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RESEARCH ARTICLE

Effects of Light, pH and Osmotic Stress on Early Seedling Growth of Hoary Cress *Lepidium draba* L.

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ABSTRACT

The experiments were undertaken to assay the effects of light, pH and osmotic potential on early seedling growth of hoary cress (*Lepidium draba* L.) an invasive species in dry-land farming in East-Azarbaijan, Iran in 2012. Effects of light/dark regimes (0/24, 10/14, 12/12, 14/10, and 24/0), pH levels from 2 to 12 and osmotic potential from -0.1 to -0.8 MPa were evaluated on seedling growth of *L. draba*. The experiments were conducted in a completely randomized design with four replications. Results indicated that germination (%) and rate of *L. draba* was the highest at 20/15 day/night temperature. Seedling growth of *L. draba* was influenced by different light/dark regimes, as the seedling length and weight was the highest at 12/12 h photoperiod. The seedling length and weight were not significantly different over a range of pH 4-8 and 5-9, respectively. Also increasing the pH beyond 12 reduced the seedling length and weight. The effect of osmotic potential was significant on seedling length and weight. The seedling length and weight of *L. draba* decreased with increasing osmotic stress form 0 to -0.8 MPa and the reduction in seedling length was greater than that of seedling dry weight. These results indicate that the osmotic potential (drought stress) was the main limiting factor for *L. draba* growth and could be used for its management in the wheat fields.

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INTRODUCTION

Hoary cress (*Lepidium draba* L.) is a perennial invasive species that spreads by seed and creeping roots. One hoary cress plant can produce 1200 to 4800 seeds (Hinz *et al.*, 2012). In the East Azerbaijan of Iran the *L. draba* is the common weed in wheat fields (Shimi and Termeh, 2004). A weed species could be a native, but frequently it is a nonnative in the region where it is aggressive. If the invasive species becomes widely distributed and competes with crops and/or other plants that humans grow for economic profit, then it can be described as a noxious weed, in which case much money and labor are used to reduce the size of populations (Callaway and Aschehoug, 2000). Invasive species also can disrupt natural ecosystems by out-competing native species (Daehler, 2003), thereby causing a decline in species richness (Kareiva 1996; Chambers *et al*., 1999; Bakker and Wilson, 2001; Gorchov and Trisel, 2003). The genus *Lepidium* is one of the largest genera of the Brassicaceae consisting of about 175 species. It is distributed worldwide, primarily in temperate and subtropical regions; the genus is poorly represented in arctic climates and in tropical areas it grows in the mountains (Mozaffarian, 2007).

Dissimilarities amongst different parts of the world in terms of soil, light, water, temperature, and other environmental conditions lead to geographical variations in germination and emergence ecology of species. The arid and semi-arid regions are characterized by drought and commonly by saline soils; thus plants from these regions must be adapted to the adverse situations of these habitats (Epstein and Blum, 2005). The ability of seeds of some populations to germinate more rapidly or a greater percentage of the seeds to germinate under stressful environmental conditions provides an early competitive advantage to the more tolerant species (Harper, 1977).

The ecophysiological study of seed germination and seedling growth allows the understanding of mechanisms regulate seed longevity, germination and seedling establishment in natural conditions. This is an important aspect of plant biology, when studying species. The aim of this study was to examine the influence of ecological factors including light, pH and osmotic stress on early seedling growth of invasive hoary cress *L. draba*.

MATERIALS AND METHODS

Seed collection

The experiments were conducted at the Weed Biology and Ecology Laboratory of the University of Tabriz in 2012. Seeds of *L. draba* were collected during July in 2012, the time for ripening of the seeds. The observations showed the *L. draba* seeds were not dormant. The seeds were obtained from a population in wheat fields of the North-west of East Azerbaijan province, Iran (latitude 38.05^0 N, longitude 46.170 E, altitude 1369 m above sea level). The climate of the location is characterized by mean annual precipitation of 235.75 mm, mean annual temperature of 10˚C, mean annual maximum temperature of 16.1˚C, and mean annual minimum temperature of 4.2˚C. The seeds were cleaned and dried for a few days at room temperature and then stored under such conditions in paper bags until used in the experiments.

Experimental procedure

Prior to the pH and osmotic potential experiments, the day/night temperatures optimum for rapid and high germination of *L. draba* were determined. Fifty selected ripened seeds were surface sterilized in 0.8% sodium hypochlorite solution for 5 min, and then were thoroughly rinsed with distilled water for two times. The seeds were placed equidistant in covered Petri dishes (9 cm diameter) containing sterilized moist filter paper in the bottom then were incubated under fluctuating day/night temperatures (10/5, 15/10, 20/15, 25/20, and 30/25 °C) and in light/dark regimes (0/24, 10/14, 12/12, 14/10, and 24/0). The Petri dishes were wrapped in a double layer of aluminum foil to provide continuous dark conditions. The range of hydrogen ion concentration was established by adding hydrochloric acid or sodium hydroxide to distilled water to make pH levels including 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12. Osmotic stress treatments including 0 (control), -0.1, -0.2, -0.3, -0.5 and -0.8 MPa were obtained in solutions by dissolving appropriate amounts of polyethylene glycol 8000 (PEG- Michel, 1983) in deionized water as osmotica. The treatment solutions were drained off from the growth media and replaced with 5 ml fresh solutions at 2-day intervals to avoid the effect of seed leachates. After 10 d incubation period the seedlings length and dry weight for *L. draba* were measured.

Data collection and statistical analysis

All the tests lasted 10 days, with daily check on the germination and final measurements of the lengths of roots and hypocotyls of germinated seeds. For temperature test, final germination percent and germination rate were calculated according to Ellis and Roberts (1981) and Maguire (1962), respectively. All experiments were carried out tow times as a completely randomized design with four replications for each treatment. The data of the experiments were pooled for analysis of variance (ANOVA), as there was no time ×treatment interaction. The SAS Version 9.0.3 was used for ANOVA. The data that were used in ANOVA met the assumptions such as normality and homogeneity of variance and did not require transformation.

RESULTS

Lepidium draba seeds had the highest germination percentage (70%) and rate (28.3 seed/day) at 20/15 day/night temperatures and the lowest germination percentage (32%) and rate (8 seed/day) was observed at 10/5 day/night temperatures (Figs.1A and B). The germination tare at 25/20 and 30/20 day/night temperatures were not significantly different (Fig. 1A).

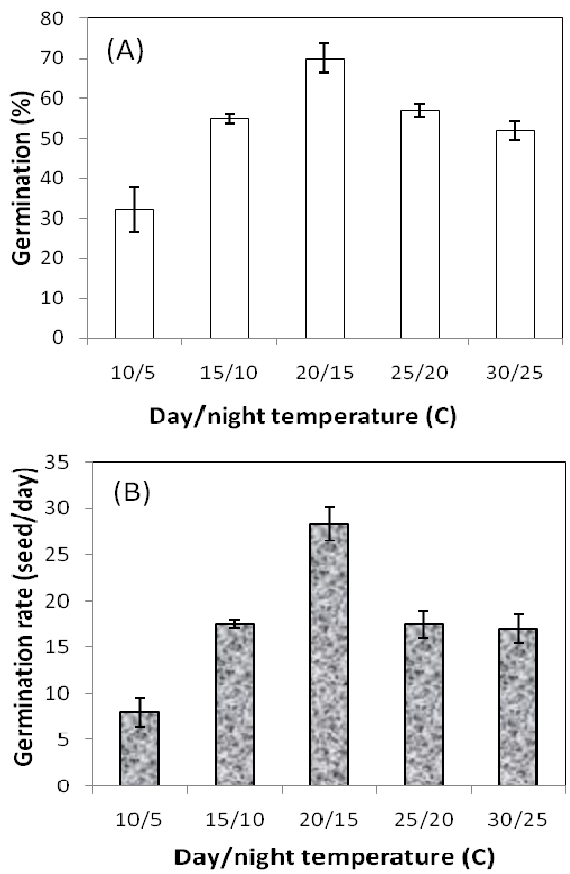

Fig. 1: Germination percentage (A) and mean germination rate (B) of *L. draba* seeds affected by altering day/night temperatures in 12 h photoperiod. Vertical bars represent standard error (±SE).

Seedling growth of *L. draba* was significantly affected by light/dark regimes (ANOVA, P<0.01). The highest seedling length was observed at 12/12 h photoperiod that was not significantly different with 10/14 and 14/10 h photoperiods (Fig. 2A). The highest seedling length was observed at 12/12 h photoperiod that was not significantly different with 10/14 and 14/10 h photoperiods (Fig. 2A). Also the 12/12 h treatment had the highest seedling dry weight and was not significantly different with 10/14 h photoperiod (Fig. 2B). Characteristics of the light that affect germination include length, quality and photon irradiance of the light reaching the seed (Casal *et al.*, 1998). Continuous light or darkness resulted in highly poor growth as compared to the other light/dark regimes (Figs 2A, B) which could be attributed to very slow germination of *L. draba* seeds under such conditions (data not shown).

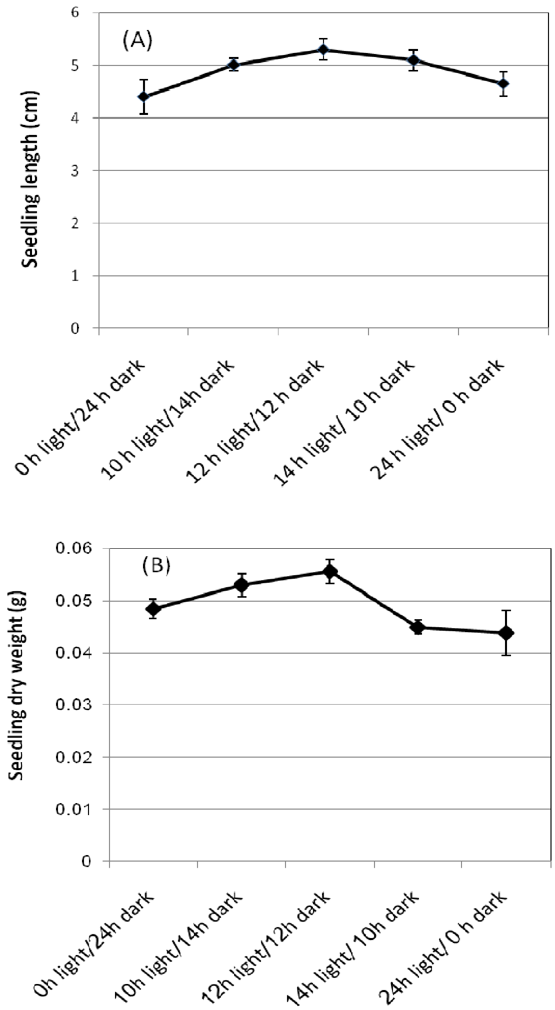

Fig. 2: Seedlings length (A) and dry weight (B) of *L. draba* affected by light/dark periods. Vertical bars represent standard error (±SE).

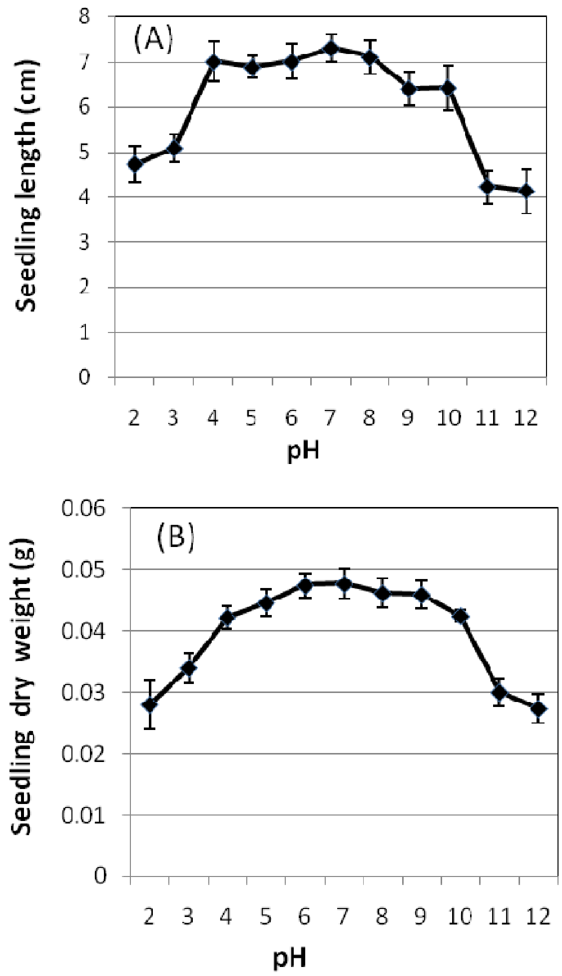

Fig. 3: Seedlings length (A) and dry weight (B) of *L. draba* affected by pH solutions after incubation at 20/10 °C day/night temperatures and 12h photoperiod. Vertical bars represent standard error (±SE).

The seedling length and weight were not significantly different over a range of pH 4-8 and 5-9, respectively. (Figs. 3 A and B) and at other pH levels the seedling growth was reduced significantly. Ability to growth over a wide range of pH supports the view that *L. draba* can adapt well to broad types of soils. The pH for soils of East Azerbaijan is neutral to alkaline and this outcome explains the wide distribution of *L. draba* in soils of this area.

The effects of osmotic potential treatment was significant on seedling length and dry weight (Figs 4 A and B). Increasing the osmotic potential from 0 to -0.8 MPa reduced the seedling length and dry weight of *L. draba*. The reduction in seedling length was greater than that of seedling dry weight.

DISCUSSION

The results of germination temperatures for *L. draba* are partially similar to those found in *Lepidium perfoliatum* (Tang *et al.,* 2010) in which final percent germination increased from 37 to 93% when temperature increased from 10/4°C (day/night) to 20/10°C. Suitable temperature plays a central role in a fast and satisfactory germination which was considered as 20/15 °C (day/night) for *L. draba* in this experiment. It could be supposed that under natural conditions in East Azarbayjan, *L. draba* could geminate appreciably and rapidly during October. Even though it could be continued up to November in the mid fall.

Morphologically, initiation of growth corresponds to radical emergence; subsequent growth is generally defined as seedling growth. Light is considered as the most important environmental factor regulating growth and development of plants, and Smith (1982) reported the light requirement of seeds is also dependent on the temperature. Several aspects such as wavelength (quality), intensity (quantity) and duration of light are important factors affecting plant growth (Arditti and Ernst, 1992). It seems that a 12/12 h daily photoperiod is required for the fastest establishment and best growth of *L. draba* with high germination percentage and rate in natural conditions.

Impairments of germination and growth of *L. draba* seedlings caused by acids or bases maybe a result of favorable or unfavorable influence on the enzymic processes concerned (Salter and Mcllvaine, 1920).

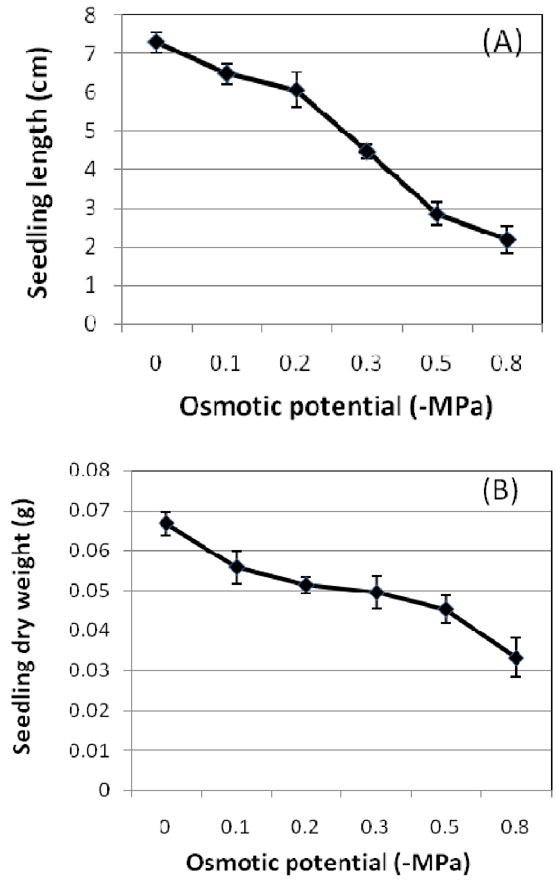

Fig. 4: Effect of osmotic stress (-MPa) on seedlings length (A) and dry weight (B) of *L. draba*after 8 days of incubation at 20/10°C day/night temperatures and 12h photoperiod. Vertical bars represent standard error (±SE).

According to Ebrahimi and Eslami (2011) there is a common feature for invasive weed species, that the acidity of environment apparently is not a critical or limiting factor for their germination and establishment in the soils, and this potentially allows them to invade diverse habitats, as is apparent in case of *L. draba* (Figs. 3A, B). Higher permeability of seed coats at acidic medium which allows the entry of oxygen-saturated water (Hinz *et al*., 2012), is a possible reason for a fast early growth initiation of *L. draba* at pHs 4-9 under the contentions of our experiment. Thereafter growth was largely impaired and the magnitude of osmotic potential impact on length was more than that on dry weight (Figs. 4 A, B). Studies with potted seedlings have shown that shoot growth is directly related to watering frequency, and the growth of plant is usually reduced under the condition of water stress (Bisht, 1993). These data conclusively prove the noxious effect of higher PEGconcentrations on seedling growth of *L. draba* due to the osmotic effect (Figs 4A, B) which causes reduced radical and hypocotyl extension because of prevention of cellular division and elongation (Boureima *et al*., 2011). The importance of resistance to drought for germination and establishment of the seedlings is clear from the literature. Seibert and Pearce (1993) showed that these small-seeded weeds develop relatively longer and smaller-diameter roots, which enable them to explore a greater soil volume early in their life cycle. We can conclude that *L. draba* seedling growth is tolerant to moderate drought stress and moisture is likely to be sufficient to its growth period during low-rainfall months in East Azarbayjan.

Conclusions

The present study provided preliminary concept about the effects of the environmental factors on the early seedling growth of *L. draba*. Among the environmental factors, the day/night temperatures and osmotic potential (drought stress) were the main limiting environmental factors for *L. draba* germination and growth and could be used for its management in the wheat fields. *Lepidium draba* seedling length and dry weight was the highest at pH range of 4-9 that indicate the ability of this invasive plant to growth at different soils. Therefore, information about the seedling growth and development of *L. draba* will help growers to develop effective management strategies for this weed species in wheat field of East Azarbayjan.

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