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DIFFUSION AND ADOPTION OF BIOCHAR INNOVATIONS IN AGRICULTURE IN GUNUNGSARI VILLAGE, BUMIAJI DISTRICT, BATU CITY INDONESIA

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ABSTRACT

The process of diffusion and adoption of biochar innovation using corn cobs is very suitable for areas that have large types of livestock such as dairy cows as was done in Gunungsari Village, Bumiaji District, Batu City. Therefore, the focus of this research study is to analyze in depth the process of diffusion and adoption of biochar innovation by farmers in adopting biochar in Gunungsari Village, Bumiaji District, Batu City. The type of research used in this study is to use a qualitative method with a phenomenological approach. The results showed that from the elements of the innovation diffusion process in biochar, it was known that one of the biochar innovations was the right way to overcome various existing problems. There are 2 main problems that can be overcome with this innovation, namely alleviating the existing problem of animal feed waste, and overcoming the scarcity of fertilizers that occur in the Gunungsari Village community. Then in terms of communication channels, it is done by providing knowledge to Gunungsari farmers, thereby creating a sense of trust and attention from the recipients of this innovation. This communication also acts as a deterrent to misunderstandings from the initial assessment to the implementation stage and is interested in adopting the biochar. Furthermore, in the social system in Gunungsari there is a social structure that gives levels of social status to its members. The leaders of Gunungsari village are the first people to be addressed in conducting communication patterns. In the socialization, Sanggat village leaders play a role in convincing that a trial is carried out first on the land of the farmer group leader. So, in the end this biochar innovation can be accepted by the community and used properly even though it has been through a long period of time.

Key words: Corncobs, Diffusion, Adoption, Innovation and Biochar

1. INTRODUCTION

The journey of agricultural development in Indonesia so far has not been able to show maximum results when viewed from the level of farmer welfare and its contribution to national income. Agricultural development in Indonesia is important from the overall national development. There are several things that underlie why agricultural development in Indonesia has an important role, among others: the large and diverse potential of Natural Resources, a fairly large share of national income, the large share of national exports, the large population of Indonesia who depend on this sector, its role in providing food for the community and being the basis of growth in rural areas.

The characteristics of the agricultural sector environment increase the degree of complexity even more, beginning with the seasonal nature of agriculture. Very often, the results of decisions to adopt new practices are not immediately evident. The results of decisions related

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to planting and use of chemicals generally take months or even years to materialize and the same is true of investments, new technologies, new supplies, and new seed. "Nevertheless, innovation is seen as one of the primary drivers of productivity, profitability, and competitiveness for family agriculture practiced by small-scale farmers (Organisation for Economic Cooperation and Development [OECD], 2013), which, in turn, casts diffusion and adoption of agricultural innovation as important measures in agricultural development" (Peshin, Vasanthakumar, & Kalra, 2009).

One of the major problems of Indonesia agricultural sector is the perpetual decline in soil fertility. This has largely been attributed to "continuous cultivation, erosion and rapid organic matter mineralisation which affect food security in the country. More than half of the labour force are engaged in agricultural activities and are mostly small scale farmers who depend on these low productive soils for farming". Indonesia agricultural sector is characterized by low productivity which is hinged on low and erratic rainfall patterns as well as low adoption and application of soil conditioners. Farmers face a lot of constraints in production and in the use of farming innovations.

Empirical evidence shows that farmers learn about new technologies after adoption of these new technologies by their neighbors (Bandiera & Rasul, 2006; Munshi, 2004; Pratiwi & Suzuki, 2017; Suri, 2011). The literature also shows the importance of social learning after adoption of a new technology. Adoption and diffusion of technologies in agriculture are processes of social learning (Feder & Umali, 1993). Empirical evidence also shows that adoption of innovations in agriculture reaps greater financial gains and greater productivity from the area under cultivation, especially through reduction of wastage of supplies and utilization of new practices and/or technologies (Coromaldi, Pallante, & Savastano, 2015; Petry & Machado, 2014; Teklewold, Kassie, Shiferaw, & Köhlin, 2013) and also leads to greater financial returns (Khonje, Manda, Alene, & Kassie, 2015; Manda, Alene, Gardebroek, Kassie, & Tembo, 2016).

The overall innovativeness of farmers in the agricultural sector will contribute a great deal towards their profitability and poverty reduction. Unfortunately the agricultural sector of the economy is characterized by low level of technology adoption such as Biochar. This is identified as one of the main reasons for low productivity in the sector. The quest to identify the reasons for low level of technology adoption among Indonesaia farmers requires that the factors that influence their decision to adopt or not to adopt specific farming technologies be investigated.

A study by Petry and Machado (2014) investigated the process of diffusion of innovations in agriculture in the green belt of greater Florianópolis, Brazil. However, agricultural areas cultivated by ribeirinhos (traditional peoples living near rivers) who live in the provincial areas of the Brazilian state of Amazonas have not been investigated. There is, nevertheless, a need to understand how the process of innovation and diffusion of farming technologies takes place in the context of ribeirinho farming populations living along the rivers in the interior of Amazonas and to investigate whether such a process of innovation and diffusion actually

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takes place at all. Adoption of new agricultural technologies is a phenomenon that remains poorly understood (Bandiera & Rasul, 2006; Conley & Udry, 2010; Pratiwi & Suzuki, 2017),

II. LITERATURE REVIEW

Soil amendments are products that are added to poor soils to improve their structure and fertility. These include (in) organic fertilizers and Biochar. Biochar is a type of charcoal produced by a thermochemical process called pyrolysis of organic waste material under high temperatures and anaerobic conditions (Sparrevik et al., 2013). The Biochar production process generates three main products. These are the main Biochar product, bio-oil and synthesis gas. A confluence of these three products provide very important agronomic, environmental and energy benefits (Duku et al., 2011).

Biochar adoption in farming is viewed as one of the most important ways of curbing environmental degradation (Bracmort, 2010; Hunt et al., 2010; Shackley et al., 2011). Its addition to soils limits nitrous oxide and methane emissions and also increases the net uptake of carbon. Soils amended with Biochar are able to trap Carbon for hundreds of years (Shackley et al., 2011). Biochar's carbon-negative effect significantly increases soil productivity whilst simultaneously reducing the environmental impact of farming.

Some practical investigations in floodplain regions in Amazonia report that promotion and implementation of new farming practices enables communities to produce better quality agriculture, producing better yields for families that engage in farming activities in floodplain lands (Abizaid, Coomes, Takasaki, & Arroyo- Mora, 2018; Miltner & Coomes, 2015), which in turn reduces destructive practices (for example, illegal logging and predatory hunting and fishing) and improves families' means of subsistence (Cotta, 2015).

Farmers' technology adoption decisions and intensity of adoption are both affected by a number of socio-economic and institutional factors (Beshir et al., 2012;Gebremichael & Gebremedhin, 2014; Yu & Nin- Pratt, 2014). The socio-economic factors include age of farmer, farm size, household size, marital status, farmer's experience in farming, gender of farmer, annual farm income, farmer's educational level, cost of technology, and off-farm income.

Martika, et al., (2018), the stages of the decision-making process in the adoption of innovations include: 1). The stage of knowledge emergence, when an individual (or other decision-making unit) is directed to understand the existence and benefits and how an innovation functions. 2). The persuasion stage, when an individual (or other decision-making unit) forms a favorable or unfavorable attitude. 3). The decision stage, this stage occurs when an individual or other decision-making unit is involved in activities that lead to the selection of adoption or rejection of an innovation. 4). Implementation stage, at the implementation stage an innovation is tried for this to be put into practice, but an innovation brings something new if the level of uncertainty will be involved in adoption. The uncertainty of the results of these innovations will still be a problem at this stage. Then the user will need technical assistance from the change agent to reduce the level of uncertainty from the consequences. 5).

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The confirmation stage, when the innovation decision has been made, then the user will depend on the support and attitude of the individual. Unsustainability is a decision to reject an innovation after previously adopting it. This discontinuity can occur during this stage and occurs in two ways: First, an individual's resistance to an innovation seeks another that will replace it. This type of decision is called a replacement discontinuance. Second, discontinuance discontinuance, namely the individual rejects the innovation because he is dissatisfied with the results of the innovation.

The literature on innovations in agriculture is diverse and has developed its own vocabulary. One line of research investigates creation of innovations (Adenle, Manning, & Azadi, 2017; Kassie, Teklewold, Jaleta, Marenya, & Erenstein, 2015; Pound & Conroy, 2017), while another avenue focuses on promotion of adoption and implementation of innovations in agribusiness (Kassie et al., 2015; Morrone, 2017; Petry & Machado, 2014). This is an area of investigation that makes distinctions between innovations that are incorporated into goods or products such as tractors, fertilizers, seeds, and other supplies. In counterpoint, there is another investigative approach that deals with promotion of rural innovation, for example, programs for promotion of integrated pest management, technical training, fieldwork days, technical meetings, and technical visits, i.e., programs founded on investment in promotion and diffusion of rural innovation (Morrone, 2017; Sunding & Zilberman, 2002). However, intensification of generalized adoption of innovations without technical supervision and/or support from specialized public bodies can have negative consequences, such as depletion and contamination of the water table and degradation of soil fertility (Kassie et al., 2015).

The institutional factors include access to credit and access to extension services. The probability of a farmer adopting the Biochar technology and his or her intensity of application will depend on these factors. However the findings of several adoption studies have indicated that the direction of effect of a particular independent variable largely depends on the type of agricultural technology being studied. Some authors (Fernandez-Cornejo et al., 2001; Chiputwa et al, 2011) assume that the same factors affect both adoption and intensity of adoption. Others (Mignouna et al., 2011; Barungi et al., 2013) have also analysed each hurdle separately

III. METHODOLOGY

The method used in this research is qualitative research, to obtain in-depth information about a person's social experience such as attitudes, motivations, beliefs, and behavior from the person's point of view. This research uses a phenomenological approach (Engkus, 2018). The stages in the phenomenological approach, namely: Intuitioning is the stage where the researcher begins to enter completely or merge with the phenomenon under study (Moleong, 2014). Bracketing is done so that the informant is natural and free from the assumptions of the researcher. Analyzing, the researcher identifies the essence of the phenomenon under study by exploring the relationships and interrelationships of its elements (Spradley, 2015). Describing, at this stage the researcher makes a broad and in-depth narrative related to the phenomenon under study.

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Data collection techniques are part of the data collection instrument that determines the success or failure of a study, "the data collection techniques used, namely; Observation, where the data collection is carried out by researchers by making direct observations in the field. In-depth interview, the process of obtaining information for research purposes by means of face-to-face question and answer". Documentation, by recording or copying existing data in the research location. The data analysis used in this study is an interactive model of analysis, namely; Data Condensity, Data Display, Concluding Drawing (Milles, Hubberman and Saldana, 2014).

VI. RESULTS AND DISCUSSION

As previously explained, various research results show that biochar has the potential to improve soil fertility. The benefits of biochar lie in its two main properties, namely having a high affinity for nutrients and being persistent in the soil. these two properties can be used to solve several important agricultural problems such as soil degradation and food security, water pollution by agrochemicals, and climate change. The impact of changes in the level of soil fertility from the process of making corn cobs biochar in Gunungsari Village can be seen from the results of the soil samples.

Table 4.1 Results of Soil Sample Analysis from Gunungsari Village

Sample	Parameter				
	pH	KTK (me 100kg-1)	C-Organik (%)	N-Total (%)	
Soil	5,3	18,90	0,84	0,12	100
		Currently	Low	Very low	

Notes : Based on the results of the lab analysis (2021)

From the table results, it can be seen that the pH of the soil tends to be acidic and the content of CEC, C-Organic and N tends to be low. The application of corncob biochar enriched with nitric acid can increase the pH of acid soils. Then the next data can be seen as follows:

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Table 4.2 Effect of treatment on soil pH

	Biochar	
	After	**Before**
Sample	5,50 A	5,73
LSD 5%		0,23

Notes : Based on the results of the lab analysis (2021)

From the data above, it is known that the numbers followed by different letters show a significant difference according to the LSD test at the 5% level if seen from the soil conditions in the basic analysis (Table 5.1) giving corncob biochar enriched with nitric acid can increase pH in acidic soils. Furthermore, the effect of corn cob biochar on the soil can be seen in the following data:

Table 4.3 Effect of Treatment on Soil

	After	**Before**
PH	5,50 A	5,73B
Ktk	17,99 A	20,39 AB
C-organic	1,13aA	1,17 aAB
N totol	0,195	0,205

Notes: Numbers followed by different letters show that they are significantly different according to the LSD test at the 5% level.

The results of the above analysis showed that the application of corncob biochar showed a higher value where corncob biochar enriched with nitric acid had a positive effect between C and Total Nitrogen in the soil which resulted in an increase in nutrients compared to the treatment without biochar. Biochar was given for 6 months, all treatments were applied to polybags containing 10 kg on each soil.

Then the process of making biochar used in Gunungsari Village is by using the double jacket furnace combustion method which includes the enumeration process. In the process of chopping corn cobs, the rest of the animal feed is cut into pieces, this is intended to make it easier when it is put in the furnace and the combustion process is more evenly distributed. The next process is combustion. After the corncobs are cut into pieces then put into the furnace and after it is deemed sufficient, then the furnace is closed tightly so that no oxygen or a little oxygen enters during the combustion process, when the combustion process occurs the fire must not be extinguished until the combustion process is complete with the intention that there is no decrease in temperature in the furnace so that complete combustion can occur. The next process is grinding. The biochar charcoal resulting from the combustion is removed

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and ground to be crushed in the form of granules and coarse powder. The final process in making biochar in Gunungsari is sieving. After the biochar charcoal is milled, then sifting is carried out to obtain biochar in the form of powder, this powder form is intended to make biochar easier when sprinkled on the ground so that it is more easily absorbed by the soil.

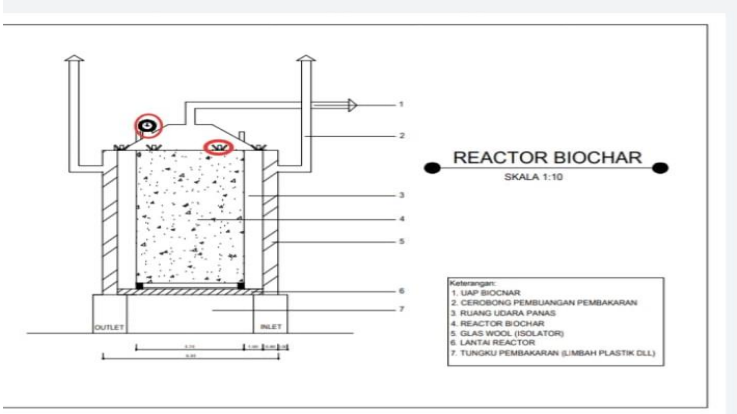

Figure 4.1 Biochar furnace with double jacket model

Therefore, the method of making corncob biochar using the double jacket method in Gunungsari is more effective and efficient than other conventional methods. This is because the double jacket method can indeed be used optimally by farmers. Based on the results of the research that has been done, it can be seen that the process of diffusion and adoption of biochar innovations by farmers in Gunungsari can be analyzed using Rogers' innovation diffusion theory. In terms of the decision-making stage, the first thing to do is the stage of emergence of knowledge, namely by providing knowledge and understanding to farmers by making experimental tools. In this experiment the results obtained are quite satisfactory with the media being the object is vegetable plants. However, at the beginning of this experiment not all farmers were willing to try it. This experiment was only carried out with the head of the farmer group, then followed by other farmer groups after getting satisfactory results in the experiment. In addition to conducting experiments, there are several other ways to introduce farmers to biochar, namely through Focus Group Discussions with farmers. In this FGD agenda, apart from discussing with farmers, direct examples were also given, namely by burning biochar.

Furthermore, from the next decision-making stage the Persuasion Stage. In this persuasion stage, it takes some time to convince people to use Biochar. Doubts about failure in the use of biochar are felt by farmers. Farmers make them choose to see first the results that will be obtained from the use of this biochar fertilizer. However, after some time and the results can be seen, farmers began to be interested in using it and flocked to give their land facilities in a trial period.

The next decision-making stage is the Decision Stage. This decision was taken by the head of the farmer group who was brave and able to be an example in the use of biochar innovation in

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Gunungsari so that other farmers were willing to make the same decision to use this biochar. The head of the farmer group not only invites them verbally but also provides an example so that the decisions taken by the head of the farmer group can be well received by the farmers. The next decision-making stage is the Implementation Stage. In convincing farmers, there are several stages that are carried out so that farmers can use biochar, which are as follows:

a. Conducting FGD, this FGD was conducted several times to support knowledge and practice to be carried out by farmer groups, the initial stage is providing information related to the benefits of this biochar to its manufacture.
b. Show the machines and the making of the burning land. There are two concepts or methods of combustion in the manufacture of this biochar. The first is the conventional method which requires a long time and a large area to implement.
c. Taking biochar fuel from livestock feed waste. This fuel is a corn hump that is found in many communities
d. Biochar manufacture. In its manufacture it has several stages, in the conventional stage starting from taking, counting, drying, burning to enrichment. In this conventional method it takes a relatively long time, because it takes time to dry and depends on the weather.
e. Applying trials to several lands belonging to the head of the farmer group.
f. Garden produce. After waiting 1-3 months the desired results can be seen.

Then the final decision-making stage is the Confirmation Stage. In this confirmation stage, how to see the reaction of the farmers in a group to the Biochar innovation that has been carried out. In practice, there was no rejection from farmers regarding the innovation of using bichar. Even though the residents are just waiting for the results because at the beginning they still had doubts about this biochar. so that they see the results of the trials conducted first before implementing them.

Furthermore, in terms of the elements of the diffusion process of biochar innovation, it is known that this biochar innovation is deemed appropriate in overcoming various existing problems. There are 2 main problems that can be overcome with this innovation, namely alleviating the existing problem of animal feed waste, and overcoming the scarcity of fertilizers that occur in the Gunungsari Village community. Then the communication channel becomes one of the important keys in the success of an innovation, this communication begins with communication with related parties and then continues with communication in the form of providing knowledge to through FGDs. Good communication will get good results too, because it will create a sense of trust and attention from the recipients of this innovation. In the communication stage starting from socialization using key informants who can connect with stakeholders in Gunungsari village.

V. CONCLUSIONS

Based on the results of the study, it is known that the process of making biochar carried out in Gunungsari Village is by using the double jacket furnace combustion method which includes the process of chiming, burning, milling, and sifting. Meanwhile, in terms of the elements of

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the diffusion process for biochar innovation, it is known that biochar innovation is considered appropriate in alleviating existing animal feed waste problems, as well as overcoming the scarcity of fertilizers that occur in Gunungsari Village farmers. Then the communication channel becomes one of the important keys in the success of an innovation, this communication begins with communication with related parties and then continues communication in the form of providing knowledge to farmers in Gunungsari through FGD.

Then for the time required to socialize and communicate the use of Biochar in Gunungsari, it is quite long. Because it takes 1 to 3 months so that people can use this Biochar evenly. Within these 3 months, several steps were taken, starting from providing information to testing the application of the use of biochar on the land of the head of the farmer group to serve as a model for farmers to be willing or interested in adopting biochar.

In addition, in the social system of the community in Gunungsari Village, the head of the farmer group is the first person to be addressed in conducting communication patterns. In the socialization, the head of the farmer group plays a role in convincing the farmers to be willing to do a trial first. The experiment was carried out in the land of the farmer group leader. So, in the end, this biochar innovation can be accepted by farmers and used properly.

DECLARATION OF CONFLICTING INTEREST

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