Effects of Light, Temperature and Pretreatment on Germination of *Rhus coriaria* L. Seeds

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Abstract:

Effects of light, temperature and pretreatments (scarification followed by cold stratification) on seed germination of Rhus coriaria L. were investigated in this study. Responses in germination varied and were clearly influenced by the methods used to break dormancy. Scarification with sulfuric acid for 60 min followed by cold stratification for 60 or 90 days in Rhus coriaria gave the highest germination percentage. Germination of the seeds pretreated with sulfuric acid for 60 min followed by cold stratification for 60 days differed significantly between light and temperature. Germination percentage and germination rate were the highest at 25/15 ^{0}C under 12 h photoperiod.

Key words: Germination performance, seed dormancy, temperature, light

Introduction:

The genus sumac consists of about 150 species of deciduous or evergreen shrubs, trees, and vines indigenous to temperate and subtropical regions of both hemispheres (Rehder 1990; RHS 1994; Rowe and Blazich 2008). They occur frequently as pioneer species on disturbed sites and abandoned fields and along woodland borders. However, they are intolerant of shade and cannot compete with invading trees (Gill and Healy 1974). Sumacs are tolerant of poor, sandy, or rocky soils, and of soil moisture regimes ranging from dry to wet (Johnson et al. 1966).The species is ideally suited for roadside plantings, revegetation of areas of eroded or depleted soils, range reclamation and mine spoils restoration, and other conservation plantings (Brinkman 1974; Humphrey 1983). Sumacs are recommended as ornamental shrubs for dry and open sites, but cultivation is easy in any garden soil. Species of sumac also provide wildlife with habitat and an important source of food. Their thicket-forming growth provides excellent cover for birds and animals. The fruits, produced in large quantities each year, are eaten by over 30 species of birds, as well as rodents and other mammals (Brinkman 1974; Elias 1989).

Elm-leaved sumac (*Rhus coriaria* L.) is a decidious shrub growing to 3 m. It is in flower from July to August and it occurs on rocky places and waysides (Huxley 1992). Seeds of *Rhus* L. species have physical dormancy caused by a water impermeable endocarp, and some have physiological dormancy as well (Brinkman 1974; Li et al. 1999a and 1999b; Rowe 2002). Mechanical scarification, dry heating, dipping in hot water, fire, and soaking in concentrated sulphuric acid were used in attempts to render seeds permeable, and the results were varied (Heit 1967; Brinkman 1974; Norton 1985; Rasmussen and Wright 1988; Tipton 1992; Li et al. 1999a). Some *Rhus* species also require a cold stratification in addition to scarification before germination will occur (Heit 1967; Norton 1985; Hubbard 1986; Tipton 1992; Li et al. 1999b). The degree of seedcoat hardness and embryo dormancy varies within and among seedlots for most species (Krugman 1974; Hartmann et al. 1997).

Temperature and light affect seed germination percentage and germination rate in some species (Bewley and Black 1994; Edwards and El-Kassaby 1996; Villiers et al. 2002; Phartyal et al. 2003; Çiçek and Tilki 2006 and 2007; Tilki ve Güner 2007; Slabaugh and Shaw 2008). Light and temperature influence germination, and when seeds were subjected to total darkness, the percentage germination of seedlots of smooth sumac (Brinkman 1974) and prairie sumac (Rasmussen and Wright 1988) were reduced. Likewise, temperature also is important. Evergreen sumac germinated at temperatures ranging from 21 to 30 ^{0}C (Tipton 1992), similar to that reported for other sumacs (Brinkman 1974). In studies with alternating day/night temperatures, percentage germination of smooth sumac and shining sumac seedlots was significantly greater when they were subjected to an alternating temperature (16/8 hours) of 20/10 ^{0}C than at 15/5 C or 30/20 ^{0}C. Germination rate was also affectedCgermination was completed within 10 days at 20/10 ^{0}C and 30/20 ^{0}C but took 20 days at 15/5 ^{0}C (Farmer et al. 1982).

Since determining the optimal pretreatments, and temperature and light demand is paramount, the objectives of this research were to examine the influence of pretreatment, temperature, and light on seed germination of *Rhus coriaria.*

Materials and Methods

Seed collection and pretreatments:

Seeds of *R. coriaria* were collected from its natural habitat in October 2011 in Artvin Turkey. Seeds were treated with concentrated sulfuric acid (H_2SO_4, 96%) for 30, 60, 90 and 120 minutes at room temperature (20 °C) followed by cold stratification (30, 60 and 90 days). Seeds in acid were stirred periodically. After the treatments, seeds were thoroughly rinsed with running water for about 15 minutes. Followed the each chemical scarification treatment (with sulfuric acid), seeds were stratified in moist sand for 30, 60 and 90 days at a constant temperature of 4±1 °C. After each treatment, the seeds were removed from the sand and placed into Petri dishes for germination.

Light and temperature treatments*:*

Seeds treated with sulfuric acid for 60 min followed by cold stratification for 60 days were germinated at 20 and 25/15 ºC in dark or 12-h light photoperiod provided by cool-white fluorescent lamps to find the effects of light and temperature on seed germination percentage and germination rate.

Seed germination tests:

Seeds were germinated in Petri dishes, 12 cm in diameter, (4 replicates of 50 seeds each) containing two layers of filter paper moistened with distilled water. Germination tests were conducted in a germination chamber kept at 20ºC at a 12 h photoperiod (with the exception of light and temperature experiment). Seeds were monitored every day and moistened with distilled water if necessary. Germination counts were recorded every day for 30 days and seeds were considered germinated when their radicle protruded. Germination percentage (GP) was calculated each day and as the final value after 30 days. Germination rate was calculated and expressed as peak value (PV), an index of germination speed which is the highest number obtained when percentage germination is divided by the number of elapsed days (Czabator 1962).

Statistical analysis:

All treatments were conducted in a completely randomized design using fifty seeds each in four replicates for all treatments. Data on percent germination were arcsine transformed to stabilize any heterogeneous variance and mean values were subjected to analysis of variance (ANOVA) using SPSS for windows. Whenever significant differences were identified, Duncan's New Multiple Range Test was estimated for the comparison of population and treatment means ($p<0.05$) (Zar 1984).

Results and Discussion:

The seeds of elm-leaved sumac showed a high degree of dormancy in this study. Responses in germination varied and were clearly influenced by the methods used to break dormancy in the species. The analysis summarized in table 1 revealed that pretreatment had a highly significant effect on the germination percentage. Germination response varied significantly across the treatments. Without treatments, 4% of seeds of elm-leaved sumac germinated, and pretreatments increased germination percentage. In this study scarification with sulfuric acid for 60 min followed by cold stratification for 60 or 90 days in elm-leaved sumac gave the highest germination percentage (>64 %). This definite response to stratification is typical of dormant seed sources. In a previous study, cold stratificaton, submersion of boiling water, high temperatures or soaking in H_2SO_4 were not effective to overcome seed dormancy in elm-leaved sumac (Tilki et al. 2013). Scarification with sulfuric acid for 30 or 60 min followed by cold stratification for 60 or 90 days in elm-leaved sumac gave the highest germination in that study. The result found in the present study agrees with the findings of Tilki et al. (2013).

Table 1. Germination of *Rhus coriaria* seeds as affected by duration of acid scarification (min) + cold stratification (day) pretreatment.

	Pretreatment		Germination (%)
1	Control		4.0h
8		30 + 30	38.0e
9		30 + 60	60.0b
10		30 + 90	61.0b
11		60 + 30	52.5c
12	Scarification (min)	60 + 60	69.5a
13	+ cold stratification (day)	60 + 90	65.0ab
14		90 + 30	59.5b
15		90 + 60	53.5c
16		90 + 90	48.5d
17		120 + 30	44.5d
18		120 + 60	46.5d
19		120 + 90	36.0e

Means falloved by same latter are not significantly different

Immersion in boiling water was the best method to render seeds of *Rhus glab*ra and *Rhus typhina* permeable, yet it was ineffective for those of *Rhus aromatica, Rhus trilobata*, and *Rhus virens*. In contrast, a 1 h-soaking in concentrated H_2SO_4 was ineffective in *R. glabra* and *R. typhina*. Thus, there seems to be a tendency for seeds ofsubgenus *Rhus* to respond well to boiling in water, but not to soaking in H_2SO_4 (Li et al. 1999a). It was found that immersion in boiling water, cold stratification, high temperatures or soaking in H_2SO_4 increase germination percentage but this increase was belowe that of a combination of scarification and stratification in this study. In another study, physiological dormancy was present in *R. aromatica*, but not in *R. trilobata*. Stratification at 5 ^{0}C for 1 week or incubation in 500 or 1000 mg/l solutions of gibberellic acid broke physiological dormancy in > 90% of the *Rhus aromatica* seeds (Li et al. 1999b).

Farmer et al. (1982) reported that without scarification, <5% of seeds of smooth sumac germinated, but 3 to 4 hours of scarification in concentrated sulfuric acid promoted an average of 58% germination. Even after 20 years, without scarification, 3% of the seeds receiving no acid treatment germinated. However, there was a gradual increase in the number of decayed seeds with increasing durations of scarification. Germination of seeds of prairie sumac scarified with sulfuric acid was greatest when they were soaked for 60 minutes but was less than that of seeds that were mechanically scarified or treated with wet heat at 94 or 97 ^{0}C (Rasmussen and Wright 1988). Gibberellins and ethylene or ethephon (2-chloroethyl phosphonic acid) are known to overcome dormancy in seeds of some species by completely or partially substituting for the moist-prechilling requirement (Norton 1985; Hartman et al.1997). In other species such as fragrant sumac and skunkbush sumac, seed dormancy is caused by both a hard seedcoat and a dormant embryo, thus requiring both scarification and stratification for optimum germination (Heit 1967). Skunkbush sumac requires 1.5 to 2 hours of scarification and 1 month or slightly longer of moist prechilling for maximum germination (Weber et al 1982). Seeds of evergreen sumac need to be acid-scarified with concentrated sulfuric acid for 50 minutes and then cold-stratified for 73 days (Hubbard 1986; Tipton 1992).

Light and temperature influenced seed germination following pretreatment (sulfuric acid for 60 min followed by cold stratification for 60 days) (Table 2). Seeds germinated at 25/15 ºC had the higher germination than that at 20 ºC when averaged over two light durations. The data in table 2 indicate that germination percentage was lower under continuous darkness than light conditions for all temperatures used in this study.

Table 2. Effects of temperature and light on seed germination percentage of *Rhus coriaria*

Light duration (h)	Temperature (^{0}C) 20	25/15	Mean
0	61,0	63,0	62,0B
12	67,5	76,5	72.0A
Mean	64,2b	69,8a	

Means falloved by same latter are not significantly different

The germination rate (PV) also varied significantly between temperature regimes and light durations (Table 3). There were no significant interactions. Light significantly increased germination rate at both temperatures. Temperature of 25/15 ^{o}C increased germination rate under darkness or light. In general, Germination rate was the highest at 25/15 ^{o}C under light condition.

Table 3. Effects of temperature and light on seed germination rate of of *Rhus coriaria*

Light duration (h)	Temperature (^{0}C) 20	25/15	Mean
0	2,2	2,7	2,5B
12	3,1	3,7	3,3A
Mean	2,6b	3,2a	

Means falloved by same latter are not significantly different

Generally, temperature and light requirements for seed germination vary among and within species (McDermott 1973; Gonzales et al. 1997; Jull et al. 1999; Jull and Blazich 2000; Phartyal et al. 2003; Çiçek and Tilki 2006 and 2007; Tilki and Güner 2007). Light and temperature influence germination, and when seeds were subjected to total darkness, the percentage germination of seedlots of smooth sumac (Brinkman 1974) and prairie sumac (Rasmussen and Wright 1988) were reduced. Heit (1967) also stressed the importance of germination in the presence of light. Likewise, temperature also is important. Evergreen sumac germinated at temperatures ranging from 21 to 30 C (Tipton 1992), similar to that reported for other sumacs (Brinkman 1974). Final percentage germination declined with increasing temperature from a predicted maximum of 52% at 21 C, whereas maximum germination rate increased with temperature to a predicted maximum of 69% germination at 31 C. These results demonstrate that under low temperatures germination would be delayed and slow, but eventually yield more seedlings. Under high temperatures, germination would also be delayed, but relatively rapid, yet it would yield few seedlings (Tipton 1992). In studies with alternating day/night temperatures, percentage germination of smooth sumac and shining sumac seedlots was significantly greater when they were subjected to an alternating temperature (16/8 hours) of 20/10 ^{o}C than at 15/5 ^{o}C or 30/20 ^{o}C. Germination rate was also affected and germination was completed within 10 days at 20/10 ^{o}C and 30/20 ^{o}C but took 20 days at 15/5 ^{o}C (Farmer et al. 1982). Maximum germination of prairie sumac occurred when seeds were subjected to alternating temperatures of 20/10 ^{o}C with a short-day light cycle of 8 hours of light and 16 hours of darkness (Rasmussen and Wright 1988).

In conclusion, this study showed that seed dormancy of elm-leaved sumac can overcome by scarification followed by startification, and germination percentage was the highest in a combination of scarification (60 min) and stratification (60 or 90 days). Light and temperature influenced seed germination following pretreatment (sulfuric acid for 60 min followed by cold stratification for 60 days), and germination percentage and germination rate were the highest at 25/15 ^{0}C under 12 h photoperiod.

Acknowledgements:

This research has been supported by Artvin Coruh University Scientific Research Projects Coordination Department. Project Number: 2011.F10.02.03.

References

Bewley, J.D., Black, M. 1994. Seeds: Physiology of Development and Germination. Plenum Press, New York.

Brinkman, K.A. 1974. *Rhus* L., sumac. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbk 450. Washington, D.C., USDA Forest Service, p. 715-719.

Czabator F.J. 1962. Germination value: An index combining speed and completeness of pine seed germination. Forest Science 8: 86-396.

Çiçek, E., Tilki F. 2006. Effects of temperature, light and storage on seed germination of *Ulmus glabra* Huds. and *U. laevis* Pall. Pakistan Journal of Biological Sciences 9: 697-699.

Çiçek, E., Tilki, F. 2007. Seed germination of three *Ulmus* species from Turkey as influenced by temperature and light. Journal of Environmental Biology 28: 423-425.

Edwards D.G.W., El-Kassaby Y.A. 1996. The effect of stratification and artificial light on the germination of mountain hemlock seeds. Seed Science and Technology 24: 225-235.

Elias, T.S. 1989. Field guide to North American trees. 2nd ed. Danbury, C.T., Grolier Book Clubs. 948 p.

Farmer, R.E., Lockley, G.C., Cunningham, M. 1982. Germination patterns of the sumacs, *Rhus glabra* and *Rhus copallina*: effects of scarification time, temperature, and genotype. Seed Science and Technology 10(2): 223-231.

Gill JD, Healy WH. 1974. Shrubs and vines for northeastern wildlife. Gen. Tech. Rep. NE-9. Broomall, PA: USDA Forest Service Northeastern Forest Experiment Station. 180 p.

Gonzalez-Malero, J.A., Perez-Garcia, F., Martinez-Laborde, J.B. 1997. Effect of temperature, scarification and gibberellic acid on the seed germination of three shrubby species of *Cornilla* L. (Leguminosae). Seed Science Technology 25: 165-175.

Hartmann, H.T., Kester, D.E., Davies, F.T., Geneve, R.L. 1997. Plant propagation: principles and practices. 6th ed. Upper Saddle River, NJ. Prentice-Hall. 770 p.

Heit CE. 1967. Propagation from seed: 7. Successful propagation of six hardseeded group species. American Nurseryman 125(12): 10-45.

Hubbard, A.C. 1986. Native ornamentals for the U.S. southwest. Combined Proceedings International Plant Propagators' Society 36: 347-350.

Humphrey E.G. 1983. Smooth sumac tested for growth on mine spoils. USDA Soil Conservation Service 4(6): 8.

Huxley, A. *1992.* The New RHS Dictionary of Gardening 1992. MacMillan Press.

Johnson AG, Foote LE, Smithberg MH. 1966. Smooth sumac seed germination. Plant Propagator 12(3): 5-8.

Jull LG, Blazich FA 2000. Seed germination of selected provenances of Atlantic white-cedar as influenced by stratification, temperature, and light. HortSci. 35: 132-135.

Jull, L.G., Blazich, F.A., Hinesley, L.E. 1999. Seed germination of two provenances of Atlantic White-Cedar as influenced by stratification, temperature, and light. J. Environ. Hort. 17(4): 158-163.

Krugman, S.L., Stein, W.I., Schmitt, D.M. 1974. Seed biology. In: Schopmeyer CS, tech. coord. Seeds of woody plants in the United States. Agric. Handbook 450. Washington, D.C. USDA Forest Service: 5-40.

Li, X., Baskin, J.M., Baskin, C.C. 1999a. Seed morphology and physiological dormancy of several North American *Rhus* species (Anacardiaceae). Seed Science Research 9: 247-258.

Li, X., Baskin, J.M., Baskin, C.C. 1999b. Physiological dormancy and germination requirements of seeds of several North American *Rhus* species (Anacardiaceae). Seed Science Research 9: 237-245.

McDermott, R. 1973. Light as a factor in the germination of some bottomland hardwood seeds. J. For. 51: 203-204.

Norton C.R. 1985. The use of gibberellic acid, ethephon and cold treatment to promote germination of *Rhus typhina* L. seeds. Scientia Horticulturae 27: 163-169.

Rasmussen, G.A., Wright, H.A. 1988. Germination requirements of flameleaf sumac. Journal of Range Management 41(1): 48-52.

Phartyal, S.S., Thapliyal, R.C., Nayal, J.S., Rawat, M.M.S., Joshi, G. 2003. The influences of temperatures on seed germination rate in Himayalan elm (*Ulmus wallichiana*). Seed Sci. Technol. 31: 83-93.

Rasmussen, G.A., Wright, H.A. 1988. Germination requirments of flameleaf sumac. Journal of Range Management 41:

48-52.
Rehder A. 1990. Manual of cultivated trees and shrubs hardy in North America. 2nd ed. Portland, OR.
RHS [Royal Horticultural Society]. 1994. The new Royal Horticultural Society dictionary index of garden plants. Griffiths M, ed. London: Macmillan.
Rowe, D. Blazich 2008. *Rhus* L.: sumac. In: Bonner and Karrfalt (ed.). The Woody Plant Seed Manual. Washington, D.C. U.S. Department of Agriculture, Forest Service. Agriculture Handbook 727.
Slabaugh, P.E., Shaw, N.L. 2008. *Cotoneaster* Medik. The woody plant seed manual. USDA Forest Service Agriculture Handbook 727.
Tilki, F. 2013. Seed germination of *Cotoneaster nummularia* as influenced by scarification, stratification, temperature and light. International Science and Technology Conference June 25-27, 2013. Rome, Italy.
Tilki, F., Güner, S. 2007. Seed germination of three provenances of *Arbutus andrachne* L. in response to different pretreatments, temperature and light. Propagation of Ornamental Plants 7(4): 175-179.
Tilki, F, Kambur, S., Göktürk, A. 2013. Requirements for seed germination of elm-leaved sumac. Proceedings of the International Scientific Practical Conference Dedicated to 100th Anniversary of Batumi Botanical Garden. 8-10 May 2013. Batumi, Georgia, 2013.
Tipton J.L. 1992. Requirements for seed germination of Mexican redbud, evergreen sumac, and mealy sage. HortScience 27(4): 313-316.
Weber, G.P., Wiesner, L.E., Lund, R.E. 1982. Improving germination of skunkbush sumac and serviceberry seed. Journal of Seed Technology 7(1): 60-71.
Zar, J.H. 1984. Biostatistical Analysis. Prentice Hall, Englewood Cliffs. N.J.