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Effects of Salt and Drought Stresses on Germination and Seedling Growth of Bindweed (*Convolvulus arvensis* L.)

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Abstract: One of the first and most important plant life stages is seed germination. In order that, growth and yield performance is related to this stage. In order to study the effects of drought and salinity stresses on germination indices in Bindweed (*Convolvulus arvensis* L.), an experiment was conducted as factorial form, using a completely randomized design arrangement, with four replications. In this study, five levels of PEG 6000 including 0 (distilled water), -3, -6, -9 and -12 bar and four levels of NaCl consisting 8, 16 and 24 ds/m were applied in Biotechnology Laboratory, Islamic Azad University-Karaj Branch, Iran in 2011. Results indicated significant differences among the treatments ($p<0.01$) in all the traits. Control treatment was better for radicle, plumule and seedling length as well as seedling fresh weight and seed vigor than the other treatments considerably. Orthogonal comparisons showed that the drought and salinity stresses effect essence on germination and early seedling growth was different. Based on three parameter logistic model fitted for drought and salinity stresses, seed germination threshold level of bindweed was 23 ds/m for salinity and -16 bar for drought stresses.

Keywords: *Convolvulus arvensis*, logistic model, NaCl, orthogonal comparisons, PEG

INTRODUCTION

Agriculture has been being affected by environmental stresses such as drought, salinity, extreme temperatures, chemical toxicity and oxidative stress which reduce crop yield fifty percent, approximately and water stress that is caused by salinity and drought is a prevalent problem in the world. However, plants are affected by drought and salinity similarly Khayatnezhad *et al*. (2010). Salinity and drought stresses are physiologically related, because both induce osmotic stress and most of the metabolic responses of the affected plants are similar to some extent Kumar *et al*. (2011) and Farsiani and Ghobadi (2009). Salinity is one of the most important restrictions on crop production in the world, particularly in arid and semi-arid regions Dadkhah and Grrifiths (2006). More than 400 million ha throughout the world face to salinity which is includes 15% of Iran's arable lands Soleimani *et al*. (2011). Mohamedin *et al*. (2006) found that salinity stress leads to soluble sugars, free proline and soluble proteins accumulation in germinating seed. Soleimani *et al*. (2011) reported that drought stress brought about protein alteration and accumulation as well as its synthesis throughout growth. Baghizadeh and Hajmohammadrezaei (2011) claimed that proline accumulation is one of the procedures which are used by plants for tackle the drought pressure. Salinity has been recognized as a crucial trouble around the world which farmers are deal with and it has been estimated that over 25% of arable lands in Middle-East countries such as Iran is saline El-Kader *et al*. (2006). Salinity through production of exterior osmotic potential which cease water uptake and Na+ and Cl-ions toxic effects influences on seed germination Turhan and Ayaz (2004). The effect of saline stress on seed germination is to make easier toxic ions ingestion which alters particular seed enzymatic or hormonal activities Sayar *et al*. (2010). Seed germination has been reported to be the most critical stage influencing crop establishment in areas under saline conditions SitiAishah *et al*. (2010). The presence of water has a considerable role in crucial processes such as enzymatic reactions, metabolites transportation and solubilization as well as a factor in proteins, lipids and carbohydrates hydrolytic breakdown in seeds Bialecka and Keoczynski (2010). Seed priming methods are safe, effective and easily adopted by farmers Dursun and Ekinci (2010) such as seed soaking in solutions of Polyethylene Glycol (PEG) was expressed as sowing seeds in an osmotic solution that permits seed to absorb water for germination, but inhibits radicle extension via seed coat Janmohammadi *et al*. (2008) and Giri and Schillinger (2003). The reaction of seed to priming is associated with some factors including duration of priming, seed maturity, species and environmental conditions Armin *et al*. (2010). It was indicated that

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priming induces synthesis of DNA in tomato radicle cells, pepper and maize radicle cells Rouhi *et al*. (2011). It has been reported that seed priming is one of the most important approaches for achieving to the higher germination percentage and velocity. However, Duman (2006) observed no positive effect of seed priming on lettuce plumule and radicle growth in both laboratory and greenhouse. For stimulating water deficit, polyethylene glycol (PEG 6000) has been utilized in many researches for keeping the same water potential during the experiment since it does not penetrate the cells and because of its molecular weight it does not create any toxicity Bialecka and Keoczynski (2010) and Radić *et al*. (2007). To increase the speed of root and shoot germination and for improving tolerance to drought pressure in wheat, chickpea, sunflower and cotton some methods have been being used including hydropriming, hardening, osmoconditioning, osmohardening and hormonal priming Yagmur and Kaydan (2008). Priming techniques has been reported to help dormancy breakdown in many vegetable crops Farooq *et al*. (2005). A practical method which has been applied to identify water stress as a restraining factor for seed germination is Polyethylene Glycol (PEG) Mantovani and Iglesias (2010) in Petri dishes because of high molecular weight and it can't pass through plant cell walls Kumar *et al*. (2011). Under water stress situation, plants adjust to water shortage by several various mechanisms like modifying their morphology, growth and development models and also biochemical and physiological process Haq *et al*. (2010). Field bindweed (*Convolvulus arvensis* L.) or small morning glory belongs to convolvulaceae family which has 250 species in the world and 39 species in Iran, native of west of Asia and Euro Degeneаro and Weller (1984) is able to grow and development under drought stress and in this situation seed performance growth and size of leaf are declined Hodges (2003). This weed has been classified as on of the ten most poisonous perennial and cripping weed around the world which produces little viable seeds and reproduces mostly in vegetative form rootstocks. Furthermore, its adventitious shoots decrease crop performance and impede harvest Khourgami *et al*. (2011). It was indicated in a tissue culture study that bindweed has proteins for adaptation to salinity pressure Ericson and Alfinito (1984).

Most of the seed priming work has been done on vegetables and other field crops with little work on weeds such as convolvulus arvensis. Therefore, this research was conducted to study the effects of drought and salt stresses induced by PEG and NaCl on germination and early seedling growth of Bindweed (*Convolvulus arvensis* L.).

MATERIALS AND METHODS

In order to study of effects of salinity and drought stresses on germination and early seedling growth of Bindweed (*Convolvulus arvensis* L.) an experiment was carried out as factorial form, using a completely randomized design arrangement, with four replications. In this study, five levels of PEG 6000 including 0 (distilled water), -3, -6, -9 and -12 bar and four levels of NaCl consisting of 8, 16 and 24 ds/m were applied in Biotechnology Laboratory, Islamic Azad University-Karaj Branchm, Iran in 2011. Osmotic potential different levels were prepared with NaCl solution, sterilized distilled water and Metrohm (Model: 712). So that with putting sensor of EC meter in distilled water and reading screener, NaCl solution was added until reaching specific salinity level. In this method, during adding sodium chloride solution to distilled water, magnetic blender was used for complete solving sodium chloride into the water. Osmotic potential levels were determined according to Michel and Kaufman (1973). In order that, the amount of polyethylene glycol was calculated by the following formula:

$$Qs = -(1.18\times10^{-2})\ C-(1.8\times10^{-4})\ C^2 + (2.67\times10^{-4})\ CT + (8.39\times10^{-7})\ C^2\ T \quad (1)$$

where, C is concentration of PEG-6000 in g LG of water, T is temperature in EC and Qs is osmotic potential in bars (converted to Mpa by dividing by 10). Before the test, the seeds were separated and disinfected. The seeds were soaked in sodium hypochloride (1%) for 20 min and then were rinsed thoroughly with distilled water for several times. Twenty-five seeds were placed and germinated into disposable sterilized Petri dishes (9 cm diameter) on Whatman No.1 filter paper. Each Petri dish was moistened with 10 mL of distilled water (control) or the respective test solutions. After packing with Parafilm, all the Petri dishes were put at growth chamber (germinator-indoosaw-6785 model) with 65% relativity humidity and 25/15 centigrade degree day/night with 8/16 h photoperiod day/night. Germinating seed were counted daily and seeds were considered as germinated when radicle had protruded 2 mm through the seed coat. After 12 days, traits such as germination percentage and rate (seeds/day), radicle and shoot length (mm), seedling length (mm), seedling dry and fresh weight (g/seedling) seed vigor and radicle length to shoot length ratio were calculated by the formula given below:

GP = 100*(Ni/S) GP = Germination percentage
Ni = Germinated seeds S = Seeds total number (2)

GR = ∑Ni/Ti GR = Germination rate Ni = germinated seeds Ti = Day numbers (3)

SV = (RL+PL)*G (%) SV = seed vigor
RL = Radicle length PL = Plumule length
G = Germination (4)

Prior to analyses the data were tested for normality of distribution with the Shapiro-Wilk test. Germination data were arcsine-transformed to ensure homogeneity of variance. Data were subjected to Analysis of Variance (ANOVA) procedures (SAS Ver 9.1 Institute Inc., 1988) and LSD test was applied at 5% probability level to compare the differences among treatment means. For estimating the potential of drought and salinity stresses different levels in bindweed seed germination percentage reduction, three parameter logistic model was fitted by using SigmaPlot 11.0 software:

Y = a / [1+ (x / x50) b] Y = Germination percentage at different levels of stress (x) (5)

A = seed vigor maximum X50 = osmotic potential concentration for 50% of germination percentage maximum inhibition b = the slope of germination percentage reduction Chauhan *et al*. (2006).

RESULTS AND DISCUSSION

Germination Percentage (GP) and Rate (GR): Results of analysis of variance showed significant difference of both factors on GP and GR at 0.01% level (Table 1a and 1b). Mean comparisons by LSD method displayed that salinity and drought stresses at 8 ds/m and -3 bar levels had the highest amount of germination percentage, respectively (Table 2b). Maximum value of germination velocity was recorded for 24 ds/m of salinity level and minimum one was observed for -3 bar of drought stress which was not statistically different with other treatments (Table 2a). Germination percentage showed the significant reduction with decrease in osmotic potential while, germination rate was increased by drought and salinity enhancement (Table 2a and 2b). But Yari *et al*. (2010) observed the highest germination rate in seeds which soaked in distilled water (control). Pérez-Fernández *et al*. (2006) announced that rate of germination of Daucus carota and Thapsia villosa significantly decreased with reducing of PEG. Germination rate prevention in Barely with polyethylene glycol is ascribed only to osmotic effects Zhang *et al*. (2010). Our results were in line with Bialecka and Keoczynski (2010) in Amaranthus caudatus, Xia and Xinfen (2010) in Indigofera, Jajarmi (2008) in Safflower, Lu *et al*. (2006) in Crofton weed and Nandula *et al*. (2006) in Horseweed who found that PEG and NaCl postponed and declined germination percentage. Whereas, Ghassemi-Golezani *et al*. (2008) reported the effect of seed priming on germination percentage of lentil seeds was not significant. Khalil *et al*. (2001) they stated that reaction to polyethylene glycol between different crops and cultivars is varied. Salinity and drought put off and decline the beginning and velocity of germination, enhancement germination events dispersal, result in decrease in crop growth, development and yield Heshmat *et al*. (2011). However, Chen *et al*. (2010) observed Germination percentage enhancement after application with polyethylene glycol was observed in Solanum lycopersicum, Cynodon dactylon, Cucumis sativus and Dursun and Ekinci (2010) in Parsley. Previous work suggested that the adverse and depressive effects of salinity and water stress on germination can be alleviated by various seed priming treatments Janmohammadi *et al*. (2008). Golshani *et al*. (2010) found that some of the essential metabolic processes for germination will be happened by the seed priming. So that it causes higher germination velocity and percentage. Borzouei (2012) claimed that restriction of germination by NaCl and PEG could not be ascribed to food reserves mobilization but the major effect of polyethylene glycol happened through prevention of water absorption and deleterious effects of chloride sodium are related to toxic ions. She discovered that Na+ and Cl− ions toxicity on the cell membrane and cytoplasm are the main factors that NaCl is more preventive than PEG levels for seed germination. In fact, seed germination reduction by PEG and NaCl was due to the seedling lower water absorption and prevention of seed reserves translocation to the embryonic axis Gholamin and Khayatnezhad (2011). Macar *et al*. (2009) showed that the effect of PEG on sunflower seeds was not toxic since after removing of polyethylene glycol all the seeds were germinated. These authors found that polyethylene glycol influenced the germination and seedling growth by inhibiting water entrance into plant organs and in comparison with PEG, Na+ and Cl-go through plant cells and were accumulated in the vacuole or cytoplasm. According to Òeèajeva and Ievinsh (2007) in Chenopodium glaucum and Khodarahmpour (2001) in corn seed germination percentage reduction is associated with decrease in water uptake by seeds at imbibitions and turgescence stages.

Plumule Length (PL), Radicle Length (RL) and radicle to plumule length ratio (RL/PL): Analysis of data presented in Table 1a and 1b showed that salt and osmotic stresses had significant effect ($p<0.01$) on RL, PL and RL/PL. According to results of mean comparison control treatment and 8 ds/m of salinity levels has the highest amounts of RL and PL (Table 2a). Also, drought stress at-12 bar and salinity level at 24 ds/m had maximum value of RL/PL (Table 2b). These results revealed that PEG and NaCl affected adversely RL and PL (Table 2a) but RL/PL was enhanced by increasing of

Table 1a: Analysis of variance (mean of square) of measured traits of bindweed under drought and salinity stress

S.O.V	Radicle length	Plumule length	Seedling fresh weight	Seedling dry weight	Germination rate
Treatment	2841.16**	2113.08**	0.002**	0.001**	0.0005**
Error	36.84	9.87	0.0004	0.00004	0.00001
C.V	16.02	10.22	28.28	12.23	7.69

**: Significant at $p \le 0.01$ level; *: Significant at $p \le 0.05$ level and ns not Significant

Table 1b:

S.O.V	Germination percentage	Seedling length	Seed vigour	Radicle to plumule length ratio
Treatment	1441.99**	9563.96**	83899231.40**	1.12**
Error	22.62	62.89	626589.1	0.15
C.V	5.80	11.55	12.86	27.72

**: Significant at $p \le 0.01$ level; *: Significant at $p \le 0.05$ level and ns not Significant

Table 2a: Mean comparison of drought and salinity stress on measured traits of bindweed using LSD method

Treatment	Radicle length (mm)	Plumule length(mm)	Seedling fresh weight (seeds day-1)	Seedling dry weight (seeds day-1)	Germination rate (seeds day-1)M
Drought stress (Bar)					
0	82.943^{a}	64.223^{a}	0.115^{a}	0.042^{c}	0.050^{d}
-3	56.610^{b}	42.000^{c}	0.077^{bcd}	0.057^{b}	0.050^{d}
-6	24.723^{c}	22.888^{e}	0.062^{cde}	0.072^{a}	0.052^{d}
-9	23.000^{c}	12.668^{f}	0.050^{de}	0.075^{a}	0.060^{c}
-12	20.555^{c}	8.333^{f}	0.047^{e}	0.075^{a}	0.070^{b}
Salinity levels (dS/m)					
8	60.333^{b}	56.973^{b}	0.097^{ab}	0.047^{c}	0.050^{d}
16	28.278^{c}	37.000^{d}	0.082^{bc}	0.042^{c}	0.050^{d}
24	3.555^{d}	1.890^{g}	0.037^{e}	0.025^{d}	0.080^{a}

Values in a column bearing different superscript are significantly different at 0.05 level using LSD method

Table 2b:

Treatment	Germination percentage (seeds day-1)	Seedling length(mm)	Seed vigour	Radicle to plumule length ratio
Drought stress (bar)				
0	89.333^{ab}	147.168^{a}	13158.2^{a}	1.290^{bcd}
-3	90.668^{ab}	101.610^{c}	9221.9^{c}	1.430^{bc}
-6	89.168^{ab}	47.613^{e}	4254.2^{e}	1.095^{cd}
-9	86.668^{b}	35.668^{f}	3101.3^{ef}	1.820^{b}
-12	76.000^{c}	28.888^{f}	2198.2^{f}	2.482^{a}
Salinity levels (dS/m)				
8	94.668^{a}	117.308^{b}	11093.6^{b}	1.057^{cd}
16	92.000^{ab}	65.278^{d}	5984.7^{d}	0.762^{d}
24	37.000^{d}	5.443^{g}	208.6^{g}	1.422^{bc}

Values in a column bearing different superscript are significantly different at 0.05 level using LSD method

drought stress and salinity levels (Table 2b) which was in line with Yagmur and Kaydan (2008) who indicated that radicle/plumule ratio in triticale was increased by application of PEG 6000 and NaCl due to the low water absorption. Our results were close conformity with Khayatnezhad *et al*. (2010) who report that the effects of salinity and drought levels on length of radicle and plumule were significant. Gholami *et al*. (2010) stated that growth of hypocotyl was reduced by PEG levels enhancement in wild almond. Taghipour and Salehi (2008) and Delachiave and De Pinho (2003) found that too much amount of salt in cell wall led to decrease in shoot length. Furthermore, secondary cell which comes out earlier and cell wall that turns into stiff as a result of turgor pressure effectiveness in cell elongation reduction would cause the plumule to stay small. However root extension decreased by NaCl, but its mechanism has not been discovered and in this regard there is a dilemma that if it is via an osmotic effect or ion toxicity. It was reported by Macar *et al*. (2009) that drought stress induced by PEG prevented epicotyl and radical extention in Chickpea. It was observed by Al-Taisan (2010) in Pennisetum divisum, Haq *et al*. (2010) in lentil, Mohammadkhani and Heidari (2008) in maize and Alam *et al*. (2002) in rice that plumule and radicle length were decreased by application of PEG and NaCl. It was claimed by Boureima *et al*. (2011) that radicle length was reduced by drought stress. They found that this reduction in radicle length was because of prevention of root division and cellular elongation. Radić *et al*. (2007) confirmed that radicle and hypocotyls of corn were affected by drought stress adversely. They declared lower osmotic potential of polyethylene glycol reduced radicle and hypocotyl length and higher levels of PEG disturbed hypocotyls formation entirely. Rahimi *et al*. (2006) in their study made clear that NaCl and PEG were inhibitory to root and shoot elongation in plantago species because of a decrease in water potential gradient between seeds and their surroundings. Rouhi *et al*. (2010) declared that with seed priming root length was enhanced besides improvement enzymes activities which led to tolerance of different pressures such as salinity. Jajarmi (2008) stated that radicle and plumule are more affected by drought stress than other features in safflower.

Seedling Fresh Weight (SFW), Seedling Dry Weight (SDW) and Seedling Length (SL): Analyze of variance showed that salt and osmotic stresses had significant effect ($p<0.01$) on SFW, SDW and SL (Table 1a and 1b). Results of mean comparison discovered that control treatment and 8 ds/m of salinity level had the highest value of SFW (Table 2a) and SL (Table 2b). Furthermore, it was observed that -9 and -12 bar of drought stress and 8 ds/m of salinity level had the maximum amount of SDW (Table 2a). With attention to Table 2a and 2b it was concluded that decreasing osmotic potential and increasing salinity levels reduced SFW and SL but when drought stress was reduced SDW was enhanced. Our findings were in agreement with results of Rouhi *et al*. (2011) in maize, Baghizadeh and Hajmohammadrezaei (2011) in okra, Garg (2010) in Phaseolus mungo, Khayatnezhad *et al*. (2010) in corn and Okcu *et al*. (2005) in pea who confirmed that seedling growth and seedling length were decreased by water stress and osmotic potential. Wu *et al*. (2011) in their study noticed that seedling fresh weights of Medicago sativa, Astragalus adsurgens and Coronilla varia decreased as a result of the combined effects of PEG and NaCl. However, Rouhi *et al*. (2010) discovered that there was no significant effect of priming on seedling dry weight. Taghipour and Salehi (2008) claimed that seedling fresh and dry weights of Iranian barley were decreased by the salt stress. These authors announced that decrease in seedling fresh and dry weights was due to the restricted provide of metabolites to younger growing organs, since metabolic performance was considerably disturbed at higher levels of salinity and also due to the low water absorption and toxicity of NaCl. Heshmat *et al*. (2011) in cowpea and Armin *et al*. (2010) in watermelon reported that cowpea seedling growth was ceased by both NaCl and PEG. Demir and Mavi (2008) cleared that seedling fresh weight was decreased in comparison to seedling dry weight by higher levels of polyethylene glycol and chloride sodium and because of higher amounts of water in plant tissues; control treatment had the highest seedling fresh weight. It was concluded that PEG and NaCl affected seedling growth of durum wheat. Nevertheless, NaCl usually created less damage than PEG. So NaCl and PEG acted through different mechanisms Sayar *et al*. (2010). The negative effect of polyethylene glycol on seedling growth was because of osmotic effect rather than the specific ion Sayar *et al*. (2010).

Seed Vigor (SV): Results presented in Table 1b revealed that osmotic and salt stresses had significant effect ($p<0.01$) on SV. Mean comparison indicated that control treatment and 8 ds/m of salinity level had the highest value of SV (Table 2b). It was concluded that decreasing osmotic potential and increasing salinity levels declined SV (Table 2b). Increase in seed vigor will lead to ease salinity adverse effects Janmohammadi *et al*. (2008). This result correlated with the findings of Kumar *et al*. (2011) who reported that increase in drought stress reduced seedling vigor index in pigeon pea. Better germination model and enhancement of seed vigor was observed in primed seeds because of keeping of nutrients mobilization, anti-oxidant enhancement in form of glutathione and ascorbate which accelerate seed germination through decrease in proxidation activity of lipid, inducing various seed biochemical alterations for the beginning of germination such as dormancy breaking, inhibitors metabolism or hydrolysis Sadeghi *et al*. (2011). Szopińska and Tylkowska (2009) announced that PEG significantly improved seed vigor. Amjad *et al*. (2007) discovered that priming with PEG considerably enhanced pepper seed vigor which was because of former germination induced by PEG that led to vigorous seedlings.

In this study for investigation and determination of different treatments on all the features, orthogonal comparison was used. So that four groups of comparison was considered: orthogonal comparison of distilled water with salinity stress different levels, orthogonal comparison of distilled water with drought stress different levels, orthogonal comparison of distilled water with drought and salinity stresses different levels simultaneously and orthogonal comparison of drought and salinity stresses different levels with each other. The results of orthogonal comparison of distilled water with salinity stress levels revealed that there was a significant difference between these two groups of treatments for all the traits except GP and GR as well as RL/PL (Table 3a,b). Also, between distilled water and drought stress treatments there wasn't significant difference for

Table 3a: Orthogonal comparisons)mean square(of measured traits in bindweed

	Radicle length	Plumule length	Seedling fresh weight	Seedling dry weight	Germination rate
Control vs. salinity stress	6673.611**	4416.962**	0.00800**	0.00200**	0.00005ns
Control vs. drought stress	9596.580**	4463.152**	0.00760**	0.00008ns	0.00050**
Control vs. stress	9285.192**	5122.918**	0.00875**	0.00067**	0.00027**
Drought stress vs. salinity stress	395.808**	0.266ns	0.00005ns	0.00297**	0.00047**

**: Significant at $p \leq 0.01$ level; *: Significant at $p \leq 0.05$ level and ns not Significant

Table 3b:

	Germination percentage	Seedling length	Seed vigour	Radicle to plumule length ratio
Control vs. salinity stress	0.74500ns	21949.991**	174763489.6**	0.07520ns
Control vs. drought stress	664.99278**	27640.356**	219753605.3**	0.06384ns
Control vs. stress	249.97212**	28203.265**	224360625.0**	0.07725ns
Drought stress vs. salinity stress	1328.16690**	375.624*	2936984.6*	0.00200ns

**: Significant at $p \leq 0.01$ level; *: Significant at $p \leq 0.05$ level and ns not Significant

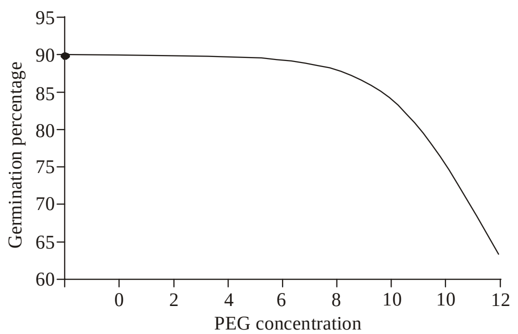

Fig. 1: Germination percentage of bindweed under different levels of drought stress concentration. Line fitted by using three parameter logistic model

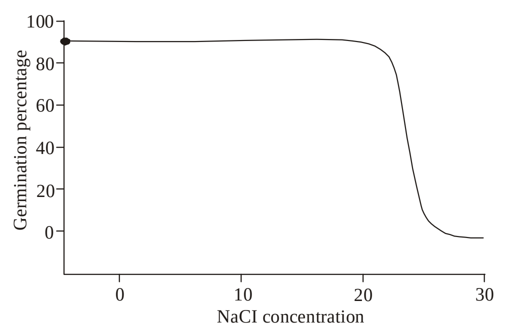

Fig. 2: Germination percentage of bindweed under different levels of salinity stress concentration. Lines fitted by using three parameter logistic model

SDW and RL/PL (Table 3a, b). Data presented in Table 3a, b showed that salinity and drought stresses treatment had significant different apart from SFW, PL and RL/PL. On the other hand, drought and salinity stresses adverse effect essence on germination and early seedling growth of convolvulus arvensis was different. Based on the results, all the investigated features except RL/PL were affected significantly under drought and salinity stresses (Table 3a,b). With respect to importance of germination percentage in emergence and establishment of germinated seedlings, the impact of this index was studied via three parameter logistic model in both treatments Chauhan *et al*. (2006). Figure 1 and 2 are fitted models of germination percentage at drought stress different levels and germination velocity at salinity pressure. With considering the results of this study, Germination Percentage = 89.66/ {1+ (X/16.40) 5.44 model stated the relationship between drought stress and germination percentage. Since Rsqr = 0.99 and Adj Rsqr = 0.98 as well as all the estimated coefficients were significant ($p<0.01$). In terms of drought stress, X50 parameter showed that at -16 bar level, germination percentage of bindweed will be reduced 50%. Furthermore, b parameter which was representative of the slope of germination percentage reduction by the enhancement of drought stress was equal to 5.44.

Output model for salinity levels was Germination Percentage = 91.99/ {1+ (X/23.72) 34.23. In this model, all the estimated coefficients were significant ($p<0.05$). In terms of salinity stress, X50 parameter revealed that at 23 ds/m bindweed germination percentage will be decreased 50%.

Since in areas with hot weather, soil salinity and drought is high considerably at the beginning of the season because of soil and weather conditions, results demonstrated that seed germination threshold level of bindweed was 23 ds/m for salinity and -16 bar for drought stresses. So, it is suggested that in the fields which weed dominant species is bindweed, the crops should be cultivated that is capable to tolerate drought and salinity more than 23 ds/m and -16 bar. With this method, germination and establishment of bindweed will be prevented in arable lands that reduce the costs of biologic and chemical methods to a great extent.

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