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Application of chlorophyll fluorescence for the diagnostic of salt stress of two olive cultivars (Chemlali and Chetoui)

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ABSTRACT

The salinity constitutes a major obstacle on the development of olive tree. So the utilization of resistant variety to the salinity is the best solution. Changes caused by salinity on physiological parameters have been measured in two olive (Oleae europaea) cultivars ('Chemlali' and 'Chetoui') growing in a greenhouse. One year old plants were planted in pot experiment and were irrigated with tap water and saline water (6g/l). The aim of the present study was to assess the salinity tolerance of two olive cultivars (Chemlali and Chetoui) based on the effects of salinity on fluorescence parameters and on the ability of the two cultivars to ovoid transport to leaves of the toxic ions sodium and chloride. We noticed that were a significant decrease on (ΔF/F'm) for Chetoui cultivar compared to a non significant decrease for Chemlali. There was a decrease in F_0, F_m and F_v/F_m during three weeks after the onset of the salt treatment. The variety Chemlali is characterized by an important accumulation of sodium in roots and an important inhibition of translocation of this element to the aerial part, contrary to variety Chetoui which showed similar sodium concentrations in the root and leaves. Chetoui is considered as moderate sensitive while Chemlali is considered as moderate tolerant.

RESUME

La salinité constitue l'obstacle majeur de développement de l'olivier. Donc l'utilisation des variétés résistantes à la salinité est la meilleure solution. Les changements causés par la salinité sur les paramètres physiologiques sont mesurés sur deux variétés de l'olivier (Oleae europaea) qui sont la variété 'Chemlali' et 'Chetoui' cultivées en conditions contrôlées sous serre. Les plantes âgées d'une année sont plantées dans des pots expérimentaux et irriguées par une eau saline (6g/l). l'objectif de ce travail est de tester la tolérance à la salinité des deux variétés d'olivier (Chemlali et Chetoui) en se basant sur les effets de la salinité sur les différents paramètres de la fluorescence chlorophyllienne. On a noté qu'il ya une diminution significative de la valeur de (ΔF/F'm) pour la variété Chetoui comparée à une diminution non significative pour la variété Chemlali. Il ya une diminution de la valeur de F_0, F_m and F_v/F_m durant trois semaines à partir de la première irrigation avec l'eau saline. La variété Chemlali est caractérisée par

une importante accumulation de sodium dans les racines et une importante inhibition de la tra conc nslocation de cet élément vers la partie aérienne, contrairement à la variété Chetoui qui montre une entration égale de sodium dans les racines et les feuilles. La variété Chetoui est considérée comme moyennement sensitive alors que celle de Chemlali est considérée comme moyennement tolérante.

1. Introduction

Olive (oleae europaea L.) is one of the most important fruit-tree crop species cultivated in the Mediterranean area, and increasing interest word-wide (Cimato et al., 2010). The climatic changes are more and more the contrast for the development of culture. One of the climatic phenomena more observed for a long time led obviously to the salinisation of the grounds (Hassani et al., 2002). High concentration of salt imposes both osmotic and ionic stresses on the plant which lead to several morphological and physiological changes (Gampeetong and Brix 2009). Salt-sensitive plants have reduced survival, growth and development when exposed to even low to moderate salinities whereas salt-tolerant species are able to grow and reproduce even at oceanic salinities (Munns and Tester 2006). Tabatabali (2006) indicated that salt tolerance in olive trees is associated with the ability to reduce uptake and/or transport of saline ions. Chartzoulakis et al. (2006) classified the tolerance of some Greek olive cultivars to salinity according to the effectiveness of exclusion mechanism at the root level (Kchaou et al. 2010) indicate the existence of an important variability concerning the degree of tolerance of the tested varieties to saline. Chartzoulakis (2005) indicate that in important mechanism to ovoid the deleterious effects of salinity in olive trees is the ability to limit uptake and/or transport of saline ions (sodium and chloride) from the root zone to aerial parts and salt tolerance in olive cultivars is associated with effective mechanisms of ion exclusion and retention of sodium and chloride in the root.

other fundamental mechanisms in stress adaptation such as ion compartmentation and/or exclusion, may be most critical in young salt stressed plants, and possibly for specific plant tissues and/or organs, whereas may result less efficient, as adaptation mechanisms, when salinisation occurs later in the growth season (i.e. during fruits on-set, when salt accumulates in proximity of the roots as a consequence of recurrent saline irrigation (Pardons et al., 1998; De Pascale et al.,2003).(article2, maggio)

high salinity causes both hyperionic and hyperosmotic stresses and finally decease of plants (Turkan, 2009), plants cannot tolerate high concentrations of salt in their cytoplasm, so they either limit that excess amount of salt in vacuole or compartmentalize essential ions in different tissues (Zhu,2003). Plants accumulate many metabolites that are also known as “compatible (organic) solutes” in the cytoplasm to increase their hyperosmotic tolerance against stress-induced water loss from the cells (Turkan, 2009). In recent years, the importance of K^+ transport systems and its cytosolic homeostasis under saline conditions have had an increasing interest and now it is becoming widely accepted that the ability of a plant to maintain a high cytosolic K^+/Na^+ ratio is vital in plant salt-tolerance mechanisms (Shabalan and Cuin, 2007). Over the years, much research has envisioned the salinity tolerance threshold as a specific target for improving plant salt stress tolerance (Maggio et al., 2001). Salt tolerance in olive cultivars is associated with effective mechanisms of ion exclusion and retention of Na^+ and Cl^- in the root (Tattini et al, 1994; Chartzoulakis et al, 2002). Sodium compartmentation into vacuole appears constitute the most effective way for cells to handle efficiently high concentration of salts and prevent their toxic effects on the cytoplasm. Na^+ compartmentation is regulated by Na^+/H^+ antiporters (Hasegawa et al, 2002). An important mechanism to ovoid the deleterious effects of salinity in olive trees is the ability to limit uptake and/or transport of saline ions (sodium and chloride) from the root zone to aerial parts (Chartzoulakis,2005). The same authors indicated that salt tolerance in olive cultivars is associated with effective mechanisms of ion exclusion and retention of sodium and chloride in the root.

The aim of the present study was to assess the salinity tolerance of two olive cultivars (Chemlali and Chetoui) based on the effects of salinity on fluorescence parameters and on the ability of the two cultivars to ovoid transport to leaves of the toxic ions sodium and chloride.

2. Materials and methods

2.1. Plant material and culture conditions

Trials were conducted at Sousse specialised station of the Olive Tree Institute, Tunisia (35°49’34”N; 10°38’24”E). Uniform one-year-old self rooted olive trees (Olea europaea L. cvs Chemlali and Chetoui) were transplanted into 36

pots filled with a mixture of soil and peat (2:1, v/v). The pots were kept in one plastic greenhouse. Salinity treatments were imposed after two months of adaptation. A factorial experiment with cultivars and saline water treatment as experimental factors was conducted. Two olive cultivars and two saline water treatments were applied in this experiment, control plants (T0)were irrigated with tap water 0 g/l and T1 irrigated with saline water with 6 g/l solution respectively. 36 plants were used corresponding to nine plants per cultivar for each treatment. Salinity treatments were applied every fifteen days during one year (January 2012 to February 2013).

9 olive plants variety Chemlali irrigated with saline water 6 g /l (T1)

9 olive plants variety Chemlali irrigated with tap water 0 g /l (T0)

9 olive plants variety Chetoui irrigated with saline water 6 g /l (T1)

9 olive plants variety Chetoui irrigated with tap water 0 g /l (T0)

2.2. Chlorophyll fluorescence

Chlorophyll fluorescence emission from the upper surface of the leaves of intact plants was measured by a modulated fluorimeter (OS1, FL). The minimal (F0) and maximal ch a fluorescence (Fm) emissions were assessed in leaves after 10 mn of dark adaptation and the maximum quantum efficiency of PSII photochemistry was calculated as Fv/Fm= (Fm-F0)/fm. Then, the leaves were continuously illuminated with a white actinic light, which was equivalent to the actual growth light of olive tree in order to measure Fs and Fm'(steady-state and maximal ch a fluorescence level in light-adapted leaves, respectively). The parameter F0 (minimal ch a fluorescence level light-adapted leaves) was estimated flowing Baker and Rosenqvist (2004). Non-photochemical quenching of fluorescence (NPQ) which is proportional to the rate constant of thermal energy dissipation BjÖrkman and Demmig-Adams, 1994), was calculated as NPQ= (Fm-F'm)/F'm. Usually, plants show NPQ values varying from 0 to 3,5 under saturating irradiance; these values may vary according to species Maxwell an Johson (2000). The coefficient of photochemical quenching (qp) was calculated as (F'm-Fs)/(F'm-F0) Schreiber et al.,1986; Van and Snel (1990).

The quantum yield of PSII electron transport, Φ_{PSII} (or actual PSII efficiency; Genty et al., 1989, Harbinson et al., 1989) was calculated as ΔF/F'm= (F'm-Fs)/F'm Schreiber et al., 1995, were ΔF=F'm-Fs.

2.3. Mineral nutrient analysis

Mineral analyses were carried out at the end of the experimentation on dry material of leaf and root. Dry ash of plant material was obtained at 400 °C after a drying time of at least 72 h at 70 °C until weight stabilization. The mineralization of the samples was obtained after a digestion process in 1 N nitric acid solution (HNO3 −). The sodium (Na+) and calcium (Ca2+) contents were measured using the flame emission photometry (Jenway PFP7, Bibby Scientific limited, Staffordshire, UK). Chloride (Cl−) content was measured using an ion titration potentiometer (pH-240L, pH/ISE/mV/ORP/Temp) after the tissue had been extracted with 0.2 N solution of nitric acid (HNO3−). All the values reported represent the means of at least three replications.

2.4. The leaf water potential

Leaf water potential was measured using a Scholander pressure chamber according to Scholander et al. (1965). One leaf per plant was obtained from the third and fourth fully expanded leaf from the tip with nine plant replicates for each treatment. After cutting, the leaf was immediately enclosed in a plastic bag and the determination of the leaf water potential was started in less than 1 min. These measurements were carried between 9:00 h and 10:00 h.

3. Results

3.1. Minimal chl a fluorescence;F_0,maximal chl a fluorescence;Fm, and maximum quantum efficiency of PSII photochemistry;F_v/F_m

Significant changes in the minimal ch a fluorescence, F_0, the maximal ch a fluorescence, F_m and therefore the maximum quantum efficiency of PSII photochemistry (F_v/F_m) occurred under salt treatment for the two cultivars, Chemlali and Chetoui.

There was a decrease in F_0, F_m and F_v/F_m during three weeks after the onset of the salt treatment. This decrease is more observed with Chetoui cultivar compared to Chemlali. The decrease in the maximal efficiency of PSII photochemistry (F_v/F_m) which may be caused by damage in the PSII reaction centre or caused by an increase in the non photochemical quenching deactivation of PSII (Genty et al., 1990) Which serve to reduce the rate of excitation of the PSII reaction centers and prevent the PSII quinine acceptors from becoming highly reduced (Baker and Rosenqvist, 2004).

3.2. Effective quantum yield (ΔF/F'm)

To follow physiological responses of plants to the treatments, measurements of effective quantum yield (ΔF/F'm) and potential quantum yield (Fv/Fm) of PSII were performed during the light period Broetto (2007). ΔF/F'm values were between 0.7 and 0.8 for the whole duration of the experiment for Chemlali cultivar and between 0.6 and 0.8 for Chetoui. We noticed that on three weeks of measurements were a significant decrease on (ΔF/F'm) for Chetoui cultivar compared to a non significant decrease for Chemlali. This decrease is attributed to salinity. This parameter indicates the fraction of light absorbed by chlorophyll associated with PSII activity and used in the photochemical processes Maxwell and Johson (2000). Under controlled conditions this parameter strongly correlates to carbon fixation efficiency Mattos et al., (1999).

3.3. Non photochemical quenching (NPQ)

Values of non photochemical quenching, NPQ oscillated between 0,3 and 0,9 for Chemlali cultivar and between 0,5 and 1,1 for Chetoui.

3.4.tissue mineral content

The analysis of graphic shows that both sodium and chloride concentration in the different plant parts (leaves and roots) increased with salinity. The accumulation of Na^+ in root is significantly higher than in leaves in both cultivars (Chemlali and Chetoui).

The accumulation of Na+ in roots provides mechanism for olive to cope with salinity in root zone and may indicate the existence of an inhibition mechanism of Na+ transport to leaves. The variety Chemlali is characterized by an important accumulation of sodium in roots and an important inhibition of translocation of this element to the aerial part. Contrary to variety Chetoui which showed similar sodium concentrations in the root and leaves.

3.5. Leaf water potential

The analyze of the graphic showed that the leaf water potential (Ψp) decreased with salinity.

In the second week the Ψp is significantly decreased to -2.02 MPa for Chemlali S (irrigated with saline water) and to -2.22 MPa in the third week compared to the variety Chetoui which is more affected by salinity and the Ψp is significantly decreased to -2.46 MPa for the second week and to -2.8 MPa for the third week.

While Chemlali T and chetoui T (irrigated with dolce water), their Ψp are significantly increased for the second and third weeks.

3.6. Statistical analysis

Data were tested by analysis of variance using the Static program (SPSS.17). All the significant differences discussed in this work were significant at $P<0.05$ in Student-Newman-Keuls test.

4. Discussion

O. europaea has long been ranked of medium tolerance stress (Hartman et al.,1966; Rugini and Fedeli, 1990; Gucci and Tattini, 1997) but recent findings do not completely support such an early classification (Melgar et al., 2009; Tattini et al., 2009).

The aim of the present study was to assess the salinity tolerance of two olive cultivars (Chemlali and Chetoui) based on the effects of salinity on fluorescence parameters. Many criteria have been reported to have genotypic variability in response to salt stress (Tattini, 1994; Chartzoulakis et al., 2002; Chartzoulakis, 2005; Vigo et al., 2005) and could be used to assess the degree of salinity tolerance.

In our experiment, salinity had a significant impact on olive tree. In order to investigate the possible changes in PSII photochemistry, the ch a fluorescence characteristics were investigated. Results revealed that the response of PSII photochemistry in two olive cultivars (Chemlali and Chetoui) to salt treatment consisted in two distinct phases. In the first phase (during the two first weeks), there were a significant decrease on the maximum quantum efficiency of PSII photochemistry (Fv/Fm). On the second phase (at the third week), a significant increase was observed in previous parameter. A significant increase was observed in F0 during the first phase for Chemlali cultivar compared to a significant decrease for Chetoui. In the second phase, a significant decrease was observed for the both cultivars. The decrease in the maximal efficiency of PSII photochemistry (Fv/Fm) which may be caused by damage in the PSII reaction centers Zribi et al., (2009). A significant increase in non photochemical quenching was observed during the two phases of both cultivars (Chemlali and Chetoui). Moderno et al., (2002) indicated that stomatal closure is associated with a down regulation of ETR, which is compensated by increase thermal dissipation (NPQ). This increased (NPQ) would dissipate some excitation energy at the expense of photochemical utilization (Brestic et al., 1995), thus leading to down regulation of PSII to ovoid over reduction of QA.

For Chemlali cultivar, there was a non significant decrease on ΔF/F'm during the first phase; For Chetoui, there was a significant decrease on ΔF/F'm during the first phase but there was a non significant increase in the same parameter during the second phase. ΔF/F'm is an indicator of the actual photosystem (PSII) efficiency in light Ball (1994). During salinity induced oxidative stress, availability of atmospheric CO2 is reduced because of increased stomatal closure and consumption of NADPH by the Calvin cycle is decreased Turkan and Demiral (2009).

Tolerance to salt appears to be cultivar-dependent and is likely due to control of net salt import to the shoot. The mechanism is located within the roots and prevents salt translocation, rather than salt absorption. It is probably that K-Na exchange at the plasmalemma is involved in regulating the transport of Na+ to the shoot, while calcium plays a key role in limiting the toxic effects of Na+ on integrity of the plasma membrane in root cells. Osmotic adjustment, stomatal closure and leaf abscission appear to play a role. Chartzoulakis (2005). Genotypic responses of olive tree to NaCl salinity have not been extensively investigated, and only recently some works have been published (Robinson, 1987; Therios and Misopolinos, 1988; Benlloch et al., 1991, 1994; Tattini et al., 1992, 1994; El-Sayed Emtithal et al., 1996; Chartzoulakis et al., 2002a; Al-Absi et al., 2003). The growth of all cultivaes tested so far is reduced under salt stress to varying degrees.

From published studies on salinity tolerance of young olive cultivars, 'Pajarero' 'Lechino', 'Chetoui' and 'Chalkidikis' are considered as moderate sensitive, 'Cordal', 'Manzanillo', 'Frantoio', 'Koroneiki', 'Chemlali' and 'Hotjiblanca' as moderate tolerant, while 'Kalamata', 'Picual', 'Lechin' de 'Sevilla' and 'Megaritiki' as tolerant (Therios and Misopolinos, 1998; Benlloch et al.,1991, 1994; Tattini et al., 1992; Chartzoulakis et al., 2002b). A list of olive cultivars tested for salinity tolerance is given in Table 1. However, the tolerance of adult plants growth under field conditions may be different of that obtained with young plants growth in pots.

Kchaou et al., (2010) indicate that the most effective mechanism at high salinity was found in Chemlali variety which is characterized by an important accumulation of sodium in roots and an important inhibition of translocation of this element to the aerial part the same author indicate that the less effective mechanism was found in Chetoui variety which showed similar sodium concentrations in the different plant parts.

Measurements of chlorophyll fluorescence, like effective quantum yield of PSII (ΔF/F'm), make it possible to evaluate the plant's photosynthetic performance and the extent of its tolerance to environmental stress (Maxwell and Johnson, 2000). This parameter indicates the fraction of light absorbed by chlorophyll associated with PSII activity and used in the photochemical process (Maxwell and Johnson, 2000). Under controlled conditions this parameter strongly correlates to carbon fixation efficiency (Mattos et al., 1999), although under certain conditions such correlation may be masked by changes in rates of photorespiration (Fryer et al., 1998). Broetto et al., 2006 demonstrated that salt stress elicited of decline of FV/FM during the day of 6 days of treatments, which was larger of high irradiance(HLSA) than at low irradiance (LLSA), showing again that salinity and high irradiance stress were additive.

More recently Barker et al., 2004 also demonstrated that high salt treatment at high irradiance elicited acute photoinhibition and increased thermal energy dissipation via the xanthophylls cycle at midday.

Gonzales-Moreno et al. (1997) have demonstrated that salinity stress inhibited the electron transfer at the quinine pool level. Similarly, high salinity decreased the amount of light energy that reached the reaction centers and inhibited electron-transport at the oxidizing side of PSII in Porphyra perforate (Sotoh et al; 1983). The inhibitory target site at PSII of high salt concentration varies with species (Greenway and Munns, 1980) and the mechanism of salt action on PSII in U.Lactuca has not been entirely elucidated. Thus, little information is available on the effect of elevated salinity on PSII in U.Lactuca during the initial stages of the response to salinity stress.

A significant inhibition of photosynthesis by high salinity seems associated with the photosystem II (PSII) complex. Salinity stress significantly decreases the PSII activity of Spirulina platensis (Lu and Vanshak, 2002), and inhibits the quantum yield of PSII electron transport in Chlamydomonas reinhardtu.

The intensity of ch a fluorescence emission in dark adapted oxygen evolving systems shows a characteristic variation with time, known as fluorescence transient or induction (Go vindjee, 1995).

It has been suggested that the inhibitory effects of elevated salinity on photosynthesis are not targeted to a specific site but rather to the whole pathway at several sites (Similie and Nott, 1982), there is general agreement that PSII is highly susceptible to salinity stress (Mosojitek et al., 2000; Corney et al., 2003; Belkhodja et al., 1994).

Xia et al., 2004 demonstrated that the reaction centers of PSII may be inactivated during exposure to high salinity. The decrease in the amount of active PSII reaction centers per excited cross section (RC/CS) also strongly supported this suggestion although the direct evidence as to low salinity stress inactive the reaction center require to be further studied .Salt stress leads to a decrease in the efficiency of photosynthesis (O.H.Sayed, 2003) and is known to influence the chlorophyll content of the plant leaves. Fedina et al (2003) and N.N.Kahn (2003).PSII is more sensitive to all types of stresses to PSI. APostolova (2006).

Ch a fluorescence analysis has proven to be a sensitive method for the detection and quantification of changes induced in the photosynthetic apparatus. Chl a fluorescence intensity of dark adapted photosynthetic organisms follows a characteristic variation with time after the onset of illumination. This effect is well known as "Kautsky effect". Kautsky and Hirsh (1931).

The fluorescence curve with increase in NaCl concentration suggests that high salt stress inhibits the electron transfer rates at the donor side of PSII. Fv/Fm ratio was not affected significantly in high salt treatment Mehta et al (2010).

Characteristics of plant stress can be measured in dependently using reflectance or fluorescence remote sensing which provides rapid and non-destructive measurements (Anderson and Perry, 1996).

Both criteria (sodium and chloride concentrations) have been reported to have genotypic variability in response to salt stress (Tattini, 1994; Chartzoulakis et al., 2002; Chartzoulakis, 2005; Vigo et al., 2005), and could be used to assess the degree of salinity tolerance. Thus, Tabatabaei (2006) indicated that salt tolerance in olive trees is associated with the ability to reduce uptake and/or transport of saline ions. Chartzoulakis et al.(2006) classified the tolerance of some Greek olive cultivars to salinity according to the effectiveness of exclusion mechanism at the root level.

Salt tolerance in glycophytes is associated with the ability to prevent the entry and/or translocation of saline ions (mainly Na^+ and Cl^-) from the root zone to aerial parts

(Greenway and Munns, 1980; Storey and Walker, 1999). Root sodium and chloride concentration in olive increases with increasing NaCl in the soil (Tattini et al., 1992; Chartzoulakis et al., 2002b). There is an increasing gradient in Na^+ and Cl^- contents from the root to the apical part of the olive tree. Furthermore, large genotypic differences are detected regarding Na+ accumulation in the roots and transport to above ground parts

At low and moderate salinity most olive cultivars exhibit a sodium exclusion
capacity (Tattini et al., 1992; Chartzoulakis et al., 2002b).

An important mechanism to avoid the deleterious effects of salinity in olive trees is the ability to limit uptake and/or transport of saline ions (sodium and chloride) from the root zone to aerial parts (Chartzoulakis, 2005). The same author indicated that salt tolerance in olive cultivars is associated with effective mechanisms of ion exclusion and retention of sodium and chloride in the root.

The most effective mechanism at high salinity was found in 'Chemlali' variety, which is characterized by an important accumulation of sodium in roots and an important inhibition of translocation of this element to the aerial part. The less effective mechanism was found in variety 'Chetoui', which showed similar sodium concentrations in the different plant parts. Similar results were found by Chartzoulakis et al. (2002), who reported that the sodium exclusion mechanism in olive trees (one year- old) seems to work effectively at moderate levels of salinity. The same authors indicated that at high salinities in most cultivars, sodium was transported and accumulated to the aerial parts, resulting toxicity symptoms except in salt tolerant genotype. Differences in effectiveness of sodium exclusion mechanism among varieties at high salinity reflect differences in salt tolerance (Tattini, 1994; Chartzoulakis et al., 2002).

A decrease in water uptake by salinized olive trees has been reported by Therios and Misopolinos (1988), caused mainly by the decreased osmotic potential in solutions containing NaCl.

The early response of olive to salinity is the reduction of leaf water potential (Ψw) and relative water content (RWC), like in most woody crops. Chartzoulakis (2005).

The decrease in RWC is a result of high salt concentration of the external solution, modulus of elasticity of olive leaves (LoGullo and Salleo, 1988; Chartzoulakis et al., 1999) and leaf dehydration can explain the substantial drop in Ψw during salinity and its ability to recover upon relief of stress. The salt-induced decrease of Ψw was accompanied by a decrease of osmotic potential (Ψp,) resulting in turgor potential (Ψp) values of salinized plants similar or higher than the Ψp of the control plants.

Negrão and al (2016) discuss how to quantify the impact of salinity on different traits, such as relative growth rate, water relations, transpiration, transpiration use efficiency, ionic relations, photosynthesis, senescence, yield and yield components. We also suggest some guidelines to assist with the selection of appropriate experimental systems, imposition of salinity stress, and obtaining and analysing relevant physiological data using appropriate indices. We illustrate how these indices can be used to identify relationships amongst the proposed traits to identify which traits are the most important contributors to salinity tolerance. Salinity tolerance is complex and involves many genes, but progress has been made in studying the mechanisms underlying a plant's response to salinity. Nevertheless, several previous studies on salinity tolerance could have benefited from improved experimental design.

The identified genotypes could be used as parents in breeding for new varieties with improved salt tolerance as well as in further genetic studies to uncover the genetic mechanisms governing salt stress response in wheat.
Ballvora and al (2016)

5. Conclusion

The salinity constitutes a major obstacle on the development of olive tree. So the utilization of resistant variety to the salinity is the best solution. The variety "Chemlali"is characterized by an important accumulation of this element to the aerial part, contrary to variety "Chetoui" which showed similar sodium concentration in the roots and leaves. "Chetoui" is considered as moderate sensitive while "chemlali" is considered as moderate tolerant.

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Tittles of figures:

Fig.1.(A): Effects of irrigation with saline water on minimal chl a fluorescence;F_0,maximal chl a fluorescence;Fm, and maximum quantum efficiency of PSII photochemistry;F_v/F_m for Chemlali cultivar. Data are means ± S.E of 5 replicates. For each data, different letters (a, b) indicate significant differences at the 5% probability level

Fig.1.(B): Effects of irrigation with saline water on minimal chl a fluorescence;F_0,maximal chl a fluorescence;Fm, and maximum quantum efficiency of PSII photochemistry;F_v/F_m for Chetoui cultivar . Data are means ± S.E of 5 replicates. For each data, different letters (a, b) indicate significant differences at the 5% probability level

Fig.2. Effects of irrigation with saline water on effective quantum yield (ΔF/F'm) for Chemlali and Chetoui cultivars. Data are means ± S.E of 5 replicates. For each data, different letters (a, b) indicate significant differences at the 5% probability level

Fig.3. Effects of irrigation with saline water on non photochemical quenching, NPQ for Chemlali and Chetoui cultivars Data are means ± S.E of 5 replicates. For each data, different letters (a, b) indicate significant differences at the 5% probability level

Fig.4. Effects of irrigation with saline water on tissue sodium content for Chemlali and Chetoui cultivars. Data are means ± S.E of 3 replicates. For each data, different letters (a, b) indicate significant differences at the 5% probability level

Fig.5. Effects of irrigation with saline water on tissue chloride content for Chemlali and Chetoui cultivars. Data are means ± S.E of 3 replicates. For each data, different letters (a, b) indicate significant differences at the 5% probability level

Fig.6. Effects of irrigation with saline water on leaf water potential for Chemlali and Chetoui cultivars. Data are means ± S.E of 5 replicates. For each data, different letters (a, b) indicate significant differences at the 5% probability level

Tittles of table:

Table 1: Classification of olive cultivars according to their salt-tolerance

List of figure

Fig.1 :

(A)

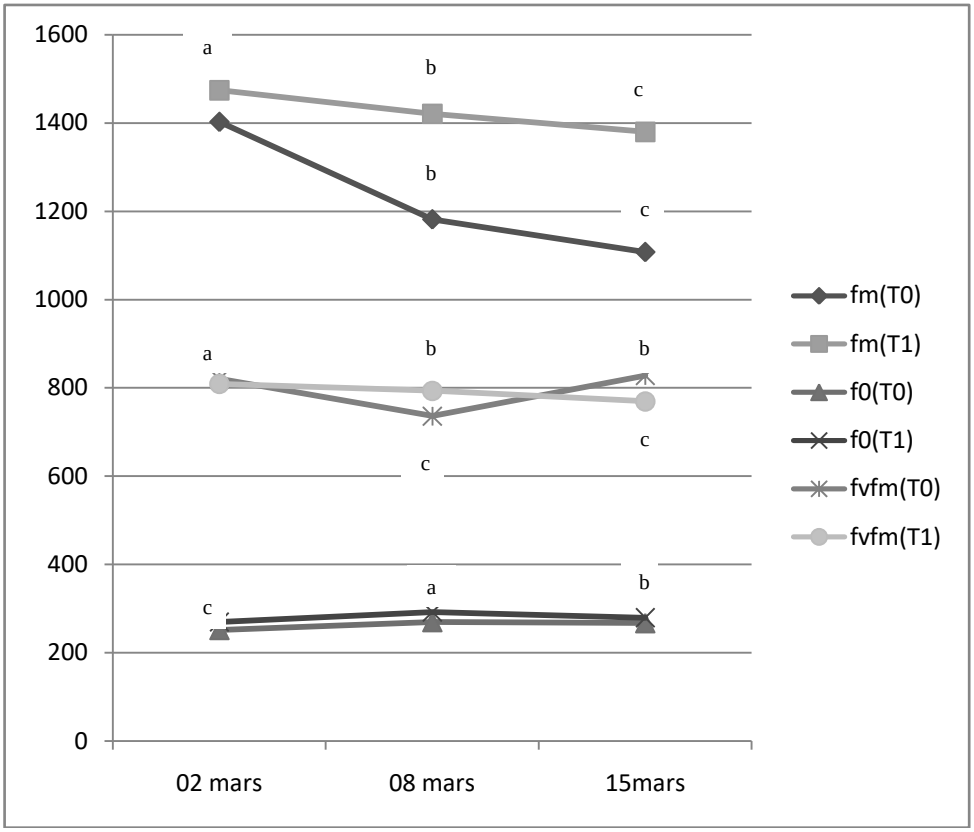


Fig.1 : different letters (a, b and c) indicate significant differences at the 5% probability level

(B)

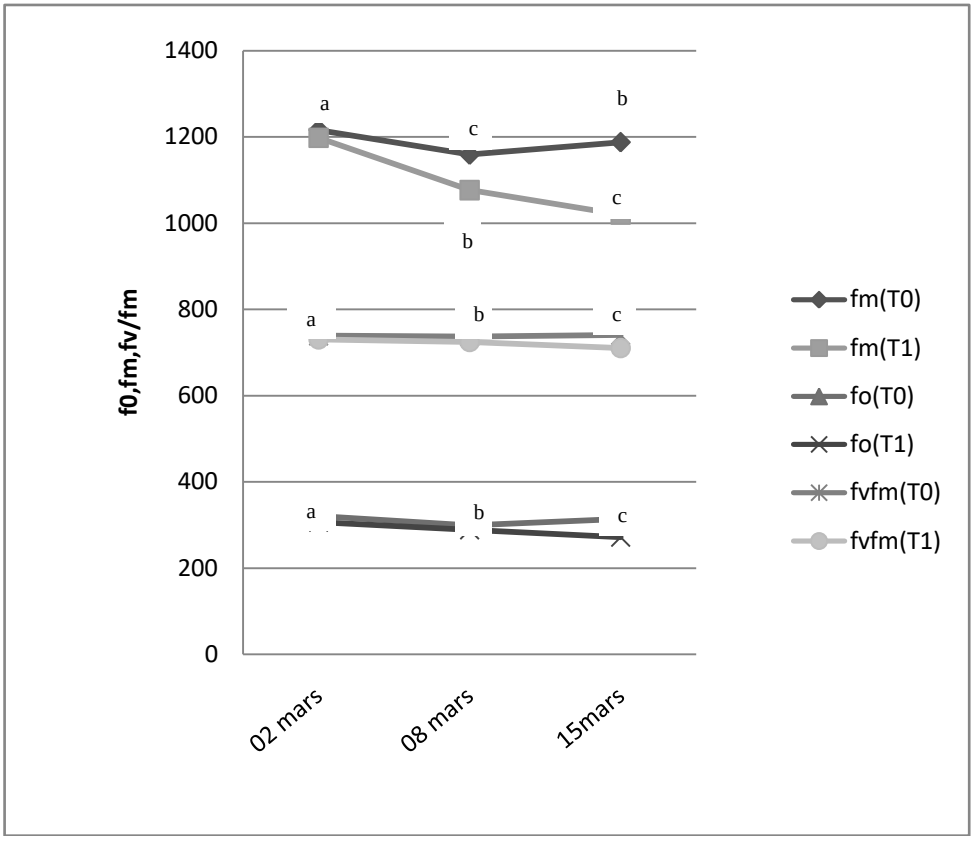


Fig.2 : different letters (a, b and c) indicate significant differences at the 5% probability level.

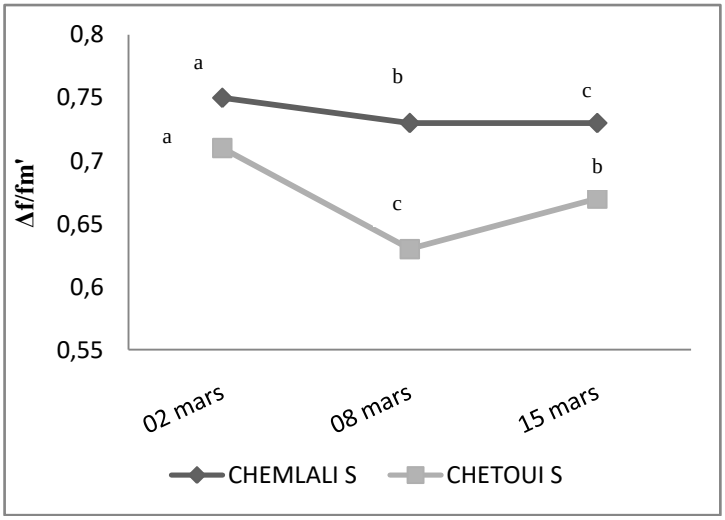


Fig.3 : different letters (a, b and c) indicate significant differences at the 5% probability level

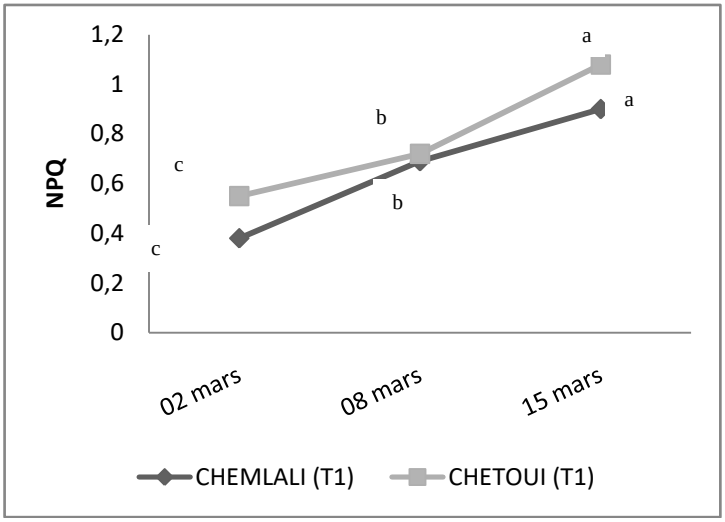


Fig.4 : different letters (a, b and c) indicate significant differences at the 5% probability level

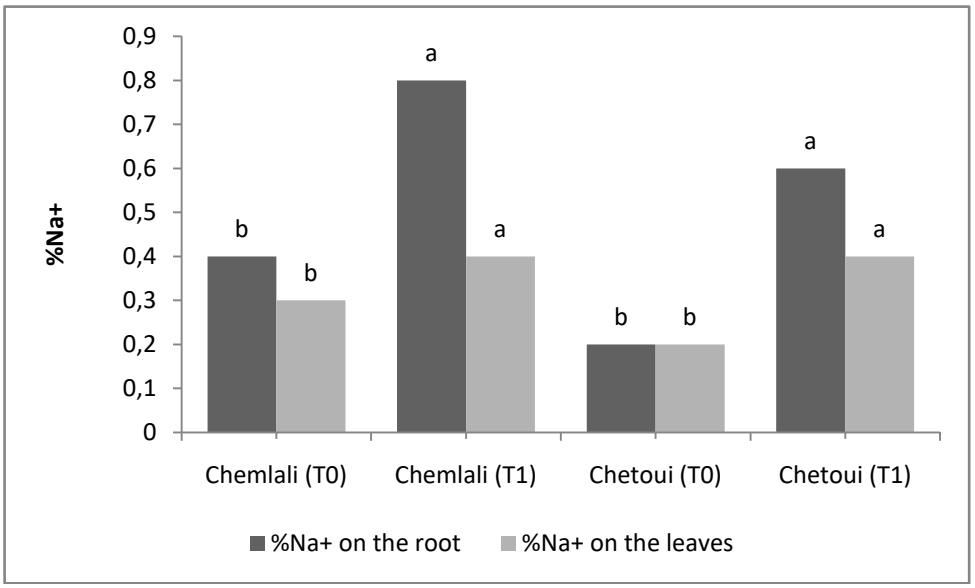


Fig.5 : different letters (a, b and c) indicate significant differences at the 5% probability level

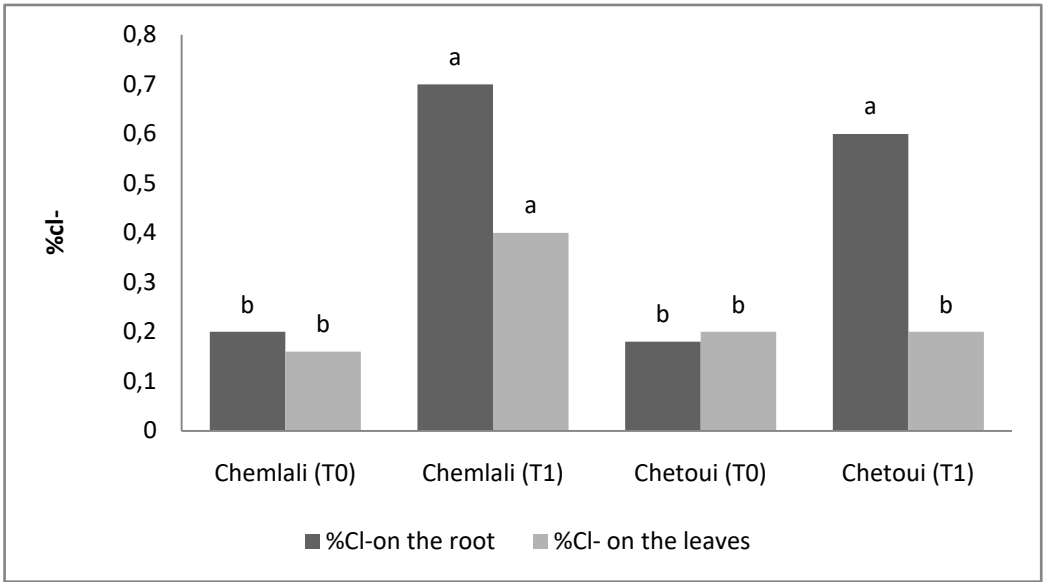
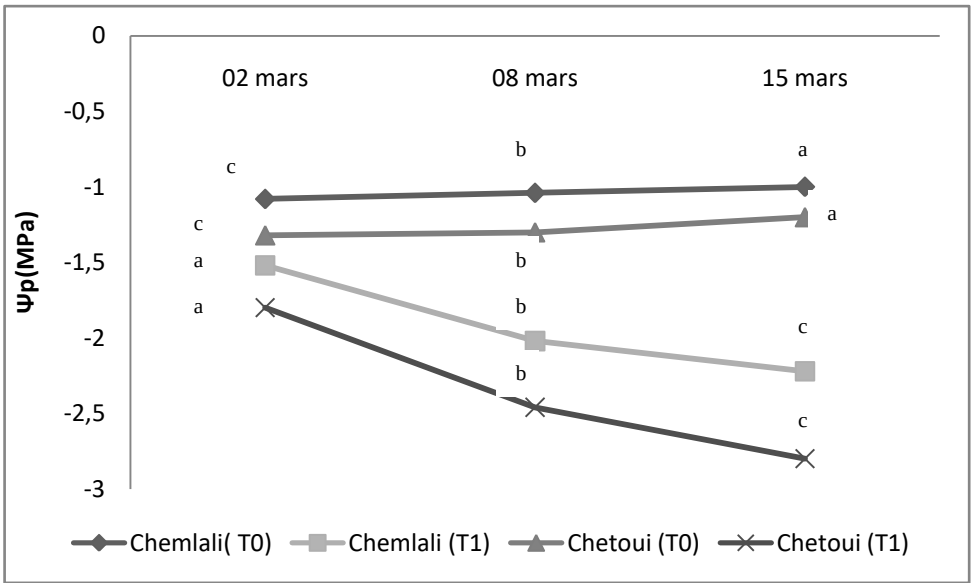


Fig.6 : different letters (a, b and c) indicate significant differences at the 5% probability level



List of table :

Table 1

Resistance	Cultivar	Country	Source
Tolerant	Megaritiki,Lianolia Kerkiras, Kalamata, Kothreiki, frantoio, Arbequina, Picual, Jabaluna Nevadillo, Lechin de Sevilla, Canivano, Esscarabajuelo, Hamed Chemlali	Greece Italy Spain Egypt Tunisia	Therios and Misopolinos (1988), Chartzoulakis et al. (2002a, b), Tattini et al. (1992, 1994), Benlloch et al. (1994, Marin et al. (1995) El-Sayed Emtithal et al.(1996) Bouaziz (1990)
Moderately tolerant	Amphissis, Koroneiki, Mastoidis, Valanolia, Adramitini Maurino, Coratina, Carolca, Maraiolo Aggezi, Toffahi Nabali Muhassan	Greece Italy Egypt Jordan	Therios and Misopolinos (1988), Chartzoulakis et al.(2002a,b) Briccoli Bati et al. (1994) Tattini et al. (1994), Bartolini et al. (1991) El-Sayed Emtithal et al.(1996) Al-Absi et al.(2003)
Sensitive	Chalkidikis, Throubolia, Aguromanaki Leccino Bouteillan, Nabal Pajarero, Chetoui, Calego, Cobrancosa, Meski	Greece Italy Egypt Spain	Therios and Misopolinos (1988), Chartzoulakis et al.(2002a,b) Tattini et al. (1994) El-Sayed Emtithal et al. (1996) Benlloch et al. (1994), Marin et al. (1995)