Increasing the capacity and adoption of certified citrus seedling producers towards recommended technology for disease-free certified citrus seedling production in Sambas Regency, West Kalimantan

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Abstract. Citrus nursery is one of the upstream sectors that is significant to support citrus agribusiness in Sambas regency as citrus production center area in West Kalimantan. Several programs have been conducted to increase the capacity and technology adoption of disease-free certified citrus seedling producers. Therefore, the objective of this study was to examine the implementation of technology support for disease-free certified citrus grafted seedling production through mentoring programs to increase the knowledge and skill capacity of the seedling producers, as well as to evaluate the adoption level of the certified citrus seedling producers towards the recommended technology for disease-free certified citrus seedling production in Sambas Regency. The mentoring programs were carried out by training and establishing a model of citrus Bud-stick Multiplication Block. The evaluation of the adoption level of recommended technology was carried out by conducting surveys before and after the mentoring programs. The adoption evaluation of the recommended technology components comprised of the use of polybags during the whole production process, sowing rootstock seeds correctly, nucellar selection, transplanting, the use of bud-stick from Bud-stick Multiplication Block, Grafting and optimum maintenance. The evaluation results indicated that several technology components got an increase in the adoption rates after the completion of the mentoring programs. However, there were still few technology components that did not experience changes in the rate of adoption.
1. Introduction
Sambas regency is one of citrus production centers in Indonesia. This district has a significant contribution to the citrus production for West Kalimantan as the third largest citrus production zone in Indonesia after East Java (27.02%) and North Sumatera (26.92%) [1]. In 2018, the total area of citrus planting in Sambas Regency was 8,442.6 ha and the total yield production was 107,096 tons [2]. Nevertheless, this district had suffered a production loss due to CVPD attacks in 2010, mainly caused by the use of 70 – 80% uncertified citrus seedlings in this area. This condition has affected the economic life of around 20% population that involved in citrus farming in Sambas Regency [3]. Hence, using disease-free certified citrus seedling is certainly vital to prevent the attack risk of CVPD disease which could result in the decreasing of citrus productivity and quality, as well as causing the death of the citrus crops. Thereby, citrus nurseries or citrus producers in Sambas Regency must be able to produce high-quality and certified citrus seedlings.

The role of nursery or seedling industry is highly important for the development of sustainable citrus agribusiness in Sambas Regency. The nursery, which includes four subsystems such as research and development, seed production and distribution, quality control, and information, takes part in the upstream sector of agricultural industry [4; 5]. The provision of high-quality seedlings is the foundation of any successful agriculture program [6]. This means that sustainable citrus farming depends on the use of high-quality seedlings which is integrated with optimum cultivation practice. A high-quality citrus seedling refers to a disease-free certified citrus seedling that includes several specifications, i.e. (1) free of systemic pathogens, i.e. CVPD (Citrus Vein Phloem Degeneration), CTV (Citrus Tristeza Virus), CVEV (Citrus Vein Enation Virus), CEV (Citrus Exocortis Viroid) and CPsV (Citrus Psorosis Virus); (2) the originality of the scion and the rootstock is guaranteed; (3) the steps of the production process follow the regulations of seedling monitoring and certification [7].

In order to provide high-quality citrus seedlings, citrus nurseries or citrus producers must comply with the technical guidelines for the production of citrus seedlings that have been structured in the Decree of Minister of Agriculture of the Republic of Indonesia No. 04/Kpts/SR. 130/D/6/2019. Additionally, the citrus seedling production process should follow the recommendation of production technology of disease-free citrus seedling suggested by Indonesian Agency for Agricultural Research and Development (IAARD) through the Indonesian Citrus and Subtropical Fruits Research Institute (ICSFRI). The components of the recommended technology are (1) using polybag in the whole production process, (2) sowing rootstock seed correctly, (3) selection of nucellar seedling, (4) using bud-stick from Bud-stick Multiplication Block, (5) grafting area is minimum at 20 cm above root crown, and (6) optimum maintenance during production process [3].

However, the condition in the field showed that the quality of citrus seedlings produced in Sambas Regency was still not satisfactory, such as seedling roots were not good, grafting area was short (less than 20 cm above root crown), no nucellar seedlings selection, not all seedling producers used the bud-stick originating from a well-managed Bud-stick Multiplication Block (BMB), and crop maintenance during the seed production process was not optimal. Furthermore, the recommendation of citrus seedling production has not been implemented correctly [3].

Hence, it is necessary to examine the implementation of technology support for certified disease-free citrus seedling production through mentoring programs to increase the knowledge and skill capacity of the seedling producers, as well as to evaluate the adoption level of the implementation of the recommended technology production of disease-free citrus seedling in Sambas Regency. This is crucial to improve the quality of the citrus seedling produced by citrus nursery or citrus seed producers.

2. Material and methods
The activities were conducted in Tebas Sub-district as it was the center area of citrus seedling production in Sambas Regency, West Kalimantan during 2018 - 2019. There were six
producers/nursery groups of certified citrus seedlings in this area. Each nursery group normally had 7 – 16 members. The head of the citrus seedling producer group had a Certificate of Seedling Producer issued by the local government that enables him to produce certified/blue-labeled citrus seedlings. As for the group members, they became his work partners and comply with the group leader’s recommendation based on the valid regulations in producing citrus seedlings [3]. Hence, each nursery group naturally holds a uniform producing method. Subsequently, the citrus grafted plants meeting the product specifications were labeled by the local Seed Monitoring and Certification Institute [8]. The profile of citrus nursery groups was presented in Table 1.

**Table 1. The profile of citrus nursery groups in Sambas Regency, West Kalimantan**

| Name of citrus nursery group | Location | Year of founded | Number of group member (persons) | Production capacity (seedlings) |
|------------------------------|----------|----------------|----------------------------------|---------------------------------|
| Tunas Muda                   | Sejiram Village, Sub-district of Tebas | 2015          | 7                                | 100,000                         |
| Puncak Mandala Agung         | Sejiram Village, Sub-district of Tebas | 2016          | 13                               | 120,000                         |
| Jaya Sempadung               | Sempadung Village, Sub-district of Tebas | 2016         | 16                               | 62,000                          |
| Agro Karya                   | Tebas Sungai Village, Sub-district of Tebas | 2018        | 7                                | 80,000                          |
| Sinar Orange                 | Sejiram Village, Sub-district of Tebas | 2010          | 12                               | 65,000                          |
| Bangkit Tani                 | Sejiram Village, Sub-district of Tebas | 2017          | 9                                | 65,000                          |

The citrus seedling producers have been fostered through several mentoring programs such as training, technical guidance, assistance activities, and demonstration farm to increase their capacity. The demonstration farm was established in the citrus nursery of Jaya Sempadung group located at Sempadung Village of Tebasan Sub-district.

The evaluation of adoption level of recommended technology was carried out by conducting surveys before and after the mentoring programs. The survey employed a face-to-face interview technique to respondents by using a questionnaire. The respondents were taken from the six certified citrus nursery groups in Sambas Regency, and each group was represented by the head of the group and several members. Thus, a sum of twenty respondents were participated in the evaluation survey.

Data analysis used descriptive method, where contingency table was presented to show the results. The determination of the adoption level of each component of the recommended technology of disease-free citrus seedling production employed a percentage tabulation that referred to a previous study regarding technology adoption [9], in which the adoption rate was grouped into four categories (Table 2).
Table 2. Categories of the adoption level of the recommended technology for certified (blue-labelled) disease-free citrus seedling production.

| Percentage | Category of adoption level |
|------------|---------------------------|
| > 75 %     | Very high                 |
| 51 – 75 %  | High                      |
| 25 – 50 %  | Low                       |
| < 25 %     | Very low                  |

The measurement was calculated based on the numbers of respondents who applied each component of the recommended technology of disease-free citrus seedling production. Then, they were converted into the percentages. The adoption level of a technology component was categorized as very high in adoption when the technology component was applied by more than 75% of the respondents. On the contrary, a technology component was categorized as very low in adoption when it was adopted by only less than 25% of the respondents.

3. Result and Discussion

3.1. Demographic profile of the respondents
Most respondents of certified citrus seedling producers considered the seedling nursery as their primary occupation (75%), and others considered seedling nursery as a secondary work since they had other primary jobs (25%). This might affect the time allocation for seed nursery activities. Seedling producers typically provided more time for their seedling production when they were citrus seedling producers as the main occupation. Previous study indicated that primary livelihood had a very significant and positive relationship with the adoption of agricultural technology [10].

Dominantly, respondents had experienced for more than 10 years as seedling producers (72.22%), thus, they held adequate skills in producing citrus seedlings. While the remaining (27.78%) had been in the seedling industry for less than 10 years. Farming experience may affect the technology adoption, as shown in the previous study by [11] that experience in farming is one factor that influences the technology adoption. The majority of the sample was 31 – 40 years of age (44.4%) and 41–50 years of age (33.3%). Hence, they were still in the range of productive age category [12]. Regarding educational background, the sample of certified citrus seed producers completed a high school education (50%). Only a few respondents achieved graduate and postgraduate education (15%). The level of education commonly affects the knowledge, literacy and the understanding of farmers. Studies have shown that technology adoption is influenced by educational level [13; 14].

3.2. Mentoring programs and the adoption of the recommended technology for disease-free certified (blue-labeled) citrus seedling production
All this time, in producing citrus seedlings, the producers have not fully applied the production technology that met the recommendation. The production process was generally based on the method of the seedling producers themselves. The differences between the production process of disease-free citrus seedlings in accordance with the recommended technology and the existing method done by seedling producers were presented in Table 3.

Table 3. The differences between the production process of disease-free certified citrus seedlings as per recommendation and by producers’ methods/traditional way.

| Technology component            | Differences |
|---------------------------------|-------------|
|                                 | Recommended technology | Producers’ method/ traditional method |
| The technique of citrus nursery | Use polybags           | Use raised-beds                |
| Sowing method                   | • In polybag          | • On raised-bed               |
Several programs have been conducted to increase the knowledge and skill capacity of the citrus seedling producers with regards to the recommended technology of certified citrus seedling production. All citrus nursery groups were fostered through training or technical guidance, and assistance activities. The training and technical guidance materials covered all components of recommended technology in producing disease-free certified (blue-labeled) citrus seedling i.e. the use of polybags during the whole production process, sowing rootstock seeds correctly, nucellar selection, transplanting, the use of bud-stick from Bud-stick Multiplication Block (BMB), grafting and optimum maintenance. It was expected that the training or technical guidance would be effective to gradually change their conventional production methods into those the recommended technology. Hence, uniform and high quality disease-free citrus seedlings can be resulted.

![Figure 1. Training of the recommended technology of disease-free certified citrus seedling production](image)

The implementation of recommended technology of citrus seedling production was shown at the demonstration farm in the area of Jaya Sempadung citrus nursery group. Citrus seedlings resulted from the demonstration farm were high quality certified seedlings produced entirely in polybags, free of systemic pathogens, i.e. CVPD, CTV, CVEV, CEV, and CPsV, the genuineness of the scion and rootstock varieties was guaranteed, and all production procedure complied with the regulation of seed certification. Furthermore, a screen house for citrus Bud-stick Multiplication Block (BMB) measuring 6 m x 12 m and contained 500 plants were also built at the demonstration farm area (Figure 2).
Optimum maintenance of BMB was performed and the BMB was able to produce 40,000 bud-sticks in 2019. The BMB had the potential to harvest 2 – 3 times a year. This BMB screen house at Jaya Sempadung group became the demonstration plot of how to produce premium quality citrus seeds for the other five breeder groups, so that the citrus seedlings resulted complied with standard specification and were high quality.

![Image](image_url)

**Figure 2.** The condition of the Bud-stick Multiplication Block (BMB) screen house at the demonstration farm

The results of the evaluation of the application of citrus seed production process by the producers after the mentoring programs carried out during 2018 – 2019 showed that there had been an increase in the adoption rate of certain components of the recommended technology for disease-free citrus seed production process. However, there were several components of the technology in which the adoption degree tends to remain comparable to that before the implementation of mentoring programs. Detailed information on the adoption level of each technology component was presented in Table 4.

In producing citrus seedlings, only a few producers use polybags throughout the production process and most producers did not apply such method, they used raised-beds for seed nurseries. Thus, this technology component was still very low adopted before and after the mentoring program. In the method of planting rootstock seeds, there was a slight increase in the adoption rate after the mentoring programs, where producers started to use spacing to sow the rootstock seeds, even though this was done on the raised-beds. This was also in line with the increasing implementation of the correct position of the rootstock seeds when planted. Previously, producers only spread the rootstock seeds on the beds. However, the adoption level of these technology components was still categorized as low. In terms of the use of shelter, almost all producers had applied a plastic cover or other materials to shade the freshly sown seeds, whereas previously very few had applied it.

At the stage of nucellar selection, most technology components were very high adopted and the rate was improved after the mentoring programs. Seed producers had implemented removal of rootstocks seedlings with yellow leaves, bent roots and experienced stunted growth. They also removed seedlings having leaves' shape change or were different from the normal JC / RL leaves, and seedlings having light purple shoots or were different from the color of the normal JC / RL leaves. However, the technology component of removing seedlings with extremely fast growth was still low, even though the adoption degree was increased after the mentoring program. This was because not all producers conducted such technique.

Furthermore, at the transplanting stage, most certified seedling producers complied with the recommendation to transplant seedlings at 2.5 - 3 months after the rootstock seed germination, thus there was an increase in adoption in this regard and the category was high adopted. Meanwhile, the adoption rate for cutting half portion of the seedlings leaves was constantly very low before and after the program, this method was still uncommon for the producers. On the other hand, dipping the seedling roots into a mixture of mud and fungicide was very high adopted.
All certified citrus seedling producers had used bud-sticks from the BMB to do grafting, as it was obligatory for certified citrus seedling producers to only use those from the BMB. Hence, the adoption was very high. In terms of grafting, the citrus seedling producers had applied grafting height at 20-25 cm above root crown, therefore, the adoption rate was very high. Likewise, the method of binding the grafting rope was also very high adopted. As for the application of putting the grafted seedlings under a shelter, the adoption rate was still low even after the program. Meanwhile, the technology component of optimum maintenance had a very high adoption degree before and after the program.

Table 4. Evaluation on the adoption level of recommended technology for disease-free citrus seedling production in Sambas Regency, West Kalimantan before and after the mentoring program

| Technology recommendation of disease-free citrus seedling production | Before the program | After the program | Category of adoption after the program |
|---------------------------------------------------------------|-------------------|------------------|--------------------------------------|
| Apply | Did not apply | Apply | Did not apply |
| 1. Using polybags in the whole production process | 0 | 100 | 10 | 90 | Very low |
| 2. Sowing rootstock seed correctly | | | | |
| a Planting the rootstock seeds by spacing | 45 | 55 | 50 | 50 | Low |
| b Putting the pointed part of the seed at the bottom | 40 | 60 | 50 | 50 | Low |
| c Shelter with plastic cover or other materials | 5 | 95 | 100 | 0 | Very high |
| 3. Roughing, nucellar selection | | | | |
| a Discard rootstock seedlings having yellow leaves | 100 | 0 | 100 | 0 | Very high |
| b Discard rootstock seedlings performing bent roots | 90 | 10 | 100 | 0 | Very high |
| c Discard rootstock seedlings performing stunted growth | 75 | 25 | 100 | 0 | Very high |
| d Discard rootstock seedlings performing extremely fast growth | 20 | 80 | 50 | 50 | Low |
| e Discard rootstock seedlings performing leaf shape changes (turn into rounded, long and pointed, trifoliate) or different with the normal JC/RL leaf shape | 80 | 20 | 90 | 10 | Very high |
| f Discard rootstock seedlings having violet young leaves or different with the normal color of JC/RL | 95 | 5 | 100 | 0 | Very high |
| 4. Transplanting | | | | |
| a Transplanting at 2.5 – 3 months after rootstock seed germination | 65 | 35 | 70 | 30 | High |
| b Cutting half portion of the leaves | 10 | 90 | 20 | 80 | Very low |
| c Dipping the roots into a mixture of mud and fungicide | 80 | 20 | 90 | 10 | Very high |
| 5. Using bud-stick from Bud-stick Multiplication Block | 100 | 0 | 100 | 0 | Very high |
The results showed that there were variation in the adoption level of each technology component of disease-free certified citrus seedling production. Most of the technology components were very highly adopted, and few components were still lowly adopted even though after the completion of the mentoring program. According to [15], the adoption level of technology components was often subject to the characteristics of the technology innovation itself, adopters’ characteristics and the performance of agent of change (researcher/extension officer). Furthermore, [16] highlighted that the characteristics of technology innovation include relative profit, compatibility, complexity, trialability and observability. Thus, when the technology components were profitable, compatible to local condition, not difficult, easy to be trial-tested and easy to be observed, the technology components would be highly adopted, and vice versa. A previous study by [3] showed that citrus seedling producers in TTS Regency of East Nusa Tenggara have shifted to the recommended technology of disease-free certified citrus seedling production because the production process is faster, the number of seed death during seed sowing and after grafting is lower, root system of seedling in the polybag is better, more profitable, and the number of grafted plant death after planting is lower as a result of its better quality. In addition, as mentioned earlier, the adopters’ demographic profile also contributed to the adoption rate of the technology such as adopter’s age, education, experience and the type of primary livelihood [10; 11; 12; 13]. The provision of agricultural extension and the availability of technology information and communication are also significant aspects for technology adoption [17].

Hence, as [18] suggested that tight supervision in developing countries was still needed to produce good quality seeds, the role of related parties such as Plant Seed Supervisors was also significant. Basically, the awareness to change from all actors in the citrus nursery industry including the seedling producers, research institutions, Seed Inspection and Certification Agency, and local government was required to achieve the success in citrus nursery system.

4. Conclusion
In conclusion, several technology components experienced an increase in the adoption rates after the completion of the mentoring programs. However, there were still few technology components that did not experience changes in the rate of adoption. In principle, citrus seedling producers have better implemented the nucellar selection, as well as improved the transplanting and grafting methods.

The development of the citrus nursery industry requires awareness among all actors in the industry, not only the producers that implement the recommended technology but also the role of related parties such as Plant Seed Supervisors as the officer of Seed Inspection and Certification Agency to commit to strictly implement the regulations on citrus grafted seedling production.
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