Some Factors Affecting Germination and Growth of *Echinochloa colona*

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*Echinochloa colona*의 發芽 및 生長에 미치는 諸要因

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ABSTRACT

A series of experiments were conducted to determine the effect of pH, salinity, seeding depth, and moisture stress on the germination and growth of *Echinochloa colona* (L.) Link. Germination significantly decreased at pH 10, but shoot lengths were not affected by the pH tested. Germination was not affected by salt concentrations of up to 0.1%, but was significantly reduced at 0.5%. A 1.0% salt concentration did not significantly reduce shoot length. Increase in seeding depth significantly reduced emergence. Irrespective of seeding depth, the coleoptilar node was always just below the soil surface. Delayed and decreased germination was obtained at −4.6 bars of simulated water potential, while no germination occurred at −9.8 bars. Soil moisture stress significantly reduced plant height, delayed panicle initiation, and reduced seed production.

Key words: pH, salinity, depth of seeding, mesocotyl length, drought stress.

INTRODUCTION

The distribution and abundance of weed species depend on attributes that adapt them to diverse environments. The adaptive characteristics may be exhibited through not only morphological adaptations such as growth habit, regeneration from fragments, or seed setting but also physiological adaptations which result in resistance to salinity or ability to withstand desiccation and wide ranges of pH.

Many weeds have a wide environmental tolerance. Evetts and Burnside[7] observed that common milkweed (*Asclepia syriaca* L.) germinated and produced normal seedlings at pH ranging from 2 to 10. Dawson and Bruns[6] reported that barnyard grass [*Echinochloa crus-galli* (L.) Beauv.] emerged best from shallow soil depths, but was also capable of emerging from 12.5 cm deep. Although increasing osmotic pressure decreases or delays germination of many weed species[10], certain species such as kochia [*Kochia scoparia* (L.) Schrad] are able to germinate at osmotic pressures as high as 13.2 bars.

E. colona is one of the most troublesome tropical annual weeds. It forms an important association with rice (*Oryza sativa* L.) as well as with other crops in many countries[9]. Mercado and Talatala[12]

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observed that an average natural density (280 plants/m^2) of *E. colona* reduced the yield of direct-seeded rainfed rice by as much as 76%.

Sahu[19] reported that *E. colona* required a higher moisture content than rice for germination. Ramakrishnan[17] also observed poor germination of this weed in drier soils.

The objectives of this study with *E. colona* were to determine the effect of (a) pH, salinity, and simulated moisture stress on seed germination, (b) seeding depth on germination and mesocotyl elongation, and (c) soil moisture stress on growth.

MATERIALS AND METHODS

The experiments were conducted in a greenhouse at the International Rice Research Institute (IRRI). *E. colona* seeds were collected from a maize (*Zea mays* L.) field at IRRI and air-dried for 7 days in the greenhouse.

Germination in various media

In the germination studies, 30 seeds were placed on Whatman No. 1 filter paper in petri dishes (9 cm diameter) or in flasks (250 ml Erlenmeyer) and moistened with 10 ml of the appropriate solution. Seeds were considered germinated when the shoot was 5 mm long. The germinated seeds were counted and their shoot lengths were determined 10 days after seeding (DAS). A randomized design with four replications was used.

pH. Various pH solutions ranging from 3 to 10 were prepared in distilled water by using 0.1N HCl or 0.1N NaOH. Solutions of appropriate pH were added to the flasks and the flasks were sealed with rubber stoppers.

Salinity. Sodium chloride (chemical grade) was dissolved in distilled water to prepare salt concentrations of 0, 0.05, 0.1, 0.5, 1.0 and 5.0%. Three ml of each solution were added to the flasks. The flasks were sealed and then placed in the greenhouse.

Simulated moisture stress. Drought conditions were simulated by using polyethylene glycol (PEG). Aqueous solutions of 0, –3.4, –4.6, –5.4, and –9.8 bars water potential were obtained by dissolving PEG (Carbowax PEG 6000, Fisher Scientific Co., New Jersey) in distilled water. The water potentials of the solutions were measured with a calibrated thermocouple hygrometer. Each solution was added to a petri dish, and from time to time small amounts were added to maintain the initial volume.

Seeding depth. To determine the ability of *E. colona* to emerge from various seeding depths, 100 seeds were planted at depths ranging from 0 to 6 cm in a sieved sandy clay loam soil in a plastic tray (24 x 32 x 11 cm). The trays were subirrigated for 2 days, and frequent top watering was done to keep the soil moist during the rest of the experimental period. Two weeks after seeding, the seedlings were harvested to determine the number of emerged seedlings and the mesocotyl length.

Soil moisture stress on growth

The effect of drought stress on the growth of *E. colona* was determined by subjecting the plants to different watering regimes. Five seeds were planted on the soil surface in a plastic tray (24 x 32 x 11 cm) and the trays were subirrigated for 2 days. Before the emerged seedlings had reached the two-leaf stage, the number of seedlings per tray was reduced to one. There were eight replications. They were divided into two lots and watered daily with 100 and 800 ml/tray, respectively. Daily watering with 800 ml/tray was sufficient to keep the soil moist. But since the plants watered with 100 ml/tray per day suffered greatly from drought stress, watering with 800 ml/tray was done from 24 DAS whenever the plants wilted. Plant height was measured 24 DAS and panicles were harvested 60 DAS to determine the number of spikelets, the number of seeds per panicle, and the weight of 100 seeds. The number of days to panicle initiation was also recorded.

RESULTS AND DISCUSSION

pH. There was no major difference in germination over the pH range of 3 to 9 (Table 1) but

Table 1. Effect of pH on germination and shoot length of *Echinochola colona*[a]

pH	Germination (%)	Shoot length (mm)
3	78 a	21 a
4	68 bc	22 a
5	63 bc	21 a
6	71 ab	20 a
7	71 ab	21 a
8	76 a	21 a
9	61 c	19 a
10	42 d	21 a

[a] In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

there was a significant decrease at pH 10. Shoot length was not affected by the pH levels studied. This implies that *E. colona* can establish normal seedlings at pH ranges of 3 to 10.

In germination and growth of plants, pH plays an important role. During germination and growth, an optimum pH level is required for maximum metabolic activity; however, the range is usually relatively narrow. Many weed species are exceptionally tolerant of extreme pH levels[7]. In the case of *E. colona*, pH does not appear to be a major limiting factor for germination and growth.

Salinity. Germination was more sensitive than early seedling growth to the presence of salt. Germination was not affected by salt concentrations of 0.1% or lower (Table 2). Although germination was significantly reduced with 0.5 and 1.0% salt solutions, the shoot length of the germinated seeds was not significantly reduced compared to that of the untreated check. There was no germination at 5.0% salt solution. Thus, *E. colona* seedlings can establish themselves in soils containing at least 1.0% salt.

Table 2. Effect of salinity on germination and shoot length of *Echinochloa colona*[a]

Salt concentration (%)	Germination (%)	Shoot length (mm)
0	84 a	14 a
0.05	74 a	15 a
0.1	77 a	14 a
0.5	53 b	13 a
1.0	31 c	10 a
5.0	0 d	0 b

[a] In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Salinity is a worldwide problem in agriculture. In coastal regions most crops are impaired by salinity, which has been considered as a "physiologically dry" but physically wet condition[4]. In contrast, certain weed species thrive in such conditions. Ryang *et al.*[18] observed that bulrush (*Scirpus maritimus* L.) occurred only in reclaimed rice fields in coastal areas of Korea and preferred 0.1 to 0.5% salt concentrations for germination and growth. Because *E. colona* can adapt to such saline conditions, crop culture may be limited not only by salinity but also by weed competition.

Seeding depth. Increasing the depth of seeding significantly reduced emergence (Table 3). Germination was highest with seeds planted on the soil surface (0 cm). Planting the seed 1 cm deep reduced emergence significantly; however, there was no significant difference in emergence between the seeds planted 1 cm and 2 cm deep. A further significant decrease in emergence occurred when seeds were planted 3 cm deep. There was, however, no significant difference in emergence between the seeds planted 3 to 6 cm deep. The great reduction in emergence due to burial is thought to be due primarily to the absence of light. Other factors which might be involved include temperature, nutrient availability, and moisture.

Table 3. Effect of seeding depth on germination and mesocotyl length of *Echinochloa colona*[a].

Seeding depth (cm)	Germination (%)	Mesocotyl length (mm)
0	72 a	0 g
1	11 b	5 f
2	12 b	19 e
3	5 c	28 d
4	6 c	39 c
5	5 c	48 b
6	5 c	57 a

[a] In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Elongation of the mesocotyl is one of the characteristics of the morphology of grass species. The mesocotyl of *E. colona* elongated from the seed to just below the soil surface irrespective of the depth of seeding (Table 3). Similar results have been reported for barnyard grass[5].

Various studies have indicated that the mesocotyl is responsible for herbicidal uptake.[13,14,20] Baker[2] explained selective control of barnyard grass seedlings in terms of spatial placement of the mesocotyl in herbicide-treated soil. The results of this experiment indicate that elongation of the mesocotyl as well as decrease in emergence of the buried seeds may contribute to a reduced population of *E. colona* when chemical and cultural weed control methods are used.

Drought stress and germination. With simulated drought, decreasing water potential decreased and delayed germination of *E. colona* seeds (Figure 1).

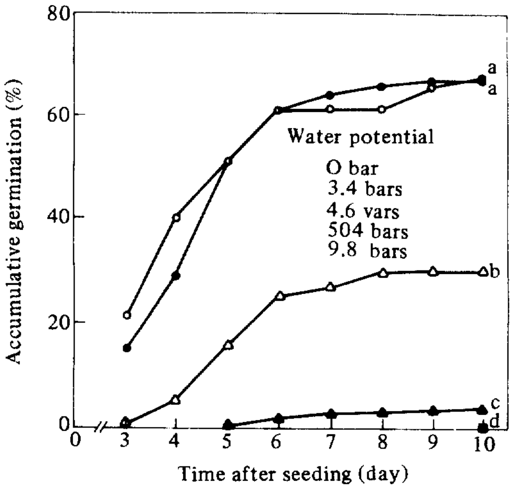

Fig. 1. Effect of simulated drought on germination of *Echinochloa colona* (Means followed by a common letter 10 DAS are not significantly different at the 5% level by Duncan's Multiple Range Test.)

Germination at −3.4 bars water potential was not significantly reduced compared to that at 0 bar, but decreasing water potential to −4.6 bars significantly decreased germination. Delayed germination was observed with seeds subjected to −5.4 bars water potential. No germination occurred at −9.8 bars.

E. colona required a relatively high moisture level for germination; the critical moisture level was −5.4 bars water potential. Pagaspas[15] observed a significant decrease in germination of *E. colona* when the soil moisture content reached 80% of saturated soil.

Drought stress and growth. The overall growth of *E. colona* was significantly reduced when the plants were subjected to drought stress (Table 4). Plants which were stressed were significantly shorter and initiated panicles later than plants which were grown under high soil moisture condition. Delayed panicle initiation was attributed to reduction in growth. Drought also significantly reduced the number of spikes and seeds per panicle as well as the mean seed weight. Decreased seed production could have been due to reduction in growth and increase in floret sterility.

E. colona seeds do not appear to have specific requirement for pH or salinity during germination. However, seeding depth and adequate water during germination are critical. The decrease in germination with seeding depth can be an important factor in controlling this weed by tillage. Other workers[1,3] have reported reduced weed seed germination with deep tillage.

Seed germination seems to be affected by the osmotic property of the salt solution rather than by a direct physiological effect of the solute ion. Germination was similar for a solution containing 1.0% NaCl (−6.6 bars water potential) and one containing nontoxic[16] PEG solution of −4.6 bars water potential; however, early seedling growth as measured by shoot length in the salt solutions was not inhibited by the solute ion.

Water stress at a critical stage of development has been shown to increase floret sterility in several grass species[11]. Although drought stress results in decreased seed production, it would not affect the germination ability of the seeds produced, which is attained relatively early in ontogeny, i.e., long before ripening and soon after anthesis[8].

Table 4. Effect of drought stress on plant height, days to panicle initiation, and seed production of *Echinochloa colona*[a].

Moisture status	Plant height (cm)	Panicle initiation (days)	No. of spikes/panicle	No. of seed/panicle	Weight of 100 seeds (mg)
Without stress	27 a	43 b	9 a	217 a	122 a
With stress	14 b	54 a	7 b	81 b	63 b

[a] In a column, means followed by a common letter are not significantly different at the 5% level by Least Significant Difference.

Considering the fact that the survival to maturity of only a few plants each year would be sufficient to reinfest an area with several thousand new weeds, any measures which prevent seed formation would be more desirable than those directed to suppress growth in relation to a long-term control program.

摘　　要

Echinochloa colona (L.) Link의 發芽 및 生長에 미치는 pH, 鹽度, 播種深度 및 水分壓迫의 影響을 調査하였다. 發芽는 pH 10에서 현저히 減少되었으나, 幼芽의 길이는 試驗된 pH의 範圍內에서 有意差가 없었다. 鹽分濃度 0.1% 以下에서는 發芽에 影響을 미치지 않으나, 0.5%에서 減少되었다. 鹽分濃度 1.0%에서는 幼芽伸長에 影響을 미치지 않았다. 播種深度가 깊어짐에 따라 發芽率은 현저히 減少되지만, 播種深度에 關係없이 葉鞘마디(coleoptilar node)는 항상 地表面 바로 밑에서 形成되었다. 水分포텐셜이 －4.6 bars에서 發芽는 減少되고 遲延되었으며, －9.8 bars의 水分포텐셜에서는 發芽되지 않았다. 土壤의 水分壓迫은 草長을 減少시키고, 出穗를 遲延시켰으며, 種子生産을 減少시켰다.

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