Effect of Water Salinity on Seeds Germination of Sterile Oat (*Avena sterilis*) and Rigid Rye Grass (*Lolium rigidum*) at Constant or Alternating Temperatures

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Abstract. Sterile oat (*Avena sterilis*) and rigid rye grass (*Lolium rigidum*) are well known grasses in many parts of the world. They grow in grasslands and arable lands. Both are recorded as serious weeds of arable lands in many countries worldwide. Seeds germination of both species were tested at four levels of water salinity concentrations (0, 100, 300, 500 mM/L of NaCl) and five different temperatures (Constant at 8 C ° or alternating temperatures of; 8/16, 10/18, 6/14, 10/20 C °). Photoperiods regime of 8 hours darkness and 16 hours of light at the constant temperature was implemented. The same was followed with the alternating temperatures with 8 hours darkness at the lower temperature and 16 hours light with the higher temperature. *A. sterilis* seeds showed better germination with high significance of (< 00.1) than *L. rigidum* seeds at all tested treatments. The mean number of germinated seeds of *A. sterilis* was (6) out of (20) seeds /petri dish whereas, it was nearly (3) geminated seeds with *L. rigidum*. Both species secured the highest germination percentage at level of alternating temperatures of (10/20 C °) with 40% (mean number of germinated seeds was 8 out of 20 seeds / petri dish) for *A. sterilis* and 25% (5 out of 20 seeds / petri dish) for *L. rigidum*. Although *A. sterilis* seeds showed some germination (25%) at constant temperatures of (8 C °), *L. rigidum* seeds were less in favorite of this climatic condition expressing its response to alternating temperatures. Generally, *A. sterilis* seeds showed better germination responses than *L. rigidum* seeds at all different level of tested temperatures. Moreover, *A. sterilis* seeds resist water salinity as high as 100 mM of NaCl/L and showed almost 50 % germination especially at its favorite alternating temperature of (10/20 C °). *L. rigidum* seeds also showed some resistance to 100 mM/L of NaCl giving about 35 % germination. However, both species gave poor germination at higher levels of water salinity of 300 and 500 mM of NaCl/L concentrations. Results confirmed that both species seeds germination are in favorite of moderate alternating temperatures condition expressing some resistance to water salinity. This explains both species invasion and persistence in arable lands being reported a serious weedy plant species especially in a Mediterranean climate and subtropical conditions. In addition those results showed some of the two species seed biological aspects, which could contribute to a better control practice of the two species in arable lands.

Keywords: Seeds germination, constant, alternating, temperature, salinity, *Lolium rigidum*, *Avena sterilis*.

Introduction

Sterile oat (*Avena sterilis*) is reported as one the most widespread and harmful weed species in Mediterranean climate (Castellanos-Frias, 2014). It is also considered to be common

grass weed of cereals in Mediterranean countries (Dimakakos, 1983) and India (Balyan, *et al.*, 1991) and North America (Carlson and Hill, 1985) and in Europe and Australia (Torner, *et al.*, 1984). Chaudhary

(1989) confirmed also the present of this species as serious weed of cereals in Saudi Arabia. *Lolium rigidum* is also considered as a major weed in regions of Mediterranean climate worldwide (Monaghah, 1980; Jauzein and Monteguat, 1983; Recasens *et al.*, 1997). It is also reported to be major weed problem in Spain (Garcia Baudin, 1982). Chauhan *et al.*, (2006) confirmed its present in southern Australia. Chaudhary (1989) confirmed that *L. rigidum* is the most serious narrow-leaf weed in cereal fields in Saudi Arabia. It has been also recorded in a check list of weed flora in Saudi Arabia (Elghazali and Alsoqeer, 2013).

Germination is a crucial stage in the life cycle of the plant (khan and Gulzar, 2003). Temperatures affect the percentage and rate of germination through its effects on seed deterioration, loss of dormancy and germination process itself (Roberts, 1988). Temperature, light, water and salinity thought to interact at the soil-atmosphere interface to regulate seed germination (Jian-guo *et al.*, 2012). Moreover, It has been reported that fluctuation in temperatures stimulate seed germination (Thompson and Grime, 1983). Soil temperature and salinity are the most important factors control seed germination in the saline soils of arid and semi-arid regions (khan and Unger, 1999). Salinity generally causes reduction in germination rate and delay germination. Salinity in soil or water is a major stresses to seed germination (Shannon 1998). Salinity stress is a major limiting factor for seed germination (Ozdener and Kutbay, 2008).

This paper investigates the effect of constant or a range of fluctuating temperatures and a range of salinity concentrations on seed germination of a very well known and serious grass weed species. The range of implemented temperatures in this experiment is related to the climatic conditions where the species of sterile oat and rigid rye grass present is

reported. Seed germination is a major stage that result in the degree of presence of the plants. Understanding the biological aspect of seed germination and factors related to it contribute to the anticipation of expected populations. The range of water salinity percentage applied in this research paper followed the range applied by Ozdener and Kutbay, 2008 in their study on *Spergularia marina*.

Martials and methods

Seeds of sterile oat (*Avena sterilis*) and annual ryegrass (*Lolium rigidum*) were collected in the late spring of 2014 from wheat farm in Aljouf area north of Saudi Arabia. Seeds were kept in glass jars and refrigerated in dry condition at 4 C ° to maintain their viability. Experiment were carried out in a five cool incubators representing the five level of temperatures under investigation (constant at 8 C ° or alternating temperatures at; 8/16, 10/18, 6/14, 10/20 C °). Programmable cool incubators is the persuasive solution for stable incubation processes. They are set to create daily cycles of heating and cooling regimes as well as light and dark rotation. Cooled incubators also work reliably in a range of -5 °C to 100 °C and are characterized by their high temperature precision.

Darkness was provided for 8 hours at the lower temperature and light was present for 16 hours at the higher temperature for the whole time of the experiment. Photo periods regime of (8/16 h) was also applied when constant temperatures of 8 C ° was applied. Salty solution was prepared at four levels of concentration of NaCl (0, 100, 300, 500 mm/L NaCl). Seeds were placed in a double layers of filter paper in a sterilized petri dishes with 20 seeds/petri dish and four replicates. GA3 solution at 200 ppm was added at amount of 10 ml/petri dish to the seeds of both species at the beginning of the experiment for 48 hours

to stimulate their germination and break seed dormancy where exist. Enough moisture of the applied solutions were maintained daily by adding few drops of the solutions daily. Petri dishes were monitored daily for 60 days to record germination. The experiment was applied in a 2 factors randomized complete block design with four replicates of each treatment. Final record of germination was analyzed using the statistical program Genstat to determine the significance between treatments through ANOVA and Least significant difference (LSD).

Results

Analysis of the final germination record showed the following findings:

Time taken for germination:

80% of seeds germination of both species occurred within the first 20 days and germination stopped after 35 days from

experiment commencement. There was not any germination after 35 days although the experiment was left for sixty days. This showed early response of both species seed to the factors under study. It also confirmed high seed viability and seed response to the treatment by GA3 solution being added as dormancy breaking agent and as a germination stimulants.

Overall germination:

1) Overall germination of the Species:

Avena sterilis seeds germinated generally in significantly higher percentage than *L. rigidum* seeds as shown in (figure 1) suggesting better response of *A. sterilis* seeds at different factors under investigation. The low germination in both species is referred to the absent of response in both species seeds to some water salinity concentrations and temperatures level under investigation.

Fig 1. General germination responses of the species.

2) Effect of temperatures on seeds germination:

A. sterilis showed better germination at different levels of temperatures than *L. rigidum* giving its highest germination percentage at alternating temperature (10/18 C⁰) and (10/20 C⁰) with (8/16 H) photoperiod. *L. rigidum* showed better germination at 10/20

C⁰ with (8/16 H) photoperiod. Both species favored higher temperatures of (10/18 and 10/20 C⁰) for germination suggesting species adaptation to warm condition. Germination of both species at constant of (8 C⁰) did not differ significantly from low alternating temperatures of (6/14 and 8/18 C⁰) whereas, it did differ from higher alternating temperature of (10/18 and 10/20 C⁰). Although *A. sterilis*

seeds showed high germination at constant temperatures of (8 C°), *L. rigidum* seeds were less in favorite of this climatic condition expressing its response to alternating

temperatures. Figure 2 represents both species seeds germination responses to different level of temperatures examined.

Fig. 2. Germination responses of the species to different level of temperatures.

3) Effect of water salinity on seed germination:

Water Salinity inhibited germination of both species significantly. Seeds of both species were not able to germinate at 300 and 500 mM/L of NaCl concentrations. However, at 100 mM/L of NaCl concentration of salt some germination occurred, *A. sterilis* seeds resist water salinity as high as 100 mM of

NaCl/L and showed almost 50 % germination especially at its favorite alternating temperature of (10/20 C °). *L. rigidum* seeds also showed some resistance to 100 mM/L of NaCl giving about 35 % germination. Fig.3 illustrates germination responses of both species at different concentrations of water salinity.

Fig. 3. Germination responses at different salinity levels.

4) Interacted effect of variation in temperature and water salinity concentrations on seeds germination:

Statistical analysis showed interaction effects. Both species showed better germination at warmer temperature of 10/20 even when moistened with 100 mM/L of NaCl concentration. The interaction effects of temperature and water salinity on germination confirmed the effects of the two factors individually. Table 1 and 2 present some of the interaction effects on both species.

Table 1. Effect of interaction between temperature and water salinity level on percentage (%) of germinated seeds of *A. sterilis* / petri dish.

Temperatures (C°)	Water salinity (mM/L)			
	0	100	300	500
8	100%	5%	0%	0%
6/14	100%	17.5%	0%	0%
8/16	91.25%	1.25%	0%	0%
10/18	100%	52.50%	0%	0%
10/20	100%	48.75%	0%	0%
LSD at (0.05%)	3.04			

Table 2. Effect of interaction between temperature and water salinity level on percentage (%) of germinated seeds of *L. rigidum* / petri dish.

Temperatures (C°)	Water salinity (mM/L)			
	0	100	300	500
8	30%	25%	0%	0%
6/14	28.75%	13.75%	0%	0%
8/16	12.5%	0%	2.5%	0%
10/18	25%	21.25%	3.75%	0%
10/20	57.50%	36.25%	7.5%	0%
LSD at (0.05%)	3.04			

Discussion

Higher germination rate of *Avena sterilis* seeds than *L. rigidum* seeds although both seed samples of the same origin and the same time of collection and storage condition can be attributed to the variation between the two species in seed structure as well as dormancy loss ability. Both species seeds germinated at the range of temperatures examined expressing their ability to germinate in a wide range of climatic conditions. However, alternating

temperatures proved to have a significant effect at warmer condition in both species. Many species seeds found to respond to various amplitudes of temperature fluctuation (Thompson and Grime, 1983). Castellanos-Frias, *et al.* (2014) reported *A. sterilis* to have a high adaptation in a global geographical distribution with a wide range of temperatures. *L. rigidum* is also reported to be adapted to a broad range of temperatures for germination between 12 and 30 °C (Turner, *et al.*, 2001). However, low germination rates of both species at some temperatures can be an effect of water salinity especially at high concentration levels of 300 and 500 mM/L of NaCl. The germination responses of both species are in line with the pattern of temperatures in the winter of Saudi Arabia which can be used in the predication of both amount and time of their germination.

Results confirmed both species sensitivity to water salinity with low germination at 100 mM of NaCl concentration and poor germination of both species with higher levels of concentration of NaCl. These findings confirmed by findings of (Chauhan, *et al.*, 2006) reporting decrease in germination of *L. rigidum* seeds by 50% above 40 mM/L of NaCl concentration. Watt (1983) reported a low germination of *L. perenne* with the increase of salinity in soil or water. The inhibitory effects of NaCl on seed germination could be attributed to its direct effect on embryo growth (Altaisan, 2010). Poljakoff-Mayber *et al.* (1994) reported that embryo elongation was strongly inhibited by high levels of NaCl concentration in irrigation solution. In addition, NaCl increases the osmotic potential of the media causing inhibitory effects on seed imbibition (Almansouri *et al.*, 2001). Reduction in germination by high salinity levels has been described by numerous authors (Altaisan, 2010). According to Mayer and Poljakoff-

Mayber (1989) salt leads to absence of embryo energy to start germination process, as energy was obtained by increments in the respiratory pathway after the ambition and in low levels of water potential tax water absorption was processed slowly. Salinity stress affect seed germination through osmotic effects (Wellbaum *et al.*, 1990) and salt induced inhibition of seed germination due to osmotic stress or ion toxicity (Faheed, *et al.*, 2005).

The increase in both species ability to resist salty conditions, could reflect their adaptation to a wider range of temperatures. This assumption could be supported by (Chauhan *et al.*, 2006) findings who reported some germination of *L. rigidum* seeds even when watered with a solution at 160 mM/L of NaCl concentration. So, the development of weed control practices should limit the species ability to produce high seed return as this will result in an intensive plant populations. High adaptation of both species to a wide range of temperatures and a degree of water salinity level explain their presence in a wide range of climatic conditions. This should be taken into account in their control strategy.

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دراسة لتأثير تراكيز مختلفة من ملوحة الماء على إنبات بذور الراي الصلب والشوفان البري في ظروف درجات الحرارة الثابتة والمتغيرة

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المستخلص. أعشاب الراي الصلب والشوفان البري هي أعشاب تنمو في أجزاء مختلفة من العالم سواء في البيئات النباتية البرية أو المزروعة، وقد سجلت كأعشاب ضارة في المناطق الزراعية في العديد من دول العالم. تم في هذه الدراسة اختبار قدرة بذور الراي الصلب والشوفان البري بعد ترطيبها بمحلول حامض الجلبرين بتركيز ٢٠٠ جزء في المليون لمدة ٤٨ ساعة على الإنبات عند ترطيبها لمدة ٦٠ يوم بإحدى تراكيز ملوحة (صفر - ١٠٠ - ٣٠٠ - ٥٠٠) ملمول / لتر من محلول كلوريد الصوديوم وذلك في خمس مستويات من درجات الحرارة (ثابتة عند ٨ درجات مئوية أو متغيرة خلال الأربع وعشرين ساعة: ١٤/٦ و ١٦/٨ و ١٨/١٠ و ٢٠/١٠) مع فترة ظلام لمدة ٨ ساعات خلال فترة درجة الحرارة الدنيا و ١٦ ساعة إضاءة خلال فترة درجة الحرارة العليا، وبنفس النظام ٨ درجات ظلام و ١٦ إضاءة مع درجة الحرارة الثابتة.

بشكل عام كان إنبات بذور الشوفان أفضل بمستوى معنوية عالية (>0.001) من بذور الراي في مختلف المعاملات التي تم تطبيقها في الدراسة حيث كان متوسط نسبة إنبات بذور الشوفان البري ٣٠٪ بينما كان متوسط نسبة إنبات بذور الراي الصلب ١٥٪. كذلك كان إنبات بذور الشوفان أعلى معنوياً من إنبات بذور الراي في كل مستويات درجة الحرارة الثابتة أو المتغيرة. كلا بذور النوعين أنبتت بأعلى مستوى إنبات لها عند درجة حرارة تبادلية ٢٠/١٠ درجة مئوية حيث كان متوسط نسبة إنبات بذور الشوفان البري ٤٠٪ (٨ بذور من ٢٠ بذرة لكل طبق بتري) بينما كان متوسط إنبات بذور الراي الصلب ٢٥٪ (٥ بذور من ٢٠ بذرة لكل طبق بتري) ما يعني تكيفها مع درجة الحرارة المعتدلة نسبياً. كما أظهرت بذور الشوفان البرية قدرة أفضل من بذور الراي الصلب على الإنبات في ظروف درجة الحرارة الثابتة ٨ درجات مئوية حيث أنبتت بنسبة ٢٥٪ لكن بذور الراي الصلب أنبتت بنسبة أقل ما يعني حاجتها للتغير في درجات الحرارة كأحد عوامل تحفيز الإنبات. في ظروف ملوحة الماء أظهرت بذور الشوفان تحمل جيد للملوحة حيث أنبتت بنسبة ٥٠٪ عند ترطيبها بمحلول كلوريد الصوديوم بتركيز ١٠٠ ملمول / لتر في درجة حرارة تبادلية ٢٠/١٠ درجة مئوية بينما أنبتت بذور الراي الصلب بنسبة ٣٥٪ عند ترطيبها بمحلول كلوريد الصوديوم بتركيز ١٠٠ ملمول / لتر في درجة حرارة تبادلية ٢٠/١٠ درجة مئوية. إنبات بذور النوعين كان ضعيفاً جداً عند ترطيبها بمحلول كلوريد الصوديوم بتركيز ٣٠٠ ملمول / لتر أو ٥٠٠ ملمول / لتر وذلك في مختلف

درجات الحرارة التي طبقت. هذه النتائج تؤكد قدرة جيدة لبذور النوعين على التكيف مع مدى واسع من درجات الحرارة المعتدلة وعلى قدرة إنبات جيدة في ظروف ملوحة المياه. كما تفسر النتائج أسباب انتشار هذين النوعين من الأعشاب الضارة في المناطق المزروعة في مناطق مناخ البحر الأبيض المتوسط والمناطق تحت الاستوائية، وكذلك انتشارها في مناطق بيئات المياه المالحة. كما تساعد هذه النتائج على فهم الخصائص البيولوجية لبذور هذين النوعين ما يساعد على مكافحتها وأخذ ذلك في الاعتبار عند اختيار طرق المكافحة.

الكلمات المفتاحية: إنبات البذور - درجات الحرارة الثابتة أو المتغيرة - ملوحة الماء - الرأي الصلب - الشوفان البري.