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# EFFECT OF DILUTED SEAWATER ON SEED GERMINATION AND SEEDLING GROWTH OF THREE LEGUMINOUS CROPS (PEA, CHICKPEA AND COMMON BEAN)

## SUMMARY

Seawater intrusion into fresh water aquifers is due to natural processes or human activities, and consequently salinization results not only from the ground but also from irrigation water. In an attempt to evaluate the effect of seawater irrigation on seedling growth and germination, seeds of three leguminous crops (*Pisum sativum*, *Cicer arietinum* and *Phaseolus vulgaris*) were irrigated with Mediterranean seawater of different concentrations (0, 10, 30, 50 and 100%) for 8-day period. Various parameters such as germination kinetics, mean germination time, germination rate index, shoot and root length, fresh and dry weight and moisture content were analysed.

The results showed that these species were able to germinate at different salinity levels, except for 100% seawater which resulted in total inhibition of germination. Compared with control, seed germination in all species remained unaffected up to 30% of seawater treatments. Indeed, the final germination percentage was maintained between 90 and 100%. A solution of 50% seawater significantly reduced germination rate index and increased mean germination time. 10% of seawater increased shoot and root length in all species compared to the control. The saline conditions reduced the growth parameter such as fresh and dry shoot and root weights of the three-studied species. Shoot and root dry weight was stable by 10, 30 and 50% of seawater except for *P. vulgaris* seedlings. The decrease in moisture content begins from 30% of seawater solution compared to the control in *P. sativum* and *C. arietinum* seedlings. However, it was maintained stable for *P. vulgaris* compared to the control.

**Keywords:** Salt-tolerance, agriculture, moisture content, irrigation.

## INTRODUCTION

Salinity is one of the major abiotic factors that limits plant growth and productivity in many regions of the world due to increasing use of poor quality of water for irrigation and soil salinization (Chen and Jiang 2010; D'Odorico *et al*., 2013; Shrivastava and Kumar, 2015). 20% of croplands in world contain high enough concentrations of salt to cause a salt stress for plants (Shelef *et al*., 2012). Considerable reduction of the plant growth is generally due to salt stress, except

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that these reductions vary from a species to the other one. Salinity tolerance of some cultivated legumes varieties turns out thus crucial for the country's economy.

The legume crops have a very important part of several research in agronomy (Williams *et al.*, 2014; Popovic *et al.*, 2015; Popovic *et al.*, 2016), genetic (Smýkal *et al*., 2015), entomology (Söğüt *et al*., 2014; Duan *et al*., 2014), phytopathology (Khan *et al.*, 2014) and physiology (Neugschwandtner *et al.*, 2015). Leguminous plants also maintain a very privileged relationship with the rhizosphere. Their agronomic interest results first of all from their ability to establish a mutualistic symbiosis with bacteria belonging to *Rhizobia* family for the utilization of atmospheric nitrogen as a nitrogen source (Giri and Joshi, 2010; Iantcheva *et al*., 2013). It is estimated that approximately 40-60 million metric tons of atmospheric nitrogen is fixed by cultivated legume plants annually (Robertson *et al*., 2013). Indeed, this symbiosis allows them to produce in abundance proteins even in the absence of nitrogenous fertilization (Pérez-Montaño *et al*., 2014). They play consequently a key role in the crop rotation (Nemecek *et al*., 2015).

The salinization results not only from the ground but also from irrigation water. Indeed, in the arid and semi-arid lands, the agricultural production requires irrigation especially with the shortage of rain (Chen *et al*., 2010). These water resources of irrigation come generally from groundwater and contain variable quantities of dissolved salts (Prasanth *et al*., 2012). In the Mediterranean countries as Algeria, the legume crops are often cultivated near the coastal regions where we attend an increase of the salt stress. Therefore, a vast use of irrigation waters calls up to the intrusion of seawater. Seawater intrusion is the movement of seawater into fresh water aquifers due to natural processes or human activities. Indeed, seawater intrusion is caused by decreases in groundwater levels or by rises in seawater levels (Werner *et al*., 2013). The use of poor quality water thus results in an increase of salinization level in the soil which can have negative effects on yield (Arslan, 2013). On the other hand, the available fresh water resources for agriculture declined regarding quantity and quality of both surface water and groundwater systems (Liu *et al*., 2016). Therefore, the use of lower quality water for irrigation purposes is inevitable to maintain economically viable crops. According to the dilution levels tested on some plants, seawater has proved even an excellent natural fertilizer and can contain several minerals very useful for the plant growth (Glenn *et al*., 1998; Tawfik *et al*., 2011; Ventura *et al*., 2015; Kheloufi et *al*., 2016a).

The plant adaptation in salt environment is crucial at the seedling stage for best species establishment. The first stage of development is thus the most vulnerable in this salt constraint because the passage of this one will determine the evolution of the cultivated species. Indeed, the salinity can affect the seedling by creating osmotic potential which prevent the imbibition of water, or by exercising toxic effects on the viability of the embryo (Chaves *et al*., 2009). The improvement of certain salt tolerant species is of a major importance. So, the scientific research should concentrate on mechanisms implied in this salt tolerance. The aim of the present study was to investigate seed germination and seedling growth of three leguminous crops: “*Pisum sativum* (L.), *Cicer arietinum* (L.) and *Phaseolus vulgaris* (L.)” to gradient salinity. For this purpose, seeds and seedlings were subjected to various levels of seawater solutions, and an analysis of the parameters related to germination, growth and moisture content was made.

## MATERIALS AND METHODS

### Experimental material and salt treatments

Factorial combinations of three species and five levels were salinity test treatments. Seeds of pea (*P. sativum* var. *Arvense*), chickpea (*C. arietinum* var. *Temouchent*) and bean (*P. vulgaris* var. *Djadida*) were kindly provided by the Technical Institute of Field Crops (ITGC), Sidi bel abbes (Algeria). Seawater was provided from coastal site of Oran (Algeria) (35°40'36.82"N; 1°1'30.54"O). Different seawater concentrations of 0, 10, 30, 50 and 100% were created using distilled water. Three replicates of 15 seeds each were used for each treatment. Germination experiments were carried out in plastic boxes (5 cm height, 15 cm length and 8 cm width) with two-layer wet filter paper (Whatman No. 1) moistened with 25 ml of the appropriate solution of seawater or distilled water for 0% (Control).

The germination rate was recorded every 2-day for 8 day-period. First of all, the seeds were surface sterilized with 5% of sodium hypochlorite for 5 minutes to avoid fungal invasion, followed by washing with distilled water. Seeds were incubated under continuous dark at 23˚C ± 2˚C (Celsius) in controlled temperature room. The papers were changed with the same treatment each 2 day to prevent salt accumulation. The seeds were moistened with the appropriate solutions of seawater and kept wet throughout the experiment. Seeds were considered as germinated when the radicle had protruded 2 mm through the seed coat (Côme, 1970).

### Germination parameters

In order to characterize salinity tolerance, several parameters were calculated:

*Germination kinetics*: for better apprehending the physiological significance of germination behaviour, the number of germinated seeds was counted every 2-days until the 8$^{th}$ day of the experiment.

*Final germination percentage* (FGP): this parameter constitutes the best identification means of salt concentration which presents the physiological limit of germination. It is expressed at the 8$^{th}$ day of the experiment by the following equation:

$$\text{FGP (\%)} = \frac{\text{Number of germinated seed}}{\text{Total Number of seed tested}} \times 100$$

*Germination rate index* (GRI): It reflects the percentage of germination on each day of the germination period (Maguire, 1962).

$$\text{GRI (\%)} = \sum \frac{\text{Number of Germinated Seeds}}{\text{Number of Days}}$$

*Mean germination time* (MGT): It represents the meantime, a seed lot requires to initiate and end germination (Orchard, 1977).

$$\text{MGT (days)} = \frac{\sum n \times D}{\sum n}$$

n: number of seeds newly germinated at time D; D: days from the beginning of the germination test; Σn: final germination.

**Seedling growth parameters**

After 8-day period, shoot length was immediately measured by caliper. Roots and shoots were separated and blotted. Fresh weight (FW) was immediately determined and then samples were dried in an oven at 80°C for 48h to obtain dry weight. Moisture content (MC) was estimated using the following formula as described by Wu *et al*. (2013):

$$\text{MC (\% FW)} = \frac{\text{FW} - \text{DW}}{\text{FW}} \times 100$$

The average of a water content of the plant is a very used method at present, to estimate the hydric state of the plant in the condition of hydric stress.

**Statistical analysis**

The experiment was made as a completely randomized design with 3 replicates of 15 seeds (n=3) for the germination parameters and with 15 replicates (n=15) for the seedlings growth parameters. The data were statistically treated by Fisher's analysis of variance (ANOVA). The Generalized Linear Model (GLM) was used in the kinetic of germination (Repeated Measures Analysis of Variance). Duncan's multiple range tests were performed to determine significant difference between means at a significance level of 5% using SAS software version 9.0 (SAS 2002).

## RESULTS AND DISCUSSION

In this study, four concentrations (10, 30, 50 and 100 %) of seawater were used to irrigate three leguminous crops in order to evaluate the effect of seawater salinity in plant germination and growth.

**Germination parameters**

The effect of salinity on germination kinetics is presented on Figure 1. First of all, using high concentration of seawater (100 %) resulted in total inhibition of germination. The effect of the external salinity on the seed germination may be partially osmotic or ion toxicity which can alter physiological processes such as enzyme activation (El-Keblawy, 2004; Chinnusamy *et al*., 2005; Nichols *et al*., 2009). This toxic effect can lead to metabolic processes changes in seedlings and at the extreme case in the death of embryo by ion accumulation (El-Keblawy, 2004). The osmotic or toxic effect can be verified by salinity recovery test (Kheloufi *et al*., 2016b). A Two-way ANOVA indicated that germination kinetics of the three leguminous seeds was significantly affected by the factor species (F=3.73, p=0.0357), time (F=1839.52, P<0.0001), seawater concentration (F=390.56, P<0.0001) and by their correlation (F=4.65, P<0.0001). Compared with control, seed germination in the three-species remained unaffected up to 30 % of seawater treatments. Indeed, the final germination percentage was maintained between 90 and 100 %. A further increase in salinity (50 % of seawater) has inhibited a few rates of seed germination in all the studied species with (86.7 %) in the case of *P. sativum*, following by (73.3 %) and (71.1 %) for *C. arietinum* and *P. vulgaris*, respectively. The decrease of FGP follows the increase of external osmotic pressure, what allocates the water absorption by seeds and/or to an ion accumulation ($Na^+$ and $Cl^-$) in the embryo (Debouba *et al.*, 2006; Ghogdi *et al.*, 2013).

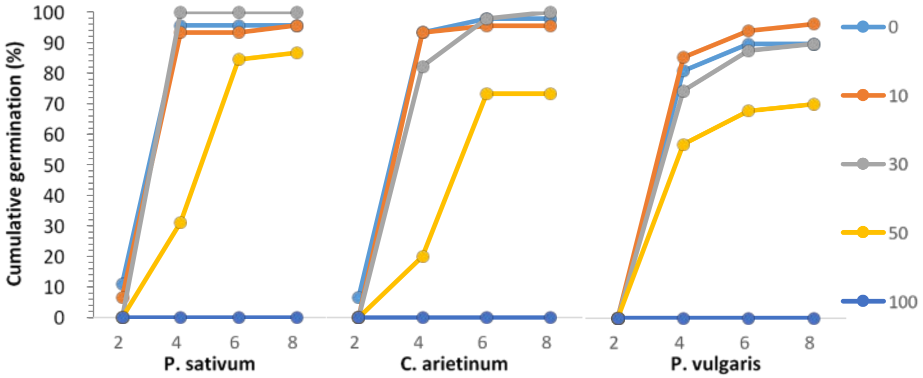


**Figure 1.** Effects of various seawater concentrations (0 to 100%) on the germination kinetics of three leguminous crops (*P. sativum*, *C. arietinum* and *P. vulgaris*) seeds over an 8-day period.

Final germination percentage was higher in non-saline controls and higher in *P. sativum* and *C. arietinum* seeds than *P. vulgaris* seeds in all treatments. Under salinity treatment, the highest rate of germination (100%) was recorded in P. sativum and *C. arietinum* seeds at 30% of seawater and the highest rate of 97.78% was obtained at 10 % of seawater in *P. vulgaris* seeds. In the three species, the germination was completely inhibited at 100% of seawater concentration. In non-saline control, highest germination was recorded at (3.77 days) in *P. sativum* following by MGT of (3.95 days) and (4.19 days) for *C. arietinum* and *P. vulgaris*, respectively (Table 1). The data presented on Figure 1 also showed marked differences in the timing of initiation and completion of germination. The MGT increased significantly (P<0.0001) by increasing the seawater concentration. Increase of salinity also delayed the germination at 50 % of seawater where the highest rate was reached at the 6th day with reduced values in *C. arietinum* seeds and at the 8th day for the seeds of *P. sativum* and *P. vulgaris* (Figure 1). Delay in germination by increased salt concentration may be explained by the lower osmotic potential of the solution (Nonogaki *et al.*, 2010).

Compared with control, a solution of 50 % seawater significantly reduced germination rate index (GRI) (p<0.05) and increased mean germination time

(MGT) (Tableau 1). It was shown that higher FGP, GRI, and lower MGT represent higher and faster seed germination (Panuccio *et al.*, 2014; Kheloufi, 2017).

The results also showed that the three-leguminous species were able to germinate at different salinity concentration. Our results indicated that high salinity remarkably inhibited seed germination and delayed germination time in all studied species. Similar results were recorded in other crops such as fava bean (*Vicia faba*) (Yang *et al*., 2013), wheat (*Triticum aestivum*) (Hussain *et al*., 2013), and lentil (*Lens culinaris*) (Al-Quraan *et al*., 2014).

**Table 1.** Effects of different seawater (SW) concentrations on final germination percentage (FGP), mean germination time (MGT), germination rate index (GRI), shoot length (SL), shoot fresh weight (SFW), shoot dry weight (SDW), shoot moisture content (SMC), root length (RL), root fresh weight (RFW), root dry weight (RDW), root moisture content (RMC) in three leguminous species (SP) (*P. sativum*, *C. arietinum* and *P. vulgaris*) for 8 day-period.

| SP | SW (%) | Germination | | | Seedling shoots growth | | | | Seedling root growth | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FGP (%) | MGT (day) | GRI (%) | SL (cm) | SFW (g) | SDW (g) | SMC (%) | RL (cm) | RFW (g) | RDW (g) | RMC (%) |
| *P. sativum* | 0 | 95.6$^{a}$ | 3.77$^{b}$ | 57.3$^{a}$ | 4.75$^{b}$ | 0.29$^{b}$ | 0.14$^{c}$ | 50.8$^{a}$ | 5.12$^{b}$ | 0.41$^{a}$ | 0.15$^{c}$ | 62.7$^{a}$ |
| | 10 | 95.6$^{a}$ | 3.94$^{b}$ | 54.2$^{a}$ | 6.07$^{a}$ | 0.32$^{a}$ | 0.17$^{a}$ | 49.2$^{a}$ | 8.73$^{a}$ | 0.38$^{b}$ | 0.16$^{a}$ | 56.3$^{b}$ |
| | 30 | 100$^{a}$ | 4.00$^{b}$ | 54.2$^{a}$ | 3.84$^{c}$ | 0.23$^{c}$ | 0.16$^{a}$ | 29.5$^{b}$ | 3.66$^{c}$ | 0.24$^{c}$ | 0.15$^{b}$ | 37.8$^{c}$ |
| | 50 | 86.7$^{a}$ | 5.32$^{a}$ | 32.7$^{b}$ | 1.41$^{d}$ | 0.18$^{d}$ | 0.16$^{b}$ | 11.9$^{c}$ | 1.64$^{d}$ | 0.18$^{d}$ | 0.13$^{d}$ | 24.9$^{d}$ |
| | 100 | 0.00$^{b}$ | - | 0.00$^{c}$ | 0.00$^{e}$ | 0.00$^{e}$ | 0.00$^{d}$ | - | 0.00$^{e}$ | 0.00$^{e}$ | 0.00$^{e}$ | 0.00$^{e}$ |
| *C. arietinum* | 0 | 97.8$^{a}$ | 3.95$^{b}$ | 55.2$^{a}$ | 5.30$^{a}$ | 0.34$^{a}$ | 0.08$^{b}$ | 73.2$^{a}$ | 8.17$^{a}$ | 0.41$^{a}$ | 0.10$^{b}$ | 73.9$^{a}$ |
| | 10 | 95.6$^{a}$ | 4.04$^{b}$ | 51.2$^{a}$ | 5.93$^{a}$ | 0.32$^{ab}$ | 0.10$^{a}$ | 66.6$^{b}$ | 6.81$^{b}$ | 0.43$^{a}$ | 0.11$^{a}$ | 73.7$^{a}$ |
| | 30 | 100$^{a}$ | 4.40$^{b}$ | 49.35$^{a}$ | 3.68$^{b}$ | 0.28$^{b}$ | 0.10$^{a}$ | 63.56$^{b}$ | 4.09$^{c}$ | 0.25$^{b}$ | 0.10$^{b}$ | 57.72$^{b}$ |
| | 50 | 73.3$^{b}$ | 5.45$^{a}$ | 26.4$^{b}$ | 0.00$^{c}$ | 0.00$^{c}$ | 0.00$^{c}$ | - | 0.58$^{d}$ | 0.14$^{c}$ | 0.09$^{c}$ | 33.0$^{c}$ |
| | 100 | 0.00$^{c}$ | - | 0.00$^{c}$ | 0.00$^{c}$ | 0.00$^{c}$ | 0.00$^{d}$ | - | 0.00$^{d}$ | 0.00$^{d}$ | 0.00$^{d}$ | - |
| *P. vulgaris* | 0 | 91.1$^{a}$ | 4.19$^{a}$ | 47.1$^{a}$ | 16.6$^{b}$ | 1.03$^{b}$ | 0.11$^{b}$ | 88.4$^{a}$ | 6.14$^{b}$ | 0.18$^{c}$ | 0.04$^{c}$ | 75.8$^{a}$ |
| | 10 | 97.8$^{a}$ | 4.28$^{a}$ | 49.8$^{a}$ | 20.4$^{a}$ | 1.66$^{a}$ | 0.17$^{a}$ | 89.8$^{a}$ | 8.29$^{a}$ | 0.28$^{b}$ | 0.09$^{a}$ | 77.2$^{a}$ |
| | 30 | 91.1$^{a}$ | 4.39$^{a}$ | 45.1$^{a}$ | 5.76$^{c}$ | 0.40$^{c}$ | 0.08$^{c}$ | 80.5$^{b}$ | 7.43$^{a}$ | 0.34$^{a}$ | 0.08$^{b}$ | 67.2$^{b}$ |
| | 50 | 71.1$^{b}$ | 4.44$^{a}$ | 34.8$^{b}$ | 0.51$^{d}$ | 0.08$^{d}$ | 0.03$^{d}$ | 66.8$^{c}$ | 1.60$^{c}$ | 0.08$^{d}$ | 0.03$^{d}$ | 70.1$^{b}$ |
| | 100 | 0.00$^{c}$ | - | 0.00$^{c}$ | 0.00$^{d}$ | 0.00$^{d}$ | 0.00$^{e}$ | - | 0.00$^{d}$ | 0.00$^{e}$ | 0.00$^{e}$ | - |

$^{a,b,c,d,e}$ Means followed by the same letters in the same column and within the same age are not significantly different ($p < 0.05$). Values are the average of 3 replicates of 15 seeds for germination parameters and the average of 15 replicates for seedlings growth parameters.

Delayed germination in seed of all species compared to controls with the increase of seawater concentration is explained by the time required to the seed to set up mechanisms allowing to adjust their osmotic internal pressure (Farissi *et* *al*., 2011). The seed reserve mobilization depends on the activation of hydrolytic enzymes (Tan-Wilson and Wilson, 2012).

**Growth parameters**

The Two-way ANOVA presented on Table 3 shows that species and treatment and their correlation (Treatment × Species) significantly ($P<0.0001$) affect all seedling growth parameters. Table 1 showed that high lengths were recorded in seedlings treated with 10% of seawater. 10% of seawater increased shoot length in all species compared to the control. Indeed, shoots length of *P. vulgaris* increased from (16.6 cm) to (20.43 cm), those of *P. sativum* from (4.75 cm) to (6.07 cm) and finally shoots of *C. arietinum* increased from (5.30 cm) to (5.93 cm) (table 1). At the same diluted solution of seawater, the root lengths also increased but only in *P. sativum* and *P. vulgaris* seedlings with mean values of (8.73 cm) and (8.29 cm), respectively. The root length decreased significantly ($P<0.0001$) with the increase of salinity until reached its low development at 50% of sweater with mean values close to one cm in the three-leguminous species. Increase the concentration of seawater up to 30% made significant delay in development by decreasing lengths by half in *P. sativum* and *C. arietinum*, and by four-times in *P. vulgaris* seedlings. At 50% of seawater, no shoots appeared in *C. arietinum*. On the other hand, the seedlings of *P. sativum* and *P. vulgaris* recorded low lengths with (1.41 cm) and (0.51 cm), respectively.

**Table 2.** Analysis of variance testing the effect of time after sowing (Time), species (SP) (*P. sativum*, *C. arietinum* and *P. vulgaris*) and seawater treatments (TRT) on the variation of germination parameters (germination kinetics, final germination percentage 'FGP', mean germination time 'MGT', germination rate index 'GRI').

| Parameters | Sources of variation | *Df* | *F* | *P* |
|---|---|---|---|---|
| Germination Kinetics | Species 'Sp' | 2 | 3.73 | 0.0357 |
| | Time after sowing 'Time' | 3 | 1 839.52 | <0.0001 |
| | Seawater concentration 'TRT' | 4 | 390.56 | <0.0001 |
| | Sp × Time | 6 | 1.28 | 0.2745 |
| | Sp × TRT | 8 | 1.73 | 0.1320 |
| | Time × TRT | 12 | 142.22 | <0.0001 |
| | Sp × Time × TRT | 24 | 4.65 | <0.0001 |
| FGP | TRT | 4 | 316.28 | <0.0001 |
| | Sp | 2 | 2.18 | 0.1306 |
| | TRT × Sp | 8 | 1.13 | 0.3723 |
| MGT | TRT | 4 | 46.64 | <0.0001 |
| | Sp | 2 | 2.67 | 0.0899 |
| | TRT × Sp | 8 | 8.09 | <0.0001 |
| GRI | TRT | 4 | 346.90 | <0.0001 |
| | Sp | 2 | 5.69 | 0.0081 |
| | TRT × Sp | 8 | 2.75 | 0.0208 |

**Table 3.** Two-way ANOVA testing the effect of species (SP) (*P. sativum*, *C. arietinum* and *P. vulgaris*) and seawater treatment (TRT) on the variation of seedlings growth parameters (shoot length 'SL', shoot fresh weight 'SFW', shoot dry weight 'SDW', shoot moisture content 'SMC', root length 'RL', root fresh weight 'RFW', root dry weight 'RDW', root moisture content 'RMC').

| Parameters | | Sources of variation | *Df* | *F* | *P* |
|---|---|---|---|---|---|
| Shoot | SL | TRT | 4 | 663.53 | <0.0001 |
| | | Sp | 2 | 491.59 | <0.0001 |
| | | TRT × Sp | 8 | 153.07 | <0.0001 |
| | SFW | TRT | 4 | 359.81 | <0.0001 |
| | | Sp | 2 | 376.64 | <0.0001 |
| | | TRT × Sp | 8 | 134.96 | <0.0001 |
| | SDW | TRT | 4 | 922.34 | <0.0001 |
| | | Sp | 2 | 604.30 | <0.0001 |
| | | TRT × Sp | 8 | 120.39 | <0.0001 |
| | SMC | TRT | 4 | 2 583.22 | <0.0001 |
| | | Sp | 2 | 1 603.99 | <0.0001 |
| | | TRT × Sp | 8 | 219.82 | <0.0001 |
| Root | RL | TRT | 4 | 344.01 | <0.0001 |
| | | Sp | 2 | 11.06 | <0.0001 |
| | | TRT × Sp | 8 | 17.20 | <0.0001 |
| | RFW | TRT | 4 | 469.08 | <0.0001 |
| | | Sp | 2 | 48.96 | <0.0001 |
| | | TRT × Sp | 8 | 35.37 | <0.0001 |
| | RDW | TRT | 4 | 6 416.88 | <0.0001 |
| | | Sp | 2 | 6 433.16 | <0.0001 |
| | | TRT × Sp | 8 | 514.27 | <0.0001 |
| | RMC | TRT | 4 | 230.30 | <0.0001 |
| | | Sp | 2 | 372.09 | <0.0001 |
| | | TRT × Sp | 8 | 60.48 | <0.0001 |

The saline conditions reduced the growth parameter such as fresh and dry shoot and root weights of the three-studied species as have been similarly reported by several authors (Long *et al*., 2010; Ventura *et al*., 2011; Vibhuti *et al*., 2015; Petrović *et al*., 2016). The reduction of the dry weights due to increased salinity may be a result of a combination of osmotic and specific ion effects (Khan *et al*., 2015). One of the initial effects of salinity on plants is the reduction of growth rate (Munns *et al*., 1995). These results are in agreement with the findings of Hirich *et al*. (2014) who reported a significant decline in shoot length at high salinity levels.

Data presented in Table 1 shows that shoot and root fresh weight was decreased with different seawater concentrations except for 10% seawater solution. In the three species, there was gradually decreased of fresh weight as compared to the control plants. Using high concentration of seawater (50%)

resulted in the highest value of decline in root than shoot. Moreover, data in Table 1 showed that shoot and root dry weight was constant by 10, 30 and 50% of diluted seawater except for *P. vulgaris* seedlings. Reduction in FW at high salinity might be due to poor absorption of water from the growth medium due to physiological drought (Munns and Gillham, 2015).

Table 1 also shows the effect of salt concentration on moisture content. The decrease in moisture content begins from 30% of seawater solution compared to the control in *P. sativum* and *C. arietinum* seedlings. However, seedlings water content of *P. vulgaris* was maintained stable compared to the control. Another related trait important to plant function is the ability to maintain water content in tissues at optimal levels in the face of environmental stress. Plants under stress often lose some water from their tissues, which can have rapid and large effects on cell expansion, cell division, stomatal opening, abscisic acid accumulation, etc. (Hsiao and Xu, 2000). Most of these effects become evident with no change in turgor pressure, although water potential can become more negative due to osmotic potential becoming more negative (Negrão *et al*., 2016).

During germination stage, the radicle emergence would be controlled by the environment osmolarity, while the later growth of the seedling would be limited by the reserve mobilization and their transport towards the embryonic axis (Hager *et al*., 2014). The study of the effects of various concentrations of seawater on the seed germination showed that neither the FGP, nor the MGT and GRI are affected by the salt to a concentration 30% of seawater. But, in higher concentrations, they become sensitive. Reduction in seedlings growth was also recorded in response to increasing salt stress. In glycophytes species, salinity can reduce the growth of plants or damage the plants through osmotic effect (it causes water deficit); toxic effects of ions; and imbalance of the uptake of essential nutrients (Roy *et al*., 2014; Parihar *et al*., 2015).

## CONCLUSIONS

The use of seawater in agriculture can offers an alternative substitute to fresh water but with respected dilution to each plant species. Our study showed that irrigation with seawater did not affect germination and seedlings growth of *P. sativum*, *C. arietinum* and *P. vulgaris* at 10 and 30% concentrations. So, at these levels, coastal underground water cannot be so harmful for these species establishment. However, further experiments are needed to evaluate the effect of saline water irrigation on yield and crop production.

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