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Research article

EFFECT OF SALINITY AND CROP RESIDUE ON SEED GERMINATION AND EARLY SEEDLING GROWTH OF CURLED DOCK (*RUMEX CRISPUS* L.)

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ABSTRACT: Curled dock (*Rumex crispus* L.) is a perennial weed species with a wide distribution in the rangelands and cropping systems in East-Azarbaijan, Iran. Tow experiments were carried out based on randomised complete block design with four replications in Tabriz, Iran in 2013 to evaluate the effects of salinity and crop residues on *R. crispus* germination and seedling growth. The salinity levels were included 0, 40, 80, 120, 160, 200 and 240 mM (millimolar) sodium chloride (NaCl). Different types of crop residues were canola, sunflower, corn and winter wheat plant residues. Results showed that the effect of salinity was significant on *R. crispus* germination (%), seedling length and dry matter. Increasing the salinity more than 40 mM reduced seed germination significantly in comparison with control. Increasing the salinity from 0 to 80 mm had no significant effect on seedling dry matter but higher than 80 mm, the dry matter decreased. Also the effect of crop residue type was significant on *R. crispus* germination (%) and seedling growth. The residue of winter wheat had no significant effect on *R. crispus* germination (%) and seedling dry matter but other crop residues significantly reduced the germination (%). The canola and sunflower residues indicated the highest germination inhibition among the crop residues. We can conclude that the residue of winter wheat had no significant effect on *R. crispus* germination and seedling growth but other types of the residues indicated inhibition effect on this weed species.

Key words: Crop residue, Germination, Salinity, Seedling growth, Straw

INTRODUCTION

Weed species affect crop growth and yield by competition [1] or allelopathy [2, 3]. *Rumex crispus* L. (curled dock) is a tap rooted perennial weed, belonging to the Polygonaceae family. It is considered as one of the five most widely distributed non-cultivated plant species in the world [4]. This species is troublesome weed in both grasslands (mainly pastures) and arable lands. This species is present on almost all soil types but less often on peat and rarely on acid soils. The range of altitude to which this species has become adapted is very great; a maritime ecotype of *R. crispus* grows on beaches and also be found at 2500 m above sea level in the Middle East and USA or at 3000 m in Iran and 3500 m in Argentina [5]. In East Azarbaijan of Iran, *R. crispus* is most commonly found in warm season crops, orchards as well as in rangelands, field margins and road sides [6]. *R. crispus* is indicator of mismanagement of agricultural land and of high soil nitrogen concentrations, and additionally indicates soil compaction [7]. Thus, one of the factors most closely associated with the occurrence of this weed species in agricultural land includes excessive application of organic or synthetic nitrogen fertilizers [8]. The *R. crispus* is particularly successful as weed on agricultural land because of the ability to flower several times a year, production of large number of seeds per plant, which remain viable in the soil for many years, its ability to establish from seeds and germination as environmental conditions provide a probability for the seedling to survive [4]. Also the *R. crispus* show considerable ability to re-grow from vegetative fragments left in the soil after cultivation or cutting [9, 10].

Germination and early seedling growth are the most critical factors for establishment of plant species [11]. Successful establishment of species is often dependent on the results of seed germination responses to environmental factors [12, 13, 14, 15]. Environmental factors such as temperature, soil osmotic potential, pH, light, seed burial depth, crop residues and management practices affect seed germination and emergence of weeds [16, 17, 18, 19]. *R. crispus* occurs in a wide range of habitats, but particularly waste ground, road sides, shingle beaches, disturbed areas, temporary grasslands, and arable land. It is found on almost all soil types, except for the most acid [20]. In recent years *R. crispus* has spread exponentially and is now a very important weed in cropping systems, orchards and rangelands of the East Azarbaijan region of Iran. However, low information is available about the effect of soil factors on its germination and emergence. Assessment of germination behaviour of *R. crispus* might play a crucial role in developing a better management strategy for this invasive species in the rangelands and cropping systems in East Azarbaijan region of Iran. Hence, the present study was undertaken to examine the effect of salinity and different crop residues on seed germination early seedling growth of *R. crispus*.

MATERIALS AND METHODS

Plant material

Experiments were carried out at the Weed Ecology Laboratory of the University of Tabriz, Tabriz, Iran in 2013. Seeds of *R. crispus* were collected during September 2012 from a naturally occurring population in the fields of East Azarbaijan province, Iran (latitude 38.050 N, longitude 46.170 E, Altitude 1360 m above sea level). The climate of the location is characterized by mean annual precipitation of 245.75 mm, mean annual average temperature of 10°C, mean annual maximum temperature of 16.6°C, and mean annual minimum temperature of 4.2°C. Collected fruits of *R. crispus* were dried at room temperature cleaning by hand-sorting, involving piece by piece removal of debris and rubbish produced a clean seed collection. The preliminary experiment indicated that the seeds are non-dormant. The seeds were dried for several days at room temperature and then stored in paper bags under the same conditions until used in the experiments.

Salinity experiment

In this experiment, 50 selected ripened seeds were surface sterilized in 2.5% sodium hypochlorite solution for 5 min, and then were rinsed with distilled water thoroughly. Sodium chloride (NaCl) solutions of 40, 80, 120, 160, 200 and 240 mM (millimolar) were prepared to induce levels of salinity stress. Salinity of 0 mM was considered as control. The seeds were placed equidistant in covered Petri dishes (9 cm diameter) containing sterilized filter paper which was moistened with either distilled water or appropriate experimental solutions. The treatment solutions were drained off from the germination media and replaced with 5 ml fresh solutions at 2-day intervals to avoid the effect of seed leachates. The *R. crispus* seeds were incubated for 14 d under conditions of 20°C constant temperature and 14h/8h light/dark period.

Crop residue experiment

To determine the effect of different types of crop residues on germination and seedling growth of *R. crispus* seeds were placed at 1 cm soil depth of in plastic pots (15 cm in diameter x 17 cm) and 4 ton/ha (28 g/pot) of residue of oilseed rape (*Brassica napus* L.), sunflower (*Helianthus annuus* L.), corn (*Zea mays* L.) and winter wheat (*Triticum aestivum* L.). Four pots (replications) for each burial depth, with 50 seeds per pot were used. Soil used for this experiment was a loam comprised of 41% sand, 30% silt and 29% clay with 0.41% organic matter and a pH of 6.8. Pots were placed in a growth chamber set at 20°C constant temperature and photoperiod of 14h/8h light/dark. Fluorescent lamps were used to produce a light intensity of 150 µmol m^{-2} s^{-1}. Pots were watered as needed to maintain adequate soil moisture. The emerged seedlings were counted daily for 14 days after initial burial.

Data collection and statistical analysis

Germination (protrusion of radicle by 1 mm) was recorded every day. Final germination percentage (G) was calculated as follows [21]:

(1)

$$G(\%) = \frac{G_S}{T_S} \times 100$$

Wher f germinated seeds and Ts is the total number of seeds at the end of the 14 d perio

Also the seedling root and shoot length and root and shoot dry matter were recorded. All experiments were carried out twice as a completely randomized design with four replications per treatment. The data of the experiments were subjected to analysis of variance (ANOVA). 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. The Duncan multiple range test was used to compare the means at $P \leq 0.05$

RESULTS AND DISCUSSION

Salinity

The results indicated that the effect of salinity was significant ($P \leq 0.05$) on seed germination (%) of *R. crispus* (Figure 1A). By increasing the salinity from 0 to 40 Mm, the germination (%) of *R. crispus* reduced but was not significantly different with control (0 mM) treatment. The salinity level of 80 mM reduced germination percentage significantly in comparison with control treatment. Also the salinity of 120 and 160 mM had the lowest germination percentage among the salinity treatments.

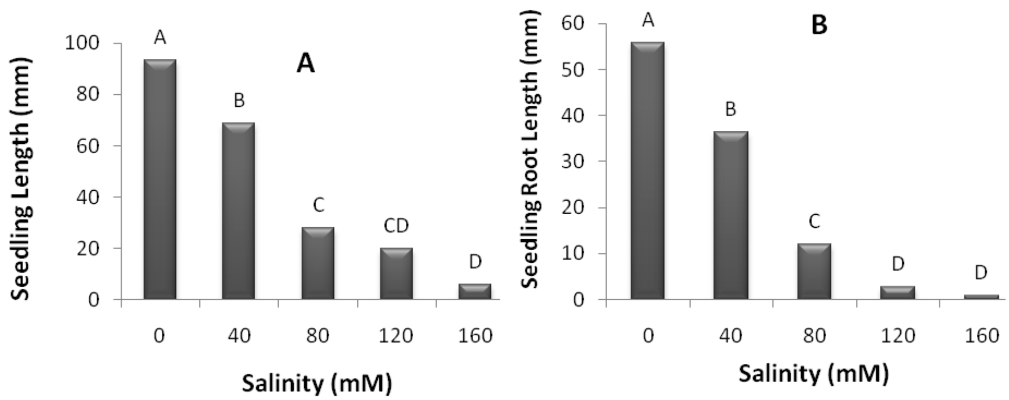

Figure 1. Effect of salinity on seed germination (%) (A) and seedling root length (B) of *R. crispus.* Different letters indicate significant difference at $P \leq 0.05$.

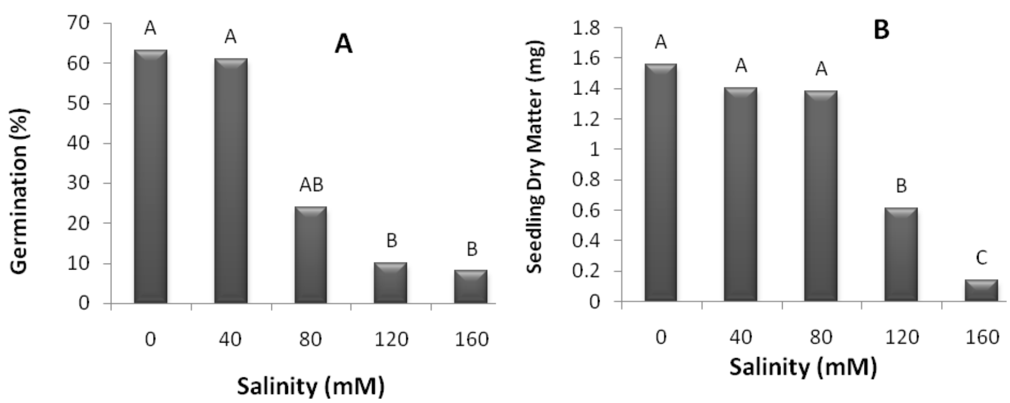

Figure 2. Effect of salinity on seedling length (A) and seedling dry matter (B) of *R. crispus.* Different letters indicate significant difference at $P \leq 0.05$.

The effect of salinity stress was significant on seedling root length ($P \leq 0.05$). Increasing the salinity stress from 0 to 40 mM reduced seedling root length significantly (Figure 1B). Also increasing the salinity level from 80 to 120 caused significant reduction in root length but the difference between the 120 and 160 mM salinity level was not significant. The seedling length of *R. crispus* was significantly ($P \leq 0.05$) affected by salinity stress (Figure 2 A). Increasing the salinity from 0 to 40 mM reduced seedling length and this reduction continued up to 120 mM salinity level. The seedling length of *R. crispus* at 120 and 160 mM salinity levels was not significantly different. The effect of salt stress was significant ($P \leq 0.05$) on seedling dry matter. Increasing the salinity level from 0 to 80 mM had not significant effect on seedling dry matter (Figure 2 B). The seedling dry matter at 120 mM salinity level was significantly lower than them in 40 and 80 mM salinity. Also the lowest seedling dry matter was observed at 160 mm salinity stress that was significantly different with other salinity levels. Ganepour *et al*. [19] also observed that increasing the NaCl concentration from 0 to 30 dSm^{-1} significantly reduced the seedling length and dry weight of pepperweed (*Lepidium Perfoliatum* L.).

In our trial, the magnitude of the adverse impact of salinity on germination of *R. crispus* was dependant on NaCl concentration (Figure 1A). Subjecting to lower NaCl concentrations did not change remarkably germination such 60% seeds germinated up to 40 mM salinity levels. Ramirez *et al*. [22] considered *Bidens alba* as a moderately-tolerant weed species to salt stress.

They observed that it is able to germinate over a wide range of salt concentrations (10 to 160 mM NaCl) but at 320 mM NaCl germination was completely inhibited. According to these results, it is likely that *R. crispus* seeds could not tolerate high salinity stress at the germination stage and this weed species infest the soils with low salinity. Haghverdi *et al*. [23] reported a range of 7-27 dS m^{-1} salinity in East Azarbaijan soils. Therefore, it could be argued that seeds that did not germinate under salinity stress could not also withstand low water potential and germinate under drought stress.

Crop residue

The results indicated that the effect of different types of crop residues was significant ($P \leq 0.05$) on germination percentage of *R. crispus.* The plant residue of wheat had no significant effect on seed germination percentage. The plant residues of corn, canola and sunflower significantly reduced germination percentage of *R. crispus* seeds (Figure 3A). The plant residues of canola and sunflower showed the highest inhibition in *R. crispus* seed germination. The effect of crop residue was significant ($P \leq 0.05$) on seedling shoot length as the control and application of wheat residue indicated the highest shoot length among the crop residue treatments (Figure 3B). The shoot lengths of *R. crispus* in corn and canola residues were not significantly different. The application of sunflower residue caused the highest inhibition in seedling shoot length. Application of crop residue significantly ($P \leq 0.05$) affected the seedling root length. The difference between control and application of wheat residue was not significant and the highest root length was obtained in these treatments (Figure 4A). Application of corn and canola residues significantly reduced the root length of *R. crispus* in comparison with control treatment. Among the crop residues treatments the sunflower treatment showed the highest reduction in seedling root length. The application of sunflower residue caused the highest inhibition in seedling root length.

Crop residue had significant effect ($P \leq 0.01$) on seedling root dry matter. All crop residues significantly reduced the seedling root dry matter in comparison with control (Figure 4 B). Among the crop residue treatments application of wheat and sunflower residues showed the lowest and highest reduction in seedling root dry matter of *R. crispus*. The root dry matters of corn and sunflower residues were not significantly different. The results indicated that the effect of crop residue was significant ($P \leq 0.01$) on *R. crispus* seedling dry matter. All crop residues except the wheat significantly reduced the seedling dry matter in comparison with control (Figure 5). The seedling dry matter in application of corn, canola and sunflower residues were not significantly different.

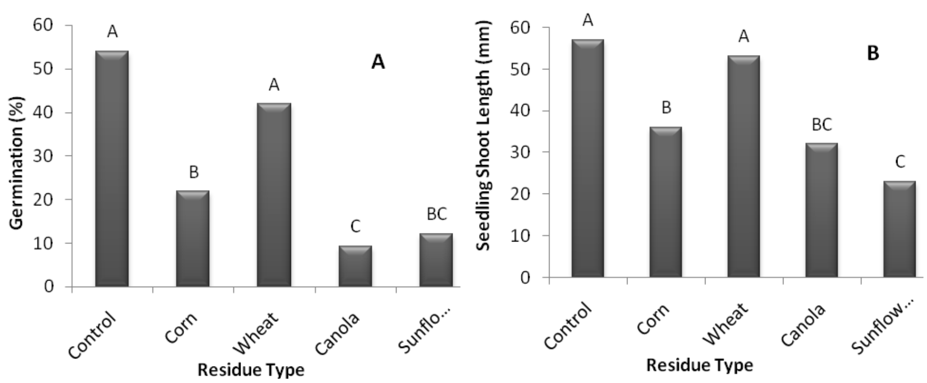

Figure 3. Effect of crop residue on seed germination (A) and seedling shoot length (B) of *R. crispus.* Different letters indicate significant difference at $P \leq 0.05$.

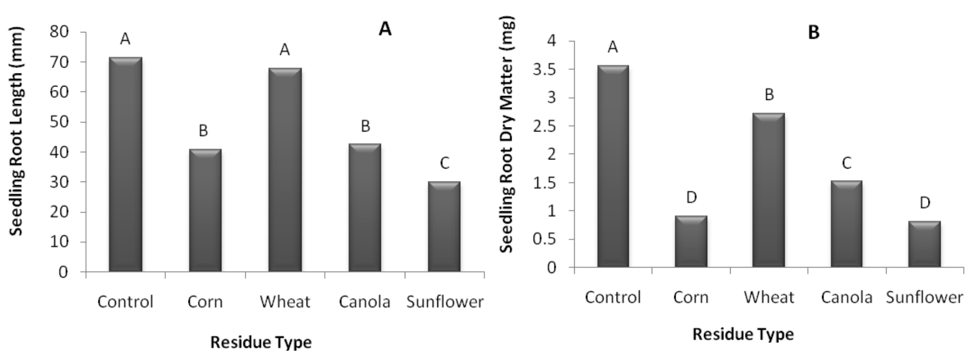

Figure 4. Effect of crop residue on seedling root length (A) and seedling root dry matter (B) of *R. crispus.* Different letters indicate significant difference at $P \leq 0.05$.

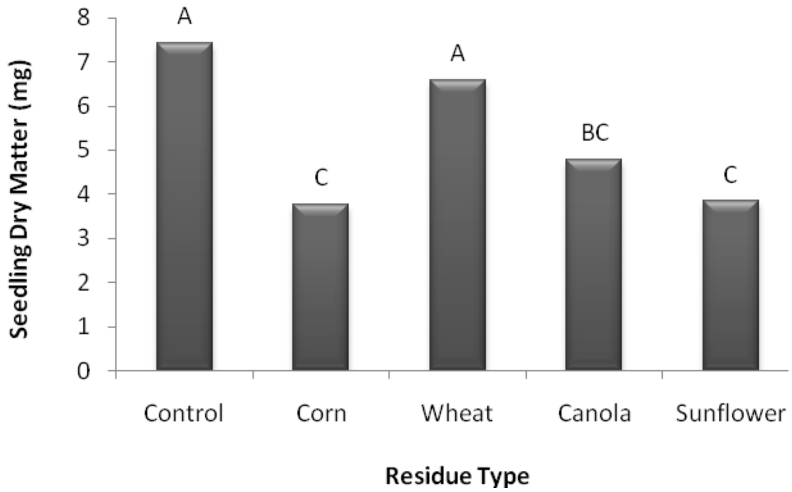

Figure 5. Effect of crop residue on seedling dry matter of *R. crispus.* Different letters indicate significant difference at $P \leq 0.05$.

In this study the crop residues might contribute to lack of seedling emergence from *R. crispus* seeds such as low light intensity, physical barrier and low rates of gaseous diffusion [24]. Lower rates of seedling emergence due to crop residues may also be due to the limitations of light availability. Furthermore, carbohydrate reserves in small seeds, similar to those of *R. crispus* might not be sufficient to support seedling emergence of buried seeds under crop residues [25]. Similar results have been reported for a number of weed species [26, 13]. Chauhan and Johnson (27) also observed that rice residue significantly reduced the seedling emergence and relative dry matter of *Portulaca oleracea*. Increased quantities of crop residue reduce emergence of various weed species [28] through shading and lowering soil temperature and by acting as a physical barrier [29]. Limited light penetration with the residue [30, 31] could also affect germination.

Among the crop residues the wheat residue had no significant effect on germination and seedling growth of *R. crispus* but the residues of corn, canola and sunflower inhibited the germination and seedling growth. These results suggest that in East Azarbaijan in the fields that *R. crispus* is troublesome, using corn, canola and sunflower in crop rotation could reduce germination and seedling growth of this weed species. Also crop rotation with winter wheat would not be effective to reduce *R. crispus* seed germination and early seedling growth. Our results will help growers to develop effective management strategies for this invasive species. The residues did not suppress germination and seedling growth completely; therefore, additional management strategies would need to be employed to achieve complete weed management. While high levels of crop residue may be desirable for high suppression of weed germination and growth, these can have negative effects such as reducing crop emergence, complicating crop management, and reducing the efficacy of soil applied herbicides.

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