In vitro cultured and supply chain porang in South Sumatra

Agustina Bidarti*, *Yulius*, and *Erni* Purbiyanti

Department of Agricultural Social-economic, Faculty of Agriculture, University of Sriwijaya, Palembang-Prabumulih Highway, 32th miles, 30662, Indralaya, South Sumatra, Indonesia

ABSTRACT. The objectives of the study are first, farmers in P4S Karya Tani can obtain superior *porang* seeds by regenerating *porang* in vitro culture through *organic plus liquitermy fertilizer*. Second, analyzing the media for growing tissue and the concentration of each *porang* plant media in P4S. Third, analysis of the supply chain structure of porang in P4S. This study uses quantitative and qualitative approaches with simple randomized design methods and SCOR methods. Based on the experiment, vitro culture of *porang* in P4S using *liquitermy fertilizer*, there were nineteen out of thirty *porang* plant accessions which had the potential as new clones for seedlings with an average tuber of 6.00 - 99.88% larger than the parent. The *porang* supply chain in P4S needs to be developed by involving wider stakeholders. This study shows that the seed production rate is better with *liquitermy fertilizer* in the *porang* in vitro culture. However, further evaluation is needed in analyzing genetic traits and *glucomannan* levels

1 Introduction

Porang (*Amorphophallus muelleri B*) is currently considered a plant that has high popularity. The popularity of *porang* is due to its high economic value in increasing farmers' income. *Porang* can also be cultivated as a plant in agroforestry systems in Indonesia [1]. The high economic value for farmers' income cannot be separated because *porang* has a high *glucomannan* content. [2] *Glucomannan* is widely used in the fields of food [3], health [4] and industry [5,6].

Porang exports in recent years have increased sharply, but *porang* production is still low. In addition, there is an interesting reality, that in the midst of *porang's* increasing popularity, unfortunately in South Sumatra, *porang* cultivation is not yet popular. There are two things that the lack of *porang* cultivation in South Sumatra, namely the problem of knowledge of nursery cultivation and the lack of knowledge of farmers on the *porang* supply chain. Another obstacle faced by farmers in cultivating *porang* in South Sumatra is the absence of mass supply and propagation of seedlings in a relatively short time. In addition, the low productivity of *porang* is also caused by a long growth period, during the third year after planting. [7] Therefore, it needs *porang* genetic improvement with a short

* Corresponding author: agustinabidarti@unsri.ac.id

growth period and high seed production. However, there are very few studies on genetic improvement of *A. muelleri*. The proper and fast *porang* seed propagation technique can be done by means of tissue culture (*in vitro*). According to [8] propagation of seeds quickly and widely can be done by utilizing seeds, because *porang* seeds have *polyembryonic* properties. In vitro culture is a plant cultivation technique by cutting plant parts such as organ parts, tissue cells and protoplasts into sterile, translucent media to facilitate photosynthesis [9].

The Rural Agricultural Training Center (P4S) is a non-governmental organization managed in groups for agricultural training and education programs. However, at P4S Karya Tani Tanjung Batu, South Sumatra, even though it already has land, there are still limited seeds. Therefore, there needs to be a first practical experiment in the development and enhancement variety of *porang* (*A. muelleri*) to produce higher seedlings. Theoretically, the propagation of *porang* plants has been through two methods, namely vegetatively by using stem tubers, part of the stem and leaf tubers (*bulbil*). While generatively through seeds, the time needed to make the seeds ready for harvest takes between 4-6 months [10].

Based on the above conditions, it is necessary to conduct research on other propagation alternatives, which allow *porang* plants to be developed in a relatively short time. The method that can be used is the in vitro technique, this method allows multiplication to be done in a fast time and in large quantities. The in vitro technique in this trial was carried out using 30 selected elite populations to develop superior clones which were given the application of *organic plus liquitermy fertilizer* and *organic pesticides my-1*. Both are produced independently by P4S Karya Tani. In addition to in vitro techniques, it is no less important in this study to form the *porang* supply chain itself from the P4S Karya Tani farmers, especially in the target market and the target of developing the *porang* supply chain.

In this study, an in-depth discussion was carried out by observing and taking steps to improve the cultivation of *A. muelleri*, which aims to find out what media are suitable for growing *porang* plant tissue and determine the concentration of each medium, so that a superior *porang* plant is obtained. Furthermore, a study on the formation of the *porang* supply chain at P4S Karya Tani was also carried out.

2 Materials and methods

The plant material (explants) of *porang* seeds used in this study were taken from the *P4S Karya Tani* at Tanjung Batu, Ogan Ilir, South Sumatra. The explants used were *porang* tuber seeds for germination, while for *embryogenic* callus induction, frog seeds resulted from in vitro germination of *porang* seeds which were 42 days old.

Apart from using some tissue culture media. The growth regulator used is *P4S Karya Tani* self-produced *organic plus liquitermy fertilizer*, which is a liquid organic fertilizer and is registered as a patent. *Organic plus liquitermy fertilizer* is a macro fertilizer made from phosphorus (P) -calcium (K) and a micro fertilizer made from fe, ca, al, mg, cr, mn, na and the active ingredient consists of *auxin* and gibberellin. Meanwhile, *organic pesticides my-1* for germination and embryogenic callus induction.

This study used a completely randomized factorial design. The research was started by preparing the explants that were placed in a petridisk plate, then separated from the seeds by cutting them to the edge of the bud.

The first factor is the growth regulator *organic plus liquitermy fertilizer* with concentrations of: 0 mg/I, 0.5 mg/l, 1.0 mg/l, 1.5 mg/l and 2.0 mg/l. While the second factor was *organic pesticides my-1* with a concentration of 0 mg / l, 0.5 mg / l and 1.0 mg / l, so that 15 treatments were obtained and each treatment was made 15 replications.

Germination observations were carried out for 42 days. As for the induction of embryogenic callus for 45 days. The data obtained were analyzed using two-way Analysis of Variance (Anava). If there is a significant difference between treatments, continue with the Duncan Multiple Range Test (DMRT) at the 5% level. Data processing was assisted by using SPSS 15.0 software.

The *porang* supply chain structure method follows the work of [11] with a descriptive method. The design of the performance measurement method refers to the SCOR modeling which includes supply chain performance attributes. To calculate supply chain performance, hierarchical design and weighting were carried out using fuzzy AHP. The assessment indicators provided in the SCOR model to measure supply chain process performance are expressed in quantitative measures called assessment matrices.

3 Results and Discussion

3. 1 Shoots in In Vitro Seeds of *Porang*

Organic plus liquitermy fertilizer, which is an independent organic liquid fertilizer produced by P4S Karya Tani, is able to minimize dormancy in *porang* seed germination due to the content of phosphorus and calcium and elements of Fe, Ca, Al, Mg, Cr, Mn, Na which are added with *auxin* and gibberellins.

Based on observations on the in vitro germination of *porang* seeds with the addition of *organic plus liquitermy fertilizer*, the analysis was that the coefficient of variability had a value below 0.5%. Based on the results of the study showed that in vitro culture of *porang* in P4S using organic fertilizers plus liqueur, there were twenty two out of thirty accessions of *porang* plants that had the potential as new clones for seedlings with an average tuber of 6.00 - 99.88% greater than the parents.

Fig. 1. Organic plus liquitermy fertilizer.

This condition shows that gibberellin in the *organic plus liquitermy fertilizer* can play a role in inhibiting dormancy as well as accelerating the germination by activating enzymatic reactions in *porang* seeds in the embryo process. The results of the coefficient of diversity shown in this way are almost similar to the findings of [12] in doing in vitro for pineapples and [13] for in vitro dates with more modern plant growing substances. Observations on stem length on *porang* seed sprouts also had a different average number between all treatments. The lowest treatment in all treatments was indicated by the control treatment, where the *organic plus liquitermy fertilizer* was significantly different given to the other *porang* seed treatments. The best treatment of all treatments was shown in PorLT3 as much

as 1.5ppm which had a height of 10.250cm longer than the control treatment which was only 2.75cm high.

Fig. 2. Organic plus liquitermy fertilizer and organic pesticides my-1.

The data above shows that the in vitro process during the *auxin* imbibition of the *organic plus liquitermy fertilizer* can be absorbed by the *porang* seeds. The study of [14] and [15] stated that *auxin* is an important *phytohormone* that mediates various developmental processes in plants. The chemical process of *porang* seed germination is faster along with the entry of water and other substances contained in the *auxin* contained in the *organic plus liquitermy fertilizer*. The results of observations and root length tests of *porang* seeds showed a high level of effectiveness.

Fig. 3. *Porang* slicing for in vitro culture.

The growth regulating agent for *organic plus liquitermy fertilizer* shows an important role in controlling the biological processes of plants. The *auxin* germination process in *organic plus liquitermy fertilizer* active ingredient, which enters the high *porang* seeds, simultaneously affects the phototropism. According to [16] phototropism is an important component in vitro because it is a process of determining the bending of plant stems towards light. Similar phototropism effects with LED lights [17] and electric fields [18].

In the process of *porang* seed germination, the content of phosphorus and calcium as well as elements of Fe, Ca, Al, Mg, Cr, Mn, Na in *organic plus liquitermy fertilizer* play an important role in the process of cell division and enlargement, especially at the beginning of

the formation of *porang* seed roots. This condition is in accordance with the working mechanism of phosphorus and calcium elements in *organic plus liquitermy fertilizer*. The root formation process will begin when the phosphorus and calcium elements in *organic plus liquitermy fertilizer* slow down the activity of compounds that affect the formation of calcium pectate, causing the cell walls to become more elastic. The elastic cell wall causes ions such as H+, K+, Ca+ to enter the *porang* seed cells. As a result, it is easier for the cytoplasm to push the cell walls outwards and expand the volume of *porang* seed cells.

Fig. 4. Observation of callus porang in vitro culture

In addition, *organic plus liquitermy fertilizer* causes an exchange of H+ ions and K+ ions. K+ ions will enter the cytoplasm and stimulate water absorption into the cytoplasm to maintain pressure in the *porang* seed cells. After experiencing swelling, the cell wall will become hard again due to metabolic activities in the form of absorption of Ca + ions from outside the cell as well as perfecting the composition of calcium pectate in the cell wall.

The cell elongation that occurs in the stems of *porang* seeds is given *organic plus liquitermy fertilizer* hormone and will grow into roots which function to absorb nutrients. Water and ions that enter the cytoplasm will activate the growth enzyme, so that the cells that are initiated by hormones contained in organic *liquitermy fertilizer* are able to elongate cells in *porang* seeds.

3. 2 *Porang* seed embryogenic callus induction

Callus is a mass of cells that have not differentiated into organs of plants. The callus that appears is the result of the division of cells in the explant network. In the callus induction process, *porang* seeds are applied by adding the *organic pesticides my-1*, a patent-registered product of P4S Karya Tani. *Organic pesticides my-1* contain growing substances as well as organic pesticides and pesticides that control fungi, pests and are rich in micro-elements. Based on the observations, the highest percentage of curing was produced in almost all treatments. The highest percentage of PorLT 1 mg / l is 7.57%. The study of [19] and [20] state that callus formation occurs through three stages of development, namely cell induction, cell division, and cell differentiation. The results of this study also show that there are developments in these three stages.

Fig. 5. Organic pesticides my-1 sprayer.

The treatment of *organic pesticides my-1* on *porang* seed callus was able to increase osmotic pressure, protein synthesis and cell permeability to water. This study is similar to the research of [21], where these conditions can cause water to enter the callus cells while causing an increase in callus volume. The increase in volume together with the increase in protein synthesis, causes the emergence of a source of energy in the growth of callus *porang*.

Interestingly, the results of the analysis of variance showed that the administration of the hormone *auxin liquitermy fertilizer* and *organic pesticides my-1* to the callus of PortLT 3 *porang* seeds also interacted well with contamination of the growth of *porang* callus. The highest contamination was found in PortLT 0 reaching 46.67%, but the percentage of contamination was statistically not significantly different from all treatments.

This result is similar to the [22] study, where callus contamination depends on the sterilization of the work environment, growing media or planting material. Inadequate sterilization results in the growth of microorganisms on the media as well as creates a weakness in the immunity of fungi and pests.

Observation of callus quantity for 45 days obtained Anava results that the effect of the addition of *organic pesticides my-1* on the quantity of *embryogenic* callus in *porang* explants F count > F table. These results showed that there was an effect of the addition of *organic pesticide my-1* on the induction of callus *embryogenic porang* in vitro.

Furthermore, the analysis of the coefficient of diversity is used to determine further tests with results below 5%. In addition, the results of this test also show several things. First, the coefficient of variability test results on the day when the callus appeared showed that *porang* explants had different mean values between treatments.

The lowest treatment in the emergence of callus from the two explants was the 0ppm treatment (control / PortLT 0), because it was significantly different from all treatments. For *porang* explants, the best in the emergence of callus was at 3ppm (PortLT 4) and 2ppm (PortLT 3) for the application of *organic pesticides my-1*. This is due to the treatment of Port 4 and PortLT 3 *porang* explants were not significantly different and only significantly different from the treatment of PortLT 2 and others.

Based on the statement above, PortLT 0 *porang* explants (0 ppm/control) at 45 days of growth period actually had the lowest ability to induce *embryogenic* callus of *porang*. This trait is due to the very small amount of endogenous hormone in the PortLT 0 callus so that exogenous plant growth substances are needed in the *organic pesticides my-1* to help the endogenous hormones present in *porang*. This result is also explained from the study of

[23] which proves the addition of *auxin* or *cytokinin* in culture media. This *auxin* becomes an increase in the concentration of endogenous growth regulators in the cell so that it becomes a trigger factor for the process of tissue development.

Based on the treatment, the best average value was found in the PortLT 4 callus with the fastest concentration level in inducing *porang embryogenic* callus. These results also showed that the administration of the *organic pesticides my-1* at PortLT 4 was able to become the fastest day for *porang embirogenic* callus to appear. The [24] study supports the explanation that plant growth substances that are most often used in callus cultures with a stable level of activity in spurring cell differentiation are able to suppress organogenesis and maintain callus growth in plants.

Second, based on the results of the coefficient of diversity test, it showed a permanent increase in the size of the callus cells. *Porang* callus wet weight measurement can be observed from the irreversible increase. The results of this test showed that the best *porang* callus explants were sequentially found at PortLT 2 (1ppm), PortLT 4 (3ppm) and PortLT 3 (2ppm) because they were not significantly different between treatments and only significantly different from PortLT 0 (0ppm) which was the control.

The callus formation in the results of this study was influenced by *auxins* and *cytokinins* in the growth regulator *organic plus liquitermy fertilizer* and *organic pesticides my-1*, with the right and appropriate ratio. Therefore, it can be said that the appropriate ratio will support the growth of *porang* callus.

The mechanism of action of *porang* callus formation begins when *cytokinins* play a role in transcription and translation processes in cells. This process takes place in the metaphase stage and is continued by the formation of amino acids as basic components of protein. The proteins formed include enzymes that play a role in cell division. These enzymes, such as polymerases, are used to lengthen DNA chains and repair errors in the preparation of *porang* DNA nitrogen. In the [25] study, the presence of enzymes in cells causes the effectiveness of the process of cell division.

Third, based on the results of the coefficient of diversity test, callus observations really need *auxin* to induce *porang* callus. Also, it really depends on the level of endogenous *auxin*, both in the growth regulator *organic plus liquitermy fertilizer* and the *organic pesticides my-1*. The study of [26] showed that the callus process was highly dependent on explants and the addition of growth regulators to in vitro basic media. Based on the results of the coefficient of diversity test, the best *porang embryogenic* callus explants were seen in PortLT 3 (2ppm) because they were not significantly different from PortLT 2 (1ppm) and others.

The results of the coefficient of diversity test above, it can be said that the highest average value to determine the best results is found at the concentration of PortLT 3 (2ppm) of 100% explants at the shoot stage. While at the explant stage, the *porang* callus was at PortLT 3 (2ppm) of 99.17%. This finding is in line with the studies of [23] and [24], with the statement that the need for exogenous hormones at the shoot stage is highly dependent on the input of endogenous hormones from explants at the *embryogenetic* stage. The mechanism of this callus process occurs when treatment is given to explants at the *embryogenetic* stage. In this step, the process of cell wall expansion and water absorption causes the cells in the explants at the *porang* bud stage that are damaged to repair themselves.

3. 3 *Porang* Supply Chain at P4S Karya Tani

The establishment of the *porang* supply chain at P4S Karya Tani, South Sumatra is the second study in this paper. The method of forming the *porang* supply chain is a briefing for Karya Tani P4S members, as many as 106 farmers, in transferring knowledge about supply

chains, especially suppliers. The existence of suppliers is important in the supply chain as the right program target. In addition, P4S is not too difficult to establish cooperation because in essence, one of the roles of P4S in empowering farmers is to develop cooperation networks.

First, the formation of the *porang* supply chain at P4S Karya Tani must be complete. Starting with self-involvement at the stage of ordering products from suppliers, to the stages of manufacturing, transportation and warehouses, as well as retailers, thus giving rise to the nature of the existence of customers. [11] The most important thing at this supplier stage is cutting the supply chain that is not too long, namely developing suppliers at the local level who can deal directly with the main supplier, the exporter of the *porang* factory.

The emphasis of a supply chain is the existence of a main target as an achievement of the goals of the members involved in a supply chain. [27] This target is divided into two, namely the target market and the target development. The target market for the *porang* supply chain at P4S Karya Tani is *porang* exporters, namely *porang* processing factories. Currently the main exporter of *porang* in Indonesia, most of the factories are on the island of Java and there are only two factories on the island of Sumatra. These companies include PT Ambico, PT Asia Prima Konjac, PT Algalindo, CV Agro Alam Raya, CV Jia Li in East Java, PT Star Konjac Nusantara, CV Porang Center Indo, CV Sanindo Putra in West Java, and PT Jagat Raya Indonesia in Jakarta. Meanwhile, the two factories in Sumatra, namely PT Mitra Porang Nusantara (MPN) in Riau and PT Paidi Indo Porang (PIP) in Lampung which will start operating in 2021. Geographically, the closest target market at P4S Karya Tani is to become a representative of PT PIP Lampung as a customer partner for its *porang* products.

In addition to the target market, in the supply chain the most important thing is the development target. This target includes increasing the production of quality *porang* at P4S Karya Tani in meeting the needs for *porang* raw materials at PT PIP. PT PIP is very concerned about the quality of *porang*. Therefore, the quality of *porang* in P4S Karya Tani in this case must pay attention to: (1). *porang* tuber dryness level, (2). The water content is at least 10% and not moldy. and (3) *porang* price above IDR. 75,000/kg.

Furthermore, following the thought of [28] on the formation of the supply chain. The actors in P4S Karya Tani in the development targets, apart from dealing with partner management and external networks, must also strengthen internally. *Porang's* internal supply chain network at P4S Karya Tani focuses on collaboration between P4S members in the supply chain. Urgency collaboration is the formation of cooperatives among *porang* farmers coordinated by P4S management. This cooperative is engaged in distributing seeds, purchasing the results of *porang* farmer members through *Gapoktan* at a cash price.

Another internal factor in this supply chain development target is the support from the Government of Ogan Ilir. The Government of Ogan Ilir, through the Department of Agriculture, must make a self-sufficiency program for *porang*. Furthermore, the program for opening *porang* land expansion, procurement of cheap *porang* seeds, subsidies for *porang* fertilizer, including purification of *porang* seeds with local characteristics. The Department of Agriculture of Ogan Ilir must also provide counseling on cropping patterns to provide assistance in the form of procurement of tuber washing equipment and *porang* choppers.

4 Conclusions and recommendations

Based on the results of the study, it was shown that in vitro culture of *porang* in P4S using *organic plus liquitermy fertilizer*, there were twenty-two out of thirty *porang* plant accessions that had the potential as new clones for seedlings. The test value obtained was quite high with an average tuber of 6.00 - 99.88% larger than the parent seed.

In the in vitro process of *porang* seeds, the plant growth agent *liquitermy fertilizer*, was proven to be effective, especially during *auxin* imbibition. The chemical process of germination of *porang* seeds is getting faster along with the entry of water and other substances contained in *auxin* of *organic plus liquitermy fertilizer*. Growth regulators in *organic plus liquitermy fertilizers* show an important role in controlling plant biological processes. In the process of callus metabolic activity, growth regulators in *organic plus liquitermy fertilizer* are able to supply energy needs, together with the provision of *organic pesticides my-1*. Both of these substances when applied to callus can cause cells to swell, thus creating *porang* embryos that are immune to fungi and other pests.

In the formation of the *porang* supply chain at P4S Karya Tani, there needs to be a community empowerment process in the form of knowledge transfer about the flow of the *porang* supply chain. The target market in the *porang* supply chain at P4S Karya Tani must be shortened which leads to the main *porang* exporting company, PT PIP Lampung representative. The supply chain development target is aimed at maintaining the production and quality of *porang* among farmers in order to obtain high selling prices by strengthening the collaboration of farmer members in the form of cooperatives and support from the Ogan Ilir Government.

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