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**STUDY OF MOLECULAR RESEARCH RESULTS AS A MATERIAL FOR  
DEVELOPING A PLANT TAXONOMY TEXTBOOK**

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**Abstract**

The purpose of writing this article was to describe the study of molecular research results as a material for developing a plant taxonomy textbook. To achieve these objectives, the researcher conducted library research, which was directed to the search results of molecular research through: the journal of research, the results of research that had been done, scientific articles, e-books, library, and data bases.

Based on the study results, it was obtained a plant taxonomy textbook which was implied by some discussion of molecular studies, which served to supplement facts of morphological study results, so that it was more accurate and comprehensive. Accurate, means that the discussion about the morphological facts, which is influenced by environmental conditions comes through molecular studies. Comprehensive, means that plant taxonomy topics will be studied more widely and deeply, because it is reviewed in terms of morphology and molecular.

**Keywords:** morphological markers, molecular markers, genetic variation, textbook, plant taxonomy.

**INTRODUCTION**

Biodiversity is the natural resources which is necessary for human survival. But along with the increase of population which continues to increase, humans are constantly exploiting the living natural resources. As a result, many natural resources are damaged. Therefore, the exploitation of natural resources needs to be prevented, so that biodiversity remains stable and can be utilized in a sustainable manner.

Faced with such problems then the role of education is necessary. One of the education about biodiversity in college, is given in Department of biology Education through the courses of plant taxonomy. The position of that courses is a compulsory subjects. It is expected that through the course of this plant taxonomy can provide students knowledge of the taxonomy. Taxonomic knowledge gained can be used by the student to understand the biodiversity that can foster awareness of efforts to conserve and utilize biodiversity in a sustainable manner.

The implementation of plant taxonomy learning process needs to be supported by the availability of textbook. This is in line with the Permendiknas 11/2005 article 2, which stated that in order to achieve the national educational goals, it is necessary to use textbooks as an obligatory reference. However, the availability of plant taxonomy textbooks is still few, even if there are textbooks, their studies are still dominated by the morphological aspect and the conventional techniques. The plant taxonomy textbooks that examine morphological aspect and molecular are still rare, so that textbooks which are available so far have not completely given

knowledge of the plant taxonomy. Study of plant taxonomy of the morphological aspect has a weakness, that it is influenced by environmental conditions. Example: a plant has a genetic variation of morphological aspects, but not necessarily has the genetic variation of molecular aspects. Variations that occur can due to the influence of different environmental conditions. Therefore the molecular aspects can be used to complete the weakness, because of its fixed nature because it is not affected by environmental conditions. In addition the discussion of the molecular aspects in the plant taxonomy textbook in accordance with the taxonomy as a fundamental science and peaked. Fundamental means taxonomy used as the basis for other sciences, while peaking means that taxonomy is the science that always follow the development of science and technology (Wisanti et al., 2012). The importance of molecular studies in plant taxonomy is supported also by the opinion Rifai (2012) which says that the molecular approach should be taken into breakfast biology students. This means that the students do not have to continue to receive the biological sciences of the 20th century which began to expired, but we should equip students with the necessary knowledge to be able to compete in the 21st century. The 21st century is the century of biology, therefore the world of education necessary to prepare human resources which have sufficient knowledge of modern biology. Additionally Rifai (2008) explains that the writing of textbook should be based on the progress of the development of science that are generally obtained through research studies up to date. Thus students who are taught based on the contents contained in the book will be able to continue cutting-edge knowledge and science.

Based on the above then the development of plant taxonomy textbook-based on molecular research needs to be done. Whereas the meaning of based on molecular research is uses information and molecular data either in the form of theory or the results of molecular studies to complete the discussion of plant taxonomy that still has weaknesses. The problem is how to develop textbook plant taxonomy based on molecular research? So to answer the above problems is done through a literature study: research journals, research that has been done, scientific articles, e-books, Library, and data base. The objectives to be achieved is to obtain data and information on molecular research results as the material for the preparation of plant taxonomy textbook. It is expected that the study results of molecular research are useful to complete the facts of the results of morphological studies, so the discussion in plant taxonomy textbook which is the development result, is more accurate and comprehensive. Accurate, means that discussion of taxonomy which is reviewed of morphological aspect has the disadvantage that is influenced by environmental conditions and then complemented by molecular studies. Comprehensive, means that plant taxonomy topics will be studied more widely and deeply, because it is reviewed in terms of morphology and molecular.

## **DISCUSSION**

### **1. The Importance of The Molecular Aspects in The Plant Taxonomy**

Based on the data and information used in the plant taxonomy then the taxonomy of plants can be divided into conventional and modern taxonomy (Gandjar et al., 2006). Conventional taxonomy using phenotypic information, that is the information derived from the protein and its function, chemotaxonomic characters, physiology and morphology. While modern taxonomy work based on genotypic and phylogenetic information. Genetic information derived from nucleic acids (DNA and RNA) that is in the cell. In line with the development of molecular biology today, it give the possibility for taxonomists utilize DNA data as molecular markers which is quite significant (Suranto, 2000). Based on the information used in the conventional taxonomy, Radford (1986) in Sharma (2009) said that the data and information on plant morphology was easily observed and obtained, therefore, morphological data was the most commonly used in taxonomic studies. However, the data and information used by conventional

taxonomy has a weakness, those are they are influenced by environmental conditions, they take a long time, they are relatively expensive, and diversity which is obtained is limited and inconsistent (Zulfahmi, 2013). Furthermore, the results which are obtained from the conventional taxonomy are used as basic information for plant characterization, identification, classification, and kinship. Although the information obtained from the conventional taxonomy has its disadvantages, but the data and the information is useful in the development of plant taxonomy. As proposed by Sharma (2009) that the morphological characters of plants have given the foundation and framework for Taxonomy.

Furthermore Sharma (2009) suggested that a complete knowledge of plant taxonomy, was only obtainable through the merger of several approaches and using various disciplines of science. Therefore, the data which is obtained from the genetic information that is based on the nature of the DNA polymorphisms can be used to complete the weakness of the data and phenotypic information. Because the information is not influenced by environmental conditions (Pandin, 2010). In addition, Park et al. (2009) says that thanks to the significant advances in the field of molecular, using DNA markers has helped to overcome the problem of the use of morphological markers. Merging phenotypic and genotypic information in the characterization of plants, identification, classification, and kinship will give a more accurate result, and a more complete result in plant taxonomy knowledge, and this is what is done today by modern taxonomy. Some of the disciplines that play an important role in the development of plant taxonomy, among others, plant anatomy, cytology, palynology, embriology, physiology, ecology, genetics, geography plant. The old understanding about classifikasi and phylogeny of plants changes with the entry of new aspects in the taxonomy as biosystematics, cytotaxonomy, chemotaxonomic, molecular taxonomy, etc.

The complete knowledge of plant taxonomy must also be possessed by the students of biology education in order for students to understand the taxonomy of plants deeper and more comprehensive. Therefore, the development of plant taxonomy textbook based on molecular research needs to be done. Through the study of the results of molecular research then the data and molecular information which are obtained are used to compile textbook plant taxonomy which is useful to complete the previous material.

## **2. Scope of Molecular Materials**

After sorting and choosing material either in the form of molecular theory or molecular research results that are relevant and necessary for the preparation of plant taxonomy textbook then the the material will be packed into 4 Chapters as a constituent of plant taxonomy textbook, namely: 1) a chapter about the role of molecular studies in plant taxonomy; 2) the role of molecular markers in plant taxonomy; 3) application of RAPD molecular markers in plant taxonomy; 4) application of molecular markers microsatellite in plant taxonomy.

At this time the progress in the field of molecular continues to grow rapidly and is widely used in a variety of disciplines both pure and applied. The plant biology project predicted that by 2020 every gene of *Arabidopsis* will be the subject of one or more experiments (Somerville and Dangi, 2010). This progress has certainly contribute into human life to improve their welfare. This situation is certainly a challenge for the Department of Biology and Biology Education to always be able to follow the development of molecular biology by equipping students with the knowledge of molecular biology. Therefore, in the chapter about the role of molecular studies in plant taxonomy, it is discussed about: 1) the importance of molecular studies on plant taxonomy; 2) the basic principles of molecular research; 3) an overview of the molecular genetic (Central Dogma of Molecular Genetics DNA, RNA, and protein molecules).

Molecular taxonomy known as molecular systematics, that is the use of molecular structure to obtain information about evolutionary relationships of organisms. Molecular

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systematics often also called molecular phylogenetics. The results of molecular phylogenetic analysis in the form of a tree called a phylogenetic tree (Wikstro et al., 2001)). According to Pandey (2007) that the molecular systematics is primarily a series of approaches to look at the relationship filogenetik by using information of macromolecules studied organisms. The type of data which is obtained includes: DNA sequences, DNA restriction sites, microsatellites, RAPD (Random Amplified Polymorphic DNA), AFLPs (Amplified Fragment Length Polymorphism). Various kinds of molecular markers which are used to identify DNA polymorphisms are categorized as follows: 1) markers based on hybridization example RFLP (Restriction Fragment Length Polymorphism); 2) markers based on PCR (Polymerase Chain Reaction) for example RAPD, Microsatellite and AFLPs (Joshi et al., 1999; Varshney et al., 2005). Therefore in the chapter about the role of molecular markers in plant taxonomy, it is discussed about: 1) molecular markers; 2) PCR (Polymerase Chain Reaction); 3) molecular approaches based on the nature of DNA polymorphism.

Currently DNA markers that are widely used in plant taxonomy to see genetic variation, kinship, and the genetic structure of the plant both forestry and horticulture crops are RAPD and microsatellite molecular markers, therefore, both of the markers will be discussed each in a separate chapter namely the chapter about application of RAPD molecular markers in plant taxonomy and a chapter about the application of molecular markers in plant taxonomy Microsatellite.

Some specific examples of the role of molecular markers in plant taxonomy, among others: Hussain et al., (2008) studied molecular analysis of dicot-monocot split and relationship among major angiosperm group. By using RAPD (Random Amplified Polymorphic DNA)-technique, they established relationship among major angiospermic group based on cladistic analysed. The phylogenetic trees of relationship derived from molecular data confirm dicots as the ancestral class of monocots, there seems no dicot-monocot split. Dicots form an ancestral class of magnoliids and the monocot lineage was derived from one of the basal magnoliids. Their studies also pinpoint dicots as the possible close relatives of the monocots. In Pandin (2010), it is described the use of RAPD and Microsatellite DNA markers for the analysis of genetic variation, evolution / migration coconut, linkage of certain genes, and analysis of quantitative trait loci.

Fofana et al. (2009) conducted a research by using 15 microsatellite markers to study genetic variability and structure of teak (*Tectona grandis*) which spread naturally. The results showed that there were four centers of genetic variability. Two groups were in India which was considered as the main center of genetic diversity of teak. One group in Thailand and Laos who were genetically different from India and one group in Central Laos who showed less genetic variability. The other research which used microsatellite were: Verhaegen et al. (2010) compared 22 provenances of exotic teak and 17 teak from nature. Roy et al. (2004) in *Hevea brasiliensis*; Ng (2010) developed a microsatellite of *Shorea leprosula*; Draheim et al. (2009) studied about gene flow in 21 individuals *Virola surinamensis*.

### **3. Characteristics Textbook of Plant Taxonomy-Based on Molecular Research**

Textbooks plant taxonomy based on molecular research that will be produced has the following characteristics: 1) it is planned to be arranged in 14 chapters which composed of 10 Chapters are plant taxonomy material before where each chapter comes with practice questions and 4 Chapters are a matter of the development which discusses molecular studies on plant taxonomy; 2) the materials which are used for this molecular discussion draw largely from the study of molecular and molecular theories which are taken from the book; 3) presents the application of RAPD molecular markers and application of microsatellite molecular markers in the plant taxonomy detail and completely that is packaged in two Chapters ; 4) practice guidance will be equipped with the data of the molecular research that have been done as an exercise to analyze the data.

Textbooks of plant taxonomy based on molecular research that will be produced has advantages such as the following: 1) provides information on the taxonomy of plants more complete and comprehensive; 2) presents the knowledge of molecular either theoretical or application; 3) application of molecular markers which was chosen is the easiest to be understood.

## CONCLUSION AND SUGGESTION

From the study of the result of molecular research, it was obtained a plant taxonomy textbook that presented information about taxonomy accurately and comprehensively. Accurate means that the material which was presented apart from morphological aspects that had a weakness because it was influenced by different environmental conditions also come from molecular aspects that were fixed in the sense of not influenced by environmental conditions. While comprehensive means that the data and information which were presented in the textbook plant taxonomy were reviewed, either morphological or molecular aspects.

In this textbook molecular research studies only in higher plants, the future may also need to study the molecular study of low-level plants.

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