Seed Germination and Flowering in Vallisneria spiralis

G. N. Choudhuri
Botany Department, Washington State University
Pullman, Washington

Vallisneria spiralis is a widespread species occurring from tropical (Bengal, India) to cool temperate climate (Canada) and inhabiting temporary as well as permanent bodies of water. Over such a great range of environments the various phases of life cycle must be regulated by very different conditions. This paper presents the results of studies aimed at discovering what ecologic responses permit this submerged aquatic plant to grow successfully in the region of Varanasi, India, near the southern edge of its latitudinal distribution.

Germination Studies

The usual unresponsiveness of seeds of aquatic plants to normal germinative conditions has led some to believe that normal propagation by seeds might not be as effective as vegetative means, or even in certain cases entirely ineffective as a means of perpetuation of the species. Seeds of *Vallisneria spiralis* are quite unresponsive to external conditions that would seem to favor germination. In nature the seeds mature during the late winter (cool and dry in Varanasi), and the seedlings appear in the early autumn (the end of the hot rainy season).

Crocker (1907) has shown that a number of aquatic plants produce viable seeds, but that seeds of most of these plants fail to respond to normal germinative conditions because their embryos remain covered by impermeable seed coats. If the seed coats are removed, the seeds germinate promptly.

In order to determine whether or not Crocker's findings are applicable to the seeds of *Vallisneria spiralis,* the following steps were taken. Ripe seeds were collected when mature in January from the ponds in Varanasi. They were immediately freed from the pulpy fruits by removing the pericarp in a slow-motion homogenizer, washed well, spread out over cheese cloth for drying, and subsequently stored in paper envelopes under normal laboratory conditions. The dried seeds were treated for lengths of time ranging from 1 to 10 minutes in a volume of concentrated sulfuric acid equal to about five times the volume of the seeds, and were stirred continuously with a glass rod. They were then washed thoroughly in running tap water for about 10 minutes, and placed in petri dishes containing water; temperature was held at 30° C until germination. The seeds were considered germinated when the coleorhiza protruded through the seed coat to an extent of 2 mm. The percentage germination and the time required for the initiation of germination are shown in Table 1. The germination percentages in the tables represent averages of five replicates of 100 seeds. A treatment time of three minutes seems to be sufficient to render the seed coat water-permeable. These findings are similar to those reported by Crocker (1907).

TABLE 1. Percentage germination and the time required for initiation of germination of seeds of *V. spiralis* after treatment with concentrated sulfuric acid, for varying periods of time. Test was made at temperatures around 30° C.

	Time of Treatment in Minutes			
	1	3	5	10
Days to begin germination	8	3	4	—
Maximum per cent germination in 10-day period	10	83	37	—

In nature, *Vallisneria* usually remains confined to the shallow margins of ponds, seldom occurring at depths greater than one meter. Postmonsoon recession of water in ponds causes fatal exposure of plants about the edge of the water. However, by means of their efficient vegetative propagation, the plants maintain a population in the shallow margins of ponds through a downward migration in harmony with the receding water level, until the sexual cycle is completed. Then, upon the advent of summer, the leafy parts decay everywhere while the subterranean rhizomatous parts perennate, provided the ponds do not dry. Leaves reappear from these perennating structures, and germination occurs following the monsoon rains when the water becomes clear due to settling of the suspended solids. This timing of leaf appearance and germination of seeds suggest a sensitivity of these plants to light penetration into water.

In order to determine whether germination is affected by light intensity or light duration, seeds that had been treated with concentrated sulfuric acid for three minutes were germinated in water under different light conditions during a 12-day period at approximately 30°C. The results of this experiment are given in Table 2. Germination appears to be favored by normal photoperiod but is not affected by light intensity.

TABLE 2. Percentage germination of seeds of *V. spiralis* after treatment with concentrated sulfuric acid for three minutes, under different light conditions during 12-day period, at temperatures around 30° C.

	Per cent Germination
Continuous light	26
Normal day with normal night	89
Continuous darkness	10
Diffused light in the laboratory alternating with night	81

Appearance of seedlings in nature at a particular season suggests also a possibility of temperature sensitivity. Accordingly, seeds scarified for three minutes were tested for germination at different temperatures, and the results are embodied in Table 3. The range of temperature conducive to germination of these seeds appears to be quite broad, but the optimum temperature was found to be around 30°C. This compares quite well with the pond temperature. In ponds this temperature is attained twice a year, once in the spring and once in fall. However, optimal temperature during spring is of little value to these plants because subsequent summer desiccation kills the seedlings. In permanent ponds also, germination at this time of the year is of no benefit, because the receding water level causes death of the tender seedlings before they become mature enough to start vegetative propagation. Thus, the appearance of seedlings in fall in this region reflects the best possible adaptation of the species to the environment.

TABLE 3. Percentage germination of seeds of *V. spiralis* after treatment with concentrated sulfuric acid for three minutes, under different conditions of temperatures.

	Temperatures in Degrees C.						
	10	20	26	30	35	40	45
Maximum per cent germination in 12-day period	0	0	22	97	92	60	0

In Varanasi, the pond waters supporting *Vallisneria* populations have a pH range of 7.5 to 8.2. This alkalinity is due to high calcium levels. In other parts of the world[1] where these plants have been reported to occur, the waters have been known to be neutral to alkaline. The germination behavior of the species was tested under different pH conditions, with the pH controlled by use of buffers of suitable range. Table 4, in which the results of this experiment are presented, shows that pH of the medium, in addition to temperature, can be an important factor playing a significant role in controlling the geographical distribution of this species.

TABLE 4. Percentage germination of seeds of *V. spiralis* after treatment with concentrated sulfuric acid for three minutes, under different pH conditions of the medium, at 30° C.

	pH of the Medium							
	3	5	6	7	7.5	8	9	10
Maximum per cent germination in 12-day period	0	0	20	55	70	89	4	0

[1] Information obtained through personal correspondence with persons in different parts of the world.

Flowering

In Varanasi, *Vallisneria* usually starts flowering in November, with the first flowering observable in ponds which are slightly shaded by trees or some other structures along the banks. Winter flowering suggests dependence on shorter days and lower temperatures associated with winter months.

Seedlings germinated in the laboratory were transferred to earthen pots containing a thin layer of pond mud with water above. Photoperiods of varying lengths were given to these plants. Photoperiods longer than eight hours were obtained by supplementation of daylight with electric lamps of 100 watts suspended at a height of four feet from the water surface. Photoperiods shorter than 10 hours were obtained by covering the pots with rubberized cloth covers. The results of these experiments are given in Tables 5 and 6.

TABLE 5. Flowering, vegetative propagation, and fruit development in *V. spiralis* under different photoperiods at an average nyctotemperature of 8° C, and an average day temperature of 21° C. Each figure is a mean value for 10 plants, based on 40 individuals.

	Photoperiods in Hours						
	4	6	8	10	12	16	24
Number of female plants developing flowers	0	0	2	75	51	0	0
Number of male plants developing flowers	0	0	1	53	46	0	0
Number of plants developed vegetatively	0	0	32	301	57	0	0
Number of fruits developed	0	0	13	456	200	0	0

Flowering appears to be conditioned by photoperiod as well as by temperature conditions. During winter months a combination of low temperature and short photoperiods induces flowering (Table 5). In summer months both high temperature and long photoperiods prevent flowering. Under high

TABLE 6. Flowering, vegetative propagation, and fruit development in *V. spiralis* under different photoperiods at an average nyctotemperature 30° C, and an average day temperature of 38° C. Each figure is a mean value for 10 plants, based on 40 individuals.

	Photoperiods in Hours					
	3	4	8	10	12	16
Number of female plants developing flowers	0	0	10	16	0	0
Number of male plants developing flowers	0	28	33	31	0	0
Number of plants developed vegetatively	0	0	0	0	0	0
Number of fruits developed	0	0	0	0	0	0

temperature (Table 6) these plants can be made to flower weakly, but no seeds are produced. Temperature, therefore, plays an important part in fruit development. Fruit setting occurs always in winter and never in summer even under photoperiods conducive to flowering.

Annual Life Cycle

From these studies it appears that the different phases of the life cycle of *Vallisneria spiralis* are determined by the environment.

In Varanasi (India), the plant occurs in temporary as well in perennial ponds. In temporary ponds regeneration depends exclusively on seeds that germinate during the later part of the monsoon (warm and wet) season, in response to a lowering of temperature to about 30°C and a shortening of the day length. The plants in such cases behave as annuals.

In perennial ponds the plants behave as perennials, and regeneration occurs both by seeds and vegetative means. The plants that are exposed due to postmonsoon recession of water level behave as annuals and die before flowering can take place. Perennation is effected by the subterranean rhizomes that persist under water during summer months when high temperature causes death of leaves. Monsoon rains, resulting in a flow of water into these ponds from the surrounding uplands, cause a release of these perennating structures from the pond mud, whereupon they float and come to rest in the shallow marginal waters where they take root and again form the population that recedes as the pond dries.

Acknowledgement

I wish to express my sincere thanks to Professor Rexford Daubenmire for his constructive criticisms and guidance during the preparation of the manuscript for this paper.

Literature Cited

Crocker, W. M. 1907. Germination of seeds of water plants. Bot. Gaz., 44:375-380.