Utilization Of Plant Waste as A Seed Source to Anticipate Agriculture Global Environmental Challenges and Increase Robusta Coffee Farmers' Income

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Abstract. Coffee is one of the leading plantation commodities in the world trade area. The utilization of plant waste in the form of water shoots from BP308 robusta coffee is a new innovation in anticipating global environmental changes. The research aims to support seed availability by utilizing wastewater shoots as seed candidates in anticipation of global environmental changes that can provide added value and income for farmers. The research was conducted in the District of Pupuan, Tabanan, Bali. The implementation period is 2 years (2018-2020). This study was designed using a paired experimental design in the form of existing technological innovations and new seed innovations. Data were analyzed using the t test. The results showed that the seeds of existing technological innovations and new innovations were significantly different and not significantly different. Coffee leaf rust disease showed no significant differences in attack rates. Wet weight, total seed weight and shoot oven dry weight were higher in the new innovations respectively 42.14; 51.99 and 40.59%. The added value obtained from wastewater shoots is IDR 10,500.00 per tree. Conversion of added value for each farmer with ownership of 0.3–0.8 hectares (population 300-800) of trees generates an added value of IDR 3,150,000.00 to IDR 8,400,000.00 per year per farmer.

1 Introduction

In general, tropical areas have great potential for plantation crops. One plantation commodity that is currently my favorite is coffee. Coffee is a leading plantation commodity that is widely traded in the world. Coffee plays a role as a source of foreign exchange, farmers' income, job creation, regional development and supports environmental conservation [14;22]. Most of the coffee plantation businesses in Indonesia are smallholder plantations (96%), the remaining 4% are national and private plantations [19].

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According to [9], the distribution of coffee in Indonesia is uneven, causing coffee commodity bases. In the Province of Bali, coffee plants, especially robusta coffee, are dominant in the Mount Batukaru belt, covering the Pupuan and Selemadeg sub-districts in Tabanan Regency and the Busungbiu and Seririt sub-districts in Buleleng Regency. This condition is in accordance with the opinion [17] which states that robusta coffee grows optimally at an altitude of 400-1000 m above sea level.

Productivity and quality of robusta coffee is still low. In 2017 its productivity was only 0.6 tons/ha and in 2018 it decreased to 0.4 tons/ha of HS coffee beans (hard seeds). The low productivity is due to several factors, including old/damaged plants, unbalanced fertilization, shade plants not functioning optimally, pruning and use of seeds that are not as expected and unfavorable climatic factors. While the low quality is caused by cultivation factors, harvest and post-harvest handling are not in accordance with standard operating procedures (SOP) for coffee. In other words, farmers have not fully followed the technology and innovation of modern coffee farming [25]. All these conditions are challenges in the world of agriculture globally.

One of the breakthroughs in supplying plantation seeds was carried out by the Ministry of Agriculture through the Directorate General of Plantations by launching the 500 million Superior Seeds (BUN500) program. The BUN500 program is a program to provide 500 million high quality seeds for plantation commodities in the period 2019 – 2024. Provision of superior seeds is supported by establishing seed logistics, in other words, the quantity is massive with good quality and efficient distribution. Seed logistics is built in the centers of plantation areas, so that these superior seeds are easy to distribute and do not require large costs [12].

Plantation crops generally have a planting period to produce which takes quite a long time *(long term period)*. Therefore, the existence of plantation seeds is needed to support productivity, yield quality and resistance to pests and diseases. The use of seeds that are not of good quality in plantation commodities will result in both material and time losses. The use of quality seeds is also expected to reduce risks such as water stress and increase production and productivity. The results of the study show that superior and quality seeds have a greater impact than the other two production inputs, namely fertilizers and medicines, but problems in the field indicate that the availability of superior seeds is relatively limited. The availability of certified superior seeds for farmers is an absolute requirement to improve yield quality and productivity [4].

Currently, there is still a large area of robusta coffee that requires seeds, for rejuvenation of 442 ha (old or damaged plants) and replacement of 2,796.1 ha from other plantation crops. The seed production process is carried out starting from a single mother tree, scion gardens, scion eyes and propagation of seed propagation. Furthermore, the provision of seed logistics is carried out by 2 (methods), namely self-management and non-self-management. Self-management is the provision of seeds carried out by government agencies themselves or in collaboration with community groups. While the supply of non-self-managed seeds means that the supply of seeds is carried out by third parties in terms of seed providers/producers [12]. [1] added that Factors that influence the success of coffee cultivation include the type of plant and cultivation techniques, including cutting materials. [20] stated that plants through cuttings have advantages including no false shoots, no bad influence from the rootstock and one year of faster production.

Many researchers have carried out research related to agricultural waste utilization and seed treatment, but no one has researched the use of coffee plant waste. [26] researched about sustainable oil palm biomass waste utilization in Southeast Asia: Cascade recycling for mushroom growing, animal feedstock production, and composting animal excrement as fertilizer, [27] researched about environmental waste utilization score to monitor the performance of waste management systems: A novel indicator applied to case studies in

Germany, [28] researched about biogas based polygeneration plant options utilizing dairy farms waste: A Bolivian case and [29] researched about bioremediation potential of green wastes and plant growth promoting rhizobacteria and its enhancement by their combination.

The research of seed treatment done by researchers to increase plant resistance and yield as anticipation of the global climate. [30] researched about plant productivity and seed quality under long term drought, The negative effects of high temperature stress on gametophyte performance and their consequences for seed reproduction in wild plants by [31], [32] researched about the effect of abamectin on plant growth and infection of root, [33] researched about seed treatment with plant defince elicitors on wheat roots, [34] about Impact of planting density in soaking seeds in melatonin solution on yield. The research of Bio priming of seed has been done by [35] and [36] researched about plant use and vegetation trend and [37] researched about Alpine plant to climatic stress. Optimizing plant density for fiber and seed production by [38] and [39] researched about seed priming with plant growth promoting bacteria improve growth and water stress tolerance of secale montanum.

Based on these conditions, research was carried out regarding the preparation of cheap, simple, practical, and efficient seeds by utilizing plant waste in the form of water shoots with the aim of supporting the availability of seeds by using water shoots as seed candidates to anticipate changes in the global agricultural environment that can provide added value and farmers' income.

2 Methodology

2.1 Place and Time of Research

The research was conducted in Sanda Village, Pujungan, Belatungan, Pupuan District, Tabanan Regency. These three locations are coffee development centers with quite a high farmer response. The implementation period was 2018-2020.

2.2 Research Method

2.2.1 Implementation Method

Every person or community group requires a different approach to be able to adopt technology and solve existing problems. So, a combination of several methods is needed to get more accurate data. In solving various problems faced by coffee farmers in the Pupuan District, Tabanan Regency, several methods/approaches were taken, namely:

1. Participatory approach method in the form "*Focus Group Discussion"* pioneer farmers and coffee observers, discussions and limited technical guidance to farmers who concentrate and live in coffee plantations. A total of 20 respondents came from farmer representatives from Pujungan, Belatungan and Sanda village farmer groups. As supporting data for collecting secondary data, a garden survey was carried out on aspects of farmer behavior. Direct observations were carried out in the farmer's garden, especially in the aspect of agronomic actions. Additional supporting data were also obtained from field agricultural extension workers, local community leaders and coffee observers. The data collected included the timing of the implementation of maintenance pruning and the number of water shoots that had the potential to become an opportunity for budding sources and were studied. The entire field data is finalized with *Group Focus*.
2. Technical guidance on coffee cultivation with the IPM Coffee approach and "*Entrepreneurship Capacity Building" (ECB)* aims to increase the ability of farmers in

coffee cultivation and entrepreneurship by seeing and making efforts to use waste or other materials to become economically valuable. (3). Technology transfer, namely empowering farmers through the transfer of appropriate technology. In this case the technology transfer provided adjusts the technological components and the needs of farmers at each stage of coffee cultivation activities. This technology transfer activity was immediately practiced by making nursery demonstration plots on farmer's land as Table 1.

Table 1. Main Components of Existing and Innovations BP308 Robusta Coffee Germination

No.	Description	Existing	Innovation
1.	Types of cuttings	Old cutting materials from the 2nd and 3rd segments to the 7th or 8th in one method	Super cuttings in the form of plant waste/ water sprouts
2.	Growing Media	A mixture of fertile soil and manure (60:40)	Soil mixture: organic matter (a mixture of manure, husk charcoal, and cocofit) with a ratio of 60:40
3.	Cuttings treatment	growth regulator	growth regulator

This study used a paired experimental design, namely seeding using existing cuttings paired with new innovations using plant waste/water shoots. The total sample is 200 plant samples. The parameters observed included dominant pests and diseases, plant height, number of leaves, number of roots, root length, total fresh weight, shoot wet weight, root wet weight, shoot oven dry weight, and root dry weight.

2.2.2 Data Analysis

The data were analyzed using analysis of t test with the SPSS 17.0 program and presented in tabular form. Meanwhile, to observe changes in farmers' knowledge and attitudes towards the components of IPM technology, assessment using a non-parametric test (Wilcoxon Signed Rank Test), available in the SPSS.20 program.

3 Result and Discussion

3.1 Regional Resource Characterization of Geographical Indication Regions for Robusta Coffee, Pupuan District

Pupuan subdistrict consists of 14 service villages with regional boundaries in the north and west of Buleleng subdistrict, in the east of Selemadeg subdistrict, and in the south of Selemadeg subdistrict west (Figure 1).

The topography is hills with a slope of 5-80°, and the village is located at an altitude of between 450-1200 meters above sea level. This area has soil with a clay loam texture and a small amount of sandy loam. The average rice fields 1,939.00 ha, gardens 14,784.00 ha, ponds 12.00 ha, yards 228.00 ha, forests 1501.00 ha, etc. 352 ,00 ha. The majority (90%) of the population earns their livelihood from the agricultural sector, especially on dry land/plantations. The average productivity of Robusta coffee in 2017 was 658 kg HS coffee/ha/year, then decreased the following year to 403 kg with a productivity standard below the carrying capacity of 1,300 kg. Therefore, leaving an average difference of 530.5 kg or 40.81% [5].

The available superior coffee clones include BP 42, BP358, SA 237, and BP 308 for the rootstock. The development of the superior Bangelan coffee clone (BP 42) was carried out in the Pupuan sub-district, covering an area of 7,740 ha, with a production of 3,733 tons per year. It also includes the villages in the sub-district, namely Pujungan, Kebon Padangan, Munduk Temu, Sanda, Batungsel, Munduk Temu, Belatungan, Jelijih Punggang, and Pajahan (Figures 1 and 2). Moreover, the geographic indication protection society robusta coffee Pupuan Bali group is found in Pujungan Village, Pupuan District, Tabanan Regency, supported by 30 SA throughout Pupuan District, and assisted by the processing group in providing the equipment assistance using the product processing business unit [5].

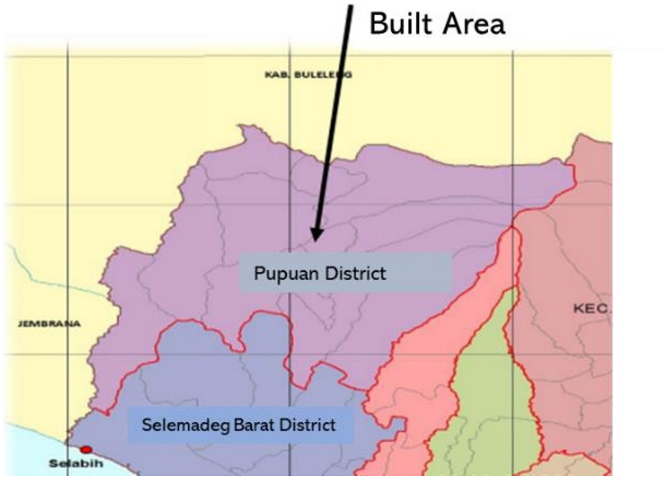

Fig. 1. Map of Pupuan district

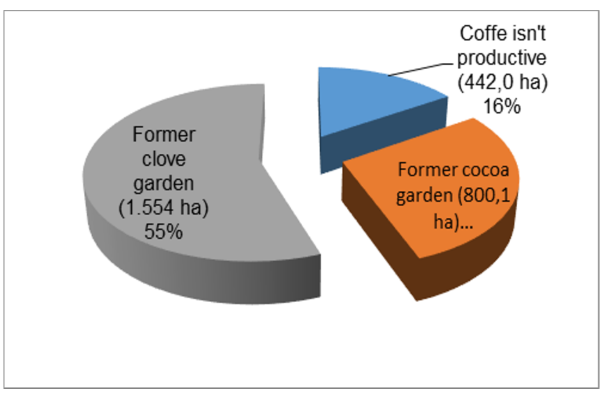

Fig. 2. Robusta coffee development potential

3.2 Individual and social aspects of coffee farmers in Pupuan, Tabanan

The farmers' age affects their learning ability. The higher the age of the farmer, the lower the learning ability. According to [6], the productive age for labor is between 15-64 years old. The dominant age of the respondents was in the potential, i.e., 90.00% were between 15-64 years (Table 2.). According to [10], age affects a person's level of maturity (both physical and emotional maturity). Young people usually have the spirit of curiosity and tend to quickly adopt innovations despite being inexperienced.

Table 2. age classification of respondents

No.	Age Classification (Year)	Farmer's Age	
		Number of Farmers (person)	Composition (%)
1.	15 – 64	18	90.00
2.	≥ 65	2	10.00
Total		20	100.00

The level of education generally affects the power of reasoning and thinking, as well as improve economic conditions. It also affects the mindset in making decisions for their farming business, especially in adopting existing technology. The educational factor influences the formation of attitudes since it covers the basic understanding of moral concepts in individuals. [8] stated that education is a learning tool that instills a favorable attitude towards modern agricultural practices. Those with higher education are relatively quick to adopt modernity. While those with low levels of education generally are not interested in innovation, resulting in a lack of mental attitude to increase knowledge, especially agricultural science.

Based on the education aspect, 20.00% of farmers have completed elementary school (Table 3.). This low level of education hinders the progress in farming. This does not indicate a lack of desire to advance, however, it is majorly because of limited means, time, and opportunities. In addition, education is received not only from formal, and also from non-formal.

Table 3. Education Level of Respondent

No.	Education Level	Education Level	
		Number of Farmers (person)	Composition (%)
1.	Elementary	4	20.00
2.	Junior High	4	20.00
3.	Senior High	12	60.00
	Total	20	100.00

In farming, the area of ownership or control of agricultural land is closely related to the efficiency of cultivation and businesses. This affects the scale of business and efficiency. In addition, narrow land is also inefficient in the use of production factors [6].

Based on Table, 4.95% of farmers' land is more than 0.5 ha. Farmers possessing large lands find it easier to implement innovations than those with narrow fields, due to efficiency in the use of production facilities. According to [11], many households own a land area of less than 0.5 ha, which does not indicate a decrease in their farming income and welfare. There are still other factors that need to be considered, namely changes in land-use intensity, modification in cropping patterns, and types of commodities. Therefore, the development of agribusiness and agro-industry in rural areas are important to increase the intensity of land use, change cropping patterns, select high-value commodities, improve product quality, increase added value, and business efficiency.

Table 4. Respondent's land ownership area

No.	Land Ownership Area	Land Ownership Area	
		Number of Farmers (person)	Composition (%)
1.	< 0.5 Ha	1	5.00
2.	> 0.5 Ha	19	95.00
	Total	20	100.00

3.3 Changes in Farmers' Knowledge and Attitudes towards Coffee Cultivation Technology

The most important objective of the dissemination activity is to change the behavior of the target and apply technological innovations. Knowledge is the initial stage of perception that forms attitudes and ultimately creates potential. In agricultural development, knowledge has an important benefit since it enhances the ability to adopt new technologies. Every individual has a different ability to develop their knowledge, due to the variety of counseling, towards characteristics, physical and social environments, needs, motivations, and goals. Farmers' knowledge on the coffee cultivation technology are shown in the following table.

Table 5. Farmer Knowledge Before and After Technical Guidance Activities on Coffee Cultivation Technology in the Jongkok Praktiyasa Farmer Group, Belatungan Village, Pupuan District, Tabanan Regency in 2019.

No	Technology Components	Average Knowledge Score		Changes in Farmer Knowledge (Person)		
		Initial	Finale	Positive	Negative	Ties
1	Land Preparation	3.08[a]	4.53[b]	19	0	1
2	Patron Planting	3.08[a]	4.73[b]	19	0	1
3	Superior Planting Material	3.00[a]	4.15[b]	20	0	0
4	Nursery Making	3.00[a]	4.09[b]	20	0	0
5	Planting Seeds	3.00[a]	4.10[b]	20	0	0
6	Fertilization	3.00[a]	4.05[b]	20	0	0
7	Pruning	2.73[a]	4.10[b]	20	0	0
8	Integrated pest control	2.65[a]	4.05[b]	20	0	0
9	Harvest	3.00[a]	4.70[b]	20	0	0
10	Post-harvest	2.50[a]	4.10[b]	20	0	0
Average Score		2.90	4.26			
Category		Sufficiently knowledgeable	Highly knowledgeable			

Notes: The numbers followed by different letters in the same row show significant differences based on the Wilcoxon Test (P<0.05).

Based on Table 5, the farmers' knowledge at the beginning of the activity falls into the category of sufficiently knowledgeable (2.90), due to their experience in coffee farming (an average of more than 20 years). However, observing fthe components of coffee cultivation, there are still technological components that fall into the category of not knowledgeable, namely the post-harvest (2.50). This shows that all components of coffee cultivation technology have not been socialized, under the recommendations of the Agricultural Research and Development Agency. At the end of the activity, it showed that the implementation of technical guidance on coffee cultivation had run as expected. The achievement of the activity was marked by the difference in farmer's knowledge (4.26). Furthermore, the results of the Wilcoxon test on farmers' knowledge towards coffee cultivation technology at the beginning and after the end of the activity, showed that all were significantly different, and turned positive.

The knowledge greatly assists and supports the ability to adopt technology for sustainable farming. The higher the level of knowledge, the higher the ability to adopt the technology. The increased knowledge of farmers is expected to accelerate the adaptation process of coffee cultivation technology. Attitude is the driving potential that exists in individuals to react to the environment. It is not always fixed in a certain period, however, changes due to the influence of others through social interaction. In social interaction, there is a mutually influencing relationship between individuals with one another. Individuals react to form certain patterns of attitudes towards various psychological objects they face. [21] stated that attitudes acquired through experience have a direct influence on behavior. Attitude is an internal ability that plays a very important role in carrying out an objective. People with a clear attitude choose decisively between several possibilities and alternatives. They tend to accept or reject based on their assessment of whether the object is useful/valuable or not. Changes in farmers' attitudes towards the components of coffee cultivation technology is shown in Table 6.

Table 6. Farmer Attitude Before and After Technical Guidance Activities on Coffee Cultivation Technology

No	Technology Components	Average Knowledge Score		Changes in Farmer's Knowledge (Person)		
		Initial	Finale	Positive	Negative	Initial
1	Land Preparation	3.93[a]	4.53[b]	19	0	1
2	Patron Planting	3.93[a]	4.53[b]	19	0	1
3	Superior Planting Material	3.80[a]	4.45[b]	20	0	0
4	Nursery Making	3.80[a]	4.15[b]	20	0	0
5	Planting Seeds	3.95[a]	4.45[b]	20	0	0
6	Fertilization	3.10[a]	3.70[b]	20	0	0
7	Pruning	3.95[a]	3.80[b]	20	0	0
8	Integrated pest control	3.00[a]	4.05[b]	20	0	0
9	Harvest	2.85[a]	4.55[b]	20	0	0
1 0	Post-harvest	3.18[a]	4.29[b]	20	0	0
Average Score		3.55	4.25			
Category		Agree	Strongly Agree			

Notes: The numbers followed by different letters in the same row show significant differences based on the Wilcoxon Test (P<0.05).

Based on Table 6, farmers' attitudes towards coffee cultivation technology at the beginning of the activity were included in the category of agree (3.55). It is also due to their experience in coffee farming (more than 20 years on average). This is in line with the statement by [3] that the factors influencing attitudes include education, occupation, age, interests, knowledge, and information. At the end of the activity, it was shown that the implementation of technical guidance on coffee cultivation had run as expected. This is indicated by the difference in farmers' attitudes (increasing) from agree (3.55) to strongly agree (4.25). Furthermore, the results of the Wilcoxon test on farmers' attitudes towards the components of coffee cultivation technology at the beginning and after the end of the activity, showed that all were significantly different, and turned positive.

3.4 Research on the utilization of plant waste in the form of robusta coffee shoots

The results from the garden observations showed that, the dominant plant waste/ water sprouts sprouts that grew from rootstocks were generally pruned at olden age for various reasons. This makes the pruned biomass wasted and even interfered with other agronomic activities. It is not yet fully understood that allowing water sprouts to grow to maturity affects the growth and development of other organs, even reducing economic yields. Various opportunities to use plant waste/ water sprouts as potential seeds, with the tendency to increase the income of farming families are very open. [7] stated that BP-308 is one of the superior clones used as rootstock for grafting with other varieties. Planting material is usually taken from sprout cuttings. While the use of cuttings from plant waste/ water sprouts also has great potential. Plant waste/ water sprouts should be pruned on coffee plants. When water sprouts do not undergo pruning, it interferes with the fertilization process because plant nutrients are absorbed for growth.

The statistical analysis showed no significant differences in the parameters of sprouts height, number of leaves and roots, root length between existing technology and innovations. Meanwhile, the total wet weight of the seeds showed a significantly better difference with new seed innovations, than with those existing. Wet weight is an indicator of seed health to grow and develop better (Table 7 and 8.).

Table 7. Average sprouts height, number of leaves and roots of robusta coffee

Treatment	Sprouts Height (cm)		Number of Leaves (blade)*		Number of Roots (stem)*	
Existing	18.48	a	2.54	a	3.17	a
Innovation	18.35	a	2.86	a	3.04	a
Sig	0.865		0.429		0.662	

Note: the numbers followed by the same letter in similar column show a significant difference (P‹ 0.05) * data transformed by √(x+0.05)

Table 8. Average length of roots, wet weight of total seed and wet weight of sprouts of robusta coffee

Treatment	Length of roots (cm)*		Wet Weight of Total Seed (gr)*		Wet Weight of Sprouts (cm)*	
Existing	3.36	a	2.16	b	1.87	b
Innovation	3.75	a	3.07	a	2.84	a
Sig	*0.1*		*0.04*		*0.005*	

Note: the numbers followed by the same letter in similar column show a significant difference (P‹ 0.05) * data transformed by √(x+0.05)

The average percentage of coffee leaf rust and cercospora brown spot attack, wet weight of sprouts and roots, the oven-dry weight of sprouts and roots due to the treatment of existing technology and innovations of robusta coffee cuttings are shown in Table 8, 9 and 10. This indicates a significant difference in the wet weight of sprouts and oven-dry weight of BP308 coffee seed buds with an average increase of 51.87 and 39.64%, respectively. And also, other parameters that tend to be better with innovations of robusta coffee seeds.

Table 9. Average percentage of coffee leaf rust and cercospora brown spot attack (%)

Treatment	Percentage of coffee leaf rust attack (%)*		Percentage of cercospora brown spot attack (%)*	
Existing	1.43	a	4.15	a
Innovation	1.37	a	3.55	a
Sig	*1.307*		*0.829*	

Note: the numbers followed by the same letter in similar column show a significant difference (P‹ 0.05) * data transformed by Arcsin√ X%

Table 10. Average wet weight of roots, the oven-dry weight of sprouts and roots due to the treatment of existing technology and innovations of robusta coffee cuttings

Treatment	Wet Weight of Roots (gr)*		Oven-Dry Weight of Sprouts (gr)*		Oven-Dry Weight of Roots (gr)*	
Existing	1.29	a	1.11	b	0.87	a
Innovation	1.34	a	1.55	a	0.95	a
Sig	*0.824*		*0.008*		*0.115*	

Note: the numbers followed by the same letter in similar column show a significant difference
*Data transformed by square root (x+0.05)

The results [15] showed that young cuttings (tip) on coffee plants had the highest percentage of callus, compared to the middle and base cuttings. Root formation occurs in the stem book and callus first. This result is in line with the research of [13], which found that the leaf cuttings at the ends gave a significantly higher percentage of live plants, than the middle and base. [22;16] explained that the root occupies a very important position in the development of cuttings. With root development, cuttings take water from the media and use it in chemical reactions in the plant body and release it in the form of vapor. The activity of absorbing water and releasing it back in the form of vapor is very important to maintain a stable plant body temperature, to avoid plant wilting. [24] stated that the process of root formation is the most important factor for the success and survival of plants from cuttings, since it absorbs nutrients directly from the soil. [18;20] added that several applications of growth regulators were used to promote root development. [2] also stated that the treatment of coconut water concentration on robusta coffee seedlings had a significant effect.

3.4 Analysis of the added value of coffee seed farming by plant waste

The calculation results showed that the added value of water sprouts for selected rootstock cuttings in an average of 14 stems per tree, cost the same as the ordinary of IDR 750.00, therefore, earning IDR 10,500.00 per tree. Moreover, it obtains an annual added value of IDR 3,1500,000.00 to IDR 8,400,000 per farmer, with the conversion of plant population of 300 – 800 per hectare.

4 Conclusion

Coffee plant waste in the form of water shoots can be utilized and has the potential as a rootstock seed candidate. The growth and development of seeds from plant waste in the form of water shoots is better than ordinary cuttings. The added value of cuttings originating from plant waste in the form of water shoots is IDR 3,150,000.00 to IDR 8,400,000.00 per farmer each year.

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