Chapter 4

Technology Transfer and Extension Approaches

This chapter covers the extension approaches commonly used by the extension agents on transferring the improved technological practices on coffee production at the study area. The chapter is divided into two sub-topics. The extension approaches included demonstrations, lecture in classroom, mass media, T & V system, and farmer-led approach while the technological packages consisted of fertilization, pruning, propagation, pest management, and irrigation.

4.1 Definition of technology transfer

Technology transfer is a broad concept, which includes the efficient transfer of agricultural innovations to the farmers and the provision of prerequisite needs to make adoption possible. Technology transfer focuses on technology generation by scientists, and passing on to farmers via the extension agents, and farmers are basically considered as passive receivers of expertise from outside (Arnon, 1989).

4.2 Research-extension linkage

Van Den Ban and Hawkins (1996) stated that the role of the extension organization is the transfer of technologies developed at the research institutes to farmers aim to increase producers' production, income and employment on one hand and providing essential feedback about problems encountered by farmers in order to influence the research. On the other hand, the purpose of research is to enable the extension service to have access to continue flow of reliable information. An effective linkage between agricultural research and extension is quite important for agricultural and rural development. Oakley *et al.* (1985) stated that extension is not only a one-way process in which the extension agents transfers knowledge and ideas to farmers, which is often based on the findings of researchers, but also the flow of information from farmers to the extension agents and researchers is equal important. Van Den Ban and Hawkins (1996) found that the extension as an effective instrument only when combined with others, such as research, provision of inputs, and market. It will be weak when it stands alone, but it becomes powerful when it is combined with others. Eklund (1983) stated in Guatemala for instance, the agricultural research system was successfully changed towards a farming systems approach. Technology of proven relevance was generated for small farm systems. The impact of the system remained limited because the extension system was not incorporated or assigned a role in the technology development process.

It is a well-know fact that increased agricultural productivity depends largely on the dynamics of technical and organizational changes in farming systems. The decisive factors are the generation of innovative knowledge through research, dissemination through extension agencies, and the users are farmers (Blanckenburg, 1984). The communications should not flow only from research through extension to the farmers, but also vice versa. The effectiveness of the technology transfer process will be determined largely by the degree of harmonization between these three sub-systems. More precisely, it calls not only for the interlinking of the three sub-systems, but also ensuring that the components within each sub-system are adequately coordinated and integrated.

The agricultural extension system in DakLak province heavily obtains improved technologies on coffee practices from research institutes inside and outside province. These technologies are normally subjected to re-screening or testing before transfer to farmers. In many circumstances, the constraints for particular environments may be identified and tested at the location to provide location-specific recommendations. The linkage between extension and research institutes, therefore, plays an important role in performing this task. The institute will continuously provide adaptive technologies for the extension agents bring to farmers. It is, however, there were currently a lack of interaction between extension center and coffee research institute and limited feedback from farmers in transferring process in this province because the institutional separation and the weak mechanism for cooperation have led the relevant organizations to operate in isolation (Khai, 2000). Schematic model for extension-research linkage is attached in Appendix II.

4.3 Diffusion of improved technologies to farmers

4.3.1 Fertilization

Continued high productivity of coffee requires a high level of initial fertility and the regular replacement of nutrients, particularly the amount of nitrogen and potassium elements removed by the fruits. As coffee is a long-lived crop, application of nutrients is not only supply nutrients for fruit setting, but also needed to be incorporated into vegetative growth above and below ground. Higher yield and vegetative growth require correspondingly higher amounts of all other nutrients. Ripperton *et al.* (1935), cited in Clifford and Willson (1985) discovered that the nutrients removed from the bean, pulp, and parchment equivalent to one ton of robusta green beans coffee were 45.5 kg N, 7.67 kg P_20_5, and 27.4 kg K_20 in bean; 2.27 kg N, 0.3 kg P_20_5, and 1.87 kg K_20 in parchment; 15.33 kg N, 3.67 kg P_20_5, and 1.87 kg K_20 in pulp.

In DakLak province, in order to get higher yield, farmers applied at a very high rate of chemical fertilizers on coffee, it ranged from two to seven times year^{-1} with an average amount of 501 kg N + 271 Kg P_2O_5 + 311 kg K_2O ha^{-1}. The amount of fertilizer application was quite high compared to the requirement of coffee trees to be productive. Aside from that, the application of imbalance nutrients often leads to impacts on the soil properties related to lower pH, loose soil structure, micro-element deficiency, all these have incidence of root diseases caused by nematodes and fungi proliferating (Hong *et a.*, 1997).

Table 3 Fertilizer application for bearing coffee at different sites in DakLak

Sites	Quantity of three main nutrients, kg ha^{-1} $year^{-1}$		
	N	P_20_5	K_20
Buon Ma Thuot	190 – 744	25 – 192	64 – 720
Dak Mil	180 – 530	80 – 528	108 – 480
Cu Mgar	40 – 528	286 – 528	264 – 580
Krong Buk	400 – 936	336 – 600	120 – 540
Krong Pach	391 – 1410	90 – 160	80 – 450
Krong Ana	215 – 1030	180 – 480	90 – 486
Ea Kar	220 – 680	70 – 330	180 – 550
Average	501	271	311
Recommendation rate	340	100	230
Surplus	161	171	81

Source: Hong et al. (1997).

Thai *et al.* (1999) surveyed 65 coffee farmers in nine districts of DakLak province and found that the average yield of coffee farms were 3.54 ton coffee bean ha^{-1} with the total chemical fertilizers used in total of 1,044 kg ha^{-1} $year^{-1}$ at the rate of 449.6 kg N + 195.1 kg P_2O_5 + 399 kg K_2O equal to ratio at 2.30: 1: 2.05 of N: P_2O_5: K_2O. Another results came from the survey of 26 farmers, who their coffee gardens produced from four ton dry bean ha^{-1} upward in 1998 found that the farmers used in total of 1,168 kg fertilizer ha^{-1} $year^{-1}$, of which 506 kg N + 214 kg P_2O_5 + 462 kg K_2O equal to ratio of 2.38: 1: 2.16 of N: P_2O_5: K_2O. The both above results illustrated that the more fertilizer application, the more yield got, and the farmers who applied in balance rate of N: P_2O_5: K_2O often get higher yield than others.

Table 3 proves us that the surplus of fertilizer resulted from overuse compared with recommendation rate annually was quite high. The total loss is estimated about \$145 ha^{-1} $year^{-1}$ compared to the recommendation ratio, of which 161 kg nitrogen equal to 350 kg urea or \$58, 171 kg P_20_5 equal to 1,068 kg super-phosphate or \$70, 81 kg K_2O equal to 135 kg muriate (potassium chloride) or \$17. DakLak currently has 264,000 ha, if getting a half equal to 130,000 ha that farmers used the same above fertilizer level, the whole province would waste up to \$18,850,000 $year^{-1}$. It can be concluded that the overuse of fertilizers was not only lose in term of money but also results in ecosystem deterioration would occur, especially soil degradation and the ground water resource exhausted. Rozelle *et al.* (1997) found that the land degradation is a major contribution in declining crop yields worldwide while the erosion, acidification, salinization are important aspects related to overused of external inputs application.

Based on the results obtained from on-farm trials on fertilization conducted in different robusta coffee growing zones, Nam (1999) recommended the application rate of 340 kg N, 100 kg P_20_5 and 230 kg K_20 ha^{-1} $year^{-1}$ on the basaltic soil for bearing coffee that might be enough to ensure the product of more than 3 tons of coffee bean ha^{-1}, and suggested to keep leaf-fall and pruning material remain within the plantation as they decompose, release mineral nutrients back to the soil for improving soil fertility.

4.3.2 Irrigation

Less than one percent of water taken up by the roots of the coffee tree is used in photosynthesis process (Wrigley, 1988). Coffee being an evergreen crop, transpires water throughout the year and the nutrients required by the coffee tree are mainly in the topsoil. If the surface soil becomes dry, despite the full and free transpiration of water from deeper layer, the tree will be deprived of nutrients as there is no uptake by the surface root system. Nutrients will diffuse slowly in dry soil, and where the release of soil nutrients depends upon the activity of microorganisms. Thus, moisture is essential factor for coffee tree for normal growth.

Irrigation is a decisive factor for most robusta coffee growing areas with long and severe prolonged five to six dry months in DakLak province. Therefore, coffee gardens should be concentrated growing around the surface water resources. Coffee tree in reality has been grown even where there was no good source of water resources. WASI (2000) stated that in a normal year condition, irrigation should reach a ratio of 2,500 cubic meters ha^{-1} splited into three to four times a year. This amount of water would secure a good harvest against drought conditions.

The most common irrigation method in DakLak was basal irrigation, where water is conveyed into plastic pipes to individual trees around, which a bund has been constructed to hold water. In constructing these bunds, the soil is often disturbed to a depth of 10 to 15 centimeters. This technique often causes a serious damage to the mass of surface roots, run out of water resource, and labor cost intensifies. Besides, drip irrigation, sprinkler techniques were also applied in some places, such as big coffee state farms or research stations. Those methods have not applied broadly on individual farm household so far because of high establishment cost and complicated installation and management of the system, and the layout of the equipment requires carefully planning to avoid over-watering in some areas while other parts remain dry.

On one hand, the over exploitation of ground water resource has caused long lasting negative impacts on ecological conditions. On the other hand, over exploitation of ground water has made it is more difficult and costly to satisfy growing demand for expanding coffee areas in recent years. A number of areas were considered to be marginal have become new coffee farms without promising success so that in the severe drought of 1998, for instance, several coffee farms were destroyed. Again, it should be noted here that irrigation input accounts for around one fifth to one sixth of total production cost, a large amount cost but a necessity component. Challenges from more scarce water resources need urgent measures to control land allocation for coffee, change the cropping pattern, and find the proper irrigation technique to minimize the water use and how to use the efficiently the water resource in the long term for sustainable coffee production.

It is important, therefore, to know how best to utilize the water or the optimum time to irrigate, the minimum requirement to obtain the optimum benefits, and also when will not to irrigate. Therefore, when planning irrigation, it is necessary to consider the frequency and amount of water application to the growth cycle of coffee plantation as it will not upset the natural growth and flowering rhythm of the coffee trees. Cannell (1973), cited in Wrigley (1988) found that applying water to prevent from wilting, especially the development of coffee berries are sensitive to moisture stress in the periods of the 8th to the 17th week after flowering. The size of the coffee beans is often correlated with the total quantity of rainfall and irrigation that the tree receives in this period.

Sung (1999) recommended that watering needs to be consistent with the climatic condition, coffee after harvesting need a certain time to be restored. Seven to ten week's moisture stress is needed to induce producing a good uniform flowering. Then, the first irrigation should be applied when dormancy of flower buds is broken, normally at the end of January or the first of February. Depending on the specific climatic condition of a certain year, 1st irrigation can start early or later but normally about 50 to 60 days after finished harvesting. The first time should be high amounts of water about 800 cubic meters ha^{-1} to promote uniform flowering. The frequency of irrigation depends upon the balance between the loss of water from evaporation, and the rainfall, but three weeks interval between two times is recommended, and it should irrigate three to four times per dry season in the drought years with the total of 2,000 cubic meters ha^{-1}. In Kenya Pereira (1957), cited in Wrigley (1988) based on 20 years data, such as rainfall, evapo-transpiration (E_0), temperature, and daily rate recommended to irrigate within every 20 days in the months from December to March, April and May, irrigate every 40 days in June to August and in 25 days in September to October.

4.3.3 Pruning

Punning is a thinning process that concentrates the vigour of the tree in those parts, which will produce the most crop cover over a number of seasons. It also cuts away the dead, unnecessary suckers, diseased, and over-aged wood for allowing necessary access to coffee tree (Wrigley, 1988). Furthermore, it shapes the trees into an easily management, open form to promote better penetration of air, which helps to control certain pests and diseases, and facilitates efficient spray coverage and even on harvesting. Pruning can minimize biennial and consequent risk of dieback phenomenon also (Clifford and Willson, 1985).

Moreover, pruning promotes rising new branches that will bear a crop next year, but if this pruning is delayed too long, these branches will not have enough time to mature in time to flower within the short raining. Pruning also encourages the production of new shoots, which can keep as second stem. Once there is sufficient soil moisture after pruning, a flush of new shoots arises, which will provide the bearing wood for the following years, which must be thinned out in this second pruning. Unpruned trees for some years will develop a mass of thick cross branches and intertwined leaves, and the trees become tangled and make difficult to manage.

There is no such thing as the best system for growing coffee. Indeed, no best system for pruning because the requirements of coffee growers are different from their coffee gardens so that their pruning practices will be different (Wrigley, 1988). The pruning system chosen for any particular plantations must be related to the cultivars planted, the location, spacing, the need to obtain an early return on capital invested, the quality and quantity of labor and supervision (Clifford and Willson, 1985).

Bau (1999) recommended that the regular pruning of coffee single stem trees in DakLak province for robusta coffee should carry out twice a year, with an interval of a few months in between. The time of the main pruning is very important. It should start as soon as the last harvesting round is completed. All dead wood, broken branches, young suckers, crossing branches, touch ground branches are removed. Any bare or weak branches are cut out and replaced with more vigorous growths further back. The final frame should be a tree about the height of 1.6 meters, slightly wider at the base than at the top, open in the center to let in light and air. As the vigour of the tree tends to go to the top, where the trees carry most of the berries, the top two primaries are cut back. If this is not done, an umbrella-shaped tree will develop.

Haarer (1962), cited in Clifford and Willson (1985) recommended that coffee trees should prune just after harvesting because the tree at the end of harvest look like scarecrows, such as a lot of dead, diseased, and obviously weakened wood are formed which is also doomed to die, and many of primary or a main stem has been broken by the pickers as they reached for the fruit so it is desirable to tidy up the trees, get rid of diseased and dead tissues, and bring the trees back into a better shape.

Wrigley (1988) recommended that if the coffee tree is already suffering from die-back phenomenon, it must be left unpruned until the second pruning. Pruning towards the end of the main raining season must be avoided because the crop well formed and branches are carrying the berries. Earlier pruning produces new shoots and leaves, which will concentrate the nutrients to promote the development of fruits. Pruning before the Coffee Leaf Rust spraying season starts allows better penetration of the spray with a better deposit of fungicide on the leaf, which is important in controlling this disease.

4.3.4 Pest and disease management

4.3.4.1 Pests

The most serious pests on coffee plants are insects. Over 850 species are known to be infected coffee. Of these, 34 percent are Coleoptera, 28 percent Hemiptera, 21 percent Lepidoptera, six percent Orthoptera, four percent Hymenoptera, three percent Diptera, three percent Thysanoptera, and Isoptera one percent (Bardner 1985, cited in Wrigley, 1988). Chaves *et al.* (2001) found out that coffee berry borer (CBB) is the most damage pest in the world because it enters the seeds itself feeds and reproduces inside causing damage not only to the weight but also the coffee quality. In estimation, the losses of coffee production attributable to insects were 15 percent in Africa, ten percent in Asia, and ten percent in Oceania (Kramer 1967, cited in Clifford and Willson, 1985).

Each part of a coffee tree has its own spectrum of pests. Roots are attacked by nematodes, stems and woody branches are often attacked by larvae of boring beetles, of which, the foliage of coffee trees support the greatest number of pests, mealy bugs, and flower buds can also be damaged by caterpillars.

Sung (2000) found out that the best policy for controlling insects is to encourage the parasites and predators and limit using of insecticides because using the insecticide will destroy the natural predators or any other potential pests. Consequently, insecticides only advise when the pest is out of chemical control and cultural management has failed.

Loang (1999) stated that there is no economic way of controlling the nematodes, which are outbreak on coffee plantations. Better management in advanced, including put more manure, mulching and weeding can alleviate their adverse effects, but where the nematodes have caused threshold productivity reduction to an uneconomic levels, it had better to uproot the trees and use the land for an alternative crop, which is not a host for a long time. It may be occurred many years before the land is sufficiently free from nematodes to replant with coffee.

The stable environment of a coffee plantation with its diverse and resident population of pests and their parasites predators makes it particularly favorable for the practices of integrated control technique. This seeks to utilize and coordinate appropriate methods of chemical, cultural, and biological to keep pests population below levels, which effects coffee yield. In certain cases, the importance of some pests can be reduced by pruning to open up the center of the coffee bushes, sanitation coffee plantation or development of coffee varieties resistant to the pests attacking.

Whenever controlling measures are planned, it must be kept in mind that they should be carried out sensibly, taking into account economic and ecological considerations. The availability of equipment and products, and the choice of the most appropriate times for treatment should pay more attention, such as when will be the pests and diseases at its most vulnerable development or what will be the beginning of the reproductive phase of development of insects. Cambrony (1992) stated that the optimum intensity of spraying, application rate and frequency are important. Excessive applications may lead to a risk of toxicity to the plant or its environment, low level of treatment introduce the possibility of the pathogen developing tolerance, such as pests become resistant to some chemicals.

The use of pesticides for coffee should select having the maximum effect the pest and minimum effect the beneficial organisms. The methods used must minimize risks to the operators and the local population and also be compatible with available application equipment. Pesticide application should concern on those used as overall treatment, and those applied selectively to smaller areas, but it is important to ensure that the overall treatments should be made as selective as possible. It is important to test new materials and ensure that they have no greater toxicity or residual against common beneficial insects. Sung (1999) suggested that the pest should be targeted at a susceptible life stage, and the host must be at a stage where the pesticides will not damage the plant or appear later as undesirable residues in fruits. It should be regarded on identifying the suitable times to control, for instance, it is essential pay more attention on observing and forecasting of temperature, moisture or other relevant factors to reduce or eliminate the negative impacts to human beings and environment.

4.3.4.2 Diseases

Coffee diseases are caused by pathogenic micro fungi, bacteria and some viruses. They affect different plant organs, resulting in delibility, deformity and sometimes cause death of the whole plant. Appropriate controls are often necessary to prevent diseases from developing to a level that would reduce the productivity or quality of the crop so the need to undertake disease control depends upon the effect of particular diseases.

There is a heavy concentration of coffee plantation in a large-scale operations in DakLak province. This is one of the favorable conditions for many diseases to develop, and they have been causing huge controlling cost for coffee growers so far.

Of these diseases, coffee leaf rust (CLR) is by far the most dangerous, widespread, and has caused the most damage for coffee producers. Then, it is followed by coffee berry disease (CBD), the root diseases. It is similar to Malawi where coffee yield is most affected by the coffee berry disease (*Colletotrichum Kahawae*) and leaf rust (Hillocks *et al*., 1999).

CLR is caused by the fungus (*Hemileia vastatrix)*, it is recognized by the orange-yellow circular spots composed of clusters of sori that is visible on the under-surface of the leaves. Many infections cover most of the leaf, which becomes increasingly necrotic and fall prematurely from the tree. Heavy and repeated defoliation can cause dieback and generally weakening of the whole plant lead to the yield and quality reduction of the current season crop.

CBD is caused by a virulent of the fungus (*Collectotrichum coffeanum)*. It attacks young berries about 5 to 20 weeks old, which causes fruit rotting and shedding. Ripe berries are also susceptible to this disease, and overlapping of successive crops can increase disease severity. The disease is favorable to develop in wet condition as rainfall required for spore production, dispersal and infection. Root diseases, caused by fungus *Armillaria mellea* with the symptoms usually appear as a debilitation, wilting, and death of affected trees.

Sung (1999) recommended that general plantation hygiene is one of the most important aspects of controlling coffee diseases, especially root, trunk, and CLR diseases. These diseases tend to be spread slowly and locally, eliminating the source of the pathogen, usually an infected tree or branch as soon as possible will prevent the pathogen from spreading to neighboring trees. Adequate pruning and mulching at the start of the raining season will help to allow air circulation in coffee canopies assists more rapid drying of plants surfaces so that infection is restricted, spray penetration is also facilitated, thus, improving the efficiency of chemical control. Optimum cultural conditions to ensure a good growth of the tree helps to offset the ill effects of diseases by making the trees physiologically more tolerant with the changing of environment.

However, there are occasions when natural control measures either ineffective or slow that the coffee growers may lose their crop before they take effect. Then, the use of pesticides, if justified, must be chosen with great care. The first consideration is the safety to the person doing the spraying. The choice should fall on an insecticide of short persistence that has a narrow range of activity and will have the minimum effect on the natural enemies of pests. And which substance, how much to use, how to apply it to the trees, and when should it be used. For CLR for instance, it is essential just before the spores start to arrive needed to apply a protective fungicide, which can remain available on the underside of the leaves even in a wet weather and yet is sufficiently soluble in the water film destroy germinating spores to avoid spreading to neighboring trees. Sung (1999) proposed that it is essential to spray from one to three times during the disease season (depending on the concentration and the kind of disease) with the frequency between two times about three to four weeks. Bordeaux mixture is recommended with dose from 0.75 to one percent, or other labels like Anvil, Bayleton, Sicaron should be used with the dose ranges from 0.3 to 0.4 percent.

Rayner (1957), cited in Wrigley (1988) pointed out that copper sprays have shown to have a tonic affected by prolonged leaf retention and boosting plant growth. As the disease enters the leaf through the stomata, which is on the underside of the coffee leaf, it is a good sense to try to deposit as much of the fungicide as possible on the underside of the leaf.

Loang (1999) suggested that it had better not to surface flooding irrigation on the slope coffee gardens in situation of root diseases, making the bund to prevent water running down from the top, application manure to promote root system development. Reduction application of chemical fertilizers and apply balance of N, P, K elements. Finally, it is better to root up the dead trees out the garden and born to eliminate the epidemic of the diseases.

4.3.5 Grafting techniques

Because of fast expansion of coffee growing areas in the 1990s, most coffee farmers and coffee state farms used unselected seedlings, which resulted in a fairly high proportion of trees that have produced low yields for the whole coffee area of Daklak province. Furthermore, this has resulted from the small bean size or susceptible to leaf-rust disease (*Hemileia vastatrix*) and mealy bugs. Also, the uneven blooming and non-uniform ripening among trees on coffee plantations have caused a big impediment for harvesting and processing. The size and weight of coffee beans were still small compared to the export standards of many coffee exporting countries, which limits the number of customers as well as reduces the competition capacity of coffee price in the world market.

In order to curb the aforementioned problems, from 1990 up to present, multi-clonal seeds and grafted seedlings of high yield and disease resistant clones have been widely used in new coffee plantation that has been contributed significantly to the improvement of yield, quality in terms of bean size, pest and disease resistance capacity (Minh, 1999). A long-term program of renovating the old plantations, which were planted with unselected seedlings by grafting of high yielding clones were recommended from the extension agents to coffee growers, aiming to change the available unproductive and small bean size coffee varieties. According to Sung (1999) the unproductive coffee tree should be grafted at the end of the dry season, and in the first coming days of raining season by selected bud from productive varieties and the selected trees with disease resistance.

4.4 Extension approaches

DakLak extension system is one of the key players in transferring improved technologies that obtained from research institutes to the rural communities throughout the whole province. As the top down process of traditional extension dictated farmers to adopt technologies developed by scientists resulted in poor extension performances in the past years (PEC, 1998 and Khai, 2000). The new approach of participatory extension methods advocated and supported by the NGOs, foreign projects such as DANIDA, GTZ, VIE 96 etc. have made considerable improvement in advanced technologies in recent years (Ngau, 1998).

The challenges to the extension programs are the development and adoption of the extension approaches, which will be effective in different leaning situations. It should be recognized that there is no single method, which can be considered the only or the most effective in every learning situation compared with others, each method has its own merits and shortcomings in certain situations. There are currently five extension methods, namely: lecture in classroom, demonstration, mass media, T & V system, and farmer-led approach that the extension agents have been applying in dissemination the improved coffee techniques to farmers in DakLak province.

4.4.1 Lecture in class room

The lecture is a formal, verbal presentation by an extension staff to a group of farmers. This method is easy to implement and it can be introduced to many people at the same time. Currently, the contents on coffee production are introduced in general knowledge. The trainees learn mostly theory while the practical items are very limited. For this reason, the results are not so much successful in term of farmers' adoption on improved technologies from the extension agents' recommendations (DEC, 1998). Farmers are soon forgetting and have trouble on applying. Most farmers have not been accustomed to learn their information from a lecture. They are unlikely to remember much detail from these lessons. Extension agents often organize the class trainings at the commune office or at the meeting room of the villages for about 40 to 45 farmers. It takes about less than two days per component of coffee techniques and these classes often organizes at the sensible times. For instance, pruning technique often takes right after harvesting, pest and disease control normally arranges during the raining season or irrigation technique rather organized during irrigation period.

4.4.2 Demonstration

Demonstration shows a group of extension's clients how new technologies and practices can be applied step by step. This technique as Mosher (1987) found that hearing can enhance understanding, seeing is believing, but learning require doing. Farmers conduct a model under the direct supervision of an extension worker. The benefit of demonstration is that it could show, for examples, how to use a tool to control pests or diseases, how to graft for coffee. This method convinces that a particular technology is better than the other ones they are practicing. Usually, time does not permit more than a few farmers to participate, which is a limitation of the demonstration approach currently in real situation.

Demonstration stimulates farmers to try out innovations themselves or may ever replace a test of the innovations. They can show causes of problems and possible solutions without complicated technical details. Results of the demonstrations can be given on demonstration fields or on demonstration farms during the harvesting period, where farmers can observe the real results and discuss their implications. It is currently in DakLak province during the field-day workshops, farmers often get a set of leaflets, which describes the technological package so that they may avoid making mistakes when applying in practical production (Ngau, 1998 and Khai, 2000). Oakley and Garforth (1985) stated that demonstration fields used to compare results of the traditional practices with the new practices. It is a very useful method for convincing farm people who have not learned by thinking abstractly or it uses to prove that the advanced coffee practices advocated can be applicable locally. While Swanson *et al.* (1997) found that field day allows farmers to see what they have been hearing, thus providing the opportunity for the building the desired attitude towards the innovations. Normally, the contact farmers under the supervision of the extension agents carried out the demonstration models. A successful demonstration can produce positive results for the extension workers by creating confidence in their judgment and ability. It is an effective way to promote the new practice and can open the way for further interaction between farmers, who demonstrated the practices to their neighbors. The other farmer's visit the results of demonstration plots foster improved communication situations at local. This occasion provides them opportunities on exchanging experiences and gaining more specific and in-depth information about new technologies else.

4.4.3 Mass Media

Mass media, such as newspaper, radio and television are being applied broadly for providing the information to farmers; it means training of farmers through distances by communication facilities. These mass media help the extension agents to reach in large numbers of farmers simultaneously. Currently, DakLak Television Broadcasting Station often shows the extension programs related to crop and livestock production one every week whilst the ratio station provide every day in the evening. Compared to others methods, newspaper, magazines, radio and television generally are the least expensive media for sending the messages to masses of people (Van Den Ban and Hawkins, 1996). However, there is little opportunity for these farmers to interact among themselves or provide feedback to the extension agents. Furthermore, farmers in the remote areas had limitations in accessing to the mass media, especially illiterate women farmers. Newspapers are not often distributed in the rural areas, and even when they are available, it might be too expensive for most families. Television is also too expensive for many or there may be no electric power supplies in rural villages. Print media as well as radio and television were only supplementary sources in nature because they frequently lack a target group or specific location and information is not up-to-date (Khai, 2000).

4.4.4 Training and visit system (T & V system)

The T & V system (Training & Visit) is based on the total number of farm families to be assisted in a given area, where one extension worker can reasonably be expected to cover. The T & V system concentrates its initial efforts only on field aspects of farmers' production, which offer greatest scope for increasing yields through relatively unsophisticated techniques for better crops (Benor *et al.*, 1984). Through group discussion, farmers at the study area said, the extension agents often visit farmers' field or coffee garden at home one to two times every month at the sensitive periods, such as at pruning, irrigation or pests and disease outbreak periods. The extension agents often discuss both with individual or a group of farmers directly at coffee gardens related to proposal technologies from farmers. These techniques often call for reducing in cash inputs (fertilizer, pesticides, or water), and the focus is on the improvement of basis agricultural practices like fertilizer application, weeding, irrigation etc. In the field, the extension workers teach farmers practicing and show them how to implement these practices, motivate them to adopt at their fields, evaluate production constraints and advise farmers how to overcome them. This method has accelerated the adoption of new technologies through intensive, regular interaction between the government extension agents and the contact farmers in order to disseminate a package of key agricultural messages.

4.4.5 Farmer-led approach

The farmer-led extension method is responsive for intending beneficiaries' of agricultural development problems and information needs. Extension objectives, strategies, methods, messages, and multimedia materials are specifically developed based on the survey results of farmers' knowledge, attitude and practices vis-à-vis the recommended agricultural technologies. Such a participatory approach in planning activities increases the degree of relevance and acceptability of the extension messages or recommendations among intended beneficiaries, who are consulted during the planning process regarding their priority concerns and needs. In short, it follows the well-known principles of rural reconstruction: "Start with what people already know", and "Build on what they already have" (Adhikarya, 1994).

Currently, the participation of farmers on the extension programs at the study area are attending meetings, conduct the demonstration model of new methods on their farms, ask the extension agents questions and providing information which is necessary for planning an effective the extension program. Farmers' role is to act as equal partners and decision-makers in the planning, implementing, monitoring and evaluating of their own advancement on the extension programs. Other role is to facilitate this participatory development process. Farmers normally are invited to participate on the meetings to plan the extension programs and together with the extension agents to monitor and evaluate these programs. Van Den Ban and Hawkins (1996) found out that the desirability of farmers is to participate in the extension programs as they have information at their own villages, which is crucial for planning, including their goals, situation, knowledge, experiences, and they will be greater for cooperation in the programs if they share responsibility for it. Phillips (1994) stated that farmer-led programs failures in the transfer of technology was often associated with outsider's misconception of what farmers want and need, which lead them either to deal with problems wrongly or address the wrong problems.

4.5 Constraints to efficient performances of extension programs

The extension system in DakLak province is run from the province to the district then to commune level with a headquarters in the province center and sub-departments in each district. Funding for activities of the extension center comes from government and provincial funding resources. The system is highly centralized and its operation is depended entirely on national budget. Lack of funding was usually a problem that limits the service areas and the number of activities that the system would provide to farmers. Extension workers are small in number with total for the whole province of 76 staff, of which female extension staff accounts for only 20 percent, this disequilibrium limits their capacities in contacting farmers who normally pay much attention on farm activities.

Since the extension system has just been established in 1993 so its service was really new for extension staff who were trained in general subjects graduated to work for organizations like state coffee farm, rubber company, or agricultural department in stead of the basis training subjects on extension like extension methods, communication and planning skills need to be covered on extension work. Furthermore, the extension service area is very large throughout whole province whilst means of transportation is limited, poor transportation and inadequate of working conditions. In addition, low salary does not provide enough incentive for the extension officers to effectively perform their services. These constraints have been attributed for the poor performance of the extension performances in DakLak province in term of ineffective extension program, and inadequate coverage areas.

As mentioned above, the working areas and clients of the extension agencies in DakLak province are very large and difficult in reaching farmers because of diverse ethnic minority groups, large area, limited extension agencies on communication skills, and lack of advancement possibilities for extension staff. Therefore, the extension has just been access to a certain group of farmers. Furthermore, there is high number of illiterate and poorly educated farmers; it is very difficult for the extension agents to disseminate their messages to their clients.

These above findings shows similar to the statements made by Dejene (1989) that in many developing countries the extension programs often lack of organizational structure to reach farmers directly at the villages, and also the lack of coordinated and regular linkage between the extension service, research department and farmers at the field, or inadequate transportation facilities for the extension agents, which severely impedes their mobility, the shortage of extension agents particularly women agents and experience technical specialists working closer to farm level.