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Cordia dichotoma G. Forst. : Bioecology and population density

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Abstract. Kendal tree is declared as an identity flora of Kendal Regency, Central Java, Indonesia. It is predicted as a rare species; most of the local people do not know the existence of this tree. The study aimed to describe some aspects of bioecology and a population density of Kendal tree. An explorative study was conducted from March to July 2016, through interview, observation, and literature review. The respondents were determined by purposive and snowball sampling methods. The data were analysed descriptively. Results showed that there were very limited numbers (only five trees) of Kendal tree throughout Kendal Regency. The species was identified as *Cordia dichotoma* G. Forst. The tree is 3–15 m in height. The leaves are simple and arranged spirally, inflorescence dichotomous, bisexual, with five gamosepalous and gamopetalous. Generative reproduction occurred at a low rate. The tree grew optimally in a dusty, sandy loam soil, pH 6.0-6.5 with a temperature ranged from 27-34 °C, a light intensity of 450-1580 lux, and an altitude of about 10 meters above sea level. In conclusion, *C. dichotoma* is a rare plant in Kendal Regency. This plant needs an alternative method of propagation, regeneration and conservation using *in vitro* technique.

1. Introduction

Kendal Regency is one of 35 regencies/cities in Central Java Province, Indonesia. As other cities and regencies, Kendal has a plant species declared as an identity flora, namely Kendal tree. This declaration is based on the historical value of Kendal tree. The data compiled by Environment Agency of Central Java in 2015 show that the existence of the identity plant has not fully and well documented. In fact, most of the local people or people had lived for a long period in Kendal Regency also do not know this plant. As a flora of identity, the data of Kendal tree should be available completely.

The population density in an area is determined by the capacity of plants growth and development. The growth and development of plants are influenced by internal factors and external factors. External factors include biotic factors (competitors, pollinators, symbionts, and others) and abiotic (edaphic and climatic) factors. The width of the optimum range of abiotic factors determines the spaciousness of plant habitats. Edaphic factors can be divided into physical and chemical properties of the soil, whereas the climatic factors include temperature, rainfall pattern per year, and others. Also to the edaphic and climatic factors, people density also influences plant population through the intensity of cultivation. The more intensive cultivation of a species, the higher the plant population will grow.

The total area of Kendal Regency is 1,002.23 ha, which can be divided into lowland area with an altitude range from 0-10 m above sea level, and the Highland on altitude between 10-2.579 m above sea level. The lowland area is located in the northern as well as the coastal with temperature ranges around 27 °C, while the highland or mountainous area is located in the southern area has a temperature around 25 °C [1]. Kendal Regency is suitable for the growth and the development of Kendal tree. In



the other countries, Kendal tree is abundant at low altitudes from sea level upwards to about 500 m altitudes, on the dry side of mangroves, coastal hills below 100 m, inland forests along rivers, and on limestone [2].

This study aimed to describe the bioecology aspects of Kendal tree and the population density at Kendal Regency. The results can be used as a recommendation of the plant germplasm preservation to get more beneficial to the society and environment. Also, the present study provides a baseline data for future pharmacological studies.

2. Materials and methods

The study was conducted in Kendal Regency during March-August 2016. The population studied was all (20) of districts of Kendal Regency, which can be divided into two groups, i.e. the lowland and highland districts. The lowland districts located along the northern coast consisted of 12 districts, namely Weleri, Rowosari, Kangkung, Cepiring, Gemuh, Ringinarum, Pegandon, Ngampel, Patebon, Kendal City, Brangsong, and Kaliwungu. Whereas, the highland district located in the southern part which includes eight districts, i.e. Plantungan, Pegeruyung, Sukorejo, Patean, Boja, Limbangan, Singorojo, and South Kaliwungu (Fig. 1).

Proportional random sampling took the area samples (30%). Area sample for lowland taken by random sampling was four districts, namely District of Kendal City, Patebon, Cepiring, and Kaliwungu. Area sample of the Highland taken by random was three districts, namely Plantungan, Boja and Limbangan. From each district selected as the sample, the observation areas were selected purposively based on the result of the interview before. The variables observed in this study were the biology, ecology and population density of Kendal trees. The biological aspects include morphological characters, reproduction techniques, and utility for human lives. The observed ecological aspects were altitude, soil texture, soil pH, temperature, and light intensity. The population density was determined by the number of the plant.

An early interview was carried out through face to face interviews with 30 informants in the age of 17 to 62 years; these included males and females to get information about the number of Kendal tree. They are the student, lecturer, and other person living in Semarang City who was born and had been lived for several years in Kendal Regency.



Figure 1. Map of Kendal Regency bordered by Batang Regency, Java Sea, Semarang City, and Temanggung Regency

The interview at an early step of the research was followed by some observations using observation sheet and depth interview with local people in the area selected as the sample. The observation methods were done to obtain some information including the morphological characters, reproduction techniques, the level of knowledge of the existence and utility of Kendal tree. The respondents of depth interview were selected from local people through purposive and snowball sampling methods; by considering the status and role in society and their adequacy of information about Kendal tree. They were employees of Regency office, village heads, and community leaders over 50 years old.

Snowball method was implemented by using recommendation of initial informants to other informants who considered know about Kendal tree.

The morphological characteristics of Kendal tree were observed carefully, taken photos in place or partially transported to the laboratory to be photographed using stereomicroscope. Environmental factors measured at a point of plants grow to a radius of 10 m from the outer of the plant canopy. After collecting the specimens, we represented these specimens to different people to confirm the accuracy of the results. Subsequently, specimens were identified at Bogor Botanical Garden, West Java.

Data collection tool were GPS (Global Positioning System), altimeter, thermohydrometer, soil tester, and digital camera. Finally, the data were analysed using descriptive statistics.

3. Results

The early interview showed that only one person of 30 respondents knew about Kendal tree. She said that there is only one Kendal tree in a sacred tomb located in the town of Kendal. Based on this information the observation was conducted directly to the location. The observation was also carried out at the seven districts which selected as area samples. We found five Kendal trees only, i.e., two trees in the area of the tomb of Wali Gembyang, Sub-district of Patukangan; one tree in the West Square, and two trees in the yard the Office of Kendal Regency. Observations conducted in the District of Patebon and Cepiring did not find any Kendal tree. It seems that Kendal tree name was a homonym which was the local name (i.e. Kendal tree) was used for some species. People in the District of Patebon and Cepiring called Kendal tree for *Ficus sp.* In Kaliwungu, Plantungan, Boja and Limbangan we also did not find any Kendal trees. Some respondents questioned it, including the people of old age did not know anything about the tree.

The five Kendal trees were found well grow and develop in a dusty, sandy loam soil, pH 6.0-6.5 with a temperature of 27-34 °C, a light intensity of 450-1580 lux at an altitude of about 10 meters above sea level.

Kendal tree has many synonym scientific names, i.e. *Cordia obliqua* auct. non. Willd., *C. dichotoma*, *C. blancoi* Vid., *C. griffithii* C.B. Clarke, *C. myxa* auct. non. L., *C. suaveolens* Bl., *C. suaveolens* Vidal, *C. subdentata* Miq. [4]. The taxonomic position of this species is as follows.

Kingdom	: Plantae
Subkingdom	: Tracheobionta
Superdivision	: Spermatophyta
Division	: Magnoliophyta
Classis	: Magnoliopsida
Subclassis	: Asteridae
Ordo	: Lamiales
Family	: Boraginaceae
Subfamily	: Cordioideae
Genus	: Cordia
Species	: <i>Cordia dichotoma</i> G. Forst
Local names	: cordia tree (English), nona burung, petekat, sekendal (Malaysia), kanonang, kendal, knadate, lantolo, mampapu, manonang, toteo (Indonesia)



Figure 2. The habitus, stem and leaf morphology of *C. dichotoma* which grown at Kendal Regency. Tree grew in the Kyai Gembyang tomb (a) and the yard of Kendal Regency Office (b), stem bark of old tree (c), lenticellate branchlet (d), leaf buds (e), and the leaf shape (f)

Kendal tree forms a rounded canopy. The stem erect, the old tree could reach about 15 m as found in the yard of Wali Gembyang tomb (Fig. 2a), but the relatively younger just only 3 m (Fig. 2b). Its branching is sloping upwards (Fig. 2a, b). The bark of old stem shallowly fissured or wrinkled longitudinally, brown or blackish (Fig. 2c). The branchlets are slender; its lenticellate is grey, greyish brown to brownish (Fig. 2d). The leaf buds are longitudinally folded, flat, and brown to orange (Fig. 2e). The leaves are simple, arranged spirally, generally lanceolate, dentate leaf edge, acute at apex, and obtuse at base. The venation pinnate, lateral nerves 3–5 pairs (Fig. 2f). Petioles are 1.5–2.5 cm long, and leaf blade ranged at 6–10 x 3–4 cm.

The inflorescence located terminally (Fig. 3a) or axillary (Fig. 3b) of branches. It is a cyme, forking repeatedly or dichotomous, 4–11 cm in length, with 4–many flowers (Fig. 3c). Flowers are bisexual, complete, short-stalked, and actinomorphic. A fully open flower is 3–5 mm in average diameter. The calyx is cup-shaped. Sepals are about 3–4 mm in length, light green and gamosepalous. The corolla has five yellow whitish colour petals which are 4–5 mm in length and gamopetalous. Androecium contains five stamens, each having a long filament and epipetalous. The ovary is located inferior (Fig. 3d), one

locus (Fig. 3e), 4 mm in length and having a globular shaped ovary. In recent years, the Kendal trees formed many flowers, but only a few of flowers develop into fruits (Fig. 3f).

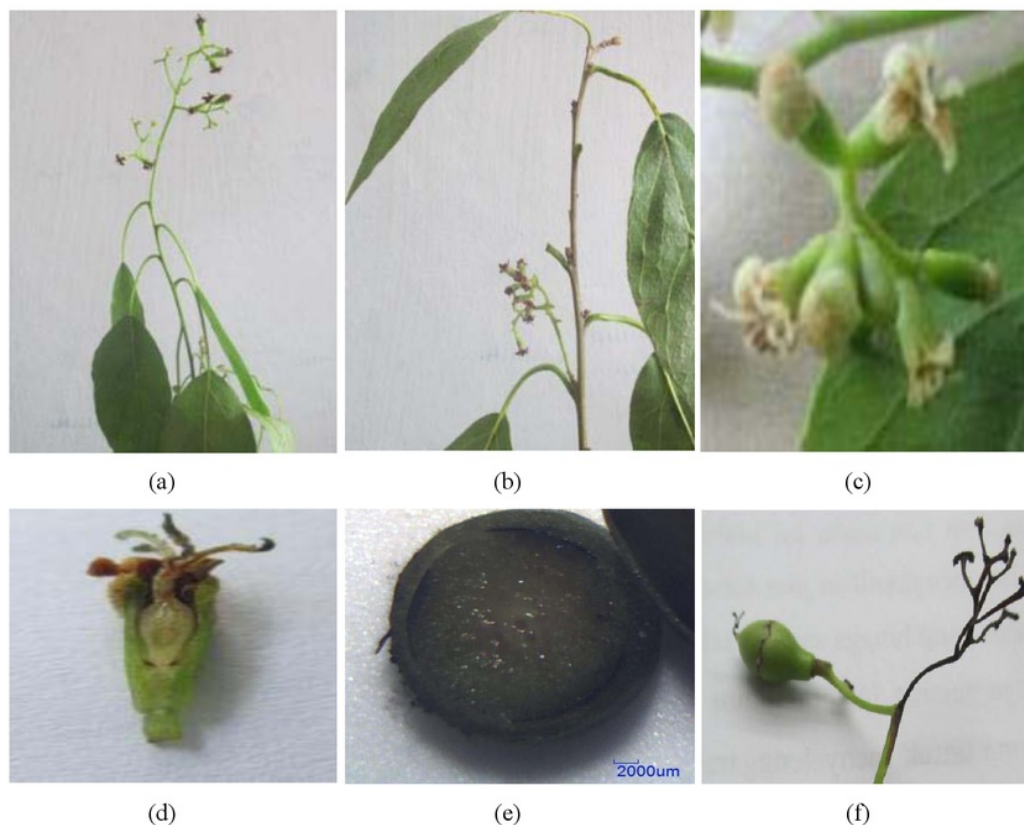


Figure 3. The Flower and Fruit of Kendal tree. A terminal inflorescence (a), axillary inflorescence (b), dichotomous flowering (c), longitudinal section of the ovary (d), the cross-section of one locus ovary (e), and among some flowers just one fruit is formed (f).

The breeding effort of *C. dichotoma* has been initiated by the Government of Kendal Regency by planting a few trees in the yard of regency office. Based on the interview with employees of the office, the obstacles encountered were the difficulty of breeding this plant. Seeds are difficult to obtain. The propagation by cuttings was also difficult. The people around the tomb of Wali Gembyang had tried to propagate through cuttings, but the success rate was only 3%.

4. Discussion

Based on the survey results, Kendal tree is very rarely used by local people. Therefore, the people almost have never been cultivated this plant. Some respondents stated that many people from outside Kendal Regency often seek the leaf, bark and fruit of Kendal tree for medicinal usage, especially for the diseases because of degeneration of human body function.

Kendal tree organs have proved to produce many secondary metabolites which useful in various fields. The leaves of *C. dichotoma* contains arabinoglucan and linolenic acid [5], apigenin, hentricontanol, hesperidin, octacosanol, lupeol, amyrin, robonine, rutin, betulin, dihydrorobenetin [6, 7, 8]. From the seed extract 2 compounds alpha-amyrin and 5-dirhamnoside have been isolated [2].

There are some studies evaluating many activities of organs of *C. dichotoma*, such as anti-microbial, anti-inflammatory, anti-fertility, anti-snake bite, hypolipidemic, insecticidal and antioxidant

[5, 9]. Its bark is often used for treating headaches and fevers [4]. The anti-inflammatory activity of the seeds extract at a dose of 100 mg/kg, aqueous and ethanol extracts show maximal inhibition of oedema [10]. It indicates the efficacy of the seed extract as an anti-inflammatory agent. Extract of the bark inhibits the growth of three common pathogenic fungi (*Aspergillus niger*, *Aspergillus clavatus*, and *Candida albicans*) [11]. The acetone extract of seed also shows significant antibacterial activity against *S. aureus* [12]. Meanwhile, the extract obtained from leaves has anti-fertility activity. A potential anti-implantation activity has observed. At a dose of 800 mg/kg, pregnancy was blocked 100%, and there were no alterations in the behaviour of test animal [6].

Besides being used for medicinal purpose, organs of *C. dichotoma* are also useful for various purposes. Fruit contains a sticky gum and can be used as paper glue. The wood is used for house construction or local material for making agricultural tools (e.g. ploughs). The leaves yield good feed. The seed kernel contains a high proportion of fatty oils and proteins (46 and 31%, respectively) which have potential as cattle feed. Fruit extract has evaluated to suppress larval hatching of *Meloidogyne incognita* [2].

Considering the many uses of Kendal tree, it is feasible to breed this species in the area of Kendal Regency. Moreover, this tree has been declared as the flora of identity. Kendal tree should be grown in all areas of the regency. The ecological conditions of Kendal region are suitable for the growth and development of Kendal tree. *C. dichotoma* is a quick-growing tree, performing well under semi-arid conditions and suitable for planting along boundary and farm roads [2].

When a tree produces fruit, it is suggested to collect ripe fruits and rubbed to remove the flesh. The healthy seed is dried in the shade and kept in tin containers. The seed can be stored for one year in airtight containers kept in a dry place to avoid insect attack. Furthermore, seed germination requires special conditions. Young seedlings are suffered by exposure to direct sunlight. However, the healthy seedlings usually grow fast become young trees. On optimal sites, the trees reach a height of 4 m in 4 years and a diameter of over 20 cm in 8-9 years [2].

Because the seeds are not easily formed, it is recommended to perform vegetative reproduction by cutting or grafting. For this matter, it is necessary to study the optimisation techniques of vegetative reproduction. The aspects need to be examined are the cutting or grafting medium, the addition of growth regulators, the modification of physical environment (temperature, pH, moisture), and others. On the other hand, it also needs to consider alternative techniques to breed Kendal tree with an innovative method, using *in vitro* technique. The advantages of this technique are producing pathogen-free plantlets and efficient in terms of time and place. The efficiency of this technique will be achieved when the protocol which has been found suitable for certain species.

5. Conclusion

In conclusion, *C. dichotoma* was a rare plant at Kendal Regency. The plant was not well known and commonly found. Its distribution is very limited because it is underutilised by local people. As a result, there are no significant cultivation activities. There are many types of research exploring the utility of *C. dichotoma* organs. Because *C. dichotoma* proved as a very beneficial and have a role as identity flora of Kendal Regency, it is necessary to planting it on a large scale. This activity requires the optimum breeding techniques. The generative reproduction is difficult to implement. Therefore, it is recommended to develop a vegetative reproduction technique through cuttings, grafting and tissue culture.

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