International Journal of

Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 10 (2): 54-64, 2015
ISSN 1816-4897 / DOI: 10.3923/ijar.2015.54.64

Farmers' Based Technology Development for Sustainable Cassava Production System

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ABSTRACT

The decrease in productivity and degradation process in land cropped with cassava occurs very rapidly. A conventional soil conservation approach has been shown do not give satisfactory result. A new approach, which is termed "land husbandry", seems to have a more prospective future. Different from soil conservation approach, which is aimed to control erosion rate to level of less than acceptable limit erosion, the aim of land husbandry is to obtain a high yield and income. Secondly, in contrary with soil conservation approach where most of the technology package is developed based on and by researchers, in the land husbandry approach the development of technology is based on farmers' idea and willingness and done by the farmers themselves. The methodology used in this study was Farmers' Participatory Research. The study shows that the FPR methodology have promising prospect for developing the sustainable cassava production technology. The introduced technology spread up quickly and the adoption sustained for a long periods. After 5 years of the project, 65% of the farmers in the study area had planted UB 477-2 variety and 76% of the cassava farmers had use cattle manure for their cassava crops. Ten years after the project, in addition to UB 477-2 variety, some farmers planted another introduced variety i.e., Malang 6 and Markonah. The number of farmers using manure also increased substantially and some farmers practiced compost technology. At the beginning of the project there was no farmer planted UB 477-2 and only few farmers used cattle manure.

Key words: Land husbandry, farmers participatory research, sustainable agriculture

INTRODUCTION

The 14th ISTRC triennial symposium, which was held in 2007, has recommended that root crops are the future crops. This recommendation is based, first, these crops can be used for many purposes, from human food, animal feeding and a lot of industrial based material, include plastic and bio fuel industries. Secondly, in contrast with cereal crops, the possibility of increasing the production, both through the extension of the land area and increasing of yield per unit area is still open widely. Because of special requirements, the land suited to cereal crops is very limited and decreasing yearly due to industrial and human settlement needs. Increasing the unit per area is already facing levelling off, either due to the genetic of plant environmental capacity. On the other hand, cassava crops are able to grow in a marginal soil condition and hence the possible extension is still open widely. The potential of increasing cassava yield per unit area is also very high. The cassava yield in cassava country production, such as Brazil, Nigeria, Indonesia and Thailand, is around 12-19 t ha^{-1} (Howeler *et al*., 2004). This is still far below the potential production (more than 40 t ha^{-1}) or even field production achieved by India which can as high as 30 t ha^{-1} (Amponsah *et al*., 2014).

However, the development of cassava, however, face a numbers of constraints, one of them is a fast soil deterioration and degradation (Yuniwati *et al*., 2012; Islami *et al*., 2011). Many efforts to combats these land degradation has not yield a good success yet. These facts indicated that soil conservation approach failure to control land degradation in cassava fields. So far, soil conservation approach is aimed to decrease erosion rate to a level of which called "tolerable" or "acceptable" erosion rate. This is scientific idea which is often not directly related to farmers' need. Secondly, most soil conservation technologies are developed based on researchers' idea. This is not wrong, but often, it does not suit with farmers' needs and condition. The new approach of combating soil erosion and land degradation called "land husbandry", which is introduced by Hudson (1992), then followed Roose (1996) and Hellin (2006), seems have a better prospect to control soil erosion and land degradation of cassava fields.

Basically the purpose of farmers to crop their land is to obtain a high crop yield and hopefully a high income. Whatever occurs on their land, as far as they got a high yield farmers do not take it in their accounts. Thus, if we want our idea and technology adopted by farmers, it should able to increase crop yield. This is the first key of land husbandry. De Graaff *et al*. (2008) in his review of soil conservation work five countries, concluded that generalization of the influence the technology adoption is impossible, but one can be accepted i.e., that the continues adoption and use of technology is mainly determined by the actual profitability and to some extend by the labour requirement for recurrent maintenance and use.

Furthermore, the persons who will adopt and work with technology are the farmers, not the researchers or Extension Department. Therefore, the second key of land husbandry is that the technology developed should meet the farmers' needs and conditions. Farmers themselves are the persons who know exactly what their problems, their conditions and what their needs. Consequently, the farmers should be given a chance to express widely what their problems, willingness, idea and needs. Basically, the approach is based on the interaction between target audiences (in these case farmers) with researchers or extensions workers. The farmers should be actively involved from the beginning of the technology generation process i.e. to identification of the problems so possible solutions of the problems is to test and to choose the best technologies according to their criteria. With some success, this methods has been practiced in many work of agricultural technology transfer and extension with a varieties name such as participatory technology development (Fujisaka, 1989), farmers' participatory research (Utomo *et al*., 1998; Howeler, 2001; Howeler *et al*., 2004), participatory approach (Fagerstrom *et al*., 2003).

Participatory approach in agricultural technology development and dissemination has have a long story of success and failure. It seems that in the recent years, almost of all technology generation and dissemination works use the term "participation". However, the work of "participation" is often only used to justify for mobilizing the people in the works. Therefore, participation become meaningless and the activity just "as usual", top down and passive participation, whereas the adoption and the continuous use of the technologies is influenced by the degree of user participation. Webler *et al*. (2001) developed 5 criteria for good participation. A critical review of participatory approach has been given by Pretty and Shah (1997).

The purpose of the work describe here is to develop sustainable production technology for cassava based on farmers' idea and willingness. The promising of technology development based on farmers' initiative for a better land husbandry has been stressed by Mutunga *et al*. (2001) and Critchley and Mutunga (2003). It is expected that by using this approach, not only cassava production will sustainable, but also the adoption and practice of the technology itself.

MATERIALS AND METHODS

Research approach: The development of the technology was done with farmers' participatory approach as described by Howeler *et al*. (2004) and shown in Fig. 1. The outstanding feature of this approach is that farmers participate in every step and make all important decisions. As indicated in Fig. 1, the first step in conducting FPR trials is to select an appropriate site. In this case the selection of the site is based on the area where cassava plays an important role in agricultural cropping. Based on this criteria, the study was conducted at Jatikerto village, about 25 km South West of Malang City, East Java, Indonesia.

Jatikerto, village has total agricultural land of about 2,000 ha, in which 40 ha is for lowland paddy rice crops and the rest is for upland mainly cassava and maize. There are 1.600 farmers household with 1300 farmers grow cassava. Cassava is mostly sold to tapioca factories and a little part is used for human consumption either consumed directly or processed into chips and krupuk.

After the establishment of the research team which consist of project staff and the local farmers, an initial meeting was done on 19 August, 2004. The objective of the meeting is to explain the aims of the study and to gauge the interest of farmers and local leaders and extensions officers to participate the project staff visits the community and conducts a Participatory Rural Appraisal (PRA) as described by Chambers (1994a, b). This activity was done to learn more about cassava production and utilisation practices and to diagnose, together with farmers, the problems that need attention. After prioritizing the problems and possible solutions, farmers can decide what type of trials they want to conduct on their own fields.

Farmers who volunteer to conduct these FPR trials were taken to a demonstration plot of nearby Brawijaya University's experimental station, where experiments are already being conducted. Farmers evaluate and discuss the various treatments being demonstrated and then select those they consider most suitable for their own conditions. Several farmers in the same

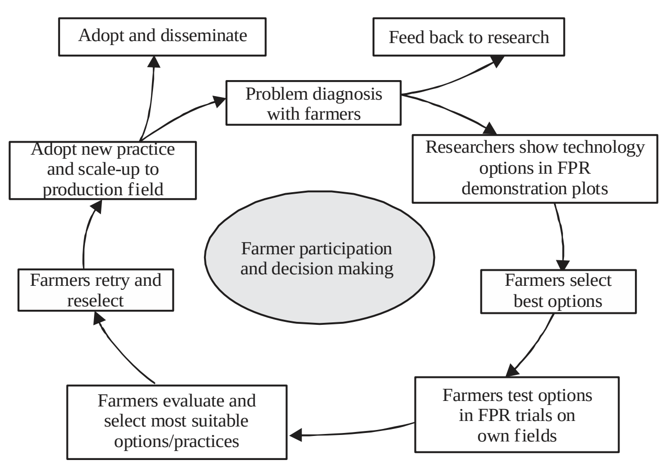

Fig. 1: Farmer participatory model used for the development of sustainable cassava-based cropping systems in Asia

village can decide together a set of treatments for a particular experiment then each farmer can be considered a replication and results can be averaged over those replications to obtain more reliable data.

Thus, farmers discuss and decide while researchers and extension workers help farmers in selecting reasonable treatment but without imposing their own opinions. At time of planting, the project staffs helps the farmers set out the experiments and provides the planting material, seed or fertilizers, if required. Farmers themselves are the owners and managers of the trials but project staff should visit regularly to discuss and solve any problems that might occur. Most of these trials have 4-5 treatments with one treatment being the traditional farmer's practice for comparison. To facilitate accurate yield measurements the trial was conducted in regular plots, often 5×5 or 6×6 m and that stakes are planted at regular plant spacing, often 1×1 or 0.9×0.9 m. Most farmers interplant with other crops as long as all treatments are managed in the same way except for the variable under study.

At time of harvest, the collaborating farmers in the village, together with project staff, help each other harvest all the trials and determine the yields in all treatments. Later in the day, or the following day, a farmer field day is organized in which other farmers in the village or from neighbouring communities can visit the trials, see the piles of harvested roots and evaluate the usefulness of each treatment. Finally, the yield data is tabulated, averaged and presented to the group for discussion and selection of best treatments by raising hands. The farmer selected varieties or practices may then be tested again the following planting season or be directly adopted in their production fields.

Most FPR trials are conducted for 2-3 years until farmers have tested and selected the best options for adoption, at which point other new villages are selected and the process is repeated. Once farmers see in their own trials that a certain variety or practice produces higher yields or at a lower cost, they will want to adopt those varieties or practices. The project staff can help farmers to obtain the necessary planting material, seed of intercrops, or other inputs that are sometimes hard to find. Farmers from other new villages may want to visit those villages that have already adopted some new technologies in order to see and discuss their benefits. These farmers may either want to conduct their own FPR trials or start adopting those practices that others have already tested and selected. These cross-visits between villages is one way to stimulate farmer-to-farmer extension which is often more effective than the traditional extension practices.

Survey: In order to obtain a deeper understanding about cassava practices in the study location, a detail survey was done in November, 2004. There were 92 farmers of 890 total cassava farmers used as the respondent in survey. The data collected was including the experience of the farmers, cropping practices, the utility of their cassava as well as the socio-economic condition of the farmers.

Farmers' trials: After selecting the technologies, farmers conducted experiment in their own land. All experiments activities include the selection of the treatments and measurements were done by farmers. Project staff assists with the procedure of conducting a reliable experiments such as setting of the experimental plots and some measurement. At a certain time and/or activities, especially during harvest, a farmers' day was conducted. The participants were not only the collaborator farmers, but also the neighbour farmers who had not involved in the project. During this field day the participant were asked to do the experimental works and then to evaluate and select the treatment tested. Soon they selected the treatments; some of them participated in the next year activity. The farmers usually did the trial for 2-3 years, after sure with the results, they adopt the most suitable technology in whole of their land.

Impact of the works: To study the impact of the works, two surveys were conducted in February, 2009 and March 2015. The main data collected is the number of farmers who had adopted the technology developed by farmers who involved in project activities.

RESULTS

Existing cassava practices: Both PRA and detail survey showed that the cassava farmers in Jatikerto has had a long history of planting cassava. Only less than 5% of the total cassava farmers had experience of planting cassava less than five years. These are young farmers with age less than 30 years. In the past, cassava was mostly used for human consumption either directly for rice substitution or simply processed for chips and crackers. By the year of 1980, the aims of farmers growing cassava changed to industry orientation in which it was sold to tapioca factory which was built nearby.

Most of cassava farmers (about 65%) have agricultural land of less than 1.0 ha, only 15% of the cassava farmers have agricultural land of more than 4.0 ha. With this condition, most cassava farmers (76%) planting cassava in a mixed cropping system, mainly (85%) with maize and some with other crops such as peanut, soybean and upland rice.

In accordance with the aim of planting cassava, the major cassava varieties planted in this village is Faroka a high yield variety (the tuber yield can approach to 40 t ha^{-1}) with bitter because of its high HCN content and used for industrial purpose. The other variety found in the village is Kaspro and Mentega. Kaspro is also a bitter cassava variety and planted for starch production and Mentega is sweet variety which is used for human consumption.

At the beginning of the study, most cassava farmers practiced the traditional production technology. Eighty one percent of the respondent said that they applied only nitrogen fertilizer with a rate of about 90 kg N ha^{-1}. They hardly apply phosphate and potassium fertilizers. Only 16% of the respondent applied manure fertilizers. With this management, the cassava tuber yield obtained is around 20 t ha^{-1} and the yield decrease rapidly from year to the following year. The farmers (76% of the respondent) realized the important of correct and balance fertilizers. However, the price of the fertilizers is too high for them and often difficult to find fertilizers at the right time.

In sloping agricultural land, there was no respondent practice any soil conservation measure. They (86% respondent) understood that with no soil conservation practice so soil productivity will decrease. Actually there was some soil conservation project conducted in the area. These include the construction of terrace and alley cropping system. However, soon after the project ended, farmers whose joined the project, back to the traditional practices. These farmers argued that the soil conservation work is labour intensive, expensive and complicated with no real yield.

During the discussion with farmers, it is known that actually most of the farmers (92% of the respondent) realized the importance of the improve production technology, either for increasing crop yield or for maintaining soil productivity. However, farmers hardly practiced these technologies because it was that practicing an improved technology did not always increase farmers' income. It is true that cassava yield increase with a proper fertilizer application, but the price of cassava is unstable; it was often very low so that the additional output obtained from yield increase was still lower than the additional input for fertilizers. At the beginning of the study the price of fresh cassava tuber is only Rp. 200 kg^{-1} (equal to about US $ 0.02 kg^{-1}), whereas the price of medium quality of grain rice is about Rp. 3,000 kg^{-1}.

The instability of cassava price was due to the limited utilization of the cassava tuber. As discussed before, since the year of 1980, the orientation of cassava grower change from human consumption to tapioca industry factory. These orientation changes had resulted in the dependency of cassava farmers to the factory. Soon the factory reduces the demand, the price of cassava decrease to a very low level and hence, farmers getting lost of their money. Therefore, a development of alternative use of cassava tuber will help to stabilize the price of cassava tuber.

Some of the respondent (81%) said that actually they did not have any objection to adopt any new technology. However, they said that most of the production technology introduced by the extension workers was expensive, require a lot of labour and complicated. Some farmers (60%) said that the reason for did not practice soil conservation measure because most of the technologies introduced by the extension workers did not directly resulted in yield increase. The extension workers explained that the soil conservation works need a longer time to give the effect on crop yield. Most of the respondent (92%) said that they will adopt the improve technology, as far as, these technology give a direct impact and of course it does not too expensive and too complicated.

Based on the above findings, the main problems faced by cassava farmers can be summarized as follow:

- The yield of their cassava crops was low and the yield decreased rapidly when they grew cassava continuously on the same field
- The soil planted with cassava continuously became unproductive
- The fertilizer requirement of their soil tends to increase
- Difficulty to find fertilizers at the right time and the price of the fertilizer was expensive
- Limited of promising cassava varieties
- Lack of good planting material, there was a tendency the decrease of planting material quality
- The introduced improve production technologies were mostly expensive, complicated and need a lot of work
- The introduced soil conservation technologies were mostly did not increase their crop yield and even often decreased the crop yield
- The limited consumer and use of cassava tuber
- The price of cassava tuber was unstable and very often the price was low

To overcome these problems, the alternative solutions suggested by the collaborated farmers are:

- Introducing new cassava varieties, so that farmers have more alternative to choose the correct varieties
- Explore the alternative plant nutrient resources, especially that of easy to find in the surrounding area and of course cheap such as manure, compost and by product of sugar industry (blotong)
- Develops soil conservation technologies that are not complicated, not expensive and capable of increasing crop yield
- Explore the alternative utilization of cassava such as develop of cassava industry/processing at home scale or promote the use of cassava product for animal feeding

Farmers' trials: Based on the above findings farmers then proposed themselves to conduct variety trials and soil management trials on their own land. Before deciding the experimental treatment, the farmers were brought to and let them to evaluate the variety and soil management trials conducted by Brawijaya University staff.

In the first year, there were 3 farmers did variety trials and continued their experiment until the second year. At the third year, two of them changed to soil management trials and the other one after examining the soil management trials conducted by Brawijaya University and that of done by the other farmers, prefer to practiced one of soil management treatment (planting UB-4772 cassava variety which intercropped with maize and fertilized with 135 kg N ha^{-1}+5 t ha^{-1} of cattle manure) on whole of his land. In the second year there were 7 farmers involved in the variety trials, 5 of them are new farmers. In third year there were only 3 farmers did variety trials and other 4 farmers practiced the selected improve technology on their whole land. The variety tested and the results of the trial are presented in Table 1.

All activities such as harvesting and yield measurement were also done by the collaborator farmer. During the harvest, both the maize intercrop and the cassava crop, the all collaborator farmers and the neighbour farmers (all together was about 30 farmers) were brought to the field and ask them to make choice. For the first year 33% of the farmers select UB 477-2 as the first choice, 50% select Faroka, 10% select Kaspro and 7% select Mentega variety. The preference changes in the second and third year. In the third year, with 54 farmers attended the field day, 63% of them select UB 477-2, 27% select Faroka and 19% select Malang 6. This farmer's preference is not surprisingly because most of the cassava farmers growing cassava as a cash crop sold to the tapioca factory. So far, farmers only considered to total yield of cassava tuber because they did not know whether the factory used starch content for determining the price.

The soil management trial was done by 8 farmers in the first year of the project. In the second year, the number of the farmers involved in the soil management trials increase to 10 farmers, 2 of them are new farmers. In the third year, 8 of the collaborated farmers decided to select one of the treatment for growing cassava in their whole field. In addition, there was 6 more farmers who did not involve in any trial, select this treatment. Thus, in the third year, there were 14 farmers decided to practice one of the soil management treatment in their whole land. In this year, there was an addition of 7 farmers to do soil management trials.

The cropping system was intercropping of cassava and maize. In the first year farmers used Faroka cassava variety, but in the second and third year they changed to use UB 477-2 variety. The maize variety used was BC-2, a hybrid maize variety. The experimental treatment and results of soil management trials done by farmers are presented in Table 2. The data given in Table 2 show that the yield of cassava without fertilizer was much lower compared to the other

Table 1: Result of FPR trials: variety experiment

	2004/2005		2005/2006		2006/2007		Means	
Cassava varieties	Cassava	Maize	Cassava	Maize	Cassava	Maize	Cassava	Maize
Faroka	37.54	3.72	38.56	3.45	40.39	3.78	38.83	3.65
Kaspro	35.67	3.92	32.75	3.87	38.80	4.05	35.74	3.65
UB 477-2	41.55	3.56	45.37	3.88	44.14	3.71	43.68	3.65
UB ½	35.15	4.12	35.34	3.48	39.85	3.95	36.78	3.85
Mentega	29.36	4.02	-	-	-	-	29.36	4.02
KU 50	-	-	-	-	36.54	3.80	36.54	3.80
Malang 6	-	-	-	-	39.18	3.78	39.18	3.78
Markonah	-	-	-	-	35.62	3.62	35.62	3.62

Table 2: Experimental treatment and result of FPR soil management trials

Treatments	2004/2005 Cassava	Maize	2005/2006 Cassava	Maize	2006/2007 Cassava	Maize	Means Cassava	Maize
No fertilizer	21.45	1.76	-	-	-	-	21.45	1.76
N (90 kg ha^{-1})	31.37	2.97	32.38	3.15	31.54	2.77	31.76	2.96
N (180 kg ha^{-1})	37.46	3.56	38.64	3.36	33.53	3.04	35.54	3.32
N (180 kg ha^{-1})+ 50 P_2O_5+100 K_2O	38.52	4.02	39.42	3.46	37.14	3.90	38.36	3.79
N (180 N kg ha^{-1})+5 t manure ha^{-1}	37.06	3.30	40.21	3.75	41.25	3.68	39.51	3.58
N (135 kg ha^{-1})+5 t compost ha^{-1}	36.16	3.42	39.06	3.74	37.12	3.84	37.43	3.66
N (135 kg ha^{-1})+5 t blotong ha^{-1}	35.45	3.54	34.95	3.02	-	-	35.20	3.28

Table 3: Extent of adoption of new technologies on cassava and intercropped maize yields in three villages in Ngajum subdistrict of Malang district

Farmer name	Village	Planted area (ha)	Maize yield (t ha^{-1})	Cassava yield (t ha^{-1})
Saimun	LowokGempol	0.20	-	40.45
Joni	Jatisari	0.25	4.26	41.34
Tarib	LowokGempol	0.40	-	42.62
Siamun	LowokGempol	0.20	3.86	36.38
Urip	LowokGempol	0.30	-	46.76
Yasmani	LowokGempol	0.25	4.34	38.25
Samidi	Jatisari	0.20	3.75	39.86
Nurasim	Selobekiti	0.30	3.15	41.65
Wandi	Selobekiti	0.25	-	44.38
Maun	Jatisari	0.20	3.45	45.38
Sunar	Jatisari	0.35	-	40.39
Warno	LowokGempol	0.25	2.94	33.29
Kancil	Jatisari	0.30	-	35.78
Kasemi	Jatisari	0.25	-	32.30
Average C monoculture	-			40.38
Average C+M				3.68
				39.45

treatment. This fact had caused no farmer willing to do this treatment (no fertilizer application) in the second year trials. In the third year, blotong treatment was also avoided by farmers.

An evaluation during the field day indicated that in the first year 50% of the collaborated farmers selected the treatment (3) as the first choice, 30% select treatment (5) and 20% select treatment (2). There was no farmer select treatment (4 i.e., 180 kg N+50 kg P_2O_5+100 kg K_2O ha^{-1}) although this treatment produce the highest yield. The farmers argued that the price of the fertilizer was too expensive so that the additional input can be compensated by the increase in crop yield. In addition, so far it was very difficult to find P and K fertilizers. The reason for the farmers avoiding treatment 7 (blotong) because farmers did not see the effect of this treatment.

In the second and third year, the preference of the farmers changed. In the third year, 44 farmers from total of 54 farmers involved in the field day selected treatment (5 i.e., 180 N kg+5 t cattle manure ha^{-1} for inter cropping and 135 kg N+5 t cattle manure ha^{-1}) as the first choice and the rest selected treatment (3 i.e., 180 kg N ha^{-1}) as the first choice. The reason for the selection is simply because this treatment yielded higher cassava tubers and in addition, this high yield was relatively stable from year to year. Treatment 6 (180 kg N ha^{-1}+compost) also produced a relatively stable high yield. However, no farmers selected this treatment. Farmers said that making compost needs too many works and complicated. The labours they have are very limited to do the work.

The data presented in Table 3 is the name of the farmers that had practiced one of the technologies tested in the farmer' trials. All these farmers planted cassava variety of UB 477-2, some planted in monoculture system and some in intercropping system with maize. All farmers used 180 kg N ha^{-1}, in the form of urea (5% N) with addition of 5 t cattle manure per hectare.

Table 4: Number of farmers practicing production technology

	2009			2015		
Technology	No. of farmers	Land area (ha)	Yield (t ha^{-1})	No. of farmers	Land area (ha)	Yield (t ha^{-1})
Variety adoption						
UB-4772-2: mono crop	35	24.7	32.78-45.75	28	15.5	29.85-43.54
UB-4772-2: mixed cropping	21	5.6	27.20-35.28	16	6.7	24.36-32.75
Malang 6: mono crop	0	0.0	0	15	9.8	30.67-41.65
Malang 6: mix cropping	0	0.0	0	8	2.8	28.60-35.27
Markonah: mono crop	0	0.0	0	5	4.2	28.37-36.25
Markonah: mixed cropping	0	0.0	0	12	3.4	24 .35-28.46
Soil management						
Manure: mono crop	47	28.6	35.26-45.75	45	30.6	30.56-42.35
Manure: mix cropping	18	4.9	29.76-35.28	28	6.9	28.36-36.35
Compost: mono crop	0	0.0		8	9.6	32.15-46.55
Compost: mix cropping	0	0.0		0	0.0	0

Impacts of the project: The survey done in February 2009 (five years after the project in which two years with no supervision from the project's staff) showed that from 86 respondent of cassava farmers, 56 respondents (65%) planted UB 477-2 variety and 65 respondents (76%) used cattle manure for their cassava crops (Table 4).

Furthermore, data in Table 4 show that in 2015, in addition to UB 477-2 variety, some farmers planted another introduced variety i.e., Malang 6 and Markonah. The number of farmers using manure in 2015 also increased substantially and some farmers practiced compost technology. The data presented in Table 3 and 4 have demonstrated the effectiveness of the farmers participatory research for transferring any improve technology. The traditional method of transferring technology in Indonesia especially a release a new variety which requires several years of multi-location testing. To follow this work, it requires a lot of money and personnel, which in case of cassava is not always available. Thus, some good varieties may be locally popular but are seldom officially released and widely distributed. Only when cassava becomes a more valuable industrial crop will either the government or the private sector feel motivated to invest in the production and distribution of planting material of the best of the high yielding varieties.

DISCUSSION

This study showed that the assumption of most experts that small farmers are traditional, conventional and have a little understanding of cassava production system (Pretty and Shah, 1997; Utomo *et al*., 1998) is not always true. As discussed before, this study showed that 92% of the respondents had realized the importance of the improve production technology either for increasing crop yield or for maintaining soil productivity. The reason they did not practice these technologies because the technologies did not always increase farmers' income. Thus income is the primary consideration for adopting of any introducing new technology. A similar phenomenon was observed by Howeler *et al*. (2004). Another reason that could be suggested as the reason for farmers did not adopt soil conservation technology was because the technology is expensive or too complicate (De Graaff *et al*., 2008). In this study about 81% of the respondents said that they did not have any objection to adopt any new technology as far as the technology is not expensive, not require a lot of labour and not too complicate. Thus, soil and land degradation in farmer fields is not only technical problem but more complex include social and economic problems as has been suggested by Hellin (2006).

Looking that phenomenon it is reasonable to suggest that any soil management technology will be adopted by farmers if this technology is met to farmers' needs and farmers' conditions.

Fujisaka (1989) has suggested that participatory approach is the most suitable method to obtain this requirement. There is no one better than farmers themselves who know their needs and their conditions (Critchley and Mutunga, 2003). Therefore, giving the opportunities to the farmers to advance their needs would make the technology more suits to farmers' needs (Mutunga *et al*., 2001).

This study also showed that the use of participatory approach could advance farmers to farmers' extension. With no formal extension service, the number of farmers adopted the introduced technologies increased substantially during 6 years after the first evaluation. At the first evaluation (2009) the numbers of farmers adopted the new cassava varieties was 56 and increased to 84 in 2015. The number of farmers practicing manure in 2009 was 65 increased to 81 in 2015. This result indicated that the FPR approach could make adoption of any new technology sustainable. Pretty and Shah (1997) successfully employed the participatory approach to make sustainable soil conservation work.

CONCLUSION

The study shows that the FPR methodology have promising prospect for developing the sustainable cassava production technology. With this method, farmers were able to develop a sustainable production for cassava. The technology developed by farmers spread up quickly and it had been proven that the adoption sustained for a long periods. After 5 years of the project, 65% of the farmers in the study area had planted UB 477-2 variety and 76% of the cassava farmers in the study area had use cattle manure for their cassava crops. Survey done in 2015 (10 years after the project) showed that, in addition to UB 477-2 variety, some farmers planted another introduced variety i.e., Malang 6 and Markonah. The number of farmers using manure also increased substantially and some farmers practiced compost technology. At the beginning of the project there was no farmer planted UB 477-2 and only few farmers used cattle manure.

ACKNOWLEDGMENTS

This study was part of PHB research of the first author at University of Brawijaya, Malang, Indonesia. The research was partly funded by CIAT-ACIAR Project CIM/2003/066 and partly by Indonesian Ministry of National Education under post graduate award scheme.

REFERENCES

Amponsah, S.K., J.T. Sheriff and G. Byju, 2014. Comparative evaluation of manual cassava harvesting techniques in Kerala, India. Agric. Eng. Int.: CGIR J., 16: 41-52.

Chambers, R., 1994a. Participatory Rural Appraisal (PRA): Challenges, potentials and paradigm. World Dev., 22: 1437-1454.

Chambers, R., 1994b. The origins and practice of participatory rural appraisal. World Dev., 22: 953-969.

Critchley, W.R.S. and K. Mutunga, 2003. Local innovation in a global context: Documenting farmer initiatives in land husbandry through WOCAT. Land Degrad. Dev., 14: 143-162.

De Graaff, J., A. Amsalu, F. Bodnar, A. Kessler, H. Posthumus and A. Tenge, 2008. Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. Applied Geogr., 28: 271-280.

Fagerstrom, M.H.H., I. Messing and Z.M. Wen, 2003. A participatory approach for integrated conservation planning in a small catchment in Loess Plateau, China: Part I. Approach and methods. CATENA, 54: 255-269.

Fujisaka, S., 1989. A method for farmer-participatory research and technology transfer: Upland soil conservation in the Philippines. Exp. Agric., 25: 423-433.

Hellin, J., 2006. Better Land Husbandry: From Soil Conservation to Holistic Land Management. CRC Press, USA., ISBN: 9781439844243, Pages: 288.

Howeler, R.H., 2001. The use of farmer participatory research (FPR) in the Nippon foundation Project: Improving the sustainability of cassava-based cropping systems in Asia. Proceedings of the 6th Regional Workshop on Cassava's Potential in Asia in the 21st Century: Present Situation and Future Research and Development Needs, February 21-25, 2000, Ho Chi Minh city, Vietnam, pp: 461-489.

Howeler, R.H., W. Watana, W. Wongkasem and K. Klakhaeng, 2004. Working with farmers: The challenge of achieving adoption of more sustainable cassava production practices on sloping land in Asia. Proceedings of the International Conference on Innovative Practices for Sustainable Sloping Land and Watershed Management, September 5-9, 2004, Chiangmai, Thailand.

Hudson, N., 1992. Land Husbandry. Batsford Books, London.

Islami, T., B. Guritno and W.H. Utomo, 2011. Performance of cassava (*Manihot esculenta* Crantz) based cropping systems and associated soil quality changes in the degraded tropical uplands of East Java, Indonesia. J. Trop. Agric., 49 : 31-39.

Mutunga, K., W.R.S. Critchley, P.Lameck, A. Lwakuba and C. Mburu, 2001. Farmers' initiative in land husbandry: Promising technologies for the drier area of east Africa. Technical Report No. 27. UNDP. RELMA/SIDA, ICRAF House, Gigiri. Nairobi, Kenya.

Pretty, J.N. and P. Shah, 1997. Making soil and water conservation sustainable: From coercion and control to partnerships and participation. Land Degrad. Dev., 8: 39-58.

Roose, E., 1996. Land husbandry: Components and strategy. FAO Soils Bulletin No. 70, Food and Agriculture Organization of the United Nations, Rome.

Utomo, W.H., S. Suyamto and A. Sinaga, 1998. Farmer participatory research in soil management in Indonesia. Proceedings of the 5th Regional Workshop on Cassava Breeding, Agronomy and Farmer Participatory Research in Asia, November 3-8, 1996, Danzhou, Hainan, China, pp: 471-481.

Webler, T., S. Tuler and R. Krueger, 2001. What is a good public participation process? Five perspectives from the public. Environ. Manage., 27: 435-450.

Yuniwati, E.D., N. Basuki, E.W. Wisnubroto and W.H. Utomo, 2012. Combating land degradation in cassava field by crop yield improvement. J. Basic Applied Sci. Res., 2: 4975-4982.