

**MEMPERTAHANKAN TINGGINYA KERAGAMAN GENETIK DAN
KEBERLANGSUNGAN REGENERASI CENDANA (*Santalum album* Linn.) DI
IMOIRI, RASLAHAN TERTUA DI GUNUNG SEWU**

INTISARI

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Raslahan cendana di Imogiri, Zona Barat Gunung Sewu, memiliki keragaman genetik tinggi (H_o 0,414 hingga 0,672) serta merupakan cendana tertua di Gunung Sewu yang telah ada sejak abad ke-18; sehingga menjadi *center of genetic diversity* cendana di Gunung Sewu. Raslahan di Imogiri diharapkan menjadi alternatif sumber materi genetik untuk kegiatan rehabilitasi. Namun dijumpai permasalahan keterbatasan permudaan alam cendana di Imogiri, yang diduga disebabkan oleh sedikitnya individu berbunga, asinkroni pembungaan, populasi terisolasi, serta keterbatasan *seed bed* di alam. Studi mengenai cendana di Imogiri baru dilakukan pada aspek keragaman genetik induk. Penelitian ini bertujuan untuk: (1) Mengkaji keragaman genetik spasial dan temporal berbasis isoenzim; (2) Mengestimasi aliran gen berbasis isoenzim; (3) Mengobservasi aspek pembungaan; (4) Mengestimasi kemampuan reproduksi; serta (5) Mengkaji pengaruh keragaman genetik induk, aliran gen, dan aspek-aspek pembungaan terhadap kualitas (keragaman genetik anakan) dan kemampuan reproduksi, pada raslahan cendana di Imogiri.

Lokasi penelitian adalah lima kelompok tegakan cendana di Imogiri yaitu (1) Dusun Karangtengah; (2) Bukit Panguk-Kediwung; (3) Bukit Mojo; (4) Dusun Gumelem; dan (5) Kebun Buah Mangunan. Tahapan penelitian terbagi menjadi (1) inventarisasi induk berbunga dan berbuah; (2) analisis isoenzim untuk estimasi keragaman genetik dan aliran gen; (3) observasi aspek pembungaan (ontogeni, fenologi dan sinkroni); (4) mengestimasi kemampuan reproduksi (*Pollination Effectiveness*, *Reproductive Success*, viabilitas benih dan jumlah permudaan alam); (5) mengkaji pengaruh keragaman genetik induk, aliran gen, dan aspek-aspek pembungaan terhadap kualitas (keragaman genetik anakan) dan kemampuan reproduksi.

Keragaman genetik secara spasial (antar kelompok tegakan) dan temporal (antar generasi induk dan anakan) pada cendana di Imogiri tinggi, namun masih ditemukan alel langka dan alel hilang. Secara spasial, rerata H_o antar kelompok adalah 0,660; sedangkan secara temporal, heterozigositas meningkat ke generasi selanjutnya (induk tahun 2019 H_o 0,542; induk tahun 2022 H_o 0,680; semai biji dan cabutan H_o 0,660. Nilai D_{ST} yang rendah (0,008-0,088) menunjukkan keseragaman persebaran dan frekuensi alel antar lokasi, sedangkan nilai G_{ST} menunjukkan variasi genetik rendah sampai dengan tinggi antar lokasi (1,4%-16,2%). Aliran gen (N_m) yang terjadi di Imogiri sebesar 1,28 individu per generasi, dan antara Zona Barat Gunung Sewu sebesar 2,76 individu per generasi. Pembungaan memiliki tahapan yang sama, namun durasi serta waktu inisiasi berbeda. Periode pembungaan hampir serentak antar lokasi, namun puncak musim bunga berbeda. Kemampuan reproduksi bervariasi, dengan kisaran nilai *Pollination Effectiveness* 6,14%-20,76%; *Reproductive Success* 0,31%-2,33%; viabilitas benih 0,001%-50% dan total jumlah permudaan alam 531 cabutan. Hasil uji regresi menunjukkan bahwa keragaman genetik anakan dan potensi reproduksi dipengaruhi oleh H_o induk (berbunga) dan PE yaitu masing-masing 69,5% dan 48,8%. Informasi mengenai pengaruh keragaman genetik induk, aliran gen, dan pembungaan terhadap kualitas dan kemampuan reproduksi ini diharapkan dapat memberikan rekomendasi tindakan yang tepat seperti infusi genetik, memfasilitasi aliran gen dan mengoptimalkan sistem perkawinan dalam menyusun strategi konservasi genetik cendana di raslahan Imogiri berbasis manipulasi faktor internal (keragaman genetik dan potensi reproduksi) serta eksternal (kondisi tapak dan lingkungan tempat tumbuh).

Kata kunci: aliran gen, keragaman genetik, reproduksi, raslahan cendana Imogiri, regenerasi alam, Zona Barat Gunung Sewu

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MAINTAINING HIGH GENETIC DIVERSITY AND SUSTAINABLE REGENERATION OF Sandalwood (*Santalum album* Linn.) IN IMOIRI, THE OLDEST LANDRACE IN GUNUNG SEWU

ABSTRACT

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Sandalwood landrace in Imogiri, Western Zone of Gunung Sewu, performs high genetic diversity (H_o 0.414 to 0.672) and is the oldest landrace alive in Gunung Sewu, which has been existed since the 18th century; and therefore considered the center of genetic sandalwood genetic diversity in Gunung Sewu. Landrace in Imogiri is projected to be an alternative source of genetic material for rehabilitation activities. However, previous studies reported problems related to limited natural regeneration of sandalwood in Imogiri, and the less flowering individuals, the occurrence of asynchronous flowering, isolated populations, and limited seed beds in nature might explained this condition. Studies on sandalwood in Imogiri have only been conducted on the aspect of parental genetic diversity. This study aims to: (1) Assessing isoenzyme-based spatial and temporal genetic diversity; (2) Estimating isoenzyme-based gene flow; (3) Observing flowering aspects; (4) Estimating reproductive ability; and (5) Examining the effect of parental genetic diversity, gene flow, and flowering aspects on quality (sapling genetic diversity) and reproductive ability, in sandalwood landrace in Imogiri

This study was conducted in five groups of sandalwood in Imogiri: (1) Karangtengah Village; (2) Panguk-Kediwung Hill; (3) Mojo Hill; (4) Gumelem Village; and (5) Mangunan Stand. Research activities were: (1) inventory of flowering and fruiting parents; (2) isoenzyme analysis for estimation of genetic diversity and gene flow; (3) observation of flowering aspects (ontogeny, phenology and synchrony); (4) estimate the reproductive ability (Pollination Effectiveness, Reproductive Success, seed viability and natural regeneration); (5) examine the effect of parental genetic diversity, gene flow, and flowering aspects on quality (offspring genetic diversity) and reproductive ability.

Results showed that sandalwood in Imogiri has high genetic diversity, both at spatial (among sites) and temporal (between parents and next generations) levels. However, there were rare and missing alleles observed. Spatially, the mean H_o between groups is 0.660; while temporally, heterozygosity increased to the next generation (parents in 2019 H_o 0.542; parents in 2022 H_o 0.680; and seedling H_o 0.660. A low D_{ST} value (0.008-0.088) indicates similar distribution and frequency of alleles between sites, while the G_{ST} value showed low to high genetic variation among sites (1.4%-16.2%). Gene flow (N_m) occurred among sites in Imogiri was 1.28 individuals per generation, while gene flow among landraces in the West Zone of Gunung Sewu was 2.76 individuals per generations. Flowering has the same stages, but differs in the duration and initiation time. The flowering period is nearly simultaneous among sites, however the peak flowering season was asynchronous. Reproductive ability varies, with a range of Pollination Effectiveness of 6.14% - 20.76%; Reproductive Success of 0.31%-2.33%, seed viability of 0.001%-50% and the total number of natural regenerations of 531 seedlings. The results of the regression test showed that the genetic diversity of the offspring and reproductive ability were affected by H_o of flowering parents and PE, with the levels of 69.5% and 48.8%, respectively. Information regarding the effect of parental genetic diversity, gene flow, and flowering on reproductive quality and ability might provide recommendations such as genetic infusion, facilitating gene flow and optimizing mating system for suitable action in developing sandalwood genetic conservation strategies in the Imogiri landrace, based on the manipulation of both internal (genetic diversity and reproductive potential) and external (site and environment conditions) factors.

Keywords: gene flow, genetic diversity, reproduction, Imogiri sandalwood landrace, natural regeneration, West Zone of Gunung Sewu

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