Available online at www.sciencedirect.com
SCIENCE DIRECT®
Environmental and Experimental Botany 53 (2005) 259–269
Environmental and Experimental Botany
www.elsevier.com/locate/envexpbot

Responses of *Cyperus brevifolius* (Rottb.) Hassk. and *Cyperus kyllingia* Endl. to varying soil water availability

Azrianingsih Rodiyati [a,b,*], Endang Arisoesilaningsih [b], Yuji Isagi [a], Nobukazu Nakagoshi [a]

[a] *Graduate School for International Development and Cooperation, Hiroshima University, 1-5-1 Kagamiyama, Higashi-Hiroshima 739-8529, Japan*
[b] *Department of Biology, Faculty of Mathematics and Sciences, Brawijaya University, Jalan Veteran, Malang 65145, Indonesia*

Accepted 23 March 2004

Abstract

Different responses of *Cyperus brevifolius* and *Cyperus kyllingia* to varying soil water regimes were examined to explain their successful existence in a diverse range of habitats throughout the year in Indonesia. Thirty 43-day sprouts of each species were grown in three soil conditions, namely drought, field capacity, and flooding under greenhouse conditions. Plant height, leaf length, tiller number, and flower number were measured twice a week, from 45 to 98 days after sowing (DAS), while the other 12 traits were recorded at the end of the observation time. Ten out of the twelve traits were substantially influenced by the soil water content. Both species exhibited their best growth, production, and reproduction under field capacity conditions, and these traits were greatly subdued under drought conditions. Under drought conditions, both species manifested reduced growth and leaf expansion; however, stomatal aperture and frequency did not exhibit strong response to the soil water content. *C. brevifolius* showed a significantly greater biomass production and reproductive traits in field capacity and flooded conditions, but under drought conditions, growth was greatly hampered and only vegetative propagation occurred. On the other hand, *C. kyllingia* showed a higher tolerance to drought conditions, indicated by both a higher biomass and a higher number of flowers. The results obtained suggest that survival ability when faced with drought conditions was more apparent in *C. kyllingia* than in *C. brevifolius*, but where there was sufficient soil water, *C. brevifolius* was more prolific. This could be the explanation for the dominance of *C. brevifolius* in flooded areas and during the rainy season, and the occurrence of *C. kyllingia* in a wider range of habitats throughout the year.

Keywords: Drought; Flooding; Indonesia; Invasive species; Water stress; Weed

1. Introduction

Cyperus brevifolius and *Cyperus kyllingia* are pantropic sedges, which are similar in morphological characteristics and are mainly distinguished based on inflorescence color, namely green for *C. brevifolius*

* Corresponding author. Tel.: +62-341-575842; fax: +62-341-554403.
E-mail address: rodiyati@brawijaya.ac.id (A. Rodiyati).

0098-8472/$ – see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.envexpbot.2004.03.018

and white for *C. kyllingia* (Soedarsan et al., 1983). *C. brevifolius* grows widely in tropical and temperate regions across the world, whereas *C. kyllingia* is commonly found in tropical regions of Asia but rarely found in tropical regions on the continents of Africa, America, and Australasia (Kern, 1974). The oldest record of *C. brevifolius* has been obtained from far eastern Asia (Koyama, 1961; Delahoussaye and Thieret, 1967), but the actual origin of both species has not been clearly defined. Although they are commonly known as perennial weeds usually growing in various fields (Heyne, 1987; Yamakawa and Ueyama, 1991; Holm et al., 1997), they can be prospectively exploited in perfumery (Neal, 1965; Komai and Tang, 1989), for medicine (Sudarnadi, 1996; Helliön-Ibarrola et al., 1999) and for fodder (Kern, 1974; Heyne, 1987).

Both species are found throughout the year in tropical areas, such as Indonesia. *C. brevifolius* is mostly found in moist to wet habitats (Kern, 1974; Holm et al., 1997), whereas *C. kyllingia* is usually found in slightly wet lands (Kern, 1974). They usually occupy the same habitats such as paddy fields, open lawns, riversides, street sides, and yards. Furthermore, they exhibit a wide range of ecological amplitude of adaptation to varying soil water availability during the rainy flooding season and the sunny drought season. Understanding such interesting phenomena is necessary as the problem of *C. brevifolius* and *C. kyllingia* as weeds and as rapid invasive species that are difficult to eradicate particularly with their ability to establish themselves in various habitats throughout the year. Therefore, the main motivation in this research was to ascertain the growth, productive, and reproductive responses of the two species depending on water availability in the soil.

The immediate eco-physiological effect of the water supply on plants is on stomatal aperture. When plants experience some degree of drought stress, stomatal closure takes place, and consequently there would be a reduction in the movement of CO_2 and water vapor. This reduction has detrimental effects on photosynthesis, leaf wilting, and chlorosis. Furthermore, prolonged drought stress influences the outcome of total biomass production, biomass partitioning, and reproductive capacity (Hsiao, 1973; Ludlow, 1976; Kozlowski, 1984; Radosevich et al., 1997). A number of researchers have characterized the sensitivity of wetland plants to drought conditions, which significantly hindered their growth and productivity (i.e. Alcocer-Ruthling et al., 1989; van Oorschot et al., 2000; Li et al., 2001), while flooding conditions could decrease their productivity (Blanch et al., 1999; Chen et al., 2002) or insignificantly influence their production (van Oorschot et al., 2000). Moreover, drought conditions have been thought to trigger a signal that causes an early switch to flower formation (Desclaux and Roumet, 1996), whereas vegetative reproduction is more favored by wet soil condition (Li et al., 2001).

Common parameters of plant responses to soil water availability can be obtained from life history traits such as plant height, leaf size, stomatal apparatus, partitioning biomass, and flower and tiller numbers (Bunce, 1977; Schulze, 1986; Younis et al., 1993; Clifton-Brown and Lewandowski, 2000; Li et al., 2001). Such parameters can vary within a genus or a species because they can be plastic in their responses to soil water conditions as observed in some C_4 plants (i.e., Clifton-Brown and Lewandowski, 2000; Li et al., 2001). Sumaryono and Basuki (1986) observed the growth and reproduction of *C. brevifolius* and *C. kyllingia* and found only slight differences between them under favorable conditions. Hence, this study is aimed at assessing different responses of *C. brevifolius* and *C. kyllingia* to drought, field capacity, and flooding conditions, which could be linked to define their successful existence in a wide range of areas throughout the year in Indonesia. The following hypotheses were tested: (i) growth, productivity, and reproduction of *C. brevifolius* and *C. kyllingia* are significantly influenced by the soil water conditions; (ii) *C. brevifolius* and *C. kyllinga* have different growth, productive, and reproductive behavioral responses to each of the conditions of drought, field capacity, and flooding, and (iii) *C. kyllingia* is more resistant to drought conditions than *C. brevifolius* because *C. kyllingia* is more visible during the dry season.

2. Materials and methods

2.1. Plants and medium

Cyperus brevifolius and *C. kyllingia* were collected from 10 study sites in Malang, East Java, Indonesia (Fig. 1), from March to November 2000. They were identified using the descriptions of Kern (1974)