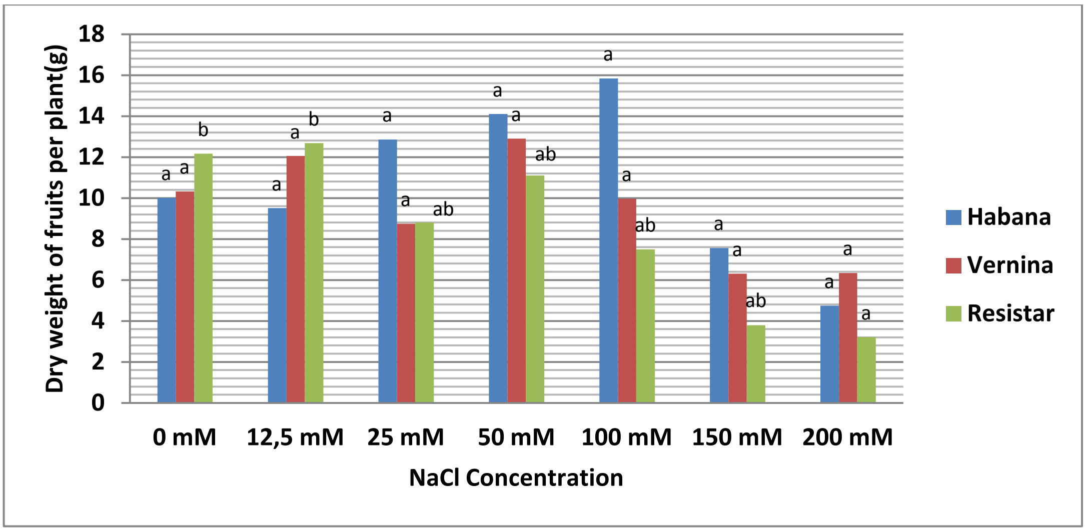


Figure 4.38 Effect of NaCl on the dry weight of fruits of eggplant hybrids (Habana , Vernina) and two rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At Figure 4.39 Habana had bigger differences compared to other plant types in the fresh weight of the stem. In Habana, stem fresh weight did not changed significantly up to 100 mM NaCl, while Vernina had no significant differences. In the contrary at 12, 5 mM NaCl the stem mean fresh weight was significantly higher than in the control plants

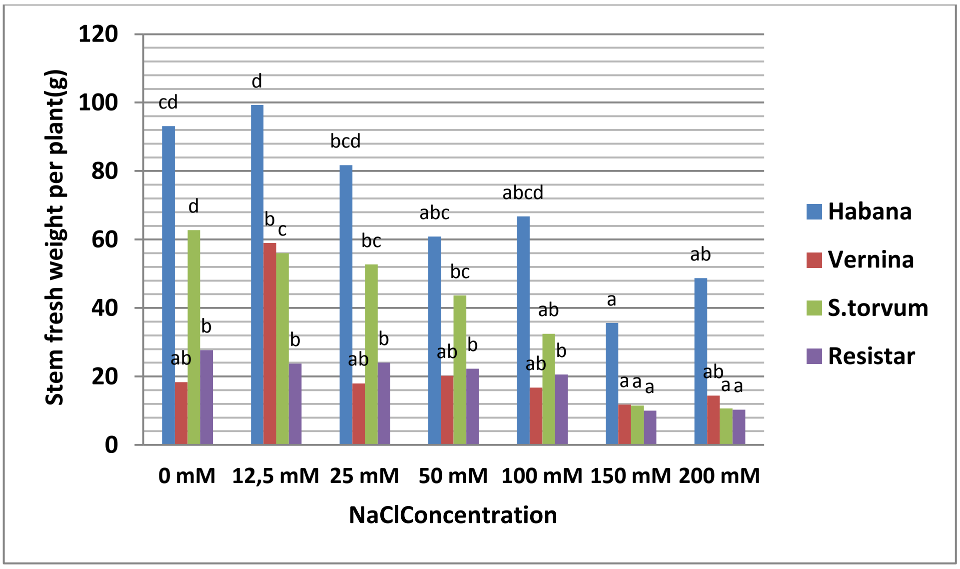


Figure 4.39 Effect of irrigated NaCl on the stem fresh weight of eggplant hybrids (Habana , Vernina) and two rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At Figure 4.40 the dry weight of the stem had not many significant differences in all cases exept Habana . The stem dry weight was significantly redused in 100, 150 and 200 mM.

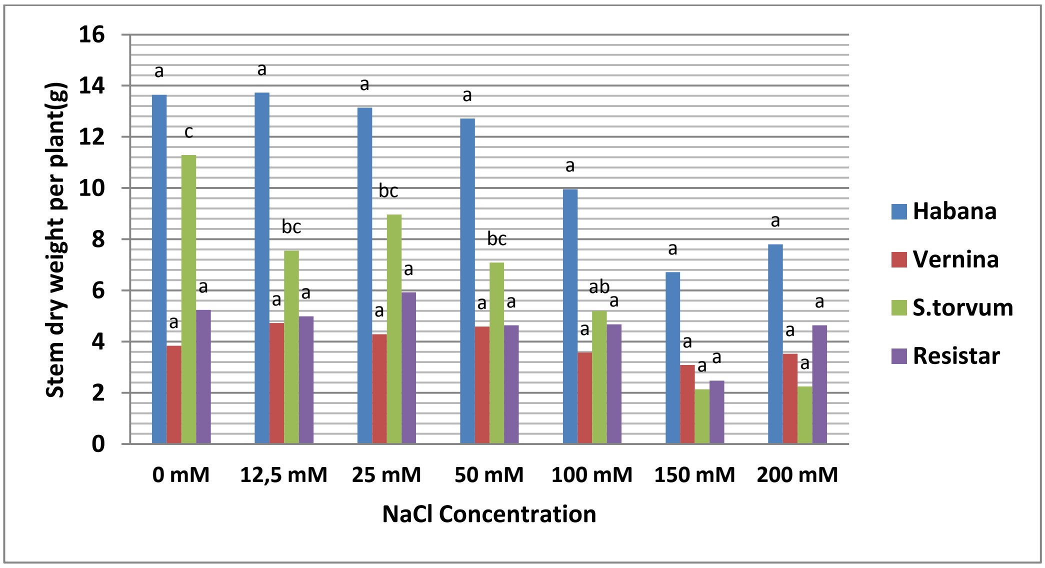


Figure 4.40 Effect of irrigated NaCl on the stem dry weight of eggplant hybrids (Habana , Vernina) and two rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.2.7 K and Cl concentration.

In Figure 4.41 it is shown the percentage concentration of K^+ in dry tissue. Even at higher concentrations of NaCl treatment Vernina has a big amount of K^+ in the tissues. Habana has also high concentrations of K^+ but at 100 mM and higher concentrations, there is a significant reduction. In Resistar and *S.torvum* there were significant reductions at 25 mM NaCl and higher concentrations.

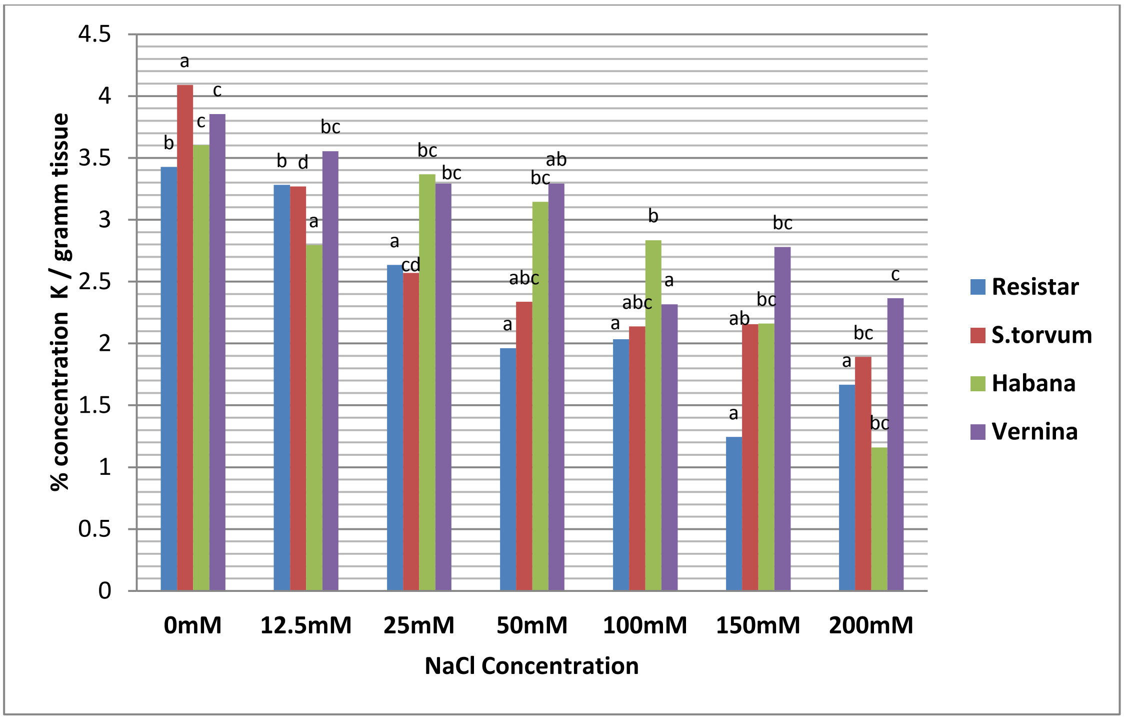


Figure 4.41 Effect of irrigated NaCl on the K concentration of eggplant hybrids (Habana , Vernina) and two future rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**<u>Bars with the same color</u>,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

In Figure 4.42 it is shown the concentration of Na^+ / gram dry tissue. No matter how small, Vernina has the higher absorption at 200 mM, S. Torvum is higher only in 12,5 ,50 and 150 mM S.torvum has the bigger Na absorption at all concentrations except the 100mM.

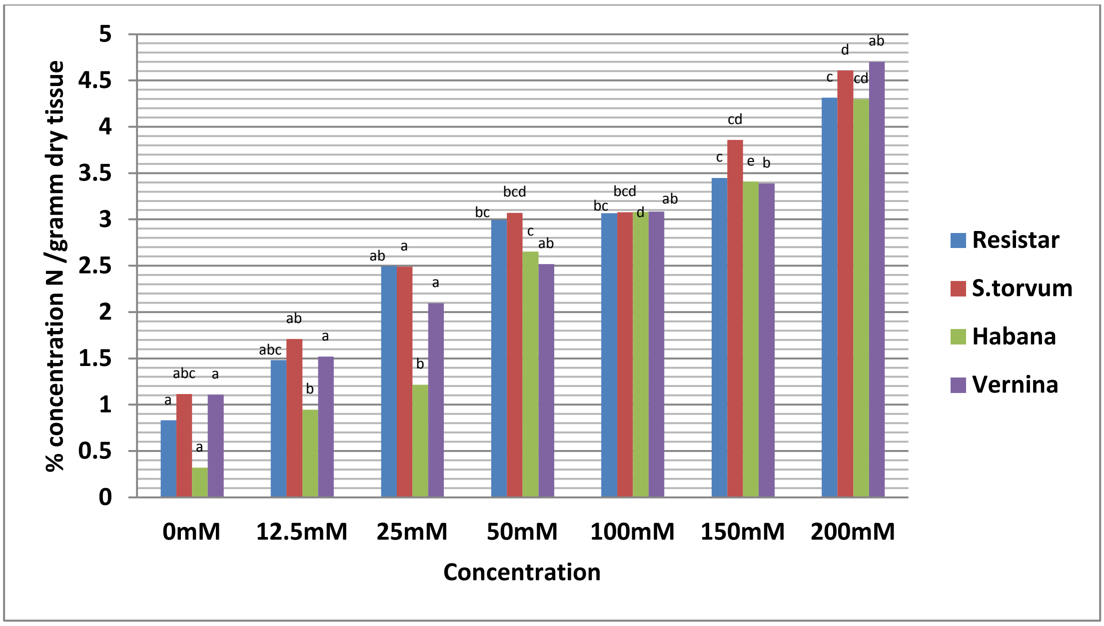


Figure 4.42 Effect of NaCl on the Na concentration of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**<u>Bars with the same color</u>,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3 Grafted plants in hydroponic culture in perlite.

The measurements were taken for seven weeks. After this period the plants had major leaf loss, especially at the higher concentrations making unable to take measurements. Also the temperature was starting to fall during the period of the experiment causing an extra stress to the plants. All the plant types were grafted.

In the sections below are presented the results for each species and hybrid regarding the height (cm), the number of fully developed leaves, the chlorophyll fluorescence and the chlorophyll content and photosynthetic rate.

At the end of the experiment the fresh and dry weight of each part of the plant was measured. The roots were not measured because these plants will be used in the future experiment as grafted plants. Also the K^+ and Na^+ concentration in the tissues were measured.

The average temperatures for the months that the experiment lasted were presented at Table 4.3:

Table 4.3

Month	DAY	NIGHT
September	26	17
October	23	15
November	16	12

The above averages were calculated from the data which were taken from the data logger inside the greenhouse that the experiment took place.

4.3.1. Plant height.

The plants of the Habana/S.torvum were affected by the salinity. The plant height at the 100, 150 and 200mM concentrations of NaCl were progressively lower (figure 4.43) showing a smaller rate of growth. The effect on the height of the plants started after the fifth week of the experiment. The average height of the plants of the hybrid Vernina/S.torvum (Fig 4.43) also was affected by salinity. The higher concentration of 200mM presented the smaller growth rate compared to the other concentrations from the week five.

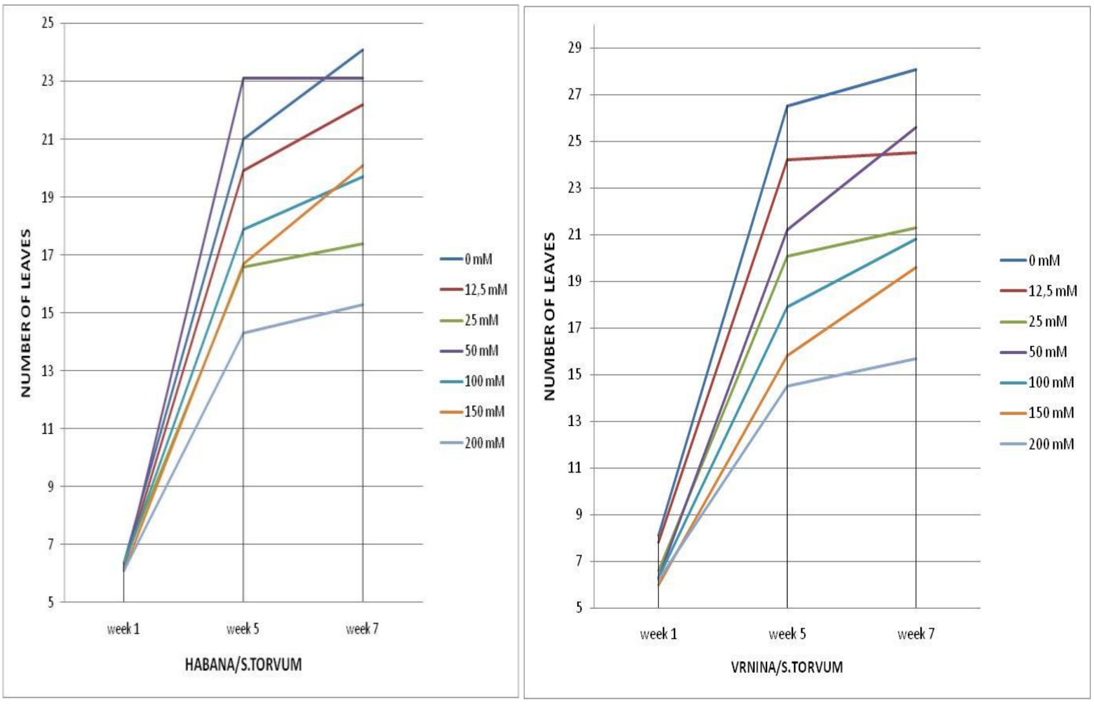


Fig 4.43 Effect of the irrigation water salinity on the average height of Habana/S.torvum and Vernina/S.torvum eggplants after culture in perlite for seven, irrigated with NaCl at different concentrations.

The plants of the Habana/tomato (Fig 4.44) at the concentrations of 200 and 100mM have shown a lower height increase than the other concentrations. Figure 4.44 shows Vernina/tomato plants height, which was not affected at the lower concentrations. In the higher two concentrations of 150 and 200mM the height of the plants was affected, showing a significantly smaller growth than the other concentrations.

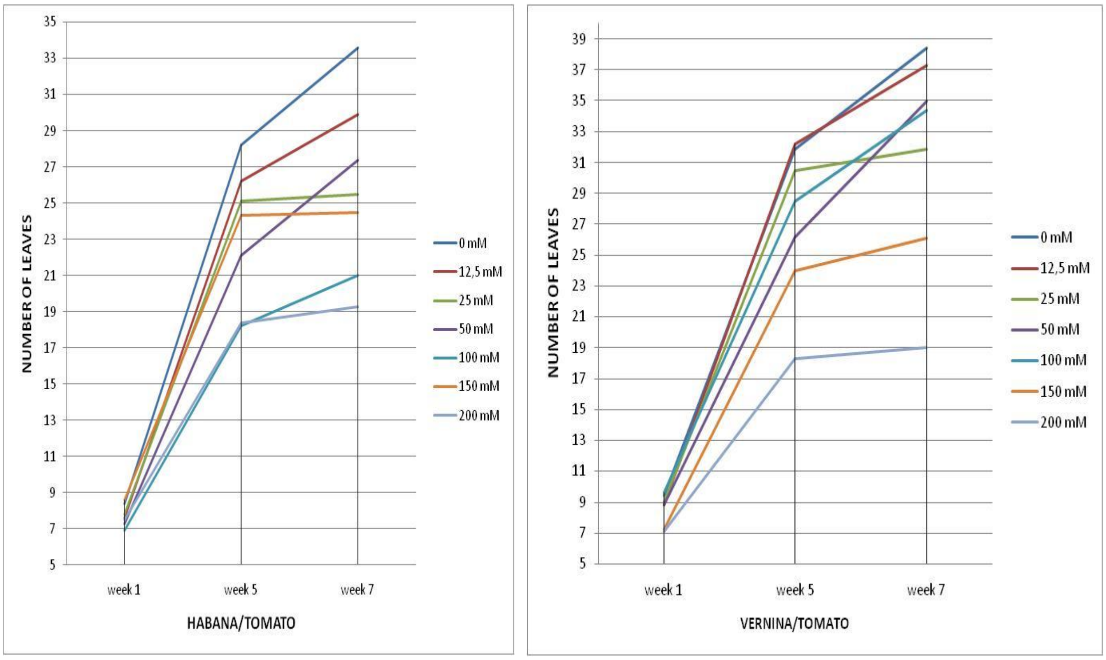


Fig 4.44 Effect of the irrigation water salinity on the average height of Habana/tomato and Vernina/tomato eggplants after culture in perlite for seven, irrigated with NaCl at different concentrations.

As show in Figure 4.45, Vernina/S.torvum had differences with the Vernina/tomato plants. All the grafted plants had statistical differences although the results were different with Vernina grafted to tomato giving better results.

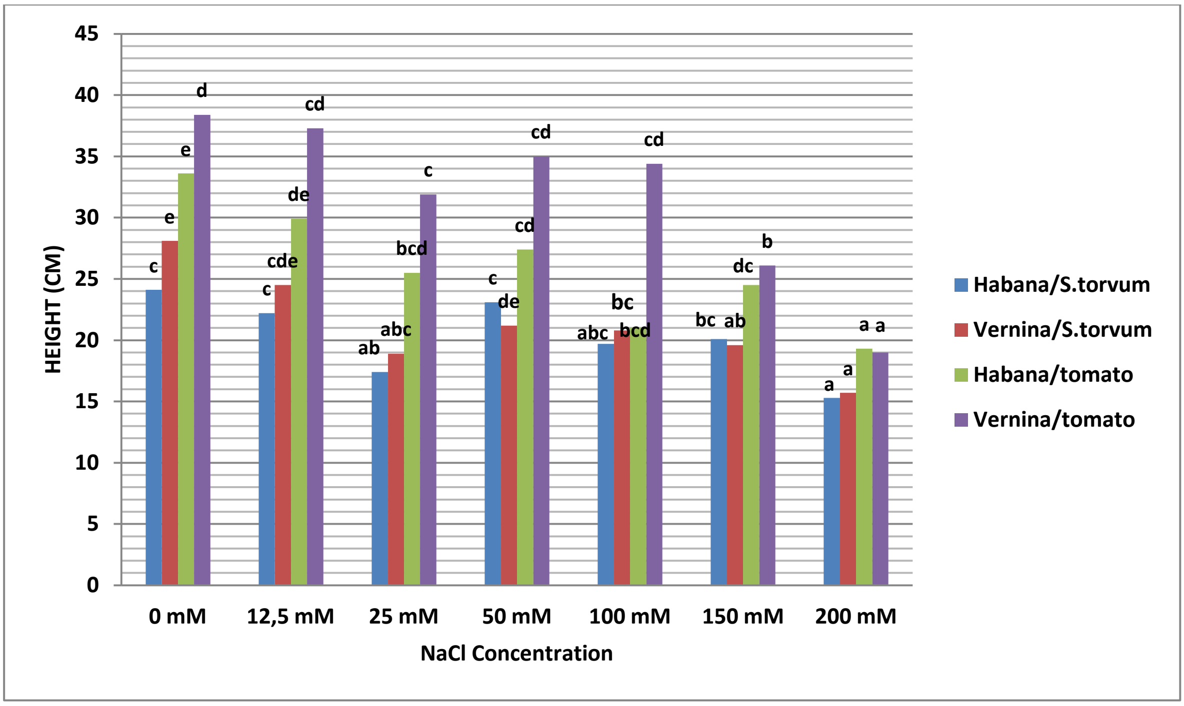


Figure 4.45 Effect of NaCl on the height of eggplants hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks, and irrigated with 0mM, 12.5mM, 25mM, 50mM, 100mM, 150mM and 200mM NaCl.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3.2 Effect of Nacl treatments on at number of leaves.

The number of fully developed leaves of Habana/S.torvum plants was affected by the salinity from the fifth week of the experiment. The lowest numbers of leaves were at the 200mM concentration. The control plants started losing leaves as well. All the concentrations were affected after the week five. Control plants started losing leaves after the week five as well. The control lost approximately 1, 3 leaves from each plant.

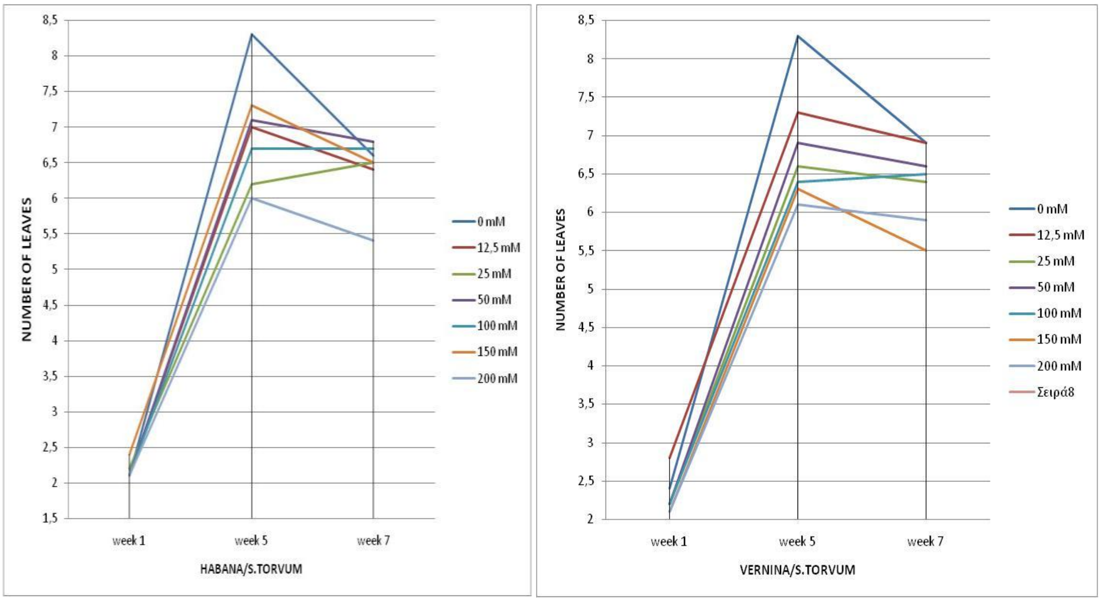


Fig.4.36 Effect of salinity on the average number of fully developed leaves of Habana/S.torvum and Vernina/S.torvum eggplants cultured hydroponically for seven weeks, irrigated with NaCl at different concentrations.

In Fig 4.37 below is presenting the effect of salinity on leaf number of Habana/tomato plants. The leaves started falling after the fifth week. The concentration had similar results. The results concerning the number of the leaves of Vernina/tomato plants are shown in Figure 4.37. Here plants treated with the two higher concentrations of NaCl, lost more leaves than plants in lower concentrations.

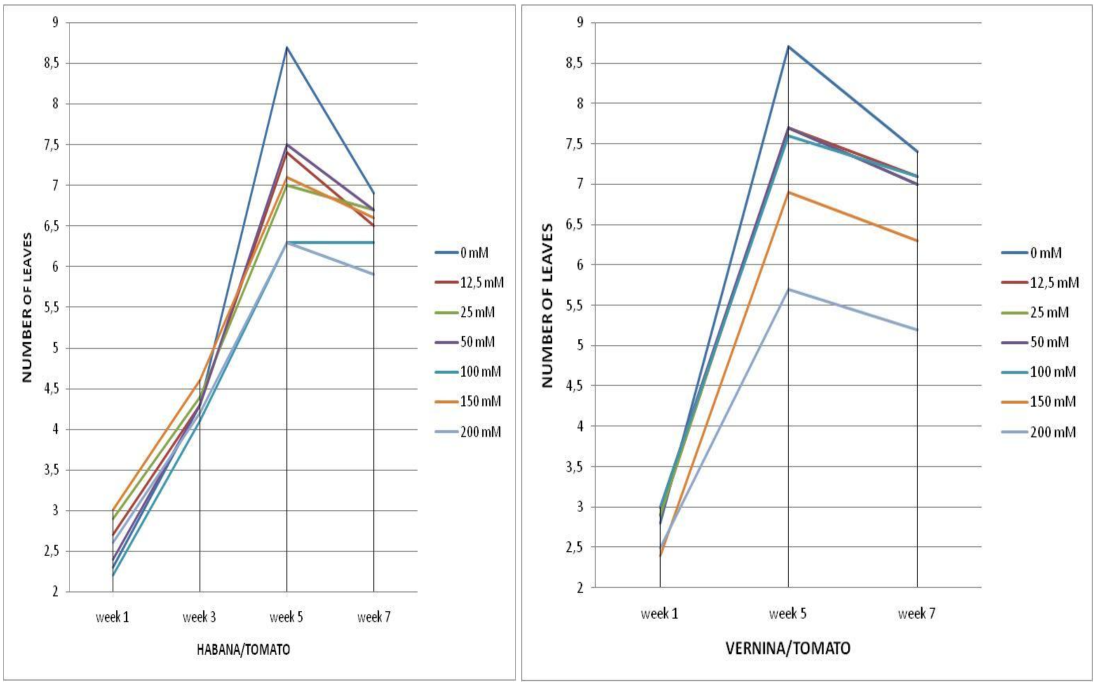


Fig 4.37 Effect of salinity on the average number of fully developed leaves of Habana/tomato and Vernina/tomato eggplants cultured hydroponically for seven weeks, irrigated with NaCl at different concentrations.

All the plant types did not have any significant statistical differences at all concentrations. Better results had the Vernina/tomato plants. At the 200mM concentration the results were without significant differences.

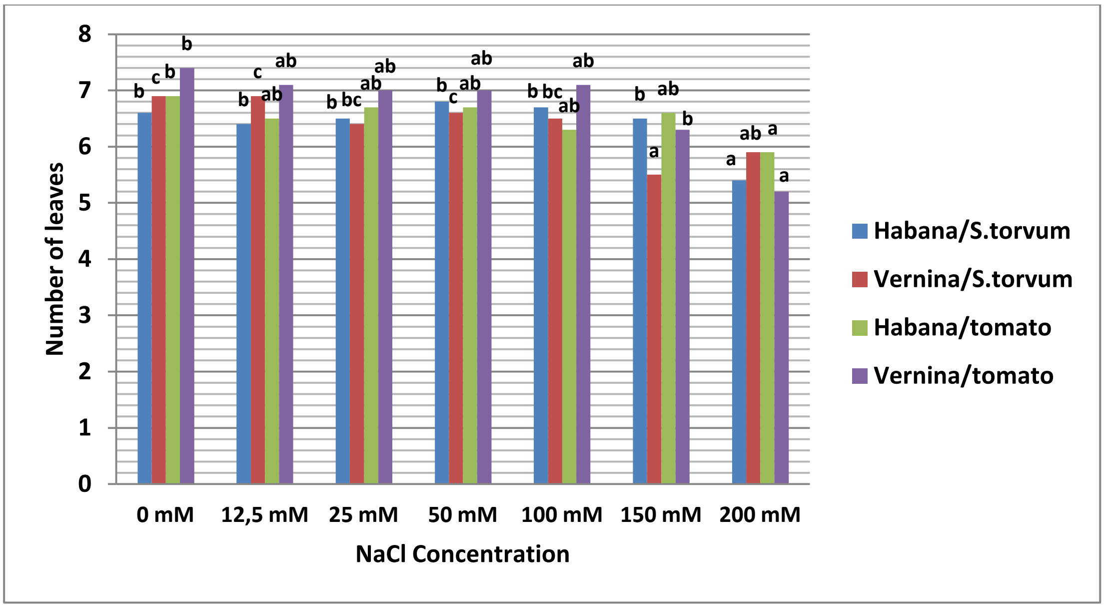


Figure 4.38 Comparison of different NaCl concentrations in the average number of fully developed leaves of eggplants hybrids (Habana , Vernina) grafted on rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3.3. Effect of NaCl treatments on Chlorophyll content.

The chlorophyll content of Habana/S.torvum eggplants was reduced at the higher concentrations of NaCl (Fig 4.39) after the third week of the experiment. At concentrations of 100mM was similar with the lower concentrations. The chlorophyll content in Vernina grafted plants was also negatively affected at all the concentrations (Fig 4.39) after the week three. The two highest concentrations had similar result at the end of the experiment.

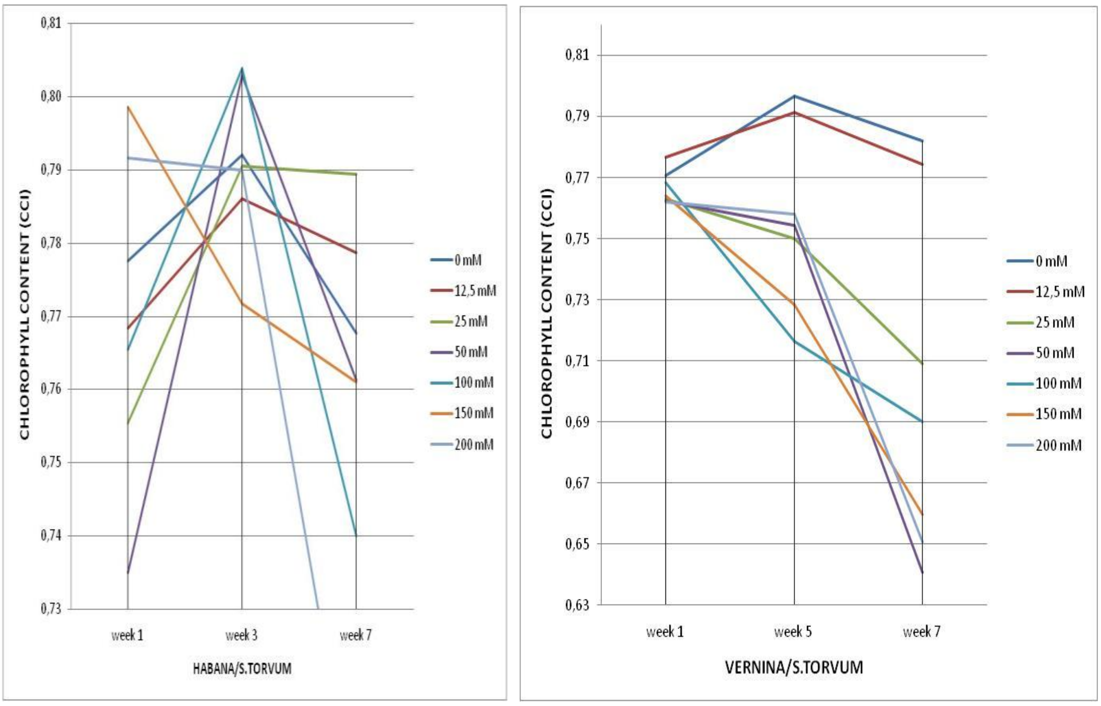
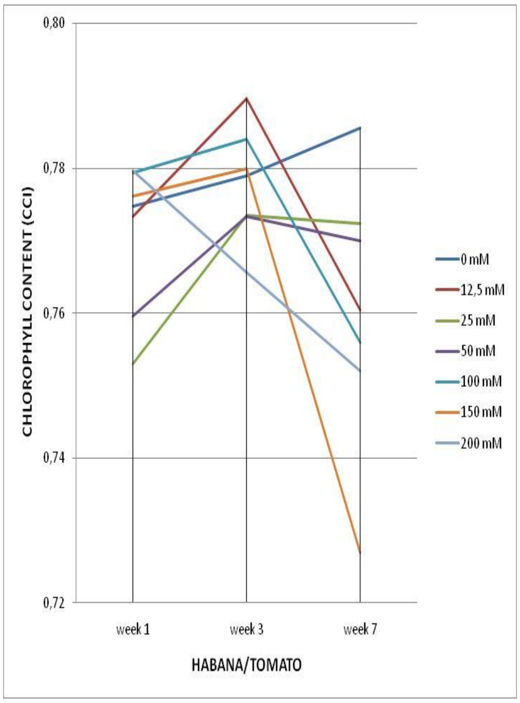


Fig 4.39 Effect of salinity in the average chlorophyll content of Habana/S.torvum and Vernina/S.torvum eggplants cultured hydroponically for seven weeks, irrigated with NaCl at different concentrations.

The leaf chlorophyll content of Habana/tomato eggplants, (Fig 4.40) was affected at all the concentration. After the fifth week the chlorophyll content was reduced further, especially at the concentration of 150mM. The effect of salinity on the leaf chlorophyll content of Vernina/tomato plants is shown in Fig 4.40 Chlorophyll content was affected at all the concentrations after the third week. The highest concentrations had similar results at the end of the experiment.



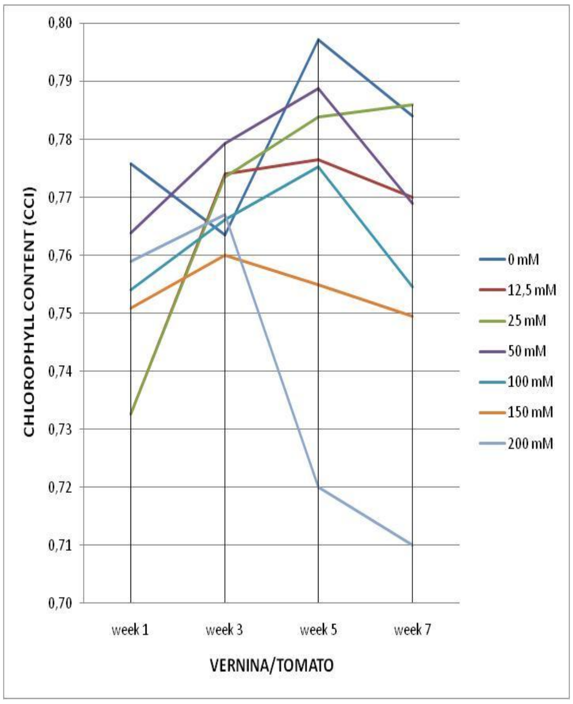


Fig 4.40 Effect of salinity in the average chlorophyll content of leaves of Habana/tomato and Vernina/tomato eggplants cultured hydroponically for seven weeks, irrigated with NaCl at different concentrations.

All plant types except the Vernina/torvum had a statistical difference at the higher concentration with the others. At the concentration of 200mM there was not any significant difference among the grafted plants but there was a difference with Vernina grafted to S.torvum showing a better response.

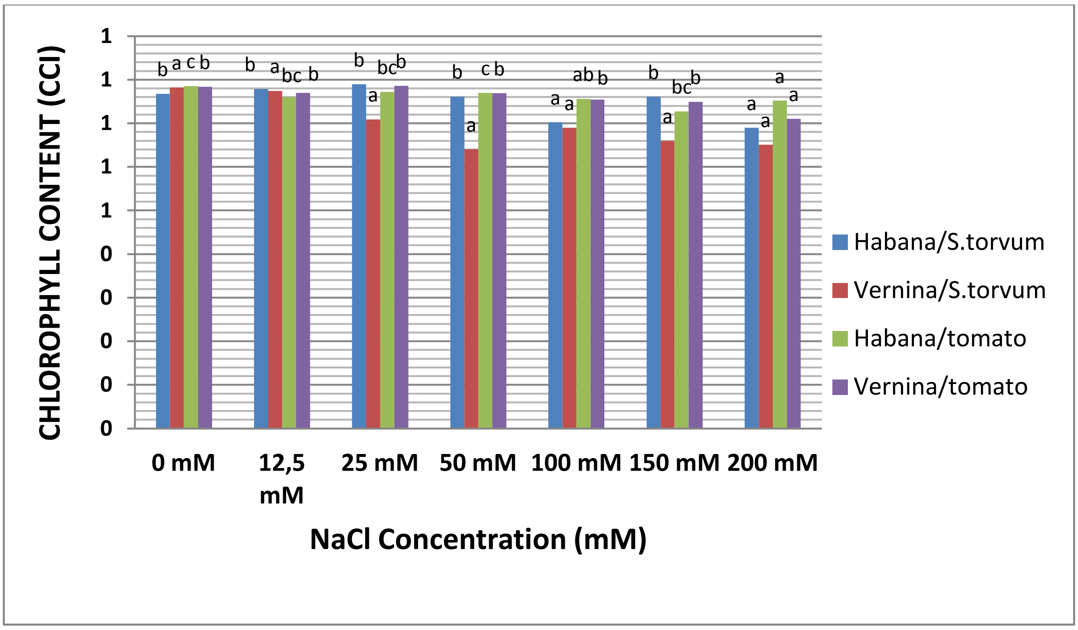


Figure 4.40 Comparison of different NaCl concentrations in the average number of chlorophyll content of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**<u>Bars with the same color</u>,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3.4. Effect of NaCl concentrations on the chlorophyll fluorescence.

The average chlorophyll fluorescence of Habana/S.torvum eggplants was reduced at the concentrations of 100 and 200mM after week three, with the biggest difference from the other concentrations. The chlorophyll fluorescence of Vernina/S.torvum eggplants (Fig 4.41) had similar results at the end of the experiment except at all concentrations. The 12.5mM concentrations was affected less at the end of the experiment.

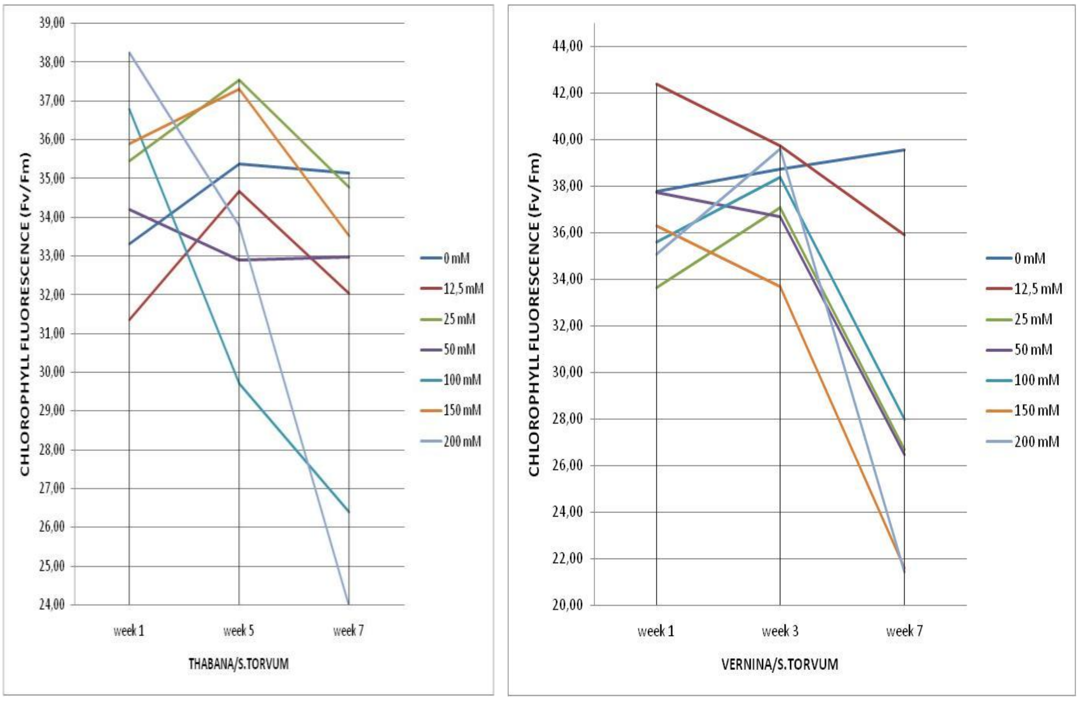


Fig 4.41 Effect of salinity on the leaf chlorophyll fluorescence of Habana/S.torvum and Vernina/S.torvum eggplants cultured hydroponically for seven weeks, irrigated with NaCl at different concentrations.

Salinity affected the chlorophyll fluorescence at all the concentrations (Fig 4.42) of the Habana/tomato eggplants after the fifth week. The concentration of 150mM was affected more than the other concentrations at the end of the experiment.

Salinity affected the leaf chlorophyll fluorescence at all the concentrations of the Vernina/tomato eggplants Fig (4.42) compared to the control, which also showed a small decline. Except from the concentration of 200 150 and 100mM the rest had similar results at the end of the experiment.

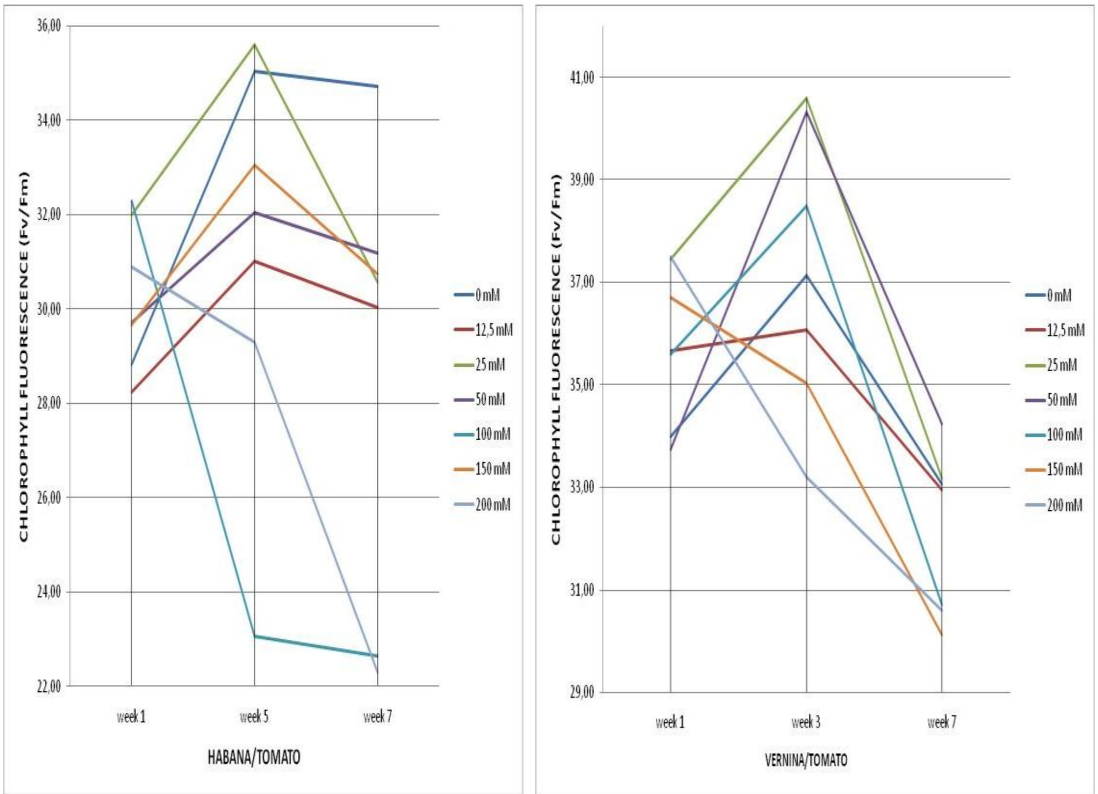


Fig 4.42 Effect of salinity on the leaf chlorophyll fluorescence of Habana/Resistar eggplants hydroponically cultured for seven weeks, irrigated with NaCl at different concentrations.

All plant types at the statistical analysis of chlorophyll florescence did not have many differences.

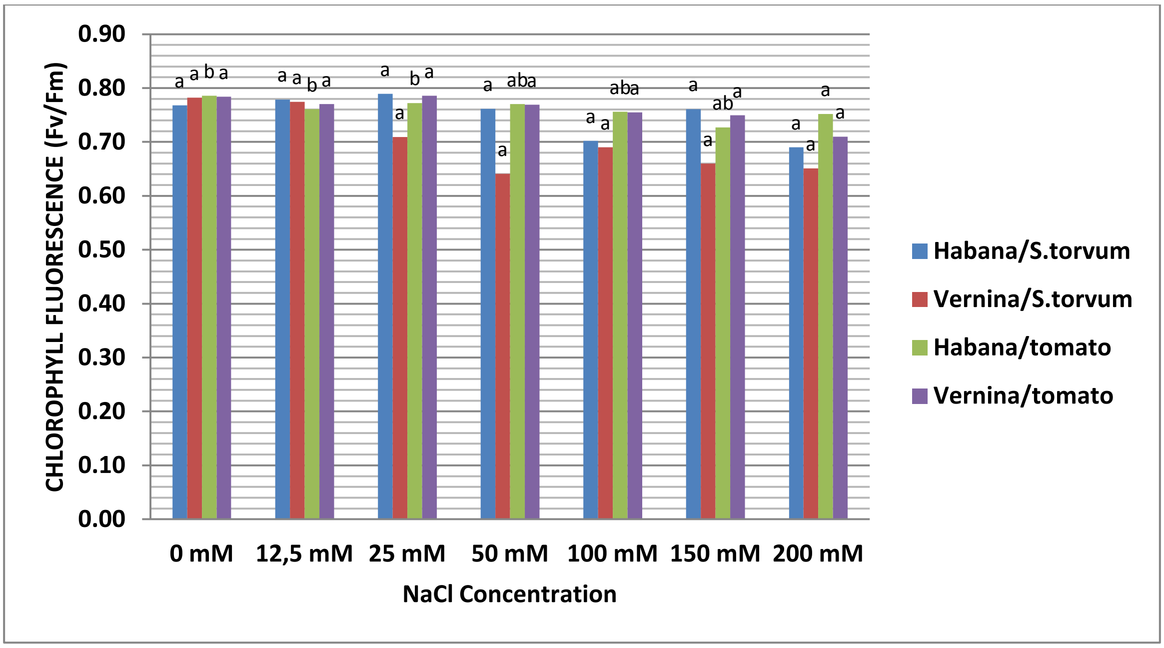


Figure 4.43 ffect of NaCl on the leaf chlorophyl fluorescence of eggplants hybrids (Habana , Vernina) grafted on differend rootstocks (tomato hybrid Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color**, followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3.5. Effect of NaCl treatments on Photosynthetic rate.

According to Fig.4.44 the photosynthetic rate was reduced during the experiment at all plant types. At the highest concetration all the plant types had similar results but in midle-range concentration did not.

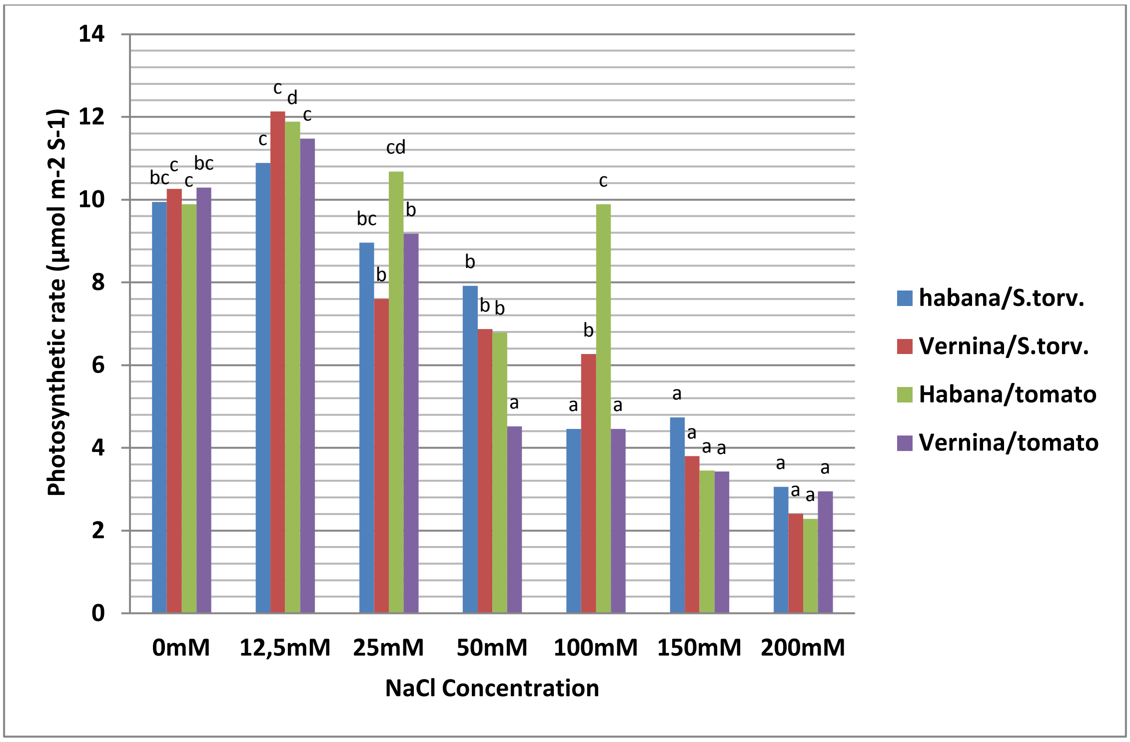


Figure 4.44 Effect of NaCl on the leaf photosynthetic rate of eggplant hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3.6 Fresh and dry weight.

At the tables below the fresh and dry weight of different parts of the plants is presented. In figure 4.45 the fresh weight of the leaves. The Habana/resistar plants had the biggest fresh weight. Also the Vernina/resistar plants had differencecs after the25mM concentration.

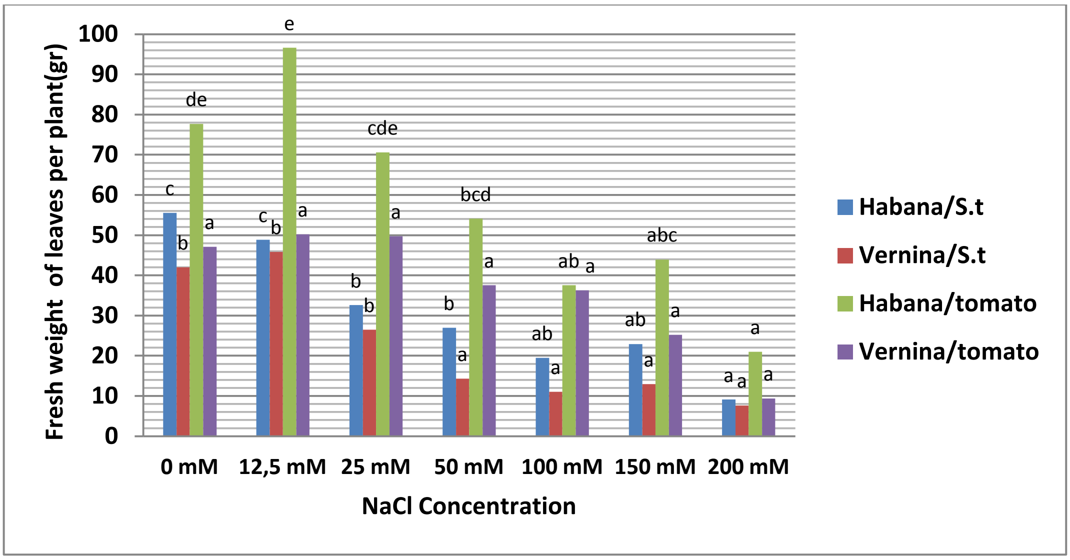


Figure 4.45 Effect of NaCl on the fresh weight of leaves of eggplants hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.46 shows the dry weight of the leaves. The hybrids grafted on tomato plants had the biggest dry weight. At the concentration of 200mM all plants had no statistical differences.

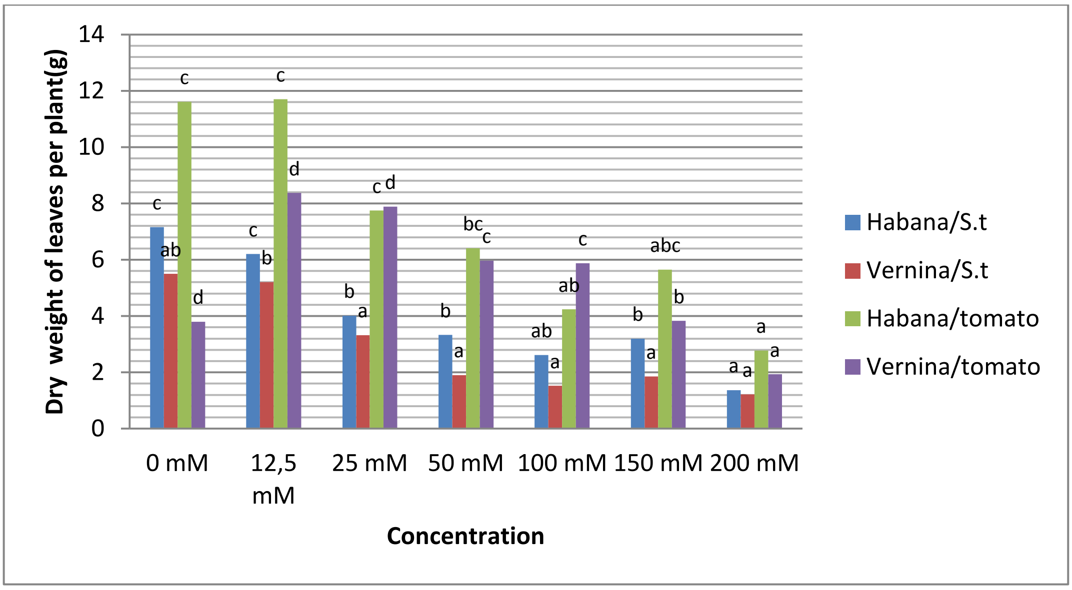


Figure 4.46 Effect of NaCl on the dry weight of leaves of eggplants hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

In dry weight of fruits the grafted Vernina/tomato results had differences with the other plants up to the 50mM treatments. On the other hand, had similar results with the rest grafted plants in the higher concentration. Also there were no siqnificant differences in the 200mM treatment.

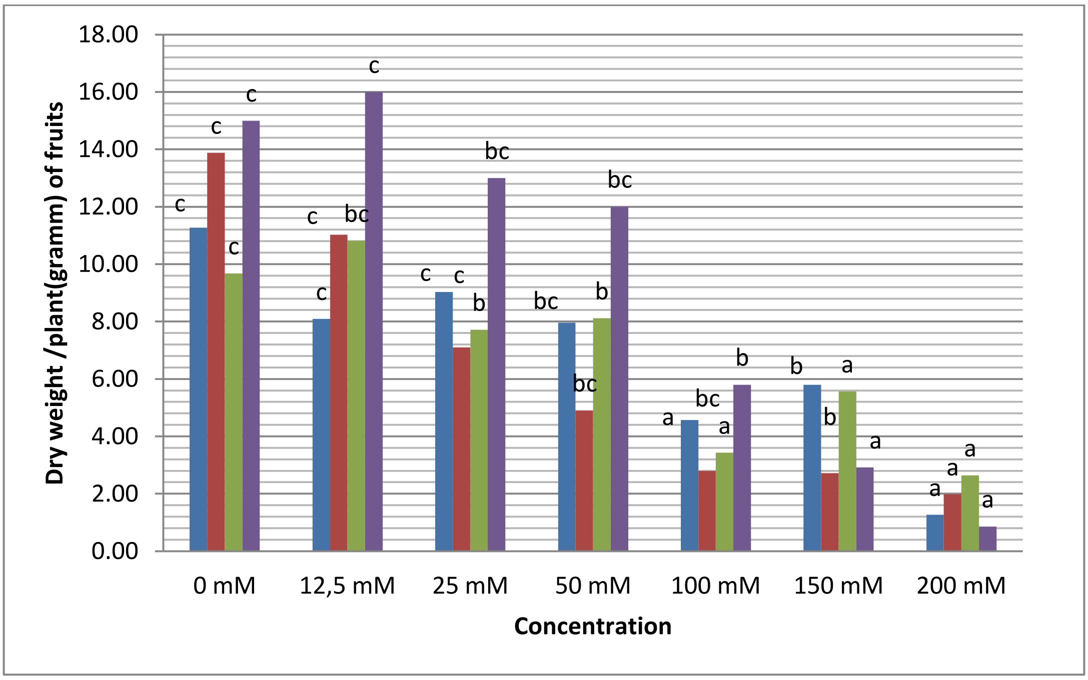


Figure 4.47 Effect of NaCl on the fresh weight of fruits of eggplants hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

Figure 4.48 shows the differences in the fresh fruits of the grafted plants. At the 0mM concentration the Vernina grafted plants had the biggest weight but at the highest cncetration plants had similar results. Although Habana / S.torvum produced less than Vernina /S.torvum this changed at higher concentrations

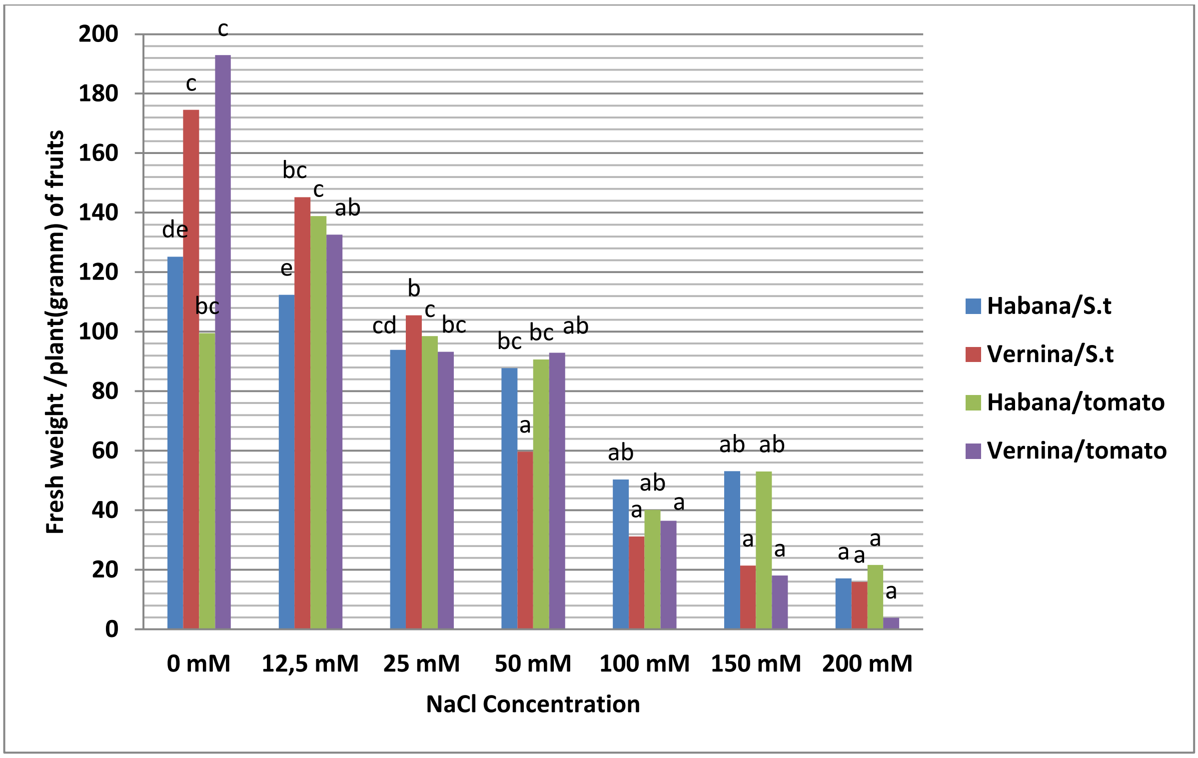


Figure 4.48 Effect of NaCl on the fresh weight of fruits of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At figure 4.49 the dry weight of the Vernina/tomato plants was bigger than the other plant types. Also at the higher concentration all the plant types had similar results with no significant differences.

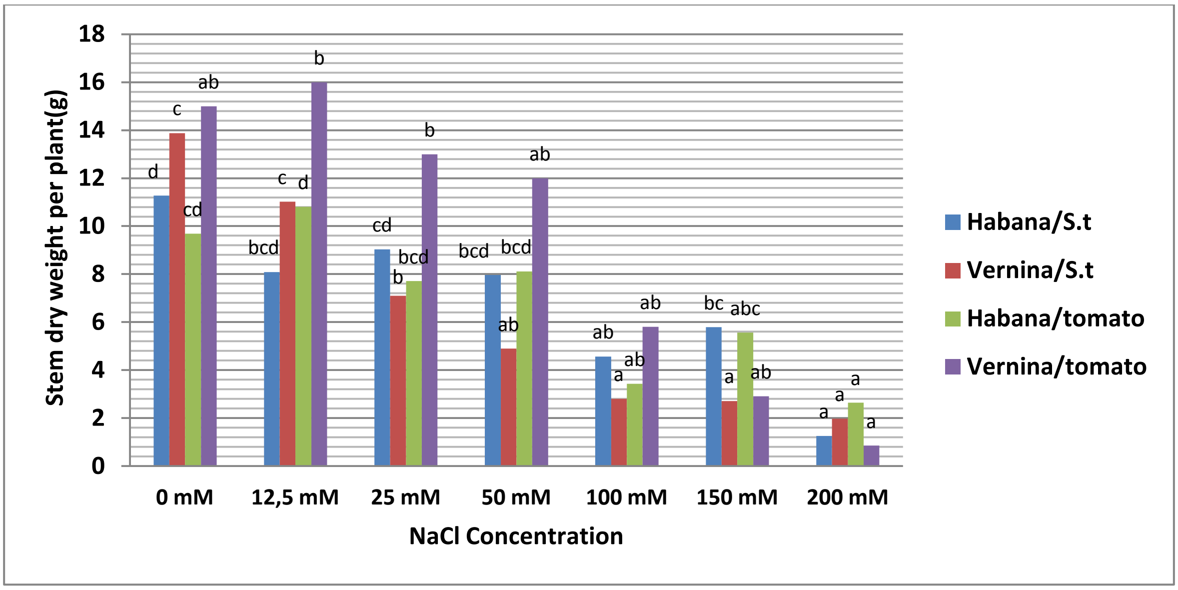


Figure 4.49 Effect of NaCl on the dry weight of fruits of eggplants hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At figure 4.50 Habana/tomato plants had big difference at all concentrations from the other plant types at their stem fresh weight. There were no significant differences in the 200mM treatments.

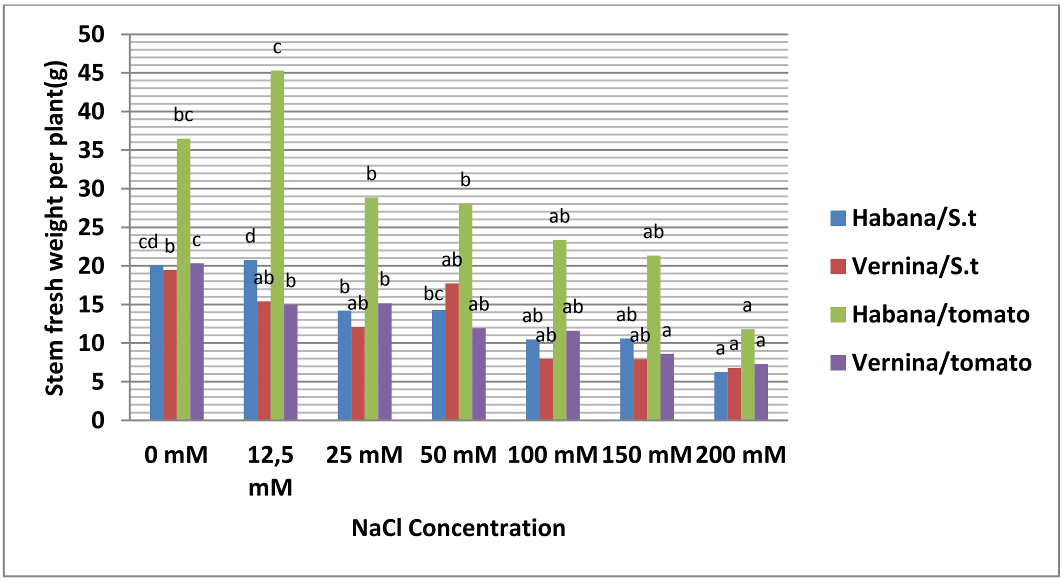


Figure 4.50 Effect of NaCl on the fresh weight of stem of eggplants hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

At figure 4.51 as in fresh weigh the Habana/resistar had the biggest dry weight at almost all concetrations from the other plant types. The same had Vernina/tomato and Vernina/S.torvum.

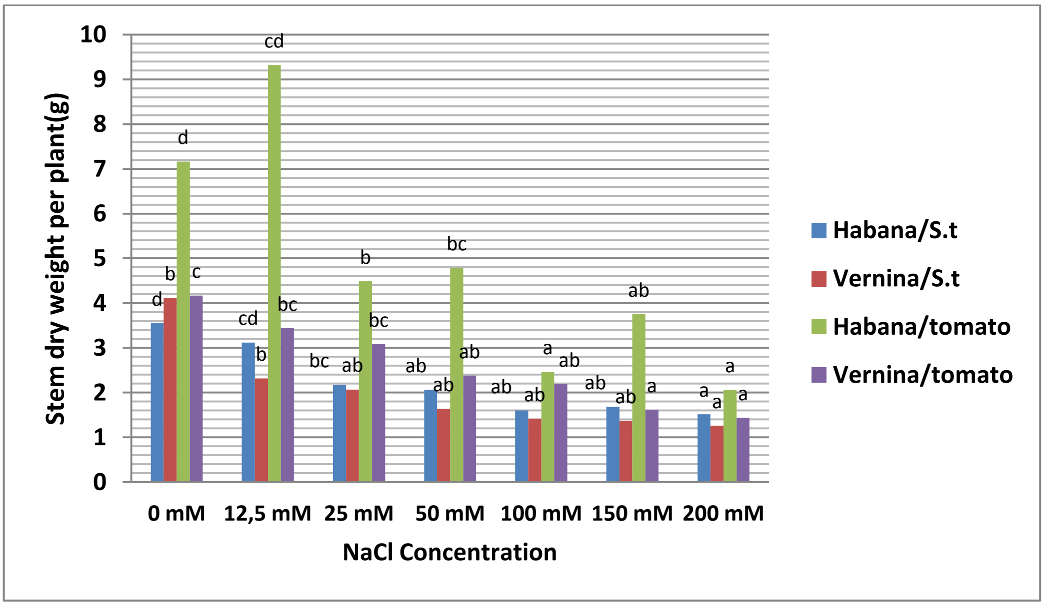


Figure 4.51 Effect of NaCl on the dry weight of stem of eggplants hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**<u>Bars with the same color</u>,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3.7 K and Cl concentration.

In figure 4.52 it is shown the concentration of K^+ / gram dry tissue. Except from the control plants the rest concentrations had similar results with better results of Habana /tomato.

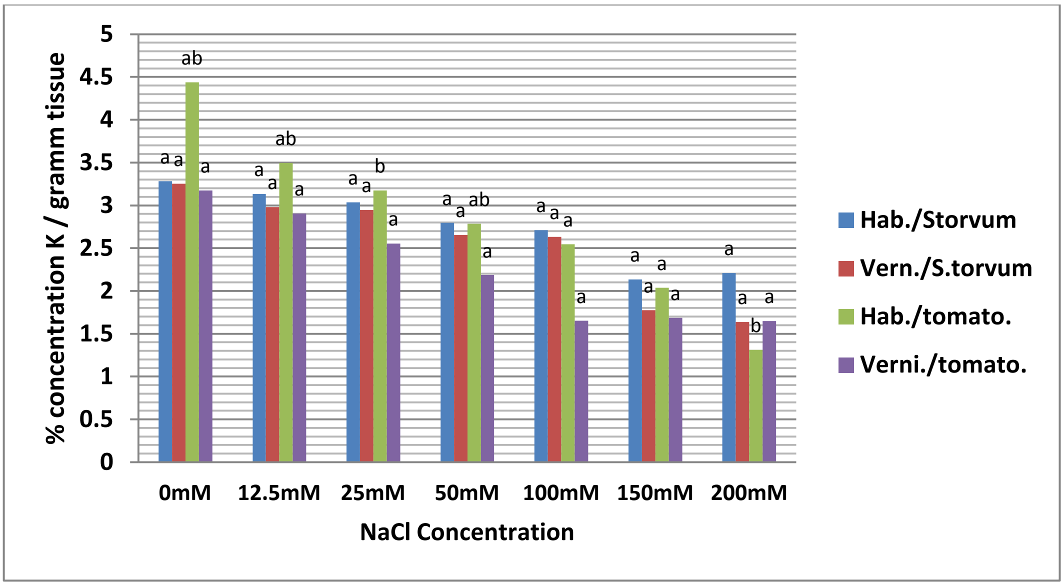


Figure 4.52 Effect of NaCl on the K concentration of tissues of eggplant hybrids (Habana , Vernina) grafted on rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

In figure 4.53 it is shown the concentration of Na / gram dry tissue. The Habana/S.torvum had in almost all concentrations the biggest Na concentration. On the other hand Vernina/tomato has the lowest.

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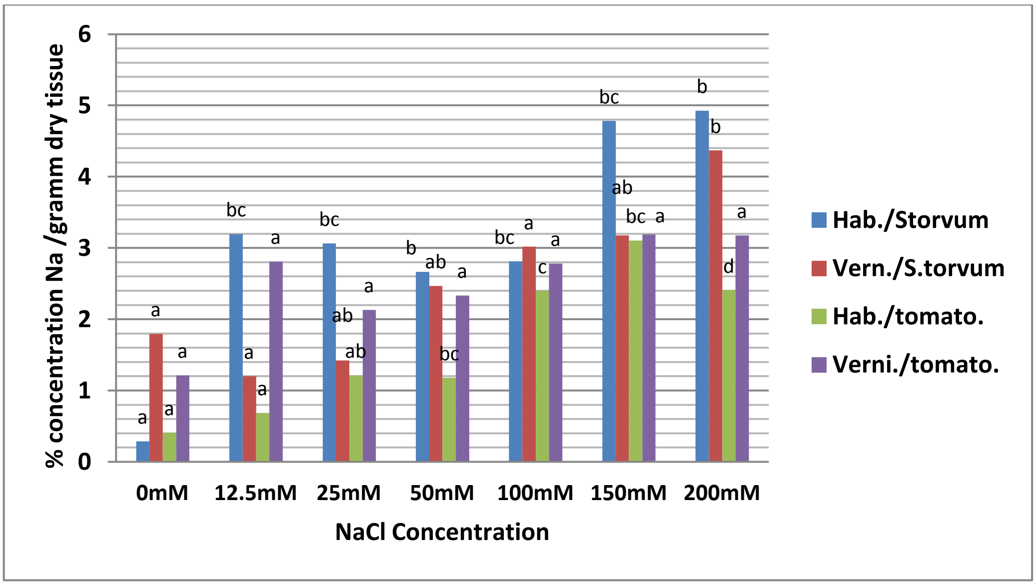

Figure 4.53 Effect of NaCl on Na concentration of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in perlite for 7 weeks.**Bars with the same color,** followed by the same letter are not significantly different at p = 5% level, using Duncan's test.

4.3.8 Enzyme activity

In Table 4.4 the enzyme activity of APX is represented for the grafted plant types. A the higher concentrations the enzyme activity was decreased at all plant types. Habana/resistar had the biggest enzyme activity.

Table 4.4: Effect of NaCl on total activity of APX in leaves of grafted eggplants cultured in perlite for 7 weeks.

NaCl Concentration	Total activity of APX (U mg FW)			
	Habana/S.torvum	Vernina/S.torvum	Habana/resistar	Vernina/resistar
0 Mm	0,061 c	0,084 c	0,079 b	0,070 c
12,5 mM	0,061 bc	0,062 bc	0,041 a	0,099 cd
25 mM	0,053 c	0,049 bc	0,063 b	0,063 bc
50 mM	0,049 bc	0,059 bc	0,112 c	0,107 d
100 mM	0,023 ab	0,029 ab	0,022 a	0,028 ab
150 mM	0,008 a	0,005 a	0,027 a	0,020 a
200 Mm	0,009 a	0,012 a	0,022 a	0,009 a

In Table 4.5 the activity of GPX is represented for the grafted plant types. At the highest concentration the biggest enzyme activity had the Vernina/resistar plants.

Table 4.5: Effect of NaCl on total activity of GPX in leaves of grafted eggplants cultured in perlite for 7 weeks.

NaCl Concentration	Total activity of GPX (U mg FW)			
	Habana/S.torvum	Vernina/S.torvum	Habana/resistar	Vernina/resistar
0 Mm	0,054 a	0,118 ab	0,145 a	0,145 abc
12,5 mM	0,087 a	0,060 a	0,055 a	0,052 a
25 mM	0,167 ab	0,080 ab	0,214 a	0,214 bc
50 mM	0,124 ab	0,379 c	0,115 a	0,378 d
100 mM	0,280 bc	0,217 b	0,054 a	0,102 ab
150 mM	0,426 c	0,061a	0,251 a	0,111 abc
200 Mm	0,179 ab	0,229 b	0,089 a	0,262 cd

In Table 4.6 the activity of POD is represented for the grafted plant types. A the higher concentrations the enzyme activity was similar at the four plant types.

Table 4.6: Effect of NaCl on total activity of POD in leaves of grafted eggplants cultured in perlite for 7 weeks.

NaCl Concentration	Total activity of POD (U mg FW)			
	Habana/S.torvum	Vernina/S.torvum	Habana/resistar	Vernina/resistar
0 Mm	0,004 c	0,003 a	0,004 b	0,004 b
12,5 mM	0,003 bc	0,002 a	0,002 a	0,003 ab
25 mM	0,002 a	0,002 a	0,002 ab	0,002 a
50 mM	0,003 bc	0,003 a	0,004 b	0,005 c
100 mM	0,004 c	0,003 a	0,003 ab	0,003 ab
150 mM	0,002 a	0,002 a	0,003 ab	0,003 a
200 Mm	0,003 bc	0,003 a	0,002 ab	0,003 ab

5. DISCUSION

Salinity as a biotic stress factor affects glycophytes in many part of their function. Plant height and number of leaves can be an indicator of growth rate. According to Fernandez-Munoz (1999) reduction of height is an adjustment of plants to higher concentrations of salinity. In all three experiments the height was reduced as the salt concentration was getting higher. Similar result have been reported at cherry (Papadakis et al 2007), pear trees (Okubo et al 2000) and apple trees (Motosugi et al 1987).

In the results from the experiment in soil the Habana plants and the Vernina had similar results as it concerns the height. Both plant types at the three NaCl lower concentrations had similar height and also similar results in the control plants. At100 and 150 and 200mM treatments, show reduced growth rate in both plant types. In case of Vernina at 150 and 200mM treatments, the height stabilized in the two last measurements (weeks 7 and week 9). On the other hand Habana plants continued to grow in lower NaCl concentrations. The paradox from these measurements' was that although the differences were similar when compared to the control, they had similar results with the lowest concentrations of salt. For the Habana plants 25mM and for the Vernina plants 12.5mM gave similar results with the control plants.

The two plant types that they were as rootstocks showed more differences of the height. That is probably because of the different plant types. The tomato plants were more robust than the *S. torvum* and if the two higher concentrations are excluded, the plants reacted well to salinity, up to 100 mM. The S. torvum plants were not as robust as the tomato plants but they seem to be more resistant to salinity during the period of the experiment.

For the tomato (Resistar) the salinity started to affect plants height after the third week showing a better salt tolerance. By the last measurements the differences were clearer for each concentration. The concentrations of 200mM show the reduction in growth rate and the concentrations of 100 and 150mM had significant differences, with the concentrations of 12.5 25 and 50mM. The concentrations of 12.5 25 and 50mM gave similar results as the last measurements and this could be the salt tolerance of this plant type.

The S.torvum plants showed a very different behavior. The height was smaller than the Resistar plant but the salt tolerance was much higher. The plants were having similar results in almost all concentrations even at week 9, with the exception of the 200mM. This shows a higher salt tolerance of that plant type up to 150mM NaCl.

In the specific the two eggplants had similar results in height and, the Vernina plants had better response. Both plant types in the concentrations of 150 and 200mM were affected negatively than in the rest concentrations. Also at this experiment the control plants did not have the best results compared with the three lowest NaCl concentrations.

For the Resistar and S.torvum the results were different. The Resistar plants had better response at the salinity even at the concentration of 100mM. For the S.torvum plants only the three lower concentrations had similar results with the concentrations of 150 and 200mM in both plant types presenting further reduction. The height results were smaller than the experiment in soil and that could be explained with better conditions in light which gave more compact plants but with better growth as it could be seen in the leaves results.

The grafted plant in hydroponic culture experiment shows that all plant types were affected. The Habana and Vernina grafted with tomato had similar results in the maximum heights On the other hand grafted to S.torvum the maximum heights were significant lower. Similar results were also at salinity tolerance for each concentration. Similar differences had also in the previous experiments when the tomato and S.torvum used as self-rooted. That is an indicator salinity response when grafted or not.

Comparing the two scions Vernina and Habana when grafted to S.torvum had similar results in almost all concentrations, but when grafted to tomato Vernina had slightly better to salinity response up to 100mM NaCl. That might show a better relation between rootstock and scion. Reports of studying grafted tomato plants (Lee 1994 and Ioannou et al 2002) found that were more vigorous and taller as self routed.

Number of leaves is also an important factor that could be affected from salinity and could also be measured as a growth indicator of plants.

In height results the Vernina plants had better results in the leaf number and the Habana plants although they had similar results up to third week, at fifth week the leaf loss was faster than the Vernina plants which started after fifth week. Vernina at concentrations of 150 and 200mM had lower number of leaves compared to Habana. Comparing the tomato and S.torvum plants the results were not in relation with the height. The S.torvum plants did not keep the leaves in all concentrations after seventh week Tomato showed a better response up to the concentration of 100mM. That might has to do with the way the two different plant types handle the concentrations of Na^+ at leaves spaces. Another factor that might have affected the number of leave was the lower temperatures from the other two experiments.

The results from hydroponic experiment the two Hybrids were different as in soil. The Habana plants had a better response compared to the Vernina plants at the last week measurement, but at the meantime of experiment the Vernina had better average number of leaves. The two rootstocks behave similar as in soil experiment. The tomato gave bigger average number of leaves but both plant types started leaf loss after fifth week and also had the lowest number of leaves in the two last concentrations of 150 and 200mM NaCl. Comparing the average number of leaves in all concentrations to the soil cultivation the second experiment had better results due to the better conditions for plants that were at the greenhouse.

In the experiment with grafted plants, the four plant types had similar results. All plants were affected by salinity after the fifth week with higher concentrations presenting the bigger leaf loss. Although the results were expected for the salinity concentration they did not had significant differences capable to result which of grafted plants responded better to salinity.

Chlorophyll content is one of the parameters of salinity tolerance in cultivars (Hernadez *et al*., 1995; Srivastava *et al*., 1998). Garcia-Sanchez et.al., (2002) in citrus cultivars and Papadakis *et al*. (2007) in two varieties of cherries the decreased chlorophyll content in citrus cultivars happened due to the high concentrations of Na^+ and Cl^- ions in the leaves. In soil experiment the Vernina plants in first measurements had higher numbers in Chlorophyll content then they were seems to be affected more than the Habana plants at the end of the measurements. Both plant types at the end of the experiment showed that they were affected from the salinity in all concentrations and the results from the last measurement were similar. The results of tomato and S.torvum were better for S.torvum. The S.torvum had higher chlorophyll concentration in the duration of the experiment than the tomato. At the last week of the experiment the S.torvum plants had higher numbers compared to the tomato.

In the hydroponic experiment the results were similar compared to the soil cultivation. The Vernina plants chlorophyll content had better response compared to the Habana plants. Comparing the two rootstocks the S.torvum plants had better results than the tomato. The *S.torvum* plants at the last week of measurements in the concentration of 200mM had no significant differences. The tomato after the third week had a reduction in the chlorophyll content.

The grafted plants in the third experiment using the tomato as rootstock, the Vernina plants had better response to salinity than the Habana. On the other hand using S.torvum as rootstock the Habana plants had better results compared to Vernina. Vernina at the last measurement had a further reduction of chlorophyll content in all concentrations from the third week. Similar results gave when used with tomato as rootstock.

Chlorophyll fluorescence same as chlorophyll content could be affected by increased salinity.

In the soil experiment all plant types were affect at all concentrations. They were not any significant differences that could give a clear result for the better response to the different salinity treatments. In hydroponic cultivation the Vernina plants had better response than the Habana plants. Although at the last measurement seventh week the differences were not significant. As it concerns the tomato and S.torvum the results show that tomato had better response as previous the differences were not significant.

At the experiment with grafted plants both Vernina and Habana had similar results when grafted at tomato than grafted with S.torvum, Vernina was affected more than the Habana. All concentrations except 12.5mM and control plants showed a significant reduction at chlorophyll fluorescence.

At this experiment as in previous the results were similar presenting that all plant types were affected by salinity and the chlorophyll fluorescence could be used as indicator for measuring salinity responses.

The same could be in effect for the photosynthetic rate.

In the soil experiment the Habana plants were affected more than the Vernina plants. The differences started at the concentration of 25mM up to at the concentration of 100mM. The rootstocks also affected, with S.torvum plants giving better results than tomato. The biggest differences were at 100mM NaCl. All four plant types at the concentration of 200mM had extremely low photosynthetic rate.

At second experiment the results were similar as the soil experiment. The higher concentration had higher numbers of rates than in soil. The Habana plants did not have significant differences with theVernina plants, except in the concentration of 100mM NaCl. The concentration of 200mM Vernina had better results compared to

Habana but not significant one to prove the better tolerance from Habana. The tomato at this experiment had similar results with S.torvum plants, as previously the concentration of 100mM had slight better results for the S.torvum.

The grafted plants experiment also gave similar results as the previous experiments for the final measurements of photosynthetic rate. The Habana when grafted to tomato compared to the S.torvum had a better salinity response. The Vernina plants had opposite results when grafted to tomato and compared to the S.torvum. Also at this experiment the concentration of 100mM seems to be the limit of tolerance for the Habana plants as well as grafted.

The results for all experiments of the photosynthetic rate, chlorophyll content and chlorophyll fluorescence were similar in the majority of the concentrations, despite the fact that the experiment of soil and the other two were under different external weather conditions such as sun light duration and temperatures. This might show that apart from salinity these indicators did not affect the measurement.

Salt stress results in a considerable decrease in the fresh and dry weights of leaves, stems, tillers, fertile tillers, roots and grain yield (Chartzoulakis and Klapaki 2000). It is apparent that soil salinity range has an important determinative effect on fruit yield of eggplant but not on fruit number.

At the experiment in soil, the fresh weight of stem, tomato had a significant difference from the S.torvum and the same as in dry weight. The Habana and Vernina plants although they had similar results at fresh weight, the dry weight results show a higher dry weight of Habana at all concentrations. Comparing the results with the hydroponic cultivation experiment we had similar results as it concerns the plant types itself, the minimum and maximum numbers were higher than in the soil cultivation. This could be relative to the result of height. As previously the Habana had significant differences from the Vernina. The two rootstocks had big differences with better results of *S.torvum. In* the concentration of 150 and 200mM the results were similar. As in the photosynthetic rate results the 100mM seems to be a limit for the rate of growth of the plants.

For the grafted plant experiment, the Habana grafted to tomato had the biggest weight in fresh and in dry weight as also. The rest of grafted plant types had similar results at all concentrations with small difference of Vernina grafted to tomato as well.

Considering the results from the number of leaves we could expect similar results for the fresh and dry weight of them. In soil experiment the Habana and Vernina plants had similar results up to the concentration of 100, but in 150 and 200mM the Habana had bigger weight numbers than Vernina. The dry weight of Habana leaves was significant bigger than all other plant types at all concentrations. The tomato compared to S.torvum plants also has significant differences at all concentrations at fresh and dry weight. The S.torvum plants have similar results at all concentrations and seem not to be affected as the other plant types.

At the hydroponic cultivation in both fresh and dry weight Habana has the significant differences compared to the Vernina plants. The dry weight of Vernina did not affected at all concentrations, although there were small differences at fresh weight and more specific at the concentrations of 100,150 and 200mM. The dry weight also has similar results with the control plants. The two rootstocks had similar results with the exception of control plants compared with other concentration and as previously the concentration of 100mM and more were a limit for leave mass. At the grafted results, Habana grafted to tomato had the bigger weight followed by Vernina grafted to tomato as well. The rootstock of S.torvum had lower weight at with both scions and at all concentrations. The 12.5 and 200mM compared to the rest concentrations had similar results. That happens at both grafted plant types with S.torvum.

The overall differences at leave weight were the maximum and minimum numbers in soil compared with the hydroponic experiments, could be explained with the better conditions that existed in the last two experiments.

It is apparent that soil salinity range has an important determinative effect on fruit yield of eggplant but not on fruits number. In other words, decreased yield of eggplant was not a result of decreased fruit number in plant but decreased mean fruit weight (Shalhevet et al 1983). Also Savvas and Lenz (2000) stated that the detrimental effects of moderate salinity on the yield of hydroponically grown eggplants are due only to a decreased mean fruit weight. This yield response of eggplant was observed at EC values up to 8.1 dS m_1.

The fruit weight at the first experiment show a significant difference in tomato plant and eggplants. More specific the eggplant almost did produce any fruit at the concentrations of 150 and 200mM. The dry weight had similar results. That shows a major affection of eggplant crop production compared to the tomato. In the second experiment the results differ. The eggplants seemed to have better results in fruit production than tomato but when compared the two eggplants, the Habana was affected less than Vernina. At the third experiment where all plant types produced fruits up to the concentration of 100mM and then there was a reduction to production and also to dry weight as well. The Vernina grafted to tomato has better results up to 50mM but in higher concentration the Habana plants were better grafted to both rootstocks.

Once more there were significant differences in maximum and minimum numbers comparing soil and Hydroponic culture.

Akıncı et al. (2004) reported that increasing NaCl in the solution led to a decrease in the K/Na ratio and increased Na in several eggplant varieties. Their investigation showed that as NaCl concentration increased, Na content increased in leaves indicating that the eggplant (which has a glycophytic reaction) could not control uptake of Na.

At the first experiment the Habana plants were more tolerant at salt because of the Na concentration results. The K concentration was reduced at higher concentration at all plant types and Habana plant compared with Vernina has slightly better results up to the concentration of 200mM. S.torvum plants absorbed the greater amounts of Na probably in leaves and that could explain the small numbers in leaves measurements. The self rooted hydroponic experiment as it concerns the Na concentration all four plant types had similar results but in K concentration the Vernina plants affected less than Habana. For the grafted experiment there were no significant differences as it concerns the K absorption at all four plant types. As it was meant to be the higher the Na concentration became with lower K concentrations. On the other hand at Na concentration Habana grafted to S. torvum seems to be affected more than the other plant types. At 200mM the plant grafted with tomato gave better results than the grafted to S.torvum.

In most reported experiments concerning antioxidant enzyme activity under salinity stress, the stress was imposed to plants for a few days only or a few weeks. For example in alfalfa for seven days (Wang et al., 2009) and in Cassia for five and seven days, (Agarwal and Pandey 2004). A possibility is that after a long period under salinity stress the antioxidant enzyme activity changes.

Unfortunately there were no significant changes in the activity of POD as the concentrations increased in all plant types. The GPX activity Habana grafted to torvum was affected by salinity. There was an incresed GPX activity up to 150mM. Higher activity was presented at Vernina grafted to tomato and S.torvum but only up to the 50mM concentration. At APX enzyme activity the results were not clear for all plant types. Only a increased activity was measured at the concentration of 50mM for Habana and Vernina when grafted to tomato than grafted to S.torvum.

6. General conclusions and Future work.

- Affected all the plants types grafted or not.
- Stronger effect at the 50mM and higher.
- Grafting improved salinity tolerance.
- Enzyme activity did not have clear results.

Future work

For future work we could be continue the:

- Research trying different K concentrations to the hydroponic recipe.
- Further research at fruit production and if taste of them is affected from salinity.
- Trying other eggplant hybrids as grafted
- Measuring the weight of roots of rootstocks might help to define salinity tolerance.

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Appendix A

Plate A0. Cultivation in soil at primary and subsequent time.

Plate A1. Salinity effect to Habana eggplants in soil cultivation, after seven weeks from 0mM to the left up to 200mM to the right.

Plate A2. Salinity effect to Vernina eggplants in soil cultivation, after seven weeks from 0mM to the left up to 200mM to the right.

Plate A3. Salinity effect to Resistar tomato in soil cultivation, after seven weeks from 0mM to the left up to 200mM to the right.

Plate A4. Salinity effect to Solanum torvum eggplants in soil cultivation, after seven weeks from 0mM to the left up to 200mM to the right.

Plate A5. Salinity effect to Resistar tomato plants in perlite cultivation, after seven weeks from 0mM to the left up to 200mM to the right.

Plate A6. Salinity effect to Solanum torvum plants in perlite cultivation, after seven weeks from 0mM to the left up to 200mM to the right.

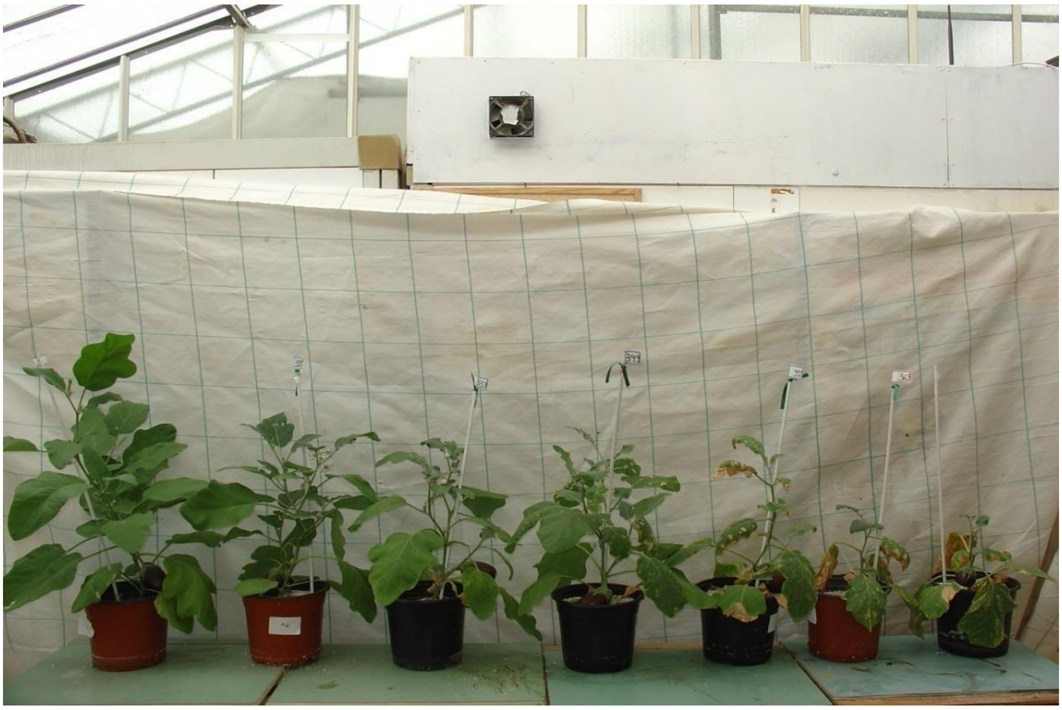

Plate A7. Salinity effect to Habana eggplants in perlite cultivation, after seven weeks from 0mM to the left up to 200mM to the right.

Plate A8. Salinity effect to Vernina eggplants in perlite cultivation, after seven weeks from 0mM to the right up to 200mM to the left.

Appendix B

Hydroponic Culture in Perlite

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	704,405	6	117,401	1,587	,162
	Within Groups	5696,167	77	73,976		
	Total	6400,571	83			
Vernina	Between Groups	1406,407	6	234,401	2,773	,017
	Within Groups	6508,083	77	84,521		
	Total	7914,490	83			
S.torvum	Between Groups	112,905	6	18,817	2,973	,012
	Within Groups	487,417	77	6,330		
	Total	600,321	83			
Resistar	Between Groups	2995,905	6	499,317	29,280	,000
	Within Groups	1313,083	77	17,053		
	Total	4308,988	83			

Figure 4.1.1 Effect of NaCl on the height of eggplant hybrid and rootstocks plants after cultured in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	50,432	6	8,405	12,163	,000
	Within Groups	48,373	70	,691		
	Total	98,805	76			
Vernina	Between Groups	305,344	6	50,891	27,613	,000
	Within Groups	125,323	68	1,843		
	Total	430,667	74			
S.torvum	Between Groups	62,905	6	10,484	18,313	,000
	Within Groups	44,083	77	,573		
	Total	106,988	83			
Resistar	Between Groups	237,786	6	39,631	45,603	,000
	Within Groups	66,917	77	,869		
	Total	304,702	83			

Figure 4.1.2 Effect of NaCl on the number of leaves of eggplant hybrid and rootstocks plants after cultured in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	599,311	6	99,885	1,523	,182
	Within Groups	5050,517	77	65,591		
	Total	5649,828	83			
Vernina	Between Groups	2090,123	6	348,354	4,190	,001
	Within Groups	6151,993	74	83,135		
	Total	8242,116	80			
S.torvum	Between Groups	1937,712	6	322,952	5,194	,000
	Within Groups	4663,116	75	62,175		
	Total	6600,828	81			
Resistar	Between Groups	576,326	6	96,054	4,589	,000
	Within Groups	1611,673	77	20,931		
	Total	2188,000	83			

Figure 4.1.3 Effect of NaCl on the number of chlorophyll content of eggplant hybrid and rootstocks plants after cultured in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	,033	6	,006	,141	,990
	Within Groups	3,014	77	,039		
	Total	3,047	83			
Vernina	Between Groups	71,577	6	11,930	1,015	,422
	Within Groups	869,658	74	11,752		
	Total	941,235	80			
S.torvum	Between Groups	,085	6	,014	2,901	,013
	Within Groups	,367	75	,005		
	Total	,453	81			
Resistar	Between Groups	,054	6	,009	8,831	,000
	Within Groups	,078	77	,001		
	Total	,132	83			

Figure 4.1.4 Effect of NaCl on the number of chlorophyll fluorescence of eggplant hybrid and rootstocks plants after cultured in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	754,151	6	125,692	6,562	,000
	Within Groups	1359,988	71	19,155		
	Total	2114,139	77			
Vernina	Between Groups	649,012	6	108,169	15,098	,000
	Within Groups	508,676	71	7,164		
	Total	1157,688	77			
S.torvum	Between Groups	823,623	6	137,270	4,128	,001
	Within Groups	2560,722	77	33,256		
	Total	3384,345	83			
Resistar	Between Groups	917,227	6	152,871	11,331	,000
	Within Groups	1038,800	77	13,491		
	Total	1956,027	83			

Figure 4.1.21 Effect of NaCl on the photosynthetic rate of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	1503,725	6	250,621	15,142	,000
	Within Groups	1191,702	72	16,551		
	Total	2695,427	78			
Vernina	Between Groups	3271,394	6	545,232	38,971	,000
	Within Groups	993,341	71	13,991		
	Total	4264,735	77			
S.torvum	Between Groups	252,361	6	42,060	23,467	,000
	Within Groups	134,424	75	1,792		
	Total	386,784	81			
Resistar	Between Groups	5941,188	6	990,198	17,501	,000
	Within Groups	4356,602	77	56,579		
	Total	10297,790	83			

Figure 4.1.22 Effect of NaCl on the fresh weight of leaves of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	24,011	6	4,002	11,880	,000
	Within Groups	23,918	71	,337		
	Total	47,929	77			
Vernina	Between Groups	24,775	6	4,129	37,442	,000
	Within Groups	7,720	70	,110		
	Total	32,494	76			
S.torvum	Between Groups	5,639	6	,940	23,564	,000
	Within Groups	2,992	75	,040		
	Total	8,631	81			
Resistar	Between Groups	48,593	6	8,099	36,251	,000
	Within Groups	17,203	77	,223		
	Total	65,795	83			

Figure 4.1.27 Effect of NaCl on the dry weight of leaves of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	270,515	6	45,086	6,223	,000
	Within Groups	521,683	72	7,246		
	Total	792,198	78			
Vernina	Between Groups	223,326	6	37,221	5,419	,000
	Within Groups	494,561	72	6,869		
	Total	717,887	78			
S.torvum	Between Groups	6,055	6	1,009	7,330	,000
	Within Groups	10,601	77	,138		
	Total	16,656	83			
Resistar	Between Groups	521,826	6	86,971	21,533	,000
	Within Groups	311,007	77	4,039		
	Total	832,833	83			

Figure 4.1.26 Effect of NaCl on the fresh weight of stem of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	2,733	6	,455	6,321	,000
	Within Groups	5,188	72	,072		
	Total	7,921	78			
Vernina	Between Groups	47,466	6	7,911	,908	,494
	Within Groups	626,969	72	8,708		
	Total	674,435	78			
S.torvum	Between Groups	,219	6	,036	6,151	,000
	Within Groups	,457	77	,006		
	Total	,675	83			
Resistar	Between Groups	4,190	6	,698	12,924	,000
	Within Groups	4,161	77	,054		
	Total	8,351	83			

Figure 4.1.27 Effect of NaCl on the dry weight of stem of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	142,381	6	23,730	3,725	,007
	Within Groups	197,513	31	6,371		
	Total	339,894	37			
Vernina	Between Groups	162,511	6	27,085	4,799	,003
	Within Groups	129,812	23	5,644		
	Total	292,323	29			
Resistar	Between Groups	1168,529	6	194,755	7,616	,000
	Within Groups	1687,741	66	25,572		
	Total	2856,270	72			

Figure 4.1.27 Effect of NaCl on the fresh weight of fruits of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	4,886	6	,814	3,671	,007
	Within Groups	6,654	30	,222		
	Total	11,540	36			
Vernina	Between Groups	1,027	6	,171	1,523	,211
	Within Groups	2,810	25	,112		
	Total	3,838	31			
Resistar	Between Groups	29,227	6	4,871	1,539	,179
	Within Groups	208,931	66	3,166		
	Total	238,158	72			

Figure 4.1.27 Effect of NaCl on the dry weight of fruits of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	11,755	6	1,959	2,104	,118
	Within Groups	13,034	14	,931		
	Total	24,789	20			
Vernina	Between Groups	7,772	6	1,295	1,491	,251
	Within Groups	12,162	14	,869		
	Total	19,934	20			
S.torvum	Between Groups	17,694	6	2,949	5,287	,005
	Within Groups	7,808	14	,558		
	Total	25,502	20			
Resistar	Between Groups	6,012	6	1,002	,915	,513
	Within Groups	15,332	14	1,095		
	Total	21,344	20			

Figure 4.1.28 Effect of NaCl on the K concentration of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	10,827	6	1,804	2,220	,103
	Within Groups	11,378	14	,813		
	Total	22,204	20			
Vernina	Between Groups	6,215	6	1,036	1,655	,205
	Within Groups	8,762	14	,626		
	Total	14,976	20			
S.torvum	Between Groups	19,474	6	3,246	4,581	,009
	Within Groups	9,919	14	,709		
	Total	29,393	20			
Resistar	Between Groups	6,489	6	1,082	1,423	,274
	Within Groups	10,639	14	,760		
	Total	17,128	20			

Figure 4.1.29 Effect of NaCl on the dry weight of stem of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 9 weeks.

Hydorponic cultivation

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	164,286	6	27,381	4,478	,001
	Within Groups	385,200	63	6,114		
	Total	549,486	69			
S.torvum	Between Groups	122,943	6	20,490	8,830	,000
	Within Groups	146,200	63	2,321		
	Total	269,143	69			
Habana	Between Groups	232,743	6	38,790	12,274	,000
	Within Groups	199,100	63	3,160		
	Total	431,843	69			
Vernina	Between Groups	119,200	6	19,867	1,631	,153
	Within Groups	767,500	63	12,183		
	Total	886,700	69			

Figure 4.2.5 Effect of NaCl on the height of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	584,771	6	97,462	26,813	,000
	Within Groups	229,000	63	3,635		
	Total	813,771	69			
S.torvum	Between Groups	240,286	6	40,048	36,725	,000
	Within Groups	68,700	63	1,090		
	Total	308,986	69			
Habana	Between Groups	211,371	6	35,229	10,275	,000
	Within Groups	216,000	63	3,429		
	Total	427,371	69			
Vernina	Between Groups	468,371	6	78,062	22,183	,000
	Within Groups	221,700	63	3,519		
	Total	690,071	69			

Figure 4.2.10 Effect of NaCl on the number of leaves of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	689,885	6	114,981	6,274	,000
	Within Groups	1154,645	63	18,328		
	Total	1844,530	69			
S.torvum	Between Groups	1842,173	6	307,029	5,644	,000
	Within Groups	3318,248	61	54,398		
	Total	5160,421	67			
Habana	Between Groups	562,557	6	93,760	11,968	,000
	Within Groups	493,546	63	7,834		
	Total	1056,103	69			
Vernina	Between Groups	2071,457	6	345,243	11,393	,000
	Within Groups	1818,246	60	30,304		
	Total	3889,703	66			

Figure 4.2.15 Effect of NaCl on the chlorophyl content of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	5826,400	6	971,067	389,345	,000
	Within Groups	157,128	63	2,494		
	Total	5983,529	69			
S.torvum	Between Groups	,107	6	,018	3,064	,011
	Within Groups	,367	63	,006		
	Total	,473	69			
Habana	Between Groups	3979,227	6	663,204	2501,272	,000
	Within Groups	16,704	63	,265		
	Total	3995,931	69			
Vernina	Between Groups	,024	6	,004	,871	,521
	Within Groups	,284	63	,005		
	Total	,308	69			

Figure 4.2.19 Effect of NaCl on the chlorophyl fluorescence of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	742,120	6	123,687	201,243	,000
	Within Groups	38,721	63	,615		
	Total	780,841	69			
S.torvum	Between Groups	553,497	6	92,249	140,772	,000
	Within Groups	41,285	63	,655		
	Total	594,782	69			
Habana	Between Groups	601,628	6	100,271	91,251	,000
	Within Groups	69,227	63	1,099		
	Total	670,855	69			
Vernina	Between Groups	512,154	6	85,359	85,858	,000
	Within Groups	62,634	63	,994		
	Total	574,788	69			

Figure 4.2.20 Effect of NaCl on the photosynthetic rate of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	21154,073	6	3525,679	3,590	,005
	Within Groups	45179,804	46	982,170		
	Total	66333,877	52			
S.torvum	Between Groups	41998,260	6	6999,710	15,561	,000
	Within Groups	22491,775	50	449,835		
	Total	64490,035	56			
Habana	Between Groups	46609,726	6	7768,288	1,766	,126
	Within Groups	211104,710	48	4398,015		
	Total	257714,436	54			
Vernina	Between Groups	16052,622	6	2675,437	3,263	,009
	Within Groups	40999,097	50	819,982		
	Total	57051,719	56			

Figure 4.2.21 Effect of NaCl on the fresh weight of leaves of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	1035,780	6	172,630	1,829	,114
	Within Groups	4341,361	46	94,377		
	Total	5377,141	52			
S.torvum	Between Groups	1090,318	6	181,720	2,411	,039
	Within Groups	4144,769	55	75,359		
	Total	5235,087	61			
Habana	Between Groups	828,773	6	138,129	2,254	,054
	Within Groups	2941,419	48	61,280		
	Total	3770,192	54			
Vernina	Between Groups	125,524	6	20,921	2,236	,055
	Within Groups	467,803	50	9,356		
	Total	593,327	56			

Figure 4.2.21 Effect of NaCl on the dry weight of leaves of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	35214,295	6	5869,049	2,184	,062
	Within Groups	120949,902	45	2687,776		
	Total	156164,198	51			
Habana	Between Groups	54652,874	6	9108,812	7,926	,000
	Within Groups	59762,221	52	1149,273		
	Total	114415,095	58			
Vernina	Between Groups	50653,223	6	8442,204	1,525	,189
	Within Groups	276753,439	50	5535,069		
	Total	327406,662	56			

Figure 4.2.22 Effect of NaCl on the fresh weight of fruits of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	528,579	6	88,096	1,918	,099
	Within Groups	2066,884	45	45,931		
	Total	2595,463	51			
Habana	Between Groups	2153,553	6	358,926	,638	,700
	Within Groups	28149,838	50	562,997		
	Total	30303,392	56			
Vernina	Between Groups	967,814	6	161,302	1,045	,407
	Within Groups	8183,539	53	154,406		
	Total	9151,353	59			

Figure 4.1.23 Effect of NaCl on the dry weight of lfruits of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	1669,597	6	278,266	3,229	,010
	Within Groups	4050,953	47	86,190		
	Total	5720,550	53			
Habana	Between Groups	32553,493	6	5425,582	3,355	,007
	Within Groups	84087,083	52	1617,059		
	Total	116640,576	58			
Vernina	Between Groups	12366,302	6	2061,050	1,230	,306
	Within Groups	87139,833	52	1675,766		
	Total	99506,136	58			
S.torvum	Between Groups	31487,133	6	5247,855	10,776	,000
	Within Groups	26784,544	55	486,992		
	Total	58271,677	61			

Figure 4.2.24 Effect of NaCl on the fresh weight of stem of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Resistar	Between Groups	37,668	6	6,278	,915	,493
	Within Groups	315,471	46	6,858		
	Total	353,139	52			
Habana	Between Groups	419,204	6	69,867	1,820	,114
	Within Groups	1919,301	50	38,386		
	Total	2338,505	56			
Vernina	Between Groups	17,653	6	2,942	,864	,528
	Within Groups	170,256	50	3,405		
	Total	187,910	56			
S.torvum	Between Groups	600,960	6	100,160	6,215	,000
	Within Groups	870,276	54	16,116		
	Total	1471,236	60			

Figure 4.2.25 Effect of NaCl on the dry weight of stem of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	18,650	6	3,108	5,511	,004
	Within Groups	7,896	14	,564		
	Total	26,546	20			
Vernina	Between Groups	12,429	6	2,072	5,750	,003
	Within Groups	5,044	14	,360		
	Total	17,473	20			
S.torvum	Between Groups	15,927	6	2,654	5,617	,004
	Within Groups	6,616	14	,473		
	Total	22,543	20			
Resistar	Between Groups	11,890	6	1,982	4,908	,007
	Within Groups	5,653	14	,404		
	Total	17,542	20			

Figure 4.2.26 Effect of NaCl on the K concentration of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana	Between Groups	26,761	6	4,460	2,859	,049
	Within Groups	21,842	14	1,560		
	Total	48,604	20			
Vernina	Between Groups	38,666	6	6,444	52,394	,000
	Within Groups	1,722	14	,123		
	Total	40,388	20			
S.torvum	Between Groups	25,953	6	4,326	6,319	,002
	Within Groups	9,584	14	,685		
	Total	35,537	20			
Resistar	Between Groups	25,177	6	4,196	4,473	,010
	Within Groups	13,133	14	,938		
	Total	38,310	20			

Figure 4.2.27 Effect of NaCl on the Na concentration of eggplants hybrids (Habana , Vernina) and two future rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

Hydroponic cultivation with grafted plants.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Habana S.torvum	Between Groups	596,943	6	99,490	4,279	,001
	Within Groups	1464,900	63	23,252		
	Total	2061,843	69			
Vernina Resistar	Between Groups	2871,143	6	478,524	13,161	,000
	Within Groups	2290,700	63	36,360		
	Total	5161,843	69			
Habana Resistar	Between Groups	1472,286	6	245,381	8,444	,000
	Within Groups	1830,800	63	29,060		
	Total	3303,086	69			
Vernina S.torvum	Between Groups	1035,686	6	172,614	7,263	,000
	Within Groups	1497,300	63	23,767		
	Total	2532,986	69			

Figure 4.3.5 Effect of NaCl on the height of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	13,086	6	2,181	2,993	,012
	Within Groups	45,900	63	,729		
	Total	58,986	69			
VerninaResistar	Between Groups	33,943	6	5,657	6,376	,000
	Within Groups	55,900	63	,887		
	Total	89,843	69			
HabanaResistar	Between Groups	6,486	6	1,081	1,285	,277
	Within Groups	53,000	63	,841		
	Total	59,486	69			
VerninaS.torvum	Between Groups	16,086	6	2,681	6,374	,000
	Within Groups	26,500	63	,421		
	Total	42,586	69			

Figure 4.3.10 Effect of NaCl the average number of fully developed leaves of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	587,067	6	97,844	13,486	,000
	Within Groups	181,382	25	7,255		
	Total	768,449	31			
VerninaResistar	Between Groups	1239,008	6	206,501	5,796	,004
	Within Groups	463,201	13	35,631		
	Total	1702,209	19			
HabanaResistar	Between Groups	669,188	6	111,531	5,252	,002
	Within Groups	424,751	20	21,238		
	Total	1093,939	26			
VerninaS.torvum	Between Groups	434,457	6	72,410	,491	,809
	Within Groups	3539,182	24	147,466		
	Total	3973,639	30			

Figure 4.3.15 Effect of NaCl in the average number of chlorophyll content of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	,034	6	,006	1,792	,157
	Within Groups	,057	18	,003		
	Total	,092	24			
VerninaResistar	Between Groups	,014	6	,002	,728	,641
	Within Groups	,026	8	,003		
	Total	,040	14			
HabanaResistar	Between Groups	,035	6	,006	2,949	,037
	Within Groups	,034	17	,002		
	Total	,069	23			
VerninaS.torvum	Between Groups	,071	6	,012	2,210	,109
	Within Groups	,070	13	,005		
	Total	,141	19			

Figure 4.3.20 ffect of NaCl on the chlorophyl fluorescence of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	554,116	6	92,353	15,477	,000
	Within Groups	375,937	63	5,967		
	Total	930,052	69			
VerninaResistar	Between Groups	763,660	6	127,277	32,632	,000
	Within Groups	245,725	63	3,900		
	Total	1009,385	69			
HabanaResistar	Between Groups	840,641	6	140,107	44,301	,000
	Within Groups	199,246	63	3,163		
	Total	1039,887	69			
VerninaS.torvum	Between Groups	692,633	6	115,439	25,418	,000
	Within Groups	286,127	63	4,542		
	Total	978,760	69			

Figure 4.3.21 Effect of NaCl on the photosynthetic rate of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	16154,015	6	2692,336	12,397	,000
	Within Groups	13682,336	63	217,180		
	Total	29836,351	69			
VerninaResistar	Between Groups	1681516,329	6	280252,721	1,185	,326
	Within Groups	1,466E7	62	236519,155		
	Total	1,635E7	68			
HabanaResistar	Between Groups	40328,327	6	6721,388	7,597	,000
	Within Groups	55740,943	63	884,777		
	Total	96069,270	69			
VerninaS.torvum	Between Groups	14489,882	6	2414,980	16,600	,000
	Within Groups	9165,296	63	145,481		
	Total	23655,178	69			

Figure 4.3.22 Effect of NaCl on the fresh weight of leaves of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	247,615	6	41,269	15,937	,000
	Within Groups	163,144	63	2,590		
	Total	410,759	69			
VerninaResistar	Between Groups	389,651	6	64,942	16,593	,000
	Within Groups	242,655	62	3,914		
	Total	632,306	68			
HabanaResistar	Between Groups	714,033	6	119,005	12,061	,000
	Within Groups	621,633	63	9,867		
	Total	1335,666	69			
VerninaS.torvum	Between Groups	2410,312	6	401,719	1,858	,102
	Within Groups	13623,365	63	216,244		
	Total	16033,677	69			

Figure 4.1.23 Effect of NaCl on the dry weight of leaves of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	105626,383	6	17604,397	10,397	,000
	Within Groups	88048,498	52	1693,240		
	Total	193674,882	58			
VerninaResistar	Between Groups	212040,006	6	35340,001	5,100	,000
	Within Groups	332604,881	48	6929,268		
	Total	544644,887	54			
HabanaResistar	Between Groups	68064,150	6	11344,025	3,167	,010
	Within Groups	179070,563	50	3581,411		
	Total	247134,713	56			
VerninaS.torvum	Between Groups	198507,828	6	33084,638	14,245	,000
	Within Groups	118453,149	51	2322,611		
	Total	316960,977	57			

Figure 4.3.24 Effect of NaCl on the fresh weight of fruits of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	476,598	6	79,433	6,139	,000
	Within Groups	763,461	59	12,940		
	Total	1240,059	65			
VerninaResistar	Between Groups	5254,651	6	875,775	2,013	,081
	Within Groups	22190,385	51	435,106		
	Total	27445,036	57			
HabanaResistar	Between Groups	413,177	6	68,863	3,383	,007
	Within Groups	1038,028	51	20,353		
	Total	1451,205	57			
VerninaS.torvum	Between Groups	1196,234	6	199,372	19,891	,000
	Within Groups	581,336	58	10,023		
	Total	1777,570	64			

Figure 4.3.25 Effect of NaCl on the dry weight of fruits of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	1655,590	6	275,932	6,360	,000
	Within Groups	2733,123	63	43,383		
	Total	4388,713	69			
VerninaResistar	Between Groups	1108,566	6	184,761	6,471	,000
	Within Groups	1741,572	61	28,550		
	Total	2850,138	67			
HabanaResistar	Between Groups	6994,311	6	1165,718	4,584	,001
	Within Groups	16020,403	63	254,292		
	Total	23014,714	69			
VerninaS.torvum	Between Groups	1584,754	6	264,126	2,016	,077
	Within Groups	8255,195	63	131,035		
	Total	9839,949	69			

Figure 4.3.26 Effect of NaCl on the fresh weight of stem of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	38,377	6	6,396	6,194	,000
	Within Groups	65,062	63	1,033		
	Total	103,439	69			
VerninaResistar	Between Groups	56,409	6	9,402	4,341	,001
	Within Groups	132,101	61	2,166		
	Total	188,510	67			
HabanaResistar	Between Groups	207,265	6	34,544	10,673	,000
	Within Groups	200,664	62	3,237		
	Total	407,929	68			
VerninaS.torvum	Between Groups	60,065	6	10,011	9,700	,000
	Within Groups	65,018	63	1,032		
	Total	125,083	69			

Figure 4.3.27 Effect of NaCl on the dry weight of stem of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	3,560	6	,593	,311	,921
	Within Groups	26,707	14	1,908		
	Total	30,267	20			
VerninaS.torvum	Between Groups	6,853	6	1,142	,776	,602
	Within Groups	20,600	14	1,471		
	Total	27,454	20			
HabanaResistar	Between Groups	26,767	6	4,461	3,250	,032
	Within Groups	19,217	14	1,373		
	Total	45,984	20			
VerninaResistar	Between Groups	7,245	6	1,207	1,901	,151
	Within Groups	8,892	14	,635		
	Total	16,137	20			

Figure 4.3.28 Effect of NaCl on the K concentration of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	43,086	6	7,181	5,557	,004
	Within Groups	18,090	14	1,292		
	Total	61,176	20			
VerninaS.torvum	Between Groups	22,700	6	3,783	3,031	,041
	Within Groups	17,477	14	1,248		
	Total	40,177	20			
HabanaResistar	Between Groups	39,583	6	6,597	11,706	,000
	Within Groups	7,890	14	,564		
	Total	47,473	20			
VerninaResistar	Between Groups	8,789	6	1,465	,822	,571
	Within Groups	24,953	14	1,782		
	Total	33,743	20			

Figure 4.3.29 Effect of NaCl on Na concentration of eggplants hybrids (Habana , Vernina) on grafted rootstocks (Hybrid tomato Resistar and *Solanum torvum*) after culture in soil for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	,012	6	,002	6,421	,002
	Within Groups	,004	14	,000		
	Total	,017	20			
VerninaS.torvum	Between Groups	,015	6	,002	6,457	,002
	Within Groups	,005	14	,000		
	Total	,020	20			
HabanaResistar	Between Groups	,021	6	,003	23,595	,000
	Within Groups	,002	14	,000		
	Total	,023	20			
VerninaResistar	Between Groups	,027	6	,004	10,920	,000
	Within Groups	,006	14	,000		
	Total	,033	20			

Figure 4.3.1: Effect of NaCl on total activity of APX in leaves of grafted eggplants cultured in perlite for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	,292	6	,049	5,066	,006
	Within Groups	,135	14	,010		
	Total	,427	20			
VerninaS.torvum	Between Groups	,254	6	,042	6,699	,002
	Within Groups	,088	14	,006		
	Total	,342	20			
HabanaResistar	Between Groups	,106	6	,018	1,103	,408
	Within Groups	,225	14	,016		
	Total	,331	20			
VerninaResistar	Between Groups	,229	6	,038	5,979	,003
	Within Groups	,089	14	,006		
	Total	,318	20			

Figure 4.3.2: Effect of NaCl on total activity of GPX in leaves of grafted eggplants cultured in perlite for 7 weeks.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HabanaS.torvum	Between Groups	,000	6	,000	3,385	,028
	Within Groups	,000	14	,000		
	Total	,000	20			
VerninaS.torvum	Between Groups	,000	6	,000	,615	,715
	Within Groups	,000	14	,000		
	Total	,000	20			
HabanaResistar	Between Groups	,000	6	,000	2,515	,073
	Within Groups	,000	14	,000		
	Total	,000	20			
VerninaResistar	Between Groups	,000	6	,000	6,889	,001
	Within Groups	,000	14	,000		
	Total	,000	20			

Figure 4.3.3: Effect of NaCl on total activity of POD in leaves of grafted eggplants cultured in perlite for 7 weeks.