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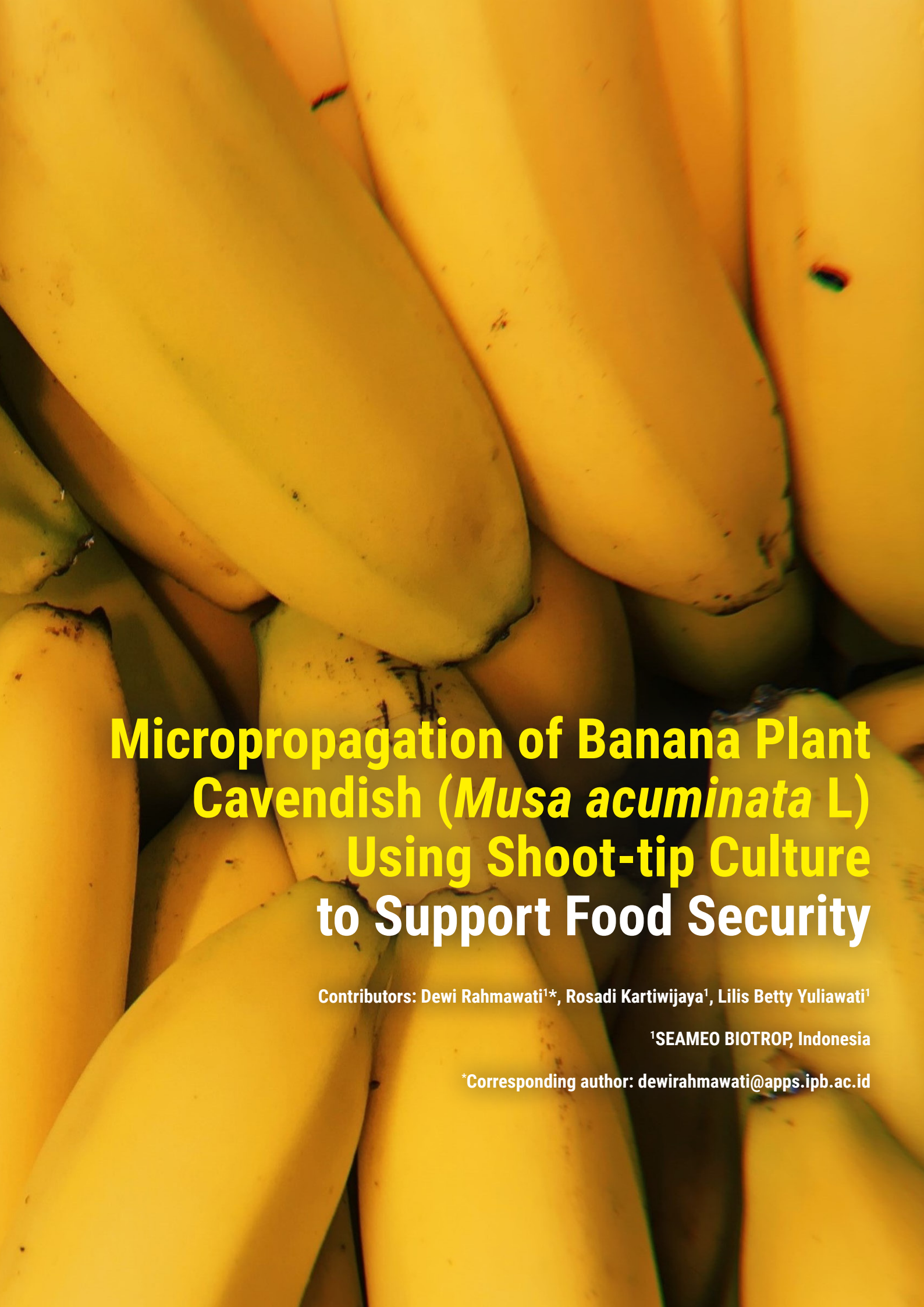

Micropropagation of Banana Plant Cavendish (*Musa acuminata* L) Using Shoot-tip Culture to Support Food Security

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Abstract

Banana is one of the world's most important fruit crop. From a nutritional perspective, bananas are an excellent opportunity to diversify staple foods in Indonesia. An increase in the human population will increase the need for food. The application of biotechnology is a solution to facing the challenges and threats of the world food crisis, including Indonesia. Therefore, using a propagation method to produce seedlings quickly and on a large scale and to make disease-free seeds through tissue culture techniques is necessary.

Keywords: banana, biotechnology, food, micropropagation, tissue culture.

Introduction

An increase in the human population will increase food needs. One way to grow food productivity to achieve domestic food sovereignty is by applying biotechnology. Biotechnology solves the challenges and threats of the world food crisis, including Indonesia. Food crops with biotechnology must be carried out and developed to anticipate the danger of a world food crisis, which is predicted to peak starting in 2050. Biotechnology can also answer global climate change, the water crisis, and reducing pesticides and world carbon emissions. FAO predicts that food demand will increase by as much as 60% so that the world's population does not sink into poverty and hunger. Banana plants are the fourth most important crop in developing countries after rice, wheat, and corn. From a nutritional perspective, bananas are an excellent opportunity to diversify staple foods in Indonesia. According to the Central Statistics Agency (BPS) records, Banana production in Indonesia reached 9.60 million tons in 2022. It showed a figure 9.79% higher than the previous year, which was 8.74 million tons.

The main problem of bananas in Indonesia's decline in banana production is the high disease incidence. The expected technology includes all production systems to produce quality fruit that is safe for consumers and protects the environment. Therefore, obtaining good-quality parental donors, resistance to pests and diseases, and resistance to environmental changes is essential. In Indonesia, the development and cultivation of cavendish bananas still have many obstacles, including the need for quality seeds, *Fusarium* wilt rot, and uniform quality (Ministry of Agriculture, 2014). The limited availability of quality banana seeds in Indonesia is caused by the low quantity and quality of banana seeds produced using conventional methods. Conventional propagation of banana seeds by taking saplings from the stem of the mother plant cannot meet the demand for quality banana seeds on a large scale. In addition, the time needed to get seeds is quite long. Therefore, using a propagation method to produce seedlings quickly and on a large scale and to make disease-free seeds through tissue culture techniques is necessary.

Methods

Figure 1 shows the in vitro propagation of bananas in SEAMEO BIOTROP. The tissue culture process included initiating cultures from sterilized shoot tips obtained from the banana plant (Fig. 1a), shoot initiation (Fig. 1b), shoot multiplication, elongation and rooting (Fig. 1c), acclimatization (Fig. 1d), and banana nursery in the field (Fig. 1e).

Figure 1. Micropropagation of banana in SEAMEO BIOTROP: a. explant sterilization, b. shoot initiation, c. shoot multiplication, elongation and rooting, d. acclimatization, e. banana nursery in the field

Results and Discussion

One of the goals of plant tissue culture is micropropagation. Micropropagation is plant propagation in vitro by carrying out explant multiplication activities. The initial stage in explant selection is the selection of the mother plant or the so-called explant source. The choice of explant sources is essential for the success of micropropagation selection of explant sources and continuous improvement of parent plant quality. Starting banana tissue culture involves looking for and determining banana trees that will be used as quality mother plants. The mother plant factor is essential to maintain and improve its quality. Increasing the quantity and quality of bananas need quality banana seeds. If the mother of the banana plant is a superior seed, the resulting embryo will also have excellent characteristics. Mother plants are to be used as a source of explants from species or varieties with healthy vigor and are free from symptoms of pests and diseases.

Sterilization of banana explants by using 70% alcohol solution for 10 minutes, then immersing the explants in 50% NaOCl solution (Sodium hypochlorite) for 30 minutes. Multiplication of banana shoots is done by stimulating an increase in axillary shoot proliferation from the shoot hump. Shoot multiplication can be induced by adding growth regulators to the media. Media is essential in inducing shoot formation and proliferation, influenced by the concentration and type of hormone used. The multiplication stage of banana plants uses cytokinins combined with auxins. The often-used high concentration of cytokinin is BAP (6-Benzyl Amino Purine), 2-5 mg/L.

In contrast, the often used auxin is NAA (1-Naphthaleneacetic acid) with a low concentration, between 0.1-0.5 mg/L. The most suitable plant growth regulators for in vitro plant propagation are often species-specific or even specific to certain cultivars within a species (Gahan & George, 2008). Therefore, the optimal combination of growth regulator concentrations for each type of banana is often different. Optimal concentration combination obtained through empirical research. Several studies have been conducted on banana explants, including micropropagation of abaca banana (*Musa textillis* Nee) using BAP 5 mg/L gave the best results with an average of 8.6 micro shoots per explant (Avivi & Ikrarwati, 2004), on *Musa paradisiaca* L using MS media with the addition of 0.2 mg/L IAA combined with 5 mg/L BAP gave the highest shoot multiplication by forming 6-17 shoots (Fitramala et al., 2016), in *Musa paradisiaca* cv. Raja Bulu, the best concentration to increase the number of shoots is BAP 5.8 mg/L (Yosafat, 2020), banana (*Musa paradisiaca* L.) Kusto cultivar using 6 mg/L BAP treatment (Apriani et al., 2016), banana (*Musa* spp .) cv. Giant Cavendish 5.0 mg/L BAP + 0.5 mg/L NAA (Gebeyehu, 2015), multiple *Musa sapientum* shoots were induced in vitro from shoot meristems with Murashige and Skoog's medium supplemented with BAP 3.0 mg/L and NAA 0.2 mg/L (Kalimuthu et al., 2007). The best BAP concentration to induce propagules plant bananas Cavendish is 3.0 mg/L (Maulida et al., 2018), whereas using a low BAP combination of 0.2 mg/L + IAA, 0.1 mg/L in *Musa paradisiaca* L also resulted in a low number of shoots

(Dhanalakshmi & Stephan, 2016) and the same thing for Kepok Amorang Banana shoot multiplication using ¼ MS + 1 ppm BAP, the rate of shoot multiplication obtained in this study was low, which ranged from 1-3 (Supriati, 2010). BAP primarily influences the development of explants, namely in the formation of shoots, shoot multiplication, and spurring cell division in plant metabolism to form the necessary organs (Faridah et al., 2017). BAP is a type of cytokinin that is more commonly used in in vitro culture because it is more effective and stable than other cytokinin hormones. Shoot propagation of various bananas in vitro using BAP shows that the higher the concentration of BAP can produce more banana shoots at a specific optimum concentration. However, cytokinins that are too high can inhibit and become mutagens for banana plants. Auxin in the right concentration plays an active role in cell differentiation, but it can be toxic at levels that exceed the optimum concentration. In vitro rooting induction for Cavendish banana plants was MS media without ZPT with macro content half of the normal concentration, plus 1 g/L of activated charcoal.

Tissue culture is a technique used to grow plant cells, tissues, or organs under sterile conditions on a known composition nutrient culture medium. The basis of tissue culture techniques is that plant cells have totipotency, namely the ability of cells to grow and develop to form complete plants. The success of propagating banana seedlings through tissue culture is influenced by several things, including the media used, explant sterilization methods, plant varieties, sub-cultures, and acclimatization. The advantage of banana seeds from tissue culture is their uniform plant growth. Therefore, when it is time to bear fruit, banana plants originating from tissue culture will bear fruit simultaneously, making it easier to manage

banana gardens. In addition, tissue culture technology does not depend on the season and other environmental factors, helps in efforts to eliminate pathogens, only a tiny part of the original plant is used as inoculum, can produce large quantities of plants in a short time, and has superior characteristics (Rahmawati & Sandra, 2021). Tissue culture technology to propagate banana seedlings promises bright prospects to support the procurement of bananas as one of the export commodities. Banana is also crucial in fulfilling food security and food sovereignty and elevating farmers' income. Indonesia has many superior varieties that can be cultivated from seedlings produced using tissue culture technology.

Conclusions

This article describes shoot propagation and plant regeneration of the banana cultivar cavendish. Micropropagation has played a crucial role in banana improvement programs worldwide. The culture method can be developed as a micropropagation protocol. Micropropagation is one of plant biotechnology's most commercially efficient and practically oriented applications, producing fast and pathogen-free plant propagation. Banana plantlets generated through tissue culture have a higher survival rate, reduce the cost of disease and pest control, show vigorous growth, and have a shorter harvesting period. This information can support food diversification, cultivation, and sustainable banana productivity to support food security.

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