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Adoption of Shoot Grafting Technology in People's Coffee Based on Internal and External Factors of Local Farmers in Bengkulu Province

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Abstract: The application of the practice of grafting technology to people's coffee plants is very encouraged by the people of Bengkulu Province. This of course cannot be separated from the factors that influence people in practicing grafting. Based on this phenomenon, this research was conducted to find out the internal and external factors that influence people to practice grafting in Bengkulu Province. This research is quantitative, primary data was obtained through a questionnaire by distributing a list of questions that had been prepared. The sample was selected using the multi-stage sampling method. The total number of frame samples was 326, consisting of 120 grafted frame samples and 206 coffee frame samples that had not been grafted. Coffee plants can be propagated vegetatively, that is, using parts of the plant itself, and generatively, that is, using seeds or grains. Grafting in coffee plants is vegetative propagation. The research results show that internal factors inherent in coffee farmers in Bengkulu are the dominant drivers in adopting grafting technology, that is the farmer's age, knowledge, experience in the field of grafting, convenience, and results obtained.

Keywords: Connect the Shoots; Local Farmers; People's Coffee; Technology Adoption

Introduction

The development of the agricultural sector in general, especially coffee, is considered to be right on target if existing policies are ultimately able to position this commodity as the main driver and improvement of the rural economy that is highly competitive, just, and sustainable. The increasing need for raw materials for both export and domestic consumption depends on the production produced by farmers, providing incentives to farmers will encourage the sustainability of coffee cultivation in Indonesia (Sarirahayu & Atik, 2018). Making the agricultural sector the mainstay of the economy implies the importance of increasing agricultural production capacity (Food and Agriculture Organization of the United Nations, 2017). Increasing production capacity can be done by expanding agricultural land or increasing productivity (Strassburg et al., 2014; Ruslan, 2021). In the book (Food and Agriculture Organization of the United Nations, 2017) entitled "The Future of Food and Agriculture: Trends and Challenges" modern agriculture is characterized by the rapid expansion of technology and information, which arises from monitoring, control, storage, and organization and sustainable agricultural activities. According to Rahim et al. (2012), one of the factors that cause an increase in production is technological improvements, from the use of old technology to new technology (Susilayati, 2022) whether in the form of production tools, consumption tools, production inputs, or goods consumption. For this reason, technology is the most important part of agricultural development as a driver of increasing production and farmers' income (Pawlak & Kołodziejczak, 2020).

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Technology implementation is one of the main factors thought to influence fluctuations in coffee production and productivity (Marbun et al., 2018). In the productive sector, technology is very important to increase competitiveness and sustainable development (Contreras et al., 2020). The application of technological practices combined with environmental sustainability during the production and processing stages of coffee plants is thought to be able to produce production at maximum levels (DaMatta et al., 2018). Research Andika & I Wayan (2020), found that technology has a direct and significant effect on the production and income of coffee farmers. This shows that the application of technology will have an impact on increasing production and sustainability of the coffee sector (Sott et al., 2020). One effort to develop and increase coffee production is by providing superior coffee seeds. Currently (2019) Indonesia has 5 types of hybrids for robusta coffee, namely Hibiro 1, Hibiro 2, Hibiro 3, Hibiro 4, and Hibiro 5 which are produced by the Coffee and Cocoa Research Center (Puslitkoka) Jember, East Java. These five types of hybrids are the result of a combination of crosses from several BP series robusta coffees such as BP 936, BP 534, BP 939, BP 436, and SA 13, through a selection and crossbreeding process using hand pollination, five superior, high-yielding robusta coffee varieties were obtained. These five types of robusta coffee have a production of up to 2.5 tons/ha/year if planted with a population of 1600 trees, one of which has a production potential that can reach 2.8 tons/ha/year, namely Hibiro 1 (PPKKI, 2019).

Coffee plants can be propagated vegetatively, namely using parts of the plant itself, and generatively, namely using seeds (Ardiyani, 2015). Generative propagation is more commonly used because it is easy to implement, and takes less time to produce seeds ready for planting, but the characteristics of the plants produced are less uniform and the period from planting to fruiting is relatively longer when compared to vegetative propagation (Ardiyani, 2015; Ashebre, 2016). Grafting in coffee plants is vegetative propagation. Some of the advantages of vegetative propagation include having the same characteristics as the parent plant, the quality of the results obtained being more uniform, having two superior characteristics at once, namely the superior properties of the scion and the superior properties of the rootstock, and having an age when it starts to bear fruit (precocity) earlier (Andrade Júnior et al., 2013a; Limbongan & Fadjry, 2013; Evizal et al., 2018; Pham et al., 2020).

According to (Kartika et al., 2022) excess grafting on mature plants will result in plants that bear fruit quickly. According to (Kementan, 2018) in general, the aim of grafting coffee plants is to combine two plants that are still in the same family but have different productivity; make good coffee according to our wishes; make harvesting easier; increase the aesthetic value of plants and; increasing plant productivity in terms of quality, quantity of plants and coffee berries. This makes grafting an innovation in genetic resource technology as an effort to increase coffee production. The application of grafting technology is expected to increase people's coffee production. Grafting technology is recognized as having good advantages and benefits (Li et al., 2019) but several supporting facilities are also needed to take advantage of these advantages, both directly through the use of inputs and indirectly through infrastructure and policies.

Coffee has quite high economic value, in Bengkulu province coffee is used as a leading commodity, so it is not surprising that Bengkulu is the third national coffee-producing area in Indonesia, especially for robusta coffee. In line with the development of coffee in 2019, Bengkulu province, through a community group that advocates for the protection of geographic indications of robusta coffee in Rejang Lebong district (MP2IG-KRRL), introduced local coffee varieties capable of producing a production of 2.17 tonnes/ha, namely Sintaro 1, Sintaro 2 and Sintaro 3 with ID number G 000 000 087 which was developed in an area of 21,634ha (Kementan, 2020), previously (2018) the robusta kepahiang coffee with ID number G 000 000 072 was introduced by the Geographical Indicası Protection Society (MPIG) Bukut Sari Village, Kabawetan District Kepahiang Regency (Kementan, 2019). The plantation sector, especially coffee commodities in Bengkulu Province, has an important role in various aspects of people's lives, both in the field of trade in agricultural products, the processing industry as raw materials, and tourism which has brought Bengkulu province the best Robusta coffee brand so that it competes with Arabic coffee (Sahlan, 2023). These brands include Bencoolen Rejang Lebong, Bencoolen Kepahiang, and Bermani Coffee Rejang Lebong which received 3 award categories at the AVPA (Agency for the Valorization of the Agricultural Products) International Coffee Championship - France at the 34th Indonesian Trand Expo 2019 in Serang - Banten – Indonesia.

The success of developing the plantation sector cannot be separated from the hard work and support of agronomists through grafting technology. This discovery is a solution to obtain superior plants that can be cultivated or applied by farmers in their plantations as an effort to increase farmers' production and income, especially for robusta coffee plants. Robusta coffee plants have cross-pollination properties, in generative breeding the superior characteristics of the parent plant cannot be passed on to its offspring (Pranowo & Supriadi, 2013). Research (Myers et al., 2020) suggests that plants propagated by grafting produce higher

production and productivity, but this research does not provide figures for the production and productivity achieved. Creating superior clonal populations with desired plant characteristics such as precociousness, productive stability, architectural uniformity, higher productivity, fruit quality, and increased production, are fundamental factors in the application of this technology (Andrade Júnior et al., 2013). Problems arising from the genetic narrowing of the species and a shallower radicular system can be observed in the field. Some clones in the field have shown allometric growth, indicating an uneven relationship between the upper stem portion and its radicular system, in various cases resulting in plant death (Andrade Júnior et al., 2013). This is one of the possible factors that coffee farmers do not apply this technology, due to the farmers' limited abilities and skills.

It is hoped that the implementation of grafting technology will increase production and productivity and at the same time the income of smallholder coffee farmers, especially in Bengkulu province, will increase. For this reason, efforts to encourage people's coffee farmers to be willing and able to adopt technology must continue to be encouraged as an effort to increase productivity and efficiency as a basis for realizing long-term national development in the agricultural sector, especially in the coffee commodity, which has been practiced by the farming community.

Shoot grafting technology has been carried out by coffee farming communities in Bengkulu Province. Still, on the other hand, there are interesting things to study and understand about the factors of coffee farmers' interest in grafting or shoot grafting which has been carried out by farming communities in Bengkulu Province. If the factors for increasing interest can be identified, policies can be formulated to increase coffee production and productivity appropriately to increase farmers' income with the aim of regional income independence. In this research, the grafting referred to is the grafting carried out as an effort to rejuvenate old coffee plants and get the desired new plants.

Method

The research was carried out from October 2022 to April 2023, located in Bengkulu Province consideration apart from being the third national coffee-producing area, especially robusta (Direktorat Jenderal Perkebunan, 2021), Bengkulu is also known as an area that produces the best superior variant of Robusta coffee which is ranked fifth at the National Coffee Research Center (Wulan, 2017). In 2019 Bengkulu coffee branding, namely; Bencoolen Rejang Lebong, Bencoolen Kepahiang, and Bermani Coffee Rejang Lebong received 3 award categories at the AVPA (Agency for the Valorization of the Agricultural Products) International Coffee Championship – France at the 34th Trand Expo Indonesia 2019 in Serang – Banten – Indonesia. Apart from that, Bengkulu also has local coffee varieties capable of producing a production of 2.17 tons/ha, namely Sintaro 1, Sintaro 2, and Sintaro 3 with ID number G 000 000 087 (Kementan, 2020), robusta kepahiang coffee with ID number G 000 000 072 (Kementan, 2019).

Meanwhile, the selection of Rejang Lebong Regency and Kepahiang Regency was part of the sampling technique which divided Bengkulu province based on the geographical area of smallholder coffee plantations. Based on data, this area is the main producer of coffee in Bengkulu province as well as the area of origin of Bengkulu's best coffee brands. The next stage is to re-determine several subordinate areas (districts) and finally determine several of the smallest areas (villages). The aim is to focus on only a few areas (Taherdoost, 2016). The sample in this research is coffee farmers as owners of productive coffee plantations, in other words, coffee plantations are in producing condition. The sample was selected or obtained using the multi-stage sampling method considering a huge population and a large area. The multi-stage sampling method is part of the probability sampling method, meaning that each item in the population has the same chance of being sampled. Probability sampling or random sampling has freedom from possibility but can represent a large number of samples and can also save time and costs (Hammed Tahedos, 2020); (Fen Yu, 2007). The Multi-stage sampling method is moving from a broad sample to a narrow sample, using a step-by-step process (Ackoff, 1953). The main aim of the Multi-stage sampling method is to select samples that are concentrated in certain areas.

The sampling procedure and sample size in selecting farmers from whom data will be collected is obtained based on regional divisions based on sub-districts or villages which represent the population of farmers who have implemented top grafting and farmers who have not implemented top grafting on coffee plants cultivated on their coffee plantations. The designation of population-representative areas for farmers who have implemented top grafting is based on the highest average productivity in the sub-district, while to determine the population area of farmers who have not implemented top grafting, it is selected based on the lowest average productivity, apart from that it is also seen based on the number of farmer population and the year the implementation started. shoot grafting in the study area. The number of samples representing farmers who have applied shoot grafting on coffee plants is 120 farmers, while the number of samples

representing farmers who have not implemented shoot grafting is 206 smallholder coffee farmers using the following formula (Cochran 1977).

$$n_0 = \frac{Z^2 pq}{e^2}. \quad (1)$$

Where n_0 is the required sample size, Z is the t value at a 95% confidence level from the normal table (1.96), p is the probability that the respondent has measurable characteristics, q is (1 p) namely the probability of respondents not having measurable characteristics, and e is the 5% significance level. Assuming the possibility that 50% of respondents have the measurable characteristics, the sample size can be calculated as follows:

$$n_0 = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} = 384. \quad (2)$$

Based on the population in the area selected as a sample of farmers who have implemented top grafting in producing conditions, there are 925 farmers, and 1,895 farmers in the area selected as a sample of farmers who have not implemented top grafting. The appropriate sample size uses the recommended equation (Cochran 1977) for small-size finite population correction as follows:

$$n = \frac{n_0}{1+(\frac{n_0-1}{N})}. \quad (3)$$

$$n = \frac{384}{1+(\frac{384-1}{801})} = 120\ shoot\ grafting\ farmer \quad (3.1)$$

$$n = \frac{384}{1+(\frac{384-1}{1375})} = 206 \text{ non-shoot grafting farmers} \quad (3.2)$$

The total number of frame samples was 326, consisting of 120 grafted frame samples and 206 coffee frame samples that had not been grafted. The number of samples by group was obtained based on group proportions using the formula (Ackoff, 1953) (Taherdoost, 2016) aimed at ensuring that each stratum is adequately represented.

This research is quantitative research that uses primary data through a questionnaire using a list of questions that have been prepared. Secondary data as supporting data in this research was obtained from various literature, related departments, or agencies. Descriptive research analysis describes the phenomenon of the condition of research subjects and objects at the time of research, which is more concerned with what rather than how or why something happens, for this reason, observations and surveys are also used to collect data (Nassaji, 2015).

$$p_{ij} = \frac{N-n_{ij}}{N}. \quad (4)$$

Where:
P = A portion of the sample population
n = Number of members of the population (sample)
N = Total population of the region
i-j = Total population of each group

To make it easier to understand this research, the research flow is described below. First, determine the research location, namely Bengkulu Province, and then narrow down the research location by choosing Rejang Lebong Regency and Kepahiang Regency. The next stage was to determine samples from farmers who used the top grafting system and those who did not use the top grafting system, then distributed questionnaires and collected the data for analysis using quantitative data analysis methods. The final stage is concluding the results of the research that has been carried out.

Result and Discussion

The size of the land determines how farmers can make decisions to implement an element of innovation. Farming land size is positively related to adoption. Farmers who have large areas of land will find it easier to implement extension recommendations, as will the adoption of innovations for those who have small areas of land. This is because it is related to efficiency in the use of production facilities (Amala et al., 2013). The grouping of land areas in this research was obtained from data obtained in the field during the research and can be seen in Table 1.

Table 1. The land area of coffee farmers in Bengkulu Province.

Land area (Ha)	Number of farmers	Percentage (%)
0 – 1	169	51.84
1 – 2	149	45.71
2 – 3	8	2.45
Total	326	100.00

Based on the Table 1, it is found that farmers who have a land area of 0-1 Ha are 169 people with a percentage of 51.8%. Farmers who have a land area of 1-2 Ha are 149 people with a percentage of 45.7% and those who have a land area of 2-3 Ha are 8 people with a percentage of 2.5%. The average land owned by coffee farmers is 1.4 hectares. The following is an overview of agricultural land used by the community as a field for the practice of adopting shoot grafting on people's coffee.

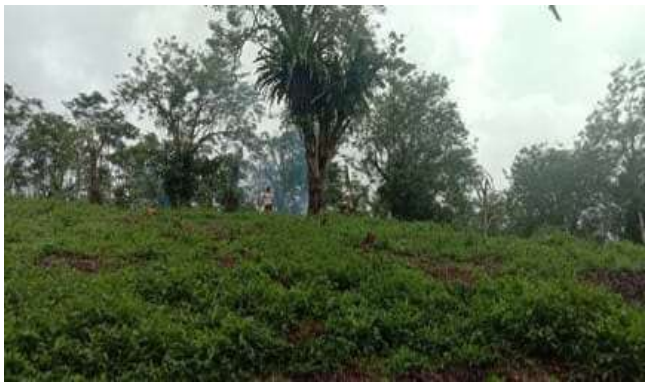

Figure 1. Practice field for adopting grafting.

The younger the farmer, the more enthusiastic they will be to learn new things. So in this way, they try to adopt innovation more quickly (Amala et al., 2013). Age groupings in this study were searched using interval classes, so the age range results were obtained as in Table 2

Table 2. Age of Coffee Farmers in Bengkulu Province

Age (year)	Number of farmers	Percentage (%)
26 – 35	43	13.19
36 – 45	103	31.60
46 – 55	112	34.36
56 – 65	67	20.55
> 66	1	0.31
Total		100.00

From the results of the table above, it is found that farmers aged 46-55 years are at most 34.4%, while farmers aged over 66 years are at least 0.3%. The average age of coffee farmers in Bengkulu province is 47 years old. The following is a picture of the situation where farmers are resting after adopting shoot grafting

Figure 2. Farmers resting after adopting shoot grafting.

Education is a means of learning which will then instill an attitude of understanding that is beneficial for the development of more modern agricultural practices. Those with higher education are relatively quicker in implementing adoption, and vice versa, those with low education find it rather difficult to implement innovation adoption quickly (Dewi & Rahmawati, 2020) The educational groupings in this research were obtained from the results of research in the field and can be seen in Table 3. Based on the data above, most coffee farmers in Bengkulu province have an average education level of completing high school with a percentage of 42.6%. Bachelor's level is the education that the fewest farmers have taken, namely 7 people with a percentage of 2.1%.

Table 3. Education Level of Coffee Farmers in Bengkulu Province

Education	Number of farmers	Percentage (%)
Elementary School	127	38.96
Junior High School	53	16.26
Senior High School	139	42.64
Diploma/bachelor	7	2.15
Total	326	100.00

The experience factor has a positive relationship with the speed of innovation adoption. Experienced farmers adopt technology more quickly than farmers who have no or less experience. Compared to novice farmers or new farmers, farmers who have been farming for a long time will find it easier to implement innovations or advice on the extension and application of technology (Fitria, 2022). The grouping of farming experience in this research was searched using interval classes, so the results for a range of farming experiences were obtained as in Table 3.

Table 4. Farming Experience of Coffee Farmers in Bengkulu Province

Work experience (year)	Number of farmers	Percentage (%)
01 – 10	42	12.88
11 – 20	123	37.73
21 – 30	115	35.28
31 – 40	40	12.27
41 - 50	6	1.84
Total	326	100.00

From the 326 frame samples that have or have not implemented top grafting technology on coffee plantations cultivated by coffee farmers in the Bengkulu province area, based on the results of the logistic regression model, an R square value of 0.225 or 22.5% of the influence of the independent variables X1 to influencing the adoption of grafted coffee technology. The following is an overview of training and counseling activities regarding the adoption of graft grafting.

Figure 3. Training and counseling on graft graft adoption.

Factors that can influence the adoption of Sambung Pucuk coffee

Based on Table 5, a formula for variable X which influences Y in this case the level of influence of the adoption of shoot grafting coffee technology is as follows:

Adoption of Grafting Technology = (-2.347) + (-0.492) + 0.048+ (-0.013) + (-0.049) + (-0.043) + (-0.101) + 0.051 + 0.050 + (-0.385) + 0.966 + (-0.561) + 0.336 + 1.098 + (-0.780) +0.625

From the regression results, it is found that the constant value is negative, which means that if there is no change in farmer characteristics, external factors, and farmer perceptions from variables X1 to X15 will not be affected by the adoption of grafting technology, the chance it has is 0.

Table 5. Logistic Regression Results

Variable (X)	B	Sigma
Land Area (X1)	-0.49	0.07
Farmer Age (X2)	0.05	0.03
Education (X3)	-0.01	0.80
Experience (X4)	-0.05	0.02
Other Jobs (X5)	-0.04	0.62
Kindergarten in the family (X6)	-0.10	0.57
Number of children (X7)	0.05	0.63
Distance from house to garden (X8)	0.05	0.48
Source of info on connecting coffee (X9)	-0.39	0.05
Counseling about grafted coffee (X10)	0.97	0.00
Farmer group membership (X11)	-0.56	0.18
Availability of experts (X12)	0.34	0.26
Government assistance (X13)	1.10	0.00
Access to credit/capital assistance (X14)	-0.78	0.04
Perception of roasted coffee (X15)	0.63	0.03
Constant	-2.35	0.11

The variable X is divided into 3 level groups where the first is farmer characteristics, namely X1 to X8, the second group is external factors, X9 to X14 and finally the farmer's perception of grafted coffee, X15, which looks at the availability of grafting material, easy access to grafting material, production of grafted plants, and resistance to pests and diseases. The results of the regression showed that the farmer's age, number of children, distance between plantation houses, source material for information/counseling related to grafted coffee, availability of grafted coffee experts/technicians, farmer's perception of shoot grafted coffee have a positive value, so this will influence the adoption of shoot grafted technology, and government assistance has a high chance because it has a probability value of 1.

Based on the results of the logistic regression analysis, it can be seen that in general age, education, farming experience, land area, and number of dependents correlate with lowland rice farmers who adopt Jajar Legowo, but not all influencing factors. Then, to see what factors influence the adoption of grafted coffee technology in Bengkulu province, it can be seen partially and it can be concluded that land area has a sigma value of 0.074, which means the sigma value is greater than 0.05, which means land area does not affect farmers' decisions to adopt coffee. shoot grafting in Bengkulu Province. According to (Thompson et al., 2023) socio-demographic variable factors and agricultural structure factors are more often insignificant than significant.

The result of the sigma value for the variable X2 age of the farmer is 0.029, which means that age is influential in making decisions to adopt roasted coffee, where the more mature the person is, the more it will influence someone to make decisions about adopting technology. The sigma value of education is 0.801, which means that education does not influence the decision to adopt grafted coffee. The average education attained by coffee farmers in Bengkulu province is high school level. This indicates that the better a person's education will not affect adoption.

Experience has a sigma value of 0.015. This illustrates that the more experienced people become as coffee farmers, the more they will be influenced to try to become experts in adopting grafted coffee. The sigma value obtained from experience is greater than the alpha value of 0.05. This is by the opinion (Mardikanto, 2014) that the success of outreach and acceleration of technology adoption cannot be measured by how much knowledge transfer occurs, but by how far there is interaction or discussion and sharing of experiences between fellow participants and facilitators and participants.

The sigma value of other jobs is 0.623, which means that other jobs have no real influence on a farmer's decision to adopt grafted coffee. The labor factor used within the family does not affect the adoption of grafted coffee. The sigma value shows 0.570, which means it is not significant or influential. According to (Hussein et al., 2020) The use of labor can streamline the costs incurred by coffee farmers so that they can optimize family income.

The number of children a farmer has does not influence the adoption of grafted coffee technology

because the resulting sigma value is 0.625. Farmers who have many or few children have no influence on the decision to adopt grafted coffee. As with labor in the family, more children will influence the use of labor from within the family which will reduce the cost of external labor.

The distance between the house and the garden has a sigma value of 0.482. This means that the distance between the house and the garden does not affect farmers who want to adopt grafted coffee. The development of coffee plants does not require difficult care even if the distance from the coffee plantation to the house is too far. Sources of information about grafted coffee have a sigma value of 0.047 which influences farmers who want to adopt grafted coffee technology. Sources of information about coffee development and increasing coffee productivity are needed by coffee farmers so that farmers know the positive impact of grafting coffee technology.

Source materials for information and education related to grafted coffee have a sigma value of 0.01, which means that source materials for information and education related to grafted coffee influence farmers adopting grafted coffee technology. When extension workers provide information, two-way communication usually occurs which can convince farmers to see the benefits of the information provided.

The role of extension workers in accompanying farmers, both as facilitators and motivators, is very good and is felt by farmers running coffee farming businesses where farmers in running farming businesses, especially in cultivation (Abdul Syukur, 2018) are always accompanied by extension workers, while the quality of extension workers and farmer participation in farmer groups is already good. by the needs of farmers for information and knowledge in farming, while the form of participation carried out by farmers is to contribute energy, thoughts, time, and costs for the development of adoption of connective shoot coffee (Pello & Putra, 2021).

Membership in a farmer group has no significant effect on farmers adopting shoot grafting technology with a sigma value of 0.183. The sigma value obtained from the availability of top grafting coffee experts is 0.256, which means there is no significant influence of variable X on Y. Government assistance has a significant influence of variable X on Y as seen from the sigma value of 0.002. Government assistance will usually be right on target and help farmers in adopting technology. Access to credit will usually also affect farmers. Farmers will feel helped in terms of financing their farming business if there is open access to credit. This can be seen from the sigma value which has a significant influence of variable X on Y of 0.040. Farmers' perceptions of grafted coffee looking at the availability of grafting material, easy access to grafting material, production of grafted plants, and resistance to pests and diseases have a significant influence with a value of 0.026.

Conclusion

Based on the research results, it can be concluded that the factors influencing the adoption of grafting coffee technology in Bengkulu Province are dominated by internal factors, namely the farmer's young age so he always wants to try new things, knowledge and experience in the field of grafting are already very familiar to him. , ease of farming, and satisfactory harvest results. Meanwhile, external factors in the form of sources of information and counseling related to grafted coffee, namely mean as a source of information, both directly and indirectly, which results in farmers knowing and understanding about grafting coffee in the form of brochures, pamphlets, banners, and visual videos that serve as a conveyor of information to coffee farmers in Bengkulu province, government assistance, access to credit or capital assistance to manage coffee plantations that they (farmers) receive both from the government and other parties and farmers' perceptions of grafting coffee itself.

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Author Contribution

This article was prepared by four authors, namely E.S, H.S, R.P, and H. Each author worked together at every stage to complete this article.

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Conflicts of Interest

The researchers in this study have no conflicts or interests in certain parties.

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