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RESEARCH NOTE

Seed Dormancy and Germination Characteristics of *Rumex obtusifolius*

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Abstract

Exotic weeds are considered as one of the major threats for agro-ecosystem and global food security. Since, *Rumex obtusifolius* is one of the dominant exotic weeds in Korean landscape, turfgrass, or river banks, there is an urgency for its efficient management to protect the Korean agro-ecosystem. This study was conducted to investigate the germination characteristics under various environmental conditions such as seed dormancy, temperature, salt stress as well as effect of soil depths on seed emergence. *R. obtusifolius* seeds germinated 100% until 30 days after harvesting (DAH), after that the seed germination rate started to decrease until 270 DAH. The germination rate recovered from 300 DAH and finally reached 98.3% 360 DAH. Optimum temperature for *R. obtusifolius* seed germination was 25/15°C to 30/20°C (day/night). NaCl greatly affected the germination of *R. obtusifolius* seeds. Less than 50% of seeds germinated at 20 mM of NaCl and ceased at 320 mM. *R. obtusifolius* seedling emergence was strongly inhibited by burial depth. The germination declined with increasing the soil depth and stopped where the burial depth exceeded 3 cm. These results could be useful to develop integrated exotic weed management in the *R. obtusifolius* infested area in Korea.

Keywords: Distribution, Environmental factors, *Rumex obtusifolius*

Natural introduction and accidental introduction of exotic weed occurs through the movement of winds (Benvenuti, 2007). Moreover, massive industrialization has influenced the exposure of exotic plants through climate change and the expansion of international trade (Adebayo and Uyi, 2010; Oh et al., 2002). Exotic plants may have no effect or minor effect but sometimes may become invasive and show significant effect on the bio-diversity and ecological system (Clements and Ditommaso, 2011; Kim et al., 2015; Kim et al., 2017). In agriculture, exotic weeds colonization has enhanced serious loss in grain production and have been reported for the global threat for food security (Orapa, 2001). In livestock, exotic weeds can result in severe diseases when consumed by livestock in hay or pasture, if it contains toxic (Puschner, 2017).

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In Korea, the influx of exotic plant is rising rapidly. It has been reported that at least 158 annual weed species among which 100 species were inflowed within the last one decade. These inflows comprise 42% from Europe, 23% from North America, 9% from Eurasia and 8% from tropical America (Kim et al., 2000; Ko et al., 2019).

Rumex obtusifolius is a broad-leaved dock, native to Europe. It was introduced in Korea before 1994 and spread out almost everywhere in Korea (Jung et al., 2017). *R. obtusifolius* is a major weed in gardens and arable land (Holm et al., 1977; PIER, 2007). The GCW (2007) listed the *R. obtusifolius* as an agricultural and environmental weed. On agricultural land it commonly grows in meadows and pastures, abandoned fields, field borders, hedgerows and orchards. It also occurs as a ruderal on roadsides, ditch banks, and along riversides and streams, and can be found in woodland margins and forest clearings (CABI, 2018). Broad-leaved dock is a pernicious weed throughout its native and introduced range. It invades agricultural land, particularly heavily managed pasture land. Seeds and vegetation of docks can be toxic to animals because contains oxalic acid (Royer and Dickinson, 1999).

Due to its ecological effects and global consequences, considerable attention has been given to exotic weeds in recent years (Bai, 2014). An understanding about biology, ecology and germination characteristics is a necessary first step to achieve complete control. Likewise, in order to effectively manage rapidly spreading weeds, we need to know how weeds occur first (Lee et al., 2017). Therefore, the objectives of this study were to determine the effect of different environmental factors on seed germination and seedling emergence of *R. obtusifolius*.

Dormancy of *Rumex obtusifolius* seeds after harvest

To study the effects of after-ripening time, seed germination tests were carried out at 0 to 360 days after harvest. Tests were installed with three replications of twenty seeds per Petri dishes (60×15 mm), two filter papers and moistened with 5 mL of distilled water. After that, it was incubated for 15 days in 16/8 h light/dark condition at a room temperature (20-25℃). Water was replenished as needed. Germinated seeds were counted and removed every 24 h throughout the experiment. Finally, the total of germinated seeds were calculated.

Results illustrated that the germination percentage of seeds of *R. obtusifolius* was reached to 96.7% (up to 100%) during first 2 months after harvest. After that, seeds exhibited a degree of dormancy at 150 to 210 days after harvest where the seed germination was decreased. The dormancy was progressively lost after several months of storage at room temperature; results indicated that the seed germination was almost 90% after storage 330 days after harvest (Table 1).

Germination by temperature

Twenty seeds were placed on a Petri-dish (60×15 mm) with two layers of filter paper and 5 mL of distilled water was added. Then it was placed into a Growth Chamber under 16/8 h (day/night) photoperiod. Germination temperatures were 15, 20, 25, 30 & 35℃ and 5, 10, 15, 20 & 25℃, at day and night time respectively. There were three replications, and the final germination was determined at seven days after sowing (DAS).

Table 1. Dormancy of *Rumex obtusifolius* seeds after harvest.

Days after harvest	Germination (%)
0	100.0±0.00a
30	100.0±0.00a
60	96.7±0.58a
90	85.0±0.00c
120	50.0±0.00e
150	38.3±0.58f
180	35.0±0.00f
210	35.0±0.00f
240	48.3±0.58e
270	48.3±0.58e
300	65.0±1.00d
330	90.0±1.00b
360	98.3±0.58a

The means and standard deviations were calculated from three replications.
a-f: Letters indicates significant differences (*P*<0.05) according to Duncan's multiple range test.

Temperature fluctuation was also found to act as a strong germination trigger for germination. *R. obtusifolius* seeds were reported to give maximum germination in light at 25/15℃ to 30/20℃ (day/night). Many studies agreed that ideal temperature condition for the seed germination of *R. obtusifolius* in the growth chamber is 25℃ (Benvenuti et al., 2001; Khalid, 2018). The germination was below 60% at 15/5℃ (day/night) and it will increase with rising temperatures. However, at high temperature above optimal temperature limits the seed germination as a result of the damage the seeds. Our results are in line with Cavers and Harper (1964) who reported the seeds can germinate throughout the year but most are found in the spring and in the autumn (Fig. 1).

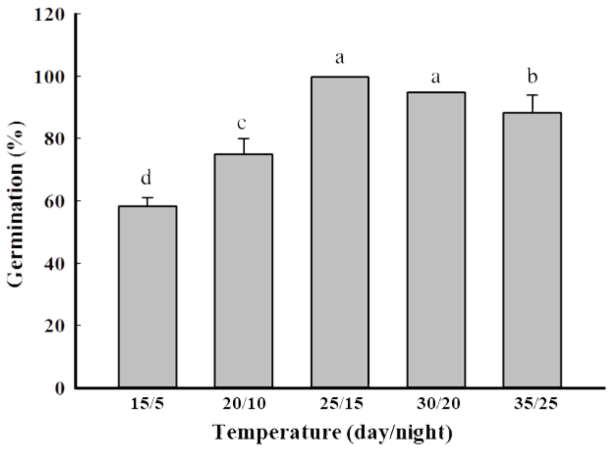

Fig. 1. Germination of *Rumex obtusifolius* seeds at different temperatures. The means and standard deviations were calculated from three replications.a-d: Letters indicates significant differences (*P*<0.05) according to Duncan's multiple range test.

Salt stress

To investigate the effect of salinity on the germination of seeds, different concentrations of NaCl solutions (0, 10, 20, 40, 80, 160, and 320 mM) were used in the germination test. Twenty seeds were incubated on two layers of filter paper in a Petri dish (60×15 mm), to which 5 mL of each NaCl solutions were added. For each of these trials, the treatment with sterilized distilled water was included as a control. All petri dishes were placed in an illuminated incubator subjected to a 16h daily photoperiod at 25/15℃ (day/night). The seed germination was determined at seven DAS.

In general, germination was significantly affected by salinity. Our preliminary results showed that increased salinity results in decreased germinability and delayed rate of germination. At the salinity of 10 mM, the germination was 70% and seed germination percentage did not reach 30% at salinities exceeding 20 mM. *R. obtusifolius* germinated in very low percentage (under 10 %) at 160 mM salinities and no seeds germinated at salinities greater than 320 mM (Fig. 2).

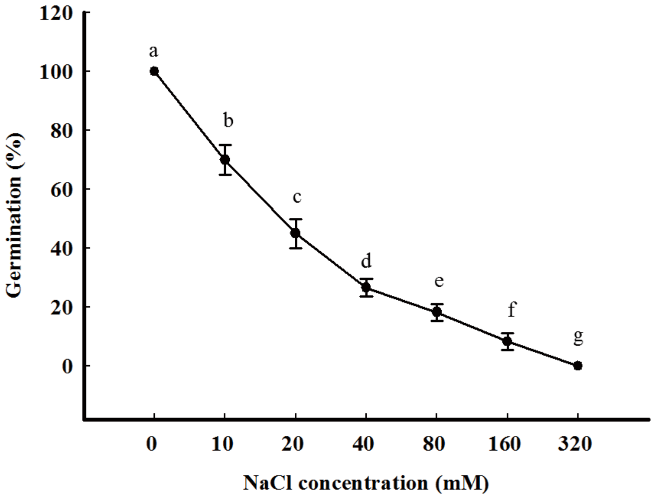

Fig. 2. Effect of salinity on the germination of *Rumex obtusifolius* seeds. The means and standard deviations were calculated from three replications. a-g: Letters indicates significant differences ($P<0.05$) according to Duncan's multiple range test.

The relative growth of plants in the presence of salinity is termed their salt tolerance. A high salt level interferes with the germination of seeds. Published data shows that the effect of NaCl on seed germination is mostly osmotic (Loercher, 1974; Reynolds, 1975). It can be concluded that salt reduces the water potential of soil solution, which prevents the water supply and proper nutrient balance in plants. Although salinity stress mostly reduces the germination percentage and delays the onset of germination, seeds have stayed viable at soil and being able to germinate under appropriate external conditions such as temperature and light (Khan and Ungar, 1997). Seed germination takes place after high precipitation, i.e., under conditions of reduced soil salinity (Khan and Rizvi, 1994), rain dissolves and washes away salt deposits and provides enough water for germination. That's why, *R. obtusifolius* is considered as one of the most widely distributed weeds in the world.

Emergence by burial depth

Ten seeds were sown into a plastic pot (size: 7 cm diameter, height 10 cm) filled with mixed soil (1:1 [w/w]) of horticultural nursery soil: rice nursery soil. Burial depths were 0.5, 1, 2, 3 and 4 cm and replications were three. At 21 DAS, the number of seedlings was measured. Plastic pots were placed in a greenhouse subjected to a 16h daily photoperiod at 20-25/10-15℃ (day/night).

R. obtusifolius seedling emergence was strongly inhibited by burial depth. The germination was declined with increasing depth of soil cover. The germination of *R. obtusifolius* was significantly higher at 0.5 cm (100%) as compared to other sowing depths. Shallow burial, even at a 1 cm depth, halved reduced the percentage seedling emergence of *R. obtusifolius*. The threshold depth level for seedling emergence was considered 2 cm as none of the seedling emergence was observed at 3 cm depth and deeper (Fig. 3). Our results are similar to Van Assche and Vanlerberghe (1989), Weaver and Cavers (1979) who have reported the burial depth effects on *R. obtusifolius* seedling emergence.

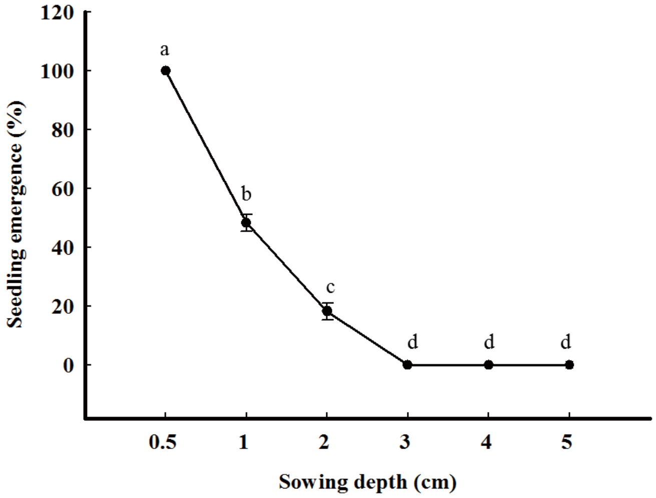

Fig. 3. Effect of sowing depth on the seedling emergence of *Rumex obtusifolius*. The means and standard deviations were calculated from three replications. a-d: Letters indicates significant differences ($P<0.05$) according to Duncan's multiple range test.

Based on these results, it can be concluded that the *R. obtusifolius* seeds thrive better at 25/15℃ to 30/20℃ (day/night) and more successful in salt-free settings or in those having extremely low saline conditions (20 mM of NaCl). Until 60 days after harvest, *R. obtusifolius* seeds were non-dormancy, then exhibited a degree of dormancy at 150 to 210 days after harvest. After long time storage at room temperature, the dormancy was progressively lost and got reaching full germination (330 days after harvest). The sowing depth of 0.5 cm is considered optimum for *R. obtusifolius* emergence. These results will be useful to develop integrated exotic weed management in the *R. obtusifolius* infested area in Korea.

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