Highlights

1. Salinity decrease linearly water use of wild rocket
2. Reduction in yield of wild rocket by salinity occurs mainly for decline in leaf area and secondly leaf number
3. Salinity reduced specific leaf area and increased leaf succulence of wild rocket
4. Y_WUE of wild rocket was lowered from moderate to high salinity
5. Wild rocket ranks among moderately salt sensitive species

Water use and crop performance of two wild rocket genotypes under salinity conditions

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Abstract

In literature, the parameters of salinity tolerance of the main cultivated species are known, but are missing for many minor species such as wild rocket, whose cultivation in many areas of southern Italy affected by salinity is growing. Therefore, a research has been carried out i) to evaluate the response to salinity in water use, water use efficiency, yield characteristics and morfological features, and ii) identify the salinity tolerance parameters of two genotypes of wild rocket: *Diplotaxis tenuifolia* (L.) DC and *D. muralis* (L.) DC. The study was carried out in the spring of 2007 and 2008 in Policoro (MT), southern Italy, under unheated plastic greenhouse conditions. Wild rocket was sown in plastic pots containing 20 dm^3 of soil. For each genotype, six soil salinity levels were compared, obtained by accurately mixing before sowing, the soil with, 0.0, 0.5, 1.0, 2.0, 3.5 and 5.5 g dm^{-3} of $NaCl + CaCl_2$ 1:1 (on a weight basis). Irrigation was performed with fresh water having electrical conductivity of 0.5 dS m^{-1}. In each year, 3 harvests were performed; water use and the main production and plant growth parameters were recorded. *D. tenuifolia* provided a yield 47.3% higher than *D. muralis*. By rising salinity, progressive decline in marketable yield and growth of the leaves was recorded, while the dry matter content increased. The increase in salinity has led to the progressive reduction of water use in both genotypes. From moderate salinity values (about 5.5 dS m^{-1}), the reduction in yield water use efficiency as a result of increased salinity has been observed. In addition, salinity reduced specific leaf area and increased leaf succulence. Both genotypes rank among moderately salt sensitive species, according to Maas and Hoffman's model (1977). However, *D. tenuifolia*, with a critical threshold of 1.98 dS m^{-1} and a slope of 6.61% m dS^{-1}, showed a slightly higher tolerance than *D. muralis* (threshold 1.34 dS m^{-1} and slope 7.25% m dS^{-1}).

Reduction in yield due to salinity occurred mainly for the decrease in leaf size and, secondly, number of leaves.

Key words: *Diplotaxis tenuifolia*; *D. muralis*; critical threshold; slope; salinity tolerance; WUE

Introduction

The beginning of 21st century is marked by global scarcity of water resources, environmental pollution and increased salinization of soil and water (Shahbaz and Ashraf, 2013).

It has been estimated that worldwide 20% of total cultivated and 33% of irrigated agricultural lands are affected by high salinity. Furthermore, the salinized areas are increasing at a rate of 10% annually for various reasons, including low precipitation, high surface evaporation, weathering of native rocks, irrigation with saline water, and poor cultural practices. It has been estimated that more than 50% of the arable land would be salinized by the year 2050 (Jamil et al., 2011). Particularly, in the Mediterranean countries groundwater discharge increased over the second half of the 20th century and, as a consequence, a great number of aquifers are currently overexploited and at risk of seawater intrusion (Polemio, 2016). This overuse is concentrated in coastal areas, where increasing population, growth of urban areas, and increases of irrigation and industrial demands and tourism are occurring (Polemio et al., 2013; Taniguchi et al., 2009; Tulipano et al., 2005). These trends were also observed in Italy, where seawater intrusion is the main cause of groundwater quality degradation in coastal karst aquifers, the largest of which are located in the Apulia region (Polemio et al., 2011).

Salinity is one of the most serious factors limiting productivity of agricultural crops, which causes major reductions in cultivated land area, crop productivity and quality (Flowers, 2004; Munns and Tester, 2008; Shahbaz and Ashraf, 2013; Yamaguchi and Blumwald, 2005). Salinity inhibits plant growth i) for osmotic effect which reduces the plant ability to take up water, affects a wide variety of metabolic activities, and causes an oxidative stress because of the formation of reactive oxygen species such as superoxides and hydroxy and peroxy radicals (Munns, 2002; Munns, 2005; Sergio et al., 2012), ii) by specific ion toxicity (*e.g.*, Na^+ and Cl^-) (Munns, 2002; Munns, 2005; Yeo et al., 1991) and iii) by ionic imbalances acting on biophysical and/or metabolic components of plant growth (Grattan and Grieve, 1999).

On the whole, the above effects lead to a reduction of net photosynthesis (Cantore et al., 2007; Munns et al., 2006; Munns and Tester, 2008), the rate of leaf surface expansion (Wang and Nil, 2000), the fresh and dry weights of leaves, stems, and roots (Chartzoulakis and Klapaki, 2000; Hernandez et al., 1995). The listed adverse effects result in a reduction in yield that, for a given level of salinity, may vary depending on the genotype, salt type, climatic conditions and agronomic techniques (Cucci et al., 2000; Flagella et al., 2002; Maas, 1986).

In many coastal areas of Southern Italy (as Apulia and Basilicata regions) where the problem of irrigation water's salinity is increasing, the cultivation of wild rocket (i.e. *Diplotaxis tenuifolia* L. DC., *D. muralis* L. DC.) is widespread and in further expansion. Indeed, the last decades wild rocket has become popular and widely cultivated in greenhouses and open field. In Italy, several species of the genus *Diplotaxis* are consumed as vegetables since ancient times. The leaves, characterized by a unique aroma and piquant flavor, can be eaten raw in salads or cooked in many recipes. Compared to other leafy vegetables, wild rocket has high content of fiber and iron, ascorbic acid, phenols, carotenoids and glucosinolates (Barillari et al., 2005; Cavaiuolo and Ferrante, 2014; D'Antuono et al., 2009; Di Venere et al., 2000), to which important bioactive properties (e.g., antioxidant, antitumour, etc.) are often ascribed (Ramos-Bueno et al., 2016).

Experimental evidence on the behaviour of wild rocket in the presence of salinity are scarce and conflicting. In particular, de Vos et al. (2013) ranked *D. tenuifolia* as a salt tolerant species, having found that yield reduction occurs with the salinity of nutrient solution greater than 100 mM NaCl. These authors claim that the species can be considered among the new halophytes. However, opposite results were obtained by Bonasia et al. (2017) that, for the same species, reported significant reductions in yield (about 20%) passing from the salinity of 2.5 dS m^{-1} to 3.5 dS^{-1}. The latter authors also observed a positive effect of moderate salinity (3.5 dS m^{-1}) on different qualitative parameters. In fact, they report a reduction in the content of nitrates, which is widely recognized as being harmful to health (Buttaro et al., 2016), and an improvement in certain qualitative features, health beneficial, such as vitamin C, polyphenols, carotenoids and antioxidant activity. With an higher salinity, however, they did not find any further qualitative improvements. Also Hamilton and Fonseca (2010) found an increase in the phenols with the salinity increase from 1.5 to 9.5 dS m^{-1} only in one of the two experiments conducted, while they did not observe any effect on vitamin C content.

Considering the growing economic importance of wild rocket cultivation in many salt-affected areas, as the case of Mediterranean countries, and the conflicting literature data on the salt tolerance of this vegetable, this work is proposed to provide further insights on the crop performance of two genotypes of wild rocket (*D. tenuifolia* and *D. muralis*) in response to the soil salinity levels. The information obtained from the research aim to provide useful information for the optimal crop management of wild rocket under salinity conditions.

Material and methods

Experimental site characteristics

The research was carried out in the spring 2007 and 2008 at experimental farm ‘E. Pantanelli’ of the University ‘Aldo Moro’ of Bari, Policoro (MT), Southern Italy (40°10’ NL, 16°39’ EL, altitude 15 m a.s.l.). This site is characterized by sub-humid climate according to the De Martonne classification (Cantore et al., 1987).

The experiment was performed under unheated plastic greenhouse conditions (covered by an EVA 200 µm thick film), using cylindrical pots (0.34 m diameter and 0.3 m height) adequately equipped with flowerpot saucers, each containing 20 dm^3 of soil, collected in the same location. The soil was a fine, mixed, subactive, thermic Chromic Haploxererts (Cassi et al., 2006), with the following physical and chemical characteristics: sand ($2 > Ø > 0.02$ mm) 29.5%, silt 37.5%, clay ($Ø < 2$ μ) 33.0%; pH 7.6; total N (Kjeldahl method) 1.48 g kg^{-1}, available P_2O_5 (Olsen method) 25.9 mg kg^{-1}, exchangeable K_2O (ammonium acetate method) 249 mg kg^{-1}, organic matter (Walkley–Blackmethod) 33.7 g kg^{-1}, total limestone 14 g kg^{-1}, active limestone 4.5 g kg^{-1}; saturated paste extract electrical conductivity (ECe) 0.90 dS m^{-1}; ESP 2.0%; bulk density 1.24 kg dm^{-3}; soil moisture at field capacity (measured in situ) 31.8% and at wilting point (−1.5 MPa) 15.3% (w/w) of soil dry weight.

Weather data were measured in the greenhouse by an automatic weather station including a pyranometer (model CM 4, Kipp and Zonen, Delft, The Netherlands), thermistor (model E001, Tecno.El, Rome, Italy), hygrometer (C-83_N Rotronic, Zurich, Switzerland) and anemometer (model VT 0805B, SIAP Bologna, Villanova di Castelnaso-BO, Italy), for measuring solar radiation, air temperature, relative humidity and wind speed, respectively. Data were collected by the electronic system operated through a data-logger (model Kampus, Tecno.El, Rome, Italy) connected via modem to a PC. The trend of global radiation (R_g), minimum and maximum air temperature (T_{min}, T_{max}) was increasing from sowing time until the end of the experiment according to the typical one of the area concerned by the experiment. R_g ranged between about 5.0 and 19.5 MJ m^{-2} d^{-1}, and about 4.5 and 19.0 MJ m^{-2} d^{-1}, respectively in the first and second year. T_{max}, of about 14 °C in the period of sowing, increased gradually until the period of last harvest, reaching 28 and 29.5 °C in the first and second year, respectively. T_{min} ranged between 4 °C to about 16 °C for both years.

Experimental design and crop management

The following treatments were compared: two genotypes of wild rocket (*D. tenuifolia* and *D. muralis*) and six soil salinity levels, obtained by accurately mixing to the soil, before sowing, 0.0, 0.5, 1.0, 2.0, 3.5 and 5.5 g dm^{-3} of NaCl + $CaCl_2$ 1:1 (on a weight basis), indicated with S_1, S_2, S_3,

S_4, S_5 and S_6, respectively. A completly randomized block experimental design with 4 replicates was adopted. Each plot consisted of tree pots.

Before sowing, the soil of each pot was fertilised with 1.78 and 2.26 g of diammonium phosphate and urea, respectively. The wild rocket was sown on February 1st 2007 and 2008. Fifteen days after sowing (DAS), thinning was performed by leaving five plants per pot, arranged in an homogeneous manner with respect to the pot surface. Each year three growing cycles were performed by exploiting the ability of this species to re-growth after harvest. The harvests (on March 20th, April 23th, May 25th 2007, and on March 25th, April 28th, May 30th 2008) were performed cutting off leaves 1 cm above the collar with a knife. Evapotranspiration (ET) was estimated by the water balance method (Moazed et al., 2014) by weighing every days the pots that were considered as a weight lysimeter.

In order to satisfy water requirements of the rocket, fresh water having an electrical conductivity of 0.5 dS m^{-1} was supplied manually from the top of the pots. Water was applied when the allowable water depletion (p) was reached in the S_1 treatment of each genotype. The threshold was assumed to be 0.45 of total available water ($p = 0.45$) during the whole growing cycle, in accordance with the values of *Brassicaceae* vegetable species (Allen et al., 1998). In all treatments the whole amount of water consumed was restored at each irrigation event. The water that eventually leached in the flowerpot saucers, was collected and used for the subsequent watering in the same pots.

Throughout the growing cycle, water was supplied 28 times in the first year and 27 times in the second one. The seasonal irrigation volume was higher for *D. tenuifolia*, and decreased from the non-saline treatment to the more saline one, according to the differences in ET measured.

Yield and plant biometric characteristics

At each harvest, shoots (leaves and stems) collected in each pot were utilized to determine yield (total, marketable and unmarketable), number of leaves per plant, leaf area (LA) per plant and leaf area index (LAI). LA was measured using a leaf area meter (Li-COR, 3100, Lincoln Nebraska, USA). Specific leaf area (SLA) was calculated as the ratio between LA and leaf dry weight. Leaf succulence (LS) was calculated as the ratio between leaf fresh weight and LA.

Leaves that were yellow, necrotic or damaged by pests or fungi were considered unmarketable.

The leaf dry matter (DM) content was assessed on the marketable product. To determine DM, a sample of about 80 g of marketable product was dried in a ventilated oven at 60 °C, until a constant weight was reached (about 48 h).

Water use efficiency, yield response factor

The water use efficiency (WUE) was calculated for each harvest as the ratio between marketable yield and ET, i.e. yield WUE (Y_WUE).

Yield response factor to water (K_y), to predict wild rocket yield under saline conditions, was calculated as angular coefficient of the following linear equation (Stewart et al., 1977):

$$1-Y_a/Y_m = K_y\ (1-ET_a/ET_m)$$

where Y_a (kg ha^{-1}) and ET_a (mm) are actual marketable yield and evapotranspiration for saline treatments, respectively; Y_m (kg ha^{-1}) and ET_m (mm) are maximum marketable yield and evapotranspiration for non-saline treatment; K_y is yield response factor.

Soil salinity

At the beginning of the growing cycle and at each harvest, soil samples were taken along the profile of each pot through a cylindrical probe (∅ 2.5 cm), and tested for the electrical conductivity of the saturation extract (ECe).

Statistical analysis

The data collected were elaborated by analysis of variance (ANOVA) procedure; mean values were separated by Student-Newman-Keuls (SNK) test at $P = 0.05$. The SPSS 17 software was used for the analysis.

Results and Discussion

Soil salinity

Soil salinity, as planned, did not show any considerable difference during the two cycles of cultivation (Tab. 1). In fact, ECe has undergone only a slight increase during the growing cycles of wild rocket, both as a result of the low salts content of irrigation water and for the correct calibration of the irrigation volumes that avoided percolation and, consequently, the leaching of the salts. In the few cases in which the percolation of excess water occurred, this was collected and redistributed in the same pot in the successive irrigation. The described trend was not differentiated between the two genotypes of wild rocket.

Therefore, as average of genotypes and years, ECe was growing in relation to the saline treatments from 0.9 dS m^{-1} of S_1 to 12.3 dS m^{-1} of S_6 at sowing time, and from 1.6 dS m^{-1} of S_1 to 13.0 dS m^{-1} of S_6 at the last harvest (Tab. 1). The salinity response models that will be reported below are related to the average salinity of the crop cycle obtained from the average ECe measured at sowing time and at each harvest.

Yield and morphological features of plants

There were no significant differences in growth and yield behaviour of *D. muralis* between the two years, while *D. tenuifolia* provided higher yield in the second year, mainly for the largest number of leaves per plant and, secondly, for the largest leaf medium surface (Tab. 2).

D. tenuifolia, with 45.8 g plant^{-1} of total yield and 42.8 g plant^{-1} (as a total of the three harvests) of marketable yield, was more productive than *D. muralis* which, however, provided a total and marketable average yield respectively of 32.0 and 29.1 g plant^{-1}.

The differences in yield between genotypes were mainly determined by the different number of leaves per plant (11.9 and 16.3 respectively for *D. muralis* and *D. tenuifolia*) and, secondly, by the different average surface area of the leaves (16.4 and 17.6 cm^2 leaf^{-1}, respectively for *D. muralis* and *D. tenuifolia* respectively). Also Cantore et al. (2000) observed a greater yield of *D. tenuifolia* than *D. muralis*, regardless of the cultivation period.

For both genotypes, yield was declining between the first and the third harvest. In fact, as the average of the two years, the marketable yield has gone from 13.1 and 16.6 g plant^{-1} of the first harvest to 7.4 and 13.4 g plant^{-1} of the third one, respectively for *D. muralis* and *D. tenuifolia* (Fig. 1).

Also other authors (Bianco and Boari, 1997; Boari et al., 1998) reported a considerable yield decline after the 1st growing cycle of wild rocket cultivated during spring-summer period. Contrary, the wild rocket cultivated in autumn-spring period showed an increasing trend of yield between the first to the last harvest, proving that the different period of the crop cycle is the main factor affecting the re-growth capacity of wild rocket (personal communication).

The production behaviour of the two genotypes in relation to saline treatments was very similar. In general, the increase in salinity level was shown to progressively reduce the plant vegetative growth and, consequently, yield (Tab. 2). For both genotypes, total yield and marketable one began to decrease significantly in correspondence with the S_3 treatment. Total yield ranged from 43.2 and 58.8 g plant^{-1} of S_1 to 14.5 and 23.5 g plant^{-1} of S_6, respectively for *D. muralis* and *D. tenuifolia*; instead, marketable yield ranged from 42.4 and 57.2 g plant^{-1} of S_1 to 8.9 and 17 g plant^{-1} of S_6, respectively for the two genotypes. It should be noted that the differences between S_1 and S_6 for marketable yield are higher than those found for total yield due to the greater incidence of the waste that occurred with the increase in salinity. The adverse effects of osmotic stress and toxic stress for the accumulation of toxic elements (ie: Na^+, Cl^-) induced by salinity, in fact, are more pronounced on old leaves with early phenomenon of chlorosis and senescence, contributing to the increase of waste, as observed also on other species (Munns and Tester, 2008; Wang et al., 2012; Yasar et al., 2006; Negrão et al., 2017). It should be stressed that the wild rocket is among those vegetables belonging to the salad category, whose commercial product requires the complete absence of yellowed or necrotic leaves (Charfeddine and Gonnella, 2009). Reduction in yield caused from increased salinity was mainly determined by the reduction in leaf area and, secondly, by decrease in number of leaves (Tab. 2). Specifically, for both genotypes the leaf area per plant began to decrease significantly in S_3, while the number of leaves per plant began to decrease in S_4. With the highest salinity level, compared to control (S_1), the leaf area was reduced by about 79% and 70%, respectively for *D. muralis* and *D. tenuifolia*, while the reduction in the leaf number was 44.5 and 40.8% respectively. On different species have been found a similar behaviour, with a adverse effect of salinity which is initially manifested on the morphology of the leaves such as the leaf surface and, second, on the number of leaves (Ünlükara et al., 2008; Ziaf et al., 2009). On the other hand, in species such as spinach, increasing salinity would lead to the progressive reduction of the leaf surface without affecting the leaf number (Ünlükara et al., 2017). Increasing salinity led to the progressive increase in leaf dry matter content, which increased from 8.8 and 9.0 g 100 g^{-1} FW in $S_{1,}$ to 11.0 and 10.9 g 100 g^{-1} FW in S_6, respectively for *D. muralis* and *D. tenuifolia*. In addition, rising salinity caused a progressive reduction in SLA and increase in LS. In fact, from S_1 to S_6, SLA decreased by 35.0% for *D. muralis* and 33.8% for *S. tenuifolia*. LS, on the other hand, increased by 23.9% for *D. muralis* and 23.8% for *D. tenuifolia*. SLA, an indicator of leaf thickness, is an important variable in crop growth models, as it relates dry matter production to leaf area expansion and consequently to light interception and photosynthesis (Gary et al., 1993). Generally, evidence shows that salinity increases the leaf lamina thickness, due to an increase in mesophyll cell size or number of layers (Kozlowski, 1997; Longstreth and Nobel, 1979). The increase in SLA or, conversely, the increased leaf thickness or succulence with increased salinity results in conservation of internal water, efficient water storage and dilution of accumulated salts (Flowers and Yeo, 1986; Munns and Tester, 2008). Increase in LS or decrease in SLA with rising salinity has also been reported for *D. tenuifolia* (Bonasia et al., 2017; de Vos et al., 2013) and others *Brassicaceae* species as *Cochlearia officinalis* (de Vos et al., 2013), *Cakile maritima* (Debez et al., 2004), *Crambe maritima* (de Vos et al., 2010) and *Thellungiella salsuginea* (M'rah et al., 2006) and indeed appears to be a common adaptation to salinity among species of the *Brassicaceae*. Probably, changes in leaf traits are linked to osmotic effect of NaCl (which resembles a water-stress effect) rather than the ionic effect (Munns, 1993; Munns and Tester, 2008).

Effect of salinity on ET, WUE and yield response factor

The ET of the wild rocket did not change significantly between years (Tab. 2). In agreement with the leaf surface differences observed between the two genotypes, *D. tenuifolia* had a higher water consumption than *D. muralis*. In fact, the leaf surface is one of the main factors influencing ET (Allen et al., 1998).

Y_WUE was not different between the years for *D. muralis*, while for *D. tenuifolia* in 2008 there was a 18.7% higher Y_WUE than in 2007, probably due to the higher yield obtained, to which corresponded an higher LAI (Tab. 2).

Salinity influenced ET of the wild rocket. Specifically, as occurred for leaf production and leaf surface, this parameter began to decrease in S_3 until reaching the 44.3 and 36.0% reduction in S_6, respectively for *D. muralis* and *D. tenuifolia* (Tab. 2; Fig. 2). The reduction of ET caused by the increase in soil salinity is due to the combined effect of salts on the soil and on the plant. In particular, the soil evaporative component is influenced because soil salts result in increased soil osmotic potential (Caruso, 1993), which in turn causes water activity to drop and consequently reduces evaporation. Moreover, the formation of a crust due to salt precipitation decreases porosity and increases tortuosity, which further contribute hindering evaporation (Gran et al., 2011).

The transpiration component was influenced by the concomitant reduction of leaf surface (Wang and Nil, 2000), the variation of the morphological characteristics of the leaves (i.e. thickening, reduction of stomatal density and of pore size), reduction of xylematic potential and of stomatal conductance (Boari et al., 2014; Brugnoli and Lauteri 1991; Omamt et al., 2006; Sharma et al., 2005). Decreases in plant water use due to salinity should be taken into account in irrigation scheduling in order to prevent excess of water applications and excess of leaching, which in turn can lead to excessive consumption of resources, waterlogging and radical asphyxia.

Although salinity has led to a reduction in water use, it had a growing adverse effect on Y_WUE from moderate salinity conditions due to the concomitant greater reduction in yield. The reduction of Y_WUE recorded with highest salinity, compared to control, was of 62.2 and 52.2%, respectively for *D. muralis* and *D. tenuifolia* (Tab. 2). Probably this is attributable to the ionic (toxic) effect of salinity. At low salinity, however, where the osmotic effect prevails (physiological drought), the Y_WUE has not undergone any significant changes, as observed also on different species subject to moderate water shortage (Boutraa et al., 2010; Chen et al., 2013; Favati et al., 2009;). The reduction in Y_WUE with increasing salinity was found both on leafy and fruit vegetable crops such as lettuce (Ünlükara et al., 2008), eggplant (Ünlükara et al., 2010) and tomato (Zhang et al., 2016). A contrasting effect, however, was observed for species with high salinity tolerance as amaranth (Omamt et al., 2006) and some *Brassicaceae* (Ashraf, 2001).

Stewart and Hagan (1973) proposed a model to predict crop yield from ET. The relation between relative ET and relative yield decreases for water stress with yield response factor (K_y) has been used to evaluate plant tolerance to water stress (Doorenbos and Kassam, 1979). If $K_y \leq 1$, the plant is tolerant and if $K_y \geq 1$, the plant is sensitive to water stress. According to some authors that have also used this method for salinity (Katerji et al., 1998; Shalhevet, 1994; Stewart et al., 1977; Ünlükara et al., 2010; Ünlükara et al., 2017), the model was used to predict wild rocket yield under saline conditions.

According to the Stewart and Hagan (1973) model tested in this study on wild rocket, the relationship between relative yield and relative ET showed a slope (K_y) of 1.80 and 1.78, for *D. muralis* and *D. tenuifolia*, respectively (Fig. 3). This high K_y value indicates that wild rocket is highly sensitive to water stress caused by salinity.

Salinity tolerance model application

To identify the typical parameters of Maas and Hoffman (1977) model of response to salinity, the linear regression of relative yield was calculated as a function of the average ECe of the growing cycle.

The data of the two years were plotted together since there were not differences about the effects of salinity level on the yield and related parameters between the two years.

From the linear regression we pointed out the critical threshold values of ECe above which the relative yield starts to decrease, the slope, namely the relative yield reduction for each additional increase of ECe above the critical threshold, ECe_{50} or the ECe value corresponding to 50% reduction in relative yield.

The above mentioned salinity tolerance parameters was similar between the two genotypes of wild rocket, but shown a slight trend to the better salinity tolerance of *D. tenuifolia* (threshold 1.98 dS m^{-1}; slope 6.61% m dS^{-1}; ECe_{50} 9.54 dS m^{-1}) in respect to the *D. muralis* (threshold 1.34 dS m^{-1}; slope 7.25% m dS^{-1}; ECe_{50} 8.24 dS m^{-1}) (Fig. 4). Despite these differences, the results demonstrate the ranking of both genotypes among moderately salt sensitive species, among which we find several vegetable species such as fennel (Cucci et al., 2014; Semiz et al., 2012), broccoli, cabbage, turnip, carrots, lettuce, spinach (Flagella et al., 2002). More specifically, applying the Maas and Hoffman (1977) model to the relative yield obtained in each harvest, a decreasing trend of salinity tolerance between the first and the last harvest can be observed as can be seen from the trends of the characteristic parameters of the model (Fig. 5). This is probably attributable to two factors: i) the progressive accumulation of harmful salts in the parts of the plant that are not removed by the harvest (roots and collar) and ii) the increase in air temperature between the sowing and the last harvest. As it is well known, in fact, many authors report the reduction in salinity tolerance with the increase in the duration of exposure to saline stress and the increase in the air temperature and the evaporative demand of the atmosphere. In fact, the application of saline water in the presence of high temperature conditions exacerbated the process of salt accumulation and plant growth reduction (Helal and Mengel, 1981; Li et al., 2001; Meiri et al., 1982). From Maas and Hoffman's model (1977) applied to the relative number of leaves and to the relative leaf surface, it is confirmed that the reduced yield in relation to salinity was mainly due to the decrease in leaf surface and, to a lesser extent, to number of leaves (Fig. 6, 7). Contrasting results, compared to those obtained in this research, are reported by de Vos et al. (2013). Indeed, these authors observed that *D. tenuifolia* grown in soiless conditions has begun the reduction in total fresh weight with the salinity of nutrient solution greater than 100 mM NaCl (about 10 dS m^{-1}). Unlike these last results, Bonasia et al. (2017) observed about 20% reduction in yield by increasing the salinity from 2.5 to 3.5 dS m^{-1}. Differences in the results of the literature and those obtained in our research can be attributed to the different growing conditions. In particular, in our research the direct sowing of wild rocket in saline soil was carried out. In this way seedlings experienced salt stress since the germination phase. de Vos et al. (2013), instead, used a 15-days seedlings that had been subjected to saline stress 6 days after transplantation (when they had already spend beyond 50% of the vegetative cycle). Bonasia et al. (2017), on the other hand, expose the wild rocket seedling to salt stress immediately after emergence. We believe that direct sowing is the most appropriate method for assessing the salinity tolerance of this species, as direct sowing represents the most common technique for the production of wild rocket for baby leaf.

Conclusions

D. tenuifolia has been more productive than *D. muralis*. The increase in soil salinity has led to a progressive reduction in water use. This aspect is to be considered in irrigation scheduling to save water and to avoid the risk of water excesses with negative effects on the environment and yield. Until moderate salinity levels, the Y_WUE has not undergone variations while it has decreased with high salinity. *D. muralis* and *D. tenuifolia* rank among the species moderately sensitive to salinity according to the Maas and Hoffman (1977) model. *D. tenuifolia*, compared to *D. muralis*, has a milder salinity sensitivity. The information obtained in this research may be useful to farmers, operating in salty soils or forced to irrigate with brackish water, in order to apply appropriate strategies to avoid significant yield decline or even crop failure. Specifically, taking into account also the results obtained by de Vos et al. (2013), in the presence of high salinity, the transplant technique could be used, though much more expensive.

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References

Allen, R.G., Pereira, L.S., Raes, D., Smith, M., 1998. Crop evapotranspiration. FAO Irrig. and Drain. Paper 56. FAO, Rome, 300 pp.

Ashraf, M., 2001. Relationships between growth and gas exchange characteristics in some salt-tolerant amphidipoid Brassica species in relation to their diploid parents. Environ. Exp. Bot. 45, 155-163.

Barillari, R.N., Canistro, D., Paolini, M., Ferroni, F., Pendullini, G.F., Iori, R., Valmigli, L., 2005. Direct antioxydant activity of purified glucoerucin, the dietary secondary metabolite, contained in rocket (*Eruca sativa* Mill.) seeds and sprouts. J. Agric. Food Chem. 53, 2475-2482.

Bianco, V.V., Boari, F., 1997. Up-to-date developments on wild rocket cultivation. Workshop “Rocket: a Mediterranean crop for the world”, 1996 Legnaro (Padova), 41-49; IPGRI Rome.

Boari, F., Cantore, V., De Palma, E., 1998. Influenza del regime irriguo sulla ruchetta selvatica, *Diplotaxis tenuifolia* (L.) DC. Atti "IV Giornate Scientifiche SOI", Sanremo 1-3 aprile 1998, 355-356.

Boari, F., Cucci, G., Donadio, A., Schiattone, M.I., Cantore, V., 2014. Kaolin influences tomato response to salinity: physiological aspects. Acta Agric. Scand. – Section B – Plant Soil Sci. 64(7), 559-571.

Bonasia, A., Lazzizera, C., Elia, A., Conversa, G., 2017. Nutritional, biophysical and physiological characteristics of wild rocket genotypes as affected by soilless cultivation system, salinity level of nutrient solution and growing period. Front. Plant Sci. 8, 300, 1-15, doi: 10.3389/fpls.2017.00300.

Boutraa, T., Akhkha, A., Al-Shoaibi, A.A., Alhejeli A.M., 2010. Effect of water stress on growth and water use efficiency (WUE) of some wheat cultivars (*Triticum durum*) grown in Saudi Arabia. JTUSCI 3, 39-48.

Brugnoli, E., Lauteri, M., 1991. Effects of salinity on stomatal conductance, photosynthetic capacity, and carbon isotope discrimination of salt-tolerant (*Gossypium hirsutum* L.) and salt-sensitive (*Phaseolus vulgaris* L.) C(3) non-halophytes. Plant Physiol. 95(2), 628-635.

Buttaro, D., Renna, M., Gerardi, C., Blando, F., Santamaria, P., Serio, F., 2016. Soilless production of wild rocket as affected by greenhouse coverage with photovoltaic modules. Acta Sci. Pol. Hortorum Cultus 15(2), 129-142.Cantore, V., Boari, F., Bianco, V.V., De Palma, E., 2000.

Influenza dell’epoca di semina su *Diplotaxis* spp.. Atti "V Giornate Scientifiche SOI", Sirmione 28-30 marzo 2000, 221-222.

Cantore, V., Boari, F., Pace, B., Bianco, V.V., Bianchimano, V., 2007. Brakish water and physiological aspects of artichoke. Acta Hort. 730, 231-237.

Cantore, V., Iovino, F., Pontecorvo, G., 1987. Aspetti climatici e zone fitoclimatiche della Basilicata. CNR-IEIF 2, 49 p.

Caruso, G., 1993. Risposta fisiologica del pomodoro (*Licopersicon esculentum* Mill.) alla concentrazione salina dell’acqua di irrigazione. Italus Hortus 1, 32-37.

Cassi, F., Viviano, L., et al., 2006. I Suoli della Basilicata - Carta pedologica della Regione Basilicata in scala 1:250.000. Regione Basilicata - Dip. Agricoltura e Sviluppo Rurale. Direzione Generale.

Cavaiuolo, M., Ferrante, A., 2014. Nitrates and glucosinolates as strong determinants of the nutritional quality in rocket leafy salads. Nutrients 6(4), 1519–1538.

Charfeddine, M., Gonnella, M., 2009. Insalate e IV gamma. In: Orticoltura (a cura di Santamaria P., Serio F.), 123-135. Settore Biblioteca – CRSA, Locorotondo, ISBN 9788896578087.

Chartzoulakis, K., Klapaki, G., 2000. Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages. Sci. Hortic. 86, 247-260.

Chen J., Kang S., Du T., Qiu R., Guo P., Chen R., 2013. Quantitative response of greenhouse tomato yield and quality to water deficit at different growth stages. Agric. Water Manage. 129, 152– 162.

Cucci, G., Cantore, V., Boari, F., De Caro, A., 2000. Water salinity and influence of SAR on yield and quality parameters in tomato. Acta Hort. 537, 663-670.

Cucci, G., Lacolla, G., Boari, F., Cantore, V., 2014. Yield response of fennel (*Foeniculum vulgare* Mill.) to irrigation with saline water. Acta Agric. Scand. – Section B – Plant Soil Sci. 64 (2), 129-134.

D’Antuono, L.F., Elementi, S., Neri, R., 2009. Exploring new potential health promoting vegetables: Glucosinolates and sensory attributes of rocket salads and related *Diplotaxis* and *Eruca* species. J. Sci. Food Agric. 89(4), 713–722.

de Vos, A.C., Broekman, R., de Almeida Guerra, C.C., van Rijsselberghe, M., Rozema, J., 2013. Developing and testing new halophyte crops: A case study of salt tolerance of two species of the *Brassicaceae, Diplotaxis tenuifolia* and *Cochlearia officinalis*. Environ. Exp. Bot. 92, 154-164.

de Vos, A.C., Broekman, R., Groot, M.P., Rozema, J., 2010. Ecophysiological response of *Crambe maritima* to airborne and soilborne salinity. Ann. Bot. 105, 925–937.

Debez, A., Ben Hamed, K., Grignon, C., Abdelly, C., 2004. Salinity effects on germination, growth, and seed production of the halophyte *Cakile maritima*. Plant Soil 262, 179–189.

Di Venere, D., Calabrese, N., Linsalata, V., Cardinali, A., Bianco, V.V., 2000. Influence of sowing time on phenolic composition of rocket. Acta Hort. 533, 343-350.

Doorenbos, J., Kassam A.H., 1979. Yield to water response. Irrigation and Drainage Paper 33. Rome, Italy, FAO, 193 p.

Favati, F., Lovelli, S., Galgano, F., Miccolis, V., Di Tommaso, T., Candido, V., 2009. Processing tomato quality as affected by irrigation scheduling. Sci. Hortic. 122, 562–571.

Flagella, Z., Cantore, V., Giuliani, M.M., Tarantino, E., De Caro, A., 2002. Crop salt tolerance: Physiological, yield and quality aspects. In: S.G., Pandalai (Ed.), Recent Res. Devel. Plant Biol. 2, 155-186, ISBN:81-7736-149-X.

Flowers T.J., Yeo A.R., 1986. Ion relations of plants under drought and salinity. Austr. J. Plant Physiol. 13, 75-91.

Flowers, T.J., 2004. Improving crop salt tolerance. J. Exp. Bot. 55, 307–319.

Gary, C., Jones, J.W. Longuenesse, J.J., 1993. Modeling daily changes in specific leaf area of tomato: the contribution of the leaf assimilate pool. Acta Hort. 328, 205-210.

Gran, M., Carrera, J., Olivella, S., Saaltink, M.W., 2011. Modeling evaporation processes in a saline soil from saturation to oven dry conditions. Hydrol. Earth Syst. Sci. 15, 2077–2089.

Grattan, S.R., Grieve, C.M., 1999. Salinity-mineral nutrient relations horticultural crops. Sci. Hort. 78, 127-157.

Hamilton, J.M., Fonseca, J.M., 2010. Effect of saline irrigation water on antioxidants in three hydroponically grown leafy vegetables: *Diplotaxis tenuifolia*, *Eruca sativa*, and *Lepidium sativum*. HortSci. 45, 546–552.

Helal, H.M., Mengel, K., 1981. Interaction between light intensity and NaCl salinity and their effects on growth, CO_2 assimilation, and photosynthate conversion in young broad beans. Plant Physiol. 67, 999-1002.

Hernandez, J.A., Olmos, E., Corpas, F.J., Sevilla, F., del Rio, L.A., 1995. Salt-induced oxidative stress in chloroplasts of pea plants. Plant Sci. 105, 151–167.

Jamil, A., Riaz, S., Ashraf, M., Foolad, M.R., 2011. Gene expression profiling of plants under salt stress. Crit. Rev. Plant Sci. 30(5), 435–458.

Katerji, N., van Hoorn, J.W., Hamdy, A., Mastrorilli, M., Karam, F., 1998. Salinity and drought, a comparison of their effects on the relationships between yield evapotranspiration. Agric. Water Manage. 36, 45–54.

Kozlowski, T.T., 1997. Responses of woody plants to flooding and salinity. Tree Physiology Monograph, 1–29.

Li, Y.L., Stanghellini, C., Challa, H., 2001. Effect of electrical conductivity and transpiration on production of greenhouse tomato (*Lycopersicon esculentum* L.). Sci. Horti. 88, 11-29.

Longstreth, D.J., Nobel, P.S., 1979. Salinity effects on leaf anatomy. Consequences for photosynthesis. Plant Physiol. 63, 700–703.

M'rah, S., Ouerghi, Z., Berthomieu, C., Havaux, M., Jungas, C., Hajji, M., Grignon, C., Lachaâl, M., 2006. Effects of NaCl on the growth, ion accumulation and photosynthetic parameters of *Thellungiella halophila*. J. Plant Physiol. 163, 1022–1031.

Maas, E.V., 1986. Salt tolerance of plants. Appl. Agric. Res. 1, 12-26.

Maas, E.V., Hoffman, G.J., 1977. Crop salt tolerance – current assessment. J. Irr. and Drain. Div. ASCE 103, 115-134.

Meiri, A., Hoffman, G.J., Shannon, M.C., Poss, J.A., 1982. Salt tolerance of two muskmelon cultivars under two radiation levels. J. Amer. Soc. Hort. Sci. 107, 1168-1172.

Moazed, H., Ghaemi, A.A., Rafiee, M.R., 2014. Evaluation of several reference evapotranspiration methods: a comparative study of greenhouse and outdoor conditions. IJST Trans. Civil Engin., 38, 421–437.

Munns, R., 1993. Physiological processes limiting plant growth in saline soil: some dogmas and hypotheses. Plant Cell Environ. 16, 15-24.

Munns, R., 2002. Comparative physiology of salt and water stress. Plant Cell Environ. 25, 239–250.

Munns, R., 2005. Genes and salt tolerance: bringing them together. New Phytol. 167, 645–663.

Munns, R., James, R.A., Lauchli, A., 2006. Approaches to increasing the salt tolerance of wheat and other cereals. J. Exp. Bot. 57, 1025-1043.

Munns, R., Tester, M., 2008. Mechanisms of salinity tolerance. Annu. Rev. Plant. Biol. 59, 651–681.

Negrão, S., Schmöckel, S.M., Tester, M., 2017. Evaluating physiological responses of plants to salinity stress. Ann. Bot. 119, 1–11.

Omamt, E.N., Hammes, P.S., Robbertse, P.J., 2006. Differences in salinity tolerance for growth and water-use efficiency in some amaranth (*Amaranthus* spp.) genotypes. New Zeal. J. Crop Hort. Sci. 34, 11-22.

Polemio, M., 2016. Monitoring and management of karstic coastal groundwater in a changing environment (Southern Italy): a review of a regional experience. Water, 8, 148.

Polemio, M., Dragone, V., Limoni, P.P., 2011. La disponibilità di acque sotterranee in Puglia negli ultimi 80 anni. In: Le modificazioni climatiche e i rischi naturali. Polemio M. (Ed.), CNR-IRPI, Bari, 201-204, ISBN: 9788890508806.

Polemio, M., Dragone, V., Romanazzi, A. 2013. La risorsa idrica. Sfruttamento, depauperamento dei serbatoi sotterranei e utilizzo razionale nel caso della Calabria. In L'acqua in Calabria: Risorsa o Problema?; Dramis, F., Mottana, A., Eds.; Aracne: Roma, Italy, 2–29.

Ramos-Bueno, R.P., Rincón-Cervera, M.A., González-Fernández, M.J., Guil-Guerrero, J.L., 2016. Phytochemical composition and antitumor activities of new salad greens: rucola (*Diplotaxis tenuifolia*) and corn salad (*Valerianella locusta*). Plant Foods Hum. Nutr. 71, 197–203.

Semiz, G.U., Ünlükara, A., Yurtseven, E., Suarez, D.L., Telci, I. 2012. Salinity impact on yield, water use, mineral and essential oil content of fennel (*Foeniculum vulgare* Mill.). J. Agric. Sci. 18, 177–186.

Sergio, L., De Paola, A., Cantore, V., Pieralice, M., Cascarano, N.A., Bianco, V.V., Di Venere, D., 2012. Effect of salt stress on growth parameters, enzymatic antioxidant system, and lipid peroxidation in wild chicory (*Cichorium intybus* L.). Acta Physiol. Plant. 34, 2349-2358.

Shahbaz, M., Ashraf, M., 2013. Improving salinity tolerance in cereals. Crit. Rev. Plant Sci. 32, 237–249.

Shalhevet, J., 1994. Using water of marginal quality for crop production: major issues. Agric. Water Manage. 25, 233-269.

Sharma, N., Gupta, N.K., Gupta, S., Hasegawa, H., 2005. Effect of NaCl salinity on photosynthetic rate, transpiration rate, and oxidative stress tolerance in contrasting wheat genotypes. Photosynthetica 43(4), 609-613.

Stewart, J.I., Cuenca, R.H., Pruit, W.O., Hagan, R.M., Tosso, J., 1977. Determination and utilization of water production functions for principal California crops. W- 67 California Contribution Project Report. University of California, Davis, United States of America.

Stewart, J.L., Hagan, R.M., 1973. Functions to predict effects of crop water deficits. ASCE, J. Irrig. Drain. Div. 99, 421– 439.

Taniguchi, M., Dausman, A., Howard, K., Polemio, M., Lakshmanan, E., 2009. Trends and sustainability of groundwater in highly stressed aquifers; IAHS Publications: Wallingford, UK, 329, 312 p.

Tulipano, L., Fidelibus, M.D., Panagopoulos, A., 2005. Groundwater management of coastal karst aquifers; COST Action 621, Report EUR 21366; European Commission: Brussels, Belgium.

Ünlükara, A., Cemek, B., Karaman, S., 2008. Response of lettuce (*Lactuca sativa* var. *crispa*) to salinity of irrigation water. New Zeal. J. Crop Hort. Sci. 36, 265-273.

Ünlükara, A., Kurunç, A., Kesmez, G.D., Yurtseven, E., Suarez, D.L., 2010. Effects of salinity on eggplant (*Solanum melongena* L.) growth and evapotranspiration. Irrig. Drain. 59, 203–214.

Ünlükara, A., Yurtyeri, T., Cemek, B., 2017. Effects of Irrigation water salinity on evapotranspiration and spinach (*Spinacia oleracea* L. Matador) plant parameters in greenhouse indoor and outdoor conditions. Agron. Res. 15(X), xxx–ccc, 2017 https://doi.org/10.15159/AR.17.041

Wang, H., Zhang, M., Guo, R., Shi, D., Liu, B., Lin, X., Yang, C., 2012. Effects of salt stress on ion balance and nitrogen metabolism of old and young leaves in rice (*Oryza sativa* L.). BMC Plant Biol. 12,194.

Wang, Y., Nil, N., 2000. Changes in chlorophyll, ribulose biphosphate carboxylase-oxygenase, glycine betaine content, photosynthesis and transpiration in *Amaranthus tricolor* leaves during salt stress. J. Hortic. Sci. Biotechnol. 75, 623–627.

Yamaguchi, T., Blumwald, E., 2005. Developing salt-tolerant crop plants: challenges and opportunities. Trends Plant Sci. 10 (12), 615–620.

Yasar, F., Uzal, O., Tufenkci, S., Yildiz, K., 2006. Ion accumulation in different organs of green bean genotypes grown under salt stress. Plant Soil Environ. 52(10), 476–480.

Yeo, A.R., Lee, K.S., Izard, P., Bourssier, P.J., Flowers, T.J., 1991. Short- and long-term effects of salinity on leaf growth in rice (*Oryza sativa* L.). J. Exp. Bot. 42, 881-889.

Zhang, P., Senge, M., Dai, Y., 2016. Effects of salinity stress on growth, yield, fruit quality and water use efficiency of tomato under hydroponics system. Rev. Agric. Sci. 4, 46-55.

Ziaf, K., Amjad, M., Pervez ,M.A., Iqbal, Q., Rajwana, I.A., Ayyub, M., 2009. Evaluation of different growth and physiological traits as indices of salt tolerance in hot pepper (*Capsicum annuum* L.). Pak. J. Bot. 41(4), 1797-1809.

Table 1. Values (±SD) of electrical conductivity of saturated paste extract of soil (ECe, dS m^{-1}) at sowing time and at each harvest in the two years. The values represent the average of the two genotypes.

Salinity treatments	2007				2008			
	Sowing	1st harvest	2nd harvest	3rd harvest	Sowing	1st harvest	2nd harvest	3rd harvest
S_1	1.0 ±0.17	1.2 ±0.15	1.4 ±0.19	1.6 ±0.18	0.9 ±0.10	1.1 ±0.12	1.3 ±0.18	1.5 ±0.19
S_2	2.1 ±0.18	2.2 ±0.14	2.4 ±0.19	2.5 ±0.20	2.0 ±0.16	2.1 ±0.18	2.3 ±0.20	2.4 ±0.21
S_3	3.4 ±0.25	3.4 ±0.30	3.6 ±0.38	3.6 ±0.35	3.2 ±0.31	3.4 ±0.36	3.4 ±0.28	3.6 ±0.39
S_4	5.3 ±0.37	5.5 ±0.29	5.8 ±0.35	6.1 ±0.44	5.4 ±0.42	5.4 ±0.33	5.5 ±0.46	5.7 ±0.46
S_5	8.5 ±0.43	8.6 ±0.42	9.1 ±0.31	9.3 ±0.47	8.6 ±0.48	8.7 ±0.40	8.8 ±0.43	8.9 ±0.39
S_6	12.3 ±0.40	12.6 ±0.53	13.0 ±0.60	13.1 ±0.61	12.4 ±0.58	12.4 ±0.55	12.6 ±0.41	12.8 ±0.63

Table 2. Effect of year and salinity on total and marketable yield, leaves number per plant, leaf area per plant, leaf dry matter, specific leaf area (SLA), leaf succulence (LS), evapotranspiration (ET) and water use efficiency (Y_WUE), of *D. muralis* and *D. tenuifolia*.

Treatments	Total yield (1) (g plant^{-1})	Marketable yield (1) (g plant^{-1})	Leaves number (2) (n. plant^{-1})	Leaf area (2) (cm^2 plant^{-1})	Leaf dry matter (2) (g 100 g^{-1} FW)	SLA (2) (m^2 kg^{-1} DM)	LS (2) (g FW cm^{-2})	ET (1) (L pot^{-1})	Y_WUE (2) (kg m^{-3})
					Diplotaxis muralis				
Year (Y)	ns	ns	ns	ns	ns	ns	ns	ns	ns
2007	31.3	28.8	11.6	192.9	9.7	21.4	0.049	13.3	10.3

2008	32.7	29.3	12.2	197.6	9.5	20.6	0.052	14.3	9.8
Salinity Levels (SL)	**	**	**	**	**	*	*	**	**
S_1	43.2 a	42.4 a	13.7 a	285.7 a	8.8 c	24.6 a	0.046 d	16.7 a	12.7 a
S_2	42.2 a	41.2 a	13.8 a	274.5 a	8.9 bc	24.0 a	0.047 d	16.0 a	12.9 a
S_3	39.1 b	36.9 b	13.6 a	248.7 b	9.2 b	22.4 ab	0.049 cd	15.1 b	12.2 a
S_4	30.0 c	26.2 c	12.6 b	175.5 c	9.5 ab	20.7 b	0.051 c	13.7 c	9.6 b
S_5	23.0 d	18.9 d	10.4 c	127.8 d	10.1 a	18.4 c	0.054 b	12.0 d	7.9 c
S_6	14.5 e	8.9 e	7.6 d	59.2 e	11.0 a	16.0 d	0.057 a	9.3 e	4.8 d
Y x SL	ns	ns	ns	ns	ns	ns	ns	ns	ns
Diplotaxis tenuifolia									
Year (Y)	**	**	*	*	ns	ns	ns	ns	*
2007	40.2	38.6	15.2	259.2	9.6	23.3	0.046	15.2	12.3
2008	51.4	47.0	17.5	314.0	9.8	22.3	0.047	15.6	14.6
Salinity Levels (SL)	**	**	**	**	*	**	*	**	**
S_1	58.8 a	57.2 a	18.4 a	381.7 a	9.0 c	26.6 a	0.042 d	17.8 a	15.7 a
S_2	57.7 a	56.0 a	18.3 a	374.8 ab	9.0 c	26.1 a	0.043 cd	17.5 a	16.0 a
S_3	55.5 ab	53.4 b	18.9 a	356.7 b	9.3 bc	24.2 ab	0.044 cd	16.6 b	16.1 a
S_4	45.9 b	41.4 c	17.2 b	277.7 c	9.7 b	22.4 b	0.046 c	15.2 c	13.7 b
S_5	33.6 c	31.8 d	14.2 c	215.3 d	10.2 ab	20.0 c	0.049 b	13.7 d	11.6 c
S_6	23.5 d	17.0 e	10.9 d	113.5 e	10.9 a	17.6 d	0.052 a	11.4 e	7.5 d
Y x SL	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns, *, ** indicate *F* test not significant or significant at $P \leq 0.05$ and $P \leq 0.01$, respectively. Mean separation within columns by SNK test ($P \leq 0.05$).

(1) The values are the sum of three harvests.

(2) The values are the average of three harvests.

Figures captions

Fig. 1. Effect of salinity on marketable yield obtained at each harvest in 2007 and 2008 for *D. muralis* and *D. tenuifolia*. Vertical bars indicate ±SD (n = 4).

Fig. 2. Effect of salinity on relative evapotranspiration of *D. muralis* and *D. tenuifolia*. Pooled data of the two years.

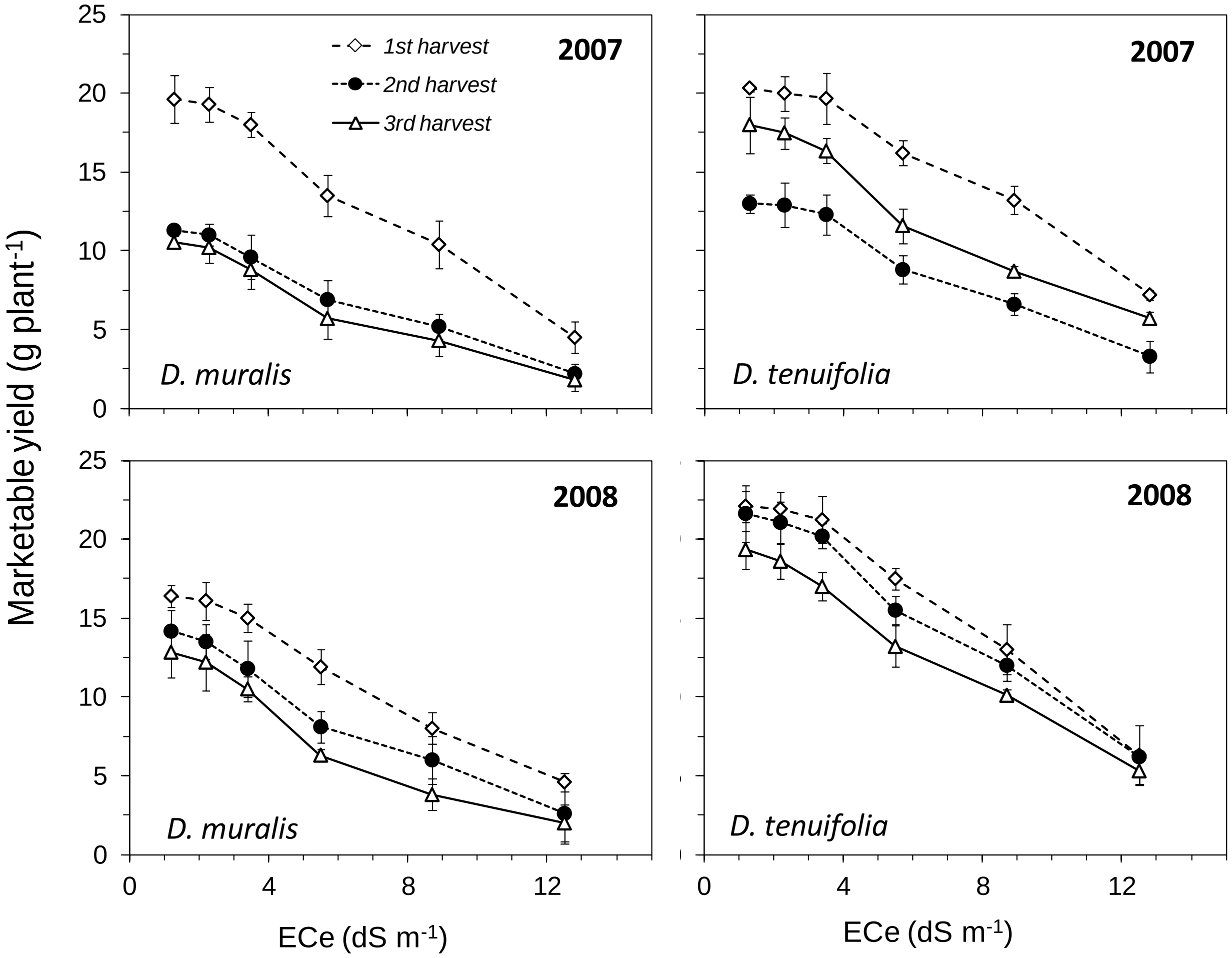
Fig. 3. Relationships of relative marketable yield decrease [1-(Ya/Ym)] vs relative ET decrease [1-(ETa/ETm)], for *D. muralis* and *D. tenuifolia*. Pooled data of the two years.

Fig. 4. Maas and Hoffman (1977) model applied to the relative marketable yield (sum of three harvests) of the two crop cycles for *D. muralis* and *D. tenuifolia*.

Fig. 5. Trend of threshold and slope derived from Maas and Hoffman (1977) model applied to the relative marketable yield for each harvest for *D. muralis* and *D. tenuifolia*. Pooled data of the two years.

Fig. 6. Maas and Hoffman (1977) model applied to the relative leaf area per plant (average of three harvests) of the two crop cycles for *D. muralis* and *D. tenuifolia*.

Fig. 7. Maas and Hoffman (1977) model applied to the relative leaves number per plant (average of three harvests) of the two crop cycles for *D. muralis* and *D. tenuifolia*.



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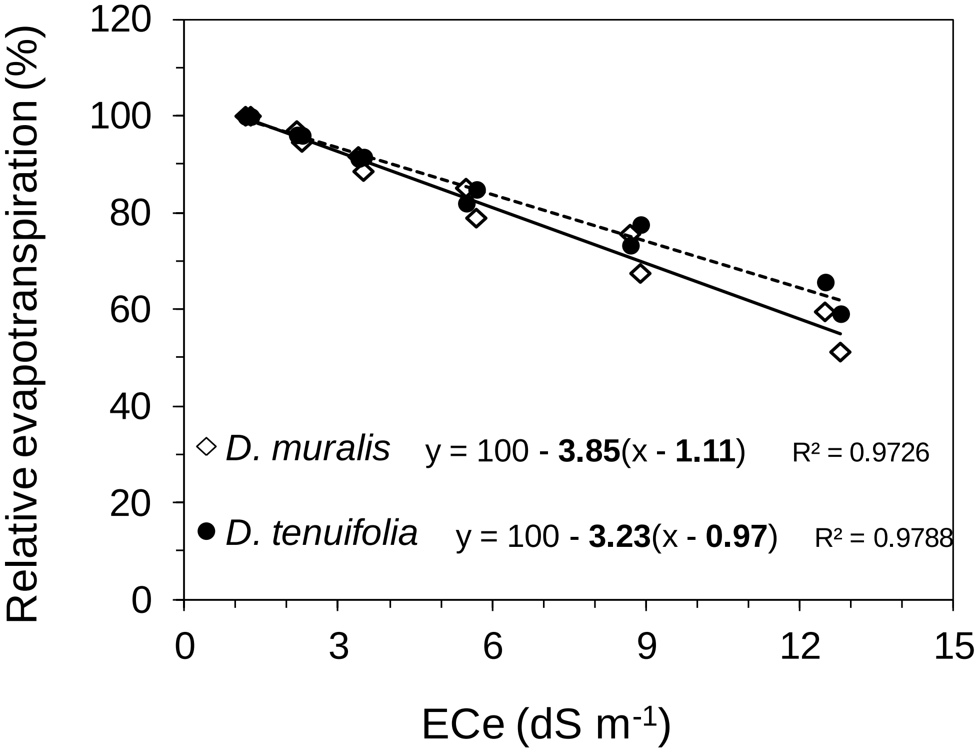


Fig. 2. Effect of salinity on relative evapotranspiration of *D. muralis* and *D. tenuifolia*. Pooled data of the two years.

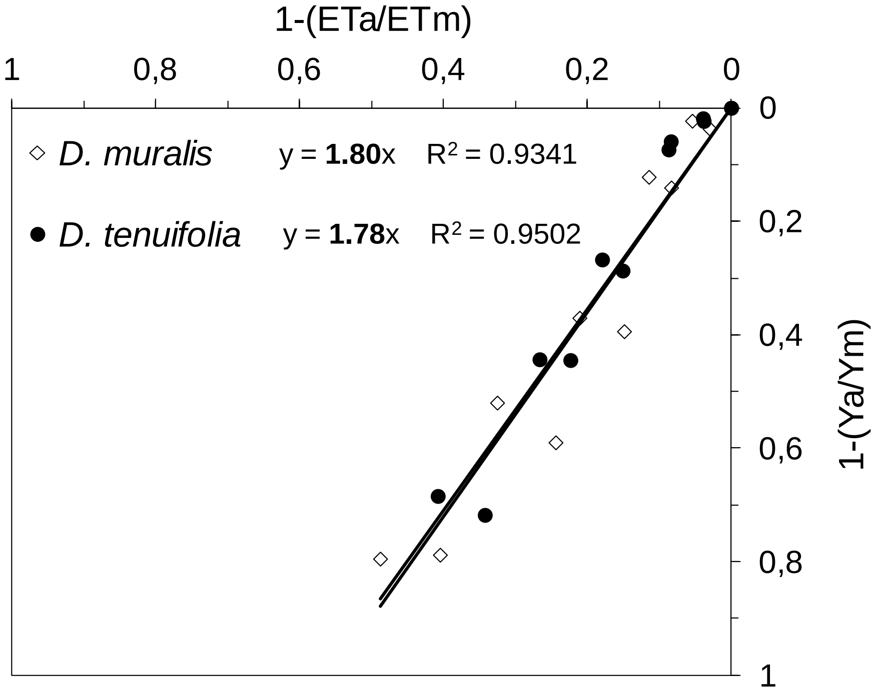
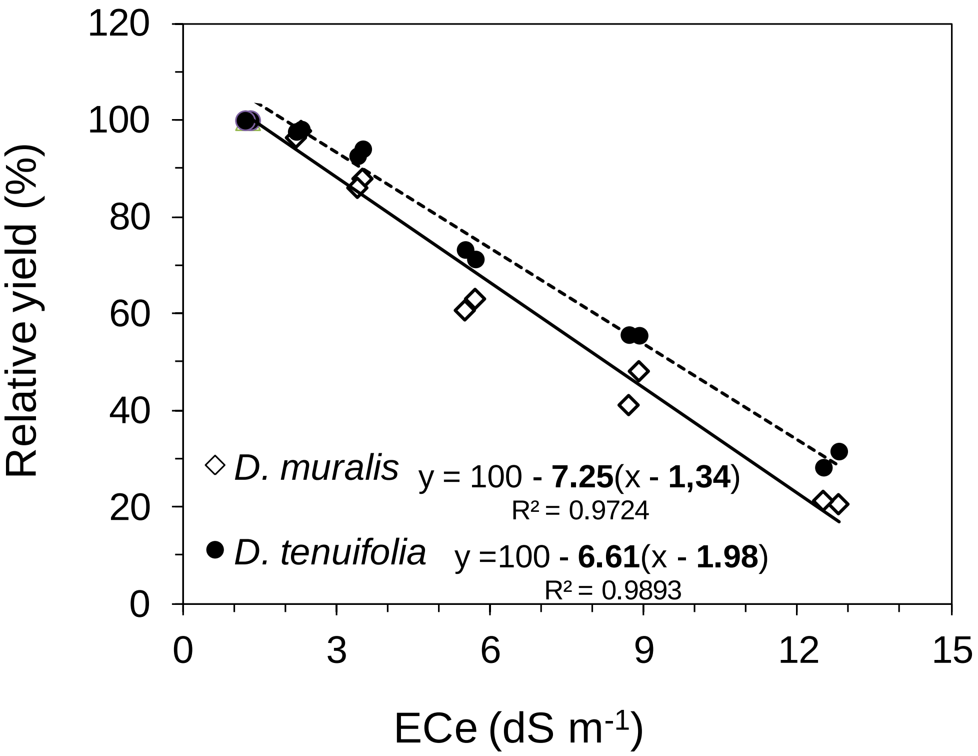


Fig. 3. Relationships of relative marketable yield decrease [1-(Ya/Ym)] vs relative evapotranspiration decrease [1-(ETa/ETm)], for *D. muralis* and *D. tenuifolia*. Pooled data of the two years.



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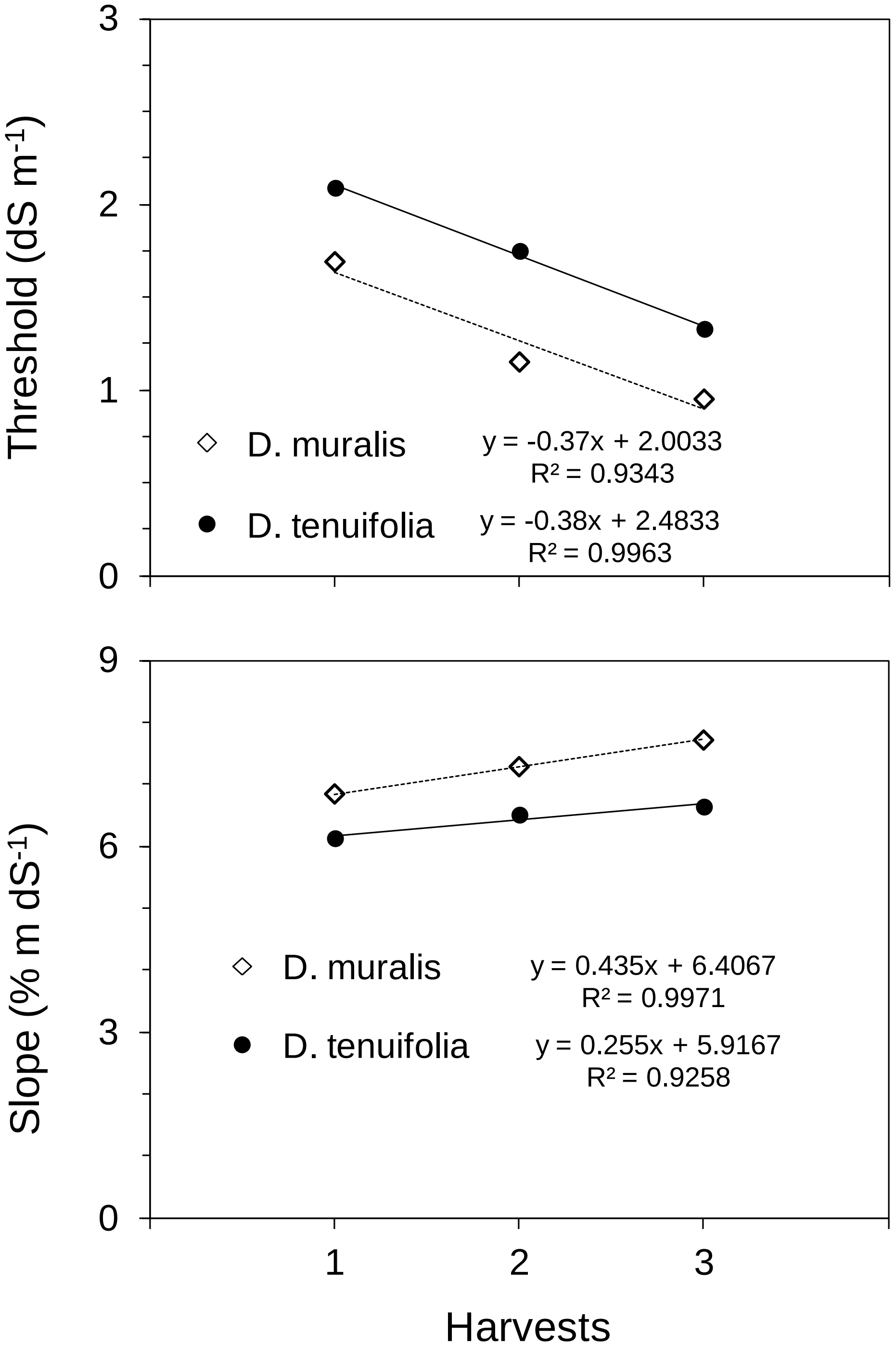

Fig. 5. Trend of threshold and slope derived from Maas and Hoffman (1977) model applied to the relative marketable yield for each harvest for *D. muralis* and *D. tenuifolia*. Pooled data of the two years.

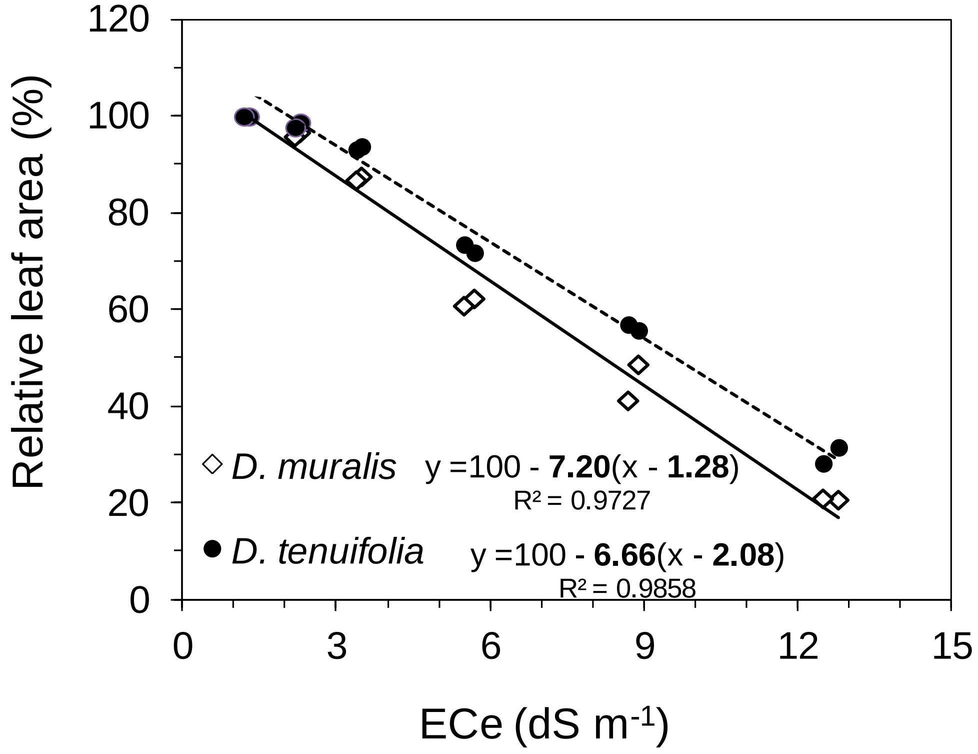

Fig. 6. Maas and Hoffman (1977) model applied to the relative leaf area per plant (average of three harvests) of the two crop cycles for *D. muralis* and *D. tenuifolia*.

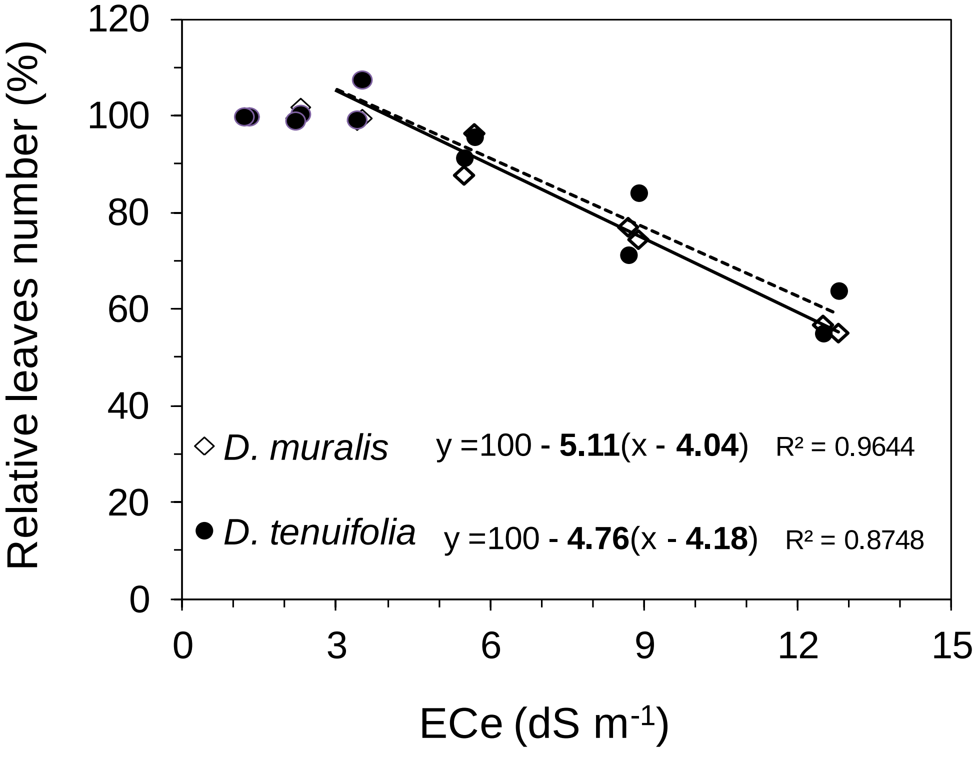

Fig. 7. Maas and Hoffman (1977) model applied to the relative leaves number per plant (average of three harvests) of the two crop cycles for *D. muralis* and *D. tenuifolia*.