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Evaluation of Growth, Flowering and Seed Morphology of Bat flower, *Tacca chantrieri* Andre

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Abstract

Tacca chantrieri is a perennial plant belongs to Taccaceae family that has the potential to be marketed as an ornamental plant due to its unique shape and dark color inflorescence. To date, very limited publication on *T. chantrieri* are available. The aim of this research was to examine plant growth pattern and flower phenology of *T. chantrieri* from West Borneo, Indonesia, and from Queensland, Australia in relation to their potential development as ornamental pot plants. The study was extended to examine *T. chantrieri* seed morphology with an inclusion of an accession from Thailand. The field experiment was conducted at the Leuwikopo experimental station in Darmaga, Bogor, Indonesia. Seed morphology examination was conducted at the Histology Laboratory of Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University. *T. chantrieri* from West Borneo blooms six times a year whereas the Queensland accession twice a year. West Borneo accession had smaller bractea, fewer numbers of flowers per inflorescence and shorter flower stalk than Queensland accession. In addition, *T. chantrieri* Queensland grew faster than Borneo with the one leaf formed every two to three weeks, whereas it was at least four weeks in the Borneo accession. Both accessions were susceptible to leaf brown spot disease caused by *Cercospora taccae*. *T. chantrieri* Queensland seeds are oval dark brown, whereas West Borneo and Thailand accessions were shaped like kidneys (reniform) with a lighter brown color. This study demonstrated that there is great diversity in *T. chantrieri* including plant morphology, seed shape and color, which are important for species identification and for development of *T. chantrieri* as ornamental pot plant.

Keywords: bat flower, phenology, seed germination, Cercospora

Introduction

Tacca chantrieri Andre or bat flower is a flowering plant from the family of Taccaceae (Fu and Jin, 1992). The name bat flower was derived from the plant's bractea shape that is similar to bats. *T. chantrieri* is an understory plant and requires high humidity. It is increasingly difficult to find *T. chantrieri* in its natural habitat due to forest destruction and clearing (Zhang et al., 2006).

T. chantrieri has inflorescences which consisted of dark color bractea, small flowers, and long filiforms; these unique characters have great potentials to be further domesticated and commercialized as ornamental potted plants. Information on *T. chantrieri* culture is very limited; most published information on the species is mostly in relation to the phytochemical and medicinal properties of their rhizomes which have been used as a source of traditional medicine in China (Yokosuka and Mimaki, 2012) and Thailand (Steinrut et al., 2011). A number of studies have reported that *T. chantrieri* seeds had low and slow germination; it can take several months for Tacca seeds to germinate *in vivo* (Krisantini et al., 2017; Charoensub et al., 2008; Sulong et al., 2013). The low germination percentage was possibly related to the rudimentary embryo (Krisantini et al., 2017). The plants grow rather slowly and take at least three months before a side shoot develops. Further Wawo et al. (2015) reported that genus *Tacca* generally has low ability to form shoots.

Our study aims to examine the plant growth patterns, flowering phenology and seed morphology of *T. chantrieri* from West Borneo, Queensland, and Thailand. This information would be useful for species identification and to introduce *T. chantrieri* to the ornamental plant market, and for propagation and culture of this species for possible development as medicinal plant.

Materials and Methods

The study was conducted from December 2014 to April 2017. Plants were grown in a screen house Leuwikopo Experimental Station in Darmaga Campus, West Java, Indonesia. Seed morphology study was conducted in the Histology Laboratory of Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University.

Seed Morphology

Observation on internal and external seed structure and morphology was conducted on accessions from West Borneo, Queensland and Thailand. Seed external structures were viewed under an Olympus DP25-BX51 stereo microscope with a magnification of 1.25 x 10. To examine the internal structure, 30 seeds from each accession were transversely dissected in half using a sharp razor blade to determine the presence or absence of endosperms and embryos.

Plant Growth and Flowering Phenology

The study on plant growth and flowering phenology was conducted on *T. chantrieri* plants from West Borneo and from Queensland, ten plants of each accession. The planting materials were rooted shoots separated from about 18-month-old plants and planted on media consists of equal volumes of compost, charcoal husk, and coconut husk. Media was pasteurized by steaming at 120 °C for two hours prior to transferring into pots of 40 cm diameter. Plants were watered every two days and fertilized with 2 $g.L^{-1}$ of GrowMore (N:P:K = 32-10-10) every fortnight. GrowMore 10-55-10 was applied when the plant started entering the flowering phase. Scoring was conducted on the number of new leaf weekly, stem diameter at flower initiation (mm), time to flower initiation, which is the number of days from planting to visible floral bud, number of days to anthesis, number of leaf and stem diameter at anthesis, inflorescence longevity which was measured from anthesis until the first flower wilted, the number of florets per inflorescence, the length of stalk, measured from the base of the stalk to the bractea, and the maximum width of the bractea (mm) at anthesis.

Results and Discussion

Seed Morphology

The seeds of *T. chantrieri* from West Borneo (Figure 1B) and Thailand (Figure 1C) have a similar form of circular or reniform. Queensland seeds have a different shape than the other two accessions with elongated and more rounded sides and dark brown testa (Figure 1A). Testa of West Borneo seeds are light brown (Figure 1B), whereas Thailand seeds were slightly darker brown (Figure 1C). Unlike Queensland seeds, West Borneo and Thailand seeds have clear hilum.

Figure 1. Seed morphology of *T. chantrieri* Queensland (A), West Borneo (B) and Thailand (C).

The internal structure of *T. chantrieri* seeds is mostly filled by endosperm; a small embryo is located at the end of the seed (Figure 2). The embryos in Queensland seeds are located at the tip of the seed with the tapered side. The embryo of the West Borneo and Thailand seeds were more difficult to see as the seeds have two symmetrical tipped ends. The endosperm of all seeds was colorless and consists of lipids.

Plant Morphology and Growth

T. chantrieri Queensland was much taller (66.59 cm) than the West Borneo (51.78 cm), had more rounded leaves and a faster leaf growth than the West Borneo accession. A new leaf was formed every two to three weeks in Queensland accession whereas it took at least four weeks for the West Borneo accession to grow a new leaf. The leaf size of both accessions was

Figure 2. Internal seed structure of *T. chantrieri* from Queensland (A), West Borneo (B) and Thailand (C). Arrow was the location of the embryo

similar, but the Queensland accession was generally taller and had larger stem diameter at anthesis (Figure 4).

We recorded that both accessions are prone to a disease with symptoms of leaf blackening starting from the leaf tips which was then expanding to the entire leaf blades (Figure 3). The causal pathogen was identified at the Plant Pathology Laboratory at the Bogor Agricultural University to be *Cercospora taccae*. The symptoms of the disease were similar to those described in Kohler et al. (1997), Wright et al. (2005) and Jackson (2016). Similar pathogen has been reported to infect *T. leontopetaloides* (Hunter and Shafia, 2000).The infection by *C. taccae* was started by the presence of blackish concentric spots and was particularly severe during the wet rainy season.

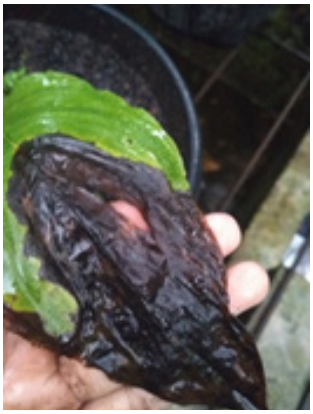

Figure 3. *T. chantrieri* leaf infected by *Cercospora taccae*

Flowering Phenology and Flower Morphology

T. chantrieri of West Borneo reached anthesis about 13 days after floral initiation whereas the Queensland accession took 40 days (Table 1). The difference in the number of days to reach anthesis might be related to the size of the inflorescence (Elle et al., 2010). The Queensland accession has larger bractea, longer and upright stalk, more florets per inflorescence and longer filliform than those of West Borneo's. The number of florets and filiforms per inflorescence of Queensland accession were 20 and 34 respectively whereas in the West Borneo accession it was 3 and 6, respectively (Table 1). Large inflorescences with strong color are more striking (Figure 4), a character that could attract pollinator (Zhang et al, 2005). However, the West Borneo accession flowered more frequently than Queensland accession. Three out of 10 plants of West Borneo accession had two inflorescences at the same time and this did not occur in the Queensland accession (Table 1). According to Zhang et al. (2005), the flowering period of *T. chantrieri* in China occurred in the range of April to mid-May, which is similar to the flowering period of the Queensland accession in this study.

T. chantrieri flower is a hermaphrodite that has anther and stigma in one flower (photo not shown). According to Zhang et al (2007) pollen in anther matured before the anthesis, whereas the stigma started to be receptive when the flowers open.

None of the flowers of the Queensland accession formed fruits during the course of the study, and this could be caused by self-incompatibility, or lack of pollination since the flower did not have nectar, abundant pollens, or other insect attracting traits such as aroma. Eighty percent of the West Borneo plants set fruits with fruit set percentage of 65%.

Based on the above flower morphological characteristics, particularly the large inflorescence with long and upright stalk that rises above the

Table 1. Growth and flowering characteristics of *T. chantrieri* Australia and West Borneo

Growth Characteristics	Accession	
	Queensland	West Borneo
Days to anthesis (days)	39.8 ± 1.13	13.4± 0.57
Number of inflorescence per plant	1± 0	1.3± 0.21
Number of florets per inflorescence	20± 0.56	2.8± 0.33
Number of filiform	33.4± 0.5	6± 0.33
Bractea diameter (cm)	14.82±0.39	8.58± 0.46
Stalk height (cm)	60.34± 0.93	13.74± 0.58
Plant height (cm)	66.59±0.88	51.78± 0.81
Stem diameter at anthesis (mm)	25.95±0.15	23.36± 0.16
Percentage of plants produced fruits	0	80
Percentage of fruit set	0	65

Note: values are average of ten plants per accession ± standard error.

foliage (Figure 4) the Queensland accession have more attractive characters as ornamental pot plants. Therefore the study was extended to study the flowering phenology of Queensland accession. Flowering phenology of the West Borneo accession was described in Putri (2016).

Figure 4. Plant morphology and inflorescence of the Queensland accession (left) and West Borneo accession (right). Queensland accession had a longer stalk, larger bractea, longer filiforms and more flowers per inflorescence than the West Borneo accession.

The flowering of the Queensland accession can be divided into seven stages (Figure 5). The initial stage of inflorescence development began with the initiation of bractea from the leaf axil (stage 1). In stage 2, the bractea had started to elongate and were more developed which lasted three to five days. At stage 3 the flower stalk began to grow and elongate quickly reaching 70 cm, and this stage had the longest duration in the inflorescence development. The bractea grew rapidly from small-sized buds to enlarged and almost fully opened bractea. The duration of stage 3 varied considerably between 10 to 20 days. Stage 4 is marked by the change in the external bractea color from green to purple with floral buds that had started to develop and the filiforms started to look yellowish green. Approximately 7 to 15 days later, the inflorescence arrangement entered stage 5, where the purple bractea were opened, and filiform developed rapidly and changed color from yellowish green to purple green. Stage 5 lasted for three to five days. In stage 6 the bract turned dark purple in color, filiforms further elongated and floral buds enlarged with purple color. Approximately two to three days later, inflorescence reached anthesis which is the final stage (stage 7) of the flower development. At this stage the bractea were fully opened and the tip of the filiforms started to wilt.

Figure 6. Flower phenology of *T. chantrieri* Queensland; (A) each floret has 6 petals consisting of 3 large and 3 small purple petals; (B) Filaments did not develop, young stamen were reddish purple and changed to dark purple when maturing; (C) stigma had a stylus which does not developed and remain attached to the ovaries; (D) a cross section of the flower showing position of the stamen to be very close to the stigma with the ovules divided into three locules.

Conclusion

The shape and color of West Borneo *T. chantrieri* seeds is similar to those of Thailand accession but different from the Queensland accession. Queensland accession grew at faster rate, had a larger bractea, and more florets per inflorescence than the West Borneo accession. West Borneo accession flowered more frequently than Queensland accession. Queensland accession has more potentials to be developed as ornamental pot plants.

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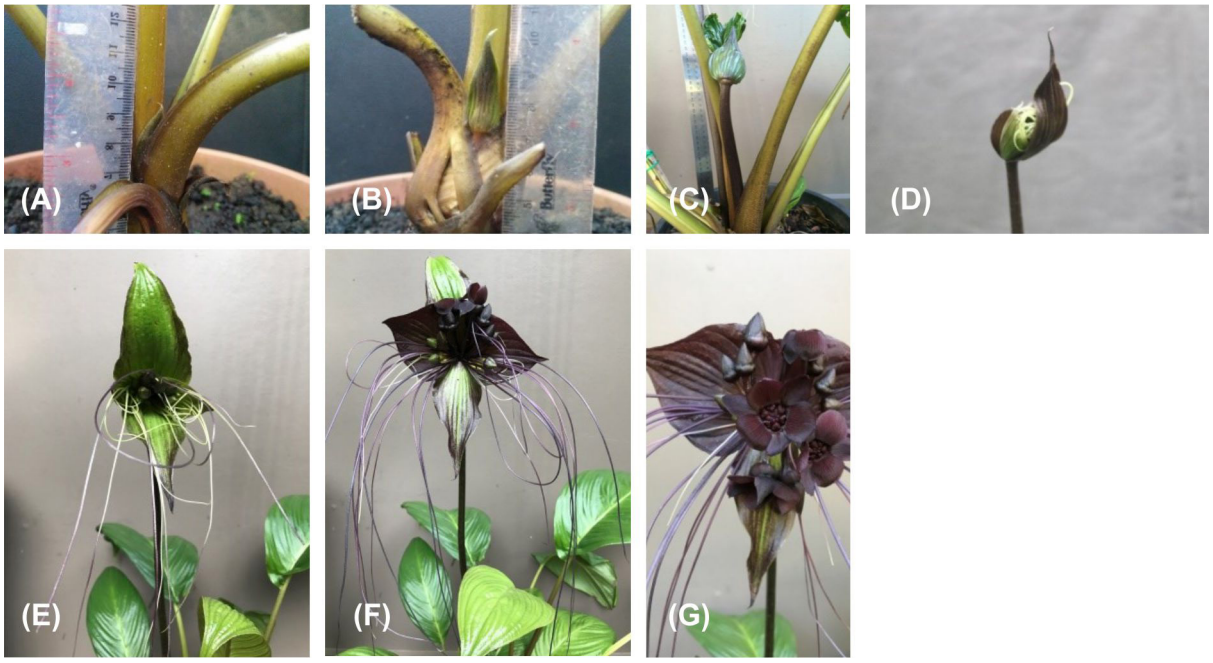

Figure 5. Stages of inflorescence development of *T. chantrieri* Queensland: (A) dark green bractea emerged from leaf axil; (B) bractea started elongating and enlarged to about 30-35 mm with dark green color with purple edges; (C) stalks continued to extend rapidly up to 46 to 70 cm and had purple color; (D) the stalk and the external bractea were dark purple; the bractea started to grow and one to four floral buds were visible on the inside; (E) the edges of the bractea was purple, the inner bractea were green in color with purple hue, the green floral buds started forming, yellowish green colored whiskers started elongating; (F) the inner bright purple bractea grew rapidly and were starting to shape like a bat's wing, one of the outer top bracts started to fold back, the floral buds in the middle started to stand upright and were purple in color; (G) floral buds on the sides were still small and green, bracteols / whiskers grew longer; (H) newly opened florets turned dark on maturation and were erect, but bend downwards at the end of the day.

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