Short Communication

Seed germination and emergence ecology of *Monochoria vaginalis* (Burm. f.) Kunth

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Abstract

Monochoria vaginalis is a noxious herbaceous semi aquatic weed in the family Pontederiaceae, present in paddy fields throughout the rice growing areas of the world. A study was conducted to determine the effect of depth of burial, pH, salinity, flooding, light and temperature on germination of *Monochoria vaginalis*. *Monochoria* seeds germinated on soil surface, but not when placed below 2 cm depth. The germination was found to be higher in solutions of pH 6 and 7, but seeds did not germinate when immersed in buffered solutions of pH 4, 5, 8, and 9. Saline solutions with concentrations ranging from 25 to 250 mM NaCl inhibited the germination. Seeds kept in continuous dark condition failed to germinate irrespective of the temperature provided. *Monochoria* seeds germinated at a temperature of 38°C in continuous light, and in alternate light and dark condition. Seed germination in *Monochoria* was significantly influenced by flooding depth and duration. Greater germination was obtained when seeds were kept in saturated soil condition and low flooding depth (*i.e*., less than 5 cm) for more than 4 days.

Keywords: Depth of burial, Flooding, Light, pH, Salinity, Semi aquatic weed, Temperature.

Monochoria vaginalis, a typical wetland weed of rice, is native to Asia and Western Australia and is commonly called as oval-leafed pondweed or heartleaf false pickerelweed. *Monochoria* occurs in all systems of rice (except dry land rice) including transplanted, both wet and dry direct-seeded, and in deep water and tidal swamp (Moody, 1989). *Monochoria* is often gregarious and highly competitive because of its discontinuous germination, rapid growth and high plasticity.

Germination requirements of weeds may vary with the location and prevailing conditions. Based on specific requirement of weeds, management practices to reduce weed seed germination could be included in integrated weed management programmes. Weed seed germination is mainly affected by light exposure, soil moisture status, depth of burial, flooding, soil pH and temperature. The factors affecting weed seed germination have to be thoroughly understood before formulating a weed management strategy. Hence this study focussed on seed germination and emergence ecology of *Monochoria vaginalis.*

The study was conducted during March 2019 to May 2019, at the College of Horticulture, Vellanikkara, Thrissur, Kerala. The *Kole* lands of Thrissur which lie between the latitudes of 10°20' to 10°40' North, and longitudes of 75°58' to 76°11' East and are located 0.5 m to 1 m below mean sea level are a major rice production tract of Kerala. During December 2018 to January 2019, seeds of *Monochoria vaginalis* were collected from *Kole* lands. Mature seeds were collected from more than 25 plants in paddy fields in separate location.

Germination test was carried out by placing 25 seeds

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evenly in Petri dishes containing Whatman No.1 filter paper moistened with 5 ml distilled water. The test was conducted in Petri plates with and without lid. Another method in which 100 seeds were immersed in distilled water in 25 ml glass vials was also used. The number of germinated seeds were counted daily for 14 days after the start of the experiment, with the visible protrusion of the radicle being the criterion for germination. The mean germination per cent was then worked out.

Effect of depth of burial on germination was tested by keeping seeds buried at 0, 5, 10 and 15 cm depth in pots. 12 pots were filled with soil collected from the *Kole* area which had been solarised for one month. Number of seedlings emerged from different depths of burial upto one month after sowing was observed and mean germination per cent was worked out.

The experiment on effect of light and temperature on germination was conducted in a seed germinator in which light, temperature and humidity conditions could be maintained. Fully matured seeds were incubated at 28 ^{o}C, 33 ^{o}C, and 38 ^{o}C temperature in continuous light, continuous dark, and alternate light and dark (12 h each) regimes. Germination was observed as in the germination test. Mean germination per cent was calculated.

The effect of pH on germination was tested in solutions with pH ranging from 4 to 9, which were prepared using 4, 7 and 9.2 buffer capsules. These solutions were used to moisten 100 seeds each in 25 ml glass vials and germination was recorded as in the germination test and mean germination per cent was noted. Unbuffered distilled water was used as control.

Effect of salinity on germination was studied in solutions with different NaCl concentrations. Sodium chloride amounting to 0, 0.146, 0.242, 0.584, 0.877, 1.169, and 1.461 g was dissolved in 0.1 L water to obtain final NaCl concentrations of 0, 25, 50, 100, 150, 200 and 250 mM respectively. Seeds of *Monochoria vaginalis* were placed in 25 ml glass vials containing these solutions and germination was recorded as in the germination test. Mean values for germination per cent were calculated.

The study on effect of flooding depth and duration on germination was conducted as pot culture. Twenty seeds were sown on the surface of soil. The pots were filled with solarized soil collected from the *Kole* area. Four flooding depths (0, 2, 5 and 10 cm) and three flooding durations (flooding for 2, 4 and 7 days) were adopted. After 2 weeks, emerged seedlings were counted and mean values worked out.

All the above experiments were laid out in completely randomized design with three replications each. The experiments were conducted twice and as the observations were similar both times, the data were pooled.

Preliminary germination test

No seed germination occurred in Petri plates lined with Whatman No. 1 filter paper, both in open condition and with lid. The mean germination percentage was observed to be 20 in glass vial with distilled water. The results were in accordance with the findings of Kataoka and Kim (1978), who witnessed that no seeds of *Monochoria vaginalis* germinated on wet filter paper with atmosphere as the air condition, while Chisaka and Kataoka (1977) reported that seeds incubated under low oxygen level exhibited a high germination per cent.

Effect of depth of burial on germination

Seeds placed at 5, 10 and 15 cm depth of soil failed to emerge. Seeds sown on soil surface germinated and the mean germination percentage was 23.5. Many workers have reported germination of *Monochoria* seeds when placed at a depth of less than 2 mm depth (Kataoka and Kim, 1978; Chen and Kuo, 1995; Koarai and Shibayama 2001).

Table 1. Effect of depth of burial on germination

Depth of burial (cm)	Germination %
0	23.5
5	0
10	0
15	0

Effect of pH on germination

The seeds germinated in solutions of pH 6 and 7, and the mean germination per cent was 22.5 and 24.5 respectively. The seeds placed in buffered solutions of pH 4, 5, 8, and 9 did not germinate. In field conditions, pH and germination of *Monochoria* were in negative correlation, as long as the soil solution pH ranged between 4 and 7 as also observed by Nozoe et al. (2018).

Table 2. Effect of pH on germination

pH	Germination %
4	0
5	0
6	22.5
7	24.5
8	0
9	0

Effect of salinity on germination

The mean germination percentage was 21 for the seeds immersed in non-saline (0 mM NaCl) solution. The experiment was done twice and it was observed that the seeds did not germinate in concentrated saline solutions. Putra (2014) observed that at high concentration of NaCl, the growth of *Monochoria* was reduced. Similarly Nozoe et al. (2012) observed a negative correlation between electrical conductivity of soil and germination of *Monochoria*.

Table 3. Effect of salinity on germination

Salinity (mM NaCl)	Germination %
0	21
25	0
50	0
100	0
150	0
200	0
250	0

Effect of light and temperature on germination

Monochoria seeds kept in continuous dark condition failed to germinate irrespective of the temperature provided. The seeds maintained at 28°C and 33°C did not germinate in all the three light conditions. *Monochoria* seeds germinated only at a temperature of 38° C and the mean germination percentages were 20.67 and 22.17 in continuous light, and alternate light and dark condition respectively.

The result was in contrast to the findings of Chen and Kuo (1995), who observed 30.4°C as the optimum temperature for germination. Park et al. (2010) observed that both seedling emergence and initial growth occurred early at elevated temperature (28°C) than ambient temperature (25°C) as the Effective Accumulated Temperature (EAT) was obtained early in elevated temperature. It was concluded that *Monochoria* seeds required light for germination as confirmed by the findings of Chisaka and Kataoka (1977), Kataoka and Kim (1978), and Chen and Kuo (1995).

Table 4. Effect of light and temperature on germination

Temperature	Mean germination %		
	Continuous light	Continuous dark	Alternate light and dark
28°C	0	0	0
33°C	0	0	0
38°C	20.67	0	22.17

Effect of flooding depth and duration on germination

The result showed that seed germination in *Monochoria* was significantly influenced by flooding depth and duration. The germination percentages recorded under 0, 2 and 5 cm of flooded depth were 23.50, 24.67 and 21.83 respectively, which were significantly higher than that under 10 cm water column (7.33 %). The germination percentages recorded for 4 and 7 days of flooded duration were 19.88 and 20.33 respectively, which were on par and significantly higher than that of 2 days' duration (17.79 %). Considering the interaction effect, it was seen that highest germination percentage (26.83) was obtained when seeds were immersed in 2 cm depth of water for 4

days. This was on par with germination percentage of the combinations, 2 cm for 7 days and 0 cm for 7 days (*i.e*., no flooding). All other combinations were on par except 10 cm flooded depth for 2, 4 and 7 days.

Pons (1982) observed that the *Monochoria* plant had adaptation to flooded condition. Matsuo and Shibayama (2000) obtained results that water condition and size of soil particles were important factors for establishment of juvenile seedlings of *M. vaginalis*, and adhering strength of seedlings was more in a saturated puddled soil than in a flooded soil where soil hardness was alleviated by flooded water. It was observed that in field conditions, plant height, leaf area and dry weight of *Monochoria* decreased, and anatomical structures were changed at greater flooded depth (Putra, 2014).

Table 5. Effect of flooding depth and duration on germination

	Treatments	Germination percentage
Flooding depth (cm)		
	0	23.50
	2	24.67
	5	21.83
	10	7.33
CD (0.05)	1.598	
Flooding duration (days)		
	2	17.79
	4	19.88
	7	20.33
CD (0.05)	1.384	

Table 6. Interaction of flooding depth and duration on germination

	Flooding duration (days)		
Flooding depth (cm)	2	4	7
0	21.67	23.50	25.33
2	21.67	26.83	25.50
5	23	20.33	22.17
10	4.83	8.33	8.33
CD (0.05)		2.768	

From the current investigation, it was clear that *Monochoria vaginalis* germinated only in light condition under anaerobic (saturated or submerged) condition. The seeds germinated on soil surface, but when placed below 2 cm depth, germination was inhibited due to lack of light. The germination required neutral pH in lab condition, and germination was retarded under concentrated saline conditions. An elevated temperature of 38°C favoured the germination more than 28°C or 33°C. Flooding depth greater than 5 cm decreased the germination percentage, may be due to less penetration of light.

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