

EVALUATING THE ECOPHYSIOLOGY OF SURVIVAL FOR *MAPANIA CUSPIDATA* (MIQ.) UITTEN (CYPERACEAE) TRANSPLANTATION

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ABSTRACT

SHABDIN, Z., NORI, H., MEEKIONG, K. & FAIZ, M. F. M. 2021. Evaluating the ecophysiology of survival for *Mapania cuspidata* (Miq.) Uittien (Cyperaceae) transplantation. *Reinwardtia* 20(2): 69–75. — This study aimed to investigate the ecology of the sedge *Mapania cuspidata* at three different locations in East Malaysia, namely Gunung Gading, Matang and Bengoh, and the survival of *M. cuspidata* transplanted in pots exposed to different light intensities in Universiti Malaysia Sarawak, East Malaysia. The highest species density was recorded in Matang with a total density of 1.98 individuals/ha followed by Bengoh (1.42) and Gunung Gading (0.96). In these locations, the soil pH ranged from 4.9 in Bengoh to 5.7 in Matang where as soil organic matter content was between 3.47% in Bengoh and 8.68% in Gunung Gading. The highest light intensity was recorded in Matang with 0.94 kLux, and produced plants with the highest chlorophyll content (64.8 SPAD value). This study found that the transplanted *M. cuspidata* had 90% survival over a four month experiment, produced ~ 8 new leaves, took an average of 15.8 days to produce a new leaf and had a chlorophyll content of ~30.3 SPAD value regardless of the intensity of light where the plants were exposed to. The findings of this study suggests that *M. cuspidata* can grow well in any light conditions and therefore it is also possible to transplant and re-establish other *Mapania* species in new location. It is hoped that the initiative to relocate other *Mapania* species of conservation concern will be effective if adequate post-harvest handling methods are practiced.

Key words: Ecophysiology, light intensity, *Mapania*, vegetative propagation.

ABSTRAK

SHABDIN, Z., NORI, H., MEEKIONG, K. & FAIZ, M. F. M. 2021. Evaluasi ekofisiologi ketahanan transplantasi *Mapania cuspidata* (Miq.) Uittien (Cyperaceae). *Reinwardtia* 20(2): 69–75. — Tujuan penelitian ini adalah untuk mengkaji faktor-faktor ekologi jenis tersebut di tiga lokasi di Malaysia Timur, yaitu Gunung Gading, Matang dan Bengoh, serta menganalisis kemampuan bertahan hidup *M. cuspidata* yang ditanam di dalam pot terbuka yang terpapar sinar matahari dengan intensitas cahaya yang berbeda-beda di Universiti Malaysia Sarawak, Malaysia Timur. Kerapatan jenis tertinggi tercatat di Matang dengan jumlah 1,98 individu/ha, diikuti Bengoh (1,42) dan Gunung Gading (0,96). pH tanah di lokasi tersebut berkisar dari 4,9 di Bengoh hingga 5,7 di Matang, dengan kandungan tanah organik berkisar antara 3,47% di Bengoh dan 8,68% di Gunung Gading. Intensitas cahaya tertinggi tercatat di Matang dengan 0,94 kLux, dan menghasilkan tumbuhan dengan kandungan klorofil tertinggi (nilai SPAD 64,8). Penelitian ini menunjukkan bahwa *M. cuspidata* yang ditanam dalam pot setelah melalui durasi pertumbuhan selama empat bulan mempunyai kemampuan bertahan hidup sebesar 90%, menghasilkan 8 daun baru, dan membutuhkan waktu rata-rata 15,8 hari untuk menghasilkan daun baru serta mempunyai kandungan klorofil dengan nilai SPAD 30,3 terlepas dari intensitas cahaya di mana tanaman terpapar. Penelitian ini menunjukkan bahwa *M. cuspidata* dapat tumbuh dengan baik dalam semua kondisi cahaya, oleh sebab itu memungkinkan untuk penanaman dan menanam kembali jenis *Mapania* lainnya di lokasi baru. Diharapkan inisiatif untuk merelokasi jenis *Mapania* lain yang menjadi perhatian konservasi akan efektif jika dilakukan metode penanganan pasca panen yang memadai.

Kata kunci: Ekofisiologi, intensitas cahaya, *Mapania*, perbanyak vegetatif.

INTRODUCTION

Cyperaceae (sedges) is a monocotyledonous angiosperm plant family with over 5387 species (Govaerts *et al.*, 2007). They are of economic, ethnobotanical, conservation and environmental importance. Their economic importance has often been underestimated due to their local and regional use (Simpson & Inglis, 2001). Since early Egyptian civilization, sedges have been recognized, particularly through the role of papyrus (*Cyperus papyrus*), in providing writing and construction materials. Their importance has since wide-ranging, from the trouble they cause as weeds (*e.g.* *Cyperus rotundus* L.), to the substantial number of uses such as providing materials for basketry, matting, construction, perfumery, medicine and fuel, as well as food and animal fodder (Negbi, 1992; Govaerts *et al.*, 2007, Simpson & Inglis, 2001). They also serve as dominant components of many wetland ecosystems and are reliable indicators of habitat degradation in such systems (Simpson *et al.*, 2003), consequently acting as environmental indicators for conservation. They also play a vital role in preventing erosion and flooding in many ecosystems (Naczi & Ford, 2008). This family currently includes two subfamilies, Mapanioideae and Cyperoideae (Govaerts *et al.*, 2007; Muasya *et al.*, 2009), with genus *Mapania* being under subfamily Mapanioideae. The diversity of *Mapania* species from Sarawak is tremendous, with 31 out of 71 world's total number are recorded (Miraadila *et al.*, 2016). Studies on *Mapania* of Sarawak since 2008 by Shabdin *et al.* (2013a, 2013b, 2016) has observed the high tendency of endemism of the species to Borneo (*M. longiflora*, *M. angustifolia*, *M. lorea*, *M. debilis*, *M. maschalina*, *M. obscuriflora*, *M. richardsii*, *M. borneensis*, *M. latifolia* and *M. hispida*), and hyper-endemism (*M. foxworthyi*, *M. graminea*, *M. sapuaniana* and *M. multiflora*). Only a few species are widespread; for instance, *M. cuspidata*. This species is well-distributed in South-East Asia, including Thailand, Peninsular Malaysia, Singapore, Sumatra, Java, Borneo, Brunei Darussalam, Philippines, Maluku, Papua, Sulawesi, Papua New Guinea, Solomon Islands and New Hebrides. In Sarawak, this species may occur in mixed dipterocarp, kerangas, swamp, limestone and degraded forests. *Mapania* is locally known as rumpit serapat or pandan tikus by the Malay people. In Sarawak, *Mapania* is also called as daun meing by the Iban, tenduh in Bidayuh language, daon sisiet by Melanau, iee in Saban and Kelabit language, and da'aah in Kenyah

and Penan dialectal (Miraadila, 2018). Although many Cyperaceae members are heliophytes adapted to open environment, this does not apply to members of *Mapania* which prefers growing on the ground layer of tropical rainforests in low light conditions (Simpson, 1992). According to Engelbrecht *et al.* (2007), drought has a limiting effect on the tropical plant distributions and observed that global warming in tropical rainforests could result in loss of diversity and species extinction. Drier conditions could, therefore, accelerate the decline, and extinction of many *Mapania* species throughout the tropics (Simpson *et al.*, 2011). Other factors such as dispersal ability of the species and niche suitability certainly play parts in the survival of *Mapania* spp. However, how well *Mapania* could migrate with changing climate or adapt to new conditions is unknown.

Most *Mapania* species occur in an uncommon habitat of Cyperaceae, which prefer open areas with direct sunlight (Miraadila, 2018). Members of this genus occur where little light penetrates through the canopy, and usually in areas where the soil is damp, muddy, or peaty, or in swampy depressions or by the side of pools or streams (Simpson, 1992). Some species occur in a very restricted habitat, resulting in a high number of endemic species. *M. sapuaniana* for example, has so far only been recorded in a small area at Sungai Joh (approx. 3 km radius) of Lanjak Entimau Wildlife Sanctuary (LEWS) (Shabdin *et al.*, 2016), while *M. ballehensis*, *M. kipas* and *M. mirae* are recorded only from Baleh National Park. In many field expeditions conducted since 2008, the effort of collecting living specimens to be planted in our arboretum has failed, although the collection includes preserving some soil of the species original habitat. We have been attempting to plant several species of conservation concern, such as *M. kadi-miana* which was found only in Sarikei to this date, but unable to survive in its transplanted habitat. Another notable attempt at transplanting involved the vulnerable species *M. multiflora*, which was discovered in 2008 in Limbang. This species has not been found in Sarawak since the site of its discovery was cleared for development in 2010. Should we understand the physiology or translocation management of the species, we might have been able to transplant this species to a new habitat for its conservation. As *ex situ* transplanted for *Mapania* species are difficult to be done due to sensitivity of the plants to a new environment and incapable to uphold the water in evaporation from the root system, this paper aims to understand how environmental factors affect the distribution of



Fig. 1. The locations of Matang, Gunung Gading and Bengoh where *Mapania cuspidata* inhabits. (Source: Google Map).

Mapania cuspidata in different natural habitats and then quantify key ecophysiology metrics of this species concerning survival, growth and development following attempt in transplanting at a new location.

MATERIALS AND METHODS

Observational field study

Three locations in Sarawak, Malaysia were selected for this study, namely Matang (1°37'52.4"N, 110°08'11.3"E), Gunung Gading (1°41'29.15"N, 109°50'46.33"E) and Bengoh (1°18'24.4"N, 110°13'09.3"E) (Fig. 1). These three locations were selected due to accessibility and the presence of *M. cuspidata*. In each location, the sampling was conducted in five random plots with each plot measuring 250 m². Within each plot, 10 quadrates of 25 m² were randomly placed to quantify plant populations, chlorophyll content, soil pH and organic matter content. Non-destructive approach was used to count plant populations and a chlorophyll meter (SPAD-502Plus, Konica, Minolta) was used to measure the plant chlorophyll content. Soil samples were collected at 0–200 mm depth using a soil auger. The soil samples were then sent to the laboratory for chemical analysis. Soil pH was measured using a pH meter whereas soil organic matter was measured using Loss on Ignition (LoI) method (Ball, 1964). For light intensity, five

readings were taken from each plot using a hand-held light meter (Extech EA30, Massachusetts, U.S.).

Transplantation experiment

A total of 36 healthy and disease-free individuals were collected from the Matang habitat for a transplantation experiment on survival and growth in Universiti Malaysia Sarawak. Plants from Matang were selected because of it was the nearest location to Universiti Malaysia Sarawak (approximately a two hour drive) and thereby reduced the lag time of plant recovery due to injury and stress. At the sampling location, the soil around the plants was explored to determine the extent of feeding roots prior to lifting. Using a hand shovel, the plants were dug with a mass of soil around the roots while keeping as much of the root ball intact as possible. The sampling was done early in the morning and the plants were selected with no particular age consideration. All leaves were removed during the transportation process, to reduce the water stress due to evaporation. Upon arrival at the destination, the plants were placed in plastic buckets filled with 1.5 L tap water to keep the roots moistened and stored in an unlit, air-conditioned laboratory at 25°C for five days to restore the plant vigor. This was also intended to simulate the natural living conditions of *M. cuspidata* as this species were found living in damp and

wet areas near to the rivers and streams with moist and wet soil conditions (Miraadila *et al.*, 2015). Then, the plants in the buckets were placed in a corridor outside the laboratory (sheltered condition) for another five days to acclimatize before transplanting into polybags measuring 254 × 305 mm. These polybags were filled with potting mix containing a mixture of coco peat, burnt soil, river sand, burnt husk, rich humus and charcoal powder (Kean Beng Lee Industries (M) Sdn. Bhd.).

The transplantation experiment comprised of four light intensities, *i.e.* 7, 18, 54 and 100% with nine replicates each. To do this, three mini-green houses were built with different shading netting percentage (1 layer created 54%, 2 layers created 18% and 3 layers created 7% light intensity). For 100% light intensity, the plants in polybags were exposed under full sunlight. The relative light intensity was obtained by comparison of light readings taken inside and outside of the mini-green house. No fertilizer and pesticide were applied during the experiment. Any fungus or weed growth were removed manually and polybags were watered daily to ensure the soil remained moist. The plants were left to grow for a period of 130 days with observations taken at weekly intervals, starting at 30 days from the date of transplanting. Four ecophysiology parameters were measured, *i.e.* final number of leaves, leaf production rate, chlorophyll content and survival rate of each treatment. The leaf production rate was calculated from the regression of the leaf number against accumulated days. The chlorophyll content was measured using a chlorophyll meter (SPAD-502Plus, Konica, Minolta). Plant survival rate was calculated by dividing the number of survived plants in the end of the experiment against total number of transplanted plants at the beginning of the experiment.

Data analysis

Statistical analysis used VassarStat (<http://vassarstats.net/>) (Richard Lowry, 1998-2021). All variables were analyzed using analysis of variance (ANOVA) and treatment means were compared by Tukey's Honest Significant Test (HSD) using an alpha value of $P < 0.05$ for establishing statistical significance. Pooled standard errors of the mean were reported for each measured variable.

RESULTS

The density of *M. cuspidata* was highest at Matang with total density of 1.98 individuals/ha

compared to Bengoh (1.42) while Gunung Gading showed the lowest density of 0.96. However, statistical analysis showed no significant difference in the populations of *M. cuspidata* per 250 m² among these three locations (Table 1). Matang recorded the highest light intensity of 0.94 kLux on the forest floor, whereas both Gunung Gading and Bengoh had an average of ~0.34 kLux. Plants in Matang also had the greatest chlorophyll content (67.4 SPAD unit) compared with those in Gunung Gading and Bengoh (~56.2 SPAD unit). In terms of soil parameters, the pH and organic matter content varied among the locations (Table 1). The soil in all locations was found to be acidic with the lowest pH recorded in Bengoh (pH 4.9) followed by Gunung Gading (pH 5.5) and Matang (pH 5.7). The soil organic matter ranged from 3.47% in Bengoh to 8.68% in Gunung Gading.

Observation after 130 days from transplanting found that there was no significant difference in the ecophysiology of *M. cuspidata* with an average survival rate of 88.9% across all light treatment (Table 2). In addition, the plants successfully produced an average of ~7.7 new leaves throughout the growing period with ~15.8 days interval to produce each successive leaf. These new, developing leaves had an average chlorophyll content of ~30.3 SPAD unit across all light conditions. In contrast, plants in the natural habitats despite living under low illumination had a higher chlorophyll content (52.6–67.4 SPAD unit) (Table 1) because the leaves had fully developed and matured. Lower chlorophyll content in the new, young leaves was expected because the leaves have not attained their maximum size and therefore were unable to maximize photosynthetic activity.

DISCUSSION

Observation of *M. cuspidata* in its natural habitat found that the population densities of the species were similar across all locations in Gunung Gading, Matang and Bengoh with an average density of 14.4 individuals per 250 m² area. The results from statistical analysis showed that presence of *M. cuspidata* was not affected by the differences in light intensity (0.32–0.94 kLux) and soil chemical properties (pH 4.9–5.7, organic matter 3.47–8.68%) (Table 1). This observation is consistent with the generalized expectation that most *Mapania* species are found in shaded areas with water-logging soil conditions or near bodies of water (Simpson, 1992). Despite variation in light intensity among the locations, the highest illuminance of 0.94 kLux on the forest floor is

Table 1. Plant populations, chlorophyll content, light intensity and soil parameters in Gunung Gading, Matang and Bengoh where *Mapania cuspidata* (Miq.) Uittien were observed.

Location	<i>M. cuspidata</i> populations/250 m ²	Light intensity (kLux)	Chlorophyll content (SPAD unit)	Soil parameters	
				pH	Organic matter (%)
Gunung Gading	9.2	0.32 ^b	59.8 ^b	5.5 ^a	8.68 ^a
Matang	19.8	0.94 ^a	67.4 ^a	5.7 ^b	5.77 ^b
Bengoh	14.2	0.35 ^b	52.6 ^b	4.9 ^c	3.47 ^c
S.E.M	1.90	0.078	2.03	0.15	0.953
P-value	0.062 (ns)	<0.001	<0.001	<0.001	<0.001

S.E.M., Standard Error of Means; ns, P>0.05. Means with the same letters are not significantly different (P>0.05) based on Tukey's HSD test.

Table 2. Survival, leaf production rate, number of leaves and chlorophyll content of *Mapania cuspidata* (Miq.) Uittien grown under different levels of light intensity in Universiti Malaysia Sarawak, East Malaysia.

Relative light intensity (%)	Ecophysiology parameters			
	Survival ¹ (%)	Leaf production rate (days/leaf)	Number of leaves ¹	Chlorophyll content ¹ (SPAD unit)
7	77.8	14.4	8.2	31.9
18	88.9	16.0	8.2	32.8
54	100.0	16.2	7.2	26.6
100	88.9	16.5	7.3	29.7
S.E.M.	5.31	0.80	0.41	1.95
P-value	0.553 (ns)	0.818 (ns)	0.754 (ns)	0.707 (ns)

¹Survival, final number of leaves and chlorophyll content were measured after 130 days from transplanting. S.E.M., Standard Error of Means; ns, P>0.05.

equivalent to an overcast weather in an open area and therefore is considered as conditions of low brightness. This study suggests that *M. cuspidata* can thrive in conditions of acidic soil with significant amount of organic matter. Associated with this is the need to identify other *Mapania* species that may inhabit the same ecological niche with *M. cuspidata* in future work.

The results of transplantation experiment have shown successful establishment of *M. cuspidata* under shaded and open area conditions with an average survival rate of 89% (Table 2). During the course of 130 days post-transplanting, *M. cuspidata* developed an average of 7.7 new leaves with leaf production rate of 15.8 days/leaf. The findings of this study are substantial yet confounding given

extensive reviews on *Mapania* species being shade loving plants that grow well in conditions of damp and wet soils (Simpson, 1992; Shabdin *et al.*, 2013a, 2013b; Miraadila *et al.*, 2016a) and failing attempts to plant the species in new locations (Z. Shabdin, pers. comm.). Following successful pot transplantation experiment, the individuals of *M. cuspidata* were relocated to the arboretum of Universiti Malaysia Sarawak and observation two years later found these plants remain thriving the new environment (Fig. 2). These new findings on high survival of *M. cuspidata* in the transplantation study implies that there is a good chance to plant other *Mapania* species that are of a greater conservation concern in new locations.



Fig. 2. Mature (left) and juvenile (right) *Mapania cuspidata* successfully established in the arboretum of Universiti Malaysia Sarawak two years after the pot transplanting experiment.

Nevertheless, the success in transplantation and growing *M. cuspidata* in different environments was likely aided by careful considerations of the impact of lifting, transporting and pre-transplanting during the process of plant relocation. Careful lifting of plants from the ground is critical because the roots need to be protected during handling. This is because the survival and performance of any transplanted plant is largely dependent on the ability of roots to develop and recover from injury and stress (Jackson *et al.*, 2012). Equally, the conditions of transport and storage determine the survival rate and quality of plants after transplanting. Water stress during transport or storage of plants can delay root regeneration and subsequent growth following transplanting, while worst case scenario could result in high mortality rate (Apostol *et al.*, 2009). Therefore, transit time, temperature, moisture and duration of storage are important parameters that need to be optimized (Goyette *et al.*, 2014). Additionally, plants should be acclimatized to prepare them for survival under higher temperatures and levels of irradiance. Transplanting should be carried out under ideal conditions, *i.e.* late afternoon or overcast weather to allow the plants to recover from transplanting injury while avoiding midday heat and being subjected to less evaporation of water. Finally, the plants should be transplanted to the same depth in its new location. This can be done by examining the soil mark on the stem. Specifically for endemic plant species, factors concerning the plant life form, physical size, distribution range, population size and whether the relocation site is within the species historical range must be taken into account first before making decision to transplant for the

purpose of ex situ conservation (Liu *et al.*, 2015). This is because endemic species have specific habitat conditions which require stable and constant environment, making them more vulnerable than other plant species to natural changes. Due to its potential ecological risks, conservation transplantation of endemic species to new location should be within the historical range area and would require careful management and longer post planting monitoring. In short, the survival and success in establishment of transplanted plant are greatly dependent on the decisions and post harvest handling practices. With adequate knowledge and understanding on plant ecophysiology and post harvest management, it is possible to relocate and establish plant species in new locations for ex situ conservation and to increase its widespread distribution.

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