Distribution and mapping pulasan (*Nephelium ramboutan-ake* Bill. Liinh) in Riau ecosystem zone area

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**Abstract.** Pulasan (*Nephelium ramboutan-ake* Bill. Liinh.) is one of the genetic sources of the Sapindaceae family which has many benefits, including fresh fruit, processed food industry as well as traditional and modern medicines. Currently, the existence of outward appearance has experienced scarcity, even threatened with extinction. This study aims to determine the distribution and create a map of the outward distribution in the Riau Ecosystem Area. This study uses a survey method, namely the technique of getting outward distribution points by tracking using the Garmin 76cx Global Positioning System (GPS). The data obtained were processed using the Map Source program and ArcGIS 10. The basic map used was a map of the administrative boundaries of Kampar, Kuantan Singingi, Siak and Bengkalis districts as well as a map of soil types. The outward distribution of each sub-district is presented descriptively and in the form of a map. Overlays of germplasm have been explored in as many as 495 trees spread over four districts in Riau. The population of the outward distribution in the mineral soil ecosystem zone is more than the population in the peat soil ecosystem zone. Distributed in groups with unequal populations.

1. Introduction

Pulasan (*Nephelium ramboutan-ake*) is a family of Sapindaceae belonging to a group of trees that produce fruit. Its genetic source originates from Southeast Asia, especially in Indonesia, Malaysia and Thailand [1]. Rambutan and its relatives are also scattered in several areas in Asia such as India, China, Thailand, Myanmar, Peninsular Malaysia, Borneo, Sumatra, Java [2,3]. In Indonesia, Palasan spread over the islands of Kalimantan, Java, and Sumatra [1,4–9].

Pulasan is rich in ascorbic acid, which is a good source of carbohydrates. Fruit can be consumed in fresh form, containing 85 g water, 0.8 g protein, 0.6 g fat, 13 g carbohydrates, 0.1 g fibre and 0.4 g ash [10]. In addition, the seeds can be processed into food [2]. The skin of the fruit has cytotoxic and apoptotic effects [11,12] and contains a lot of anti-bacterial [13–16]. Pulasan has a high economic value, the price is more expensive than rambutan fruit because the availability of outward appearance is limited, causing some people not to recognize this species. The limited number indicates that the genetic resource
is vulnerable to extinction. This problem is caused by land damage due to fires which is a global issue of Indonesian forest fires, especially in Riau. In addition, there are also conversion of land functions into monoculture plants (oil palm plantations and industrial forest plantations) and many industrial and housing developments. It is very necessary to make conservation efforts towards local wisdom that is almost extinct. Therefore, study about this species is very important and the results of this research can be used as basic data for further research.

Riau Province has an area of 8.915.015.09 Ha which stretches from the slopes of Bukit Barisan to the Malacca Strait. The geographical location of Riau Province is at 01° 05' 00'' South Latitude to 02° 25' 00'' North Latitude and between 100° 00' 00'' East Longitude – 105° 05' 00'' West Longitude [17]. Riau has the largest peatland ecosystem agricultural land on the island of Sumatra, with approximately 5.7 million hectares or about 56.1% of the land area consists of peat. The rest is land with mineral soil types. Based on information from the community, pulasan grows well on these two types of soil.

Information from the community about the existence of the species in each area is very useful. The GIS application is designed using the paper framework and WEBGIS technology, namely Map-Server, especially the ArcGIS package that works on the Windows operating system. Geographic Information System (GIS), especially ArcGIS software and using Avenue Script can simplify and speed up the process of monitoring the object to be explored. The activity took place by including a Geographical map containing information about the areas where germplasm exploration activities were carried out. Thus, exploration and mapping can be directed at the right target. This GIS application has been widely used in the distribution and mapping of plants, including Durian [18,19]. The purpose of this study was to determine the distribution and outward population and to create a map of the outward distribution on mineral soils and peat soils in the Riau ecosystem zone.

2. Materials and methodology

2.1. Data collection

Data was collected and calculated using the GPS program. The working system of this tool first determines the coordinate points, then marks and simultaneously calculates the outward population per area. The data in the field is stored in the GPS program and read by the system in the ArcGIS program. The study was conducted at the centre of outward fruit in the districts of Kampar, Kuantan Singingi, Siak and Bengkalis. The research was conducted from May to October 2017.

The materials used were 495 outward-looking trees spread across the visual center area in Riau Province, digital maps of Kampar, Kuantan Singingi, Siak, and Bengkalis districts, maps of Kampar Kiri sub-districts, Gunung Sahilan, West Bangkinang, Sentajo Raya, Apit River, Sabak Auh, Siak Kecil, Bengkalis, and Bantan, and tally sheet to record the results of taking the coordinates. The tools used were the Garmin 76csx Global Positioning System (GPS), measuring instruments (meters), digital cameras, and a laptop/computer unit.

2.2. System analysis and system design

The coordinates of the outward crop in the field was obtained using GPS. Furthermore, data transfer was carried out using MapSource. Then the data were processed into a Shapefile (.shp) and overlaid in the form of a map using the ArcGis 10 program.

2.3. Implementation of the outward distribution map in the Riau ecosystem

Coordinate point data of outward appearance plants and tracks that have been stored in the form of "shp" were then entered and processed using the ArcGis 10 program so that it can produce an analysis map of outward distribution in the districts of Kampar, Kuantan Singingi, Siak and Bengkalis as well as produce an analytical map of the distribution of outward appearance in the ecosystem zone by soil type.
2.4. Determination of research location
The research location was determined based on information collected from the results of the survey. This survey aimed to determine the coordinates of the centre of the Pulasan plant. The survey was conducted by visiting the research location. The location of the outward germplasm distribution was successfully explored in the mineral soil ecosystem and the peat soil ecosystem zone.

2.5. Position recording
Recording of the outward coordinate position in the area was done using GPS with the Stop-and-Go positioning method. In this method, the determined points did not move (static), while the GPS receiver moved from the points in which at each point the receiver was silent for a while. During the movement between points, the receiver was not disconnected (GPS was always on) in observing the signal from the satellite. Determination of the position of the coordinate points with the stop-and-go method was applied with post-processing mode, where data processing was carried out in the laboratory after all data input was completed.

2.6. Exploration of germplasm Pulasan
In Indonesia, tropical fruits are spread all over the islands, mostly on the islands of Kalimantan, Java and few reports on the distribution of outward appearances on the island of Sumatra. Therefore, this study explored and mapped the distribution of outward appearance on the island of central Sumatra, Riau Province (figure 1). Exploration was carried out in Kampar, Kuantan Singingi, Siak and Bengkalis Regencies. In this research, a Geographic Information System is designed that can provide information about the presence of Palasan germplasm.

Figure 1. a). Map of the State of Indonesia b). Map of the island of Sumatra, the research location is in Riau Province marked with black arrows. b). Map of Riau Province (red arrows show the four distribution districts of Palasan in Riau).
3. Results and discussion

3.1. Outward survey and exploration

In general, the topography of Riau Province is lowland and undulating. Bengkalis Regency is the lowest area, located 2 meters above sea level. Siak Regency is 3 meters above sea level. Kampar and Kuantan Singingi Regencies are hilly areas along the Bukit Barisan with an altitude of 0-500 meters above sea level. Riau Province has the largest peat ecosystem in Sumatra, approximately 5.7 million hectares or about 56.1% of the total peat ecosystem area in Sumatra. Exploration of outward germplasm in the Riau ecosystem zone which has the characteristics of a mineral soil type ecosystem is found in Kampar and Kuantan Singingi regencies. Meanwhile, Siak and Bengkalis Regencies are characterized by peat soil type ecosystems. The survey results provide information that the outward appearances are scattered in various sub-districts and villages. It was found that the appearance of life in groups in a certain area, so that the population of each distribution area was not the same.

In Kampar Regency, the outskirts are located in the districts of West Bangkinang, Gunung Sahilan, and Kampar Kiri Hilir. The distribution of pulasan germplasm in West Bangkinang District was spread over 4 villages, namely Kuok, Terap Island, Koto Terap, and Tepi Sungai, where 35 trees were found. The distribution in Gunung Sahilan District is spread over four villages, namely Kebun Durian, Darek, Koto, and Rumah Godang, where 24 trees were found. In Kampar Kiri District, pulasan is spread over 12 villages, namely Sungai Sarik, Teluk Uncle, Domu, Kunto, Fold South Fabrics, Sungai Raja, Rambai River, Tanjung Emas, IV Koto Setingkai, Lubuk Agung, and Muara Selaya villages. The outward population found as many as 232 trees. Meanwhile, in Kuantan Singingi Regency, outward appearance was only found at one central point in Sentajo Raya Sub-district spread over four villages (Komang Island, Muaro, Koto and Kampung Baru) as many as 96 trees were found.

In the peat soil ecosystem zone, outward germplasm exploration was carried out in Siak and Bengkalis Regencies. In Siak Regency, the centre of outward appearance is found in the sub-districts of Sabak Auh and Sungai Apit. In Sabak Auh Subdistrict, Palasan spread over the villages of Rempak, Sungai spinach, Belading, Sabak Permai and Parit Dua, 17 trees were found. In Sungai Apit Palasan Subdistrict spread over the villages of Teluk Mesjid, Belemen, Kayu Ara and Lalan, 21 trees were found. Furthermore, in Central Bengkalis Regency, outward germplasm was found in the sub-districts of Siak Kecil, Bengkalis and Bantan which were spread over 8 villages. In Siak Kecil sub-district spread over four villages, namely the village of Seuntung, Sungai Manggis, Lubuk Muda and Tanjung Belit, an outward appearance of 17 trees was found. In Bengkalis sub-district, outward appearance is spread over three villages, namely Simpang Ayam, Pematang Duku and Ketam Putih villages, outward appearances were found to be 50 accessions, in Bantan sub-district only one village, namely Bantan village there were 3 accessions (table 1.)

| No | District | Subdistrict | Number of Villages | Number of Trees |
|----|----------|-------------|--------------------|----------------|---|
| 1  | Kampar   | Bangkinang Barat | 4                  | 35             | |
|    |          | Gunung Sahilan | 4                  | 24             | |
|    |          | Kampar Kiri   | 12                 | 232            | |
| 2  | Kuantan Singingi | Sentajo Raya | 4                  | 96             | |
| 3  | Siak     | Sabak Auh    | 5                  | 17             | |
|    |          | Sungai Apit  | 4                  | 21             | |
|    |          | Siak Kecil   | 4                  | 17             | |
| 4  | Bengkalis| Bengkalis    | 3                  | 50             | |
|    |          | Bantan       | 1                  | 3              | |
| Total|        |              | 4                  | 41             | 495 |

Table 1. Locations for survey and exploration of visible germplasm, distribution area and number of outward accessions per location in mineral and peat soil ecosystem
3.2. Outward distribution map in mineral soil ecosystem zone

The outward distribution in the mineral soil ecosystem zone has been successfully displayed in the form of a distribution map using the district's geographic base map (figures 2 and 3). The results of this map can provide information on the outward population contained in the mineral soil ecosystem zone.

**Figure 2.** Map of distribution and outward population in the mineral soil ecosystem zone in the centre of Kampar Regency. Outward tree is marked with green dots. Pulasan is spread over three sub-districts, Bangkinang Barat (brown) = 24 population, Gunung Sahilan (pink) = 36 population, Kampar Kiri (yellow) = 232 population.

**Figure 3.** Map of distribution and population of Pulasan in the mineral soil ecosystem at the centre of Kuantan Singingi Regency, the outward tree is marked with green dots. Pulasan is spread in the district of Sentajo Raya (Kuning) population = 96 trees.

Riau is an area surrounded by many rivers. In Kampar Regency, all the population in the West Bangkinang sub-district and the Gunung Sahilan sub-district thrives on the outskirts of the Kampar river with a distance of approximately 5 to 500 m from the Kampar riverbank. Likewise, in Kuantan Singingi, the outward appearance is found in areas adjacent to the Kuantan watershed. Located in the lowlands with an altitude of up to 60 meters above sea level. However, in the Kampar kiri sub-district, Palasan, the ecosystem has been explored with a hilly topography to an altitude of over 300 meters above sea level.
level. Pulasan is widely planted in the yard of people’s homes and many also grow wild on unproductive plantation lands. Outward appearance (N. ramboutan-ake) is mostly found in lowland primary forest, often on the banks of rivers but rarely in swamps, usually on sand or clay [10].

The results of the mapping can be displayed on a map of the outward distribution in the mineral soil ecosystem zone presented on two district maps. Kampar Regency has more outward access than Kuantan Singingi Regency. In Kampar Regency, three outward accession centres grow in one location. The first outward accession centre is in West Bangkinang District in which it is spread over four villages. Those four villages are side by side and located around the Kampar riverbank. In the villages of Kuok, Godang Island, Koto, and Tepi Sungai as many as 35 outward accessions were found. The second centre is located in Gunung Sahilan District which is spread over four villages, namely Kebun Durian village, Koto traditional house village, Kodai village, and Darek village where 24 outward accessions were found. The third central area is located in the Kampar Kiri sub-district, which is spread over 12 villages, namely: Sungai Sarik Village, Teluk Uncle, Domu, Kuntu, Fold South Cloth, Raja River, Rambai River, Tanjung Emas, IV Koto Setingkai, Lubuk Agung, Muara Selaya, and Across the Beach. The number of accessions found was 232 trees. The outward population in Kampar Kiri sub-district is the highest compared to the outward population found in other central areas.

Kuantan Singingi Regency has the same ecosystem zone as Kampar Regency in terms of soil type, namely both have mineral soil ecosystems, but there is only one outward centre point, namely the Sentajo Raya district. Pulasan grows in the yard of residents' houses spread over four villages, namely Pulau Komang, Muaro Sentajo, Koto Sentajo, and Kampung Baru; as many as 96 outward accessions were found.

3.3. Map of outward genetic distribution in the peat soil ecosystem zone

Peat soil in Sumatra is generally extensive and includes ombrogen peat, freshwater topogen and tidal topogen. The thickness varies from shallow (<1.0 m) to very deep (>5.0 m), above the fine-textured mineral soil substratum. The maturity level of peat is generally hemic to sapric in the upper layer, and hemic to fibric in the lower layer. Some of the peat soil gets mineral enrichment from river or tidal runoff. The current use of peatlands is mostly oil palm plantations, rubber plantations, coconut plantations, and industrial forest plantations (HTI) such as acacia, which are managed by local companies or people. Other land used are mixed gardens, shrubs and forests. Pulasan grows in groups in tidal ecosystems, some grow wild in the yard of the house and some are planted as garden plants.

The outward population of 38 cultivars was found in Siak which was spread fairly evenly in two sub-districts, 17 cultivars in Sabak Auh sub-district and 21 cultivars in Sungai Apit sub-district (figure 4). Pulasan is a native plant of Indonesia that is a close relative of rambutan, but its genetic distribution is not as wide as the distribution of rambutan which is easily found in almost all areas with diverse ecosystems. The streaks were found to live in groups at one point in a certain area together where rambutan was found, but outward appearances were not found in all areas of the rambutan distribution. Pulasan spread through population displacement, some accessions mapped on peatlands in Siak Kecil sub-district, Bengkalis district (figure 5) were from Kampar district brought by people who moved and settled in Siak Kecil. From the place of origin (Kampar) outward appearance grows well with a mineral soil ecosystem, but in Siak Kecil the outward appearance is planted in a peat soil ecosystem. The growth pattern is good, describing the Sapindaceae family as having high adaptability. Likewise, the outward appearance mapped at Simpang Ayam Bengkalis, originating from Malaysia, also grows and produces well. The results of mapping the outward distribution in Riau can complement the outward distribution data on the island of Sumatra, which previously [7] had already made an inventory of the outward appearance in West Sumatra and this means it can add to the outward distribution data in Indonesia. Based on the opinion [1, 5] that outward appearance is found in clusters on the island of Kalimantan and is an exotic fruit of Kalimantan. Furthermore, appearances from West Java were reported [5, 9, 20, 21]. So in Indonesia, Pulasan spread across the islands of Kalimantan, Java and Sumatra, with a clustered distribution type.
3.4. Mapping of pulasan genetic distribution based on a soil type map

The outward distribution map in Riau Province was successfully recorded; the outward appearances were found in groups, both in the mineral soil ecosystem zone and in the peat soil ecosystem zone. The results of this map can provide information on outward tree populations in four districts in Riau Province. Pulasan is more commonly found in the mineral soil ecosystem zone compared to the peat soil ecosystem zone. In the ecosystem zone, outward mineral soils are found in watersheds in both Kampar Regency and Kuantan Singingi Regency. Based on the Soil Type map, the soil type in Kuantan Singingi is 100% mineral soil. So all the germplasm that is being explored will certainly grow in mineral soils.

Pulasan is found to grow in groups in certain central areas but can adapt to environments that have different soil conditions. In Riau Province, outward appearance was found to grow well on agricultural
land with mineral soil types, outward appearance was also found to grow well on peat soil in a peat soil ecosystem with high salinity soil conditions.

![Figure 6. Map of the genetic distribution of Pulasan in the Riau-Mainland and Riau-Archipelagic ecosystem zones based on soil type (The outward tree is marked with a green dot). The yellow colour indicates mineral soil type, brown colour indicates Peat soil type.]

### 4. Conclusion

GPS with the ArGis system is a simple and effective method for exploring and making maps of the distribution of a plant species. Riau Province has an ecosystem of mineral soil types and peat soil types, which can adapt and grow well in these two different types of ecosystems. The outward population in the mineral soil ecosystem was 387 trees, spread over two regencies and 24 villages. The population of pulsars in the peat soil ecosystem was 108 trees spread over two regencies and 17 villages. The nature of the outward growth is clustered in certain areas. The limited genetic resources of this outward appearance are influenced by many factors, including the absence of an effective cultivation system, the lack of care for existing local trees and the influence of social and economic aspects of the community.

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### References

[1] Tindall H D 1994 Rambutan Cultivation, *FAO Plant Production and Protection* (Roma: Italia)
[2] Lim T K 2013 *Edible Medicinal and Non-Medicinal Plants* (Canberra: Springer Netherlands)
[3] Barreto L F, Andrade R A, Paula R C, Lima L L and Martins A B G 2015 *African Journal of Agricultural Research* **10** 3607–3613
[4] Morton J 1987 *Pulasan Fruits of Warm Climates* ed J F Morton (Miami: Julia F. Morton)
[5] Rukmana R and Oesman Y Y 2002 *Rambutan Komoditas Unggulan dan Prospek Agribisnis*. (Yogyakarta: Kanisius)
[6]   Uji T 2007 Keanekaragaman Jenis Buah-Buahan Asli Indonesia dan Potensinya (Bogor: LIPI)
[7]   Ediwirman and Mansyah E 2011 Embrio 4 66–73
[8]   Puhili A L, Chikmawati T and Djuita N R 2016 The Journal of Tropical 6 184–189
[9]   Harianto P A 2015 Keragaman Genetik Kapulasan (Nephelium Ramboutan-Ake) di Kabupaten Sukabumi dan Cianis berdasarkan Marka Simple Sequence Repeat dan Inter Simple Sequence Repeat PhD Thesis (Bogor: Institut Pertanian Bogor, Indonesia)
[10]  Orwa C A, Mutua, Kindt R, Jamnadass R S and Anthony 2009 Agroforestry Database: a tree reference and selection guide version 4.0 (Kenya: World Agroforestry Centre Nairobi)
[11]  Teerawutgulrag A, Jeremy D, Kilburn and Rakariyatham N 2010 Molekules 15 1453–1465
[12]  Nurhuda H H, Maskat M Y, Mamot S, Afif J and Aminah 2013 International Food Research Journal 20 1725–1730
[13]  Fatisa Y 2013 Jurnal Peternakan 10 31–38
[14]  Johnson J T, Abam K I, Ujong U P, Odey M O, Inekwe V U, Dasofunjo K and Inah G M 2013 International Journal of Science and Technology 2 71–76
[15]  Manaf N Y A, Jalaldeen M N K, Long K and Hasana M G 2013 Journal of Oleo Science 62 335–343
[16]  Yuvakkumar R, Surus J, Nathanael J, Sundrarajan M and Hong S I 2014 Materials Science and Engineering 41 17–27
[17]  BPS Badan Pusat Statistik Riau 2019 Riau Province in Figure (Riau: BPS Satistic of Riau).
[18]  Sundari, Estri L A, Luchman H and Rodiyati A 2016 Proceeding seminar Nasional Biodiversitas VI (Surabaya: Departemen Biologi, Universitas Airlangga)
[19]  Rahmawaty, Sintike F, Ridwanti B and Abdul R 2020 J Trop Soils 25 107–117
[20]  Kuswandi, Sobir and Suwarno W B 2014 J. Hort. 24 289–298
[21]  Djuita N R, Hartana A, Chikmawati T and Dorly 2017 Makara Journal of Science 21 69–76