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The Effect of Temperature, Salinity and Soil Burial on Canary Grass (Phalaris minor) Germination

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ABSTRACT

Canary grass (*Phalaris minor*) is a winter annual competitive weed in wheat crop. More research is needed to understand the germination requirement for this weed for better management decisions. Therefore, the present study was conducted to evaluate the effect of temperature, salinity, pH, and soil burial on canary grass germination. Temperature had a significant effect on the germination percentage, rate and time to reach 50% of maximum germination percentage. The highest (95.5%) and lowest (0%) germination percentage occurred under 15/25 and 20/35^{o}C (day/night), respectively. There was a decrease in germination as salinity increased. The germination percentage at a depth of 0 and 0.5 cm was found to be 95% and 93%, respectively. Overall, *P. minor* seedling emergence decreased with the increase in planting depth. The pH treatment had a significant impact on germination of canary grass. The maximum (96%) and minimum (30%) germination percentage of canary grass was observed at pHs 7 and 5, respectively.

Keywords: Acidity, germination temperature, planting depth, *Phalaris minor*, salinity.

INTRODUCTION

Understanding the germination and growth biology of weeds in crop plants is an undeniable necessity for effective weed management. Seed dormancy is a state in which seeds do not have the capacity to germinate even though conditions are favourable for germination. Germination promotion occurs when seeds receive required signals from the environment (Bradford, 2005). A wide range of factors can affect germination and emergence including temperature, solution osmotic pressure, light quality, seed burial depth in the soil and soil texture. Temperature and light is well known to play a crucial role in germination (Ren *et al*., 2002). It has demonstrated that seed germination and emergence depends on seed burial depth. A depth more than of the optimum effectively reduces weed emergence (Susko *et al*., 1990). Effect of pH on germination potential can significantly vary among plant species. Weeds can grow under acidic, alkaline or neutral pH conditions depending on species. Some weed species showed no response to pH levels (Susko *et al*. 1990; Pierce *et al*. 1999). Germination is a critical stage in the life cycle of plants which often controls population dynamics, with major practical implications (Keller and Kollmann, 1999). The germination rate of weed species like canary grass is generally very low due to seed dormancy (Radosevich *et al*., 1997). Canary grass (*Phalaris minor*), belongs to *Poaceae* family, is a herbaceous annual species with straight or curved stems and height of 30 to 130 cm which is propagated by seed. Owing to

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its tolerance and resistance to agricultural operations, *Phalaris minor* is listed as an invasive species (Dezfouli, 1997). A wide range of fields are infested by this species especially vegetables, pea field, sugar beet, cereals and orchards (Rashed *et al*., 2001). Therefore, the objective of present study was to evaluate the effect of temperature, salinity and soil burial on canary grass germination.

MATERIALS AND METHODS

Experiments were carried out during 2012 at the Seed Laboratory of the Agriculture Faculty, University of Lorestan, Iran. *P. minor* seeds were collected during June 2012 from mature plants present in wheat fields around Khorramabad. The collected seeds were kept at 25/15$^{\circ C}$ (day/night) under normal light until they were used in further experiments within approximately 2 months. Seeds were surface-sterilized 15 min in a 1% sodium chloride solution and then were rinsed three times with sterile distilled water. Germination experiments replicated 4 times with 25 seeds per replicate placed in 90-mm Petri dish containing a layer of Whatman No. 1 filter paper and 5 ml of distilled water.

To avoid seeds from drying out, distilled water was added when necessary. The petri dishes were wrapped individually with plastic film to reduce water evaporation. Petri dishes were then placed in germination incubators with fluctuating day/night temperature of 25/15$^{\circ C}$ under 16: 8 h (light: dark) photoperiod. The number of germinated seeds was counted daily for 14 days and continued until no further germination was observed. Seeds were considered germinated when radicle protrusion was visible (Chauhan *et al*., 2006).

Estimates of time taken for cumulative germination to reach 50% of its maximum at each replicate (D_{50}) were interpolated from the germination progress curve versus time. Germination rate (R50 1/h) was then calculated according to Soltani *et al*., (2001):

R50 = 1/D50

Experiment 1. Temperature and Light

To find the optimum temperature and light requirement for seed germination, seeds of canary grass were incubated under fluctuating day/night temperatures (15/5, 20/10, 30/15 and 35/20$^{\circ C}$). These temperature regimes were selected to reflect temperature variation during the spring to summer period in Iran. Germination experiment was conducted under light and dark regimes.

Experiment 2. Salt stress

To evaluate the effect of salt stress on seed germination, sodium chloride (NaCl) solutions with concentration of 0, 10, 20, 40, 80, 160, and 320 mM were used. Twenty five seeds were used per Petri dish. The osmatic pressures of these solutions are 0, - 0.1, -0.2, -0.4, -0.6, -0.8 and -1 Mpa (Michel, 1983).

To evaluate the potential salinity on seed germination reduction, the three-parameter logistic model was used:

$$Y = a / [1 + (x / x_{50})^b]$$

Y: germination in salinity level of X (%), Gmax (a): Maximum germination percentage; R50: minimum time G° to germination, D50: Time to reach 50% of maximum germination X50: salinity level required for 50% inhibition of maximum germination and b: slope represents of reduced germination by increasing salinity (Chauhan *et al.* 2006).

Experiment 3. pH of buffered solution

The effect of pH on seed germination was evaluated using buffer solutions of pH 5 to 9 prepared according to the method described by Chachalis and Reddy (2000). A 2-mM potassium hydrogen PHthalate buffer solution was adjusted to pH 4 with 1 NHCl. A 2-mM solution of MES [2-(N-morpHolino) ethanesulfonic acid] was adjusted to pH 5 or 6 with 1 N HCl or NaOH. A 2-mM solution of HEPES [N-(2-hydroxymethyl) piperazine-N '-(2-ethanesulfonic acid)] was adjusted to pH 7 or 8 with 1 N NaOH. A pH 9 or 10 buffer was prepared with 2-mM tricine [Tris(hydroxymethyl) methylglycine] and adjusted with 1 N NaOH. Non-buffered deionized water (pH 6.3) was used as control. Twenty five seeds of *P. minor* were placed evenly on Whatman No. 10 filter paper in 9 cm diameter Petri dishes. Ten ml of solutions with different pH was given to each Petri dish, and then the solution was applied whenever needed. Maximum and minimum temperatures during this experiment were recorded 25/15$^{\circ C}$ (day/night), respectively.

Burial Depth

The effect of seed burial depths on canary grass seedling emergence was studied in a glasshouse. Fifty seeds of canary grass were placed in 15 diameter plastic pots and covered with soil cover of 0, 0.5, 1, 2, 3 and 4 cm. The soil type used for this experiment was clay loamy with 3.1% organic matter. To understand the seed bank of canary grass in the soil, pots with no seeds were considered as a control. There was no emergence of any grass from these control pots during the course of the experiment, suggesting that there was no background seed bank of canary grass in the soil. The temperature of the glasshouse was set at 25/15 ± 5$^{\circ C}$ (day/night). Pots were watered initially with an overhead sprinkler and later with sub irrigation as needed. The appearance of two cotyledons was considered as emergence.

Statistical Analyses

A randomized complete-block design with four replications was used in all experiments. Each replication was arranged on a different shelf within the germination chambers and considered as a block. Each experiment was conducted twice except the burial depth. Data were subjected to an analysis of variance, using SAS 9.1 software and the difference between means were compared by LSD test at 5% level of probability. Germination rate and time to reach 50% of maximum germination was calculated by Germin program in Excel software.

RESULTS AND DISCUSSION

Temperature and Light

The germination percentage, rate, and time to reach 50% maximum germination of *P. minor* were affected by the different temperature regimes (Table 1). Temperature plays an important role in controlling the growth and development of plants and the effect of temperature on seed germination is quite complex because it affects each stage of germination process in a different way and is not independent of other factors (Mayer *et al*., 1982). For many annual grass weeds, the response to light has been well established (Frankland and Taylorson, 1983). It seems that seed germination of genus Phalaris is stimulated by light, as has been shown in hood canary grass (*Phalaris pardoxa* L.) (Taylor et al., 2004) and reed canarygrass (*Phalaris arundinacea* L.) (Landgraff and Junttila, 1979). However, little is known about the germination response of littleseed canarygrass seeds to light, albeit Om et al. (2005) reported the promoting effect of light on seed germination of little seed canary grass. Our results indicated that the effect of light on all studied parameters was not significant. The highest (96%) and lowest (0%) germination percentage was found under 25/15$^{\circ C}$ and 35/20$^{\circ C}$ (day/night) temperature fluctuations, respectively (Figure 1).

Table 1. Effect of light and temperature regimes on maximum, rate, and time to reach 50% of maximum *P. minor* germination

Source	df	F					
		Gmax	R50	Germination uniformity	Time to reach 10% of germination	Time to reach 50% of germination	Time to reach 90% of germination
Block	3	16.26^{ns}	0.00000024^{ns}	488.07^{ns}	43.28^{ns}	277.93^{ns}	200.87^{ns}
Temperature	4	5557.5000**	0.00002897**	7953.86**	12495.59**	24518.82**	3472.21**
Light	2	498.4200^{ns}	0.00002^{ns}	694.42^{ns}	10128.42^{ns}	19520.83^{ns}	2173.26^{ns}
Light*Temperature	8	42.17^{ns}	0.000021^{ns}	27562.34^{ns}	1012.006^{ns}	316.45^{ns}	4127.32^{ns}
CV		8.27	5.84	13.25	10.21	5.61	11.84

NS, ✳ and ✳✳ Significant at %5 and %1 level, respectively

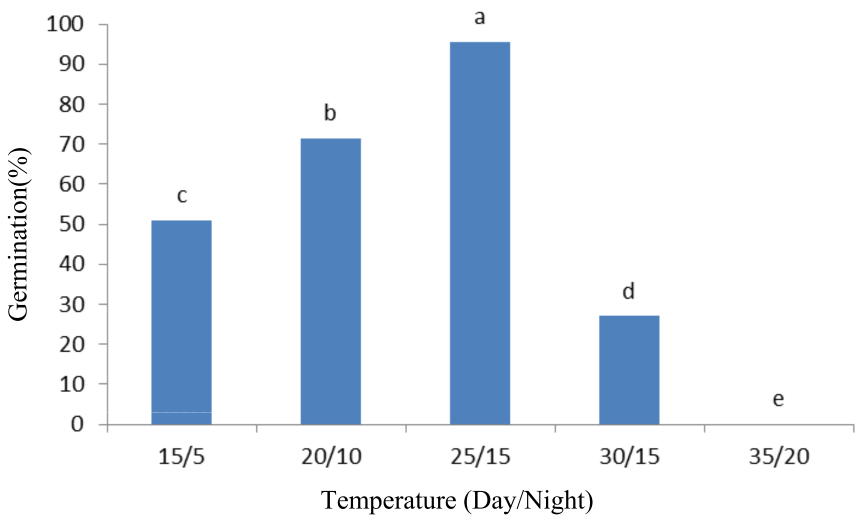

Figure 1: Effect of alternating temperatures (Day/night) on seed germination of canary grass. Columns with different letters are significantly different at 5% level based on LSD test.

Light and temperature are two environmental factors that impact on multiple levels of dormancy. Martinez-Qrsa *et al*. (2003) found that alternating temperatures dramatically overcome seed dormancy in *barnyard grass*, *common lambsquarters* and *redroot pigweed*. Tang *et al*. (2008) reported that maximum *Chenopodium album* germination occurred with red light and alternating temperatures. Our results highlight a few points. First, most annual winter weed species germinate in the fall. Only a few of these species have a secondary dormancy mechanism (e.g., winter races of *Arabidopsis thaliana*), which prevent germination in the spring (Baskin & Baskin, 1983) and many weed species that can exert phenology of winter annual plants, are found in spring crops (Hald, 1999). Second, compared with species that germinate in late spring, little overlap is found at germination time of early-spring germinated species. Winter annual weeds germinate in the fall and complete their life cycle in the spring or early summer. Seeds of winter annuals weeds must be exposed to low temperature in the summer to germinate in the fall (Roberts and Nilsson, 1982; Baskin and Baskin 1984). In general, low winter temperatures induce dormancy in winter annual species (Baskin and Baskin 1998). Linding _ Cisneros and Zedler (2001) by examining the effect of light on *Phalaris arundinacea* observed better germination rate (up to 80%) under white light for 16 hours. In another study, it was observed that *Phalaris arundinacea* germinated better (88%) under 20°C and light regime of 12 h in the dark (Kon *et al*., 2007). Depending on the species, germination response is affected by many factors, including latitude, elevation, soil moisture, soil nutrients, temperature, the type and density of vegetation, the degree of habitat disturbance in which the seeds mature (Baskin and Baskin, 1998).

Salinity

All measured parameters were affected by salinity ($P<0.001$). Seed germination of *P. minor* decreased as salinity levels increased (Figure 2). The maximum and minimum germination percentage were related to control and 320 mM sodium chloride treatments, respectively. A 50% decrease in seed germination occurred at concentration of 40 mM of sodium chloride (Figure 2).

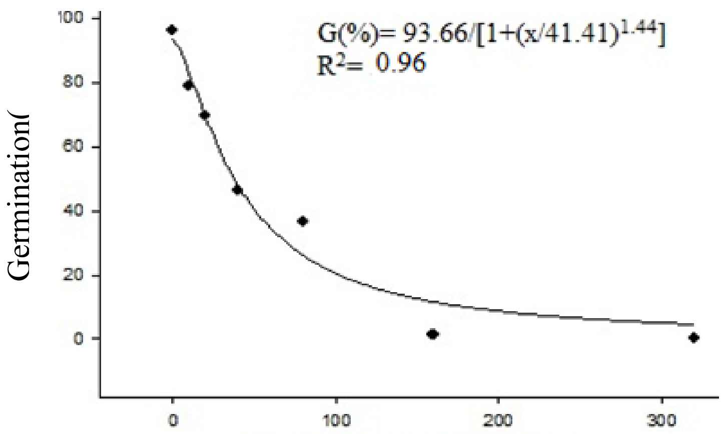

Figure2: Germination of *Phalaris minor* under different levels of sodium chloride (NaCl). Points are the observed values and lines are predicted values with the logistic equation.

Germination and seedling growth can be reduced by some abiotic factors. Salinity and drought are the most important abiotic stresses limiting the seedlings number and growth (Almansouri, 2001; kaya *et al.*, 2006). Salinity is one of the most important environmental factor threatening the sustainability of arid and semiarid regions, especially in areas where precipitation is less than evapotranspiration (Szabolcs, 1994). High salinity decreases remarkably the germination rate. Salinity inhibits seed germination through reducing the availability of water or disorder in some aspects of metabolism like changing the balance of growth regulators (Fenando *et al.,* 2000).

Burial Depth

Seedling emergence of *P. minor* was affected by planting depth, so that significant differences were observed in seedling emergence at various depths. The maximum seedling emergence (94% and 93%) occurred at soil surface (zero and 0.5 cm depth), respectively (Figure 3). Seedling emergence of *P. minor* was reduced with increasing planting depth. Data of seedling emergence was well fitted by the sigmoidal model (P<001, r^2= 0.98). A 50% reduction occurred in canary grass emergence at the depth of 2.94 cm. Our results showed that a planting depth of 3 cm reduced the seedling emergence of canary grass below 45%.

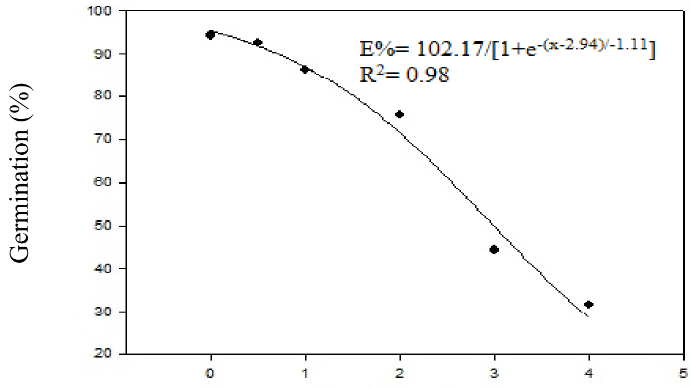

Figure 3: The effect of burial depth on seedling emergence of canary grass seed. Points are the observed values and lines are predicted values with the sigmoidal equation.

In most studies conducted on the effect of depth on seedling emergence of weeds, it has been demonstrated that seedling emergence decreased exponentially with the increase of seed burial depth (Cussans *et al*., 1996; Benvenuti, 2003; Mohler, 2001; Grundy *et al*., 1996). The Biological reasons for the poor or lack of germination are still not fully understood. However, what is certain is that the emergence of different burial depths depends on seed energy reserves (Lafond and Bker, 1986). Also, burial depth affects seed germination and seedling emergence by the availability of moisture, temperature and light (Chauhan and Johnson, 2008).

Acidity

The percentage and germination rate of *canary grass* seeds were influenced by acidity (P<0.05). The highest (96%) and lowest (54%) germination was observed at pH 7-8 and 9, respectively (Figure 4). Quadratic model was well fitted to the data of germination under different acidity of solution (P<0.05, r^2=0.95). The canary grass seeds did not germinate in pH levels below 7 using buffer solution, but it had very weak growth at pHs 5-7. It is believed that different seeds will have different responses to different pHs and different elements in the environment. Many plant species require acidic soil to grow, but other species are intolerant of soil acidity.

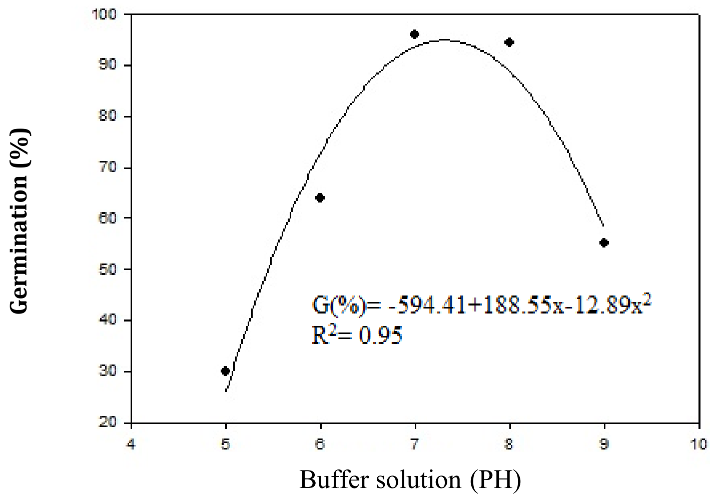

Figure 4: Effect of buffer solution pH of canary grass germination temperature

CONCLUSION

Temperature, salinity, pH, and planting depth significantly affected seed germination and seedling emergence of canary grass. According to results in this experiment *Canary grass* seed germinated over a range of 15/5°C and 30/15°C (day/night) temperatures, with optimum germination (96%) occurring at 25/15 C temperature. Decrease or increase of temperature more than this tempreture (25/15°C) redused Canary grass germination rate. The findings of the present study indicated that the final emergence percentage was decreased in the high temperatures. This result showed us that Canary grass seeds can germinate(in absence of light) in shade. As the salinity and planting depth increased, seed germination and seedling emergence decreased. There was a 50% decrease in seed germination and seedling emergence at concentration of 40 mM of sodium chloride and planting depth of 2.94 cm, respectively. The optimum pH for seed germination was 7-8. As the pH decreased below 7 or increased above 8, seed germination significantly decreased. In general it can be concluded that seed germination percentage was highly affected by the main factors of Salinity**,** pH conditions, Planting Depth, and temperature.

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تأثير درجة الحرارة والملوحة ودفن التربة على انبات عشب الكناري (*Phalaris minor*)

عبد الرضا الاحمدي *

ملخص

عشب الكناري (*Phalaris minor*) هو عشبة شتوية حولية من فصيلة محصول القمح. هناك حاجة إلى مزيد من الأبحاث لفهم متطلبات الإنبات لهذه الاعشاب لقرارات افضل في ادراتها و السيطرة عليها. لذلك، قد أجريت هذه الدراسة لتقييم تأثير درجة الحرارة والملوحة، ودرجة الحموضة، ودفن التربة على إنبات عشب الكناري. كانت درجة الحرارة لها تأثير كبير على نسبة الانبات، ومن حيث المعدل والوقت لتصل إلى 50٪ كأقصى نسبة الإنبات. سجلت أعلى نسبة انبات (95.5٪) وأقل نسبة (0٪) تحت درجة حرارة 25/15 و 20 / 35 سلسيوس (يوم / ليلة)، على التوالي. كان هناك انخفاض في الإنبات كلما زادت الملوحة. تم العثور على نسبة الإنبات على عمق 0 و 0.5 سم لتكون 95٪ و 93٪ على التوالي. وبشكل عام، نشوء شتلات نبات *Phalaris minor* انخفض بشكل طفيف مع الزيادة في عمق الغرس. كانت المعاملة بالرقم الهيدروجيني (pH) معامل الحموضة لها تأثير كبير على إنبات العشب الكناري. وقد لوحظ الحد الأقصى (96٪) والحد الأدنى (30٪) نسبة إنبات العشب الكناري على درجات حموضة 7 و 5 على التوالي.

الكلمات الدالة: الحموضة، درجة الحرارة الإنبات، وعمق الغرس، *Phalaris minor*، والملوحة.

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