EFFECT OF SALT (NACL) STRESS ON GERMINATION AND EARLY SEEDLING GROWTH OF FOUR VEGETABLES SPECIES

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ABSTRACT

Due to increasing salinity problems, in this experiment four vegetables species were treated with different concentration of salt solution to study salt effect. Results indicated that salinity caused significant reduction in germination percentage, germination rate, root and shoot lengths and fresh root and shoot weights. Liner relation was developed to find relation between salt stress and plant growth and also between germination and rest of plant characters.

KEY WORDS: vegetables, germination, seedling growth, salinity tolerance, relationship

INTRODUCTION

The two major environmental factors that currently reduce plant productivity are drought and salinity [1]. Salinity is one of the major obstacles to increasing production in crop growing areas throughout the world. In spite of this extensive literature there is still a controversy with regard to the mechanisms of salt tolerance in plants [2]. Salinity in soil or water is one of the major stresses and especially in arid and semi arid regions, can severely limit crop production [3].

Salinity impairs seed germination, reduces nodule formation, retards plant development and reduces crop yield [4]. The plants that grow in saline soils have diverse ionic compositions and a range in concentrations of dissolved salts [5]. These concentrations fluctuate because of changes in water source, drainage, evapo-transpiration, and solute availability [5]. Successful seedling establishment depends on the frequency and the amount of precipitation as well as on the ability of the seed species to germinate and grow while soil moisture and osmotic potentials decrease [6]. These salts interfere with seed germination and crop establishment [7]. Germination and seedling characteristics are the most viable criteria used for selecting salt tolerance in plants [8]. Salinity stress can affect seed germination through osmotic effects [9].

Cabbage is moderately sensitive to soil salinity but sugar beet is one of the most salt tolerant crops. But it is reported to be less tolerant of salinity during germination, emergence, and in the seedling stage [10]. The two species of canola B. napus and B. campestris are classified as tolerant to salinity reported by Maas and Hoffman [11]. Maas [12] also reported that even though both the species exhibit high salinity thresholds, the rate of yield decline above the thresholds was much greater than most other crops in the tolerant category.

The present study was initiated to investigate the influence of salinity on the germination and early seedling growth of sugar beet, cabbage, amaranth and pak-choi and also find a relationship between salt stress and growth.

MATERIALS AND METHODS

Seeds of Sugar beet (Beta vulgaris), cabbage (Brassica oleracea capitata L.), amaranth (Amaranthus paniculatus) and pak-choi (Brassica compestris) differing in salt tolerance, were used in this investigation. The seed of Sugar beet, cabbage, amaranth and pak-choi cultivars were obtained from China.

This experiment was conducted to observe the influence of different NaCl concentrations on germination, germination rate ($1/t_{50,}$ where t_{50} is the time to 50% of germination) root and shoot length and on fresh weight of root and shoot of the seedlings. Plastic Petri dishes (87 mm diameter, 15 mm height) with a tight-fitting lid were used for the experiment. The solution used for the study consisted of 0.0 (control), 4.7, 9.4 and 14.1 dS m^{-1} NaCl. For each plant species 10 seeds for each of the four NaCl treatments were used. Seeds were hand sorted to eliminate broken, small and infected seeds. Seed were allowed to germinate in laboratory condition on filter paper (Whatman No. 2) in Petri dishes soaked in a solution of the respective salt concentration. The seed germination was investigated after every 12 hours. Seed germination was started after 36 hours (seeds were considered to be germinated with the emergence of the radical). The germinating seeds were counted at regular intervals. The lengths of root and shoot of the germinated seeds which were more than 2 mm in length were measured and recorded after 15 days of sowing. In all treatments a continuous increase in the number of germinating seeds as well as in the lengths of roots and shoots was observed during the subsequent days of germination.

The experiment was designed by using a randomized complete block design with three replications. Linear trend lines were fitted to transformed final germination into arcsin form [13]. Analysis of variance was performed using MS-Excel and differences between the means were compared through LSD test ($P < 0.05$) [14]. Linear regression was obtained by using Minitab version 14.0 statistical software packages.

RESULTS

The results revealed that the germination of sugar beet, cabbage, amaranth and pak-choi was strongly affected by all salt treatments. Increased salt concentration caused a decrease in germination. Strong reduction was observed mainly at the higher level of salt concentration compared to control. Lowest germination was observed in case of pak-choi at high salinity treatments (Figure 1).while the highest germination was measured in sugar beet. Germination response of sugar beet and cabbage at 4.7 dS m^{-1} were not significantly different from control. The data presented in Figure 1 also showed the lowest concentration at which a significant reduction was observed and the highest concentration at which germination was reduced in a considerable manner in case of amaranth and pak-choi.

The data presented in Figure 1 indicated that .the germination response of the four vegetables species under observation showed marked differences in the timing of initiation and completion of germination. Germination started within 36 hours and was complete on the 8th day.

The final germination rate of these seed species under various conditions of salinity was expressed as a $1/t_{50}$ of the germination of seeds of the same population in control. Germination delayed as the level of salinity increased. Figure 1 indicated that sugar beet and cabbage completed their germination nearly in same time but sugar beet took comparatively less time to complete germination. On the other side pak-choi took more time to complete germination then sugar beet, cabbage and amaranth.

The studies were laid to investigate the influence of salinity on seedling growth of germinating seeds of sugar beet, cabbage, amaranth and pak-choi. The results indicated that emergence of root and shoot delayed as the salt stress increases compared to controls. The continuous increase in length of root and shoot was observed in frequent hours of germination in four vegetable species in control as well as salt treatments. The data on the average length (Figure 2) of root and shoot shows that sugar beet, cabbage, amaranth and pak-choi showed a strong inhibition with the increasing level of salt solution particularly at high salt levels (9.4 dS m^{-1} and 14.1 dS m^{-1}). The results presented in Figure 2 indicated that great reduction of shoot growth and particularly in root growth occurred with NaCl treatments. Decrease in length of root was more pronounced as compared to shoot in all NaCl salt treatments in sugar beet, cabbage, amaranth and pak-choi. However this decrease was more prominent in pak-choi then sugar beet, cabbage and amaranth. Cabbage,

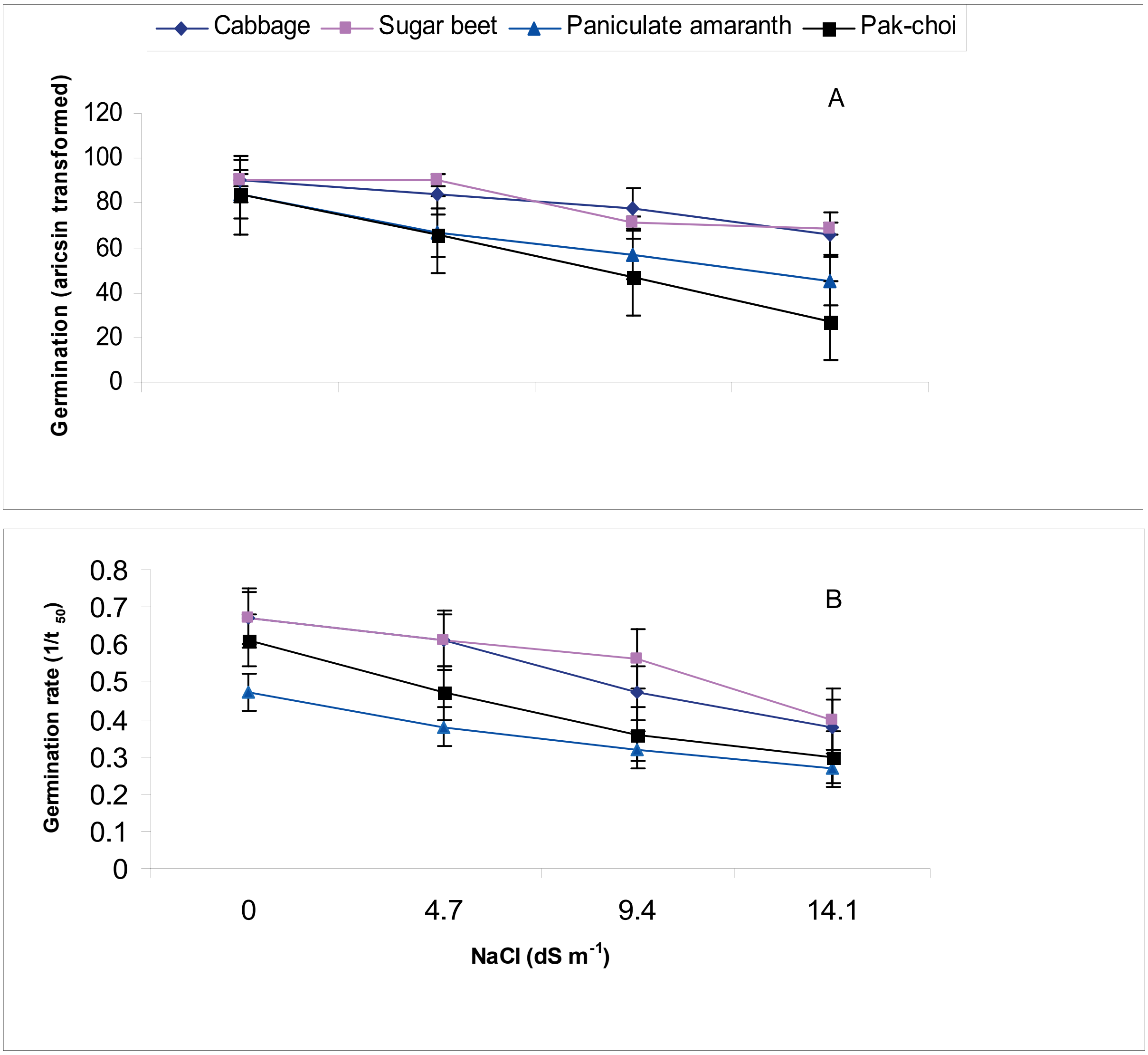

Figure 1. Effect of salt (NaCl) stress on the germination (arcsin transformed) (A) and germination rate (B) of four different vegetables. Error bars are not shown if smaller than symbols.

sugar beet and amaranth also showed sign of great affects on root length. On the other hand, great inhibition in shoot length was recorded in amaranth. In contrast, shoot growth of sugar beet was less affected (Figure 2). Non significant difference was observed in shoot length of sugar beet at 4.7 dS m^{-1} then control.

Statistical analysis showed that there were highly significant differences among all the vegetable species for root and shoot fresh weight. Figure 3 shows that fresh weight of root and shoot all four species was strongly affected by all salinity levels. Shoot and root fresh weight was significantly reduced in all accessions at all salinity levels (4.7–14.1 dS m^{-1} NaCl), whereas fresh shoot weight was reduced more as compared to fresh root weight. This trend was more prominent in cabbage then sugar beet, amaranth and Pak-choi at all salt levels (Figure 3). However amaranth showed less reduction. On the other hand fresh root weight of Pak-choi was strongly inhibited by all salinity treatments as compared to sugar beet, cabbage and amaranth. But this decrease was less in amaranth (Figure 3).

Linear regression was implemented to find the relationship between salt stress and germination, seedling growth. The relationship between salt stress, germination and seedling growth are shown in Figure 4. Linear regression showed a negative significant relationship between salt stress and germination, germination rate ($1/t_{50}$), root length, shoot length, fresh root weight and fresh shoot weight. Strong negative significant (R^2=0.71, P<0.001) relationship was examined between salt stress and root length. Figure 4 also show the weak negative significant (R^2=0.27, P=0.04) between salinity and fresh shoot

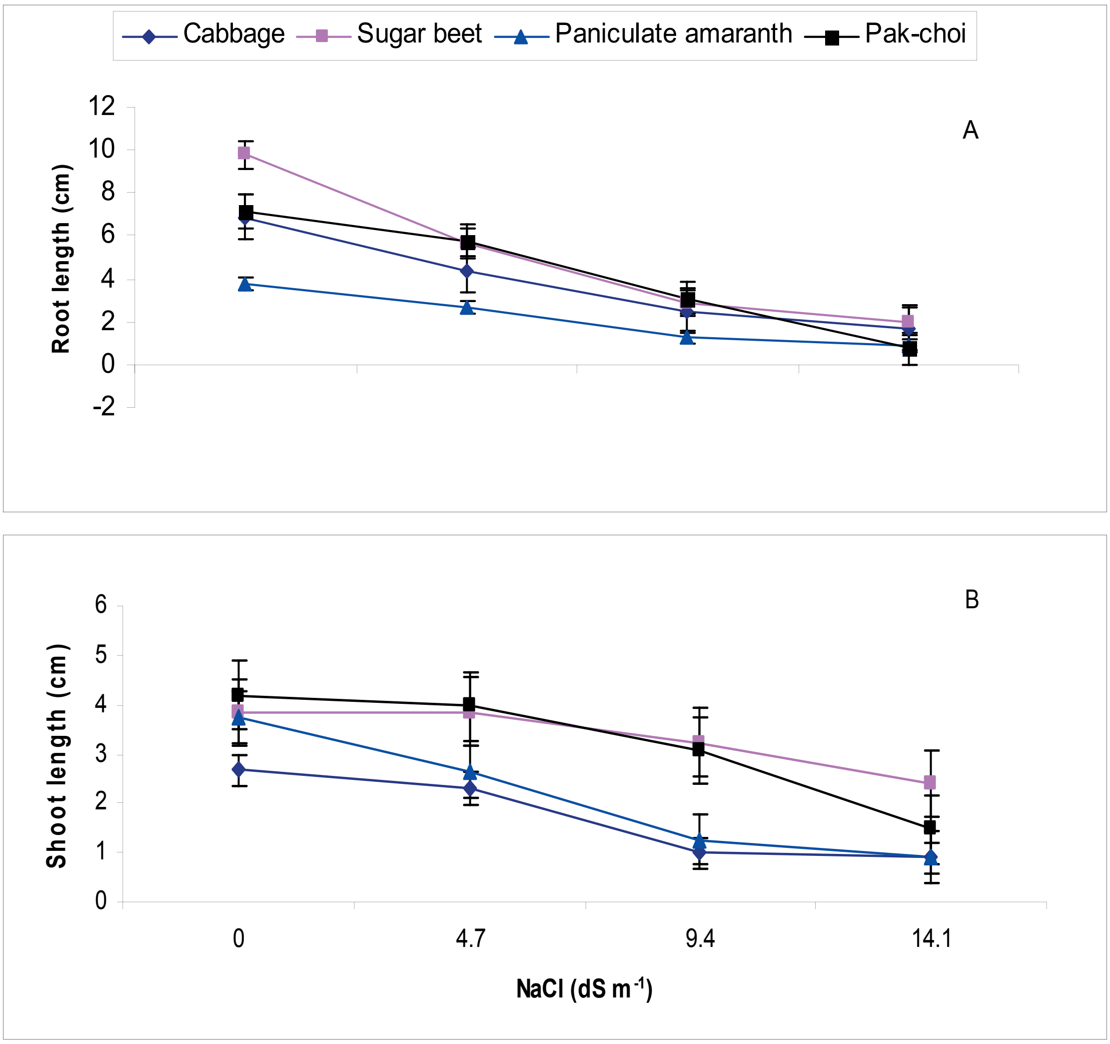

Figure 2. Effect of salinity (NaCl) stress on the root length (A) and shoot length (B) of four different vegetable
Error bars are not shown if smaller than symbols.

weight. Due to significant relation between salinity and growth parameters, it was easy to predict the relationship between germination and root length, shoot length, fresh root weight and fresh shoot weight. Significant positive relationship was examined between germination and seedling growth parameters (Figure 5). Germination had strong positive significant (R^2=0.76, P<0.001) relationship with germination rate while non significant ((R^2=0.14, P=0.14) relationship was investigated between germination and fresh root weight.

DISCUSSION

Salt stress declined the germination and also delayed the emergence of seeds in four vegetables species (Figure 1). It is also assumed that in addition to toxic effects of certain ions, higher concentration of salt reduces the water potential in the medium which hinders water absorption by germinating seeds and thus reduces germination [15]. It appears that a decrease in germination is related to salinity induced disturbance of metabolic process leading to increase in phenolic compounds [16]. It is assumed that germination rate and the final seed germination decrease with the decrease of the water movement into the seeds during imbibitions [17]. Salinity stress can affect seed germination through osmotic effects [9]. Salt induced inhibition of seed germination could be attributed to osmotic stress or to specific ion toxicity [18]. Germination percentage also significantly decreased as the level of salinity of the medium increased [19, 20]. These results are similar in line with Jeannette et al. [21]. They found that the mean time to germination of almost

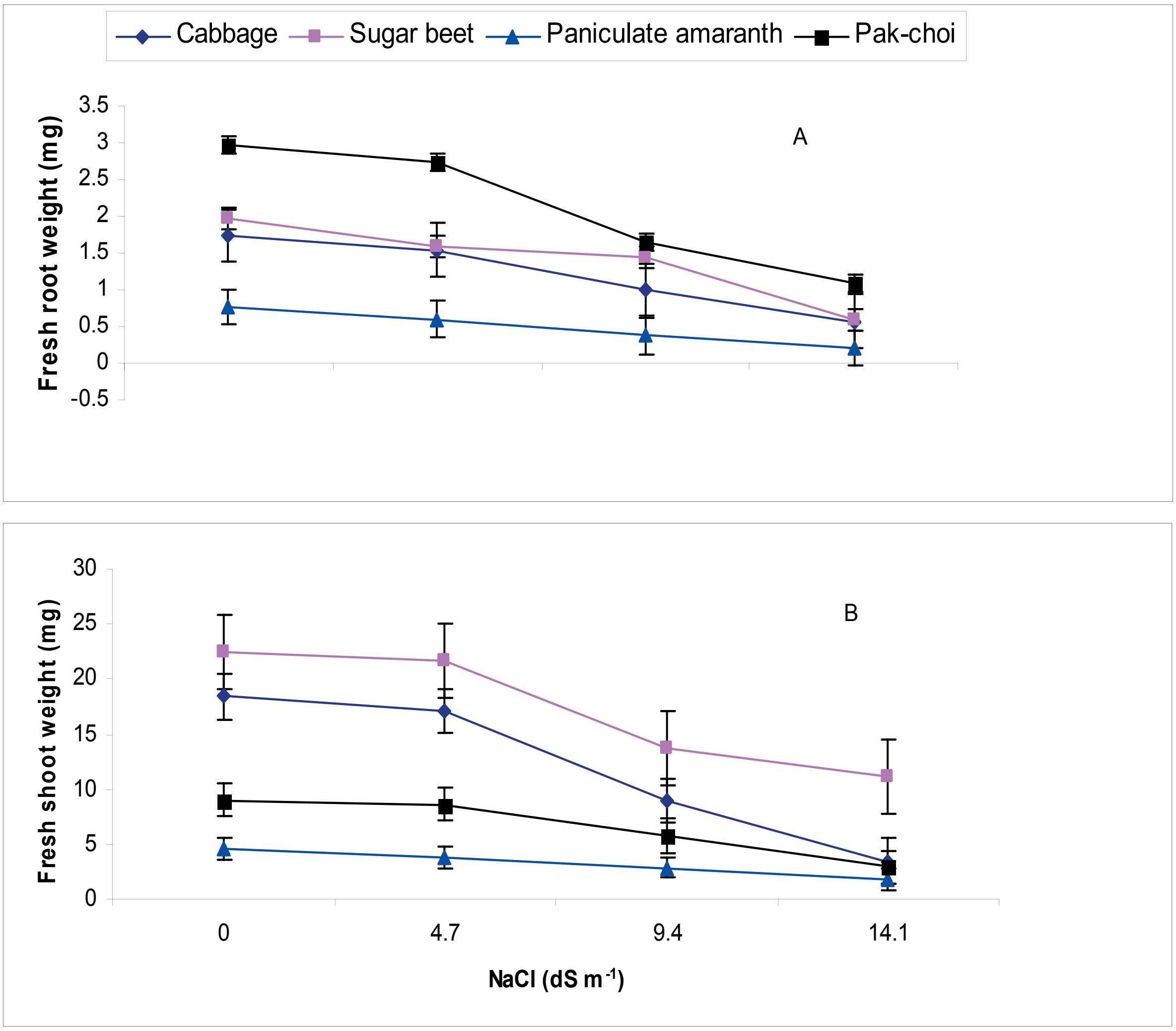

Figure 3. Effect of salinity (NaCl) stress on the fresh root weight (A) and fresh shoot weight (B) of four different vegetables. Error bars are not shown if smaller than symbols.

all Phaseolus species increased with the addition of NaCl and this increase in was greater in higher concentration as compared to low concentration.

The root and shoot lengths are the most important parameters for salt stress because roots are in direct contact with soil and absorb water from soil and shoot supply it to the rest of the plant. For this reason, root and shoot length provides an important clue to the response of plants to salt stress [22]. Salt stress inhibited the seedling growth (root and shoot length, fresh root and shoot weight) but root length was more affected then shoots length (Figure 2, 3). Inhibition of plant growth by salinity may be due to the inhibitory effect of ions. The reduction in root and shoot development may be due to toxic effects of the NaCl used

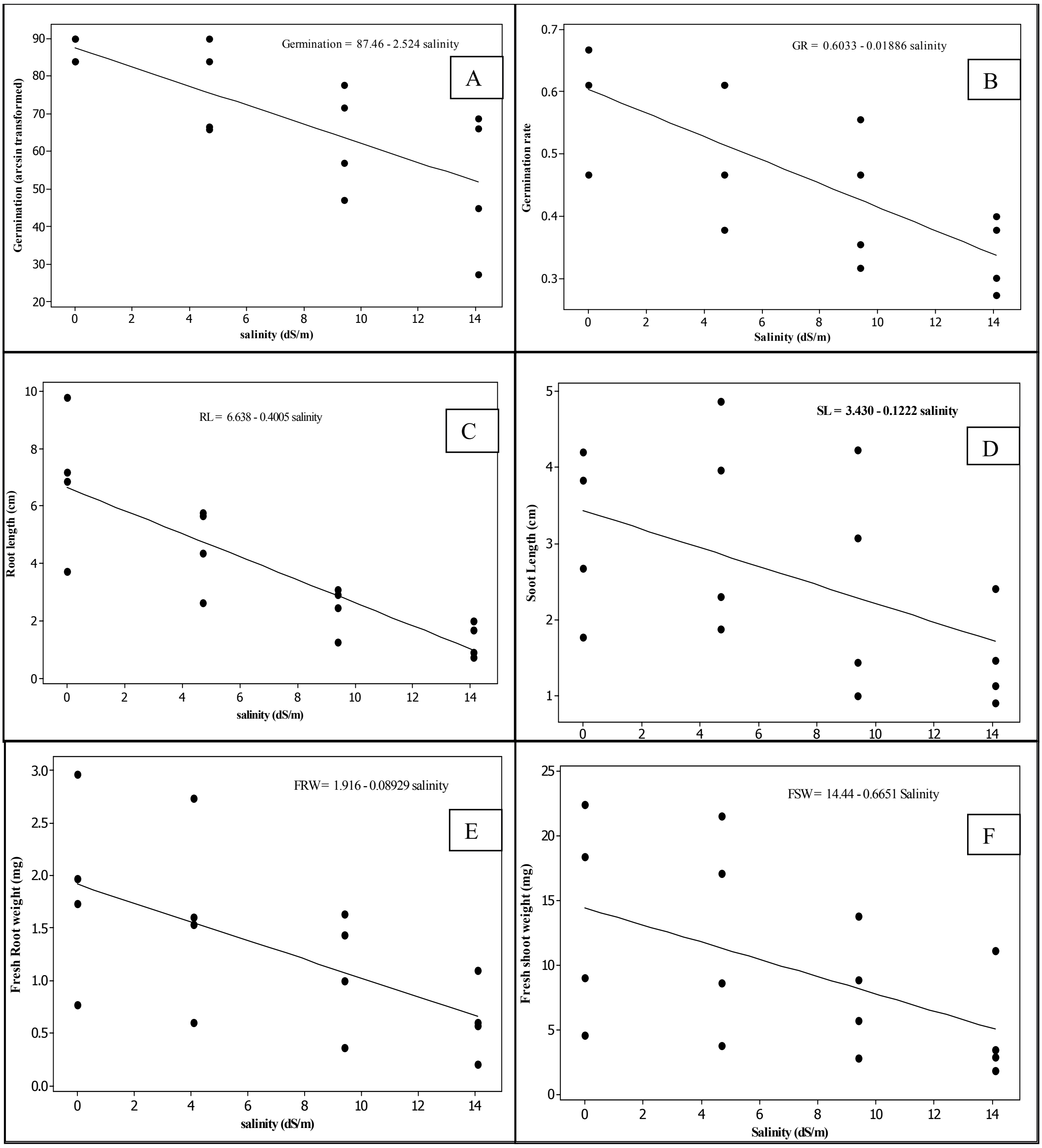

Figure 4. Relationship between salinity and germination (A), germination rate (1/t50), root length (C), shoot length (D), fresh root weight (E) and fresh shoot weight (F) in four vegetables.

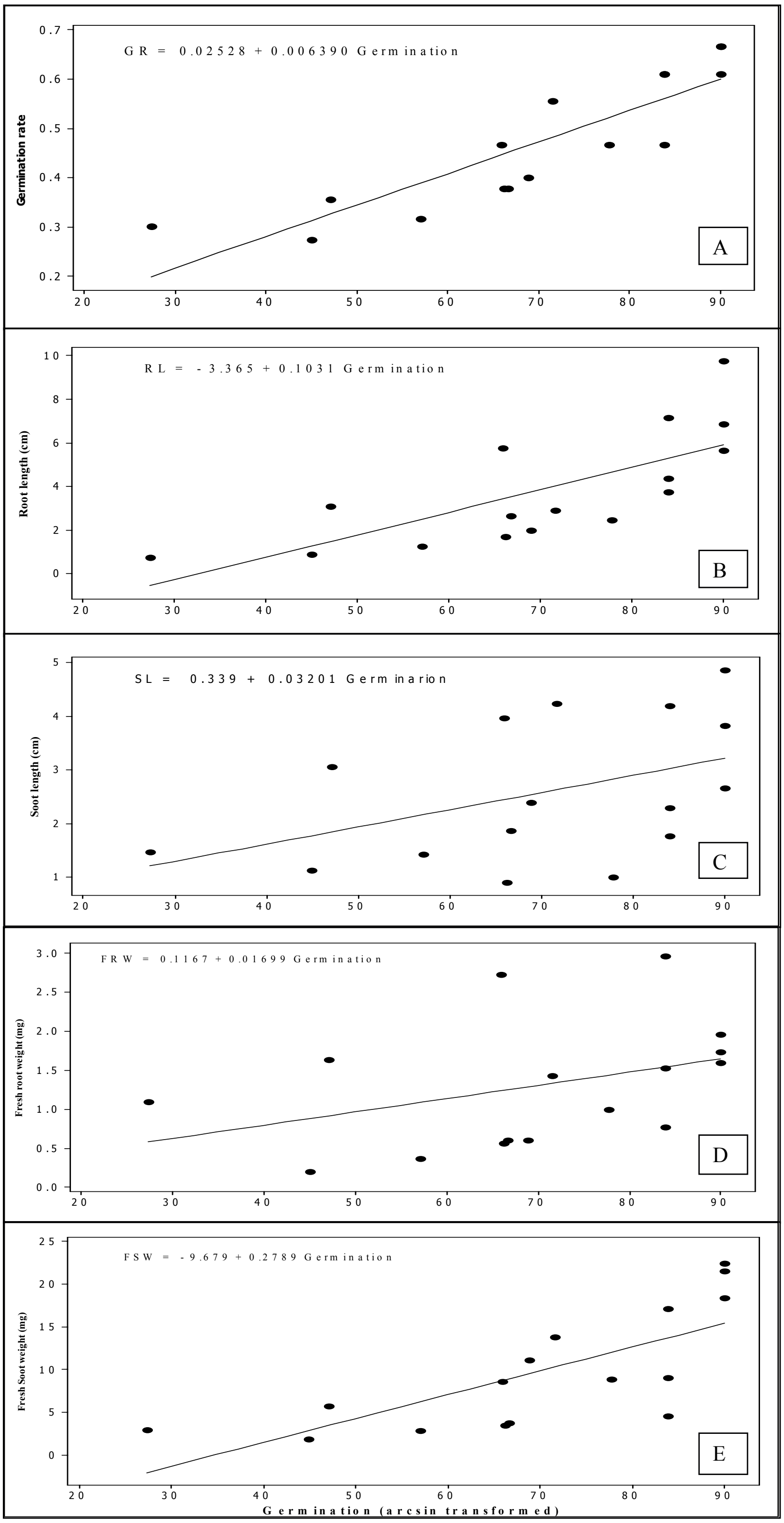

Figure 5. Relationship between germination (arcsin transformed) and germination rate (A), root length (B), shoot length (C), fresh root weight (D) and fresh shoot weight (E) in four vegetables species.

as well as unbalanced nutrient uptake by the seedlings. It may be due to the ability of the root system to control entry of ions to the shoot is of crucial importance to plant survival in the presence of NaCl [23]. High salinity may inhibit root and shoot elongation due to slowing down the water uptake by the plant [24] may be another reason for this decrease. Neumann [2] indicated that salinity can rapidly inhibit root growth and hence capacity of water uptake and essential mineral nutrition from soil. Salt stress inhibited the growth of root more than shoot in all four species. Demir and Arif [25] also obtained similar results. They observed that the root growth of safflower was more adversely affected compared to shoot growth by salinity. Our results were also similar with the findings of Hussain and Rehman [26, 27]. They found that the roots of seedlings were more sensitive than the shoots. It has been reported that the plants had the reduction in their fresh weights because of the proportional increase in Na^+ concentration, which could imply that an ionic effect was being manifested. However, one could argue that because dry weights were not much affected compared to the fresh weights, growth reduction would be attributable to osmotic effects. Similar kind of result was observed by Jeannette et al. [21] that faster rate of germination allowed the emerging seedlings to accumulate more biomass relative to the control but conversely, total fresh weight of root and shoot of cultivated accessions was significantly reduced with increased salt stress. These results are also similar in line with Shannon and Grieve [28] indicated that Salinity reduced fresh weight (FW) of all nine vegetables.

Linear regression revealed significant negative relationship between salinity and germination, germination rate ($1/t_{50}$), root length, shoot length, fresh root weight and fresh shoot weight but significant positive relationship was observed between. Germination and germination rate, root length, shoot length and fresh shoot weight. Non significant relationship was observed between germination and fresh root weight (Figure 4, 5). It has been reported that salinity has negative relationship with germination, germination rate ($1/t_{50}$), root length, shoot length, fresh root weight and fresh shoot weight. Similar kind of observation was detected by Zeynalabedin and Jafari [29]. They reported that there was a negative relationship between salinity and germination, length of radicle and plumule and also positive and significant correlation between percent of germination and length of radicle and plumule ($p=0.01$).

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