FACTORS AFFECTING GERMINATION AND EMERGENCE OF CYPERUS DIFFORMIS L. SEEDS

ISMAIL B.S.*, NORIZA MANSOR and MOTIOR M. RAHMAN

School of Environmental and Natural Resource Sciences
Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor D.E. Malaysia
E-mail: ismail@pkrisc.cc.ukm.my

ABSTRACT

Laboratory and greenhouse studies were conducted to determine the effect of planting depth, water depth, soil moisture and environmental factors such as light and temperature on the germination and emergence of Cyperus difformis seeds. The results showed that the total germination was highest at alternating temperatures regimes of 25/30ºC. Light is an important factor in the germination of Cyperus difformis seeds as germination is inhibited in the dark. The highest percentage emergence of Cyperus difformis seedlings was observed when the seeds were sown at the soil surface (0 cm depth), with no emergence at 1 cm depth onwards. Higher germination occurred at 100% soil moisture content but decreased as the soil moisture content decreased. The highest percentage emergence was observed at saturated water conditions of the soil surface and it decreased with increased submergence.

INTRODUCTION

Cyperus difformis L. also known as dirty dora (Australia) or small flower umbrella plant (U.S.A.), belongs to the family Cyperaceae. Cyperus difformis is an annual native of tropical areas of the old world. It has been reported as a weed of rice in more than 40 countries from 35ºS to 45ºN. It is widespread throughout southern Europe, Asia as well as central and north America (Holm et al. 1977). The species grows better in flooded or very humid soils and is therefore, an important weed in irrigated rice. The plants produce abundant seeds that germinate and establish dense infestations quickly (Valillant 1967). The plants produce seeds throughout the year with the existing humidity available under tropical conditions (Holm et al., 1977). Cyperus difformis is a prominent weed of rice in Malaysia but there is insufficient current research literature available.

Several environmental factors are known to promote or inhibit weed seed germination (Taylorson, 1987; Burke et al. 2003). Temperature, moisture, light and pH requirements for germination vary considerably from species to species (Zhou et al. 2005). Some weed species can emerge from a wide range of planting depths (Singh and Achhireddy 1984; Norsworthy and Oliveira 2005), while others must be close to the soil surface (Biswas et al. 1975). Preliminary studies on the effects of environmental factors on C. difformis have been reported (Pratley et al., 2004). An understanding of the germination...
biology can help predict the potential of its spread into new areas and be useful in developing effective control measures. The purpose of this research was to examine the effects of soil moisture, seeding and water depth as well as some environmental factors such as light and temperature on germination and emergence of C. difformis seeds.

MATERIALS AND METHODS

Seed Source and Experimental Soil
Several experiments were conducted under laboratory and greenhouse conditions at the Universiti Kebangsaan Malaysia (UKM) to elucidate the germination and emergence behaviour of Cyperus difformis seeds. The C. difformis seeds used were imported from Herbiseed, New Farm Mire Lane, West End Twyford, RD100NJ, UK.

All tests on germination were conducted in 9-cm diameter petri dishes lined with one layer of filter paper (Whatman No. 2). The filter paper was moistened with 3 ml distilled water. Preliminary tests have shown that 50 seeds per petri dish are suitable for the germination test. Seeds were considered germinated when the radicle attained a length of 1 mm. The number of germinated seeds was counted and the percentage germination calculated based on the number of seeds used.

For greenhouse experiments the soil used was the Lating Series soil, which constituted 46.5% sand, 23.5% clay and 30.0% loam. The soil was sterilized by autoclaving at 121°C temperature and 101.3 kPa for 20 minutes to kill any existing weed seeds. Both laboratory and greenhouse experiments were laid out using the complete randomized design with five replications.

Effect of temperature on the germination of Cyperus difformis seeds
The experiment was conducted in a growth incubator, which was set up at different temperature levels to determine the optimum temperature for the germination of Cyperus difformis seeds. Fifty seeds were placed in each petri dish of 9-cm diameter, lined with Whatman No. 1 filter paper, moistened with 3 ml distilled water. Preliminary tests have shown that 50 seeds per petri dish are suitable for the germination test. Seeds were considered germinated when the radicle attained a length of 1 mm. The number of germinated seeds was counted and the percentage germination calculated based on the number of seeds used.

Effect of light on the germination of Cyperus difformis seeds
The light requirement was determined by comparing the seed germination in the petri dishes. For the dark treatment, the petri dishes were wrapped in aluminum foil, while the others were exposed to 40 μmol m⁻² s⁻¹ of unfiltered cool white fluorescent light. The petri dishes were placed in the incubator at temperature 25°C/30°C. In each petri dish, 50 seeds were placed. The germination was determined on day 10.

Effect of seeding depth on the emergence of Cyperus difformis seeds
Plastic pots (20 cm height X 15 cm diameter) were each filled with 800 g of sterilized soil. Seeds were sown at six different seeding depths, namely, 0, 1, 2, 3, 4 and 5 cm. Fifty seeds were sown per pot at the different seeding depth as per treatment. Pots were placed in the greenhouse with the daily temperature of 29±5°C and light intensity 800 ± 200 μEm⁻²s⁻¹. Plants were watered daily. The emergence (shoot appeared on the soil surface) of the Cyperus seedlings was determined at 10 days after sowing.

Effect of soil moisture on the germination of Cyperus difformis seeds
Plastic pots (20 cm height X 15 cm diameter) were each filled with 800 g of soil at four different moisture levels, namely 30%, 50%, 70% and 100%. In each plastic pot 81, 135, 203 and 270 ml water was applied to maintain the required moisture level. The moisture was maintained by weighing daily and adding the required amount of water. Fifty seeds were sown per pot at the soil surface. The emergence of the Cyperus seedlings was determined at 10 days after sowing.

Effect of water depth on the emergence of Cyperus difformis seeds
Plastic buckets (20 cm height X 15 cm diameter) were each filled with 1.80 kg of sterilized soil and saturated to 100% moisture content (by adding approx. 600 ml water). Fifty seeds were sown in each plastic bucket, and the buckets were then flooded to different water levels, namely, 0, 2, 4 and 8 cm above soil surface. The emergence of the Cyperus seedlings was determined at 10 days after sowing.

Statistical analysis
All experiments were laid out in a complete randomized design with five replications. All data were subjected to analysis of variance and the means were determined using Fisher’s Protected LSD test at the 5% level of significance.
FACTORS AFFECTING GERMINATION AND EMERGENCE OF CYPERUS DIFFORMIS L. SEEDS

RESULTS AND DISCUSSION

Effect of temperature on the germination of Cyperus difformis seeds

Table 1 shows the effects of temperature on the germination of C. difformis seeds. The highest germination (42.8%) was obtained at the alternating temperature regime of 25/30°C. Moderate germination occurred at a constant temperature of 30°C and at the alternating temperature of 25/35°C. The lowest percentage germination was recorded at a constant temperature of 28°C. This result showed that the germination decreased at temperature level below the constant temperature of 30°C, but a higher alternating temperature may favourably affect seed germination. Cyperus difformis germinates better at the alternating temperature of 25/35°C than at the constant temperature of 28°C. Results have shown that the optimum temperature for Cyperus difformis seed germination is similar to that found in the local environment. The present findings also coincide with the findings of Ismail and Rosmini (1996), who reported that the Siam weed (Chromolaena odorata) seeds germinate in alternating temperature regimes of 20/30°C and 25/30°C. In laboratory experiments, alternating temperature regimes (25/35°C) have also been found to be optimal for Campsis radicans seed germination whereby this weed species can germinate up to 74% (Chachalis and Reddy, 2000). A significant germination level of C. difformis required a minimum of 15°C night temperature to a maximum temperature of up to 35°C (Pratley et al. 2004). The minimum temperature reported is slightly different from that reported by Pratley et al. (2004). This may be due to difference in seed maturity and the different sources of seed used in both studies. Alternating temperature may soften the seed coat, consequently allowing gaseous exchange for metabolism and easy radicle penetration. The stimulation of seed germination by diurnal temperature fluctuation has been reported in many weed species, including Sorghum halepense (Johnsongrass, Benech-Arnold et al. 1990), Cyperus rotundus (purple nutsedge, Miles et al. 1996), and Eleusine indica (goosegrass, Nishimoto and McCarty 1997).

Effect of light on the germination of Cyperus difformis seeds

The highest germination was obtained at 12 hours light under the alternating temperature regime of 25/30°C. No germination occurred in the dark. These results show that light affects the germination of Cyperus difformis and is an essential factor for Cyperus difformis seed germination. Light has also been reported to affect the germination of other weed seeds (MacDonald et al., 1992; Reddy and Singh, 1992; Norsworthy and Oliveira 2005).

Effect of seeding depth on the emergence of Cyperus difformis seedlings

Seeding depth was shown to have a significant effect on the emergence of Cyperus difformis seeds. The highest percentage of seedlings emerged from surface seeding (zero depth) while no germination occurred when the seeding depth was increased to 1 cm or more. This result correlated with the light requirement for germination to occur. It was shown earlier that the seed only germinated under light. Maximum emergence from soil-surface-sown seeds also suggests that minimum tillage practices may expose seeds to the soil surface consequently increasing the germination of viable C. difformis seed. A light requirement for weed seed germination is common especially in species that have small seed (Taylorson 1987) which contain only limited amount of food reserves for germination. It has also been shown that limited light penetration is the probable reason for the failure of the Siam weed to emerge at lower depths (Ismail and Rosmini 1996). Only 45% germination was obtained for Brunnichia ovata seeds when seeded at 5 cm depth (Shaw et al., 1991). Many weed species seeds can germinate well at 2 cm seeding depth but germination had been found to be restricted at 6 cm depth (Froud-Williams 1984). The current study has revealed that Cyperus difformis seed could germinate well at surface seeding (0 cm) but no germination occurs from 1 cm to 5 cm seeding depth. Inhibition of germination in the dark prevents germination of seeds that are buried deep in the soil. Seeds would only germinate when seeds are buried at or near the soil surface.

Effect of soil moisture on the emergence of Cyperus difformis seeds

Figure 1 outlines the optimum range of soil moisture on the emergence of C. difformis seedlings. Soil moisture levels significantly affected the germination of C. difformis seeds. The

Table 1. Effect of temperature on the germination of Cyperus difformis seeds

<table>
<thead>
<tr>
<th>Temperature ºC</th>
<th>Germination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 (constant)</td>
<td>3.2 ± 1.78</td>
</tr>
<tr>
<td>30 (constant)</td>
<td>26.8 ± 6.10</td>
</tr>
<tr>
<td>25/30 (alternate)</td>
<td>42.8 ± 7.16</td>
</tr>
<tr>
<td>25/35 (alternate)</td>
<td>22.4 ± 4.77</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>7.17</td>
</tr>
</tbody>
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The highest percentage of seedlings emerged from surface seeding (zero depth) while no germination occurred when the seeding depth was increased to 1 cm or more. This result correlated with the light requirement for germination to occur. It was shown earlier that the seed only germinated under light. Maximum emergence from soil-surface-sown seeds also suggests that minimum tillage practices may expose seeds to the soil surface consequently increasing the germination of viable C. difformis seed. A light requirement for weed seed germination is common especially in species that have small seed (Taylorson 1987) which contain only limited amount of food reserves for germination. It has also been shown that limited light penetration is the probable reason for the failure of the Siam weed to emerge at lower depths (Ismail and Rosmini 1996). Only 45% germination was obtained for Brunnichia ovata seeds when seeded at 5 cm depth (Shaw et al., 1991). Many weed species seeds can germinate well at 2 cm seeding depth but germination had been found to be restricted at 6 cm depth (Froud-Williams 1984). The current study has revealed that Cyperus difformis seed could germinate well at surface seeding (0 cm) but no germination occurs from 1 cm to 5 cm seeding depth. Inhibition of germination in the dark prevents germination of seeds that are buried deep in the soil. Seeds would only germinate when seeds are buried at or near the soil surface.

Figure 1 outlines the optimum range of soil moisture on the emergence of C. difformis seedlings. Soil moisture levels significantly affected the germination of C. difformis seeds. The
highest germination was obtained at 100% (26%) and a decreasing trend was observed with reducing levels of moisture. Soil moisture is important in determining the germination and survival of most weed seeds. For instance, drought caused reduction in the survival rate and dry matter of field bindweed (*Convolvulus arvensis*) (Dall’Armellina and Zimdahl 1989).

**Effect of water level on the emergence of *Cyperus difformis* seeds**

Figure 2 shows the effect of water level on the seedling emergence of *Cyperus difformis*. The emergence of *Cyperus difformis* was significantly affected by the inundation of water at varying depths. Germination of *Cyperus difformis* was highest at 100% soil moisture content (0 cm). With increasing level of inundation the rate of emergence was significantly reduced. Germination was totally inhibited when submerged to a depth of 8 cm. No difference in the emergence was observed at 2 and 4 cm inundation of water. The emergence of the seedlings was reduced as the water level increased. A similar observation was made on *Echinochloa crus-galli* as the water level increased (Boyd and Van Acker, 2003). This implies that the germination of this species occurs under aerobic conditions. Therefore, it is suggested that the emergence of *Cyperus difformis* could be controlled by correct water management.

**CONCLUSION**

The results suggest that ploughing and water management may be instrumental in controlling the germination and establishment of *Cyperus*...
difformis. By ploughing the seeds get buried deep into the soil and consequently seed germination is inhibited. The species infests direct seeded rice fields but does not seem to flourish in flooded fields. However, further studies on the effect of flooding at different growth stages of the weed need to be carried out, not only in greenhouses but also under field conditions.

REFERENCES


