Salinity effects on selected tomato genotypes from the *Solanum lycopersicum* cv. ‘Moneymaker’ x *S. habrochaites* LYC4 introgression line population

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MSc

Abstract

Large agricultural areas are under salinization in many world regions, threatening world food production. High soil salinity leads to osmotic, ionic and oxidative stress in plants, affecting the plants morphology, physiology and biochemistry, resulting in lower productivity of many crops. Wild tomatoes offer an interesting gene pool that can be explored, to improve salt tolerance in cultivated tomato (*Solanum lycopersicum*).

Nine introgression lines (IL) from the LYC4 tomato population were selected to compare their responses under saline conditions (~50 mM NaCl added to the nutrient solution) with the recurrent parent line 'Moneymaker' (MM). The plant responses were evaluated in terms of growth and development, until 145 days after sowing (DAS). At 103 and 145 DAS, the ions content (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-}) were determined in young leaves, old leaves and stems.

Until 103 DAS, salinity reduced total fresh weight (TFW), total fruits fresh weight (FFW), leaf area (LA) and leaf area ratio (LAR), while the chlorophyll content (Chl) and blossom-end rot incidence (BER) were increased. In general, the concentration of K^+ and Mg^{2+}, and the K^+:Na^+ and Ca^{2+}:Na^+ were decreased. None of the ILs showed higher salt tolerance than MM, according to the evaluated traits, until that stage of development.

At 145 DAS, reductions in total dry weight (-11%) and fresh weight (-21%) were mainly owed to lower fruit dry weight (due to a decreased number of fruits and a lower average fruit weight). Reduced marketable dry yield (-22%) and fresh yield (-33%), were further explained by higher BER incidence, mainly in MM, IL2-3, IL6-1, IL6-2 and IL10-4. Different patterns of ions accumulation were found among young leaves, old leaves and stems.

Based on K^+:Na^+ and Ca^{2+}:Na^+ ratios, genotype IL12-1 showed higher salt tolerance compared with MM, while none of the ILs showed to be more salt tolerant in terms of total biomass produced (DW and FW), or in a total fruit yield basis. These findings improve our knowledge about these selected genotypes, and can be used in salt tolerance improvement of tomato, through breeding programs, by selecting characteristics of interest.

Keywords: introgression line, ions content, salinity, tolerance, tomato, yield.

Resumo

Grandes áreas de produção agrícola em várias regiões do mundo, encontram-se em condições de salinidade, ameaçando a produção mundial de alimentos. A elevada salinidade do solo leva a estresse osmótico, iónico e oxidativo nas plantas, afetando a morfologia, fisiologia e bioquímica das plantas, resultando em decréscimo da produtividade de muitas culturas. As espécies indígenas de tomate, oferecem um interessante *pool* genético que pode ser explorado, visando o melhoramento da tolerância à salinidade no tomate cultivado (*Solanum lycopersicum*).

Nove linhas de introgressão (IL) da população LYC4 de tomate, foram selecionadas para comparar as respostas sob condições de salinidade (~50 mM NaCl adicionados à solução nutritiva), com a linha parental 'Moneymaker' (MM). As respostas foram avaliadas relativamente ao crescimento e desenvolvimento, até 145 dias após a sementeira (DAS). Aos 103 e 145 DAS, o conteúdo iónico (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^- e SO_4^{2-}) foi determinado em folhas jovens, folhas velhas e caules.

Até 103 DAS, a salinidade reduziu o peso fresco total (TFW), o peso fresco total de frutos (FFW), a área foliar (LA) e o rácio de área foliar (LAR), enquanto o conteúdo de clorofila (Chl) e a incidência de *blossom-end rot* (BER) foram aumentados. No geral, a concentração de K^+ e Mg^{2+}, e os rácios K^+:Na^+, Ca^{2+}:Na^+ foram diminuídos. Nenhuma das ILs mostrou maior tolerância à salinidade comparativamente com MM, de acordo com as características avaliadas, até esse estádio de desenvolvimento.

Aos 145 DAS, reduções no peso seco total (-11%) e peso fresco total (-21%), foram principalmente devidas ao menor peso seco dos frutos (devido a uma diminuição do nº de frutos e do peso médio dos frutos). Diminuições da produção comercializável em fresco (-33%) e em seco (-22%), foram ainda explicadas por maior incidência de BER, principalmente em MM, IL2-3, IL6-1, IL6-2 e IL10-4. Diferentes padrões na acumulação de iões foram encontrados entre folhas jovens, folhas velhas e caules.

Com base nos rácios K^+:Na^+ e Ca^{2+}:Na^+, o genótipo IL12-1 mostrou maior tolerância à salinidade comparativamente com MM, porém nenhuma das ILs mostrou maior tolerância em termos de biomassa total produzida (DW e FW), ou com base na produção total de frutos. Estas descobertas melhoram o nosso conhecimento acerca dos genótipos selecionados e podem ser utilizadas na melhoria da tolerância à salinidade no tomate, em programas de melhoramento genético, através da seleção de características de interesse.

Palavras-chave: linha de introgressão, conteúdo iónico, salinidade, tolerância, tomate, produtividade.

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“One day, in retrospect, the years of struggle will strike you as the most beautiful”.

Sigmund Freud.

Table of contents

List of figures

Figures in appendixes

List of tables

Tables in appendixes

Abbreviations

ABA: abscisic acid

AFW: average fruit weight

BER: blossom-end rot

Chl: chlorophyll content

DAS: days after sowing

EC: electrical conductivity

FDW: fruits dry weight

FFW: fruits fresh weight

HKT: high affinity K^+ transporter

IL: introgression line

LA: leaf area

LAI: leaf area index

LAR: leaf area ratio

LDW: leaf dry weight

LFW: leaf fresh weight

MFDW: marketable fruits dry weight

MFFW: marketable fruits fresh weight

MM: moneymaker

NF: number of fruits

NL: number of leaves

NT: number of trusses

PTL: partitioning to the leaves

ROS: reactive oxygen species

RWC: relative water content

SDW: stem dry weight

SFW: stem fresh weight

SL: stem length

SLA: specific leaf area

SOS: salt overly sensitive

TDW: total dry weight

TFW: total fresh weight

TSS: total soluble solids

1. Introduction

Large agricultural areas are under influence of salinization in many world regions, and this abiotic stress is a major threat to world food production (Munns, 2002; Villalta *et al.*, 2007), because of its negative impact on several morphological, physiological and biochemical aspects in many crops (Cuartero *et al.*, 2006). High soil salinity imposes osmotic, ionic and oxidative stress to plants, significantly reduces crop yield and causes loss of land for agricultural purposes (Villalta *et al.*, 2007).

Roots have more difficulty in taking up water from saline soils. The resulting osmotic stress leads to rapid metabolic changes, hampers cell growth, and salt ions begin to build up within the plant, affecting its homeostasis (Munns and Tester, 2008).
Besides these osmotic and ionic constraints, also an oxidative stress is observed (Bojórquez-Quintal *et al.*, 2014). The concentration of reactive oxygen species (ROS) is increased under salinity, and their accumulation can have a harmful effect on chloroplasts and metabolic processes, since enzymes may be inactivated in their presence (Bartels and Sunkar, 2005).

Tomato (*Solanum lycopersicum*) is one of the most important crops in the world and it is widely adapted to different environmental conditions. However, this crop is considered moderately sensitive to salinity, being negatively affected in terms of growth, development and yield (Cuartero *et al.*, 2006). Since it is often cultivated in areas under salinization (Santa-Cruz *et al.*, 2002) (*e.g*. southern Europe), a growing concern has been observed regarding its salinity tolerance.

Attempts to mitigate salinity in agricultural areas are expensive, difficult and considered short-term solutions (Dasgan *et al.*, 2002). Improving tolerance through breeding has been considered a more appropriate strategy (Villalta *et al.*, 2007). Cultivated tomato shows very limited genetic variation (Finkers *et al.*, 2007), but the existence of several wild types offers an interesting gene pool that can be explored (Kissoudis *et al.*, 2015).

When crossing the cultivar MM with the wild type *S. pimpinellifolium*, the accessions demonstrated higher salt tolerance compared with the parent line, resulting in a lesser reduction in both number of leaves and total dry matter compared to non-salinized plants (González-Fernández *et al.*, 1995).

Wild tomatoes occur in different habitats, from dry deserts to high moisture environments (Easlon and Richards, 2009). One of those tomato wild types is *Solanum habrochaites*, a species found in the Peruvian Andes (Easlon *et al.*, 2014), and due to its higher resistance to salinity, a population of 30 genotypes with introgressions from this wild type in the *S. lycopersicum* cv. Moneymaker (MM) genetic background was developed (*S. habrochaites* LYC4 IL population, Finkers *et al*., 2007). In a 3-week experiment in the vegetative phase, Kissoudis *et al*. (2015) confirmed the higher tolerance of several ILs from this population to salt stress, compared with the parent line MM. However, the influence of salinity at the reproductive phase of this population (including yield parameters) was not yet evaluated.

1.1 Literature review

1.1.1 Salinity effects on plants

Despite the fact that plants can show greater susceptibility in the early vegetative phase, including seed germination (Cuartero and Fernández-Muñoz, 1999) and seedling emergence (Läuchli and Grattan, 2007), it has been shown that growth and development is also impaired during the reproductive phase (Läuchli and Grattan, 2007). A large number of crops are salt-sensitive in such an extent, that often they cannot even survive, or, at least, a significant decrease in yield is observed (Dasgan *et al.*, 2002).
Although roots are directly exposed to the salts in soils, their growth is less affected by salinity than the shoots or leaves, and the recovery after an osmotic adjustment can be more effective (Munns, 2002).

Decreased growth rate is one of the earliest responses of glycophytes (plants from sweet water environments) under salt stress, and leaves are more affected than roots (Munns and Termaat, 1986). When the reduction on leaf growth is prolonged, this will result in reduced leaf area and decreased ability to intercept light (Heuvelink *et al.*, 2003). For instance, Li *et al.* (2001) showed 8% reduction in tomato leaf area per unit increase of the EC above 6 dS.m^{-1} threshold. In general, salinity results in smaller and thicker leaves, and leaf area index (LAI; leaf area per ground area) is reduced, decreasing the total photosynthetic capacity, which further reduces biomass production (Heuvelink and Dorais, 2005). LAI threshold for tomato is 3, and lowering LAI below 2, negatively affects yield (Heuvelink *et al.*, 2003).

A highly significant correlation between leaf area and fruit yield was shown, by Villalta *et al.* (2008), in a population of tomato from the crossing of *S. lycopersicum* cv. Cerasiforme and the wild type *S. cheesmaniae*.

The ionic component of salt stress further reduces the total chlorophyll content, which has been suggested as a reliable indicator of salt tolerance for several crops (Ashraf and

Harris, 2013). For instance, James *et al.* (2002) showed 30% decrease in leaf chlorophyll content, and more dead leaves in a more sensitive wheat cultivar, after 12 days in a 4-week treatment with 150 mM NaCl. It was shown that the total chlorophyll content was negatively correlated with Na^+ concentration in leaves (James *et al.*, 2002). However, Juan *et al.* (2005) only found a weak relationship between chlorophyll content and leaf Na^+ concentration in different tomato cultivars, which suggests that different species may respond differently, in relation to this trait.

The ionic effects take more time to affect the plant, compared to those of low water potential. The plant´s response to the ionic stress of salinity is considered an important factor in distinguishing sensitive and tolerant genotypes, since it is necessary for the plant to prevent salt ions to accumulate to toxic levels in transpiring leaves (Munns, 2002). Regarding tomato plants, different genotypes show different ability to prevent Na^+ and Cl^- accumulation in the leaves (Juan *et al.*, 2005).

Similarly to drought stress, a reduction in the water uptake under salt stress increases ABA synthesis in the roots, and this hormonal signal causes stomatal closure, since it is transported to the leaves via xylem (Cuartero and Fernández-Muñoz, 1999; Ashraf and Harris, 2013). Stomatal closure can also be due to lower turgor in the stomata guard cells and may result in lowering biomass production (Heuvelink *et al.*, 2003). Despite this, a small reduction in stomatal conductance due to increased stomatal closure can have a positive effect, under moderate salinity levels, owing to improved water use efficiency (Chaves *et al.*, 2009).

Salt exposure prolongation leads to increasing amounts of salts reaching the leaves through the transpiration stream, and older transpiring leaves may accumulate more salt ions, causing their yellowing and premature senescence (Munns, 2002). Besides higher leaf death rate, reduced leaf appearance will also contribute to decrease the total number of leaves (Munns, 2002).

1.1.2 Effects on ions homeostasis

Sodium chloride is the most abundant soluble salt in soils (Tavakkoli *et al.*, 2011), which explains why most of the studies concerning salinity effects on plants, use NaCl as salt.

Despite both Na^+ and Cl^- can be toxic ions for plants, for most species, Na^+ reaches a toxic concentration before Cl^- does. However, in species such as soybean, citrus or grapevine, the effects of Cl^- ions can be greater than those for Na^+ (Munns and Tester, 2008). This is not necessarily because Cl^- is more toxic than Na^+, but because these species have better mechanisms to exclude Na^+, while Cl^- is the salt ion that accumulates more in leaves (Munns and Tester, 2008).

The plants Na^+ and Cl^- content increases with salinity, and there is a genotypic variation in the way this accumulation occurs (Munns, 2002). Tavakkoli *et al.* (2011), showed that different genotypes of barley accumulate Na^+ and Cl^- differently, and that these two ions affected plant growth in a different extent among different varieties.

Under salinity, the concentration of several nutrients such as N, P, Ca and K are lowered (Cuartero and Fernández-Muñoz, 1999), and to tolerate salt stress, most of the plants must be able to maintain the uptake of these nutrients, while restricting the uptake of salts (Tavakkoli *et al.*, 2011).

The Na^+ entry in the plant through the root is passive, and its transport to the xylem occurs both through the symplast and apoplast of root cells, until it reaches the xylem (Apse and Blumwald, 2007). An increase in the Na^+ translocated through the xylem is caused by increasing amounts of Na^+ entering the roots (Olías *et al.*, 2009b). From the xylem, Na^+ is rapidly transported to the shoots and leaves, where it progressively accumulates, since Na^+ recirculation from shoots back to roots, is very limited or absent (Tester and Davenport, 2003; Munns and Tester, 2008).

Increased Na^+ concentrations in the shoots affects both osmotically and metabolically the plant, but it is in the leaves where the toxic effect can be greater (Munns, 2002). This can be due, not only to the higher leaf Na^+ concentration, but also to a higher sensitivity of these organs (Munns and Tester, 2008).

There is a competition between Na^+ and K^+ for binding sites in the plasma membrane of the cells, thus, increased concentrations of Na^+ in the cytoplasm alters the K^+ homeostasis (Bartels and Sunkar, 2005). This results in cell damage when the Na^+ concentration is high, since K^+ plays a crucial role in protein synthesis and enzyme activation (Tester and Davenport, 2003). Moreover, the accumulation of Na^+ in roots further affects K^+ homeostasis, due to decreased K^+ uptake capacity, because of the higher selectivity for Na^+ compared with K^+ (Läuchli and Grattan, 2007).

Different tomato genotypes can show significant differences in the shoot Na^+ concentration under saline conditions, as shown in Dasgan *et al.* (2002), in a high salinity experiment (200 mM NaCl). These authors showed that more salt tolerant genotypes where those with lower shoot Na^+ concentration, and that shoot K^+:Na^+ ratio significantly correlates with salt tolerance, since genotypes that showed less damage showed higher ratios.

In barley, which is considered a salt tolerant crop, Tavakkoli *et al.* (2011) showed that the K^+:Na^+ ratios of four different genotypes were never below 1.1, and this is the critical threshold, at least for this species (Munns 1985, cited in Tavakkoli et al 2011). The cells' metabolic competence can be translated by the K^+:Na^+ ratio, and to maintain it favorable under saline conditions, plants might either restrict the Na^+ accumulation in the tissues, or prevent K^+ lowering (Shabala and Cuin, 2007).

Additionally to disturbances in the K^+ homeostasis under salinity, also the calcium content is affected. Saline conditions decreases the Ca^{2+} uptake and its activity, which can rapidly affect the root growth (Munns, 2002), explained by negative effect in cellular membrane function (Läuchli and Grattan, 2007). Since Ca^{2+} does not compete with Na^+ in the root zone, the reduction in the Ca^{2+} uptake is due to different reasons that those for K^+ (Cuartero and Fernández-Muñoz, 1999). The lowered mobility of calcium under salinity results in Ca deficiency in actively growing regions (Läuchli and Grattan, 2007), as new leaves or fruits under development.

A salt tolerant genotype which is more able to maintain a higher concentration of Ca^{2+} can significantly reduce the permeability to Na^+, resulting in a lower accumulation and transport of salts by passive influx (Dasgan *et al.*, 2002), and alleviation in the growth inhibition caused by salinity (Läuchli and Grattan, 2007). Thus, as for K^+:Na^+ ratio, Ca^{2+}:Na^+ ratio positively correlates with salt tolerance (Dasgan *et al.*, 2002).

As K^+, Ca^{2+} is also important for several physiological processes, thus, the substitution of both these nutrients for Na^+, results in nutritional imbalances (Dasgan *et al.*, 2002). Plant cells need calcium to maintain an appropriate K^+ concentration, since calcium seems to play a role in the selectivity of K^+ against Na^+ (Läuchli and Grattan, 2007).

Song and Fujiyama (1996) assessed the effect of the addition of calcium in rice and tomato plants under Na^+ salinization. These authors showed that increasing Ca^{2+} supply improved the growth of both rice and tomato plants by reducing the Na^+ uptake and increasing the K^+ and Ca^{2+} uptake, and the results in growth recovery were significantly greater for tomato, compared with rice.

Villalta *et al.* (2008), found correlation between the K^+ concentration in leaves and Na^+ in stems, and also between K^+ and Na^+ concentrations in stems from a population of *S. lycopersicum* cv. Cerasiforme x *S. cheesmaniae* grown under saline conditions (100 mM NaCl). These authors also showed that, for this population, Na^+ sensitiveness correlates to the K^+ concentration. Nevertheless, the same correlations were not found when *S. pimpinellifolium* was used as wild type parent, in the same experiment.

Relatively to Cl^-, it is a micronutrient for higher plants, and plays roles in cell turgor, osmoregulation, plasma membrane stabilization, regulation of pH gradients, electrical excitability and key enzymes activity (White and Broadley, 2001). High concentrations of Cl^- in plant tissues, however, can be toxic, contributing to chlorophyll damage, (Tavakkoli *et al.*, 2011).

Chloride can be accumulated to different concentrations in different organs, and tolerance to Cl^- toxicity is often related to the ability to control Cl^- transport to the shoot, and, as for Na^+, older leaves generally accumulate more Cl^- compared with younger leaves (White and Broadley, 2001).

Working with different soybean cultivars, Pantalone *et al.* (1997) showed strong correlation between leaf Cl^- accumulation and leaf chlorosis, explained by the higher accumulation (53.3 mg of chloride per gram of leaf DW) in the more sensitive cultivar under 5g/l NaCl (~86 mmol) treatment, compared with those considered salt tolerant (below 13.5 $mg.g^{-1}$). Nevertheless, for some perennial accessions from the same genus (Glycine) utilized in the experiment, the correlation was weaker. The authors suggested that those genotypes may be able to use Cl^- for osmotic regulation, and may have other tolerance mechanisms, rather than Cl^- exclusion alone, since increased amounts of Cl^- in leaves were less effective promoting leaf chlorosis, compared with other cultivars.

To evaluate whether Na^+ or Cl^- is more toxic, Slabu *et al.* (2009) investigated the effect of NaCl, Na_2SO_4 and KCl on ions concentration of fava bean. These authors showed that Cl^- concentration was more related to leaf chlorosis, whereas higher Na^+ concentrations, and consequent lower K^+:Na^+ ratios, resulted in spot necrosis in older leaves. A 100 mM NaCl treatment resulted in leaf chlorosis appearance and decreased chlorophyll concentration, and the authors suggested that it was mainly due to Cl^- rather than Na^+, since the Na_2SO_4 did not result in similar leaf damages. Moreover, it was hypothesized that the Cl^- toxicity may depend on Na^+ content, since NaCl exposure resulted in higher negative impact in leaves compared to KCl treatment, even though, in the latter, the Cl^- concentrations in leaves were higher. This is in agreement with the cumulative effect of Na^+ and Cl^-, suggested in Tavakkoli *et al.* (2011).

1.1.3 Mechanisms of tolerance to salinity

Plants have evolved mechanisms to either exclude salt ions from cells, or to tolerate their presence (Carillo *et al.*, 2011). Halophytes, the plants from saline environments, evolved anatomically to overcome the harmful effects of salinity. Tissue succulence, due to larger cell vacuoles, and salt glands (modified trichomes) or bladders (modified epidermal cells), from where the plant can excrete accumulated salts, are the more important adaptations that can be found in these plants (Munns and Tester, 2008). Additionally to these salt inclusion mechanisms, halophytes are also effective in salt exclusion in the root zone.

On the other hand, the majority of glycophytes, are unable to maintain a highly effective salt exclusion as halophytes, and also due to their poor ability to compartmentalize salt ions in the cells vacuoles, they build up to toxic levels within the plants organs (Munns, 2002).

The mechanisms of salt tolerance comprise those that control the entrance of salts in the plant, and those that control the accumulation of salt ions in the cytoplasm, and can be organized in three main types: *i)* tolerance to osmotic stress; *ii)* exclusion of salt ions; *iii)* tissue tolerance (Munns and Tester, 2008).

The combination of the osmotic, ionic and nutritional effects, makes salt stress a complex phenomenon, and there is variability in the way plants respond, even when comparing different genotypes within one species (Flowers *et al.*, 1997). Different processes are needed for salt tolerance, which, in turn, have to be present in different plant organs, ranging from the cellular, to the whole plant level (Tester and Davenport, 2003), and the importance of each process not only varies with the species, but also with the developmental stage, duration of the exposure, salinity level and other environmental conditions (Munns and Tester, 2008).

A large number of genes are involved in salt tolerance and the way they coordinate and crosstalk, might dictate the plant's response to the stress. Nevertheless, their effects can be highly influenced by environmental conditions (Carillo *et al.*, 2011).

Different responses assessed in closely related genotypes can be interesting, because they enable to identify factors that play a role in salt tolerance (Tester and Davenport, 2003). Additionally, comparisons between different developmental stages are also relevant, because, in many crops, salt tolerance at a specific stage if often not correlated with tolerance at a different one (Dasgan *et al.*, 2002).

1.1.3.1 Osmotic adjustment

Salinity triggers processes that induce osmotic homeostasis and osmotic adjustment, and several changes occur in plants growth and physiology, as a response to the osmotic effect of salinity (Munns and Tester, 2008). Inhibition of lateral shoots development, early flowering, increased death rate of older leaves, while maintaining the production of new leaves, all are responses to the osmotic stress present in both saline and drought conditions (Munns and Tester, 2008).

The increased osmotic pressure results in water loss, particularly in leaf cells. Signals sent from the root to the shoot enable an adaptation of the shoot to the saline conditions (Munns e Tester, 2008). ABA accumulation is induced, and this phytohormone not only regulates the expression of several stress-responsive genes, but also stimulates its own biosynthesis, further increasing ABA levels within the plant (Cheong and Yun, 2007). This accumulation promotes the synthesis of organic compounds and reduces both chlorophyll content and stomatal conductance (Ashraf, 2004).

Most of the organic compounds that accumulate in the cytoplasm are sugars (mainly sucrose), proline and glycine betaine (Munns and Tester, 2008), and their accumulation is observed not only under salt stress, but also in water stress (Munns, 2002). Their presence in the cytosol aid in the osmotic adjustment that helps turgor maintenance in the cells, without compromising metabolic processes (Cheong and Yun, 2007).

A reduction in stomatal aperture helps to reduce salts influx to shoots and leaves, and improves the water use efficiency. Thus, the accumulation of organic compounds may function in signaling to downregulate photosynthesis (Munns and Tester, 2008).

In turn, reduced photosynthetic rate enhances ROS formation, and plants respond by an increase in the synthesis and activity of enzymes that remove ROS (Munns and Tester, 2008).

Additionally to the accumulation of organic compounds, the osmotic adjustment can also be achieved by the accumulation of ions. The inclusion of Na^+ and Cl^- in the cells can alleviate the increasing osmotic pressure due to their build up outside the cell. Thus, these ions are cheap osmotica, available to the plants under NaCl stress, and their inclusion helps to maintain cell turgidity. However, to avoid the harmful effects of their accumulation, they have to be efficiently compartmentalized in the vacuoles (Shabala and Cuin, 2007).

Turgor maintenance is essential for growth, since it causes the expansion of the cell wall (Ashraf, 2004). The process of osmotic adjustment allows the plant to recover turgidity, but, despite the recovery, the continuation of the exposure inhibits cells expansion and division (Carillo *et al.*, 2011). Consequently, cell's dimensions are changed by salinity, more reduced in area than in depth, so the leaves are smaller, but thicker (Munns and Tester, 2008).

Salinity also induces the accumulation of Ca^{2+} in the cytosol, and this cation plays a role in signalling the activation of genes with functions in ionic homeostasis, particularly in the K^+ uptake regulation (Cheong and Yun, 2007).

1.1.3.2 Salt exclusion

A common feature of many plant species is the ability to exclude salts in the root zone, while maintaining the water uptake from the soil (Munns and Tester, 2008). Even for halophytes, that have anatomical structures to excrete salts, salt exclusion might be the most important characteristic in the prevention of its internal accumulation within the plant (Munns, 2002). Plant species that mostly rely on this strategy, are able to keep salts away from the shoot meristems and developing leaves that are photosynthetically active (Ashraf, 2004).

The mechanism of salt exclusion allows to postpone the entry of salt ions within the plant, but this must be compensated by K^+ uptake, otherwise the demand for organic solutes for osmotic adjustment would be so high that would give rise to an energy depletion (Carillo *et al.*, 2011).

Despite the attempts to avoid the entrance of salt ions, inevitably they end up entering through the root cells. Then, salt ions in the root can be either captured into the cells vacuoles, or transported to the shoot via the xylem (Munns and Tester, 2008). Thereafter, plants must be able to control the amount of salts reaching the transpiration stream and, consequently, the leaves, since the leaf blade is the most sensitive site for the salt ions toxicity (Munns, 2002).

The movement of Na^+ is mainly unidirectional, through the xylem. In most species, the movement of Na^+ from the shoot back to roots, via the phloem, is almost negligible, with only a small part of that Na^+ reaching the shoot, being recirculated back to the root. The SOS1 (Salt overly sensitive 1), a plasma membrane Na^+/H^+ antiporter, is thought to be involved in the Na^+ loading into the xylem (Munns and Tester, 2008).

Villalta *et al.* (2008) showed that salt tolerant tomato genotypes accumulate higher concentrations of Na^+ and K^+ in the stem, compared to the leaves, under saline conditions. These authors suggested that this might be due to mechanisms restricting Na^+ entry to the leaves, or allowing its recirculation from the leaves to the stem.

Olías *et al.* (2009a) highlighted the importance of SOS1 transporters to control Na^+ distribution among different organs. These authors showed that the silencing of SlSOS1 (*Solanum lycopersicum* SOS1) decreases tomato tolerance to salinity, since SlSOS1-silenced plants showed higher Na^+ concentration in the root and leaves compared with control plants. In the silenced plants, the lack of ability to accumulate Na^+ in the stem, led to a failure in avoiding Na^+ to accumulate in the photosynthetic tissues, thus increasing the sensibility of those plants.

The putative role of SOS1 in long-distance Na^+ transport is supported by the high expression of SOS1 in cells surrounding the xylem vessels (Pardo *et al.*, 2006). Thus, SOS1 is thought to be responsible for the Na^+ loading from the roots into the xylem. Moreover, SOS1 transporters are also present in the epidermal cells of the root tip, which suggests that SOS1 might also play a role in the Na^+ extrusion, from the root, back to the soil (Pardo *et al.*, 2006). Results from Jha *et al.* (2010) are consistent with this idea, since in their experiment with *Arabidopsis* sp., increased expression of AtSOS1 led to reduction in total plant Na^+. Another role assigned to SOS1 transporters, is the Na^+ extrusion from the cytosol into the cells apoplast in developing leaves, protecting them from the harmful accumulation of Na^+ (Olías *et al.*, 2009a).

Na^+ and K^+ homeostasis do not rely only on SOS transporters, and they are suggested to coordinate their action with other transporters, such as those of HKT (High-affinity potassium transporters) family (Pardo *et al.*, 2006). While SOS1 transporters are given as being responsible for the Na^+ control in the xylem vessels, particularly in roots, HKT transporters are thought to play a crucial role in the unloading of Na^+ from the xylem in the stem, from where these transporters could direct Na^+ to older leaves, especially (Olías *et al.*, 2009a). HKT transporters might also be able to act in the load of Na^+ into the phloem, playing a role in Na^+ recirculation (Olías *et al.*, 2009a).

1.1.3.3 Tissue tolerance

In principle, a higher accumulation of salt ions within the plant would facilitate the water uptake, in salinized soils, since those ions, acting as osmotica, would alleviate the increasing osmotic pressure imposed by salt stress (Cuartero and Fernández-Muñoz, 1999).Yet, to prevent the harmful effects within the plant tissues, Na^+ and Cl^- should be compartmentalized into the cells vacuoles (Munns, 2002).

In turn, since the sequestration of Na^+ and Cl^- into vacuoles increases the osmotic pressure in the cytoplasm and organelles, this should be compensated by K^+ and organic solutes accumulation in the cytoplasm, to maintain a favorable osmotic balance within the cells (Tester and Davenport, 2003).

Additionally, tissue tolerance implies a longer survival of old leaves, which are more vacuolated than young leaves (Carillo *et al.*, 2011). The rate of senescence of older leaves can be seen as an indicator of the ionic toxicity under salt stress, implying that higher senescence can be translated as lower tolerance to the accumulated salt ions (Munns and Tester, 2008).

The greater scarcity of vacuoles in young leaves, compared with older leaves, makes them more vulnerable to the ionic effects of salinity, and less effective in the sequestration of salt ions. Therefore, the maintenance of older leaves for longer, while acting as Na^+ and Cl^- deposition site, can provide protection of young leaves, and this has been proposed as an important feature in salt tolerance (Tester and Davenport, 2003).

Several transporters are involved in the mechanism of tissue tolerance. The displacement of Na^+ from the cytosol into the vacuoles, rely on Na^+/H^+ antiporters (Carillo *et al.*, 2011), which are transporters involved in Na^+ and K^+ homeostasis. It is suggested that they act, not only by the pumping into intracellular compartments, but also by the extrusion out of the cells. Examples of these transporters are NHX1 (Na^+/H^+ exchanger 1), and Ca^{2+}/H^+ antiporter, and their activity and selectivity are thought to be related to the ability of a plant to tolerate salt stress (Pardo *et al.*, 2006).

1.1.4 Yield components in relation to salt stress

A schematic presentation of the yield components (Figure 1) provides help in the analysis of the plants´ responses to salt stress.

Salinity reduces total fresh yield by reducing the total fresh weight of roots, stem, leaves and fruits. Reductions in fresh yield are partly explained by decreased water content, owed to significantly lower water uptake, under saline conditions (Cuartero and Fernández-Muñoz, 1999). Water loss, which is especially observed in leaves (Munns and Tester, 2008), can explain the formation of thicker leaves (lower SLA), and increased chlorophyll content, in relative terms (*i.e.* per leaf area) (James *et al.*, 2002).

The total fresh yield can be divided in two main components: total dry matter, and relative dry matter.

Under salinity, the total dry matter is decreased in all different plant´s organs: root (Munns, 2002), stem, leaves (Scholberg and Locascio, 1999) and fruits (Adams and Ho, 1993; De Pascale *et al.*, 2015). This is due to decreased production of photosynthates, that might be partitioned to different sink organs and different physiological processes that are competing for carbon (Pérez-Alfocea *et al.*, 2010). Additionally, decreased calcium uptake further reduces growth (De Pascale *et al.*, 2015).

The two main components of vegetative yield (LAI and photosynthesis), are intrinsically related. Decreased photosynthetic capacity further reduces leaf biomass, reducing the plant´s capacity to intercept light. In turn, decreased light interception further decreases photosynthesis (Cuartero and Fernández-Muñoz, 1999; Chaves *et al.*, 2009; Ashraf and Harris, 2013). Since the total leaf biomass is reduced, the total chlorophyll content is also reduced (Slabu *et al.*, 2009; Ashraf and Harris, 2013).

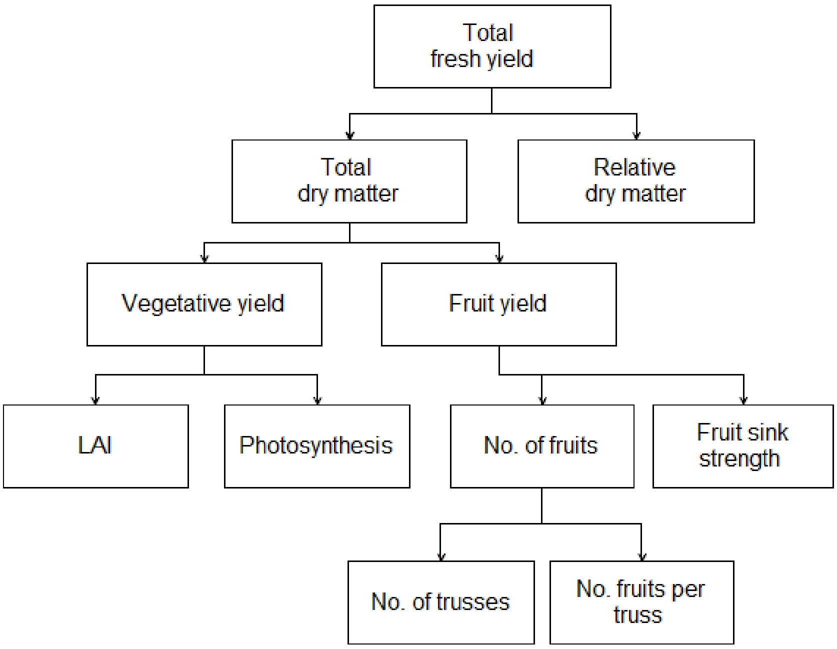

Figure 1: General components for the yield analysis (adapted from Higashide and Heuvelink, 2009).

The canopy architecture is not only modified by changes in dry mater partitioned to the leaves, but also by changes in leaf morphology (*e.g.* through SLA). Moreover, increased death rate of leaves (Munns and Tester, 2008) and reduction in the total number of leaves, can also explain LA reductions under saline conditions (Munns, 2002).

Fruit yield can be divided in two main components: total number of fruits, and fruit sink strength. Salinity reduces fruit yield by reducing the number of fruits, the sink strength of fruits, or both, simultaneously (Scholberg and Locascio, 1999; Albacete *et al.*, 2014). Nevertheless, these are interrelated factors, and an inverse relationship between them have been pointed out (Albacete *et al.*, 2014).

Differences in total number of fruits can be due to both differences in the number of trusses formed, or in the number of fruits per truss. Under salt stress, changes are often related to the number of fruits per truss, rather than decreased number of trusses (Cuartero and Fernández-Muñoz, 1999; Magán *et al.*, 2008).

The lower number of fruits, under saline conditions, can be explained by lower fruit-set, owed to increased flower abortion (Albacete *et al.*, 2014).

The marketable yield is reduced more pronouncedly, compared with the total fruit yield (Scholberg and Locascio, 1999), and this is due to additional factors influencing the correct formation and development of the fruits, such as BER incidence. In turn, BER incidence can be related to both fruit load and fruit growth (Adams and Ho, 1992).

1.2 Aims of the study

This study aimed at testing the salinity tolerance and analyzing the salinity effects on different tomato ILs from *S. habrochaites* in the *S. lycopersicum* cv. Moneymaker genome. To this end the effects of two levels of salinity (control: EC 3 dS/m; moderate salinity: EC 8 dS/m) on plant growth and yield of 9 ILs from the LYC4 population and the parent line Moneymaker were evaluated at two stages of plant development (vegetative and reproductive). The ultimate aim of this study is to contribute to identify the chromosomal regions of interest related to salinity tolerance , since for each line the introgressions' allocation in the genome is already known (Finkers *et al.*, 2007; Kissoudis *et al.*, 2015).

1.3 Hypotheses

In this study we hypothesize that some of the ILs from the LYC4 population are more salt tolerant than the parent line 'Moneymaker' resulting in increased plant dry weight and higher fruit yield. Moreover, we expect that salt tolerance will increase throughout plant development and genotypes that are more tolerant in the vegetative stage are not necessarily the same that show higher tolerance in the generative phase.

2. Materials and methods

2.1 Plant growth conditions

The *S. habrochaites* LYC4 introgression line (IL) population, composed of 30 lines, was developed by Finkers *et al*. (2007) with the aim of increasing resistance to grey mold (*Botrytis cinerea*). Each line contains one to three introgressions (some homozigous and some heterozygous) from the wild type in the *S. lycopersicum* cv. Moneymaker genome. Nine ILs from this population were selected for this experiment, based on a previous study (Chowdhury, 2012) that evaluated salinity tolerance in the whole LYC4 population (30 ILs) during only the vegetative phase (100 mM NaCl treatment applied to 3-week old plants during 21 days), which considered five of the selected ILs as promising lines in terms of salt tolerance (IL1-4, IL2-3, IL9-1, IL10-4 and IL12-1), and considered four of the selected ILs as salt sensitive (IL3-1, IL6-1, IL6-2 and IL10-1).

Besides the effects of salinity in previous studies, the criteria used to the line selection included: *i*) introgression size; *ii*) chromosome in which introgressions are placed; *iii*) absence of pleiotropic effects of the line; *iv*) introgression's zigosity (preferably homozygous); *v*) mature fruit color, representative of the line.

This study was carried out between 2nd of March and 29th of July 2015, in a compartment (11.5 x 12.5 m) of a Venlo-type greenhouse at Wageningen University, The Netherlands (51.9671° N, 5.6586° E).

The seeds were heated in a ventilated oven at 74 ºC for 48 h, to prevent possible TMV (tobacco mosaic virus) infection, and sowing took place on the 5th of March. Fifteen days later, the plantlets were transplanted into rockwool cubes (10x10 cm) and kept in a greenhouse compartment for the next 21 days. Thereafter, they were moved to the final compartment, where the cubes were placed on top of 1 m long rockwool slabs, carrying 5 plants each. The photoperiod regime was set as 16 h light and 8 h dark, and additional lighting (from 80 to 110 $\mu mol.m^2.s^{-1}$) was used in clouded days, and the minimal temperature was set to 19 ºC. After an adaptation period of 12 days, the salt treatment was gradually imposed.

A total of 360 plants (328 test plants and 32 border plants) were included in the experiment.

The experimental design was a completely randomized block design, including two blocks. Each block was composed by 4 rows, each of them with 45 plants. The number of plants per plot varied between 4 and 11, owing to lack of seeds and/or deficient germination in some genotypes (see legend in Figure 27 – Appendix I).

Nine of the 10 genotypes were included in block 1, since IL12-1, with only 9 plants available, was placed in 1 plot, in block 2.

To minimize possible positioning effects in a block, each plot from 1 genotype in EC8, was placed in parallel to the plot from the same genotype in EC3. Also a genotype positioned in one end of a row in block 1, had to be placed in 1 of the 3 remaining possibilities in the block 2, randomly. The same logic was applied to the lateral positioning. A genotype positioned on the left flank in block 1, had to be placed centrally in block 2.

From the time the height justified it, the plants were conducted through plastic strings, alternatively to the left and to the right, to equally accommodate the plants in each row. Side shoots and bottom leaves were removed according to common practice in The Netherlands.

Bumble bees (*Bombus terrestris*) were introduced, at flowering stage, into the greenhouse compartment on April 24th (51 days after sowing) for pollination, and maintained until the end of the experiment.

The control treatment consisted on irrigate the plants with full Hoagland nutrient solution (Table 3 – Appendix II). The target electrical conductivity in the root zone of the plants from control treatment was 3 $dS.m^{-1}$, and achieved by controlling the nutrients added to the irrigation water. This treatment is now on referred as EC3.

The test treatment consists in sodium chloride (NaCl) addition to the nutrient solution, until the electrical conductivity in the root zone reached 8 $dS.m^{-1}$. Since the EC of the nutrient solution was 3 $dS.m^{-1}$, the remaining 5 $dS.m^{-1}$ were achieved by the addition of approximately 50 mM of NaCl, which corresponds to 3 g of NaCl per liter of nutrient solution. This treatment is now on referred as EC8.

The EC3 treatment represents a very common scenario in greenhouse tomato production in The Netherlands, and EC8 is considered to be able to impose stressful conditions to tomato plants, having a considerably high impact on growth, yield and physiological traits in both sensitive and tolerant genotypes, although to a different extent among them, and yet allowing the plants' survival.

Treatments alternate consecutively in the layout design. Four rows of 45 plants were irrigated under EC3, and four rows under EC8. From left to right (Figure 27 – Appendix I), rows A, C, E and G were treated with EC3, and gutters B, D, F and H with EC8.

Treatment EC8 was gradually imposed to the plants, to avoid excessive stress at the early stage of the plants' life. The NaCl addition started on April 21th, 47 days after sowing (DAS), and the EC was gradually increased during 1 week, until 8 dS.m^{-1} was reached. The EC8 treatment started on the April 30th, 56 DAS. From the time the salt addition began, to the end of the experiment, the EC level for both EC3 and EC8 was monitored.

Using a syringe, the nutrient solution in each row was monitored through sampling in different spots in the same row, until 75 ml were collected. The EC was measured with an EC meter (Tasseron, The Netherlands). From the beginning of the salt addition until the EC8 was reached, the EC was measured every day (except for weekends). Thereafter, the EC was monitored twice a week, until the end of the experiment. The results are shown in Figure 2 (a-EC3; b-EC8).

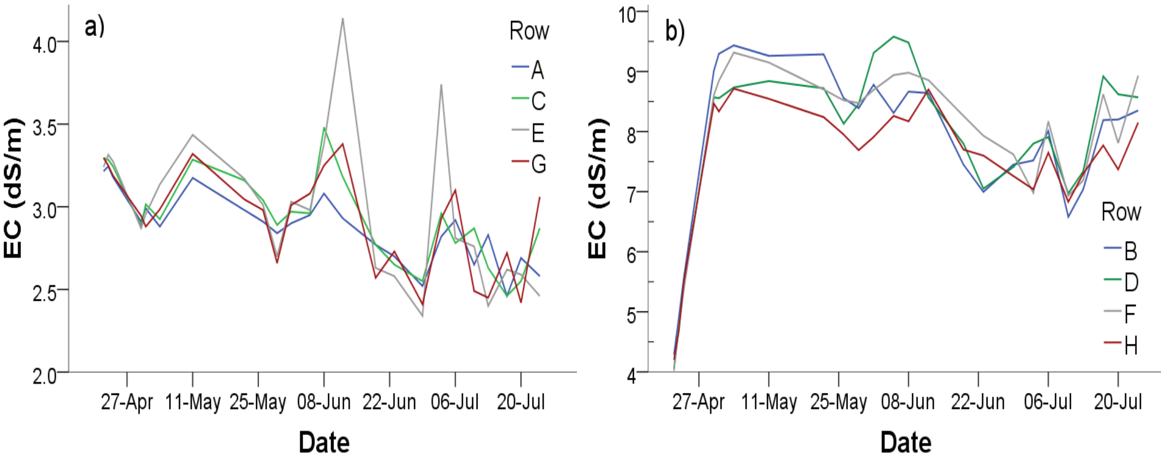

Figure 2: Electrical conductivity (EC; dS.m^{-1}) of the nutrient solution sampled from the rockwool slabs, between April 21st and July 24th, in a) four rows with 3 dS.m^{-1} as EC target, and b) four rows with 8 dS.m^{-1} as EC target.

2.2 Greenhouse compartment conditions

The temperature and relative humidity in the greenhouse compartment were automatically recorded in a computerized system, every 5 minutes, from April 13th to July 23rd.

The average daily temperature (21.5 ± 0.2 ºC) and daily relative humidity (70.0 ± 0.6%) in the compartment are shown in Figure 3 and Figure 4, respectively.

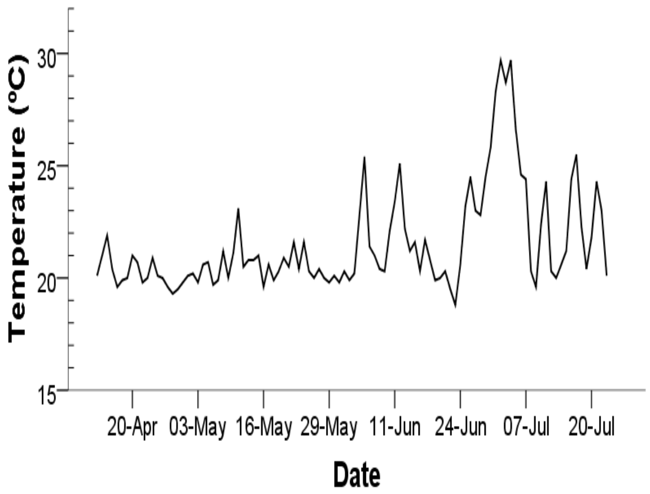

Figure 3: Average daily temperature in the greenhouse compartment, recorded from April 13th to July 23rd of 2015.

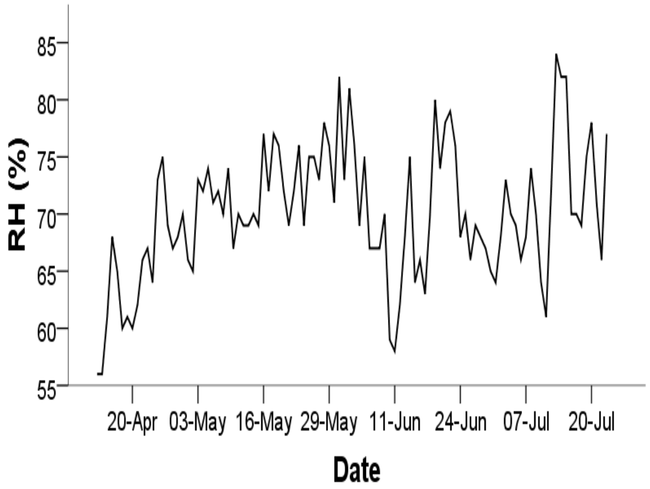

Figure 4: Average daily relative humidity (%) in the greenhouse compartment, recorded from April 13th to July 23rd, of 2015.

2.3 Measurements on the plant material

Non destructive measurements were conducted from 63 DAS (stem length, chlorophyll content) and destructive measurements were conducted in two harvest events. Each harvest was concluded in two days, harvesting half of the plants from block 1 in the first day, and the other half from block 2 in the following day. In the first harvest, 40 plants from block 1 and 40 plants from block 2 were harvested, 103 and 104 DAS, respectively.

The final harvest included 100 plants, and was conducted 145 and 146 DAS, totaling 90 and 91 days of salt treatment.

2.3.1 Growth, developmental parameters and calculations

Stem length (SL)

The SL (cm) was the stem total length, from the stem base to the apical meristem, measured with a flexible metric tape. SL was determined on five events: 63, 77, 91, 130 DAS, and at the final harvest (145/146 DAS). All plants present at the moment of the measurements were included in SL, except for the final harvest, in which only the harvested plants were measured.

Chlorophyll content (Chl)

Leaf chlorophyll content was determined in four events: 63, 77, 91 and 130 DAS. These measurements were made non-destructively using a portable chlorophyll meter SPAD-502Plus (Konica Minolta, Japan). In each event, each plant was measured 3 times in the 8th leaf from the top (>5 cm), in different leaflets within the same leaf, avoiding the leaflets tips and central vessels. Results are presented as SPAD units, which indicate the nitrogen content of the tissue, which, in turn, is highly correlated with the chlorophyll content (Evans, 1989).

Number of leaves (NL)

The total number of leaves (>1 cm) that the plant formed until the moment of the harvest.

Number of trusses (NT)

The total number of trusses present in each plant at the moment of harvest.

Leaf area (LA)

Total plant leaf area (dm^2) was measured in all harvested plants using a LI-COR 3100 area meter. LA was applied in the calculations of leaf area ratio (LAR; $cm^2.g^{-1}$), specific leaf area (SLA; $cm^2.g^{-1}$) and leaf area index (LAI; dimensionless).

$$LAR = \frac{LA}{TDW}$$

Where TDW was the total dry weight (g).

$$LAI = \frac{LA}{GA}$$

Where GA was the ground area (dm^2) that could be occupied by each plant.

$$SLA = \frac{LA}{LDW}$$

Where LDW was the total leaf dry weitght (g).

Fresh weight (FW)

Total FW (g) was determined for stems and leaves, when the plants were harvested (80 plants in the first harvest; 100 plants in the second harvest).

The fruits FW was also determined. The total fruits FW (FFW; kg) was the sum of the FW from all the fruits collected in each plant until the moment of harvest. Ripe or unripe fruits, with or without symptoms of blossom-end rot (BER), were included.

The marketable fruits fresh weight (kg) was considered as the total FW of the ripe and healthy fruits (without BER symptoms), collected from each plant until the moment of harvest.

Ripe fruits from non-harvested plants (border plants excluded) were also collected and determined the FW to increase the sample size for the average fruit weight (g). This parameter was the average FW of all collected ripe fruits, without symptoms of BER, from all genotypes.

Dry weight (DW)

The DW (g) of leaves (LDW), stems (SDW) and fruits (FDW) were determined after drying in a forced-air ventilated oven. Stems and leaves were dried for 48 h, at 70 ºC in the first 24 h, and 105 ºC in the following 24 h. Fruits were dried, after cutting in halves, for 72 h, at 70 ºC in the first 24 h, and 105 ºC in the following 48 h.

The LDW and SDW were determined when the plants were harvested (80 plants in the first harvest; 100 plants in the second harvest). The DW of removed leaves before the harvests was also determined.

As for FW, total fruits DW (FDW; g), and marketable fruits DW (g) were determined.

The fruit dry matter content (%) was also determined as:

$$Fruit\ dry\ matter\ content = \frac{marketable\ fruits\ DW}{marketable\ fruits\ FW}\ x100$$

Number of fruits

The total number of fruits (NF) was determined as the sum of all the ripe and healthy fruits (without symptoms of BER), collected from each plant included in the final harvest. This parameter was not determined for the first harvest, owing to low number of ripe fruits collected until that time.

2.3.2 Physiological parameters

BER

The incidence of BER (%) on fruits was determined. BER incidence is presented as total fresh weight from fruits with BER symptoms, internal or external, relative to the total fruit fresh weight.

Total soluble solids (TSS)

The TSS (ºBrix) was determined on selected ripe fruits from all genotypes, using a hand-held refractometer. All sampled fruits for TSS determination were collected from the 4th truss from the bottom, in a central position in each truss, fully ripe (100% colored red surface), without BER symptoms, and considered representative of the genotype. Twelve fruits per genotype, 6 per treatment, were included in these measurements.

Fruits were picked on July 8th, 125 DAS. After FW determination (to sum to FFW), fruits were washed and cut in halves, from the stem insertion to the bottom end. After the core removal, each fruit was pressed with a manual press into filter paper. The pulp was then squeezed into the refractometer prism, and registered the refractive index. Both the press and refractometer were washed and carefully dried between measurements. Finally, the fruits were dried to sum to TDW.

Leaf relative water content (RWC)

The leaf RWC was measured 140 DAS, six days before the end of the experiment.

To determine RWC, eight healthy leaflets per genotype, four per treatment, were picked. Each sample was collected from different plants, from the 8th leaf (>5 cm) from the top. Immediately after removal, the leaflets were individually placed in pre-weighed (to 0.1 mg readability) plastic tubes, and maintained tightly closed in styrofoam boxes, cooled with ice.

The sampling was done in 1 h, between 12.00 and 13.00 pm. Then, samples were immediately taken to the laboratory, were the tubes were weighed with an analytical scale

(0.1 mg readability), to determine FW. After this step, the leaflets were immediately placed to float (abaxial surface down) in small individual cuvettes with distilled water, to hydrate, to full turgidity, for 4 h. The imbibition was done under light conditions (~23 μmol.m^2.s^{-1}; photo meter LI-COR LI-250A) and normal fluctuating room temperature (~22 ºC).

After carefully removing the surface water using absorbent paper, the saturated weight was determined and the leaf area was measured (to add to the final harvest LA). After this, the leaflets were dried in a forced-air oven at 70 ºC for 48 h, and weighed to determine DW.

The leaf RWC (%) was calculated as:

$$RWC = \frac{FW - DW}{saturated\ FW - DW} x100$$

Ions content determination

For the ionic determination in leaves and stems at the first harvest, samples from 9 genotypes (all genotypes, except IL12-1) were collected, whereas all 10 genotypes were sampled at the final harvest.

Relatively to the leaves, leaflets from the 8th (young) and 22nd (old) leaf (>5 cm) from the top were picked (six per genotype, three per treatment). The stem samples were taken from the internode immediately below the old leaf sampled (six per genotype, three per treatment).

After drying (70 ºC; 48 h), samples were grinded in a hammer mill with 1 mm sieve. From the resulting fine powder, 30 mg were weighed with an analytical balance (0.1 mg readability), and put into high temperature resistant glass tubes. The samples were ashed at 580 ºC in a muffle furnace for 6 h.

After cooling, the ashed samples were dissolved by shaking the tubes with 1 ml of 3 M formic acid. The solution was 10x diluted, adding 9 ml of MilliQ water. From these samples, 200 μl were pipetted into plastic tubes, and capped with penetrable plastic caps (11 ml capacity tubes and caps specially designed for the Metrohm chromatograph). A final dilution of 500x was obtained by adding 9.8 ml of MilliQ water, using a pre-calibrated liquid dispenser.

One blank tube and eight standard tubes (four for cations; four for anions) were prepared. The standards were prepared using standard solutions (anions standard; cations standard) with known ionic profile, which enable to calibrate the system and make the final calculations of the ions content.

The concentration of Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^- and SO_4^{2-} in each sample was determined by ionic chromatography using a 850 Professional IC (Metrohm, Switzerland). The cations were determined using Metrosap C4 Supp 4, 250/4.0 mm column equipped with a Metrosap A Supp 4/6 Guard column, and the anions with Metrosap A 150, 150/4.0 mm column, equipped with a Metrosap C5/5 Supp 4/6 Guard column.

After a calibration procedure, in which the system analyses the blank tube and the standards for both cations and anions, the samples were consecutively injected into the IC, which took approximately 20 minutes to analyze each sample and finish each chromatogram (MagIC Net software; Metrohm). Results are presented as relative ions content, per gram of dry matter ($mg.g^{-1}$).

2.4 Statistical analyses

The experimental layout was a split-plot structure within two blocks. The EC levels (treatments) were the mainplots, whereas genotypes were the subplots. Thus, two-factor factorial analyses were conducted for each dependent variable.

The parental line MM had three main plots, IL12-1 had one mainplot, and all other genotypes had two main plots. Each replicate was the mean within a subplot. Exceptions were considered in TSS, RWC and ions content, in which one replicate was considered one individual measurement, since the sampled organs (fruit, stem, leaf or leaflet) were selected according to the assumptions stated above.

For all dependent variables, averages from all genotypes were compared with the parent line MM, through Dunnett’s t-tests. Means where separated only when $p<0.05$.

Statistical analyses of the data were conducted using IBM SPSS V22.0.

3. Results

3.1 Total dry weight and fresh weight

Salinity didn´t show effect on total dry weight (*p*=0.295) at the first harvest (Figure 5-a). The interaction between the EC level and genotype was non-significant, as well (*p*=0.996).

The genotypic factor showed significance (*p*=0.041), and genotype IL2-3 showed significantly higher TDW compared to MM (*p*=0.019). While the parent line showed an average TDW of 216 g (229 g in EC3; 202 g in EC8), the average for genotype IL2-3 was 53% higher, with 331 g (344 g in EC3; 318 g in EC8). The best performance shown by IL2-3 was followed by genotypes IL3-1 (268 g), IL6-2 (244 g) and IL10-4 (231 g).

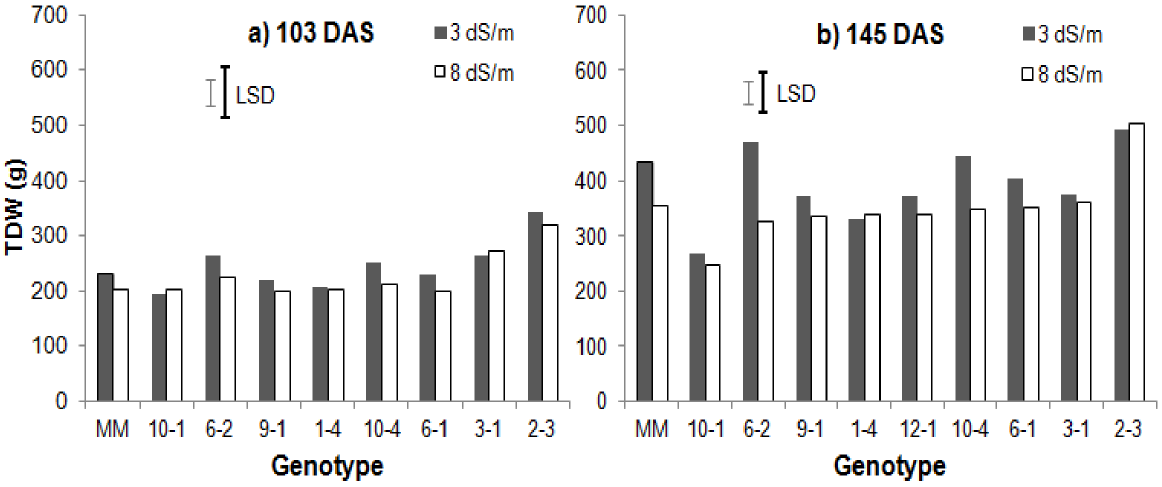

Figure 5: Total dry weight (g) of the genotypes a) included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing, and b) in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black). The ILs are placed in ascendant order of the results, under saline conditions, at the final harvest. This order is maintained from now on.

At the final harvest (Figure 5-b), 145 DAS, the TDW was reduced by salinity (*p*=0.005). In average, TDW was decreased in 11%, owing to the salt treatment. The genotypic factor significantly influenced TDW (*p*<0.001), while no significant interaction was found between the factors (*p*=0.316).

Two exceptions to the trend were observed in IL1-4 and IL2-3, which registered higher TDW in EC8 than in EC3. Genotype IL2-3 showed the highest TDW in both conditions, with 493 g in EC3, and 504 g in EC8, and showed to be significantly different than MM (*p*=0.011). The parent line was reduced in 18%, showing 434 g in EC3, and 354 g in EC8.

Genotype IL3-1 showed the lowest reduction of 4%, and showed TDW of 376 g in EC3 and 360 g in EC8. The most affected genotype was IL6-2, which showed, in EC3, TDW above the value observed for MM, with 469 g, but showed the second lowest TDW in EC8, with 325 g (31% reduction).

Genotype IL10-1 showed the lowest values for both treatments (268 g in EC3; 248 g in EC8), and was the only genotype with significantly lower TDW compared with MM (*p*=0.001).

Relatively to fresh yield, at the first harvest (Figure 6-a), salinity significantly reduced TFW (*p*=0.001), and the genotypic factor showed influence (*p*<0.001), while no significant interaction between the factors was observed (*p*=0.802). In average, TFW was decreased in 17%. The extent that the reductions were observed was considerably variable. While genotype IL1-4 showed a small reduction of only 3% (2.01 kg in EC3; 1.95 kg in EC8), other genotypes showed reductions above 20%. The parent line MM showed TFW of 2.67 kg in EC3, and 2.09 kg in EC8 (22% reduction). Genotype IL2-3 showed the highest values for both conditions, with 3.66 kg in EC3 and 2.93 kg in EC8 (20% reduction), and was the only line significantly different from MM (*p*=0.005). Genotype IL3-1 showed the second highest values for both EC3 (3.17 kg) and EC8 (2.85 kg), and a decrease of 10%.

The most affected genotype was IL10-4, which showed 29% reduction due to salinity, with TFW of 3.00 kg in EC3, and 2.12 kg in EC8.

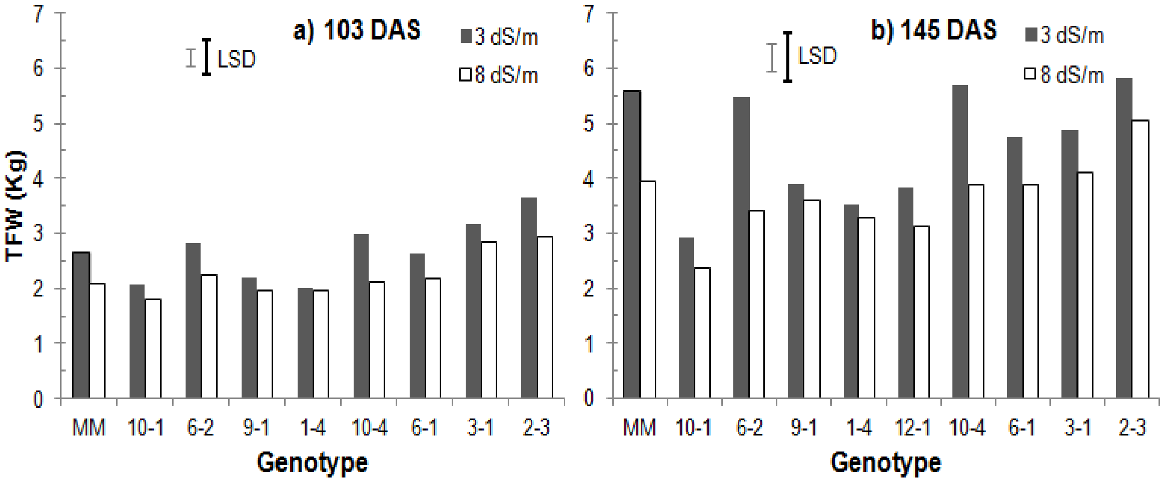

Figure 6: Total fresh weight (kg) of the genotypes a) included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing, and b) in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

At the final harvest (Figure 6-b), TFW was also significantly decreased by salinity ($p<0.001$). The genotype influenced the results ($p<0.001$), while no significant interaction was found between the factors ($p=0.187$). In average, salinity decreased TFW in 21%.

Genotype MM showed 29% reduction, with 5.60 kg in EC3, and 3.96 kg in EC8. Genotype IL10-1 showed the lowest TFW in both EC3 (2.92 kg) and EC8 (2.36 kg), and was significantly lower, compared with the parent line ($p<0.001$). Genotypes IL1-4 ($p=0.005$), IL9-1 ($p=0.047$) and IL12-1 ($p=0.044$) showed significantly lower TFW compared with MM, despite being decreased in lesser extent, with 7% (IL1-4), 8% (IL9-1) and 18% (IL12-1) reductions. The largest reduction, owing to salinity, was shown in genotype IL6-2 with 38% reduction, followed by genotype IL10-4 (-32%), which also showed the highest TFW of 5.70 kg, in EC3, but dropped to 3.87 kg due to salt stress.

The highest TFW in both conditions were observed in genotype IL2-3, with 5.81 kg in EC3, and 5.05 kg in EC8 (13% reduction).

3.2 Dry matter partitioning

No influence of salinity was found for the dry matter partitioning to the leaves ($p=0.458$), stems ($p=0.929$) or fruits ($p=0.336$), at the first harvest (Figure 7). The genotypic factor showed influence only in the partitioning to the fruits ($p=0.025$). Genotype MM showed average fraction to the fruits of 39.4% (38.4% in EC3; 40.4% in EC8). The highest partitioning to the fruits was observed in genotype IL10-4, with an average of 39.5% (40.6% in EC3; 38.5% in EC8).

Genotype IL1-4 showed significantly lower partitioning to the fruits compared with MM ($p=0.014$), with an average of 28.7% (26.8% in EC3; 30.7% in EC8). Genotype IL2-3 showed an average considerably below MM, with 31.9% (31.8% in EC3; 32.1% in EC8), but without showing statistical significance ($p=0.127$).

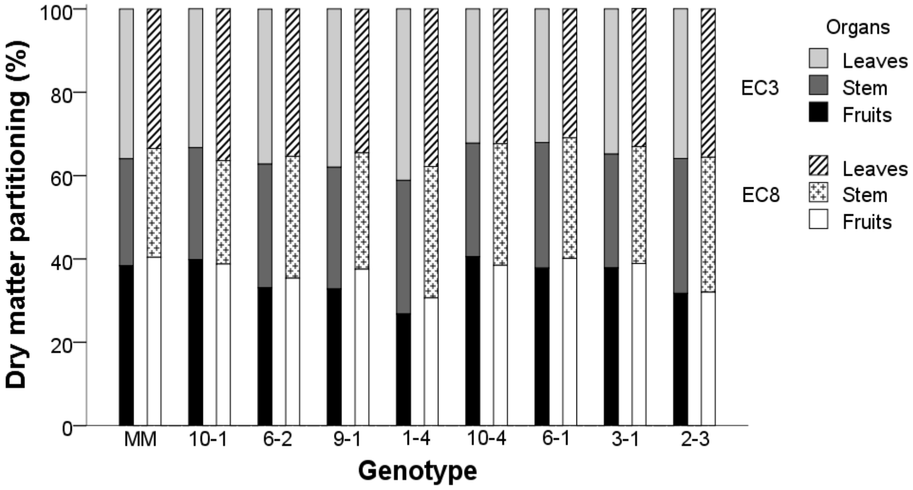

Figure 7: Dry matter partitioning (%) among leaves, stem and fruits, in the 9 genotypes (8 introgression lines and the parent line Moneymaker), under both control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}), at the first harvest (103 days after sowing).

At the final harvest (Figure 8), salinity influenced the fraction of dry matter partitioned to the leaves (*p*=0.017), but no significant effect was found in the partitioning to the stems (*p*=0.431) and fruits (*p*=0.076).

Salinity reduced the fraction to the leaves in 3%, in average. Under control conditions, the mean was 30.7%, and under saline conditions it decreased to 29.7%.

Genotype MM partitioned to the leaves 27.8% of the total dry matter, in EC3, and 28.4%, in EC8. Genotype IL1-4 showed the highest percentages in both EC levels, with 37.6% in EC3, and 34.4% in EC8, and showed to be significantly different than MM (*p*<0.001). Higher partitioning to the leaves, compared with the parent line, were also shown in genotypes IL9-1 (*p*<0.001), IL10-1 (*p*<0.001) and IL6-2 (*p*=0.001).

The only line to show significantly lower fraction to the leaves was IL6-1 (*p*=0.033), with 26.3% in EC3, and 25.4% in EC8.

Relative to partitioning to the fruits, despite no significant effect of salinity, a trend to increase the fraction under saline conditions was shown in 7 ILs, while only MM, IL10-1 and IL12-1 showed slightly lower percentages in EC8 than in EC3.

Genotype IL10-4 showed the highest values in both EC3 and EC8, with 54.8% and 56.0%, respectively. Genotypes IL1-4 (*p*<0.001), IL9-1 (*p*<0.001), IL12-1 (*p*<0.001), IL10-1 (*p*=0.001) and IL6-2 (*p*=0.005) showed significantly lower partitioning to the fruits compared with MM.

In terms of partitioning to the stem, genotypes IL12-1 (*p*<0.001), IL1-4 (*p*<0.001), IL6-1 (*p*<0.001) and IL2-3 (*p*=0.025) showed higher percentages compared with MM. Genotype IL12-1 showed the highest values in both EC levels, with 25.7% in EC3 and 24.8% in EC8, while MM showed 18.3% in EC3 and 19.0% in EC8.

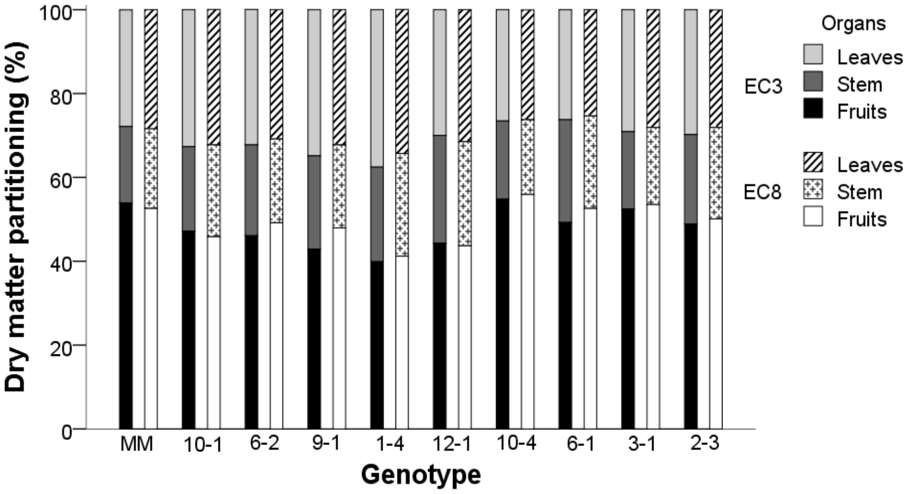

Figure 8: Dry matter partitioning (%) among leaves, stem and fruits in the 10 genotypes (9 introgression lines and the parent line Moneymaker), under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}), at the final harvest (145 days after sowing).

3.3 Total fruit dry weight and fresh weight

No effect of salinity was found on the total fruits dry weight (*p*=0.539), at the first harvest (Figure 9-a). The average FDW in EC3 was 85 g, and in EC8 was 82 g. Genotype IL2-3 showed the highest mean, with 105 g, followed by genotype IL3-1 (101 g) and IL10-4 (92 g). The lowest FDW mean was shown by genotype IL1-4, with 58 g.

In terms of FDW at the final harvest (Figure 9-b), salinity showed significant effect (*p*=0.044), decreasing FDW in 9%, in average. Three exceptions to the trend were shown in genotypes IL9-1, IL2-3, and IL1-4, which showed FDW, in EC8, slightly above the value observed in EC3.

Genotype MM was reduced in 20%, showing 232 g in EC3, and 186 g in EC8. The highest values were shown by genotype IL2-3, with 243 g in EC3, and 253 g in EC8. Genotype IL10-4 was reduced in the same extent as shown for MM (20%), and showed FDW of 243 g in EC3, and 195 g in EC8.

The most affected genotype was IL6-2, which showed a reduction of 26% (216 g in EC3; 160 g in EC8). Genotype IL10-1 showed the lowest FDW in both conditions, with 128 g in EC3, and 114 g in EC8 (11% reduction).

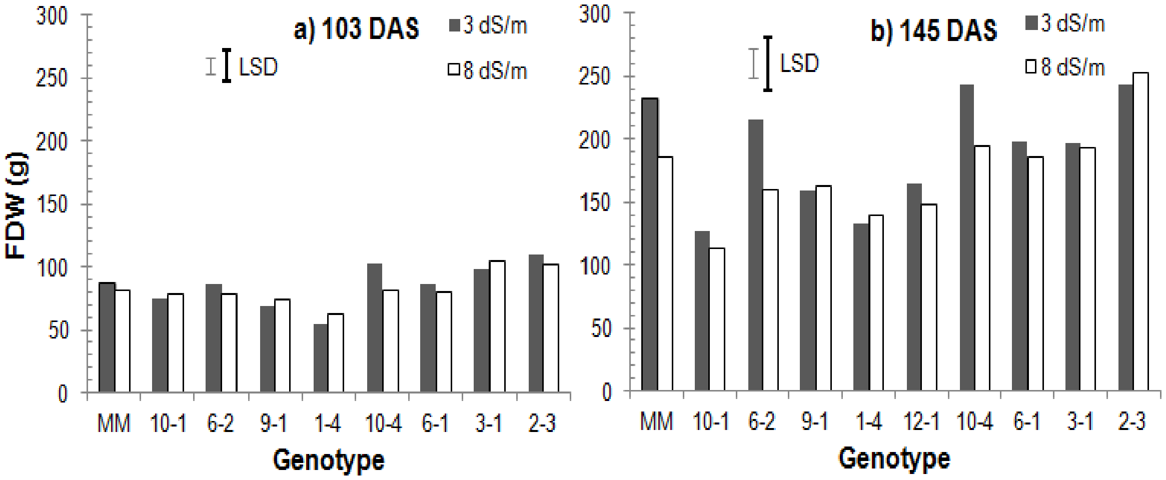

Figure 9: Total fruit dry weight (g) of the genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing, and b) in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

Until the first harvest, salinity reduced the total fruits fresh weight in 9% (*p*=0.001) (Figure 10-a). The genotypic factor showed influence on the results (*p*=0.001), while no interaction was found between the EC level and genotype (*p*=0.630). Only genotype IL1-4 showed slightly higher FFW in EC8 than in EC3, while the rest of the genotypes showed reductions due to salinity, ranging from 9% to 36%. Despite not being affected by salinity, IL1-4 showed the lowest results in both EC3 and EC8 (0.93 kg and 0.96 kg, respectively).

Genotype MM was reduced in 24%, showing 1.67 kg in EC3, and 1.27 kg in EC8. Genotype IL3-1 showed the highest FFW under both treatments (2.04 kg in EC3; 1.74 kg in EC8), and was reduced in 15%. Besides IL3-1, also genotype IL2-3 showed FFW above the observed values shown by MM, under both EC levels (1.90 kg in EC3; 1.43 kg in EC8), and was reduced in 25%. Under saline conditions, also genotypes IL6-1 (1.32 kg) and IL6-2 (1.28 kg), showed FFW above the observed value for the parent line.

At the final harvest (Figure 10-b), salinity decreased FFW in 23% (*p*<0.001), in average. The genotypic factor showed influence on FFW (*p*<0.001), but no significant interaction was found between the EC level and genotype (*p*=0.227). Genotype MM, was decreased in 32%, from 4.42 kg to 2.99 kg. Genotype IL10-4, which showed the highest FFW in EC3, was decreased in a similar extent (33%), from 4.51 kg to 3.02 kg.

Genotype IL2-3 was reduced in 14% and showed the highest FFW under salinity, with 3.76 kg, followed by genotype IL3-1 with 3.20 kg. Genotype IL6-2 showed one of the highest values in EC3 (3.94 kg), but was the most affected line, showing a reduction of 38% (2.45 kg).

Genotype IL10-1 showed the lowest results in both EC3 (2.14 kg) and EC8 (1.65 kg), and was decreased in 23%.

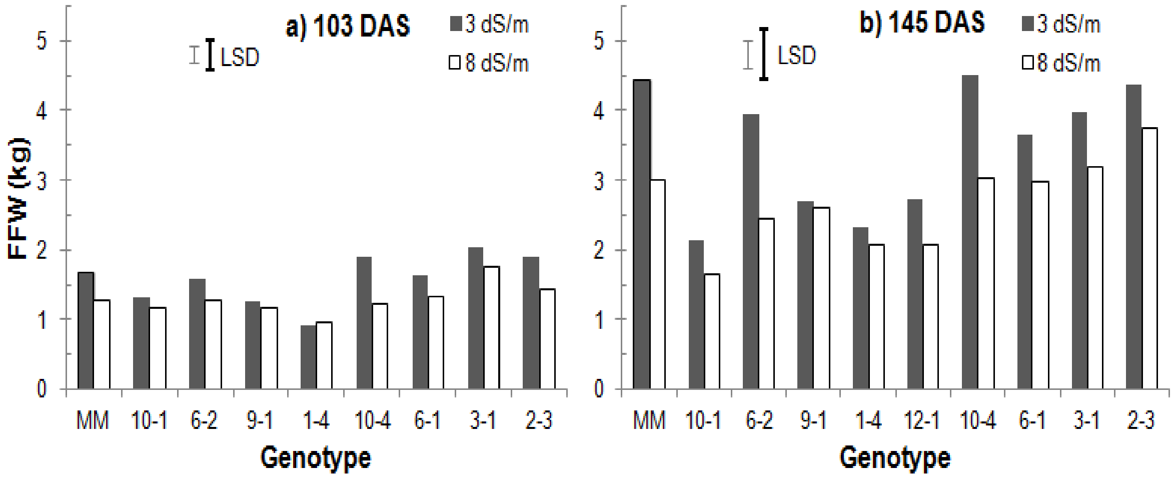

Figure 10: Total fruit fresh weight (kg) of the genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing, and b) in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

3.4 Total marketable fruits

Salinity significantly reduced the dry weight of marketable fruits (p=0.002) (Figure 11-a), in 22%, in average. The genotype showed influence on this trait (p=0.032), but no significant interaction was found between the EC level and genotype (p=0.198). Genotype IL9-1 showed to be an exception to the trend, showing higher MFDW in EC8 than in EC3.

Genotype MM was reduced in 41%, with 175 g in EC3, and 103 g in EC8. Genotype IL10-4 was most affected by salinity, being reduced in 45%, from 155 g to 86 g. Genotype IL2-3 was decreased in only 6% and showed the highest MFDW under salinity, with 140 g. Under saline conditions, besides IL2-3, genotypes IL3-1 (138 g), IL9-1 (122 g) and IL12-1 (107 g), also showed MFDW above the value observed for the parent line MM. Genotype IL6-2, which showed the second highest value in EC3 (162 g), showed the same decrease as shown for MM (41%), resulting in MFDW of 96 g, in EC8.

Genotype IL1-4, despite a poor performance in EC3, showed MFDW, in EC8, close to the value observed in MM, owing to a lesser effect of salinity, of only 5%.

Relatively to the fresh weight of marketable fruits (Figure 11-b), salinity showed highly significant effect (p<0.001), reducing MFFW in 33%. The genotypic factor showed influence on the results (p=0.007), but no significant interaction was observed between the factors (p=0.135).

Genotype IL9-1 was the only exception to the trend, since this line showed a higher MFFW under salinity than in control conditions. All the rest of the genotypes showed decreased MFFW under salinity, the reductions ranging from 20% (IL1-4) to 53% (IL10-4). The parent line MM showed the highest MFFW in EC3, with 3.41 kg, but also one of the largest reductions, with 49%, resulting in 1.75 kg, in EC8.

The highest values, under salinity, were observed in genotypes IL9-1 (2.02 kg), IL2-3 (2.24 kg) and IL3-1 (2.37 kg).

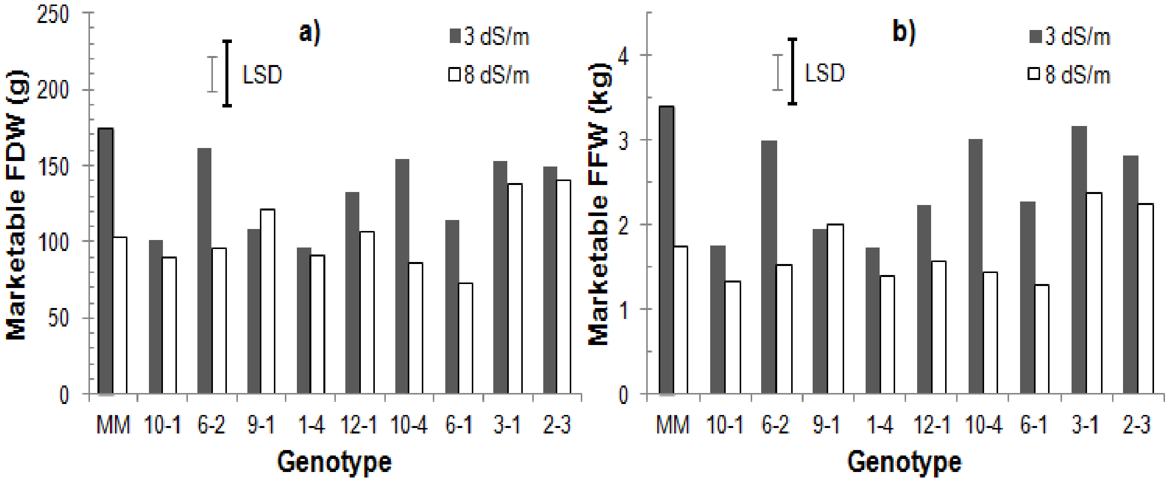

Figure 11: a) Total dry weight (g) and b) total fresh weight (kg) of the marketable fruits (healthy ripe fruits) collected, during the whole experiment, from the 10 genotypes (9 introgression lines and the parent line Moneymaker), under both control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

3.5 Total number of fruits

Significant influence of salinity was found on the total number of ripe fruits collected until the final harvest (p=0.014). Influence was also found for the genotypic factor (p<0.001), but not for the interaction between salinity and genotype (p=0.338). The NF in EC3 was 42.7, and was decreased to 37.0 under salt treatment.

Genotype MM showed an average NF of 40.5 (48.2 in EC3; 32.9 in EC8). Genotype IL3-1 showed significantly higher NF compared with MM (*p*=0.004), and showed the highest NF under saline conditions (56.2). Genotype IL6-2, despite being affected to a larger extent compared with IL3-1, also showed significantly higher NF compared with MM (*p*=0.026).

Genotype IL6-1 showed significantly lower NF compared with MM (*p*=0.047).

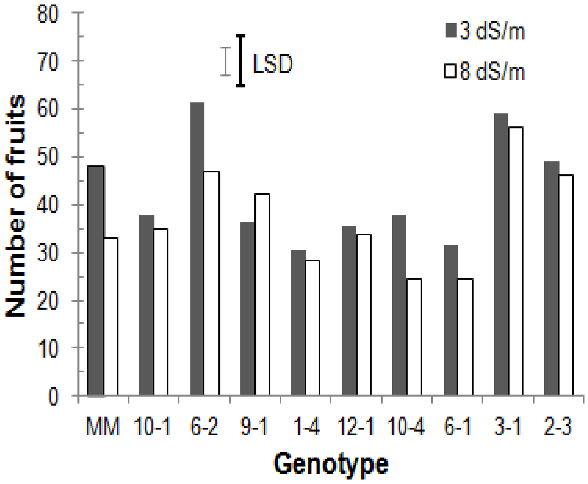

Figure 12: Total number of ripe fruits collected from the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (3 $dS.m^{-1}$) and saline conditions (8 $dS.m^{-1}$). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

3.6 Leaf area

Salinity reduced LA (*p*=0.004) in 18%, in average, at the first harvest (Figure 13-a). All genotypes showed lower LA under salt treatment, 103 DAS, and the decreases ranged from 5 to 28%. The genotype (*p*=0.005) also showed significant effect on LA, while the interaction between the factors didn´t show influence (*p*=0.967).

Under control conditions, LA in genotype MM was 117.3 dm^2 and, for EC8, the LA was 19% lower (95.1 dm^2). Genotype IL2-3 showed significantly higher LA compared with MM (*p*=0.004), showing an average LA of 164.7 dm^2 (186.2 dm^2, in EC3; 143.2 dm^2, in EC8), 55% higher than the parent line, and 27% above the LA observed in genotype IL6-2, which showed the second highest average (129.5 dm^2).

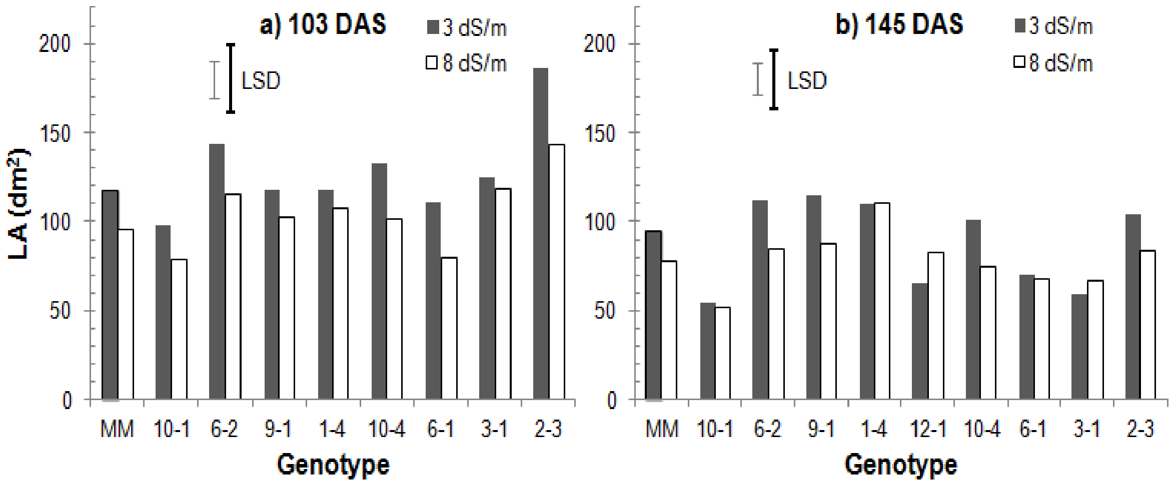

Figure 13: Leaf area (dm^2) of the genotypes included a) in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing, and b) in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

Relatively to LAI at the first harvest (Table 1), the parent line MM registered an average of 3.6 (4.0 in EC3; 3.2 in EC8). The lowest index was 2.7, shown in genotypes IL6-1 and IL10-1, under salinity. Genotype IL2-3 was the only significantly different from MM, with an average LAI of 5.6, thus, 2 units above the mean for the parent line.

Genotypes IL3-1 and IL6-2 also registered LAI above 4.0, with averages of 4.1 and 4.2, respectively. None of these lines, however, showed significantly higher LAI, compared with MM.

Salinity also reduced the leaf area ratio (*p*=0.014), at the first harvest. The average LAR in EC3 was 58.7 cm^2.g^{-1} and was reduced to 51.5 cm^2.g^{-1} due to salinity. Neither the genotypic factor (*p*=0.391), nor the interaction between EC and genotype (*p*=0.974) showed influence on this trait.

Genotype MM showed LAR of 57.6 cm^2.g^{-1} in EC3, and was reduced to 52.1 cm^2.g^{-1} in EC8. The highest values for both conditions were observed in genotype IL1-4, with 65.0 cm^2.g^{-1} in EC3 and 60.9 cm^2.g^{-1} in EC8. Genotype IL2-3, showed LAR of 60.5 cm^2.g^{-1} in EC3, but was more affected by salt stress, being reduced to 49.8 cm^2.g^{-1}.

Genotypes IL9-1 (60.4 cm^2.g^{-1} in EC3; 57.4 cm^2.g^{-1} in EC8) and IL6-2 (58.8 cm^2.g^{-1} in EC3; 55.6 cm^2.g^{-1} in EC8) were the lines which showed lesser reductions due to salinity. The largest variation was observed in genotype IL10-1, which showed LAR of 57.0 cm^2.g^{-1} in EC3, and the lowest value under saline conditions, with 41.9 cm^2.g^{-1}.

SLA was neither affected by the factors, nor by the interaction between the factors.

At the final harvest, salinity didn´t show significant influence on LA (*p*=0.144) (Figure 13-b). The genotypic factor significantly influenced LA (*p*=0.009), but none of the ILs were significantly different compared with the parent line. The highest LA was shown in genotype IL1-4, which registered 110.5 dm^2 (110.2 dm^2 in EC3; 110.8 dm^2 in EC8), followed by genotype IL9-1 with 101.5 dm^2. Genotype MM showed average LA of 86.1 dm^2 (94.5 dm^2 in EC3; 77.7 dm^2 in EC8). The lowest value was observed in IL10-1, which showed LA of 52.9 dm^2 (53.9 dm^2 in EC3; 51.9 dm^2 in EC).

Table 1: Average leaf area index (LAI), leaf area ratio (LAR) and specific leaf area (SLA) of the genotypes included in the first harvest (103 days after sowing; 8 introgression lines and the parent line Moneymaker), and in the final harvest (145 days after sowing; 9 introgression lines and the parent line Moneymaker), under both control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}).

Genotype	EC (dS.m^{-1})	*n*	LAI		LAR (cm^2.g^{-1})		SLA (cm^2.g^{-1})	
			103 DAS	145 DAS	103 DAS	145 DAS	103 DAS	145 DAS
MM	3	3	4.0	2.5	57.6	25.7	204	154
	8	3	3.2	2.1	52.1	25.8	211	159
IL10-1	3	2	3.4	1.4	57.0	25.0	215	125
	8	2	2.7	1.4	41.9	27.2	165	140
IL6-2	3	2	4.9	3.0	58.8	26.9	182	115
	8	2	3.9	2.2	55.6	48.1	191	228
IL9-1	3	2	4.0	3.0	60.4	37.0	208	157
	8	2	3.5	2.3	57.4	32.9	215	154
IL1-4	3	2	4.1	2.9	65.0	39.7	190	157
	8	2	3.7	2.9	60.9	38.1	195	163
IL12-1	3	1	-	1.7	-	20.7	-	119
	8	1	-	2.2	-	28.2	-	140
IL10-4	3	2	4.5	2.7	58.1	25.8	230	160
	8	2	3.5	2.0	52.5	25.2	206	178
IL6-1	3	2	3.8	1.9	54.7	20.2	215	132
	8	2	2.7	1.8	44.5	21.8	176	142
IL3-1	3	2	4.3	1.6	56.4	19.6	211	166
	8	2	4.0	1.8	49.0	22.1	196	159
IL2-3	3	2	6.3	2.7	60.5	25.3	202	166
	8	2	4.9	2.2	49.8	20.2	173	154
Significance								
EC			0.004	0.166	0.014	0.302	0.195	0.109
Genotype			0.005	0.008	0.391	0.006	0.838	0.622
EC x Genotype			0.976	0.743	0.974	0.367	0.844	0.289

n= number of replicates

Relatively to LAI at the final harvest, genotype MM registered LAI of 2.3 (2.5 in EC3; 2.1 in EC8). The two lines that showed highest LA, IL1-4 and IL9-1, registered average LAI of 2.9 and 2.7, respectively. Genotypes IL6-2, IL2-3 and IL10-4 also registered LAI above the index in the parent line.

LAR (*p*=0.302) and SLA (*p*=0.109) also were not affected by salinity at the final harvest. The genotypic factor only showed influence on LAR (*p*=0.006). The highest averages for LAR were shown by genotypes IL1-4 (38.9 $cm^2.g^{-1}$), IL6-2 (37.5 $cm^2.g^{-1}$) and IL9-1 (34.9 $cm^2.g^{-1}$), while the lowest LAR were observed in genotypes IL3-1 (20.9 $cm^2.g^{-1}$) and IL6-1 (21.0 $cm^2.g^{-1}$). Genotype MM showed average LAR of 25.7 $cm^2.g^{-1}$.

3.7 Number of leaves and number of trusses

The NL (*p*=0.244) and NT (*p*=0.597) were not affected by salinity, at the first harvest (103 DAS). The genotypic factor showed significant effect on NL (*p*=0.021). Genotype MM had, in average, 38.3 leaves at the time of the first harvest. Genotype IL2-3 produced significantly more leaves compared with MM (*p*=0.013), with an average of 44.0 leaves (44.8 in EC3; 43.3 in EC8). Genotype IL6-2 showed NL of 42.9, and, despite not being significantly higher than MM (*p*=0.056), the average came close to the significance threshold.

For NT, no differences were found between the ILs and MM, at the first harvest.

At the final harvest, 145 DAS, salinity didn´t affect the total number of leaves (*p*=0.340), but reduced the total number of trusses (*p*=0.001) in one unit, in average.

Relatively to NL, both the genotypic factor (*p*<0.001) and the interaction between the factors (*p*=0.037) showed significant influence on the results.

Genotype MM produced 53.1 leaves, in average. Genotypes IL6-1 and IL12-1 registered the lowest means, with 50.0 and 50.9 leaves, respectively. Genotype IL6-2 showed higher NL compared with MM, but only under control conditions (*p*=0.005), with 62.2 leaves.

The NT for genotype MM was 15.8, in average. Genotypes IL12-1 showed significantly lower NT compared to MM (*p*<0.001), registering 10.7 in average. Also IL6-1, with 14.0 trusses, in average, showed lower NT compared to the parent line (*p*=0.031).

The highest NT observed was in genotype IL6-2, with 16.7 trusses (17.7 in EC3; 15.7 in EC8), but not statistically different compared with the parent line.

Table 2: Average number of leaves (NL) and number of trusses (NT) of the genotypes included in the first harvest (103 days after sowing; 8 introgression lines and the parent line Moneymaker), and in the final harvest (145 days after sowing; 9 introgression lines and the parent line Moneymaker), under both control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}).

Genotype	EC (dS.m^{-1})	*n*	NL		NT	
			103 DAS	145 DAS	103 DAS	145 DAS
MM	3	3	37.5	52.7	10.3	16.0
	8	3	39.2	53.6	9.8	15.5
IL10-1	3	2	42.0	52.8	9.8	15.0
	8	2	41.0	53.3	8.8	13.3
IL6-2	3	2	43.0	62.2 *	11.0	17.7
	8	2	42.8	54.7	11.0	15.7
IL9-1	3	2	40.0	57.5	9.8	15.6
	8	2	42.0	57.7	10.3	14.8
IL1-4	3	2	36.8	52.2	9.3	15.2
	8	2	39.8	55.8	9.5	14.8
IL12-1	3	1	-	52.0	-	11.0
	8	1	-	49.8	-	10.3
IL10-4	3	2	39.3	53.3	9.8	15.3
	8	2	38.3	50.8	10.3	14.0
IL6-1	3	2	38.3	48.5	9.0	15.0
	8	2	40.8	51.5	9.8	13.0
IL3-1	3	2	37.5	54.5	9.3	15.5
	8	2	40.8	52.3	10.5	14.0
IL2-3	3	2	44.8	54.3	9.5	14.2
	8	2	43.3	54.0	9.0	14.2
Significance						
EC			0.244	0.340	0.597	0.001
Genotype			0.021	<0.001	0.086	<0.001
EC x Genotype			0.769	0.037	0.576	0.693

n= number of replicates

Asterisk indicates significant difference compared with MM, by Dunnett's t-test (*p*<0.005).

3.8 Stem length

No significant effect of salinity on SL was found before the first harvest. In the first measurement, 63 DAS (Figure 14-a), both the genotypic factor (*p*<0.001) and the interaction between EC and genotype (*p*=0.021) was found to be significant.

Genotype MM showed an average SL of 93 cm (92 cm in EC3; 93 cm in EC8).

At this time, genotype IL2-3 was already easily differentiated from all the other lines. This genotype showed significantly higher SL compared to the parent line (*p*<0.001), for both conditions. It´s SL was 161 cm and 153 cm, in EC3 and EC8, respectively. Thus, 76% and 65 % taller than MM.

Genotypes IL6-1 (*p*=0.002) and IL10-4 (*p*=0.027) also showed significantly higher SL compared with MM, but only under control conditions.

Significant differences were also found in genotypes IL1-4, IL9-1 and IL10-1 compared with MM. While IL9-1 (*p*=0.004) and IL10-1 (*p*=0.001) only showed lower SL in EC3, genotype IL1-4 showed significantly lower SL in both EC3 and EC8 (*p*<0.001; *p*=0.034), compared with MM.

91 DAS (Figure 14-b), still no significant effect of salinity was found on SL (*p*=0.073). In turn, both the genotypic factor (*p*<0.001) and the interaction (*p*=0.004), showed significant effect on SL.

The parent line MM showed similar SL in both EC levels, with 175 cm in EC3, and 174 cm in EC8.

Genotype IL2-3 still showed significantly higher SL in EC3 (296 cm; *p*<0.001) and in EC8 (268 cm; *p*<0.001), compared with MM. Genotype IL6-1 also showed higher SL than MM (*p*=0.041), but only under control conditions.

In EC3, genotypes IL10-1 (*p*=0.001), IL1-4 (*p*=0.002) and IL9-1 (*p*=0.017) showed lower SL compared with MM, but no differences were found in EC8.

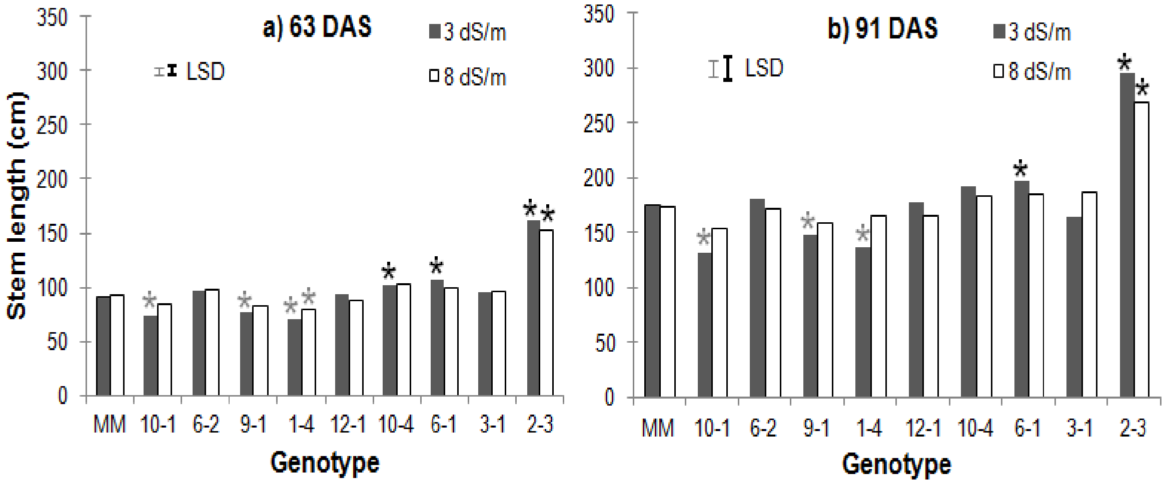

Figure 14: Stem length (cm) of the 10 genotypes (9 introgression lines and the parent line Moneymaker), a) 63 days after sowing, and b) 91 days after sowing, under control (3 $dS.m^{-1}$) and saline conditions (8 $dS.m^{-1}$). Asterisks indicate significant differences compared with MM (black: higher; grey: lower), by Dunnett's t-test (*p*<0.05). I-beams indicate least significant difference (LSD) for control (grey) and saline conditions (black).

At the final harvest, 145 DAS, salinity reduced the SL in 6% (*p*=0.010), in average (Figure 15-a). The only exceptions to this trend were shown in IL1-4 and IL10-1, which registered higher values in EC8. The latter, despite not being affected on SL by salinity, showed significantly shorter plants, compared with the parent line (*p*=0.047). MM showed 3% reduction, with 323 cm in EC3, and 313 cm in EC8. Under both conditions, the highest plants were observed in IL2-3, with average SL of 439 cm in EC3, and 381 cm in EC8, and significantly higher compared with MM (*p*<0.001).

The average internode length (Figure 15-b) was also negatively affected by salinity (*p*=0.011). MM showed average internode length of 6.2 cm in EC3, and 5.8 cm in EC8. Genotype IL2-3 (8.1 cm in EC3; 7.1 cm in EC8) showed the longest internodes, and was significantly different compared with MM (*p*<0.001). Also genotype IL6-1 showed longer internodes compared with the parent line (*p*=0.032).

Four genotypes showed significantly shorter internodes compared with MM: IL9-1 (*p*=0.001), IL10-1 (*p*=0.011), IL1-4 (*p*=0.032) and IL6-2 (*p*=0.041).

For both SL and internode length, however, no significant interaction was found between the EC level and genotype.

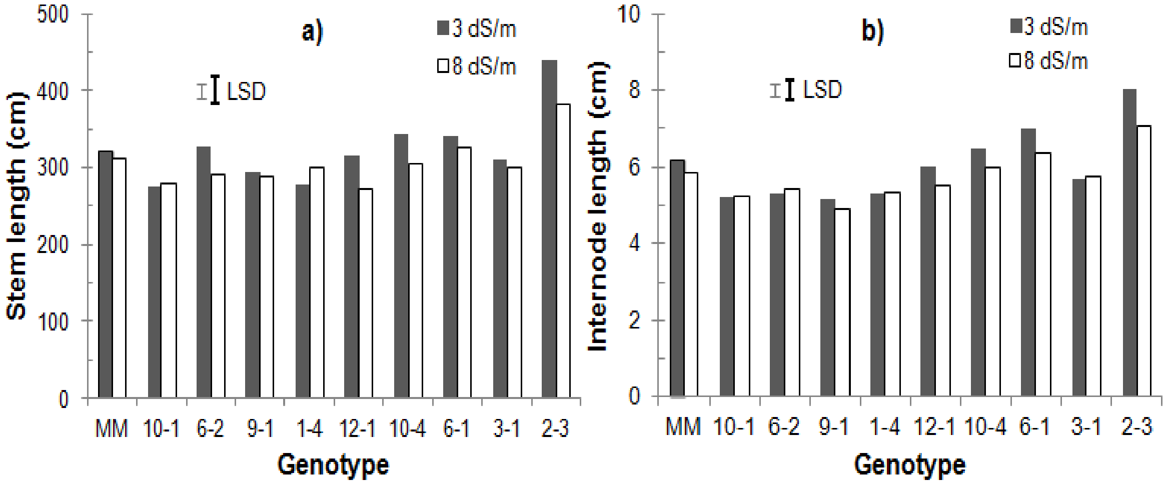

Figure 15: a) Average stem length (cm), and b) average internode length (cm) of 10 genotypes (9 introgression lines and the parent line Moneymaker), at the final harvest, 145 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

3.9 Chlorophyll content

The chlorophyll content was increased by salinity (p=0.010), and the genotypic factor also showed significant effect (p<0.001), 63 DAS (Figure 16-a). However, the interaction between both factors didn´t show influence on this trait (p=0.430).

The average chlorophyll content in EC3 was 52.4 SPAD, while in EC8 it was 54.4 SPAD.

Genotype MM showed average chlorophyll content of 52.8 (52.0 SPAD, in EC3; 53.5 SPAD, in EC8).

Exceptions to the trend to increase the chlorophyll content under EC8 were shown in genotype IL10-4, which showed higher chlorophyll content in EC3, and in IL12-1, which showed the same value in both EC levels (53.4 SPAD).

Genotype IL6-2 showed significantly higher chlorophyll content compared with MM (p=0.008), with an average of 58.1 SPAD. The lowest values were observed in genotype IL1-4, which showed significantly lower chlorophyll content compared with MM (p=0.021).

Two weeks later, 77 DAS (Figure 16-b), both the EC level (p<0.001) and the genotypic factor (p<0.001) showed significant effect. The interaction between the EC level and genotype was not statistically significant (p=0.085).

The chlorophyll content in EC8 was, in average, about 9% higher compared with EC3. The parent line MM was increased from 46.6 SPAD to 49.7 SPAD.

Genotypes IL6-2 (p<0.001) and IL10-1 (p=0.012) showed significantly higher chlorophyll content compared to MM, and their values were increased from 53.8 SPAD to 57.3 SPAD, in IL6-2, and from 50.2 SPAD to 54.1 SPAD, in IL10-1.

It is worth noting that, despite not being significantly different from MM, genotypes IL2-3 (54.2 SPAD) and IL12-1 (54.1 SPAD) registered similar averages, under salinity, compared with IL10-1, which showed to be statistically different than MM.

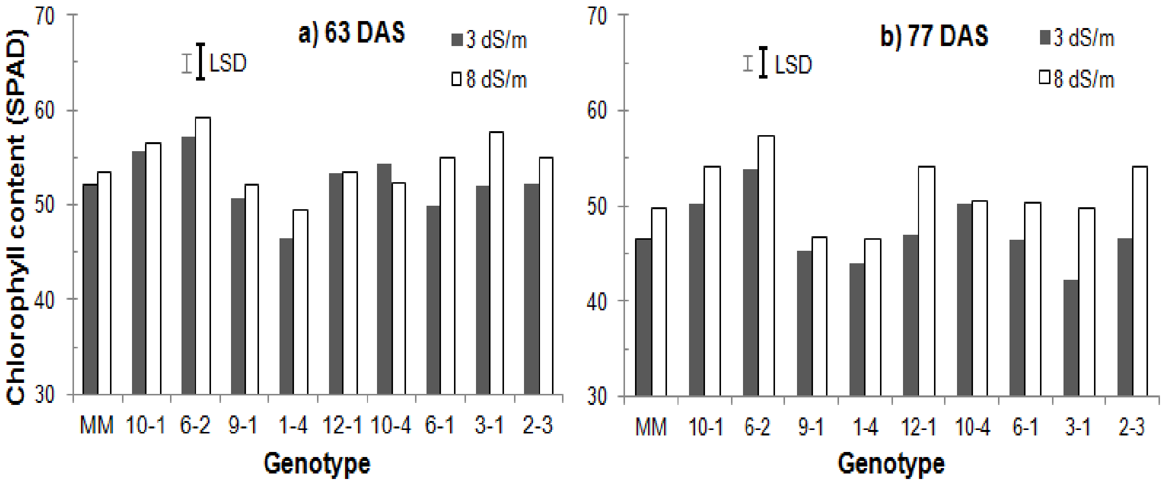

Figure 16: Chlorophyll content (SPAD units) of the 10 genotypes (9 introgression lines and the parent line Moneymaker), a) 63 days after sowing and b) 77 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

In the last measurement before the first harvest, 91 DAS (Figure 17), both the EC level (*p*<0.001) and the genotype (*p*<0.001) continued to show significant effect on the chlorophyll content. As in the first two measurements, no significant interaction was found between the factors (*p*=0.326).

At this time, salinity increased the chlorophyll content in 7%, in average. The values registered for MM were below those observed in the previous measurements, with average of 42.4 SPAD, in EC3, and 45.8 SPAD, in EC8.

Compared with MM, genotypes IL6-2 (*p*<0.001), IL2-3 (*p*=0.003), and 10-1 (*p*=0.039) showed significantly higher chlorophyll content.

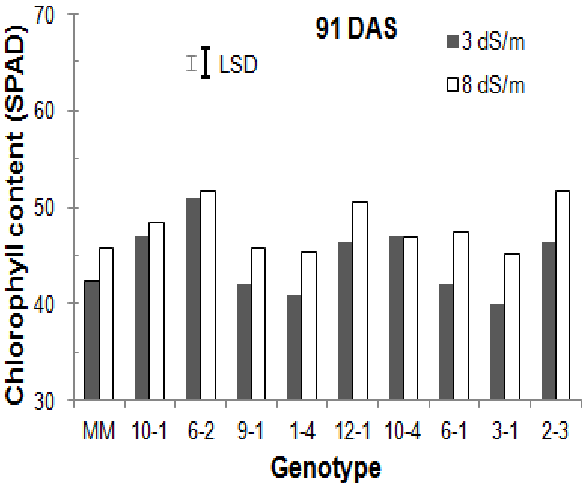

Figure 17: Chlorophyll content (SPAD units) of the 10 genotypes (9 introgression lines and the parent line Moneymaker), 91 days after sowing, under control (3 $dS.m^{-1}$) and saline conditions (8 $dS.m^{-1}$). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

3.10 Average fruit weight and fruit dry matter content

Salinity reduced the average weight of ripe fruits (*p*<0.001). In average, AFW was reduced in 20%. Also the genotype showed significant influence on AFW (*p*=0.004), but no significant interaction was found between the factors (*p*=0.977).

The AFW registered for MM were 67.9 g, in EC3, and 54.8 g, in EC8 (19% reduction).

The highest reduction was registered in genotype IL-6-2 (32%), which showed significantly smaller fruits compared with MM (*p*=0.005), with AFW of 49.1 g, in EC3, and 33.7 g, in EC8. Genotype IL-1-4 also showed significantly smaller fruits compared to the parent line (*p*=0.049), despite the lower reduction (12%).

Genotypes IL12-1, IL-6-1 and IL-2-3 showed reductions above the average (22%, 24% and 26%, respectively), but were not statistically different in AFW compared with MM.

The highest AFW was registered by genotype IL-10-4 (66.4 g) and, despite showing the lowest reduction (9%), was not significantly higher in AFW compared with the parent line.

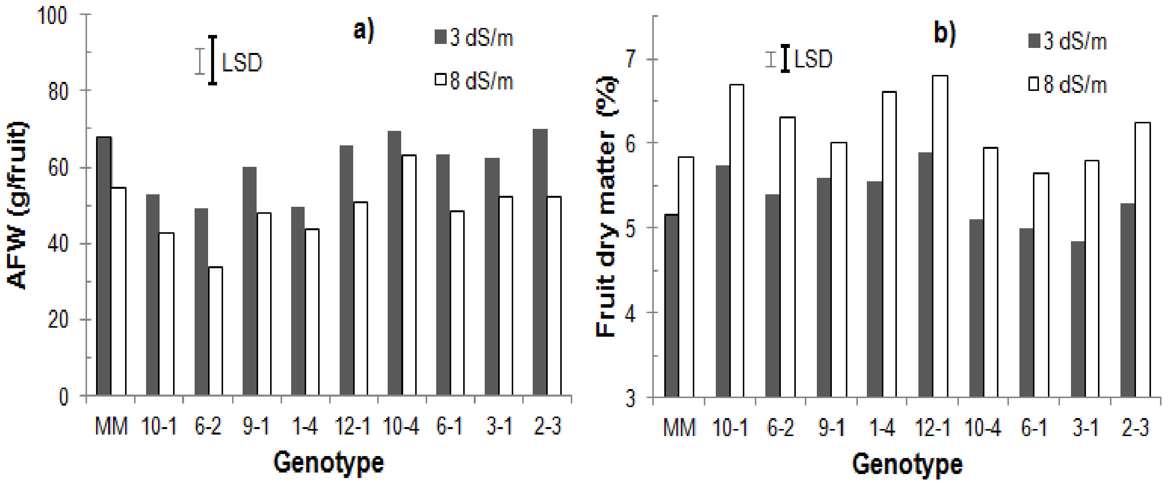

Figure 18: a) Average fruit fresh weight (g/fruit), and b) fruit dry matter content (%) of the ripe fruits collected during the experiment, from the 10 genotypes (9 introgression lines and the parent line Moneymaker), under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

The fruits relative dry matter content (Figure 18-b) was increased by salinity (*p*<0.001). The genotypic factor also showed influence on this trait (*p*<0.001), but no significant interaction between the factors was found (*p*=0.335).

In average, the fruit dry matter content in EC3 was 5.4%, and was increased to 6.2% in EC8. Genotype MM showed 5.2% in EC3, and 5.8% in EC8. Genotype IL3-1 was the most affected by salinity and its dry matter content was increased from 4.9% to 5.8%. Four genotypes showed significantly higher fruit dry matter content compared with the parent line: IL12-1 (*p*<0.001), IL10-1 (*p*<0.001), IL1-4 (*p*=0.001) and IL6-2 (*p*=0.047).

3.11 Blossom-end rot

Salinity significantly increased the incidence of BER (*p*=0.001). Under control conditions, 8% of the total fruit fresh weight was affected by BER, while the percentage increased to 18% under saline conditions.

Genotype MM registered 7% of BER in EC3, while, in EC8, the incidence increased to 24%. The genotypic factor showed significant effect on BER incidence (*p*<0.001). Despite the visible differences shown in Figure 19, no significant effect was found for the interaction between EC level and genotype. However, the *p*-value was just marginally above (*p*=0.051) the significance threshold.

Under salt treatment, higher BER were shown in genotypes IL2-3 (31%), IL10-4 (42%) and IL6-1 (43%). These genotypes also showed the highest values for EC3, ranging from

10% to 18%. The lowest BER averages were shown in genotypes IL9-1 (7%), IL10-1 (5%), IL3-1 (3%) and IL12-1 (3%). The latter didn´t show any fruit affected by BER, in EC3.

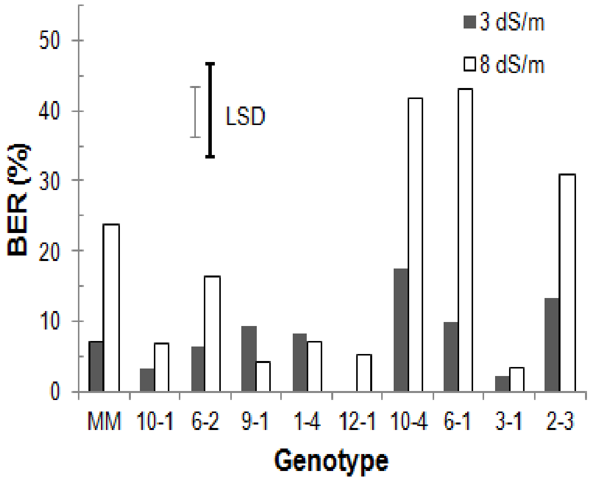

Figure 19: Percentage of fruits affected with blossom-end rot disorder, during the whole experiment, in the 10 genotypes (9 introgression lines and the parent line Moneymaker), under control (EC=3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). The percentage is fresh weight of the fruits with BER, relative to the total fruit fresh weight. I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

3.12 Total soluble solids

The EC level and the genotype showed highly significant effect on TSS of ripe fruits (p<0.001, for both). The interaction between both factors also showed influence (p=0.039).

Salinity increased TSS in 0.7 ºBrix, in average. Genotype MM was 0.6 ºBrix higher in EC8 (6.2 ºBrix) compared with EC3 (5.6 ºBrix).

Genotype IL6-1 was less affected by salinity, and showed significantly lower TSS, in EC8, compared with MM (p=0.012).

Four genotypes showed significantly higher TSS, in EC8, compared with MM: IL2-3 (p<0.001), IL1-4 (p<0.001), IL12-1 (p<0.001) and IL6-2 (p=0.046). The highest index was 7.2 ºBrix, observed in IL2-3 under salinity.

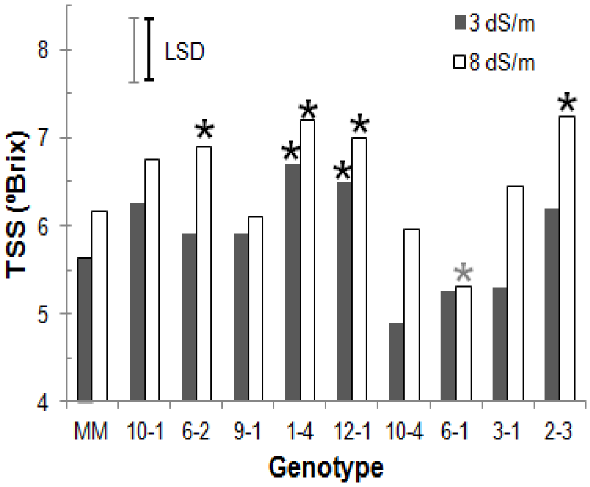

Figure 20: Total soluble solids (°Brix) of selected ripe fruits from the 10 genotypes (9 introgression lines and the parent line Moneymaker), under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). Asterisks indicate significant differences compared with MM (black: higher; grey: lower), by Dunnett's t-test (p<0.05). I-beams indicate least significant difference (LSD) for control (grey) and saline conditions (black).

3.13 Leaf relative water content

As expected, salinity significantly reduced the RWC of the leaves (p<0.001). The genotypic factor also showed significant effect (p=0.001), while the interaction between EC level and genotype didn´t show influence on the results (p=0.132).

In average, salinity decreased 3.4% the RWC. Genotype MM showed RWC of 88.3% in EC3, and 85.4% in EC8, and only genotype IL12-1 was significantly different (p=0.001), showing an average RWC of 81.6% (83.1% in EC3; 80.2% in EC8).

The highest decrease was observed in genotype IL2-3, which registered RWC of 86.6% in EC3, and 80.2% in EC8. Despite not being statistically different than the parent line (p=0.062), it is worth noting that the RWC value, for EC8, came as low as that for IL12-1, and the p-value was close to the significance threshold.

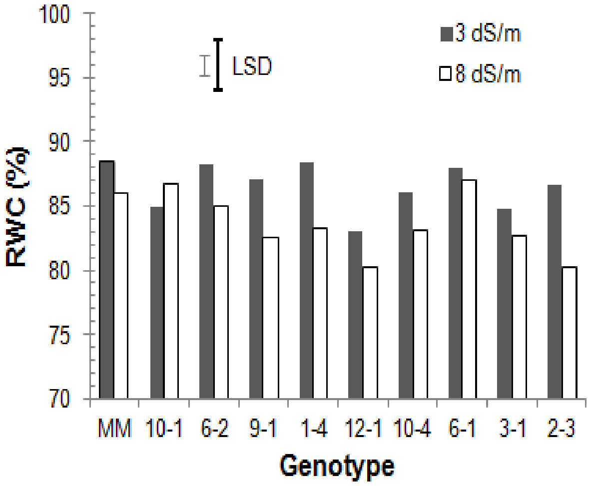

Figure 21: Leaf relative water content (%) of the 10 genotypes (9 introgression lines and the parent line Moneymaker), 130 days after sowing, under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

3.14 Ions content

Since the treatment consisted in NaCl addition, Na$^+$ and Cl$^-$ content in the sampled organs were significantly increased (p<0.001) in EC8, at both harvests (Table 26 and Table 27).

Chloride accumulation, at the first harvest, in young leaves (Figure 22-a), old leaves (Figure 22-b) or stems (Figure 23-a), was not influenced by the interaction between EC level and genotype (p=0.108, p=0.377 and p=0.428, respectively). In genotype MM, the average Cl$^-$ content in young leaves was 2.4 mg.g^{-1}, in EC3, and was increased to 5.8 mg.g^{-1}, in EC8. Genotypes IL1-4 (p=0.009) and IL9-1 (p=0.039) showed significantly higher Cl$^-$ in young leaves, compared with MM (50% and 28%, respectively). In old leaves, genotype MM showed approximately 4-fold higher accumulation in EC8, compared with EC3. Only genotype IL1-4 significantly differed from the parent line (p=0.035), showing higher Cl$^-$ content, with 3.9 mg.g^{-1} in EC3, and 10.6 mg.g^{-1} in EC8. Genotype IL9-1, which was significantly different from MM in Cl$^-$ accumulation in young leaves, was not found different in old leaves.

It is worth noting that genotype IL10-4 showed approximately 2-fold higher Cl$^-$ content in young leaves in EC8, compared with EC3, and, in old leaves, the accumulation observed was above 4-fold higher in EC8.

Genotype IL6-2 was the line which showed lesser effect of salinity on Cl$^-$ accumulation in old leaves, showing 2.4 mg.g^{-1} in EC3, and 5.3 mg.g^{-1} in EC8.

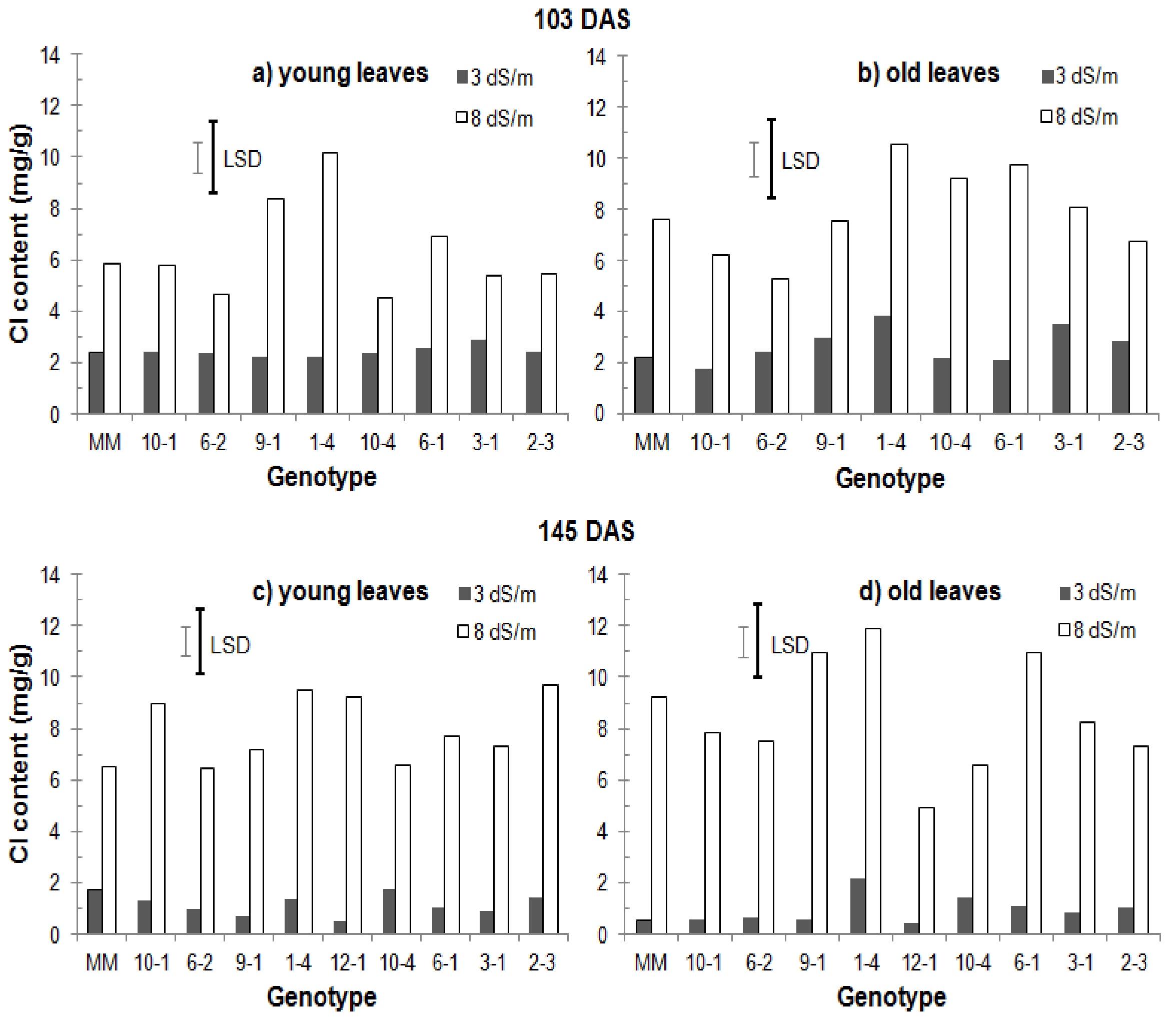

Figure 22: Chloride content (mg per gram of dry matter) in young leaves (8th leaf from the apex >5 cm) and old leaves (22nd leaf from the apex >5 cm) in the genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker; a-young leaves, b-old leaves), 103 days after sowing, and in the final harvest (9 introgression lines and the parent line Moneymaker; c-young leaves; d-old leaves), 145 days after sowing, under control (3 $dS.m^{-1}$) and saline conditions (8 $dS.m^{-1}$). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

Relatively to the final harvest, 145 DAS, genotypic influence was found on Cl^- accumulation in old leaves (*p*=0.010) (Figure 22-d), but not in young leaves (*p*=0.392) (Figure 22-c), while no significant interaction between the EC level and genotype was found, in both cases.

Under saline conditions, Cl^- content in young leaves from genotype MM was 6.5 $mg.g^{-1}$, and 9.3 $mg.g^{-1}$ in old leaves. Following the same trend, the Cl^- content observed in old leaves, from genotypes IL1-4, IL6-1 and IL9-1, was 25% above the value in young leaves. On the other hand, genotypes IL2-3, IL10-1 and IL12-1 registered higher Cl^- content in young leaves compared with old leaves. IL12-1 showed the largest difference, with 9.2 $mg.g^{-1}$ in young leaves, and 4.9 $mg.g^{-1}$ in old leaves.

Relatively to Cl^- accumulation in stems at the first harvest (Figure 23-a), 3 ILs significantly differed from the parent line, with higher accumulation: IL3-1 (p=0.002), IL9-1 (p=0.014) and IL10-4 (p=0.045). Genotype IL3-1 was the line with highest Cl^- content in stems under saline conditions, and was augmented from 6.3 mg.g^{-1} to 18.1 mg.g^{-1} under salinity.

At the final harvest (Figure 23-b), the genotypic factor significantly influenced the accumulation of Cl^- in stems (p=0.011), but no statistical significance was found for the interaction between the EC level and genotype.

The Cl^- content in the parent line MM was increased from 2.4 mg.g^{-1} to 12.8 mg.g^{-1}. Genotype IL2-3 was the only line to differ from MM (p=0.031). With an average of 11.3 mg.g^{-1}, this line showed 48% higher Cl^- content in stems, compared with the parent line, which showed an average of 7.6 mg.g^{-1}.

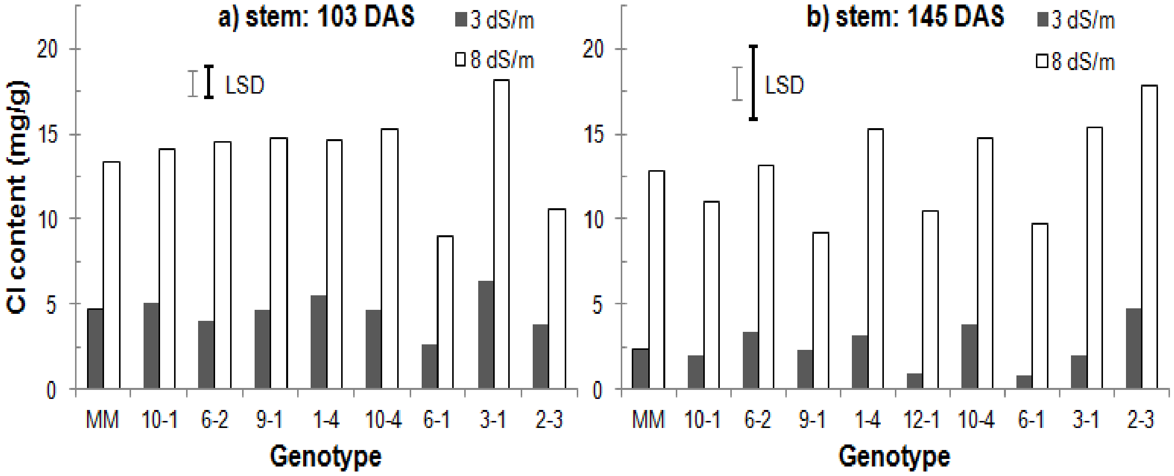

Figure 23: Stem chloride content (mg per gram of dry matter) in a) the genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing, and b) in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (EC=3 dS.m^{-1}) and saline conditions (EC=8 dS.m^{-1}). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

The salt treatment significantly reduced K^+ concentration in young leaves (p=0.027), old leaves (p<0.001) and stems (p=0.045), at the first harvest (103 DAS). The K^+:Na^+ ratios were significantly decreased by salinity, in both young leaves (p<0.001) (Figure 24-a) and old leaves (p<0.001) (Figure 24-b). In average, K^+:Na^+ ratios were 51% lower in EC8 compared with EC3, in young leaves, while the reductions shown in old leaves were in a greater extent (73%).

In young leaves, genotype MM showed K^+:Na^+ ratio of 4.7 in EC3, and was decreased in 60%, to 1.9. The most affected genotype was IL10-4, which showed 75% reduction (5.4 in EC3; 1.3 in EC8).

In old leaves, MM was significantly decreased in 72%, with ratio of 6.1 in EC3, and 1.9 in EC8. The greatest reductions due to salinity were shown in genotypes IL10-1 (87%) and IL10-4 (81%). No genotypic differences were found, however, in K^+:Na^+ ratios in young and old leaves.

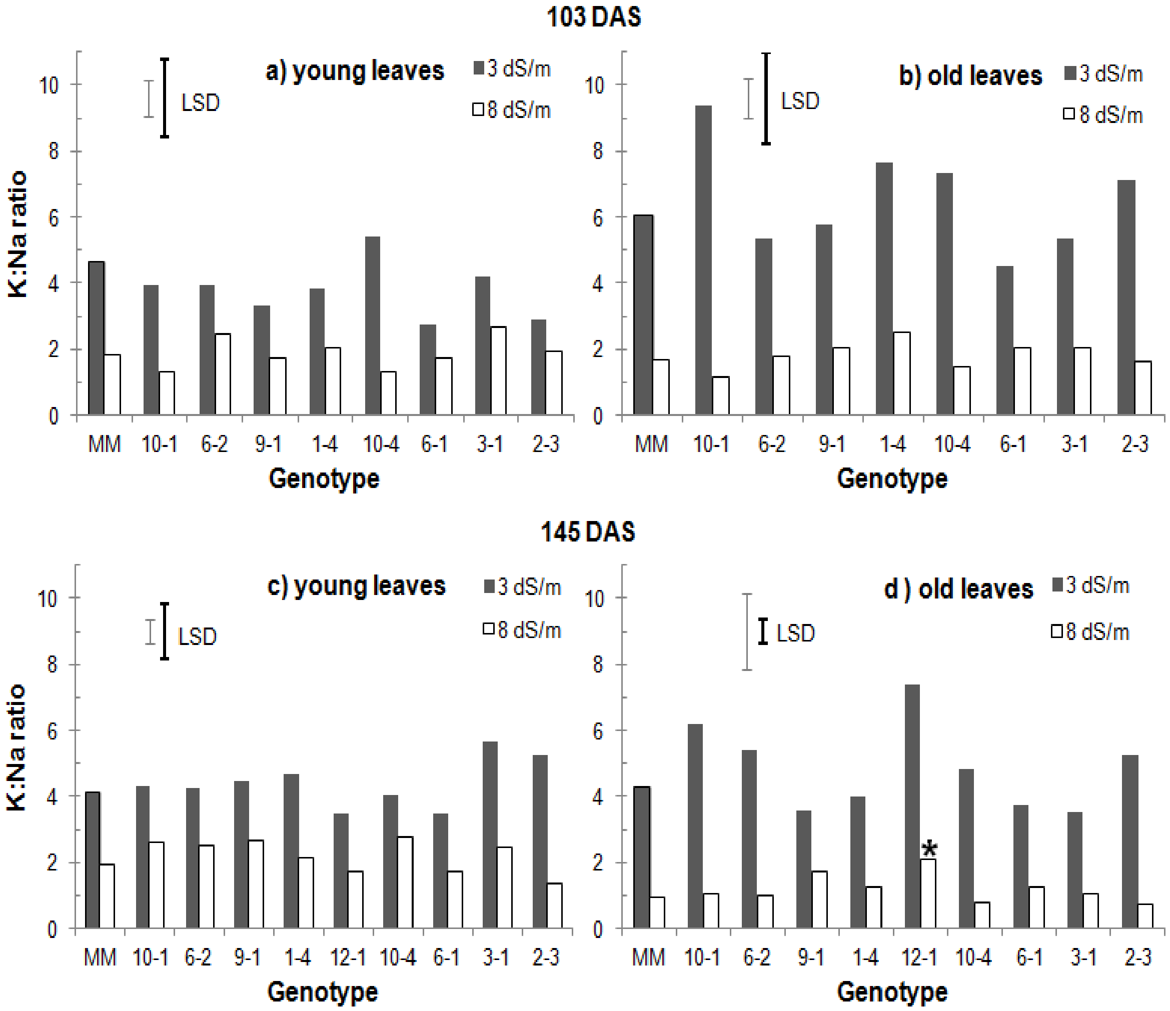

Figure 24: K^+:Na^+ ratios in young leaves (8th leaf from the apex >5 cm) and old leaves (22nd leaf from the apex >5 cm) in the genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker; a-young leaves, b-old leaves), 103 days after sowing, and in the final harvest (9 introgression lines and the parent line Moneymaker; c-young leaves; d-old leaves), 145 days after sowing, under control (3 $dS.m^{-1}$) and saline conditions (8 $dS.m^{-1}$). Asterisk indicates significant difference compared with MM, by Dunnett's t-test ($p<0.05$). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black) (graphs a, b and c), and for control (grey) and saline conditions (black) (graph d).

At the final harvest, salinity significantly decreased both K^+ concentration and K^+:Na^+ ratios in all sampled organs (Table 27 – Appendix XVI). Relatively to K^+:Na^+ ratio in young leaves (Figure 24-c), the reduction (*p*<0.001) ranged from 31% (IL10-4) to 71% (IL2-3). In old leaves (Figure 24-d), the reduction (*p*<0.001) ranged from 51% (IL9-1) to 87% (IL2-3).

Neither the genotypic factor, nor the interaction between EC level and genotype, significantly influenced K^+:Na^+ ratio in young leaves. On the other hand, in old leaves, both the genotypic factor (*p*=0.005) and the interaction between the factors (*p*=0.024), significantly affected K^+:Na^+ ratios.

Genotype MM showed K^+:Na^+ ratio of 4.6 in old leaves, under control conditions, and was reduced to 1.0 by salinity. Genotype IL12-1 showed significantly higher K^+:Na^+ ratio in EC8 compared with MM (*p*=0.019), with ratio of 2.1.

It is worth to mention the ratio of 1.8, in EC8, shown by genotype IL9-1, despite not being statistically different from MM. The lowest ratios under salt treatment, in old leaves, were observed in IL2-3 and IL10-4 (0.8, in both cases).

In young leaves, the K^+:Na^+ ratio in MM was decreased from 4.3 to 1.9. The highest average was shown by IL3-1 (4.1), which registered 55% reduction, from 5.7, in EC3, to 2.6, in EC8. Under salinity, the highest ratios were shown in IL9-1 (2.9), IL10-4 (2.8), IL10-1 (2.6) and IL3-1 (2.6).

It is worth noting the largest reduction in IL2-3 (71%), which showed the second highest ratio in EC3 (5.4), but showed the lowest ratio in EC8 (1.5).

In old leaves, genotype MM showed K^+:Na^+ ratio similar to that for young leaves, but the reduction was higher (55% in young leaves; 78% in old leaves). Genotype IL12-1 showed significantly higher (*p*=0.006) K^+:Na^+ ratio compared with MM. This IL showed the highest averages in both conditions (7.6 in EC3; 2.1 in EC8), while MM showed one of the lowest values under saline conditions (1.0).

Genotype IL9-1 registered one of the lowest ratios in EC3 (3.7), but showed the lowest reduction due to salinity (51%). Thus, it is worth to mention the second highest ratio in this IL (1.8), despite the fact that it was not statistically different compared with the parent line.

Salinity decreased Ca^{2+}:Na^+ ratios in both young leaves (*p*=0.042) and old leaves (*p*<0.001) (Table 26 – Appendix XV), at the first harvest. Salinity also decreased the stem

Ca^{2+}:Na^{+} ratios (*p*<0.001) (Figure 25-a). While no effect of the genotypic factor was found in leaves, it significantly influenced the results in stems (*p*=0.002).

The average stem Ca^{2+}:Na^{+} ratio in EC3 was 1.6, while it was 1.0 in EC8. The only exception to the trend was shown in genotype IL6-2, which showed slightly higher ratio in EC8, compared with EC3. Genotype MM was reduced in 48%, with an average Ca^{2+}:Na^{+} of 1.5 in EC3, and 0.8 in EC8. Genotype IL3-1 was the only significantly different from the parent line (*p*=0.004), and registered higher averages in both treatments (2.4 in EC3; 1.5 in EC8). The largest decrease was shown by genotype IL10-1 (58%), which showed ratio of 1.8 in EC3, and 0.8 in EC8.

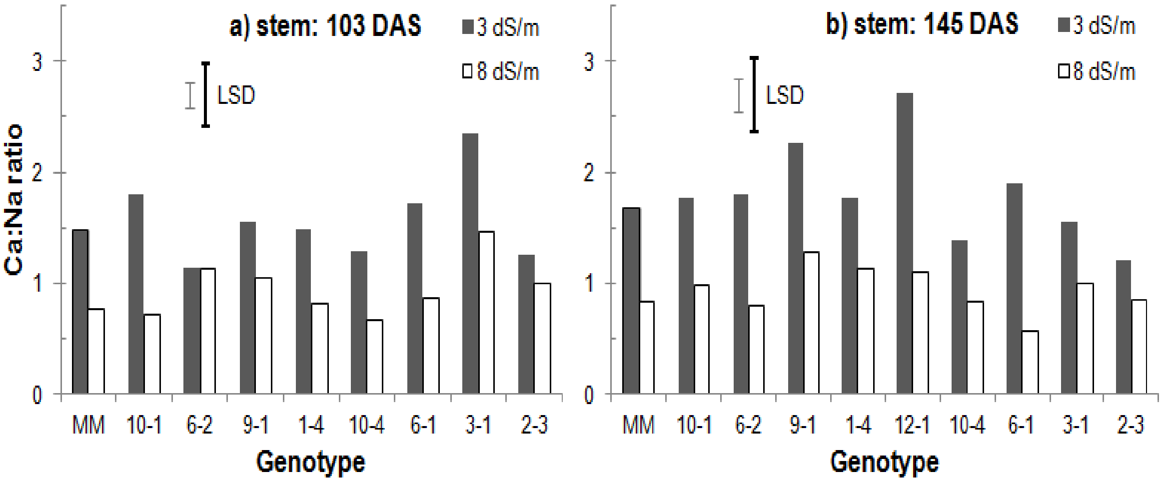

Figure 25: Stem Ca^{2+}:Na^{+} ratios in the genotypes a) included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing, and b) in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing, under control (3 $dS.m^{-1}$) and saline conditions (8 $dS.m^{-1}$). I-beams indicate least significant difference (LSD) for EC level (grey) and genotype (black).

At the final harvest (145 DAS), calcium concentration was increased in young (*p*=0.003) and old leaves (*p*=0.009), while no effect of salinity was found in the stem Ca^{2+} concentration.

Relatively to Ca^{2+}:Na^{+} ratios at the final harvest, salinity significantly decreased the ratios in young leaves (*p*=0.003), old leaves (*p*<0.001) and stems (*p*<0.001) (Figure 25-b). The reductions in stem Ca^{2+}:Na^{+} ratios, owing to salinity, ranged from 33% to 68%.

Genotype MM was reduced in 57%, from 1.5 to 0.8. None of the ILs was significantly different from the parent line. Nevertheless, it is worth to mention the highest ratios registered, under salt conditions, in IL12-1 (1.1), IL1-4 (1.2) and IL9-1 (1.3).

In young leaves (Figure 26-a), at the final harvest, no significant interaction between the factors was found (p=0.920). Genotype IL10-4 was the only exception to the trend of decreased Ca^{2+}:Na^{+} ratio under salinity, since it showed slightly higher mean in EC8.

In the parent line MM, the ratio decreased from 3.2 to 2.3. Only genotype IL9-1, with an average of 4.8 (5.8 in EC3; 3.9 in EC8) showed to be significantly different from MM (p=0.049).

In old leaves (Figure 26-b), both the genotypic factor (p<0.001) and the interaction between salinity and genotype (p=0.004) showed significant effect on Ca^{2+}:Na^{+} ratio. Reductions due to salt treatment ranged from 14%, in IL9-1, and 76%, in IL2-3.

In MM, Ca^{2+}:Na^{+} ratio was 10.9, in EC3, and 3.5, in EC8 (68% decrease). Genotype IL9-1 was less affected, showing a reduction of 14%, from 6.4 to 5.5. Genotype IL2-3 was the most affected by salinity, being decreased from 10.9 to 2.6.

Under salinity, genotype IL12-1 showed significantly higher Ca^{2+}:Na^{+} ratio compared with MM (p=0.045). This line showed the highest ratios, with 17.6 in EC3, and 6.0 in EC8.

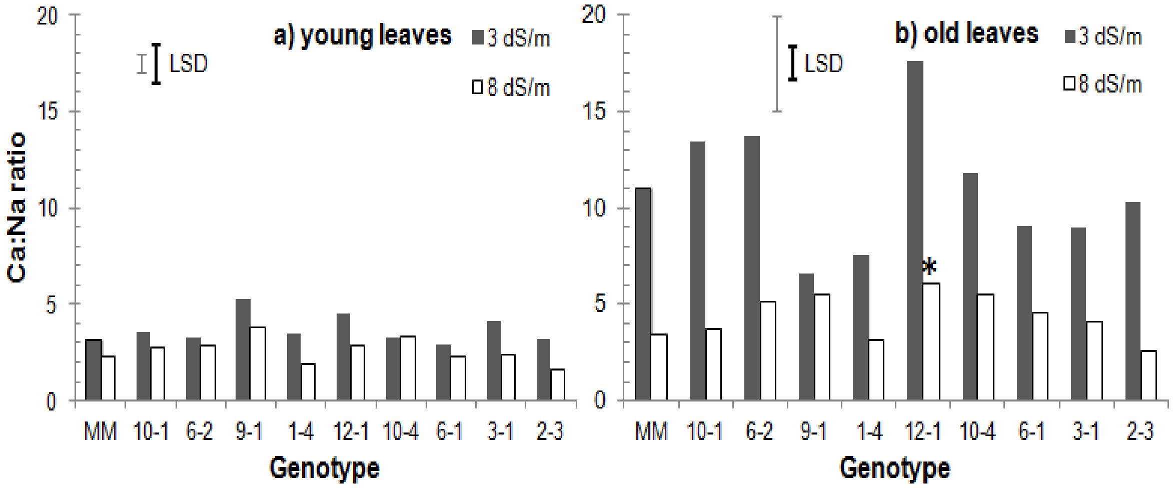

Figure 26: Ca^{2+}:Na^{+} ratio in a) young leaves (8th leaf from the apex >5 cm) and b) old leaves (22nd leaf from the apex >5 cm), in the 10 genotypes (9 introgression lines and the parent line Moneymaker), under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}), at the final harvest (145 days after sowing). Asterisk indicates significant difference compared with MM, by Dunnett's t-test (p<0.05). I-beams indicate least significant difference (LSD) for a) EC level (grey) and genotype (black), and b) for control (grey) and saline conditions (black).

Relatively to Mg^{2+} concentration at the first harvest, salinity significantly decreased the concentration in young leaves (p=0.004) and old leaves (p<0.001), while no effect was found in stems (Table 26 – Appendix XV). At the final harvest, salt stress significantly increased Mg^{2+}, but only in old leaves (p=0.001), while no effect was found in young leaves and stems (Table 27 – Appendix XVI).

No significant influence of salinity was found for the SO_4^{2-} concentration in all sampled organs, at both first and final harvest.

4. Discussion

4.1 Growth and development

Salinity significantly decreased TDW (-11%) at the final harvest, while no effect was found at the first harvest, and decreased TFW (-17% first harvest; -21% at the final harvest). The higher extent that this was observed in TFW compared with TDW, indicates that water loss in the plant's organs is one of the reasons for decreased fresh yield under saline conditions. Lower osmotic potential has been demonstrated for salt stressed tomato (De Pascale *et al.*, 2015), and this might also have been the case in this experiment, as supported by decreased leaf RWC (-3.4%), under saline conditions (Figure 21).

At the final harvest, genotype IL2-3 showed the highest TDW (Figure 5-b), and this was owed to higher yield of fruits (Figure 9-b), and stem biomass (Table 17– Appendix X). Total shoot dry weight is considered a good indicator of salt tolerance in tomato (Rao *et al.*, 2013), and IL2-3 showed the best performance in this trait. Lesser reduction in TFW shown in IL9-1 and IL1-4 (Figure 6) might indicate higher adaptation to the osmotic stress imposed by salinity.

Salinity decreased LA (-18%) and LAR, at the first harvest, while no effect of salinity was found on these traits at the final harvest. SLA was not influenced by salinity, whereas a decrease was observed on the dry matter partitioning to the leaves, but only at the final harvest.

Genotype IL2-3, which showed the longest stems throughout the experiment, also showed the largest negative impact of salinity on LA at the first harvest. In fact, a larger vegetative growth might increase the demand for water, to expand the growing cells. This is supported by the lower SLA showed in IL2-3, indicating thicker leaves and lesser expansion of the leaf cells, growing more in depth than in length.

Despite the fact that IL2-3 was more affected on LA under salinity, probably due to the osmotic effects in the first weeks of the experiment, this genotype showed a remarkable LAI of 4.9 under salt treatment, at the first harvest (Table 1). The resulting higher light interception could have supported a higher vegetative growth, and higher fruit yield (Heuvelink *et al.*, 2005).

Predominance of the osmotic component of salinity, until the first harvest, is also supported by the larger impact on LFW and SFW (16% and 10%, respectively), than LDW and SDW (11% and 9%, respectively). This indicates that the effect is better explained by decreased water content, rather than decreased number of cells. Lower water consumption, under saline conditions, was demonstrated for several tomato cultivars (Reina-Sánchez *et al.*, 2005), and it should also have been the case in this experiment, although water consumption was not measured.

Changes in leaf morphology, indicated through changes in LAR, can partly explain the changes in LA. In the case of IL2-3, the NL (Table 2) might better explain the higher LA showed by this genotype.

It can be suggested that changes in LAR at the first harvest were more influenced by changes in SLA than in dry matter partitioned to the leaves (EC *p*-values Table 1 and Table 11 - Appendix VII). This might indicate that the osmotic effect of salinity could be hampering the cells' elongation in the first stages of the plants' development.

Genotypes IL6-1 and IL10-1 showed LAI of 2.7 in EC8, at the first harvest. In the case of IL6-1, this is better explained by the combination of decreased SLA and partitioning to the leaves, while, for IL10-1, it was the reduction in SLA the cause of LA reduction and, consequently, decreased ability to intercept light. Since all other genotypes, at the first harvest, showed LAI above 3, the threshold indicated for tomato (Heuvelink *et al.*, 2003), differences in vegetative yield might be due to some other reasons, rather than just different capacity to intercept light.

The lack of effect of salinity on LA at the final harvest (90 days of salt treatment), was completely unexpected, since one of the well-known effects of salinity is LA reduction (Li *et al.*, 2001; Munns, 2002; Heuvelink *et al.*, 2003; Heuvelink and Dorais, 2005). Nevertheless, the majority of the genotypes showed lower LA in EC8 compared with control conditions (Figure 13-b), and the low *p*-value (0.144) for the EC factor, further supports the trend of decreased LA under salt stress.

Fungal infections were observed one week before the first harvest, and it was confirmed the pathological agent as being *Phytophtora sp.*, through a test on the June 4th (92 DAS). Treatments to control its incidence started on the following day, and maintained until the end of the experiment (Table 4 – Appendix II). After the first harvest, the infection spread notably throughout the whole compartment, with variable severity among the genotypes, and most likely this was the reason for the unexpected lack of effect of salinity on LA, at the final harvest.

Genotypes IL2-3, IL3-1 and IL6-1 seemed to be the most affected genotypes by the fungal infection, whose symptoms were noted in stems and leaves (Figure 43, Figure 44 and Figure 46 – Appendix III), and this resulted in lesser number of plants from these genotypes to be included in the final harvest (see legend in Figure 27 – Appendix I). Curiously, the majority of the plants affected by the infection were from the EC3 treatment, suggesting that the salinity stress may have induced some resistance to this biotic stress

At the final harvest, the highest LA was observed in genotype IL1-4, which showed similar LA under both conditions. Despite the moderate correlation found between LA and NL (r=0.45 in EC3; r=0.52 in EC8), in this genotype NL could not explain higher LA. The reason was clearly the higher LAR shown in this line (Table 1), which might indicate bigger leaflets, since SLA was not decreased. But that changes in LAR are not sufficient to explain the changes in LA is supported by the results shown by IL10-1. This genotype showed similar LAR compared with MM, but much lower LAI. In this case, the lower SLA under both conditions, can partly explain the low LA in IL10-1. Despite showing one of the highest partitioning to the leaves (Figure 8), this genotype produced lower total leaf biomass (Table 13– Appendix VIII and Table 15 – Appendix IX), resulting in a reduced canopy. In the same direction, genotype IL12-1 showed both lower SLA and LAI, under control conditions, and the higher SLA observed in EC8 might explain the higher LAI.

In genotype IL6-2, NL better explained the higher LA shown in EC3 (Table 2). This genotype showed, in EC3, similar LAR compared with MM, but the significantly higher NL resulted in higher LA. Decreased NL due to salinity can be pointed out as the main reason for the reduction in LA showed in IL6-2 (Figure 13-b). This genotype also showed the most drastic change in the leaf thickness, from EC3 to EC8, which further explains the reduction in LA.

Under salt stress, lower biomass production can be justified by reduced photosynthesis and consequent reduced availability of carbohydrates to be distributed among different organs and growth processes under competition (Albacete *et al.*, 2014). Decreased photosynthesis can be due not only to decreased LAI (Heuvelink and Dorais, 2005), but also to decreased total chlorophyll content (Ashraf and Harris, 2013) and increased stomatal resistance (Chaves *et al.*, 2009; De Pascale *et al.*, 2015). In fact, despite the increase of chlorophyll content under salinity, in relative terms, until the first harvest (Figure 16 and Figure 17), the difference disappeared at the final part (Table 20 – Appendix XII). This might indicate that the higher chlorophyll content, at the beginning of the experiment, was related to the osmotic component of salt stress, resulting in higher concentration of chloroplasts, while, at the end of the experiment, the ionic component might have been more detrimental (chloroplast damage), after the osmotic adjustment. Nevertheless, it has already been referred the chlorophyll content as a non-reliable indicator of salt tolerance, in tomato (Juan *et al.*, 2005). Therefore, higher chlorophyll content can be due to reduction in cell size, increasing its concentration in the leaf blades (James *et al.*, 2002). This is supported by the higher chlorophyll content in the genotypes which also showed the lowest SLA: IL2-3, IL6-2 and IL10-1.

No correlation was found between SLA and chlorophyll content in control conditions, but, despite being non-significant, a negative relationship, under saline conditions, can be suggested (Table 31– Appendix XXI). Thus, this could indicate a trend to increase chlorophyll content in thicker leaves. In agreement, genotypes MM, IL10-4 and IL9-1, which showed thinner leaves (higher SLA), in EC8, showed lower chlorophyll content.

The results in EC3 suggest that higher chlorophyll content in IL2-3, IL6-2 and IL10-1 might be characteristic of these lines, since higher values were always observed compared with the parent line.

4.2 Fruit yield and fruit quality

In this experiment, a significant correlation was found between LA and total fruit yield (both FDW and FFW), under control conditions (Table 30 – Appendix XX), while in EC8, the correlation lost significance for FFW, and was lowered for FDW (Table 31 – Appendix XXI). Nevertheless, changes in LA partly explain the reductions in fruit yield, as previously demonstrated (Villalta *et al.*, 2007).

A yield component analysis facilitates in the task of understanding the plants' responses to salinity (Figure 1).

At the first harvest, genotype IL10-4 showed the highest reductions in both FDW and FFW. Since no significant influence of salinity was found on the dry matter partitioned to the fruits (Table 11 – Appendix VII), and on NT (Table 2), the reductions can be explained by differences in fruit-set. In fact, no ripe fruits were collected from this line until the first harvest, indicating delayed fruit-set in this genotype.

At the end of the experiment, salinity showed significant influence on average fruit weight and total soluble solids.

One of the well-known effects of salinity is the reduction in fruit size, as demonstrated in many studies (Adams and Ho, 1992; Cuartero and Fernández-Muñoz, 1999; Scholberg and Locascio, 1999; Li *et al.*, 2001; Cuartero *et al.*, 2006). In this experiment, the extent that the reduction in AFW occurred, showed considerable variation among different genotypes (Figure 18-a).

Genotype IL6-2 showed the largest reduction in AFW (-32%), and this can partly explain the increase in TSS, owing to concentration effect. The correlation analysis confirms negative and moderate correlation between AFW and TSS (r=-0.50; Table 35 – Appendix XXV), under control conditions, but that was not maintained in EC8, despite showing the same trend (r=-0.38; non-significant), as shown in Table 36 (Appendix XXVI).

Higher TSS coincided with those genotypes which showed smaller fruits under salinity: IL6-2, IL1-4 and IL10-1. In fact, there´s a negative relationship between TSS and fruit yield, in tomato (Higashide and Heuvelink, 2009).

That the reduction in fruit size, by itself, cannot fully explain the increased sugars content, is supported by the results in genotype IL6-1. This line showed a considerable reduction in AFW due to salinity (-24%), but was not affected in TSS.

Yin *et al.* (2010) showed increased TSS with decreased size of tomato fruits, but also showed that the accumulation of sugars was apparently higher than the reduction in size. These authors suggested that sugar metabolism is increased under salinity. Additionally to the concentration effect due to the reduction in size, salinity promotes starch accumulation during the fruits development and, after their degradation in ripening fruits, TSS is further increased (Yin *et al.*, 2010). In the same direction, it was recently demonstrated that increased sucrolytic activity resulted in increased hexose concentration, in salinized tomato (Albacete *et al.*, 2014).

It was found highly significant correlation between K^+ concentration in young leaves and TSS (r=0.58; Table 34 – Appendix XXIV). This can be explained by the protective role of potassium in metabolic processes (Tester and Davenport, 2003), which might include the synthesis of sugars.

The lower leaf water content shown in IL12-1 might indicate an overall lower water potential in the plant. Lower water potential could explain the higher TSS in genotypes IL12-1 and IL2-3, which showed lower RWC, under salinity (Figure 21). The correlation analysis, however, doesn´t clearly support this idea, but suggests increased TSS when RWC is lower (r=-0.31; Table 36 – Appendix XXVI).

Highly significant correlation between TSS in fruits, and TSS in stems of tomato has been demonstrated (Quadir *et al.*, 2006). Thus, it can be hypothesized that higher TSS shown in fruits from IL2-3 could indicate higher sugar concentration in stems, allowing better osmotic adjustment and growth under saline conditions.

Considerably higher reduction in FFW (-23%) compared with the reduction in FDW (-9%), at the final harvest, further supports that reduction in the water potential might explain, to a greater extent, the different effect of salinity on fresh and dry yield.

Genotype IL10-4 showed the highest FDW and FFW in EC3, but also showed high reductions due to salinity (-20% and -33%, respectively). Curiously, this line showed the highest AFW, in EC8, so the fruit size cannot be the reason for the decreased fruit yield. The reasons might be lower NF (Figure 12) and NT (Table 2).

Genotypes MM and IL6-2 were more reduced in AFW, which can partly explain the differences in fruit yield. Additionally, also the partitioning to the fruits was reduced under salinity, which might have been the result of lower NF per truss in both cases, while NT was more detrimental in IL6-2.

Genotypes IL3-1 and IL2-3 were not affected by salinity relatively to FDW, while they showed considerable reductions in FFW. Thus, lower water content in the fruits can be pointed out as the main reason for the reduction in FFW, in those lines.

The lower fruit yield in IL1-4, under both EC3 and EC8, can be explained by lower sink strength of the fruits (Figure 8), which is represented by smaller fruits (Figure 42 – Appendix III), when compared with other genotypes. In turn, the poor performance showed by IL12-1 can be explained by low NT, resulting in reduced NF.

The marketable yield was also more affected in terms of fresh yield (-33%) than in dry yield (-22%). The correlation analysis (Table 36 – Appendix XXVI) suggests moderate positive correlation between BER and both FDW and FFW (r= 0.41, non-significant). This might indicate that some of the genotypes which showed higher fruit yield, were also more susceptible to BER. This is supported, indirectly, through the highly significant correlation between BER and SL (r=0.63), since SL was the growth parameter which showed higher positive correlation with total fruit yield (Table 36 – Appendix XXVI). Positive correlation between yield traits and BER incidence has already been demonstrated in tomato (Adams and Ho, 1992), and this is well represented by the results shown in genotypes MM, IL2-3, IL6-1 and IL10-4, which showed, simultaneously, high fruit yield and high BER incidence. On the other hand, genotype IL3-1 showed one of the best performances in terms of fruit yield, and low incidence of BER.

Susceptibility to BER was considerably variable among the different genotypes, not only under salinity, but also under control conditions. It could be seen as surprising the high incidence of BER at control conditions. If this was the result of the determined control EC level, the plant material, or the operational practices, it is hard to clear up. In the development of the trusses, it was observed that the insertion angle with the stem was steep, in the majority of the genotypes. Later, this resulted in bended trusses, owed to the weight of the growing fruits (Figure 36 – Appendix III), and it is difficult to discuss whether it may or may not have resulted in developmental problems of the fruits (*e.g*. BER). Nevertheless, this was mainly observed in the first 2 to 3 trusses, and then it was attenuated.

Even with high levels of nutrients available in the root zone, BER can still occur, and can be explained by interactions between nutrients (Adams and Ho, 1995). Additionally, susceptibility to BER can also be related to fruit size, and genotypes with larger fruits could be more likely to show higher incidence (Adams and Ho, 1992). In fact, genotypes MM, IL2-3 and IL10-4 showed larger fruits and higher BER. In the opposite direction, genotypes IL3-1 and IL12-1 also showed large fruits, but low BER. The correlation analysis confirms that the fruit size cannot fully explain the susceptibility to BER (Table 35 – Appendix XXV; Table 36 – Appendix XXVI).

Except for genotype IL9-1, salinity augmented the relative fruit dry matter content in all genotypes, (Figure 18-b), which partly alleviated the reduction in marketable fruit yield. Nevertheless, additionally to decreased water content, the reductions in marketable yield were also due to decreased total fruit dry matter.

The slightly higher marketable yield observed in IL9-1 in EC8, compared with EC3, was due to increased fruit sink strength (Figure 8). Relatively to the other genotypes, several reasons can be pointed out to explain the negative effect of salinity on marketable fruit yield. The high reductions observed in MM, IL6-1 and IL10-4 can be explained, to a considerable extent, by high BER incidence. Additionally, MM and IL6-1 were considerably affected in AFW. In the case of MM this seemed to be the result of lower fruit sink strength, while IL6-1, which showed higher sink strength in EC8, might have been reduced because of lower NT.

Genotype IL10-4 also showed higher partitioning to the fruits in EC8, so the decreased marketable yield can be partly explained by lower NT and, consequently, lower NF.

Genotype IL2-3 showed interesting performances in terms of MFDW and MFFW. The susceptibility to BER shown by IL2-3, in EC8, was compensated by higher partitioning to the fruits and lesser reduction in NF. Since BER was determined in a weight basis, this might indicate low number of fruits affected with BER, but of a large size. This line showed the same NT in both conditions, so the difference in NF was only due to decreased number of fruits per truss.

Under salinity, genotype IL3-1 showed the highest MFFW, and the second highest MFDW. This line showed low incidence of BER and increased fruit sink strength, which partly compensated the lower NT in EC8. Nevertheless, the low BER can be pointed out as the main reason for the high performance of this line, in terms of marketable yield.

Genotypes IL1-4 and IL10-1 showed lesser influence of salt stress on both MFFW and MFDW, which was the result of low BER. Despite this, these two lines showed low fruit yield performances, which can be explained by low fruit sink strength, represented by both small fruit size and low NF.

Genotype IL6-2 showed high reduction of MFFW (-49%) and MFDW (-41%), and this was due to the combination of decreased NT (-2 units), decreased AFW and BER incidence.

The low BER incidence showed by Genotype IL12-1, was not translated into high fruit yield, mainly owed to low NT, in both EC3 and EC8.

In general, the reductions in marketable fruit yield can be explained by decreased AFW, decreased NF, and increased BER. The higher extent that the AFW changed (-20%), compared with NF (-13%), might indicate that AFW was a more preponderant factor.

The reductions in NF can be explained by both lower NT and higher incidence of BER in EC8 (18%), when compared to control conditions (8%). Nevertheless, it should not be ruled out the hypothesis of lower fruit-set per truss, under salt stress.

High temperatures were registered at the final part of the experiment (Figure 3), causing flower abortion (Figure 50 – Appendix III), and it is unknown whether if it may have affected the genotypes differently, in terms of fruit yield.

4.3 Ions content

At the first harvest, genotype IL1-4 was the line to show higher accumulation of chloride in young and old leaves (Figure 22-a and Figure 22-b). The higher accumulation of chloride in leaves, might explain the low chlorophyll content observed in this line, owing to the toxic effect of this anion on the leaf blades (Slabu *et al.*, 2009; Tavakkoli *et al.*, 2011).

A moderate and negative correlation was found between chloride concentration in old leaves and chlorophyll content (Table 29 – Appendix XIX). In contrast, IL6-2 showed low chloride accumulation in both young and old leaves, and showed higher chlorophyll content (Figure 17).

Genotype IL3-1 showed the highest stem accumulation of chloride, but one of the lowest concentrations in young leaves, under salt treatment. The ability to prevent chloride accumulation in transpiring and developing leaves can be seen as an indicator of salt tolerance (Munns, 2002). Additionally, this genotype also showed higher stem Ca^{2+}:Na^+ ratio (Figure 25- b), which, in turn, was found moderately correlated with FFW (r=0.52), and negatively correlated with BER incidence (r=-0.54), as indicated in Table 29 (Appendix XIX). This is in agreement with the higher fruit yield (Figure 10-a) and lower BER (Figure 19) observed in this genotype.

Genotype IL10-4 showed significantly higher BER incidence compared with MM, and the lowest stem Ca^{2+}:Na^+ ratio, in EC8. This might reinforce the importance of the maintenance of a favorable Ca^{2+}:Na^+ ratio.

Salinity decreased K^+:Na^+ ratios in young leaves, old leaves and stems, and this was due to both decreased K^+ and increased Na^+ (Table 27 – Appendix XVII).

In young leaves, K^+:Na^+ ratio was found strongly correlated with fresh yield, while it was only moderately correlated with dry yield (Table 29 – Appendix XIX). This suggests that the maintenance of a favorable K^+:Na^+ ratio might be important for the osmotic adjustment, and can be considered as a good indicator of salt tolerance, as supported by many authors (Dasgan *et al.*, 2002; Juan *et al.*, 2005; Maggio *et al.*, 2007; Rao *et al.*, 2013).

At the first harvest, salinity strongly affected genotype IL10-4 in K^+:Na^+ ratio of young leaves and old leaves (Table 26 – Appendix XVI). This line showed the largest reduction in TFW (-29%), and this could be owed to drastic changes in K^+ homeostasis, indicated by its low K^+:Na^+ ratio. Lower K^+:Na^+ ratio in this genotype compared with MM, while showing higher expression of SOS1 and HKT1 genes, have already been demonstrated (Chowdhury, 2012). This might indicate salt inclusion mechanisms, allowing the entrance of Na^+, and its transport and accumulation into the leaves (Pardo *et al.*, 2006; Olías *et al.*, 2009a).

In young and old leaves, at the final harvest, the lowest K^+:Na^+ ratios shown in genotype IL2-3 (Figure 24-c and Figure 24-d) might indicate salt inclusion mechanisms in this genotype. Also genotype IL10-4 showed drastic reduction of K^+:Na^+ ratio, in old leaves. This could be due to increased expression of SOS1 and HKT1 genes, that has already been shown in these two genotypes (Chowdhury, 2012). Increased activity of SOS and HKT transporters in the root zone would result in increased Na^+ loading into the xylem, increasing its accumulation in the shoot (Pardo *et al.*, 2006; Olías *et al.*, 2009a). Additionally, higher expression of genes that encode for antioxidant enzymes, previously shown in these lines (Chowdhury, 2012), might have resulted in increased protection to the oxidative component of salt stress, and been translated, in the case of IL2-3, into higher TDW and TFW (Figure 5 and Figure 6).

Higher inclusion could alleviate the osmotic pressure at the root zone, allowing the plant to take up more water, which, in turn, can be one of the reasons of the higher growth showed by IL2-3. If the salt ions are not efficiently compartmentalized, however, this could result in lower availability of K^+ and Ca^{2+} within the plant. This is in agreement with the results from genotype IL12-1. This line showed, in old leaves, significantly higher K^+:Na^+ ratio compared with MM (Figure 24-d), which can be the reason for the maintenance of healthy leaves in large part of the canopy (Figure 47 – Appendix III).

Only in old leaves K^+:Na^+ ratios were below 1.0 in some genotypes, namely in IL2-3 and IL10-4, while MM showed exactly 1.0. A critical K^+:Na^+ ratio of 1.1 was indicated in Barley (Tavakkoli *et al.*, 2011). If, on the one hand, these low ratios in IL2-3, IL10-4 and MM, could be seen as an indicator of ionic stress in those genotypes, on the other hand this could also be assumed as non conclusive, since Na^+ can be compartmentalized into the cells vacuoles, rather than being located somewhere else, within the tissues. Older leaves are more vacuolated than young leaves, so they are more effective in the compartmentalization of salt ions (Tester and Davenport, 2003).

Significantly higher leaf K^+:Na^+ ratios in genotypes IL6-1, IL6-2, IL9-1 and IL12-1, compared with MM, were demonstrated in a 100 mM NaCl treatment during 21 days (Chowdhury, 2012). In my experiment, after 90 days of salt treatment (~50 mM NaCl), significantly higher K^+:Na^+ ratios, in old leaves and stems, were confirmed for IL12-1, compared with MM.

Leaf accumulation of Na^+ and Cl^- showed variation with respect to genotype and leaf category (young and old). Different pattern in the accumulation of Na^+ and Cl^- with respect to different organs and genotype was expected (White and Broadley, 2001; Dasgan *et al.*, 2002).

Higher accumulation of Cl^- in old leaves, compared with young leaves, is common, since old leaves transpire for longer (White and Broadley, 2001). Results showing the opposite trend in genotypes IL9-1 (Figure 22; first harvest), IL2-3, IL10-1, and IL12-1 (Figure 22;

final harvest) may indicate lesser ability to accumulate chloride in older leaves. Additionally, genotype IL12-1 also showed higher Na^+ concentration in young leaves than in old leaves, in EC8, at the final harvest (Table 27 – Appendix XVII). Higher salt ions accumulation in the upper part of the canopy may explain leaf damages (Tavakkoli *et al.*, 2011) shown in IL12-1, which started to show necroses in the younger and developing leaves, in the lasts weeks of the experiment (Figure 51 – Appendix III).

Genotypes IL1-4, IL2-3, IL6-1 and IL12-1 showed higher concentration of Na^+ in leaves than in stems. In the opposite direction, IL6-2 showed higher Na^+ concentration in the stem than in leaves. Higher accumulation of Na^+ in leaves has been related to salt sensitiveness in different potato cultivars (Jaarsma *et al.*, 2013), suggesting tissue tolerance mechanisms. In tomato, in turn, Juan *et al.* (2005) showed that cultivars with lower leaf Na^+ accumulation showed higher salt tolerance, through maintenance of higher K^+ concentration and, consequently, higher K^+:Na^+ ratios. The correlation analysis (Table 34 – Appendix XXIV), however, indicates that higher accumulation of Na^+ in old leaves, and not in young leaves, was favorable to total biomass production, fruit yield and SL. In fact, Na^+ and Cl^- can be used by plants as cheap osmotica (Shabala and Cuin, 2007), and it has been suggested that Na^+ can substitute K^+ for some roles, in several plant species (Hauser and Horie, 2010).

Genotype IL6-1 showed the lowest Mg^{2+} concentration in young leaves, and this can be one of the reasons for the chlorotic leaves shown by this line at the end of the experiment (Figure 45 – Appendix III), owing to the relationship between Mg^{2+} deficiency and leaf chlorosis (Hao and Papadopoulos, 2003). Additionally, this line also showed considerably high accumulation of Cl^- in leaves, which also correlates with leaf chlorosis (Slabu *et al.*, 2009). Leaf chlorosis was not quantified in this experiment, and the correlation analysis does not indicate a clear relationship between Cl^- and leaf morphological (LAR), physiological (RWC), or developmental (Chl) traits.

Genotype IL1-4 showed high foliar accumulation of both Na^+ and Cl^-, and also showed the highest LA and LAR under salinity. This indicates that tomato plants might use salt inclusion mechanisms (*i.e*. for osmotic adjustment), indicating tissue tolerance strategy to mitigate the harmful effects of salinity.

Genotype IL9-1 showed the lowest foliar accumulation of Na^+ at the final harvest, under saline conditions (Table 27 – Appendix XVII), and this can be due to the favorable Ca^{2+} status showed by this line (Figure 25), which can reduce the permeability to Na^+ (Dasgan *et al.*, 2002). In the same direction, genotype IL12-1 showed, simultaneously, significantly higher Ca^{2+}:Na^+ ratio and the lowest accumulation of Na^+, in old leaves. Additionally, negative correlation was found between stem Ca^{2+}:Na^{+} ratio and BER (r=-0.68), which can explain the low BER incidence in IL9-1 and IL12-1, and the high incidence in MM, IL2-3, IL6-1 and IL10-4.

Genotype IL2-3 showed the largest reduction and lowest Ca^{2+}:Na^{+} ratio in young leaves, under saline conditions (Figure 26-a). The higher SL showed by this line might have hampered the maintenance of a favorable Ca^{2+} status in the upper part of the canopy, owing to the low mobility of this cation. The negative relationship between SL and Ca^{2+}:Na^{+} ratio in young leaves (r=-0.64), might indicate the difficulty of calcium to reach the top of the plants of the tallest genotypes, under salinity: IL2-3, IL6-1 and MM (Table 25).

Calcium uptake is restricted by salinity (Adams and Ho, 1993; Munns, 2002), so the increased Ca^{2+} in EC8, at the end of the experiment (Table 27 – Appendix XVII), could be seen as surprising. The reasons that can be pointed out, to explain this, are the lower fruit load, reduced fruit size (Adams and Ho, 1992) and increased osmotic adaptation by the plants. Despite the favorable calcium status within the plants, however, a normal transport of Ca^{2+} into the distal part of the fruits, might not have been maintained (Adams and Ho, 1992), increasing the incidence of BER.

The transport of calcium to the fruits is inversely related to Ca^{2+} accumulated in the leaves (Adams and Ho, 1993), and this can explain the high incidence of BER in IL6-1 and IL10-4, which showed high foliar accumulation of Ca^{2+}. The highest accumulation, however, was observed in IL12-1, which, contrarily, showed low BER. It can be suggested that the lower fruit yield showed by this genotype might have alleviated the calcium demand, not affecting the normal development of the fruits.

It is also worth to mention that some of the fungicides utilized to control the fungal infections, included chloride in its formulation (Table 4 – Appendix II), and it is unknown if this could have influenced, even if in a reduced extent, the ions content results.

5. Conclusions

5.1 Growth and development

Salinity decreased LA until the first harvest, both by reducing the total biomass of leaves (LFW and LDW) and by changing the leaf morphology (LAR).

Salinity decreased TFW (-17% at the first harvest; -21% at the final harvest) to a greater extent than for TDW (no effect at the first harvest; -11% at the final harvest), and lower water content can be pointed out as one of the reasons for decreased fresh yield of fruits, stems and fruits.

Salinity decreased the dry matter partitioning to the leaves at the final harvest (-3%), and negatively affected SL (-6%), the internode length (-5%), and NT (-1 unit).

Salinity increased the chlorophyll content throughout the experiment, but the differences disappeared at the final part. The chlorophyll content can be seen as an indicator of salt tolerance, through its significant correlations with TDW, NL and SL.

5.2 Fruit yield and fruit quality

Salinity decreased FFW (-9% until the first harvest; -23% until the final harvest) to a greater extent that decreased FDW (no effect at the harvest; -9% until the final harvest).

Salinity significantly decreased MFDW (-22%) and MFFW (-33%), owing to decreased AFW (-20%), NF (-13%), NT (-1 unit) and increased BER incidence.

Genotypes IL3-1 showed to be significantly less susceptible to BER compared with MM, while genotypes IL2-3 and IL10-4 showed significantly higher BER incidence than the parent line. BER can be pointed out as the main reason of decreasing marketable fruits in genotypes MM, IL2-3, IL6-1 and IL10-4.

Salinity increased the TSS (0.7 ºBrix) and the relative fruit dry matter content (15%). Genotypes IL1-4, IL2-3, IL6-2 and IL12-1 showed significantly higher TSS compared with MM, while genotype IL6-1 showed significantly lower TSS. Owed to lack of significant correlations between TSS and important indicators of tolerance (TFW, TDW, FFW, FDW, K^+:Na^+, Ca^{2+}:Na^+), TSS cannot be seen as a good indicator of salt tolerance in tomato.

Based on FDW, FFW, MFDW and MFFW, none of the ILs showed higher salt tolerance compared with MM.

5.3 Ions content

The K^+:Na^+ ratio showed to be a reliable salt tolerance indicator through significant correlations with yield traits (TDW, TFW, FDW and FFW).

The stem calcium status, both by Ca^{2+} concentration alone, or by Ca^{2+}:Na^+ ratio, showed to be a good indicator of salt tolerance, through its correlation with fruit yield and BER incidence.

Salinity decreased Ca^{2+}:Na^+, K^+, K^+:Na^+, and Mg^{2+} in all sampled organs, except for Mg^{2+} in stems.

Higher salt tolerance, based on K^+:Na^+ and Ca^{2+}:Na^+ ratios, was found in genotype IL12-1.

6. Future research

The use of rockwool as substrate is recommendable for tomato. The use of a different kind of substrate (for example: mix of sand and perlite), however, would allow, more easily, to do relevant measurements in the roots (*e.g* fresh and dry weight, ions content), concerning salinity effects.

Leaf photosynthesis should be measured to investigate if different genotypes respond differently to the changes that occur in leaf morphology and physiology, under salt stress.

Determination of the radiation use efficiency would be more informative, owed to the diversity of factors influencing biomass production, rather than just changes in plant architecture.

The salt treatment chosen for this experiment was considered sufficient to impose considerable stressful conditions, especially due to the long duration of the salt treatment. A higher EC could result in too much damage in the more sensitive genotypes, which could compromise the experiment. Nevertheless, an EC level above the threshold indicated by Maggio *et al.* (2007) (approximately 9.6 $dS.m^{-1}$), maintaining the experiment until plant maturity, could add relevant information about the responses in a phase in which different adaptation mechanisms are thought to be triggered.

Considerably high incidence of BER, under control conditions, was observed in some genotypes, and this should be subject to consideration in future experiments. It would be important to confirm whether or not this could be due to the EC3 treatment, in those genotypes. If a lower EC level is determined as control treatment, however, it is recommended that the nutritional demands of the plants are fully complied.

A continuation of this work could be done with less ILs included, selecting the best performing ILs, relatively to salt tolerant indicators found in the literature. By selecting, for example, only three ILs, I would recommend further studies including IL2-3, IL3-1 and IL9-1.

An experiment with much larger number of plants per plot from genotype IL2-3, could allow to reduce the height of the plants from this genotype, owed to higher competition for light. It would be interesting to see if it would result in considerably less BER incidence. If that would be the case, probably it would be achieved a significantly higher marketable fruit yield compared with the parent line MM.

Gene expression analysis, with relevance to salt tolerance, has already been conducted with three selected ILs from the LYC4 population (Chowdhury, 2012). That analysis included two of the ILs included in the current study, genotypes IL2-3 and IL10-4. I would recommend the extension of the gene expression analysis to genotypes IL3-1, IL9-1 and IL12-1, owed to the performances showed by these lines, in terms of potassium and calcium statuses. Additionally, gene mapping in the introgression region of those ILs could allow the selection of genes, or groups of genes, which could be included in the genomic background of the best performing genotypes, in terms of fruit yield.

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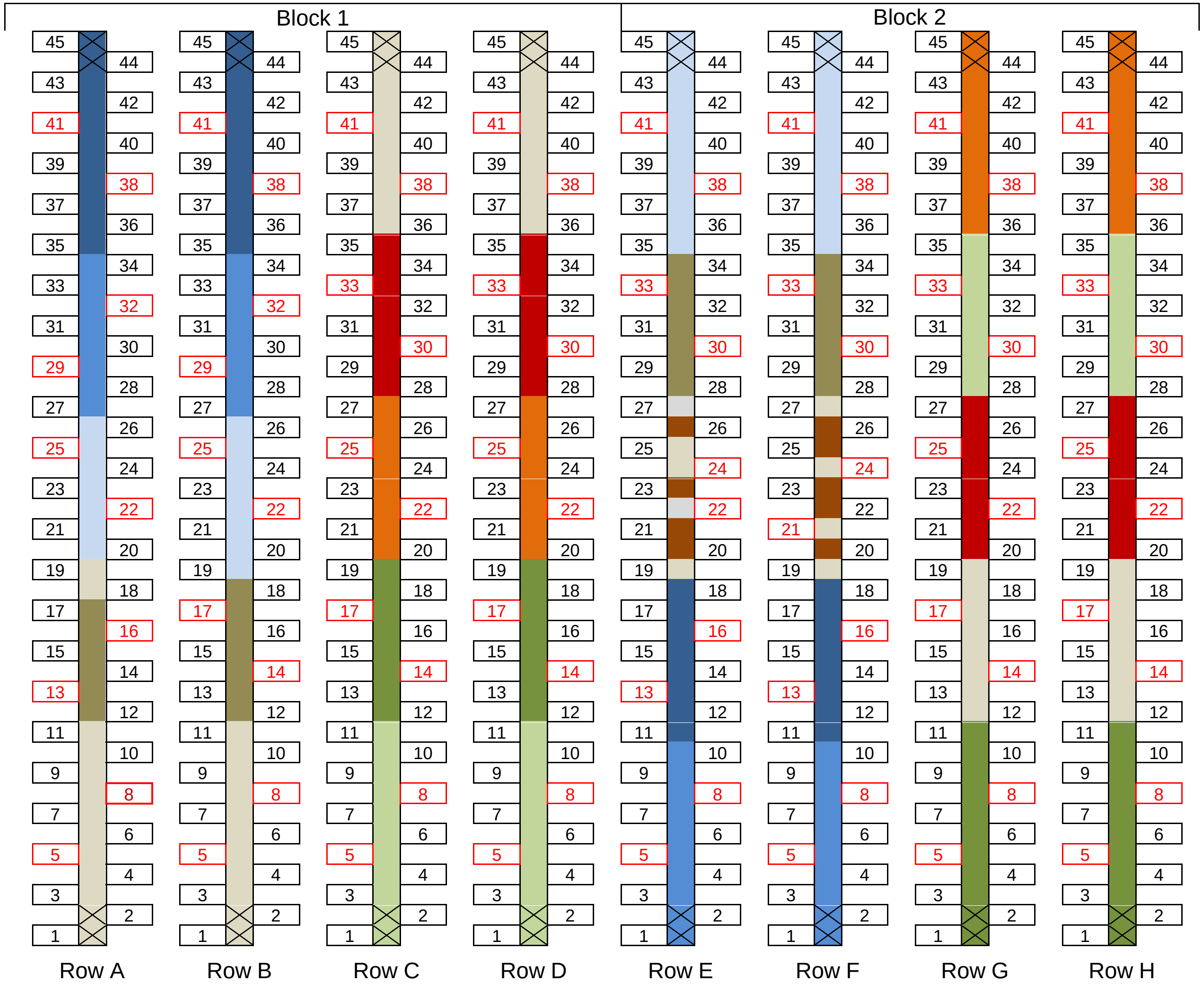
Appendix I



Legend

Genotype		**Total**	1st harvest	Final harvest EC3/EC8	BP
⬜	MM	69	16	7/8	8
🟫	1-4	27	8	6/6	0
🟦	3-1	37	8	2/6	4
🟦	2-3	36	8	4/6	4
🟦	6-1	38	8	2/2	4
🟩	6-2	38	8	6/6	4
🟩	10-4	38	8	4/6	4
🟧	9-1	36	8	6/6	4
🟥	10-1	32	8	5/5	0
🟫	12-1	9	0	3/4	0
Total		360	80	100	32

☒ BP: border plants

n First harvest (103 and 104 DAS)

Low EC (3 dS.m^{-1}): rows A, C, E and G

High EC (8dS.m^{-1}): rows B, D, F and H

Figure 27: Experimental layout.

Appendix II

Table 3: Results of the nutrient solutions analyses, sampled on 26th may, from the low (3 dS.m^{-1}) and high (8 dS.m^{-1}) electrical conductivity treatments.

Nutrient solutions										
Low EC										
Cations (mmol.l^{-1})		**Anions** (mmol.l^{-1})		**Trace elements** (µmol.l^{-1})		(mmol.l^{-1})		EC (dS.m^{-1})	pH	Temp. (ºC)
NH_4	<0.1	NO_3	17.6	Fe	36.0	Si	0.15	3.1	5.6	25
K	9.5	Cl	0.6	Mn	12.0					
Na	1.3	S	5.4	Zn	5.0					
Ca	6.8	HCO_3	<0.1	B	23.0					
Mg	3.2	P	1.3	Cu	0.8					
				Mo	0.9					
High EC										
NH_4	<0.1	NO_3	17.4	Fe	33.0	Si	0.12	8.0	5.5	25
K	10.3	Cl	50.0	Mn	6.2					
Na	53.3	S	5.0	Zn	4.0					
Ca	6.1	HCO_3	<0.1	B	21.0					
Mg	2.9	P	1.4	Cu	0.5					
				Mo	0.6					

Table 4: General information of the phytochemicals used during the experiment.

Typology	Active ingredients	Pathological target	Dosis	Application mode	Date of use
systemic fungicide	propamocarbe - hydrochloride (722 g.l^{-1})	*Pythium* spp.; *Phytophtora* spp.	150 ml	dripped into the irrigation tank	05/Jun/2015
contact fungicide	tetrachloroisophthalonitrile	*Phytophtora* spp.	300 ml	sprayed over the plants	08/Jun/2015
systemic fungicide	propamocarbe - hydrochloride (722 g.l^{-1})	*Pythium* spp.; *Phytophtora* spp.	150 ml	dripped into the irrigation tank	18/Jun/2015
contact fungicide	Tetrachloroisophthalonitrile (82.5%)	*Phytophtora* spp.	180 ml	sprayed over the plants	19/Jul/2015
systemic fungicide	fenamidone (60g.k^{-1}); fosetyl aluminium (600 g.kg^{-1})	*Phytophtora* spp.	300 g	dripped into the irrigation tank	23/Jun/2015
systemic fungicide	dimethomorph (500g.kg^{-1})	*Phytophtora* spp.	100 g	dripped into the irrigation tank	16/Jul/2015

Appendix III

Figure 28: Introduction of the plants into the final greenhouse compartment, on the April 9th, 35 days after sowing.

Figure 29: Sampling of the irrigation solution in the rockwool slab, for the monitoring of the electrical conductivity level.

Figure 30: Placement of the training wires, on the April 17th (43 days after sowing) for the plants conduction

Figure 31: Still in an early phase of the experiment, and the plants from genotype IL2-3 (plot in the foreground) were already showing clear difference in height compared with all other genoptypes.

Figure 32: Pollination by *Bombus terrestris*, introduced in the greenhouse compartment on April 24th, 51 days after sowing.

Figure 33: Many plants showed curly leaves in the beginning of the experiment, here shown on April 28th, 55 days after sowing.

Figure 34: Beginning of the fruit set, 60 days after sowing.

Figure 35: Measurement of leaf chlorophyll content, using a chlorophyll meter SPAD-502Plus (Konica Minolta, Japan).

Figure 36: Plant from genotype Moneymaker, under salinity, showing steep insertion angle of the truss, causing truss bending when the fruits became heavier.

Figure 37: High incidence of blossom-end rot in genotype Moneymaker, under salt treatment.

Figure 38: Ripe fruits showing internal symptoms of blossom-end rot.

Figure 39: Cracked fruits from genotype IL12-1 under both control (left side) and saline conditions (right side).

Figure 40: Strong truss from genotype IL12-1, here demonstrating high resistance to bend, even when carrying fully grown fruits.

Figure 41: Two characteristics from genotype IL10-1: dark green color of unripe fruits and abundance of trichomes on the stem and trusses.

Figure 42: Small fruits from genotype IL1-4, under saline conditions.

Figure 43: Plant severely affected by fungal infection (*Phytophtora sp*.), and excluded from the harvest.

Figure 44: Leaves showing severe symptoms of *Phytophtora sp*. infection.

Figure 45: Severe symptoms of leaf chlorosis in several plants from genotype IL6-1, led to reduced number of plants from this line to be included in the final harvest.

Figure 46: Severe symptoms of fungal infection in the stem of a plant excluded from the final harvest, from genotype IL3-1.

Figure 47: Plant from genotype IL12-1, under saline conditions, showing healthy stem, fruits and canopy, in the second half of the experiment, on July 3rd (120 days after sowing).

Figure 48: Leaflets floating in distilled water during the imbibition time, under light conditions (~23 µmol.m^2.s^{-1}), for the posterior relative water content determination.

Figure 49: Genotype IL6-2 produced the smallest leaflets of all genotypes, and the ionic effects of salinity were shown through necrosis in the leaflets borders.

Figure 50: Plant from genotype IL10-1, under control conditions, showing flower abortion due to high temperatures in the last two weeks of June.

Figure 51: Plant from genotype IL12-1, under saline conditions, showing chlorosis and necrosis in the youngest, developing leaves, at the final harvest (145 days after sowing).

Appendix IV

Table 5: Effect of genotype on total dry weight (g), of the 9 genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing.

EC level (dS.m^{-1})	TDW (g) Genotype									Mean	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	229	193	265	219	207	252	229	263	344	244	0.295	EC factor
8	202	204	224	199	203	211	200	273	318	226		
Mean	216	198	244	209	205	231	214	268	331 *		0.041	Genotype Factor
											0.996	EC*Genotype

Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p< 0.05$).

Table 6: Effect of salinity and genotype on total dry weight (g), of the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level (dS.m^{-1})	TDW (g) Genotype										Mean	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	434	268	469	371	331	371	444	403	376	493	396 **a**	0.005	EC factor
8	354	248	325	335	338	339	349	353	360	504	350 **b**		
Mean	394	258 *	397	353	334	355	396	378	368	498 *		<0.001	Genotype Factor
												0.316	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p< 0.05$).

Appendix V

Table 7: Effect of salinity and genotype on total fresh weight (kg), of the 9 genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing.

EC level (dS.m^{-1})	**TFW (kg)** Genotype									**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	2.67	2.08	2.81	2.18	2.01	3.00	2.62	3.17	3.66	2.69 **a**	0.001	EC factor
8	2.09	1.81	2.25	1.97	1.95	2.12	2.17	2.85	2.93	2.24 **b**		
Mean	2.38	1.95	2.53	2.08	1.98	2.56	2.40	3.01	3.29 *		<0.001	Genotype Factor
											0.802	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test (*p*< 0.05).

Table 8: Effect of salinity and genotype on total fresh weight (kg), of the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level (dS.m^{-1})	**TFW (kg)** Genotype										**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	5.60	2.92	5.49	3.91	3.53	3.83	5.70	4.76	4.87	5.81	4.64 **a**	<0.001	EC factor
8	3.96	2.36	3.42	3.61	3.29	3.13	3.87	3.88	4.11	5.05	3.67 **b**		
Mean	4.78	2.64 *	4.46	3.76 *	3.41 *	3.48 *	4.79	4.32	4.49	5.43		<0.001	Genotype Factor
												0.187	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test (*p*< 0.05).

Appendix VI

Table 9: Effect of salinity and genotype on leaf area (dm^2), of the 9 genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing.

EC level (dS.m^{-1})	**LA (dm^2)** Genotype									**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	117.3	98.2	143.9	117.9	118.3	132.4	110.7	124.6	186.2	127.7 **a**	0.004	EC factor
8	95.1	78.2	115.1	102.3	107.6	101.6	79.5	118.2	143.2	104.5 **b**		
Mean	106.2	88.2	129.5	110.1	112.9	117.0	95.1	121.4	164.7 *****		0.005	Genotype Factor
											0.967	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p < 0.05$).

Table 10: Effect of genotype on leaf area (dm^2), of the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level (dS.m^{-1})	**LA (dm^2)** Genotype										**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	94.5	53.9	112.3	115.1	110.2	65.1	100.9	70.5	59.1	103.9	88.5	0.144	EC factor
8	77.7	51.9	84.7	87.8	110.8	82.5	74.5	67.8	66.8	83.8	78.8		
Mean	86.1	52.9	98.5	101.5	110.5	73.8	87.7	69.1	62.9	93.8		0.009	Genotype Factor
												0.812	EC*Genotype

Appendix VII

Table 11: Dry matter partitioning among leaves, stem and fruits in the genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing (DAS), and included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 DAS.

Genotype	EC ($dS.m^{-1}$)	*n*	Leaves (%)		Stem (%)		Fruits (%)		Vegetative (%; stem+leaves)	
			103 DAS	145 DAS	103 DAS	145 DAS	103 DAS	145 DAS	103 DAS	145 DAS
MM	3	3	35.9	27.8	25.7	18.3	38.4	53.9	61.6	46.1
	8	3	33.5	28.4	26.1	19.0	40.4	52.6	59.6	47.4
IL10-1	3	2	33.3	32.6	26.9	20.2	39.8	47.2	60.2	52.8
	8	2	36.4	32.3	24.8	21.9	38.8	45.8	61.2	54.2
IL6-2	3	2	37.2	32.3	29.7	21.6	33.1	46.1	66.9	53.9
	8	2	35.4	30.8	29.2	19.9	35.4	49.2	64.6	50.8
IL9-1	3	2	38.0	34.8	29.2	22.3	32.8	42.9	67.2	57.1
	8	2	34.5	32.3	27.9	19.8	37.6	47.9	62.4	52.1
IL1-4	3	2	41.1	37.5	32.1	22.6	26.8	39.9	73.2	60.1
	8	2	37.8	34.3	31.6	24.5	30.6	41.2	69.4	58.8
IL12-1	3	1	-	30.0	-	25.7	-	44.3	-	55.7
	8	1	-	31.5	-	24.8	-	43.7	-	56.3
IL10-4	3	2	32.2	26.6	27.2	18.7	40.5	54.8	59.5	45.2
	8	2	32.3	26.2	29.1	17.8	38.5	56.0	61.5	44.0
IL6-1	3	2	32.0	26.2	30.2	24.5	37.8	49.3	62.2	50.7
	8	2	30.9	25.3	28.9	22.0	40.1	52.6	59.9	47.4
IL3-1	3	2	34.9	29.1	27.3	18.4	37.8	52.5	62.2	47.5
	8	2	33.1	28.1	28.0	18.4	38.9	53.6	61.1	46.4
IL2-3	3	2	35.9	29.8	32.3	21.3	31.7	48.9	68.3	51.1
	8	2	35.6	28.0	32.4	21.8	32.1	50.1	67.9	49.9
Significance										
EC			0.458	0.017	0.929	0.431	0.336	0.076	0.338	0.077
Genotype			0.534	<0.001	0.966	<0.001	0.025	<0.001	0.025	<0.001
EC x Genotyoe			0.993	0.255	1.000	0.258	0.983	0.493	0.982	0.486

n= number of replicates

Appendix VIII

Table 12: Effect of salinity and genotype on total leaves dry weight (g) in 9 genotypes (8 introgression lines and the parent line Moneymaker) at the first harvest, 103 days after sowing.

EC level (dS.m^{-1})	LDW (g) Genotype									Mean	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	58	46	79	56	63	58	52	62	93	63 **a**	0.041	EC factor
8	45	55	61	48	56	49	46	60	83	56 **b**		
Mean	52	50	70 *	52	60	54	49	61	88 *		<0.001	Genotype Factor
											0.735	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p< 0.05$).

Table 13: Effect of salinity and genotype on total leaves dry weight (g), of the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level (dS.m^{-1})	LDW (g) Genotype										Mean	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	62	44	99	73	71	55	63	53	36	62	62 **a**	0.005	EC factor
8	50	39	60	59	68	59	43	48	43	55	52 **b**		
Mean	56	41	79 *	66	69	57	53	51	39	59		<0.001	Genotype Factor
												0.114	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p< 0.05$).

Appendix IX

Table 14: Effect of salinity and genotype on total leaves fresh weight (g) of the 9 genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing.

EC level (dS.m^{-1})	**LFW (g)** Genotype									**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	581	465	775	572	696	604	543	679	948	651 **a**	0.001	EC factor
8	466	367	591	481	575	500	475	652	802	545 **b**		
Mean	523	416	683	526	635	552	509	665	875 *		<0.001	Genotype Factor
											0.971	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test (*p*< 0.05).

Table 15: Effect of salinity and genotype on total leaves fresh weight (g), of the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level (dS.m^{-1})	**LFW (g)** Genotype										**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	528	350	804	605	598	399	515	410	312	533	505 **a**	0.007	EC factor
8	441	307	490	494	584	455	366	369	388	475	437 **b**		
Mean	485	328 *	647 *	549	591	427	440	389	350 *	504		<0.001	Genotype Factor
												0.056	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test (*p*< 0.05).

Appendix X

Table 16: Total stem dry weight (g) in 9 genotypes (8 introgression lines and the parent line Moneymaker) at the first harvest, 103 days after sowing.

EC level ($dS.m^{-1}$)	SDW (g) Genotype MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3	**Mean**	Significance	
3	60	55	81	68	70	69	71	77	114	74	0.542	EC factor
8	54	52	67	58	66	62	59	81	104	67		
Mean	57	53	74	63	68	65	65	79	109		0.490	Genotype Factor
											1.000	EC*Genotype

Table 17: Effect of salinity and genotype on total stem dry weight (g), of the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level ($dS.m^{-1}$)	SDW (g) Genotype MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3	**Mean**	Significance	
3	80	54	101	83	75	96	83	99	70	104	84 **a**	0.002	EC factor
8	67	54	65	66	83	84	62	78	66	110	73 **b**		
Mean	74	54 *	83	74	79	90	73	88	68	107 *		<0.001	Genotype Factor
												0.063	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p < 0.05$).

Appendix XI

Table 18: Effect of salinity and genotype on total stem fresh weight (g) of the 9 genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing.

EC level (dS.m^{-1})	**SFW (g)** Genotype									**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	410	289	460	344	392	485	446	452	816	455 **a**	0.005	EC factor
8	348	272	378	333	413	402	376	462	696	409 **b**		
Mean	379	280 *	419	339	402	443	411	457	756 *		<0.001	Genotype Factor
											0.367	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p < 0.05$).

Table 19: Effect of salinity and genotype on total stem fresh weight (g), of the 10 genotypes included in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level (dS.m^{-1})	**SFW (g)** Genotype										**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	643	430	744	613	612	719	676	708	581	902	663 **a**	<0.001	EC factor
8	521	402	480	499	641	595	489	539	529	816	551 **b**		
Mean	582	416 *	612	556	627	657	582	623	555	859 *		<0.001	Genotype Factor
												0.063	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p < 0.05$).

Appendix XII

Table 20: Effect of salinity on the chlorophyll content (SPAD units) of the 10 genotypes (9 introgression lines and the parent line Moneymaker) in four measurement events: 63, 77, 91 and 130 days after sowing (DAS).

			Chlorophyll content (SPAD units)			
Genotype	EC (dS.m^{-1})	*n*	63 DAS	77 DAS	91 DAS	130 DAS
MM	3	3	52.0	46.6	42.4	52.3
	8	3	53.5	49.7	45.7	54.5
IL10-1	3	2	55.6	50.3	46.9	54.0
	8	2	56.6	54.1	48.4	57.4
IL6-2	3	2	57.1	53.8	51.1	61.3
	8	2	59.2	57.3	51.6	57.6
IL9-1	3	2	50.7	45.4	42.1	52.8
	8	2	56.6	54.1	48.4	57.4
IL1-4	3	2	46.6	43.9	40.9	50.6
	8	2	49.5	46.6	45.3	51.6
IL12-1	3	1	53.4	47.0	46.4	52.7
	8	1	53.4	54.1	50.4	55.3
IL10-4	3	2	54.3	50.2	47.0	57.8
	8	2	52.2	50.5	47.0	53.6
IL6-1	3	2	50.0	46.5	42.1	57.9
	8	2	54.9	50.3	47.5	52.8
IL3-1	3	2	52.0	42.2	40.1	51.9
	8	2	57.7	49.7	45.2	52.4
IL2-3	3	2	52.2	46.5	46.4	51.5
	8	2	55.1	54.2	51.7	52.7
Significance						
EC			0.010	<0.001	<0.001	0.688
Genotype			<0.001	<0.001	<0.001	0.025
EC x Genotype			0.430	0.085	0.326	0.455

n= number of replicates.

Appendix XIII

Table 21: Genotype effect on total fruits dry weight (g) of the 9 genotypes included in the first harvest (8 introgression lines and the parent line Moneymaker), 103 days after sowing.

EC level (dS.m^{-1})	**FDW (g)**									**Mean**	Significance	
	Genotype											
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	88	75	87	70	54	102	87	98	109	85	0.539	EC factor
8	82	79	79	74	62	81	80	104	102	82		
Mean	85	77	83	72	58	92	83	101	105		0.005	Genotype Factor
											0.880	EC*Genotype

Table 22: : Effect of salinity and genotype on total fruit dry weight (g), of the 10 genotypes in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

EC level (dS.m^{-1})	**FDW (g)**										**Mean**	Significance	
	Genotype												
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	232	128	216	159	133	164	243	198	197	243	191 **a**	0.044	EC factor
8	186	114	160	162	139	148	195	185	193	253	173 **b**		
Mean	209	121 *	188	160 *	136 *	156	219	192	195	248		<0.001	Genotype Factor
												0.471	EC*genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisk indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test (*p*< 0.05).

Appendix XIV

Table 23: Effect of salinity and genotype on total fruits fresh weight (kg) of the 9 genotypes (8 introgression lines and the parent line Moneymaker) at the first harvest, 103 days after sowing.

	FFW (kg)											
EC level (dS.m^{-1})	Genotype									**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL10-4	IL6-1	IL3-1	IL2-3			
3	1.67	1.33	1.58	1.27	0.93	1.91	1.64	2.04	1.90	1.58 **a**	0.001	EC factor
8	1.27	1.17	1.28	1.16	0.96	1.22	1.32	1.74	1.43	1.28 **b**		
Mean	1.47	1.25	1.43	1.21	0.94 *	1.57	1.48	1.89	1.66		0.001	Genotype Factor
											0.630	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisks indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test (*p*< 0.05).

Table 24: Effect of salinity and genotype on total fruit fresh weight (kg), of the 10 genotypes in the final harvest (9 introgression lines and the parent line Moneymaker), 145 days after sowing.

	FFW (kg)												
EC level (dS.m^{-1})	Genotype										**Mean**	Significance	
	MM	IL10-1	IL6-2	IL9-1	IL1-4	IL12-1	IL10-4	IL6-1	IL3-1	IL2-3			
3	4.42	2.14	3.94	2.70	2.32	2.71	4.51	3.64	3.98	4.38	3.47 **a**	<0.001	EC factor
8	2.99	1.65	2.45	2.62	2.06	2.08	3.02	2.97	3.20	3.76	2.68 **b**		
Mean	3.71	1.90 *	3.20	2.66 *	2.19 *	2.39 *	3.77	3.31	3.59	4.07		<0.001	Genotype Factor
												0.227	EC*Genotype

Different letters indicate mean separation by test of between-subjects effect, at 0.05 level.
Asterisks indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test (*p*< 0.05).

Appendix XV

Table 25: Average stem length (cm) of the 10 genotypes (9 introgression lines and the parente line Moneymaker), in five measurement events (63, 77, 91, 130 and 145 days after sowing), under control (3 dS.m^{-1}) and saline conditions (8 dS.m^{-1}).

Genotype	EC (dS.m^{-1})	*n*	Stem length (cm)				
			63 DAS	77 DAS	91 DAS	130 DAS	145 DAS
MM	3	3	92	133	175	281	321
	8	3	93	138	174	272	313
IL10-1	3	2	74 *	100 *	131 *	228	274
	8	2	84	120 *	154	242	278
IL6-2	3	2	97	137	181	289	328
	8	2	98	136	172	259	290
IL9-1	3	2	77 *	110 *	148 *	256	295
	8	2	84	120 *	154	242	278
IL1-4	3	2	71 *	102 *	137 *	238	277
	8	2	80 *	125	165	263	300
IL12-1	3	1	93	139	178	276	314
	8	1	88	128	166	249	271
IL10-4	3	2	102 *	152 *	192	300	344
	8	2	102	147	184	267	306
IL6-1	3	2	108 *	156 *	198 *	285	340
	8	2	99	142	185	280	325
IL3-1	3	2	95	134	165	262	311
	8	2	96	147	186	260	300
IL2-3	3	2	161 *	234 *	296 *	391	439
	8	2	153 *	216 *	268 *	359	381
Significance							
EC			0.606	0.230	0.673	0.111	0.013
Genotype			<0.001	<0.001	<0.001	<0.001	<0.001
EC x Genotype			0.021	<0.001	0.004	0.495	0.310

n= number of replicates

Asterisks indicate introgression line significantly different compared with the parent line MM, by Dunnett's t-test ($p < 0.05$).

Appendix XVI

Table 26: Salinity effect on the ions content (mg.g^{-1} of dry matter) in young leaves (YL), old leaves (OL) and stem (St), in 8 introgression lines and the parent line Moneymaker (MM), at the first harvest (103 days after sowing).

		Na$^+$ (mg.g^{-1})			K$^+$ (mg.g^{-1})			K$^+$:Na$^+$			Mg^{2+} (mg.g^{-1})			Ca^{2+} (mg.g^{-1})			Ca^{2+}:Na$^+$		
Gen.	EC	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St
MM	3	6.18	5.80	4.71	28.87	35.10	41.19	4.67	6.05	8.75	5.21	5.14	2.95	24.46	33.20	7.00	3.96	5.72	1.49
	8	9.77	13.72	9.26	18.15	23.18	34.77	1.86	1.69	3.75	3.89	4.10	2.62	24.31	44.16	7.08	2.49	3.22	0.76
IL10-1	3	5.89	5.03	4.28	23.27	47.23	35.01	3.95	9.39	8.17	5.02	5.17	2.38	14.49	32.12	7.75	2.46	6.39	1.81
	8	13.47	19.95	11.47	17.43	23.29	30.24	1.29	1.17	2.64	3.34	3.77	2.61	18.76	30.57	8.27	1.39	1.53	0.72
IL6-2	3	5.24	6.09	4.39	20.63	32.58	34.63	3.94	5.35	7.88	4.68	4.79	2.25	17.53	48.61	4.97	3.34	7.98	1.13
	8	8.00	12.54	8.62	19.57	22.62	33.92	2.45	1.80	3.94	3.97	3.16	3.58	20.04	35.53	9.67	2.51	2.83	1.12
IL9-1	3	5.83	6.53	5.91	19.18	37.76	33.49	3.29	5.78	5.67	3.74	5.02	3.31	16.06	42.65	9.16	2.76	6.53	1.55
	8	11.15	10.79	10.08	19.24	21.97	32.21	1.73	2.04	3.20	3.34	3.35	3.43	26.19	34.20	10.59	2.35	3.17	1.05
IL1-4	3	6.57	5.98	4.07	25.21	45.60	38.29	3.84	7.63	9.42	4.75	6.34	2.54	13.03	37.59	6.04	1.98	6.29	1.49
	8	11.33	11.88	8.83	23.12	29.57	40.90	2.04	2.49	4.63	4.82	5.38	2.82	27.95	42.33	7.24	2.47	3.56	0.82
IL10-4	3	4.30	4.91	4.03	23.35	36.15	43.45	5.43	7.36	10.78	4.80	5.62	2.88	18.28	44.24	5.19	4.25	9.01	1.29
	8	9.08	14.61	9.44	11.86	21.27	38.72	1.31	1.46	4.10	3.64	4.54	2.59	19.08	44.57	6.28	2.10	3.05	0.66
IL6-1	3	7.99	8.29	4.28	21.85	37.41	35.37	2.73	4.51	8.27	6.55	4.54	2.82	15.83	41.69	7.34	1.98	5.03	1.72
	8	11.20	15.05	8.44	19.50	30.60	35.63	1.74	2.03	4.22	3.18	3.34	2.18	23.38	46.92	7.26	2.09	3.12	0.86
IL3-1	3	6.68	8.58	4.95	28.08	45.94	43.43	4.20	5.36	8.77	4.01	4.56	2.88	16.12	42.37	11.62	2.41	4.94	2.35
	8	8.18	13.61	7.98	21.88	27.83	37.25	2.67	2.04	4.66	3.72	4.60	3.69	20.79	46.19	11.72	2.54	3.39	1.47
IL2-3	3	6.95	5.34	4.72	20.21	38.20	37.86	2.91	7.15	8.02	3.88	5.27	2.67	14.98	38.25	5.89	2.15	7.16	1.25
	8	9.46	12.23	7.43	18.27	19.82	32.14	1.93	1.62	4.32	3.19	4.10	2.84	19.64	43.50	7.40	2.08	3.56	0.99
Mean	3	6.18	6.28	4.59	22.98	39.37	37.62	3.79	6.29	8.29	4.64	5.15	2.80	16.68	40.34	7.41	2.71	6.38	1.57
	8	10.18	13.82	9.06	18.78	24.46	35.09	1.84	1.77	3.87	3.68	4.04	2.93	22.24	40.89	8.39	2.18	2.96	0.93
Significance																			
EC		<0.001	<0.001	<0.001	0.027	<0.001	0.045	<0.001	<0.001	<0.001	0.004	<0.001	NS	0.007	NS	0.016	0.042	<0.001	<0.001
Genotype		NS	NS	NS	NS	0.036	NS	NS	NS	NS	NS	0.024	NS	NS	NS	<0.001	NS	NS	0.002
EC x Gen		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS: non-significant.

Table 26 continued.

		Cl^- (mg.g^{-1})			SO_4^{2-} (mg.g^{-1})		
Genotype	EC	YL	OL	St	YL	OL	St
MM	3	2.42	2.21	4.73	42.13	68.43	11.21
	8	5.84	7.62	13.34	32.00	63.89	8.12
IL10-1	3	2.45	1.75	5.11	29.11	86.26	10.00
	8	5.79	6.19	14.05	27.09	68.44	9.49
IL6-2	3	2.36	2.40	4.01	45.92	82.16	6.85
	8	4.65	5.30	14.47	30.55	72.16	9.67
IL9-1	3	2.23	2.99	4.62	34.43	79.17	10.69
	8	8.36	7.56	14.78	37.87	57.59	10.28
IL1-4	3	2.21	3.87	5.54	23.97	53.35	7.70
	8	10.18	10.57	14.67	31.69	48.27	7.98
IL10-4	3	2.34	2.20	4.70	35.34	77.00	11.67
	8	4.54	9.22	15.30	26.51	64.81	9.21
IL6-1	3	2.54	2.07	2.63	24.09	65.33	11.76
	8	6.90	9.75	8.97	28.35	63.17	10.47
IL3-1	3	2.90	3.47	6.31	32.56	75.89	10.59
	8	5.41	8.08	18.14	28.93	75.15	11.08
IL2-3	3	2.40	2.84	3.83	28.17	66.52	9.94
	8	5.47	6.75	10.55	37.21	67.69	11.24
Mean	3	2.41	2.68	4.61	33.01	73.33	10.11
	8	6.35	7.89	13.81	31.13	64.57	9.73
Significance							
EC		<0.001	<0.001	<0.001	NS	NS	NS
Genotype		NS	NS	0.001	NS	NS	NS
EC x Gen		NS	NS	NS	NS	NS	NS

NS: non-significant.

Appendix XVII

Table 27: : Salinity effect on the ions content (mg.g^{-1} of dry matter) in young leaves (YL), old leaves (OL) and stem (St), in 9 introgression lines and the parent line Moneymaker (MM), at the final harvest (145 days after sowing).

		Na$^+$ (mg.g^{-1})			K$^+$ (mg.g^{-1})			K$^+$:Na$^+$			Mg^{2+} (mg.g^{-1})			Ca^{2+} (mg.g^{-1})			Ca^{2+}:Na$^+$		
Gen.	EC	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St
MM	3	5.96	3.20	4.07	24.44	13.75	25.17	4.10	4.30	6.18	4.10	4.70	3.14	18.53	35.12	6.84	3.11	10.99	1.68
	8	8.10	14.50	10.14	15.64	13.61	22.51	1.93	0.94	2.22	3.13	4.38	3.84	18.83	50.32	8.38	2.32	3.47	0.83
IL10-1	3	5.31	3.20	5.64	22.85	19.85	27.81	4.30	6.20	4.93	6.09	7.23	5.18	18.78	43.16	9.94	3.54	13.48	1.76
	8	7.49	12.66	10.31	19.56	13.18	20.78	2.61	1.04	2.02	5.58	7.47	4.60	20.89	47.19	10.18	2.79	3.73	0.99
IL6-2	3	4.35	3.32	4.31	18.63	17.94	23.97	4.28	5.40	5.56	3.16	5.25	3.39	14.28	45.63	7.78	3.28	13.74	1.81
	8	7.33	9.26	10.36	18.33	9.03	19.85	2.50	0.97	1.91	3.63	4.88	3.99	20.58	47.33	8.32	2.81	5.11	0.80
IL9-1	3	3.70	3.36	3.98	16.56	12.02	20.59	4.48	3.57	5.17	3.70	3.40	3.77	19.34	22.14	9.00	5.23	6.58	2.26
	8	6.10	9.44	7.02	16.25	16.45	16.97	2.66	1.74	2.42	4.43	6.92	3.74	23.07	51.94	8.96	3.78	5.50	1.28
IL1-4	3	5.57	6.28	4.25	26.00	24.95	27.01	4.67	3.97	6.36	4.92	6.41	3.68	19.31	47.45	7.54	3.47	7.55	1.77
	8	11.79	12.05	9.63	25.45	15.30	25.99	2.16	1.27	2.70	4.82	4.75	3.69	22.42	37.90	10.88	1.90	3.15	1.13
IL12-1	3	4.31	2.42	3.49	14.91	17.91	19.89	3.46	7.41	5.69	3.87	5.72	3.75	19.33	42.64	9.47	4.49	17.64	2.71
	8	11.38	8.62	7.34	19.51	18.18	22.49	1.71	2.11	3.06	4.72	5.68	4.44	32.26	52.76	8.04	2.83	6.12	1.10
IL10-4	3	4.68	4.04	4.74	18.84	19.48	32.34	4.02	4.82	6.82	3.04	6.29	2.74	15.36	47.69	6.57	3.28	11.80	1.38
	8	6.79	11.13	10.98	18.78	9.02	22.32	2.77	0.81	2.03	4.53	6.21	4.56	22.77	61.03	9.05	3.36	5.48	0.82
IL6-1	3	6.35	5.02	3.49	22.08	18.68	18.85	3.47	3.72	5.41	3.15	4.18	2.66	18.40	45.36	6.61	2.90	9.03	1.89
	8	9.84	13.37	9.00	17.16	16.71	23.11	1.74	1.25	2.57	2.02	4.55	3.08	22.82	60.80	5.15	2.32	4.55	0.57
IL3-1	3	4.05	5.46	4.13	22.83	19.13	24.50	5.64	3.51	5.94	3.29	5.45	2.34	16.71	49.06	6.40	4.13	8.99	1.55
	8	8.95	12.16	9.62	21.83	12.84	23.64	2.44	1.06	2.46	4.22	6.17	3.90	21.00	50.03	9.52	2.35	4.11	0.99
IL2-3	3	5.10	4.79	7.33	26.83	25.01	37.44	5.26	5.22	5.11	4.07	5.31	2.85	16.17	49.16	8.88	3.17	10.27	1.21
	8	14.63	17.73	10.30	20.26	13.26	26.39	1.39	0.75	2.56	3.30	3.29	2.78	23.09	44.96	8.73	1.58	2.54	0.85
Mean	3	4.94	4.11	4.54	21.40	18.87	25.76	4.37	4.81	5.72	3.94	5.39	3.35	17.62	42.74	7.90	3.66	11.01	1.80
	8	9.24	12.09	9.47	19.28	13.76	22.40	2.19	1.19	2.39	4.04	5.43	3.86	22.77	50.42	8.72	2.60	4.38	0.94
Significance																			
EC		<0.001	<0.001	<0.001	0.035	<0.001	0.050	<0.001	<0.001	<0.001	NS	0.001	NS	0.003	0.009	NS	0.003	<0.001	<0.001
Genotype		0.001	<0.001	NS	NS	0.020	0.032	NS	0.005	NS	0.001	NS	NS	NS	NS	NS	NS	<0.001	0.022
EC x Gen		0.009	0.002	NS	NS	0.005	NS	NS	0.024	NS	NS	0.028	NS	NS	NS	NS	NS	0.004	NS

NS: non-significant.

Colored cells indicate genotype significantly different from the parent line MM (grey: lower; blue: higher), by Dunnett t-test ($p<0.05$).

Table 27 continued.

		Cl^- (mg.g^{-1})			SO_4^{2-} (mg.g^{-1})		
Genotype	EC	YL	OL	St	YL	OL	St
MM	3	1.70	0.54	2.40	23.19	31.21	7.05
	8	6.49	9.25	12.84	22.09	52.72	9.41
IL10-1	3	1.27	0.60	2.02	23.57	39.90	10.95
	8	8.98	7.81	10.97	16.40	38.98	8.97
IL6-2	3	0.96	0.61	3.42	18.57	40.34	6.22
	8	6.42	7.49	13.16	20.49	39.77	8.80
IL9-1	3	0.72	0.59	2.34	21.04	22.80	8.12
	8	7.18	10.94	9.15	22.84	46.74	7.81
IL1-4	3	1.39	2.16	3.11	23.45	52.87	10.26
	8	9.47	11.92	15.30	20.49	25.82	7.52
IL12-1	3	0.49	0.44	0.96	21.32	51.30	10.15
	8	9.20	4.93	10.44	32.44	61.91	13.15
IL10-4	3	1.75	1.45	3.85	17.97	50.55	7.37
	8	6.55	6.57	14.72	22.59	66.78	9.78
IL6-1	3	1.01	1.13	0.77	22.68	35.75	7.25
	8	7.68	10.93	9.75	21.99	47.74	8.10
IL3-1	3	0.91	0.83	1.99	23.53	53.68	6.83
	8	7.31	8.26	15.41	26.56	54.77	9.04
IL2-3	3	1.42	1.04	4.75	27.30	61.04	8.39
	8	9.67	7.30	17.78	34.53	61.13	9.39
Mean	3	1.16	0.94	2.56	22.26	43.94	8.26
	8	7.90	8.54	12.95	24.04	49.64	9.20
Significance							
EC		<0.001	<0.001	<0.001	NS	NS	NS
Genotype		NS	0.010	0.011	0.026	0.016	NS
EC x Gen		NS	NS	NS	NS	NS	NS

NS: non-significant

Appendix XVIII

Table 28: Correlation analyses, indicated by Pearson´s coefficient (r), between the ions content and ions ratios in young leaves(YL), old leaves (OL) and stem (St), and parameters/calculations from data collected until the first harvest (103 days after sowing), in the plants under control conditions (EC=3 dS.m^{-1}).

	Na^+			K^+			K^+:Na^+			Mg^{2+}			Ca^{2+}		
	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St
TFW	-0.09	-0.32	0.06	0.20	-0.38	0.41	0.29	0.04	0.16	-0.11	-0.34	0.33	0.21	0.07	0.19
TDW	-0.11	-0.18	0.05	0.09	-0.33	0.12	0.19	-0.04	-0.04	0.00	-0.23	0.42	0.07	-0.04	0.23
LA	0.14	-0.14	-0.13	0.06	-0.34	0.09	-0.02	-0.14	0.09	-0.08	-0.04	0.32	-0.09	-0.01	0.01
LAR	0.42	0.04	-0.24	0.01	0.18	0.01	-0.33	-0.03	0.24	-0.23	0.30	-0.38	-0.24	0.02	-0.43
SLA	0.23	0.23	-0.39	0.11	-0.10	0.10	-0.11	-0.19	0.40	0.02	-0.07	-0.14	-0.18	-0.01	0.06
PTL	0.19	-0.12	0.23	-0.07	0.26	0.00	-0.20	0.13	-0.10	-0.28	0.26	-0.28	-0.05	0.04	-0.34
FFW	-0.29	-0.31	0.11	0.26	-0.39	**0.48***	0.44	0.07	0.18	-0.03	**-0.52***	0.27	0.37	0.13	0.28
FDW	-0.30	-0.31	0.11	0.18	-0.45	0.33	0.38	0.00	0.09	0.02	-0.37	0.32	0.27	0.05	0.18
SL	0.31	0.05	0.01	-0.07	-0.45	0.09	-0.18	-0.31	0.00	-0.27	0.02	0.17	0.06	0.02	-0.16
Chl	-0.21	0.05	-0.09	0.06	-0.42	-0.11	0.09	-0.35	-0.05	0.27	0.11	-0.18	-0.06	0.37	-0.31
BER	0.33	-0.15	-0.08	-0.12	-0.15	-0.09	-0.23	-0.06	0.06	-0.10	**0.60****	0.16	**-0.50***	-0.29	-0.25

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Table 28 continued.

	Ca^{2+}: Na^{+}			Cl^{-}			SO_4^{2-}		
	YL	OL	St	YL	OL	St	YL	OL	St
TFW	-0.01	-0.14	0.15	0.16	-0.05	0.44	-0.01	-0.14	0.15
TDW	-0.23	-0.15	0.04	0.10	-0.19	0.27	-0.23	-0.15	0.04
LA	-0.08	0.09	0.01	-0.16	-0.03	-0.07	-0.08	-0.24	0.01
LAR	0.23	0.44	-0.05	-0.31	-0.08	**-0.53***	0.23	0.44	-0.05
SLA	-0.31	-0.19	0.26	0.40	-0.06	0.04	-0.06	0.28	0.24
LWR	0.01	**0.48***	0.04	-0.05	-0.17	**-0.49***	0.01	**0.48***	0.04
FFW	0.43	**0.48***	0.11	0.04	-0.21	0.25	0.30	0.19	**0.60****
FDW	0.37	0.41	0.02	-0.06	-0.31	0.08	0.20	0.07	**0.54***
SL	-0.15	-0.05	-0.21	0.06	-0.22	-0.24	-0.08	-0.22	0.27
Chl	0.08	0.02	-0.27	-0.20	-0.38	-0.28	-0.04	0.30	-0.39
BER	-0.42	-0.06	-0.18	0.03	-0.23	-0.16	-0.23	**-0.49***	0.13

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **BER**: blossom-end rot incidence.

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XIX

Table 29: Correlation analyses, indicated by Pearson´s coefficient (r), between the ions content and ions ratios in young leaves(YL), old leaves (OL) and stem (St), and parameters/calculations from data collected until the first harvest (103 days after sowing), in the plants under saline conditions (EC=8 dS.m^{-1}).

	Na^+			K^+			K^+:Na^+			Mg^{2+}			Ca^{2+}		
	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St
TFW	-0.41	-0.43	-0.45	0.42	-0.06	0.16	**0.70****	0.24	**0.46***	0.07	0.21	0.37	-0.04	0.23	0.18
TDW	-0.25	-0.36	-0.32	0.36	-0.20	0.18	**0.55***	0.17	0.41	-0.04	0.15	0.37	0.00	0.02	0.11
LA	-0.34	**-0.50***	-0.44	0.27	-0.12	0.24	0.44	0.31	0.41	-0.01	0.13	0.27	-0.18	-0.08	0.00
LAR	-0.24	-0.35	-0.33	-0.12	0.21	0.09	-0.08	0.38	0.07	0.03	0.11	-0.04	-0.38	-0.03	-0.13
SLA	-0.34	-0.07	-0.37	-0.06	0.09	0.32	0.08	0.11	0.29	-0.05	-0.01	-0.24	-0.09	-0.07	-0.29
PTL	0.39	-0.07	**0.50***	-0.18	0.02	**-0.50***	-0.34	0.06	**-0.62****	0.01	0.14	0.38	-0.18	0.05	0.35
FFW	-0.38	-0.15	-0.27	0.37	-0.02	0.09	**0.74****	0.03	0.36	0.12	0.17	0.32	0.09	0.30	0.29
FDW	-0.35	-0.17	-0.18	0.26	-0.19	0.04	**0.64****	-0.04	0.24	-0.04	0.13	0.32	0.04	0.25	0.21
SL	-0.32	-0.32	-0.32	0.06	-0.11	0.05	0.26	0.11	0.22	-0.31	-0.01	0.04	-0.09	0.15	-0.25
Chl	-0.12	0.00	0.06	0.04	**-0.46***	-0.29	0.19	-0.32	-0.21	-0.17	-0.34	0.00	-0.06	-0.17	0.06
BER	-0.21	-0.22	-0.07	-0.41	-0.30	0.20	-0.24	-0.15	0.05	-0.41	-0.11	-0.38	-0.05	0.17	**-0.71****

* Correlation is significant at 0.05 level.
**Correlation is significant at 0.01 level.

Table 29 continued.

	Ca^{2+}: Na^{+}			Cl^{-}			SO_4^{2-}		
	YL	OL	St	YL	OL	St	YL	OL	St
TFW	-0.23	-0.03	-0.06	0.23	0.06	0.39	-0.23	-0.03	-0.06
TDW	-0.19	-0.14	0.01	0.26	-0.02	0.38	-0.19	-0.14	0.01
LA	0.17	0.34	0.30	-0.19	-0.22	0.10	0.22	0.04	0.27
LAR	0.02	0.02	0.12	-0.01	0.08	-0.06	0.02	0.02	0.12
SLA	0.14	0.01	-0.01	-0.28	0.01	0.09	0.07	0.05	-0.11
PTL	0.38	0.03	0.12	-0.25	0.02	0.08	0.38	0.03	0.12
FFW	0.41	0.34	**0.52***	-0.35	0.03	0.02	0.20	0.16	0.22
FDW	0.35	0.37	0.38	-0.40	-0.05	-0.01	0.24	0.14	0.39
SL	0.12	0.35	0.01	-0.25	-0.05	-0.32	0.21	0.04	**0.58****
Chl	0.07	-0.06	-0.03	-0.34	**-0.52***	-0.18	0.41	0.33	0.35
BER	0.04	0.24	**-0.54***	-0.29	-0.10	-0.27	0.00	0.03	0.32

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **BER**: blossom-end rot incidence.

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XX

Table 30: Correlation analyses, indicated by Pearson´s coefficient (r), between the parameters and calculations until the first harvest (103 days after sowing), in the plants under control conditions (EC=3 dS.m^{-1}).

	LA	LAR	SLA	PTL	TFW	TDW	NL	FFW	FDW	NT	AFW	BER	SL	Chl
LA	-													
LAR	-0.12	-												
SLA	-0.06	0.13	-											
PTL	-0.27	**0.75****	**-0.48***	-										
TFW	**0.79****	-0.45	-0.07	-0.43	-									
TDW	**0.88****	**-0.56***	-0.12	**-0.53***	**0.89****	-								
NL	**0.72****	-0.22	0.00	-0.40	0.45	**0.64****	-							
FFW	**0.51***	**-0.54***	0.07	**-0.50***	**0.77****	**0.57***	0.27	-						
FDW	**0.60****	**-0.57***	-0.03	**-0.49***	**0.82****	**0.65****	0.40	**0.96****	-					
NT	0.24	-0.43	-0.41	-0.23	0.28	0.35	0.36	0.30	0.34	-				
AFW	0.31	-0.09	0.43	-0.29	0.43	0.30	0.08	0.50	**0.52***	-0.05	-			
BER	**0.51***	0.01	-0.02	-0.04	0.31	0.41	0.31	0.04	0.20	-0.16	0.09	-		
SL	**0.76****	-0.02	0.06	-0.16	**0.72****	**0.63****	**0.49***	**0.49***	**0.58****	-0.06	**0.52***	**0.60****	-	
Chl	0.45	-0.11	0.00	-0.31	0.28	0.35	**0.72****	0.20	0.31	0.39	0.15	0.05	0.28	-

LA: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **TFW**: total fresh weight; **TDW**: total dry weight; **NL**: number of leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **NT**: number of trusses; **AFW**: average fruit weight; **BER**: blossom-end rot incidence; **SL**: stem length; **Chl**: chlorophyll content;

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XXI

Table 31: Correlation analyses, indicated by Pearson´s coefficient (r), between the parameters and calculations until the first harvest (103 days after sowing), in the plants under saline conditions (EC=8 dS.m^{-1}).

	LA	LAR	SLA	PTL	TFW	TFW	NL	FFW	FDW	NT	AFW	BER	SL	Chl
LA	-													
LAR	0.40	-												
SLA	**0.47***	**0.72****	-											
PTL	-0.41	-0.07	**-0.67****	-										
TFW	**0.69****	-0.20	-.040	-0.27	-									
TDW	**0.83****	-0.17	0.03	-0.33	**0.91****	-								
NL	**0.57***	-0.07	0.09	-0.40	**0.46***	**0.61****	-							
FFW	0.39	-0.24	-0.02	-0.16	0.40	0.26	0.31	-						
FDW	**0.50***	-0.29	-0.09	-0.13	0.39	0.28	0.36	**0.94****	-					
NT	0.33	0.31	0.44	-0.38	0.25	0.13	0.05	0.37	0.19	-				
AFW	0.17	-0.26	0.01	-0.16	0.43	0.36	0.20	0.42	0.49	-0.27	-			
BER	0.29	-0.02	0.03	-0.19	0.24	0.30	-0.06	-0.03	0.19	-0.14	0.14	-		
SL	**0.66****	-0.06	-0.03	-0.18	**0.76****	**0.77****	0.35	0.42	**0.62****	-0.13	0.42	**0.69****	-	
Chl	0.36	-0.20	-0.29	0.03	0.37	**0.46***	**0.51***	0.18	0.32	0.00	-0.38	0.35	**0.52***	-

LA: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **TFW**: total fresh weight; **TDW**: total dry weight; **NL**: number of leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **NT**: number of trusses; **AFW**: average fruit weight; **BER**: blossom-end rot incidence; **SL**: stem length; **Chl**: chlorophyll content;

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XXII

Table 32: Correlation analyses, indicated by Pearson´s coefficient (r), between the ions content in young leaves, old leaves and stems, under control (EC3; 3 dS.m^{-1}) and saline conditions (EC8; 8 dS.m^{-1}) at the first harvest (103 days after sowing).

EC3		Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	SO_4^{2-}
Young leaves	Na^+	-					
	K^+	-0.27	-				
	Mg^{2+}	-0.18	0.20	-			
	Ca^{2+}	-0.44	0.13	0.10	-		
	Cl^-	0.43	**0.50***	-0.08	-0.10	-	
	SO_4^{2-}	-0.20	0.20	-0.06	**0.47***	0.22	-
Old leaves	Na^+	-					
	K^+	-0.34	-				
	Mg^{2+}	0.01	0.00	-			
	Ca^{2+}	0.08	**-0.50***	-0.18	-		
	Cl^-	-0.17	**0.54***	-0.32	-0.14	-	
	SO_4^{2-}	-0.05	0.08	-0.39	0.31	0.03	-
Stem	Na^+	-					
	K^+	0.03	-				
	Mg^{2+}	-0.08	-0.09	-			
	Ca^{2+}	0.12	0.20	**0.47***	-		
	Cl^-	0.21	**0.73****	-0.31	0.36	-	
	SO_4^{2-}	0.14	0.26	**0.51***	0.43	0.10	-
EC8							
Young leaves	Na^+	-					
	K^+	0.13	-				
	Mg^{2+}	0.11	**0.54***	-			
	Ca^{2+}	0.08	0.01	0.06	-		
	Cl^-	**0.72****	0.43	0.37	-0.13	-	
	SO_4^{2-}	-0.29	0.13	0.03	**0.50***	**-0.53***	-
Old leaves	Na^+	-					
	K^+	-0.02	-				
	Mg^{2+}	-0.42	0.46	-			
	Ca^{2+}	-0.21	**0.48***	**0.49***	-		
	Cl^-	-0.04	**0.67****	**0.58****	**0.63****	-	
	SO_4^{2-}	0.28	-0.07	-0.38	0.20	-0.45	-
Stem	Na^+	-					
	K^+	-0.20	-				
	Mg^{2+}	0.16	-0.09	-			
	Ca^{2+}	0.10	-0.36	**0.79****	-		
	Cl^-	0.41	0.28	**0.62****	0.43	-	
	SO_4^{2-}	0.05	-0.18	0.28	0.14	-0.13	-

* Correlation is significant at 0.05 level.
** Correlation is significant at 0.01 level.

Appendix XXIII

Table 33: Correlation analyses, indicated by Pearson´s coefficient (r), between the ions content and ions ratios in young leaves(YL), old leaves (OL) and stem (St), and parameters/calculations from data collected until the final harvest (145 days after sowing), in the plants under control conditions (EC=3 dS.m^{-1}).

	Na^+			K^+			K^+:Na^+			Mg^{2+}			Ca^{2+}		
	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St
TFW	-0.08	-0.16	0.16	0.07	-0.06	0.23	0.10	0.03	0.00	-0.43	-0.36	**-0.46***	-0.10	0.04	-0.44
TDW	-0.18	-0.15	0.23	0.05	-0.02	0.16	0.14	0.08	-0.14	**-0.46***	-0.41	-0.34	-0.14	0.06	-0.28
LA	-0.10	-0.01	0.14	-0.10	-0.18	-0.06	-0.06	-0.22	-0.18	-0.25	-0.39	-0.06	-0.21	-0.31	-0.01
LAR	0.01	0.15	0.05	-0.05	-0.20	-0.19	-0.07	-0.36	-0.13	0.12	-0.16	0.18	-0.06	-0.40	0.20
SLA	0.10	0.08	0.03	0.08	-0.22	-0.10	0.03	-0.33	0.06	0.01	-0.23	-0.34	0.02	-0.27	-0.24
PTL	-0.29	0.27	0.10	-0.02	0.12	0.01	0.18	-0.11	-0.15	0.22	0.19	**0.53***	-0.12	-0.09	**0.54***
FFW	-0.03	-0.18	0.13	0.09	-0.09	0.23	0.09	0.03	0.05	-0.39	-0.34	**-0.49***	-0.05	0.05	**-0.49***
FDW	-0.06	-0.24	0.20	0.10	-0.07	0.21	0.10	0.10	-0.04	-0.39	-0.36	**-0.44***	-0.06	0.04	-0.42
MFFW	-0.08	-0.25	0.13	0.06	-0.19	0.18	0.09	0.05	-0.03	-0.27	-0.35	-0.32	0.04	-0.06	-0.39
MFDW	-0.11	-0.33	0.20	0.05	-0.20	0.15	0.10	0.13	-0.11	-0.23	-0.36	-0.24	0.01	-0.08	-0.30
SL	0.02	-0.07	0.23	0.24	0.35	0.26	0.21	0.31	0.02	-0.25	-0.16	**-0.52***	-0.19	0.17	-0.37
Chl	0.06	-0.03	-0.40	**-0.60****	0.07	-0.21	**-0.61****	0.00	0.17	**-0.53***	0.15	-0.20	**-0.50***	0.14	-0.31
TSS	-0.15	0.05	0.08	-0.01	0.30	0.02	0.08	0.28	0.02	0.29	0.39	0.44	-0.13	0.06	**0.47***
RWC	0.01	0.07	-0.02	0.19	-0.22	0.09	0.14	-0.39	0.10	-0.19	-0.36	-0.21	0.01	-0.32	-0.24
BER	0.02	0.08	0.34	0.21	0.08	0.29	0.13	-0.12	-0.07	-0.17	-0.07	-0.11	0.05	0.19	0.02
AFW	0.28	-0.14	-0.12	-0.10	-0.22	0.09	-0.30	-0.08	0.17	-0.17	-0.20	-0.17	0.21	-0.07	-0.18

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **MFFW**: marketable fruits fresh weight; **MFDW**: marketable fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **TSS**: total soluble solids; **RWC**: relative water content; **BER**: blossom-end rot; **AFW**: average fruit weight.

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Table 33 continued.

	$Ca^{2+}:Na^{+}$			Cl^{-}			SO_4^{2-}		
	YL	OL	St	YL	OL	St	YL	OL	St
TFW	0.34	-0.19	**0.47***	0.02	0.09	**-0.49***	0.34	-0.19	**0.47***
TDW	0.22	-0.17	**0.54***	0.00	0.11	-0.39	0.22	-0.17	**0.54***
LA	-0.22	-0.34	-0.08	0.10	0.20	**0.72****	-0.16	-0.06	0.11
LAR	0.01	0.38	0.34	-0.09	-0.10	0.44	0.01	0.38	0.34
SLA	-0.07	-0.41	-0.11	0.20	0.18	0.19	0.16	0.06	-0.01
PTL	-0.30	0.34	0.14	-0.07	0.10	**0.57****	-0.30	0.34	0.14
FFW	-0.05	0.14	**-0.48***	0.37	-0.22	0.38	0.06	0.08	**-0.52***
FDW	-0.05	0.21	**-0.48***	0.38	-0.23	0.43	0.04	0.08	**-0.49***
MFFW	0.04	0.16	-0.44	0.26	-0.33	0.32	0.05	-0.02	-0.38
MFDW	0.06	0.25	-0.40	0.25	-0.38	0.36	0.02	-0.04	-0.31
SL	-0.21	0.15	**-0.48***	0.23	-0.14	0.37	0.21	0.31	**-0.54***
Chl	**-0.57****	0.06	0.02	-0.30	-0.10	0.06	**-0.67****	-0.15	-0.31
TSS	-0.04	0.13	0.43	-0.38	0.19	-0.05	0.01	0.14	**0.46***
RWC	-0.06	**-0.50***	-0.22	**0.50***	0.27	0.24	-0.07	-0.17	-0.01
BER	-0.02	-0.03	-0.24	**0.46***	0.37	**0.48***	0.11	0.28	-0.07
AFW	-0.02	0.08	-0.04	0.26	0.13	0.02	0.06	-0.22	-0.15

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **MFFW**: marketable fruits fresh weight; **MFDW**: marketable fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **TSS**: total soluble solids; **RWC**: relative water content; **BER**: blossom-end rot; **AFW**: average fruit weight.

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XXIV

Table 34: Correlation analyses, indicated by Pearson´s coefficient (r), between the ions content and ions ratios in young leaves(YL), old leaves (OL) and stem (St), and parameters/calculations from data collected until the final harvest (145 days after sowing), in the plants under saline conditions (EC=8 dS.m^{-1}).

	Na^+			K^+			K^+:Na^+			Mg^{2+}			Ca^{2+}		
	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St	YL	OL	St
TFW	0.14	**0.50***	-0.20	0.13	-0.16	0.38	0.02	-0.39	0.37	**-0.46***	-0.40	**-0.55***	**-0.51***	0.02	**-0.51***
TDW	0.28	**0.48***	-0.28	0.32	-0.09	0.40	0.02	-0.32	0.43	-0.38	**-0.46***	**-0.58****	-0.43	-0.13	**-0.46***
LA	0.29	0.06	0.04	0.27	0.21	-0.17	-0.15	0.17	-0.08	0.17	0.02	-0.25	0.11	0.01	0.18
LAR	-0.05	**-0.47***	0.19	0.10	0.00	-0.19	0.07	0.27	-0.26	0.31	-0.04	0.23	0.34	-0.33	0.36
SLA	-0.03	-0.27	0.34	0.02	-0.30	0.06	-0.02	-0.06	-0.22	0.03	-0.27	0.28	0.13	-0.31	0.14
PTL	0.11	-0.41	-0.15	0.27	0.28	-0.38	0.09	**0.47***	-0.12	**0.62****	0.23	0.06	0.25	**-0.47***	**0.51***
FFW	0.02	**0.50***	-0.16	-0.01	-0.24	0.38	0.05	**-0.46***	0.34	**-0.51***	-0.34	**-0.48***	**-0.54***	0.12	**-0.55***
FDW	0.08	**0.52***	-0.18	0.08	-0.25	0.42	0.06	**-0.47***	0.38	**-0.47***	-0.37	**-0.49***	**-0.49***	0.08	**-0.56***
MFFW	-0.01	0.35	-0.24	-0.06	-0.02	-0.05	0.09	-0.16	0.19	-0.12	-0.02	-0.29	**-0.50***	-0.19	-0.16
MFDW	0.01	0.32	-0.24	-0.01	-0.02	-0.08	0.11	-0.13	0.19	-0.02	0.01	-0.26	-0.44	-0.27	-0.11
SL	0.40	**0.51***	-0.04	0.42	-0.02	**0.55***	-0.16	-0.28	0.29	-0.44	**-0.47***	-0.39	-0.41	-0.06	-0.23
Chl	-0.42	0.01	0.26	-0.28	-0.42	-0.05	0.16	-0.34	-0.21	0.17	-0.03	0.42	0.12	-0.05	0.01
TSS	0.41	0.10	-0.01	**0.58****	-0.13	-0.05	-0.02	-0.12	-0.05	**0.49***	-0.07	-0.06	-0.01	**-0.50***	0.33
RWC	-0.24	-0.10	0.16	-0.03	0.01	0.09	0.20	-0.05	-0.10	-0.11	0.13	0.13	0.05	0.24	0.11
BER	0.01	0.21	0.12	0.12	-0.25	**0.57***	0.03	-0.36	0.19	-0.41	-0.26	-0.15	-0.01	**0.45***	**-0.46***
AFW	0.01	0.20	-0.13	0.05	0.05	0.06	0.04	-0.07	0.22	-0.23	-0.03	-0.35	-0.04	0.42	**-0.46***

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **MFFW**: marketable fruits fresh weight; **MFDW**: marketable fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **TSS**: total soluble solids; **RWC**: relative water content; **BER**: blossom-end rot; **AFW**: average fruit weight.

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* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Table 34 continued.

	$Ca^{2+}:Na^{+}$			Cl^{-}			SO_4^{2-}		
	YL	OL	St	YL	OL	St	YL	OL	St
TFW	-0.39	-0.32	-0.38	-0.36	0.05	0.14	0.34	**0.46***	-0.29
TDW	**-0.46***	-0.38	-0.24	-0.26	-0.05	0.05	0.37	0.30	-0.24
LA	-0.23	0.02	0.17	0.03	0.24	-0.03	0.24	-0.07	-0.10
LAR	0.22	0.10	0.20	0.12	-0.02	0.14	-0.05	**-0.50***	0.20
SLA	0.11	-0.04	-0.20	-0.01	-0.19	**0.49***	0.13	-0.14	0.26
PTL	0.05	-0.02	**0.75****	**0.52***	0.07	-0.33	-0.23	**-0.70****	-0.09
FFW	-0.29	-0.26	**-0.46***	-0.40	0.03	0.18	0.28	**0.56****	-0.28
FDW	-0.31	-0.29	**-0.46***	-0.37	-0.06	0.17	0.31	**0.54***	-0.24
MFFW	-0.22	-0.34	0.10	-0.17	0.27	0.13	0.22	0.07	-0.29
MFDW	-0.20	-0.36	0.17	-0.09	0.23	0.10	0.20	-0.03	-0.25
SL	**-0.64****	-0.39	-0.25	-0.23	-0.16	0.14	0.32	0.40	-0.12
Chl	0.40	-0.08	-0.32	0.03	-0.24	0.13	-0.37	-0.11	0.40
TSS	-0.39	-0.38	0.34	**0.54***	-0.14	0.11	0.05	-0.41	0.07
RWC	0.20	0.12	-0.04	-0.08	0.07	-0.01	-0.29	0.02	0.01
BER	-0.02	0.15	**-0.68****	-0.28	-0.34	0.11	0.16	**0.63****	0.04
AFW	0.00	0.18	-0.33	-0.20	-0.03	-0.26	0.14	**0.59****	-0.12

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **MFFW**: marketable fruits fresh weight; **MFDW**: marketable fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **TSS**: total soluble solids; **RWC**: relative water content; **BER**: blossom-end rot; **AFW**: average fruit weight.

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XXV

Table 35: Correlation analyses, indicated by Pearson´s coefficient (r), between the parameters and calculations until the final harvest (145 days after sowing), in the plants under control conditions (EC=3 dS.m^{-1}).

	TFW	TDW	LA	LAR	SLA	PTL	FFW	FDW	MF FW	MF DW	SL	Chl	TSS	RWC	BER	AFW	NF	NL	NT
TFW	-																		
TDW	**0.94****	-																	
LA	0.38	**0.51***	-																
LAR	-0.29	-0.19	**0.73****	-															
SLA	0.11	0.02	0.41	**0.56***	-														
PTL	**-0.59****	-0.41	0.31	**0.65****	-0.07	-													
FFW	**0.98****	**0.87****	0.25	-0.39	0.15	**-0.70****	-												
FDW	**0.98****	**0.92****	0.31	-0.36	0.10	**-0.67****	**0.98****	-											
MFFW	**0.90****	**0.78****	0.22	-0.35	0.10	**-0.56***	**0.93****	**0.88****	**-**										
MFDW	**0.88****	**0.81****	0.28	-0.30	0.04	**-0.49***	**0.89****	**0.88****	**0.98****	**-**									
SL	**0.62****	**0.64****	0.18	-0.23	0.21	**-0.48***	**0.58****	**0.63****	0.37	0.36	-								
Chl	0.12	0.12	0.03	-0.16	-0.30	-0.22	0.09	0.10	-0.01	-0.03	0.08	-							
TSS	**-0.59****	-0.41	0.08	0.41	-0.06	**0.73****	**-0.67****	**-0.61****	**-0.61****	**-0.52***	-0.20	-0.19	-						
RWC	0.21	0.19	0.38	0.31	0.10	0.05	0.15	0.17	0.07	0.05	0.05	0.07	-0.05	-					
BER	**0.46***	**0.51***	**0.45***	0.09	0.14	-0.22	0.42	**0.51***	0.15	0.16	0.37	0.11	-0.29	0.27	-				
AFW	**0.46***	0.33	-0.04	-0.26	0.32	**-0.59****	**0.53***	**0.49***	0.42	0.36	0.42	-0.34	**-0.50***	-0.07	0.18	-			
NF	**0.58****	**0.54***	0.09	-0.28	-0.04	-0.18	**0.58****	**0.55***	**0.72****	**0.74****	0.28	-0.01	-0.29	0.04	-0.01	0.01	-		
NL	0.22	0.33	**0.45***	0.18	-0.18	0.37	0.12	0.14	0.24	0.30	0.06	0.26	0.02	-0.04	-0.27	-0.27	**0.59****	-	
NT	0.32	0.26	0.31	0.11	-0.14	0.12	0.28	0.23	0.35	0.32	-0.09	0.36	-0.32	0.37	-0.30	-0.30	**0.47***	**0.59****	-

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **MFFW**: marketable fruits fresh weight; **MFDW**: marketable fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **TSS**: total soluble solids; **RWC**: relative water content; **BER**: blossom-end rot; **AFW**: average fruit weight.

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XXVI

Table 36: Correlation analyses, indicated by Pearson´s coefficient (r), between the parameters and calculations until the final harvest (145 days after sowing), in the plants under saline conditions (EC=8 dS.m^{-1}).

	TFW	TDW	LA	LAR	SLA	PTL	FFW	FDW	MF FW	MF DW	SL	Chl	TSS	RWC	BER	AFW	NF	NL	NT
TFW	-																		
TDW	0.94**	-																	
LA	0.14	0.21	-																
LAR	-0.45*	-0.41	0.35	-															
SLA	-0.12	-0.18	0.05	0.77**	-														
PTL	-0.62**	-0.45*	0.35	0.60**	0.07	-													
FFW	0.97**	0.86**	-0.04	-0.53*	-0.11	-0.75**	-												
FDW	0.98**	0.93**	0.00	-0.54*	-0.13	-0.70**	0.98**	-											
MFFW	0.64**	0.60**	0.00	-0.31	-0.11	-0.22	0.65**	0.63**	-										
MFDW	0.56*	0.58**	0.01	-0.26	-0.11	-0.10	0.55*	0.56*	0.98**	-									
SL	0.63**	0.68**	0.22	-0.32	-0.08	-0.40	0.56**	0.61**	0.09	0.03	-								
Chl	-0.22	-0.19	-0.51*	0.13	0.17	-0.02	-0.15	-0.10	-0.08	0.01	-0.44	-							
TSS	0.00	0.23	0.38	0.23	0.03	0.55*	-0.15	-0.03	0.18	0.32	0.09	0.16	-						
RWC	-0.34	-0.46*	-0.19	0.16	0.12	0.02	-0.28	-0.36	-0.45*	-0.52*	0.04	-0.06	-0.31	-					
BER	0.38	0.31	-0.03	-0.30	-0.03	-0.62**	0.41	0.41	-0.39	-0.49*	0.63**	-0.16	-0.37	0.28	-				
AFW	0.47*	0.35	-0.15	-0.67**	-0.35	-0.59*	0.55*	0.53*	0.29	0.22	0.15	-0.19	-0.38	-0.29	0.29	-			
NF	0.32	0.30	-0.07	0.06	0.19	0.02	0.33	0.31	0.82**	0.84**	-0.07	0.13	0.35	-0.32	-0.18	-0.18	-		
NL	-0.06	-0.01	0.52*	0.47*	0.12	0.62**	-0.18	-0.20	0.10	0.10	0.12	-0.44	0.23	0.16	-0.45*	-0.45*	0.19	-	
NT	0.15	0.04	0.42	0.36	0.33	0.17	0.11	0.05	0.07	0.00	0.20	-0.22	0.01	0.15	-0.13	-0.13	0.13	0.66**	-

TFW: total fresh weight; **TDW**: total dry weight; **LA**: leaf area; **LAR**: leaf area ratio; **SLA**: specific leaf area; **PTL**: partitioning to the leaves; **FFW**: total fruits fresh weight; **FDW**: total fruits dry weight; **MFFW**: marketable fruits fresh weight; **MFDW**: marketable fruits dry weight; **SL**: stem length; **Chl**: chlorophyll content; **TSS**: total soluble solids; **RWC**: relative water content; **BER**: blossom-end rot; **AFW**: average fruit weight.

* Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

Appendix XXVII

Table 37: Correlation analyses, indicated by Pearson´s coefficient (r), between the ions content in young leaves, old leaves and stems, under control (EC3; 3 dS.m^{-1}) and saline conditions (EC8; 8 dS.m^{-1}) at the final harvest (145 days after sowing).

EC3		Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	SO_4^{2-}
Young leaves	Na^+	-					
	K^+	0.31	-				
	Mg^{2+}	**0.54***	**0.60****	-			
	Ca^{2+}	**0.48***	**0.64****	**0.67****	-		
	Cl^-	0.21	**0.62****	0.17	0.36	-	
	SO_4^{2-}	0.39	**0.89****	**0.67****	**0.75****	0.36	-
Old leaves	Na^+	-					
	K^+	0.42	-				
	Mg^{2+}	0.28	**0.56***	-			
	Ca^{2+}	**0.61****	**0.72****	**0.65****	-		
	Cl^-	**0.69****	0.41	0.26	0.35	-	
	SO_4^{2-}	**0.64****	**0.80****	**0.50***	**0.82****	**0.54***	-
Stem	Na^+	-					
	K^+	**0.45***	-				
	Mg^{2+}	**0.46***	0.16	-			
	Ca^{2+}	**0.51***	0.16	**0.90****	-		
	Cl^-	0.37	0.28	-0.23	-0.25	-	
	SO_4^{2-}	0.44	0.17	**0.79****	**0.75****	0.00	-
EC8							
Young leaves	Na^+	-					
	K^+	**0.63***	-				
	Mg^{2+}	-0.04	0.28	-			
	Ca^{2+}	0.22	0.21	**0.57***	-		
	Cl^-	**0.66****	**0.48***	**0.58****	0.44	-	
	SO_4^{2-}	**0.58****	0.39	0.08	0.42	0.14	-
Old leaves	Na^+	-					
	K^+	0.01	-				
	Mg^{2+}	-0.09	0.00	-			
	Ca^{2+}	0.11	-0.14	**0.59****	-		
	Cl^-	0.26	0.25	0.26	0.07	-	
	SO_4^{2-}	0.44	-0.31	0.12	**0.65****	-0.21	-
Stem	Na^+	-					
	K^+	-0.30	-				
	Mg^{2+}	**0.64****	-0.32	-			
	Ca^{2+}	**0.64****	**-0.56***	**0.55***	-		
	Cl^-	**0.68****	0.10	**0.53***	0.42	-	
	SO_4^{2-}	0.40	-0.03	**0.64****	0.22	0.31	-

* Correlation is significant at 0.05 level.
** Correlation is significant at 0.01 level.