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Effects of NaCl and KCl on Physiological Aspects of Two Canola Varieties

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ABSTRACT

In order to investigate reaction of physiologic morphological traits in canola in early growth stages an experiment was conducted at the green house conditions. Treatments consist of NaCl in four levels, two levels of KCl and two varieties of canola. Results showed that amount of photosynthesis in RGs003 in compare of Licord and control treatment increased 67 and 14 percent, respectively in T5 treatment. The stomata conductivity was greater from applied T5 treatment than other treatments except of control. The maximum biomass was observed in Licord which increased 34 percent in compared of other variety in T5 treatment. Dry root weight in RGs003 was greater than Licord variety. Results of coefficient regressions were showed positive relation between morphological traits in any level of salinity stress that is a necessity to do more investigation in range of these compositions biomass and leaf area (R2=0.86) than biomass and relative water content (R2=0.66). Our results show that under high salinity and normal conditions, Licord cultivar had the lowest and highest biomass respectively. This indicates that RGs003 cultivar showing high average performance under high salinity conditions. However, if the condition is normal, Licord cultivar is recommended for high performance

Keywords: Biomass, Photosynthesis, Pod per plant, Salinity.

INTRODUCTION

Sodium chloride is the most dominated composition in salty regions. Chloride, Carbonate, Sodium Bicarbonate, Magnesium, Calcium and Potassium are other ingredients that caused salinity in these areas. The nutrient equilibrium will disturb when Na^+ and Cl^- ions increase due to lower uptake of elements such as calcium, potassium and magnesium by plant, in these areas (Munns, 2002). Under this condition the sodium ions (Na^+) are replaced by potassium ions (K^+) and these resulted in cellule damage (Maathuis, 2006). High salt concentrations of soil are often associated with ion imbalances and hyperosmotic pressure, which eventually lead to oxidative stress conditions for plants (Abideen et al., 2014).

Under salt conditions Sodium can be replaced by calcium and decrease stability in membrane cell (Gutpa et al, 2002) and accumulation of sodium ions and chloride in chloroplasts lead to reduced photosynthesis in plants (Hasagawa et al., 2000). Also, some studies have shown the effect of salt in reduction of photosynthetic activity in photosystem II (Kao et al, 2003). However, some studies have shown that the salinity is unaffected on photosystem II (Morales et al., 1992). Furthermore, accumulation of toxic ions such as Na^+ and Cl^- on apoplast decreases leaf turgidity and

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assumed to be caused by mortality of leaf cells and plant tissues and ultimately plasmolysis of cells and high sodium: potassium ions ratio led to enzymes were be inactivated and this affect metabolic processes and results in decreased yield and plant growth(Sudhir, P. & SDS Murthy. 2004). The surveys showed that increasing potassium in rhizospher to help increase resistance of sunflower to salt and an increase in crop yield (Delgado and Sanchez-Raya, 1999). Maintaining proper amounts of potassium in the soil for survival of plants is essential in salty habitats. Potassium is an essential mineral that reduce the osmotic potential of the central cylinder to help absorption of water into the xylem vessel (Marchner, 1995). However data show that the increase Na^+ ions can reduce absorption and transportation of potassium in the plant, but little data exist that show to adding potassium to salty soils to improve growth and yield of plants (Grattan and Grieve. 1999). Cereda et al (1995) reported that the use of potassium fertilizers would increase the ratio of K^+ to Na^+ in the plants. In these circumstances, additional supplementary potassium in leaves would decrease sodium concentration and increase potassium. (Kostas and Georgios, 2006). Findings of Kaya et al (2002) showed that 35 mM NaCl salinity reduced total dry matter yield compared to control in strawberry fruit and chlorophyll concentration and when the potassium 3 mM concentration was added to the nutrient solution to in the form of (K2SO4), dry matter, yield and chlorophyll concentration improved in the plant. In other study Benlloch et al (1994) were shown that the effect of NaCl on bean plant depends on potassium ions concentration in nutrient solution. The increase of KCl in this situation cause to reduce the toxic effects of NaCl in plant (Benlloch et al, 1994). In other study also composition of the nutrient solution containing K^+ ions in wheat root causes significant reduction in the concentration of Na^+ ions in plant roots (Jeschke and Nassery, 1981).

Canola or oil-seed rape (Brassica napusL.) is grown mainly for the purpose of the production of edible oil and it is a moderately salt tolerant crop species(Moheb et al., 2012). Although maximum yields of canola are obtained under normal soil and environmental conditions, the quantity and quality of seed yields are affected by environmental stress(Banaei et al., 2015).

In canola plant with increasing salinity, the emergence of the first inter node and leaf delayed and in the later stages of growth if the salt stress is continued the height, the number of pods and seeds per plant yield will reduce and in the end the plant yield will be reduced (Boem et al 1994).

Bybordi (2012) reported that photosynthesis of salt stressed canola plants significantly decreased while respiration rate increased. This decrease in plant photosynthesis under salt stress takes place due to closing of stomata that result in a decrease in leaf transpiration rate and reduced leaf internal CO_2 concentration.

In Iran, the production of the canola plant is limited by soil salinity and drought. With regard to increasing salty lands (due to low precipitation, unsuitable management of agriculture & etc.), our experiment was performed to investigate the alleviation of the adverse effects of sodium chloride by application of supplementary potassium on canola plants.

Materials and Methods

Canola seeds (B. *napus* L. cultivars RGS003 and Licord) were obtained from the Agricultural- Jihad Organization of Khorasan Razavi province. These cultivars were used due to the differences in salt tolerance at growth stages.

This research conducted in greenhouse condition at Agriculture College of Ferdowsi University of Mashhad in completely randomized design with three replications at factoril arrangement in 2011. The pots were used in this experiment containing 12 kg of sand, soil and leaf litter with 1:1:1 ratio. Soil characteristics are given in Table 1. We used some fertilizer (based on soil test results) to fertilize plants. Treatments including: the first factor two cultivars of rapeseed (RGs003 and Licord) and second factor was composed of two levels of KCl (zero and 20 mM) at four levels of NaCl (zero, 40, 60 and 80 mM) which have eight level from T1 to T8 that is shown in Table 2.

The seeds were disinfection with fungicide of carbendazim and then they planted in each pot(10 seeds in any of pots) in October 2011. After emergence, seedlings were thinned to 4 plants per pot. Irrigation was achieved with desire treatment in every three days. For preventing accumulation salt in any pots we create many holes at bottom each pot in order to watering overflow get out from base of pots. In flowering stage the following measurements were performed. For measuring photosynthesis was used of photosynthesis apparatus (LCA4 model) upon youngest leaf at 10-12 AM. For measure Chlorophyll fluorescence we used a flourometer (MINI-PAM Portable Chlorophyll Fluormeter) and measure parameters as: reflected light fluorescence from leaf acclimate of light (Fϑ'o), maximal fluorescence acclimated to light (Fϑ'm), variable fluorescence (Fϑ'v) and maximum photochemical efficiency potential of photosystem II (F'v/F'm). In order to determine membrane stability index (MSI) (from measuring electrolyte leakage method on the leaf) 5 leaf disc with 7 mm diameter per treatment was cut out from fully developed leaves then overflow in 20 ml of distilled water and was kept at room temperature for 24 hours. The electrical conductivity of this solution as the initial leak was measured as (EC1).For measuring secondary leakage the samples was placed in Benmary apparatus in 100 degrees centigrade for one hour. After cooling this samples conveyance to Shaker for one hour. Then secondary leak was measure as the secondary electrical conductivity (EC2) (Sairm et al, 2002). Membrane stability index was calculated from equation (1) as follows:

Equation 1:

$$MSI= [1-(EC1/EC2)] \times 100$$

To measure the relative water content of leaves (RWC), two days after irrigation at 8 to 10 am, 10 leaf discs (7 mm diameters) from fully expanded young leaves were chosen and weighted (fresh weight) then the samples are put in distilled water for 24 hour and weighted as (turgidity weight) for measure dry weight samples were placed in oven 74 degrees for 48 hours and samples weighted again (dry weight). Relative water content of leaves was calculated base on equation (2) (Smart and Bingham, 1974).

Equation 2:

$$RWC = [(\text{fresh weight} - \text{dry weight})/ (\text{turgid weight- dry weight})] \times 100$$

The amount of chlorophyll a and b were calculated based on spectroscopy using a spectrophotometer (Dere et al, 1998)

For this purpose, 100 mg of leaf samples that had previously been frozen with 10 ml of 100% acetone for 10 min was centrifuged at 1600 rpm.

Then the amount of chlorophyll a in the absorption spectra of 663.2 nm and chlorophyll b in 646.8 nm using a spectrophotometer were read and after that using formulas (3) And (4) they were calculated as micrograms of chlorophyll per gram of fresh leaf (Dere et al, 1998).

Equation 3: $Ch\ a = Ca=15.65\ A666 - 7.340\ A653$

Equation 4: $Ch\ b = 27.05\ A653 - 11.21\ A666$

(Letter of A) is amount of absorption in wavelength is desired

Since some plants at the end of the growing season did not produce seeds. To test the effect of treatments we used dry matter production index.

At the end of the season, the plants were cut from the crown and then put in an oven 70 ° C for 48 hours to determine the dry weight. In order to determine the root dry weight, the roots gently pull out of the pots and washed then put in the envelope and were placed into the oven for 48 hours at 70°C. To analyze the data, was used Minitab ver. 14 software and for drawing graphs used of Excel software and the means were comparing with LSD test at 5% level in Mstat-C software.

Results

Membrane **stability index (MSI):** Analysis of variance showed that influence of cultivar, compound (KCl and NaCl) salt and the interaction cultivar × compound (KCl and NaCl) salinity on MSI trait was significant difference ($p<0.01$) (Table 3). Licord cultivar has about 8 percent MSI more than RGs003 cultivar (Table 5).

The highest and the lowest yield was obtained from treatment T4 and T8, respectively, when compared with control they showed about 2 percent increase and 28 percent decrease respectively (Table 7).

Results interaction between cultivars and CS showed that with the increase of salinity and KCl and NaC added to the medium the index of stability decrease in both cultivars. Neverthless, the trend of this trait in Licord less than the other cultivar. The highest membrane stability index was in treatment CS2 × licord that in proportion of RGs003 in this level of treatment have increased about 2%. RGs003 cultivar until of CS3 had more 80 percent had in RGs003 this trait until CS6 had more MSI (Table 9). Study Collado et al (2010) showed that the membrane stability index of maize after 28 days of salt (150 mM NaCl) was reduced by 20% in relative of control treatment. In salinity condition, ionic imbalance due to excessive accumulation of sodium and chloride ions, in cells and decreased absorption of other nutrients such as potassium, calcium and magnesium salts cause toxic effects in apoplast of leaves and occupied spaces calcium by sodium caused instability in cell membrane. In this situation the electrolyte leakage from cells is increased and membrane stability index was decreased (Nabati et al, 2011).

Relative water content of leaf (RWC): Leaf relative water content was influenced by CS and interaction between CS and cultivar ($p<0.01$), but this trait was not affected by cultivar (Table 3). Most of this trait was observed in CS1 and with increased stress levels trend of RWC was decreased (Table 7).

The results of interaction between cultivar × CS were showed that in every stress level the amount RWC in Licord was more than RGs003, however in high level of stress especially in CS7 and CS8 amount in leaf relative water content in RGs003 was 26 and 39 percent higher than Licord (Table 9). The study of Cha-um et al (2010) showed that in sensitive rice seedling (PT1) to salinity applied different concentrations of KNO3 in environment of NaCl was improved water relations of rice seedlings and these results not obtained takes of KNO3 compounds. Improved leaf relative water content of the combined application of potassium compounds with NaCl in wheat (Zheng et al, 2008) and sunflower (Akram et al 2009) have also been reported. One of the most important Potassium roles is osmotic adjustment of plant cell, thus if this ion be abundant in rhizosphere if it is plentiful in rhizosphere it can increase the absorption of this ion by roots and subsequent as a consistence assimilate caused more negative osmotic potential and then increased water flow ingredient to cell and keeps turgidity of cell (Kafi et al, 2009).

Quantum yield: Maximum potential photochemical efficiency of photosystem II (F'v/F'm) did not affected by cultivar, but effect of CS and interaction between CS and cultivar had significant difference ($P<0.01$) upon this trait (Table 7). However the quantum yield until CS7 had not significant difference in comparison with control, but with increase stress level was observed decrease trend in this trait. The lowest quantum yield obtained in CS8 (Table 7). The same trend was also observed in the study of the interaction between CS and cultivar. However until CS7 in sake of quantum yield did not considerable difference between cultivar and CS but observed this difference in CS8.

The maximum quantum yield was obtained from cult1 × CS5 that in comparison with cult2 in the same CS has increase 2 percent, but no significant difference with control treatment (Table 9). Although studies have shown that increasing salinity to be caused decreased plant is the quantum yield (Jamil et al, 2007), But study of Cha-um et al (2010) showed that treatment of susceptible rice seedlings PT1 salt combined with the 5.11 mM KNO3 plus 200 mM NaCl improved quantum yield about 44% in comparison with not using of KNO3 compound. When plants are exposed to stress the leaves of metabolism were decreased and in order to created balance between rate of photosynthic electron transport and carbon metabolism that amount of quantum yield (F'v / F'm) goes down (Krause and Weiss , 1991). It seems that abundant ions in rhizoser, potassium ion has also similar role in plants that to be caused increased osmotic stress in plant (pitman, 1984).

Chlorophyll a and b: Analysis of variance showed that the amount of chlorophyll was a significant impacted by CS and interaction CS × cultivar (P<o.o1), but it was not affected by cultivar (Table 3).

The amount of chlorophyll a decreased with increasing salinity and the highest values were obtained from the CS2 and the high loss of this trait was observed in CS8 treatment decreased about 77% compared to control (Table 7). Maximum chlorophyll a obtained from Cult2×CS2 treatment that it was 20% more than RGs003 in comparison with this value. Chlorophyll a stability in Licord was better than the other cultivar in CS1 to CS5 treatments (Table 9). Chlorophyll b was affected by cultivar, CS and interaction CS × cultivar and gave significant difference (P<0.01) (Table 3). Chlorophyll b amount in RGs003 was about 4 percent higher than the other cultivar (Table 5). Various CS (Compounds of Salinity) and KCl reduced the amount of chlorophyll b in comparison with control treatment and the lowest rate of its was observed in CS8 that was decreased 80% in comparison with the control (Table 7). The results Sakr and Arafa (2009) showed that with increasing salinity total chlorophyll content was decreased in canola. So that the in salinity 14 $dS.m^{-1}$in comparison with salinity of 10 $dS.m^{-1}$ it was reduced about 6 percent. It seems that salinity by increasing Chlorophyll degradation enzyme activity (chlorophyllaze of activity), causing damage to buildings chlorophyll and unstability pigment protein structure (Sing and Dobey, 1995).

Photosynthesis: The effect of cultivar, CS and interaction CS × Cultivar was significant difference on the amount of photosynthesis (P<0.01) (Table 3). Amount this trait in RGs003 was triple more than Licord (Table 5). Although Amount of photosynthesis was not observed significant difference until CS3, but with increased salty stress was reduced photosynthesis (Table 7). The results were also showed that the greatest amount of photosynthesis was obtained in applied CS in RGs003 that about 72 percent more than other cultivar. The results in Table 9 showed that the rate of photosynthesis Licord cultivar was heavily influenced by applying CS, so that the range of this traits was from 6.6 in the control until 0.960 mol CO2 per square meter per second, that in comparison with other cultivar had very differences in any level of salty stress. Study Cha-um et al (2010) showed that applied zero, 9.4, 11.8 and 24.1KNO3 in 200 mM NaCl salinity caused differences in the rates of photosynthesis and amount photosynthetic maximum when applied 11.8 mM KNO3 treatment was increased by 90% in comparison with control. Reduced photosynthesis in salinity condition could be known as negative effect of salinity on the photosynthetic system (chlorophyll fluorescence, chlorophyll content) or as dependent stomatal factors (Munns et al, 2006). Results of regression analysis showed that amount of photosynthesis had strongly positive correlation with quantum yield (R2=0.67) and chlorophyll a (R2 = 0.801) (Fig. 1 A and B). Chlorophyll a is one of the component the light-dependent reactions of photosynthesis that supplied the raw material for the electron photosystem I and production of NADPH and ATP is dependent on the presence of this protein pigment (Taiz and Zeiger, 2006). Therefore with decreased contents of Chlorophyll in salinity condition the amount of light photosynthesis production will be reduced.

Stomatal conductance: Stomatal conductance was affected by cultivar, CS and interaction CS × cultivarand and had significant difference (P<0.01) (Table 3). Stomatal conductance value of cultivar RGs003 79 percent higher than the other cultivar (Table 5). The most of this trait was obtain from CS2 and control treatment and with increasing stress level were reduced stomata conductance. So that the difference in any levels of stresses approximately 60 percent decreased in comparison with the other variety. The result of interaction CS × cultivar was showed that at all level of salts, the stomatal conductance of Licord cultivar was lower than the RGs003. The lowest stomatal conductance was at Licord cultivar in CS8 that in comparison with other cultivar was reduced about 91 percent (Table 9). Results showed that applied drought stress on wheat to be declined about 90 percent at flag leaf stomatal conductance, and then the amount of photosynthesis at flag leaf was reduced from 12.6 to 1.91 micro mol CO2 per square meter per second (Kafi et al , 2009). The study was showed that stomatal closing in the salinity condition is In association with accumulation of ions in around of the roots which signals induce stomatal guard cells by ABA transport from roots to remove the potassium and decrease in stomatal cells and causing decline in turgidity cells and closing them (Munns, 2002).

Area and dry weight of **Leaf**: The effect of cultivar, CS and interaction CS × cultivar on the leaf surface was significant. The Leaf weight trait was not affected by cultivar, but CS and interaction CS × cultivar had significant difference on its (Table 4). Licord had 23 percent greater leaf area with comparison in other cultivar, although leaf dry weight was not significant by cultivar, Licord had about 5 percent more leaf dry weight than RGs003 cultivar (Table 6). With applied Compound Salinity observed that there was a decreasing trend in both leaf area and leaf weight traits, but in treatment that amount KCl is high (especially in T4 and T6) weight and area of leaf was little more than zero level of KCl. Which shows the effect of K ions as osmotic regulators of plant water relations causing negative osmotic potential and thereby attract more water in cells and the they have been developed (Munns, 2002). The results of interaction between CS and cultivars was showed that the highest weight and area of leaf was obtained from Cult2×CS 432 cm^2 and 98.2 g respectively, and the lowest value of them were observed from the Cult2×CS8 . However, in high levels of stress had more prominent in Licord than other cultivar in weight and area of leaf (Table 10).

Salinity reduced leaf size in maize, rice, wheat and barley, and similarity changes were occurred in cases that used KCl, monitol or polyethylene glycol (PEG) indicating alter In association with the cell water it is due to osmotic stress of salinity (Kafi et al, 2009).

Volume and root dry weight**:** Analysis of variance showed a significant effect ($P<0.01$) by cultivars, CS and interaction CS × cultivar upon of root dry weight and root volume (Table 4). RGs003 cultivar with comparison in other cultivar had more root dry weight and volume about 47 and 25 percent respectively (Table 6). The highest and lowest root dry weight and root volume than control treatment was taken from CS6 and CS8 treatments that the volume and the root dry weight of T6 and T8, 18 and 60% decreased respectively.

(Table 8). The results of interaction CS and cultivar showed that the highest root dry weight and root volume were measured in cult1× CS6 so that in respect of Licord cultivar in same stress level had increased 28 and 68 percent root dry weight and volume respectively. Root dry weight was strongly decreased in Licord cultivar in after applied CS5. While in final levels stress, these differences were not observed in other cultivar. Increase NaCl to be caused alteration of water relations in cells that was reduced root growth and applied mannitol and KCl have also similar effect on root growth. Thus there is evidence that showed the cells are dividing or elongation at the root tip was occurred when sodium concentration is less than the toxic level. Therefore considerable decrease in root growth could be deficient Ca^{+2} that replaced by Na^{+} ion (Munns, 2002). It seems that RGs003 at the end of the stress level, had more relative resistance than the other cultivar that was shifted more assimilate into root than Licord cultivar.

Biomass: Effect of cultivar, CS and interaction CS × cultivar was significant on biomass (Table 4). Licord cultivar had 14 percent more biomass than other cultivar (Table 6). Maximum and minimum biomass were obtained from CS4 and CS8 that in contrast with control treatment increased 15 percent in CS4 and decreased 55 percent in CS8 (Table 8).

Results of effect CS on cultivar were showed that Licord cultivar in both treatments CS2 and CS4 had the highest biomass and Licord's biomass in T2 & T4 about 49 and 32 percent was more than the other cultivar at these levels of salinity. However, high levels of stress especially in CS7 and CS8. RGs003 had more biomass than Licord cultivar. The least amount of biomass was obtained from Licord cultivar and CS8 treatment that in contrast with control and other cultivar had decreased about 88 and 80 percent respectively. Ghasemzadeh Ganjei (2010) revealed that the four levels of KCl (zero, 60, 90, 120 and 150 kg ha) with water stress in wheat biomass had no significant effect on biomass yield. In other study DelInnocent et al. (2009) showed that increased concentration of K^{+} ion in salinity condition, decreases the Na^{+}/K^{+} ratio in wheat that this result in more improving water relations and biomass in plant. The Results of regression analyses showed there are a strong positive relationship between biomass and leaf area ($R2 = 0.86$) and leaf relative water content ($R2 = 0.66$) (Fig. 1), in the other hand biomass had also a strong positive correlation with the photosynthesis rate and membrane stability index (Figure 1 diagrams D, E and F). The results Cha-um et al (2010) showed that in conditions of 200 mM NaCl and KNO3, the correlation between biomass and photosynthesis was ($R2 = 0.73$). These results indicate that amount of biomass was directly influence by vital processes of plant, so that increase leaf area and growth amount of biomass was increased. Reduction of biological yield under salinity conditions can be known due to the harmful effects of salinity (ionic toxicity feeding disorders) on shoot growth plant (Guo and Tang, 1999). Long-term exposure in salinity condition increase the risk of salt accumulation of toxic ions in the leaves, following after that leaf aging accelerates in the susceptible cultivar

(Kafi et al, 2009). In these conditions, the leaves are also much reduced which can reduce plant photosynthesis and thus reduce the amount of dry matter in plant tissues (Munns, 1993).

Root to shoot ratio: Analysis of variance showed that cultivar, CS and their interaction on root to shoot ratio had significant difference ($p<0.01$) (Table 4). The maximum value of this ratio was obtained in RGs003 that had about 39 percent more than other cultivar (Table 6).

Although the Licord had more biomass than the other cultivar, but RGs003 was owned more photosynthetic assimilation in root than other cultivar and hence it had drier root weight. Maximum and minimum value of this ratio was observed in CS6 and CS3 respectively. Data results from the interaction of the CS × cultivar was showed that the highest this traits was at applied CS2 in RGs003 that was increased 15 percent in contrast with control treatment. In this respect the ratio was lowest in Licord. Comparing CS4, CS5, CS6 and CS7 in two cultivar was showed that RGs003 had more root to shoot ratio than the other cultivar, this could be explained that root growth in these treatments are the reason against salty stress and it can be seen in data of volume and root dry weight (Table 10).

Conclusion

The results of this experiment showed that compounds of (K2SO4, KNO3 & KCl) can be increased K^+ ion in root environment so this can be reduce the toxic effect of sodium and improved water relations and many of metabolic activity in plant cell, but when concentration K^+ ions in rhizospher was exceed from a limit value this incident to be caused intensify effects of stress on the plant and reduce activity of many enzymes in the cell too. It seems when the amount of potassium compounds was greater than the limit in rhizospher it can intensify plant stress and decrease many enzymatic activities in cell**.** The other results showed that until 80 mM NaCl and zero KaCl the physiological traits in RGs003 were greater than other cultivar. The highest biomass was obtained from CS treatment at Licord Cultivar with 65.3 g. Other founding in physiological traits was showed that amount of photosynthesis until CS5 treatment level (Zero KCl and 60 mM NaCl) at the RGs003 cultivar in compared to control and other cultivar was increased about 14 and 67 percent respectively. While in this treatment, stomata conductance after control treatment had the greatest amount. Results of interaction CS in cultivar was showed that the highest biomass was observed in Licord × CS5 treatment that had more 16% than control and 34% higher than other cultivar in the same stress treatment.As regards increasing root dry weight in all salty stress levels and high photosynthesis rate in RGs003 cultivar and it seems that this cultivar much amount assimilates was shifted to root for growth improvement and establishment tolerance. Results of regression analyses showed there are a strong positive relationship between biomass and leaf area ($R2 = 0.86$) and leaf relative water content ($R2 = 0.66$) too. This relationship was also observed between biomass and photosynthesis.

Table1. Results of soil in any pots

Sample	pH	EC	P	K	N	OC	SAR	Na	Mg	Ca	Ca+Mg
		dS.m^{-1}	ppm		%			meq.l^{-1}			
Soil	7.3	2.3	12.5	206	0.142	0.71	5.8	15.3	12.2	10.0	22.2

Table2. Different levels of KCl in NaCl as applied a one factor.

Compounded of	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
KCl in NaCl (mM) Salinity (CS)	0 , 0	20 , 0	0 , 30	20 , 30	0 , 60	20 , 60	0 , 90	20 , 90

Table 3: Source of variation, degree of free and mean of squares of membrane stability index, relative water content, quantum yield, chlorophyll a, chlorophyll b, photosynthesis and stomata conductivity in two variety of canola plant under Compound Salinity (CS) stress in green house condition in Mashhad.

S.O.V	**Df**	**Membrane stability index**	**relative water content**	**quantum yield**	**chlorophyll a**	**chlorophyll b**	**photosynthesis**	**stomata conductivity**
Cultivar	1	501**	23.9ns	0.001ns	0.006ns	0.002**	718**	47741**
CS (compound salinity)	7	4358**	838**	0.003**	0.371**	0.091**	37.4**	2537**
Interaction CS × Cultivar	7	467**	129**	0.001**	0.022**	0.007**	6.97**	1140**
error	32	35.2	12.8	0.0004	0.004	0.001	0.755	7.3

Ns, * and ** are non- significant and significant at the 5 and 1% probability level respectively

Table 4- Source of variation, degree of free and mean of squares of leaf area, leaf weight, dry stem, volume of root, dry root, biomass, root to shoot ratio in two variety of canola under Compound Salinity (CS) in green house condition in mashhad.

S.O.V	**df**	**Leaf area**	**Leaf weight**	**Root Volume**	**Root Dry**	**Biomass**	**Root to Shoot Ratio**
Cultivar	1	43785**	0.051ns	931**	2.07**	1.41**	1.26**
CS (Compound Salinity)	7	49054**	1.37**	85.9**	1.10**	2.27**	0.056*
Interaction CS × Cultivar	7	26644**	0.815**	49.1**	0.469**	1.62**	0.086**
Error	32	2198	0.021	4.24	0.022	0.123	0.022

Ns, * and ** are non- significant and significant at the 5 and 1% probability level respectively

Table 5. Means comparison of traits as membrane stability index, relative water content, quantum yield, chlorophyll a and b, photosynthesis and stomata conductivity in two variety of canola was studied.

Cultivar	membrane stability index (%)	relative water content (%)	quantum yield	chlorophyll a (μg.g^{-1} fresh weight leaf)	chlorophyll b (μg.g^{-1} fresh weight leaf)	photosynthesis (μmol CO2.m^{-2}.sec^{-1})	stomata conductivity (mmol/m2.s)
RGs003	78.5	55.2	0.828	0.667	0.321	10.8	79.8
licord	84.9	53.6	0.822	0.645	0.308	3.14	16.7
	**	ns	ns	Ns	**	**	**

Table 6. Means comparison of traits as leaf area, leaf weight, dry stem, dry root, biomass, and root to shoot ratio in two variety canola was studied.

Cultivar	Leaf area (Cm^2)	Leaf weight (g)	Volume root (Cm^3)	Dry root (g)	Biomass (g)	(Root to Shoot Ratio)
RGs003	201	1.48	18.7	1.68	2.09	0.83
licord	262	1.55	9.9	1.26	2.43	0.51
	**	Ns	**	**	**	**

^{ns}, *and ** are non- significant and significant at the 5 and 1% probability level respectively

Table 7. Means comparison of membrane stability index, relative water content, quntum yield, chlorophile a and b, photosynthesis and stomata conductivity Compound Salinity (CS)

Treatment	membrane stability index (%)	relative water content (%)	quantum yield	chlorophyll a (μg.g^{-1} fresh weight leaf)	chlorophyll b (μg.g^{-1} fresh weight leaf)	photosynthesis (μmol CO2.m^{-2}.sec^{-1})	stomata conductivity
CS1	94.7a	72.3a	0.839a	0.882a	0.466a	9.54a	82.1a
CS2	96.9a	62.0b	0.837a	0.925a	0.439a	9.57a	58.8b
CS3	86.1b	59.4bc	0.838a	0.803b	0.383b	9.40a	56.6bc
CS4	81.6bc	57.3cd	0.836a	0.783b	0.353b	7.46b	53.7c
CS5	78.0cd	56.0cd	0.842a	0.658c	0.294c	7.11b	55.1c
CS6	75.8cde	53.1d	0.823a	0.577d	0.272c	5.68c	36.8d
CS7	71.2de	41.4e	0.819a	0.420e	0.211d	4.20d	23.5e
CS8	69.4e	34.6f	0.766b	0.199f	0.095e	3.13e	19.7f

Table 8. Means comparison of leaf area, leaf weight, dry stem, dry root, biomass, root to shoot ratio under Compound Salinity stress.

Treatment	Leaf area	Leaf weight (g)	Root Volume (Cm^3)	Dry root (g)	Biomass (g)	Root to Shoot Ratio
CS1	309a	1.47d	16.4bc	1.82ab	2,56bc	0.748ab
CS2	286ab	1.95b	17.3b	1.81ab	2.79ab	0.761a
CS3	237a	1.7c	14.5cd	1.30c	2.52bc	0.512d
CS4	303a	2.16a	13.8d	1.96a	3.02a	0.711abc
CS5	175c	1.52d	14.2cd	1.72b	2.01de	0.702abc
CS6	231b	1.63cd	20.0a	1.38c	2.34cd	0.765a
CS7	136cd	1.01e	9.9e	0.990d	1.73e	0.572cd
CS8	85d	0.680f	8.4e	0.770e	1.13f	0.576bcd

* Means, that the difference between them is lower than tha amount of LSD, are not significantly different at α=0.05 by LSD test

Table 9: Means comparison of interaction treatment in variety on membrane stability index, relative water content, quantum yield, chlorophyll a and b, photosynthesis and stomata conductivity under Compound Salinity (CS)

Treatment	membrane stability index (%)	relative water content (%)	chlorophyll a (μg.g^{-1} fresh weight leaf)	chlorophyll b (μg.g^{-1} fresh weight leaf)	photosynthesis (μmol CO2.m^{-2}.sec^{-1})	quantum yield	stomata conductivity
CS1×Cult1	91.9ab	66.7b	0.920b	0.438bc	12.4b	0.852a	138.5a
CS2× Cult1	95.4a	56.5cde	0.820bc	0.391cd	14.9a	0.831abc	91.9c
CS3× Cult1	80.0cde	57.6def	0.787cd	0.375de	11.4b	0.827abc	86.4d
CS4× Cult1	78.7cde	56.8def	0.763cde	0.363def	11.6b	0.829abc	89.4cd
CS5× Cult1	72.3ef	55.9def	0.700def	0.333ef	14.2a	0.850ab	97.7b
CS6× Cult1	68.8f	54.5ef	0.677ef	0.322f	9.66c	0.817bc	61.5e
CS7× Cult1	65.5f	47.6gh	0.470gh	0.247g	7.31d	0.809c	36.7f
CS8× Cult1	75.1cdef	43.1h	0.200i	0.095i	5.29ef	0.806c	36.3f
CS1× Cult2	97.5a	77.9a	0.840bc	0.493a	6.59de	0.826abc	25.6g
CS2× Cult2	98.3a	64.5bc	1.03a	0.487ab	4.14g	0.843ab	25.7g
CS3× Cult2	92.0ab	61.3bcd	0.820bc	0.390cd	3.50gh	0.848ab	21.0h
CS4× Cult2	84.5bc	57.9de	0.803cd	0.342ef	2.60hi	0.843ab	20.7h
CS5× Cult2	83.6bc	56.0def	0.617f	0.255g	4.56fg	0.834abc	15.5i
CS6× Cult2	82.7bcd	51.7fg	0.477g	0.227gh	1.70ij	0.828abc	12.0ij
CS7× Cult2	73.3def	35.1i	0.370h	0.176h	1.08j	0.828abc	10.3j
CS8× Cult2	67.4f	26.1j	0.198i	0.094i	0.960j	0.725d	3.10k

Cult1: RGs003 ،Cult2 Licord, CS: Compound Salinity

Table10. Mean comparisons of interaction treatment in variety on leaf area, leaf weight, dry root, biomass, root to shoot ratio under Compound Salinity (CS).

Treatments	Leaf area (Cm^2)	Leaf weight (g)	Dry root (g)	Volume root (Cm^3)	Biomass (g)	Root to Shoot Ratio
CS1×Cult1	239cd	1.31ef	1.88bcd	20.0bc	2.06defg	0.916ab
CS2× Cult1	141ef	1.21fg	1.99ab	20.3b	1.88defg	1.08a
CS3× Cult1	241cd	2.07c	0.960h	16.7cd	2.34cdef	0.416ef
CS4× Cult1	294c	2.00c	2.16a	14.7de	2.40cde	0.936ab
CS5× Cult1	193def	1.50de	1.72cdef	18.7bc	2.16cdefg	0.844abc
CS6× Cult1	206de	1.57d	1.92abc	30.0a	2.22cdefg	0.910ab
CS7× Cult1	151ef	1.03g	1.39g	14.3de	1.77fg	0.789bcd
CS8× Cult1	146ef	1.16fg	1.39g	15.2de	1.89defg	0.751bcd
CS1× Cult2	379ab	1.62d	1.75bcdef	12.8ef	3.05b	0.580def
CS2× Cult2	432a	2.68a	1.62efg	14.3de	3.71a	0.437ef
CS3× Cult2	413a	1.32ef	1.65def	12.3ef	2.70bc	0.608cde
CS4× Cult2	313bc	2.32b	1.77bcde	13.0ef	3.65a	0.485ef
CS5× Cult2	157ef	1.55de	1.03h	9.7f	1.85efg	0.560def
CS6× Cult2	256cd	1.69d	1.52fg	10.0f	2.46cd	0.620cde
CS7× Cult2	121f	0.980g	0.600i	5.5g	1.69g	0.356f
CS8× Cult2	23.0g	0.210h	0.150j	1.7h	0.360h	0.401ef

Cult1: RGs003; Cult2: Licord, CS: Compound Salinity

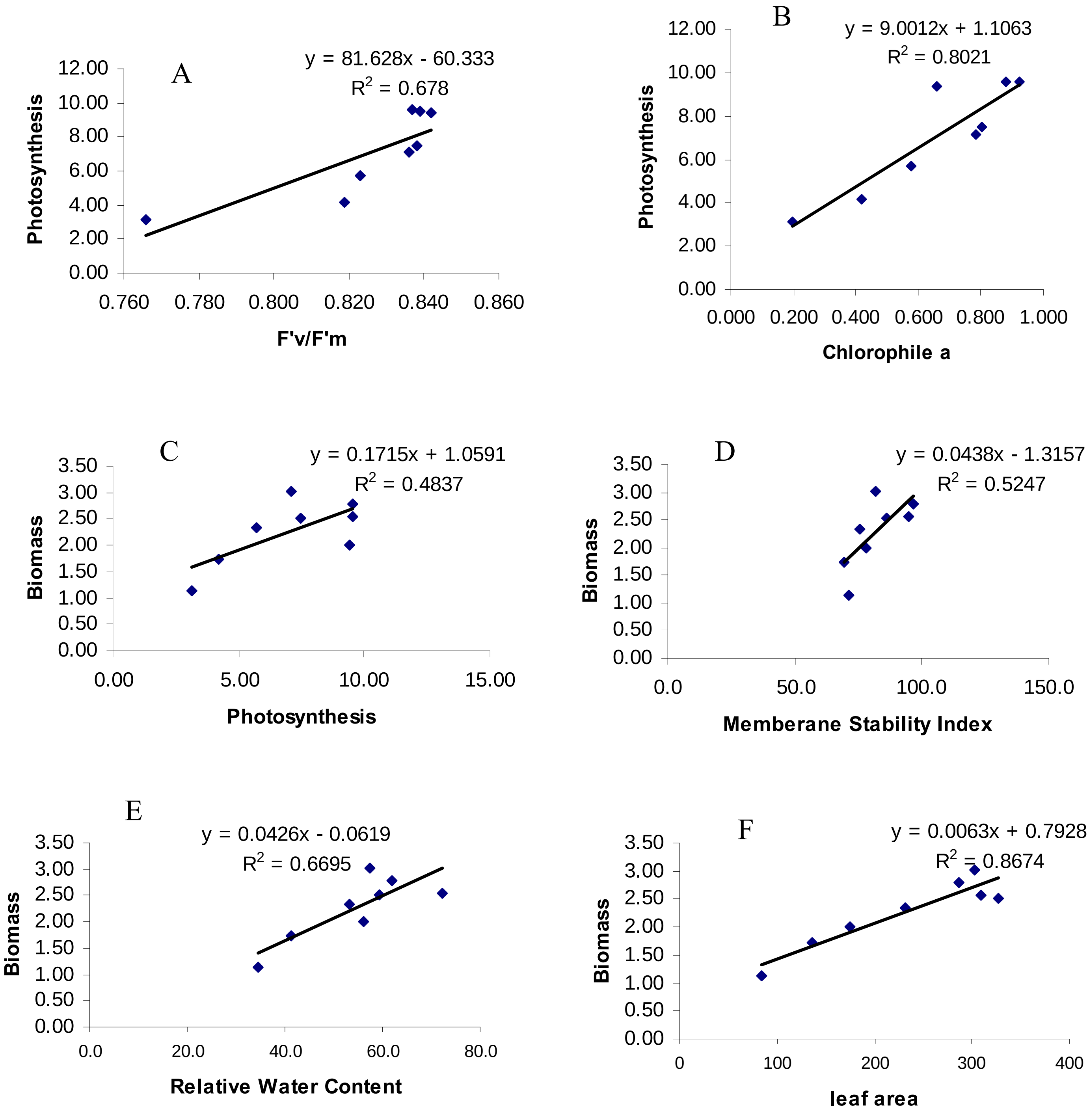

Figure 1. Relative between, A) Photosynthesis with Quantum yield, B) Photosynthesis with Chlorophyll a, C) Biomass with Photosynthesis, D) Biomass with membrane stability index, E) Biomass with Relative water content and F) Biomass with Leaf area under Compound Salinity (CS) condition.

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تأثير كلوريد الصوديوم و البوتاسيوم على الجوانب الفسيولوجية للنوعين من زيت الكانولا

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ملخص

من أجل التحقيق في رد فعل من الصفات المورفولوجية الفسيولوجية في الكانولا في النمو في وقت مبكر مراحل أجريت تجربة في ظروف الاحتباس الحراري يتكون العلاج من كلوريد الصوديوم في أربعة مستويات، مستويين من بوكل ونوعين من الكانولا وأظهرت النتائج كشف أن كمية الضوئي في RGs003 في مقارنة من Licord وزادت العلاج السيطرة 67 و 14 في المئة على التوالي في العلاج T5 كان الموصلية الثغور أكبر من العلاج T5 التطبيقية من العلاجات الأخرى باستثناء السيطرة وقد لوحظ في أقصى الكتلة الحيوية في Licord التي زادت 34 في المئة في مقابل متنوعة أخرى في العلاج كان وزن الجذور الجافة في RGs003 أكبر من Licord متنوعة وقد أظهرت نتائج الانحدار معامل علاقة إيجابية بين الصفات المورفولوجية في أي مستوى من مستويات الملوحة أنه لا ضرورة لبذل المزيد من التحقيق في مجموعة من هذه التراكيب الكتلة الحيوية وأوراق المنطقة (R2= 0.86) من الكتلة الحيوية والمحتوى المائي النسبي (R2= 0.66) نتائجنا تظهر أنه في ظل ارتفاع نسبة الملوحة والظروف العادية، كان Licord الصنف أدنى أعلى الكتلة الحيوية وعلى التوالي النتائج التي توصلنا إليها تظهر أن تحت الملوحة العالية وظروف طبيعية، الصنف ليكورد كان أدنى وأعلى الكتلة الأحيائية على التوالي. وهذا يدل على أن الصنف RGs003 تبين ارتفاع متوسط الأداء تحت ظروف الملوحة العالية ومع ذلك، إذا كان الشرط العادي، من المستحسن الصنف ليكورد عالية الأداء.

الكلمات الدالة: الكتلة الحيوية، الضوئي، قرنة للنبات، ملوحة.

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