Chapter 6

Impact of Agricultural Extension on Coffee Production

The status of extension services and coffee production practices were studied at Cu Sue commune, where coffee is the major crop that has remained a backbone of household's income and many technologies have been introduced by the extension agents to a certain group of farmers. Chief outputs of this study are furnished with a great deal of thoughts over the changes in farmers' practices on coffee production of two groups of farmers, namely, the contact farmers and the non-contact farmers, which was typically concordant with the objectives of the proposed research attempt. 145 households in three villages were selected randomly interviewed, and directly observed. Due to some incomplete information on data required for this study, 15 questionnaires were dropped and 130 farm households finally remained and classified into two groups. This chapter attempts to describe and analysis the farmers' practices on coffee production between the contact and the non-contact farmers, the impact of extension to those practices and the efficiency of inputs used, the technological practices of the contact farmers who had access to the extension programs.

6.1 Farmers' profile on accessing to the extension programs

To broaden the ideal picture of these objectives, the study involved two groups of farmers, the contact farmers and the non-contact farmers. The sample farmers were randomly selected from three villages; they were Buon Sut H'Luot, Buon Dung, Buon Nguoi Man (T5) of Cu Sue commune. The detail information of respondents is presented in Table 7.

Table 7 Farm households access to the extension at Cu Sue commune

Village	Contact farmers			Non-contact farmers			Total
	Female	Male	Total	Female	Male	Total	
Buon Sut H'Luot	0	10	10	5	27	32	42
Buon Dung	2	6	8	9	25	34	42
Buon Nguoi Man	3	10	13	7	26	33	46
Total	5	26	31	21	78	99	130
Percentage	16.2	83.8	23.8	21.2	78.8	76.2	

Source: Survey, 2002.

Table 7 indicates that male respondents dominated in this survey. Of the farmers interviewed under each category, the contact farmers and the non-contact farmers, males were 83.8 percent and 78.8 percent respectively. It indicated that there was 23.8 percent of the surveyed farmers had participated on the extension programs provided by the extension agents. Most of them were male, it appeared that males attend the extension programs more often than the female, and seem makes most decision with regards to coffee production. This finding is similar to Shinawatra *et al.* (1990) stated that women had important roles in the farming activities. However, they were not given adequate attention by the government officials both in term of generating technologies to suit their needs and to provide the relevant knowledge to improve their conditions.

6.1.1 Features of the respondents at the survey villages

Table 8 indicates the educational level and age of sample respondents, the contact farmers ranged from 30 to 47 years with an average age of 41.6. The non-contact farmers' age ranged from 21 to 60 years with an average age of 45.6. Results indicated that the average years of the contact farmers were slightly lower than the non-contact farmers. The difference in ages of two groups can be explained that the extension workers would like to select the farmers who were not so young or not so old to participate on the extension programs. Those farmers often present the

confidence or farming experiences and mature on farming practices as well as the capability in communication with other farmers.

Table 8 Educational status and farm experiences of the sampled farmers

Items	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
Average age	41.6	-	45.6	-
Educational levels				
Illiterate/no school	0	0.0	10	10.1
Elementary school	1	3.2	24	24.2
Primary school	11	35.5	44	44.4
Secondary school	17	54.8	21	21.2
College/university	2	6.5	0	0.0
Farm experience (year)				
< 5	0	0.0	0	0.0
5 – 10	18	58.0	49	49.5
> 10	13	42.0	50	50.5

Source: Survey, 2002.

Table 8 shows the respondents in both categories had differences in educational levels. The average year on education level of the contact farmers were slightly higher than the non-contact farmers. Nobody was illiterate in the contact farmer group compared to 10 percent of the non-contact farmers. Most the contact farmers were educated at the level of secondary school at 54.8 percent compared to 21.2 percent of the non-contact farmers. Blanckenburg (1984) found out that it is easier for the extension agents to work with the well-educated farmers rather than with illiterates ones, who are unacquainted with the scientific background of modern farming practices. Farmers with a good general education have to be treated quite different from those with little or no formal education.

Most respondents spent lifetime as coffee farmers. Experiences on coffee production of two groups were not much different from working on coffee, it ranged from more than five years to over fifteen years with an average 51 percent of the contact farmers had reached over ten years compared to 42 percent of the non-contact farmers.

Table 9 Composition of labour force and family size

Items	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
Size of family	6.3	-	6.2	-
Age of labour				
< 15 years	3.1	49.2	2.6	42.0
15 – 60 years	3.0	47.6	3.0	48.4
> 60 years	0.35	5.6	0.61	9.8
Agricultural labour	2.61	41.4	2.95	47.6

Source: Survey, 2002.

Table 9 shows that the respondents had rather big families. The size of the household was 6.3 persons; the percentage of population less than 15 years old was 49.2 percent and 42 percent respectively for both groups whereas 47.6 percent and 48.4 percent was between 15 to 60 years. Comparing with the composition of working age ranged from 15 to 60 for the agricultural labour composition, the number did not change much for both groups. It seems that household activities were highly characterised by the agricultural operation. About 87 percent and up to 98 percent of main family labour was engaged in agricultural activities. Aside from that, as the economically active age group from 15 to 60 years made up less than 50 percent for both groups whilst the rest of more than 50 percent was non-active age group mean less than 15 and more than 60 years old. This higher percentage of non-active would further constraints prevailing family labour shortage.

Table 10 Farm size and coffee age of sampled households

Items	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
Size of coffee farm	1.71	-	1.54	-
0 – 1	4	12.9	18	18.2
1 – 2	16	51.6	55	55.6
2 – 3	9	29.0	25	25.3
>3	2	6.5	1	1.0
Year of coffee	11.42	-	11.26	-

Source: Survey, 2002.

Table 10 shows the farm size of the contact farmers ranged from 0.5 to 3 hectares with an average size of 1.7 hectares whilst the farm size of the non-contact farmers ranged from 0.5 to 3.5 hectares with an average size of 1.54 hectares. All surveyed coffee farms, including the contact and the non-contact farmers, have planted coffee within the years of 1990 and 1991 in average of 11.4 and 11.3 years old respectively. This period was one of the most rapid expansions of coffee area in DakLak province, where there were about over sixty thousand hectares of coffee planted under the technical standard of Vietnam Coffee Association. So the farms were designed quite uniform in variety and density. Of which, robusta coffee was one of the most important varieties introduced at this commune as well as in the whole province.

Table 11 shows the soil in the study area is found to be uniform and very fertile up to 93.5 percent and 93.9 percent respectively of both groups. Most coffee areas were planted on the basaltic soil, which was evaluated as the best one for coffee cultivation in Vietnam. Farmland of the respondents is flat or slightly steep whilst the percentage of land with steep slopes is only 3.2 percent and 10 percent respectively for both groups.

Table 11 Soil features and landscape of coffee farm of sample households

Items	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
Soil feature				
Sandy	0	0.0	0	0.0
Basaltic	29	93.5	93	93.9
Other	2	6.5	6	6.1
Landscape				
Flat land	27	87.1	68	68.7
Slightly steep land	3	9.7	21	21.2
Steep land	1	3.2	10	10.1

Source: Survey, 2002.

6.1.2 Contact farmers' setting

The extension service has been official operated since 1996 at Cu Sue commune. Its system is currently run from the provincial level to district level and then to farmer associations at commune level. Their main tasks focused on transferring improved technologies for farmers, especially for coffee growers since most farmers in this commune have at least a parcel of coffee. These improved technologies included fertilization, pest control, pruning, propagation, and irrigation. Aside from that, the extension staff also concern on the other issues, such as soil conservation, renewable vegetative residues, market, credit, and processing aspects to farmers. However, respondents said that in the majority of cases, the extension worker comes on his own rather than on their requests.

As mentioned above, inadequate of fund for running the programs or lack of extension staff to cover all the farmers is one of the factors limiting the efficiency of the extension programs currently in DakLak province so that the extension agents at district level has been cooperated with the contact farmers in this commune to deal

with their programs. The contact farmers therefore, were selected gradually year by year to participate in the extension programmes. Result in Table 12 shows four farmers had access to the extension programs in 1997, then five in 1998, 1999, ten in 2000 and finally seven in 2001 at these three sample villages.

Table 12 Establishing the contact farmers through years

Village	Year					Total
	1997	1998	1999	2000	2001	
Buon Sut H'Luot	1	1	1	4	3	10
Buon Dung	1	1	2	2	2	8
Buon Nguoi Man (T5)	2	3	2	4	2	13
Total	4	5	5	10	7	31
Percentage	13.0	16.2	16.2	32.3	22.6	

Source: Survey, 2002.

The basic idea of having the contact farmers' setting is to establish the local resource person in the village who are expected to play their role as the middlemen in assisting the extension agents in technology transfer process. The rationale behind this idea is that it is not possible for the extension agents in DakLak province to contact all the farmers frequently in their areas during each of their visits or frequently organize the training courses as well as conduct the demonstrations to farmers whilst DakLak province has very large areas and inadequate extension staff. Therefore, the villagers were requested to nominate somebody among themselves to be the contact farmers. Village leaders often select those contact farmers with getting advices from the extension agents.

Phongprapai *et al.* (1988) found in Thailand the contact farmers are selected as representing proportionately the main socio-economic, farming conditions, and willing to adopt the relevant recommendations at least on a part of their land and allow other farmers to observe their demonstration plots and explain the practical

practices to other farmers. Their research also found that the contact farmers play very important role in the transferring process, they presented as coordinator between the extension agents and farmers. This relationship among them is satisfactory and has the positive contribution towards the contact farmers under their operation areas. More than half of the extension agents said that the contact farmers helped them much in the extension programs. They believed that the contact farmers had enough knowledge to disseminate to other farmers. Benor *et al.* (1984) stated that the contact farmers had to be selected with great care given their critical role in the extension work and they had better to be selected by the extension workers with the consultations from village leaders. In addition, the contact farmers should have a good standing in their community so that other farmers will respect their views on new practices.

6.2 Impact of extension on farmers' practices

6.2.1 Fertilization

Due to the fact that coffee ecosystem is an agricultural system, organic matter and nutrients are continuously exported from the system in the form of harvestable products like fruits, firewood, braches, and husk. In addition, energy is lost as a result of nutrients leaching through the soil; therefore coffee ecosystems need to be subsidized with nutrients in the form of fertilizer in order to sustain coffee productivity (Nestel, 1995).

6.2.1.1 Chemical fertilizer

The survey result revealed that all farmers applied chemical fertilizers. The number and quantity differed from two groups of farmers in terms of stage of coffee production, type of fertilizers used, and mode of application. It is mainly applied to coffee plantations during the raining season when soil moisture content was high enough for coffee trees up-taken nutrients. First fertilizer application often takes place after the coffee harvested at the end of January or beginning of February, the second

application is made in May in the first days of rainy season, and the last two applications often takes on July and end of October. It was revealed from the survey and group discussion that fertilization was a technology that farmers had less knowledge. They reported that they did not know exactly the best level of fertilizer application for their coffee gardens, how many times or when will be the suitable time, as well as the methods how to apply.

Table 13 Chemical fertilizer use (kg ha^{-1} $year^{-1}$) by contact and non-contact farmers

Fertilizers	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Quantity	SD	Quantity	SD
Nitrogen	341.0	38.1	373.5	35.6
Phosphorous	135.7	31.9	238.0	41.3
Potassium	244.2	31.1	200.0	55.1
Total	720.9		811.5	
Ratio of N/K_2O^{***}	1.4		1.9	
Number of application	4.06	0.75	3.14	0.8

Source: Survey, 2002.

SD: Standard deviation, *** indicate the significantly difference at 0.01 level determined by two-tail student's t-test.

Table 13 shows the common chemical fertilizers used by farmers at the study area were compound fertilizer, urea, super phosphorous, potassium chloride and ammonium sulphate. The compound fertilizer, such as NPK was the most popular one. The amount of chemical fertilizer applied for coffee varies quite widely among farmers. Nitrogen used by the contact farmers ranged from 235 to 420 kg ha^{-1} with an average of 341 kg ha^{-1} compared to the non-contact farmers used 373.5 kg ha^{-1} that ranged from 280 to 470 kg ha^{-1}. Phosphorous used by the contact farmers with an average of 135.7 kg ha^{-1} ranged from 110 to 270 kg ha^{-1} compared to the non-contact farmers with an average of 238 kg ha^{-1} that ranged from 150 to 350 kg ha^{-1}. Potassium used by the contact farmers with an average of 244.2 kg ha^{-1} ranged from 70 to 350 kg

ha^{-1} compared to the non-contact farmers 200 kg ha^{-1} that ranged from 90 to 320 kg ha^{-1}.

Nam *et al.* (1999) recommended the rate of 340 N: 100 P_2O_5: 230 K_2O for the mature coffee on the basaltic soil in DakLak province, where could produce yield from 3.2 to 5 ton ha^{-1}. Clifford and Willson (1985) proved that the ratio of nutrients in the compound fertilizer recommended for young coffee is different from the ratio for coffee in the bearing period, for example, a 20-5-20 and 20-20-5 compound fertilizers were recommended in Brazil for established and mature coffee gardens respectively. For young coffee, a higher ratio of phosphorous is generally recommended versus for bearing coffee, where a higher recommended ratio for potassium and nitrogen. The reason for applying high nitrogen quantity "urea" of the non-contact farmers group was that coffee trees great response in a short time for vegetative growth, and coffee trees are very susceptible to nutrients deficiencies.

Compared to the recommended practices, the results illustrate that the non-contact farmers applied quite high amount of fertilizers, especially the amount of phosphorus and nitrogen were excessive compared with the recommended quantity of 138 and 33.5 kg ha^{-1} respectively or equivalent to 862 kg super-phosphate and 72.8 kg Urea. Cardoso *et al.* (2003) proved that phosphorous can be absorbed by H_2SO_4 to Al^{-} and Fe^{-}, which turns large proportions of total P into a form that is unavailable to plants. This is one of the reasons, which often causes soil degradation to coffee plantations.

The excessive amount and imbalanced of nutrients mostly used by the non-contact farmers because of applying the compound fertilizer named NPK rated of 16: 16: 8. This kind of fertilizer is quite good for coffee trees but it is better for pre-maturing coffee as young coffee trees require a high percentage of phosphorous for the development of the root system compared to the mature coffee that need less phosphorous but potassium for forming fruits and nitrogen for vegetative growth.

Table 13 shows the total chemical fertilizers that the contact farmers applied at 720.9 kg ha^{-1} $year^{-1}$, of which nitrogen accounted for 47.3 percent, following phosphorous and potassium were 18.8 and 33.9 percent compared to the non-contact farmers with total of 811.5 kg ha^{-1} $year^{-1}$, of which nitrogen accounted for 46 percent, phosphorous and potassium were 29.3 and 24.6 percent respectively.

If we calculate the ratio of N/K_20, the value varies from 1.2 to 1.5. It indicates the balance of recommended rate of nitrogen and potassium quantity that is suitable for bearing coffee on the basaltic soil. This ratio could be used to evaluate the farmers' understanding on using reasonable fertilizers (Clifford and Willson, 1985). The survey revealed that 79.8 percent of the non-contact farmers applied unreasonable rate of main nutrients compared to 15.8 percent of the contact farmers. The finding was similar to the study of Hong *et al.* (1997) found that there was only 20 percent coffee growing households in Buon Ma Thuot used relatively reasonable chemical fertilizers as followed the recommended ratio whilst the rest of 80 percent were overused or less than required, especially with imbalance among the main nutrients. This proves us that most coffee growers in DakLak have not understood about using chemical fertilizers. There are many reasons attributed to this misperception issue, of which we cannot ignore the technical information inadequate derived from the extension agents. This ratio (N/K_2O) at the study area was 1.4 for the contact farmer compared to the non-contact farmers 1.9 (in Table 13). The non-contact farmers applied potassium less than the requirement about 30 kg ha^{-1} whilst it holds a key position in the nutrition of the plant and the development of the fruit, and it needs to be supplemented the loosen by permanently removed from the system in terms of stems, leaves and fruits. Clifford and Willson (1985) proved that potassium is moved from leaves and other vegetative parts to the fruit as they develop so the crop needs more potassium than available from the soil. This element is transferred from the leaves, the level in the leaves may be reduced to a deficiency level, and then vegetative growth will stop and result in leaf-fall and ultimately die-back phenomena. Young coffee, which has not produced fruits, it requires less potassium in relation to nitrogen but a deficiency must be avoided or this will retard the development of trees with high crop potential.

It is learned through the group discussions and survey results illustrated us that most the non-contact farmers just focus on the quantity of fertilizers. They seldom concern for the ratio among the individual fertilizers essential need for bearing coffee. Most of them would like to apply nitrogen and phosphorous whilst potassium would be applied at a lower quantity level. The results indicated that the imbalance ratio of three main nutrients N: P_2O: K_2O of the non-contact farmers as a result it retards the development of trees with high potential producing of crop. That is why some coffee gardens became degraded after harvesting seasons and have serious pests and diseases outbreak that causes coffee trees to be no longer as an economic crop.

Table 13 also shows that the farmers in both groups applied fertilizers at two seasons, rainy and dry. The contact farmers followed split fertilizers application 4.06 times a year, of which 3.19 times applied on the wet season and 0.78 time on dry season. Most of them reported that they did apply fertilizer one time in dry season on January or February as the coffee tree starts budding, flowering, forming the berries, and for better pollination process. On the other hand, that was the nutrient source provided to strengthen the crop health for resisting the harsh of climatic condition. The demand of fertilizers in this stage is not so high compared to other periods but it is essential demand and decides the number of successful flowering to form the berries as well as the size of coffee beans. Farmers also said that during dry season, many nutrients like nitrogen, potassium, phosphorous, micro-macro nutrients lose with the high amount compared to the rainy season through evopo-transpiration process. The rest of high percentage quantity and application times were major concentrated on raining season as the coffee trees in this period require more nutrients to feed the berries, develop the reserve primary branches for the next years crop.

The non-contact farmers applied 3.14 times a year, of which 2.24 times on dry and 0.7 time on rainy season. Most farmers said they did like this as following the neighbouring farmers and followed their own experiences and preferences. The result indicated that the application times was not so much difference between two groups, just slightly higher for the contact farmers. Mill (1953), cited in Wrigley (1988) proved that if too much fertilizer is applied at the same time during the rainy season

for example, nitrogen, it could be leached out as ammonium ions are held briefly in the topsoil until they are mineralised to nitrate. Because of this leaching, the contact farmers prefer to apply just after the rain stopped, and they would like to split into many times aimed at limitation nutrients loss through erosion or leaching, it was, however, higher cost for their labour requirement.

Fertilizers were applied by both groups of farmers either through broadcasting in the irrigation basin or by putting it in a shallow ring along the perimeter covered by the canopy of coffee trees. The contact farmers 73 percent followed putting in a shallow ring along the coffee canopy as they explained that the root hair which absorb the nutrients generally located in this area, and 60 percent of the non-contact farmers broadcast fertilizer in the irrigation basal.

6.2.1.2 Organic fertilizer

Table 14 shows the number of farmers applying manure and its quantity were quite low of both groups, with 54.8 percent of the contact farmers and 43.4 percent of the non-contact farmer used. Currently, the bulk of the parchment husks was collected by farmers and spread in cattle pens where the parchment husks were mixed with pig's, cow's and buffalo's dung to produce manure that is used in the coffee plantations. The amount of manure applied by the contact farmers was two times higher than the non-contact farmers at 6.3 ton and 3.63 ton ha^{-1} per two years respectively. Manure was added once per two years aim allowing enough time for its decomposition to release nutrients. It is put on the basin bund or put on the hole along the coffee row to stimulate the surface root system growth.

Wrigley (1988) stated that the soil organic matter is an important reservoir of phosphorous, nitrogen and sulphur, and it is probably better, where practical, to apply and maintain the soil phosphorous level in the organic form by the use of cattle and mulch. Saenger *et al.* (2001) promoted farmers in Kenya to optimal use of coffee's husks back to their coffee plantation since coffee's husks is characterised by moisture from 10 to 12 percent, volatile matter 65 to 72 percent, ash 1 to 1.4 percent, fixed

carbon 17 to 20 percent, nitrogen 0.6 to 1.6 percent whereas every one ton of clean coffee produced, then one ton of husks are generated on dry processing method.

Table 14 Manure and bio-fertilizer usages by contact and non-contact farmers

Items	Contact farmer (n = 31)			Non- contact farmers (n = 99)		
	Mean	SD	%	Mean	SD	%
Manure (ton ha^{-1})	6.3	6.4	54.8	3.6	4.5	43.4
Bio-fertilizer (kg ha^{-1})	706	387	90	425	397	61.6

Source: Survey, 2002.

Similar to manure, 706 kg ha^{-1} $year^{-1}$ of bio-fertilizer was used by the contact farmers compared with the non-contact farmers' 425 kg ha^{-1} $year^{-1}$ in Table 14. The ingredients of bio-fertilize consist of 20 percent of organic matters (OM), 1 percent P_2O_5, 1.3 x 10^6 cellulose, moisture 25 percent and others. There were 61.6 percent of the non-contact farmers applied the bio-fertilizer compared with 90 percent of the contact farmers. As Clifford and Willson (1985) and Poungsomlee (1995) stated that one of the easiest and most cost effective ways for obtaining higher crop yield is to use manures and bio-fertilizers as it can provide significant quantities of nutrients and organic matter, which benefit the soil, such as improving the soil structure and fertility for better production. Manures contain unbalanced amounts of nutrients, if used in sufficient quantity, create problems of imbalance nutrients for coffee garden. Nopamornbodi (1994) proved that the application of these sources could affect the soil's physical, chemical properties, moisture retention characteristics, and soil fertility for improving of degraded soils to obtain the highest crops' yield.

Saenger *et al.* (2001) found in Kenya that the bulk of the parchment husks is collected by farmers and spread in cattle pens where the parchment husks are mixed with cow dung to produce manure that is used in the coffee plantations due to the high content of K_20.

6.2.2 Irrigation

Water quantity was collected from each farm household, and also measured by calculating the capacity of the water pump, which could irrigate how many liters of water hour^{-1} on the farm site. Then, this figure was multiplied by the time needed to irrigate to get the total amount water requirement year^{-1} in Table 15.

Table 15 Quantity and number of times of irrigation (m^3 ha^{-1} $year^{-1}$)

Items	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average	SD	Average	SD
Water quantity (m^3 ha^{-1} $year^{-1}$)	2617	151.9	2905	255.3
Number of irrigation (times)	3.61	0.72	3.24	0.5
Interval between two times (days)	22.4	1.84	26.8	4.80

Source: Survey, 2002.

Irrigation is an ordinary practice for both groups of farmers. It is usually done from January to the end of April with the interval of 22.4 days for the contact farmers group and 26.8 days for the non-contact farmers on average. The number of irrigations was not much difference from both groups of farmers. A higher frequency of irrigation was recorded by the contact farmer at 3.61 times compared with those of the non-contact farmers at 3.24 times with the amount of water used at 2,617 and 2,905 cubic meters of water ha^{-1} year^{-1} respectively (in Table 15). Most farmers mentioned the previous year of this survey, due to higher amount of rainfall and a longer rainy season, farmers had to irrigate less for coffee than usual, however, in a drought years farmers would irrigate up to six to eight times and use water resource as much as they can exploit. Compared to the recommended, the result revealed that both groups applied quite high amount of water, especially the non-contact farmers overused nearly 1,000 cubic meters of water ha^{-1}. As stated above, water resource is

one of the decisive factors for coffee yield, it is essential, however, to be used in time and enough amount.

Table 15 indicates that the quantity of the non-contact farmers' usage was higher than the contact farmers while the number of irrigation was slightly lower than compared with the contact farmers. It indicated that the non-contact farmers irrigated more amount of water per coffee tree compared to the contact farmers at a certain time. They explained that the more irrigated the more yield produced. For the contact farmers, some kept irrigating as in the normal situations, while others followed the recommendations from the extension agents. Farmers explained that it had better to divide the same water amount into more times, the water resources would be saved and limited soil erosion. Therefore, farmers often apply fertilizers after irrigation so the fertilizers loss would be less through drainage.

Ground water was the most important source for irrigating coffee in the study area. On average, farmers in this area have to dig one well for getting ground water to irrigate one hectare of coffee while just a few of them have their coffee parcels located near a stream. Water from streams can only be used at the beginning of the dry season because it dries out soon in January or February. For the remaining months, farmers have to rely on ground water from their own wells for irrigating their coffee gardens.

All farmers in this commune used the basal irrigation method. Water was conveyed in light aluminium or plastic pipes to individual trees around which a bund was constructed to hold the water in depth of 10 to 15 centimetres to the surface level. The water resources were both from surface of natural streams and groundwater. Irrigation from the surface was easier to manage and has relatively lower pumping costs compared to irrigation from the wells since farmers had to invest in pumps and dig a well to pump up water. Wells were often manually dug and powered by diesel engines with average depth were 21.3 and 19.8 meters respectively. To compensate for the lower of the ground table and yearly sedimentation on the wells, many farmers were continuous deepening and broadening their wells to extract the water resource.

Thus, they had to spend more time and money on irrigation, otherwise it will be very difficult for them to maintain yield at their normal potential level.

Table 16 Time of irrigation for coffee in dry season

Starting point	Contact farmer (n = 31)		Non-contact farmer (n = 99)	
	Average No.	Percentage	Average No.	Percentage
Before January	0	0.0	34	34.3
Within January	26	84.0	50	50.5
After January	5	16.0	15	15.2

Source: Survey, 2002.

As the characteristic physiology of coffee trees require a water stress at least two months after the last harvesting season aimed limiting or stopping of normal vegetative growth and stimulate the dormant flower budding so it was suggested that farmers should irrigate within January annual in DakLak province (Bau, 1999). Wrigley (1988) stated that at this stage the buds suffer from water stress and suddenly the availability of water increase, the dormancy is broken by an external stimulus, which generally coincides with irrigation, meiosis take places and more xylem vessels develop rapidly in the peduncles. The corollas expand rapidly and all the flowers open simultaneously.

Determining the water quality need be irrigated to one ha of coffee to meet the requirement of the tree and reduction of irrigation cost were uneasy decision-making of coffee growers. But it is important to decide when will be the suitable time to irrigate, especially the starting point to promote the uniform flowering and successful pollination process. There were different ideas in selecting the starting point for irrigation of both groups, the non-contact farmers irrigated earlier before January at 34.3 percent compared with the contact farmer almost irrigated within January 84 percent. There were 16 and 15 percent of both groups respectively irrigated after January (in Table 16). If irrigation was too early or too late at the dormant flower

budding stage, the coffee tree would tend to develop branches or leaf rather than flowering, some dormant or undeveloped buds remain producing shoots and flower in subsequent season giving rise cherries on old wood. This condition may contribute to the production of abnormal flowers and no fruit are set resulting in yield losses.

Irrigation is one of the important management practices, which can either increase yields, especially where rainfall is marginal for coffee, or reduce yields by applying water in excess or at the wrong time. Water may fill all the air spaces in the soil except where air is trapped, and the soil becomes waterlogged. Should this continue for too long, the temporary exclusion of air from the roots causes coffee's death. It is important, therefore, to know how best to use the available limited water amount, when is the optimum time to irrigate to avoid the natural growth and flowering rhythm. Result found from this survey proved that farmers had less knowledge on irrigation technique; especially the non-contact farmers paid little attention on irrigation periods as well as the amount water requirement for coffee. The irrigation was often based on their accumulated experiences, availability of water resource, and inputs for irrigation.

6.2.3 Pest and disease control

Several control strategies have commonly been practiced at the study area to deal with many destructive pests and disease on coffee. These control strategies have somehow met with varying degree of success depending on the level of severity of pest infestation and the particular favourable condition of the cropping system of individual farmers from both groups.

Table 17 indicates that 100 percent of coffee growers used pesticides or insecticides to control pests and diseases for their coffee gardens, of which 16 percent and 25.3 percent of the contact farmers and the non-contact farmers applied at least one to two times $year^{-1}$. The highest percentage of the contact farmers 71 percent used three to four times $year^{-1}$ compared with the non-contact farmers 32.3 percent. Furthermore, a higher percentage of the non-contact farmers 42.4 percent applied as

many as more than four times compared with the contact farmers 12.9 percent. Since there were many kinds of insecticides and pesticides sold in the free market, farmers had many choices to buy either liquid or powdery types. Powdery types were normally used to control pests and diseases that caused the coffee' root system, others pests and diseases were controlled by liquid pesticides and insecticides.

Table 17 Frequency of pesticide and insecticide application

Number of application	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
0	0	0.0	0	0.0
1 – 2	5	16.0	25	25.3
3 – 4	22	71.0	32	32.3
> 4	5	12.9	42	42.4
Cost ($)	19		34	

Source: Survey, 2002.

Because of different styles of pesticides and insecticides to be used by farmers, so that all the plant protection inputs invested to control pests and diseases were converted into US dollar. The average number of pesticide and insecticides applied in the area changing from one to more than four times ha^{-1} $year^{-1}$ with an average cost equivalent of 19 and $34 respectively for the contact farmers and the non-contact farmers spent within one year production.

The impact of insecticides and pesticides on the productivity of coffee was a special concern of almost all the farmers in the study area. In recent years, farmers used insecticides and pesticides for crop control with an increasing trend. High percentage of the non-contact farmers answered that they would spray wherever there were insects. They did not know that there were some useful insects. The contact farmers seem relatively known correct forecast about insects and diseases damage. They were therefore awareness of the time to control, relative amount, or type of insecticides to be used. The popular insecticides used by both groups were Methyl

Parathion, Supracid etc. with dose of 0.2 – 0.3 percent for mealy bug, brown scale and green scale. Powder insecticides like Nemacur, Nemaphos, Mefutox for nematodes and other root diseases. In Malawi, Hillocks *et al.* (1999) found the most commonly used were aldrin for stem borer, copper compounds for CBD and leaf rust, botanical insecticides and soapy water against green scale.

Usually pesticides and insecticides often apply in the wet season since most pests and diseases develop during the raining season or at the transferring periods. Hydraulic hand-operated knapsack sprayer was the most common equipment used for spraying. Farmers seem pay less attention to the minimization effect on beneficial organisms and limit risks to the operators and the local population. Problems for the non-contact farmers were the safe storage and handling of toxic chemicals while lock-up storage, used protective clothing, good handling, and hygiene practices were more likely to be found from the contact farmers where there was adequate educated on pests control.

A part in questionnaire was designed to obtained information from farmers on their main pests and disease problems, how they control them etc. The result indicated that farmers were very concerned on the pest and disease problems of coffee. The majority of farmers interviewed could easily recognize all kind common serious coffee pests and diseases that they have seen in their farms. The respondents not only recognized all kinds of serious pests, and diseases but also accurately described their characteristics, behaviors and performance. There was a higher degree of awareness of pests and disease outbreaks, and had more capacity to describe by their symptoms by the contact farmers compared to the non-contact farmers.

Farmers named 8 different pests that they often see on their coffee gardens (in Table 18). Mealy bug, berry borer, woody branches borer, and brown scale were the most common insects reported by both groups. Farmers reported that the most frequently appear were mealy bugs, and berry borer and said that these pests caused the most devastation on coffee. The contact farmers could describe correctly the damage behavior of mealy bugs. They said that in some serious gardens, the trees

gradually become sick and weak with such low yield that they were not worth for retaining, and a number of different species of mealy-bug live mainly on the coffee roots and in other parts of coffee tree. The contact farmers' gardens seem less frequently pests compared with the non-contact farmers as they said that the sanitation of coffee field was regularly implemented, it was a necessary option through which the crop residues, infected plants, and other weeds known to be the alternative host of pests and diseases were removed.

Table 18 Common pests and diseases reported by farmers

Pests & diseases	Contact farmer (n = 31)		Non-contact farmer (n = 99)	
	Average No.	%	Average No.	%
Pests				
Stems & woody branches borer	10	32.0	55	55.5
Berry borer	12	38.0	70	70.3
Mealy bug	25	80.0	95	95.5
Nematode	5	16.0	30	30.3
Red ants	14	45.0	40	40.4
Leaf-rolling caterpillar	8	25.8	25	25.2
Brown scale	3	9.7	13	13.1
Green scale	7	22.5	58	58.6
Diseases				
Coffee leaf rust	20	64.5	90	90.0
Coffee berry disease	15	48.4	53	53.5
Pink disease fungus	12	38.7	29	29.3
Root rot diseases	8	25.8	70	70.7
Brown eye spot	13	41.9	55	55.5

Source: Survey, 2002.

Similarly, farmers were asked to list the most common diseases on their coffee gardens. They named five different diseases in Table 18, of which, almost all the

farmers of both groups listed the leaf rust and root rot diseases. Farmers realized that these two diseases infested the plants very fast and assumed substantial economic losses. Most the contact farmers were able to describe correctly the damage behavior of leaf rust disease. It was recognizable with the orange powdery spots on the undersides of coffee leaves. Diseased leaves shed prematurely reducing the amount of vegetative growth and consequently the following seasons' yield.

Farmers' knowledge on perception of coffee's pests and diseases was essential need for avoiding misuse of pesticides and insecticides to control infected coffee trees. Due to the introduction of IPM (Integrated Pest Management) on extension programs, the contact farmers seem to have possessed relatively higher knowledge on awareness of each pest and disease and their damage behavior to coffee. Correct using of pesticides and insecticides for each destroyable ones was not only kill the serious pest and disease outbreak, time-consuming, material costs reduction but also could maintain many beneficial insects, and hazardous limitation to the users. Wrigley (1988) stated that population of the insect predators and parasites are in general more affected by insecticides than the pests. Pests often have better protection and increase their number after spraying, faster than their enemies.

6.2.4 Labor

The maintenance activities on coffee production as reported by respondents consisted of yearly pruning, weeding, enlargement of irrigation basal, fertilizer and pesticides used, irrigation, harvesting, and finally post-harvest. Labour allocated to one hectare of mature coffee is presented in Table 19. On average, 332.8 person-days were spent $year^{-1}$ to operate one hectare coffee for the contact farmers group higher than the non-contact farmers at 272.8 labour day.

Most of the activities like fertilizer, pesticides application and weeding were performed from May to November. Higher labour requirements have been reported for October, November, and December at the harvesting season. In peak season farmers had to use either additional family members or exchange labour to their

relatives. The contact farmers spent more time than the non-contact farmers resulting from intensive activities like pruning, post harvesting. And making basal bund, for instance, soil surface erosion was one of the main causes that resulted from soil degradation, especially in sloping land.

Table 19 Labor usage on maintenance activities (man-day ha^{-1} $year^{-1}$)

Items	Contact farmers (n = 31)			Non-contact farmer (n = 99)		
	Quantity (man-day)	%	SD	Quantity (man-day)	%	SD
Pruning	55.0	16.6	10.3	19.4	7.1	11.2
Weeding	36.0	10.8	10.1	34.4	12.6	13.3
Enlarge irrigation basin	43.2	13.0	12.3	20.7	7.6	8.2
Fertilizer application	7.3	2.2	3.0	8.2	3.0	2.6
Pesticides & insecticides	3.2	1.0	1.5	6.3	2.3	3.1
Irrigation	31.3	9.4	7.5	29.0	10.6	9.6
Protection	5.4	1.6	2.6	5.3	19.0	1.2
Harvesting	129.2	38.8	22.0	127.3	46.8	23.1
Drying	15.0	4.5	6.8	10.1	3.7	3.1
Husking	5.2	1.6	1.5	5.5	2.4	1.7
Other	2.6	0.8	1.8	3.3	1.9	1.2
Overall average	332.8			272.8		

Source: Survey, 2002.

DakLak province with the hilly and gully topography, high concentration of precipitation at raining season, therefore the problem of soil surface erosion regularly happened in large scale and caused the serious damage for agricultural production. The setting up of basement for soil protection from surface erosion, such as basin and basin-bund on coffee farms played very important roles in keeping the soil in place and preventing the nutrient and organic matter losing from coffee basal. From the survey it was found that the contact farmers paid more attention on this practices than

the non-contact farmers with about 43 labor days compared with 20 labor days of the non-contact farmers. The intensive labor found in this survey seems similar to Ridler (1983) measured in average of 470 man-day ha^{-1} $year^{-1}$ to operate one ha in Columbia, author found that this higher labour resulted from changes in techniques of coffee cultivation therefore intensive of labour use had a significant economic impact for coffee growers.

6.2.4.1 Pruning

Pruning was one of the most time-consuming operations in coffee production. Table 19 shows the labour spending for pruning differed from both groups of farmers. The contact farmer group spent 55 labour day ha^{-1} $year^{-1}$ compared to 19.4 of the non-contact farmers. Almost 100 percent of the contact farmers took pruning compared to 74.5 percent of the non-contact farmers. The non-contact farmers seem less knowledgeable about pruning, how to prune and able to identify when would the suitable time for pruning. However, the contact farmers were possible to prune and maintain a reasonable canopy of coffee tree year round. Observing the coffee gardens of farmers, it indicated that there was a higher percentage of coffee trees formation of umbrella-shaped developed recorded at coffee gardens of the non-contact farmers than the contact farmers, resulted from un-pruned harder at the top of the tree to prevent concentration of the primary branches or let the shoots from growing across the general line.

Table 20 indicates that most farmers start pruning as soon as the last picking round was completed during January. This pruning stage is called "harder pruning" as all dead wood, broken branches, young suckers, crossing branches, inefficiency of primary and secondary branches etc. are removed. Also, all new shoots arise upright on the stem also thinned out at monthly interval. Sharp secateurs and manual were major instruments used for pruning by all farmers, male farmers often do this work. As inadequate labour immediately after harvesting, 42 percent and 39.2 percent respectively of both groups had to leave a part of coffee plot to be unpruned until flowering was finished or small immature fruits have just formed. If the tree was

carrying too much crop, the pruning should stop to prevent the die-back phenomenon. Although having differed from frequency and timing of pruning of two groups and among the farmers but the most important was the quality of each pruned time. Especially, farmers' skills in pruning, it requires which branches or position of branches should be cut or remain and which secondary branches should be left and how to create a well-balanced frame that required farmers at least have general knowledge about the characteristics of physiology and morphology of coffee tree.

Table 20 Farmers' practice on pruning for improving coffee gardens.

Items	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No	%	Average No	%
Pruned	31	100.0	74	74.5
Number (1)	18	58.0	50	67.5
(2)	10	32.0	24	32.5
(3)	3	9.6	0	0.0
Time of pruning				
After harvested on January	31	100.0	45	60.8
Other time "flower finish or small immature fruits formed	13	42.0	29	39.2
Maintain pruning stems on field	29	93.5	56	75.7
ther (removed, fire etc.)	2	6.5	18	24.3

Source: Survey, 2002.

Table 20 indicates a high percentage of the contact farmers kept the pruning stems on the field compared with the non-contact farmers respectively 93.5 percent and 75.7 percent. Farmers explained that leaf-fall and pruning stems remain in the plantation to decompose, release mineral nutrients back to the soil, and to keep moisture for coffee trees. A few of them removed pruning materials from the fields,

which were used as firewood. This was one of the reasons causing a heavy loss of nutrients in the coffee plantations.

Clifford and Willson (1985) analysed two kilogram of pruning stems and found containing of 0.6 percent N, 0.05 percent P_2O_5 and 0.4 percent K_2O in dry matter. Since nutrients are incorporated into vegetative growth, above and below ground. The major part of the root system does not decay when the tree is healthy so the nutrients therein are lost permanently. If leaf-fall and pruning remain in the plantation they will decompose, releasing mineral nutrients back to the soil. This recycling of nutrients is important in minimizing the requirement of fertilizer. The humus formed is valuable in maintaining soil structure and helps to keep nutrients in an available form. Grossman (2003) stated that in Mexico farmers chopped the pruned materials and coffee tree broken branches and left them on the soil surface after removing the usable firewood for home cooking. They left pruning material specifically for their fertilization potential. Farmers had a good understanding that leaf material decomposed, releasing nutrients into the soil substrate.

6.2.4.2 Weeding

Almost all farmers in this commune practice manual weeding, the number of weeding depends on the actual weed situation in different gardens. Table 21 indicates most the contact farmers 71 percent did hand weeding for mature coffee three to four times $year^{-1}$ compared with 48.5 percent of the non-contact farmers. This operation was mostly done in the period of May to October in the raining season. Hand weeding was one of the activities that required high labour inputs. The labour days spent were not so much difference from both groups, it was at 36 and 34.4 labour day respectively, it was however, a high percentage of the non-contact farmers did weeding five to six or more than six times $year^{-1}$. It means that their coffee plots seem to have higher weed infestation. This can be explained that the non-contact farmers spent less on enlarging irrigation basin and pruning or less intercropping with other crops, or poor growth that can suppress weed emergence growth.

Table 21 Frequency of hand weeding as practised by coffee farmers

Number	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
<= 2	5	16.1	9	9.1
3 – 4	22	71.0	48	48.5
5 - 6	4	13.0	25	25.3
> 6	0	0.0	17	17.2

Source: Survey, 2002.

6.2.4.3 Harvesting and post harvesting

Harvesting was the most time consuming activity on coffee production. It comprised 38.8 percent, and 46.8 percent of total labour respectively 129 and 127 person day ha^{-1} for two groups of farmers (in Table 19). The length period from flowering to ripening is influenced by the temperature, altitude, and status of the coffee plot, whether it is exposed or sheltered. But, robusta coffee often takes between ten to eleven months from flowering to ripening. As the characteristic physiology of robusta coffee, ripening is concentrated on one month so inadequate labour status often occurs during the November or December for all farmers. However, farmers were seldom hiring outside labours. They harvested themselves or exchanged with their closed relatives because of high cost for temporary labour paid on piece-work period and they controlled of their own coffee plantation needed to ensure that it is not damage to coffee trees, such as the branches of the trees were not broken or the leaves torn off, and a minimum of dirt, stones or leaves was included with the crop.

Coffee was harvested either as ripe cherry or as cherry, which has ripened and then dried out. The cherries of the red fruit were picked up when they were bright red all over, glossy in appearance, firm but not hard when pressed in the fingers, which can squeeze the beans from the pulp without pressure. The crop was usually picked into baskets, flatted or slightly curved to fit the body, or into reaping pockets made

from half jute bags carried on the body. This leaves both hands free to work simultaneously, some puts baskets on the ground into which they throw the crop.

Immediately after the cherries were harvested, post-harvesting also consumes a lot of the farmers' labour. Table 19 also indicates that this step included drying and husking, it needs about 6.1 percent of total labour spent for both groups equivalent to 20 and 16 person days ha^{-1} respectively. Sun drying was the most common and only processing method used for years since it is cheap and simple. The berries were spread thinly on any available flat surface, such as cemented flour, woven mats, sacks, or even on the ground to remove the unwanted mucilage, pulp, skin, husk and parchment and then obtain the dry coffee beans. The beans were given a further drying in the sun until moisture content was reduced down at 11 to 12 percent moisture content for storing or selling. Similar to Kenya, dry processing is the simplest techniques for processing cherries. After harvesting, the coffee cherries are dried to about 10 to 12 percent moisture content. Thereafter, the coffee beans are separated by moving the material covering the beans (outer skin, pulps, parchments and silverskin) in a de-hulling machine (Saenger *et al.*, 2001). This is similar to the report by Brand *et al.* (2000) in Brazil where is the largest producer of coffee in the world, contributing appropriately 25 percent of the world' s products also use sun dry-processing method that has resulted in coffee husk as the main residue in about 40 percent quantity to be returned to the coffee systems.

6.3 Intercropping in coffee production

In the past years, designing coffee farm exposed under sun was a desirable system of coffee state farms and individual farmers who thought that sun coffee farms produced higher yield and easier management than intercropping systems. However, in recent years, this perception has been a little bit changed on farmers' practices. Many coffee growers would like to develop their coffee farms under intercropping coffee with other crops, such as fruit trees, shading trees, black pepper, and cover crop etc. aimed to reduce the external and internal risks in production and stabilizing income, product diversification, labor generation and prevention from soil erosion.

Farmers reported that the intercultivation on coffee garden during the first three years were mainly with rice, beans, maize. These crops help supplement additional income to offset against the initial cost of establishing coffee. Once the coffee trees starts bearing fruits, intercropping is less popular. However, in recent years, most of the coffee growers have been faced with the simultaneous risks of drought, soil degradation, yield reduction, pest and disease outbreak etc., coupled with the falling coffee price in the world market. Current price is somehow lower than the costs of production, therefore, whether intensification practices occurred without consulting from extension, resulting in great income loss to coffee growers. So farmers were practicing intercropping coffee plantation with other crops aiming to stabilize income and productivity by following appropriate technologies, such as suitable or incompetent species, wide spacing enough to permit the normal growth of main crop coffee or how to improve soil conservation and other management practices were recommended from the extension agents in recent years.

Table 22 Common component crops in the coffee intercropping systems

Crops	Contact farmer (n = 31)		Non-contact farmer (n = 99)	
	Average No	Percentage	Average No	Percentage
Economic crops				
Cashew	0	0.0	8	8.0
Pepper	12	38.7	22	22.2
Fruit trees	17	54.8	36	36.4
Annual crops	2	6.5	11	11.1
Coffee monoculture	4	12.9	42	42.4
Soil conservation				
Cover crops	12	38.0	3	3.03
Crotalaria spp.,	8	25.8	2	2.0

Source: Survey and observation, 2002.

The size under intercropping currently is, however, not large enough to make significant contribution to farmers' income because the farmers have started planting

as intercropped during the pass four to five years within small percentage as compared to the coffee domination area. Except the product of black pepper, fruit trees, cashew, crotalaria spp., shading trees, other intercrop products were purely grown for home consumption.

Table 22 presents six different species of crops that farmers were interplanting with coffee plantations at the study site: cashew, pepper, fruit trees, annual crops, crotalaria, and cover crop, of which fruit trees consisted of mango, rambutan, avocado, soursop and black pepper trees were popular for both groups. There were 38.7 percent and 54.8 percent of the contact farmers who intercultivated pepper and fruit trees on coffee gardens as compared to 22.2 percent and 36.4 percent of the non-contact farmers respectively. Those crops planted as boundary for the coffee garden for windbreak purpose or planted at uproot coffee areas with low yield or pests and diseases destroyed. The fruit trees seem preferable to both groups as its long-term economic benefit. The contact farmers tend to be more concerned about intercropping than the non-contact farmers. In average 12.9 percent of the contact farmers kept their coffee gardens as pure stand or mono-coffee compared to the non-contact farmers up to 42.4 percent. During the bearing period, farmers paid less attention to annual crops as they said these crops made high competition nutrients and water with coffee and interfere with the cultural operations. Just a few 6.5 percent and 11 percent respectively of both groups planted some kind of bean crops like groundnut, green bean or soybean to supplement the crop residues for coffee.

As Grahama *et al.* (2000) stated that soil organic matter declines rapidly with mono-cultivation crops in tropic countries lead to lower fertility, diminished soil structure, water holding capacity and biological activities. Alternate approaches that integrated legumes or other crops in to the coffee system is needed to maintain the balance among nutrients. As coffee gardens currently were in severe of soil degradation but both groups of farmers, especially the non-contact farmers were less concerned about planting leguminous crops like crotalaria or other cover crops to conserve the soil erosion and improve soil fertility. There was 25.8 percent and 2 percent of the contact farmers and the non-contact farmers planted crotalaria spp., as

well as 38 percent and 3.03 percent of farmers respectively planted cover crop. Farmers, who planted crotalaria spp., indicated that this crop was planted in lines midway between the coffee lines, and it develops very fast, they planted for shading or keeping moisture in dry season for coffee trees. Crotalaria is, however often cut back regularly otherwise it quickly grows into coffee trees, the cutting leaf is returned back to the coffee plantations for decomposition or dies naturally, the nutrients therein are cycled. There may be a benefit in this process in that the nutrients are converted into an organic form in which they are easily available for coffee. Burke (1975), cited in Clifford and Willson (1985) evaluated a series of leguminous crops, which have been properly planted, will provide nitrogen by fixation of atmospheric nitrogen. Similar to the experience stated by Graham *et al.* (2000) found a number of legume or cover crop species also had value in erosion control due to both their deep rooting and rapid ground cover. Farmers' reason for intercropping was that there was intensification of crops on a unit of land generating more output per unit of area at the same level of labor input while the yield of coffee was not affected. At the same time, especially if the intercropped were leguminous, it would enhance the soil fertility, which was line with recommendations from extension to intercrop crotalaria or beans with coffee.

6.4 Inputs application trends

With the increasing international and national concern on the environmental impact, environmental issues and production costs were also given due consideration in this study. Farmers are typically more concerned with the year's crop than with the ill effects on soil degradation, soil erosion or exhausting of water resources in the future. Therefore, in coffee production, environmental issues and production costs are mainly considered by looking at the application of chemical fertilizers, water resources, and pesticides used.

Table 23 shows that the trends in application of inputs of two groups of farmers. Of which, there were completely difference between two groups on fertilizer usage. The contact farmers 58 percent seem to reduce the amount of fertilizers

compared to the non-contact farmers 26 percent, whilst 6.5 percent of the contact farmers increased the amount of fertilizer compared with 39.4 percent of the non-contact farmers. Most the non-contact farmers in the study area seem to increase the rate of fertilizers use over the years at the same farm size. The exact proportion of chemical fertilizers used on coffee production in the previous years was not known, but it was enough evident to know that the application of chemical fertilizers keep increasing across the study area, especially for the non-contact farmer group.

Table 23 Changes in input use in coffee production during 1998 - 2002

Rates	Fertilizer percentage		Water percentage		Pest control percentage		Manure percentage		Labor percentage	
	CF	NCF	CF	NCF	CF	NCF	CF	NCF	CF	NCF
Increase	6.5	39.4	38.7	49.5	16.1	39.4	22.6	21.2	83.9	41.1
Decrease	58	23.2	25.8	14.1	54.8	21.2	65.4	44.4	6.5	23.2
Same	29	30.3	32.3	24.2	29.0	35.4	12.9	28.3	9.7	28.3
Not know	6.5	7.1	3.2	12.1	0.0	4.0	0.0	6.1	0.0	7.1

Source: Survey, 2002. CF: contact farmer (n = 31), NCF: non-contact farmer (n = 99)

Exploiting ground water was the major source for irrigating coffee in the study area, the farmers do not know in the long-term it would seriously deteriorate the ground water resource and caused the environmental problems. Both groups tend to increase the amount of water usage. Farmers reported that the reasons for increasing due to the fluctuation of climate changes and they though that the more irrigated the higher yield. Up to 38.7 percent and 49.5 percent of farmer from both groups increased using water for coffee whilst 23.2 percent and 25.8 percent reported decreased the water quantity used.

Another different inputs application between the two groups of farmers was insecticide for pests and diseases control. The contact farmers tend to reduce the use of chemical pesticides compared to the non-contact farmers. There was 54.8 percent of the contact farmers reported that they had reduced using the amount of chemical

pesticides as compared to previous years and only apply the chemical pesticides when the pests and diseases affects yield reduction but there were still about at 16 percent of farmers increased the use of chemical compared with 39.4 percent of the non-contact farmers. The all above inputs application a part lead to increase the labor using, that was why the labor increasing for most farmers from both groups respectively 83.9 percent and 41.1 percent. The contact farmers reported that they spent the higher labor on pruning and enlarge irrigation basal to control soil fertility and prevent the water loss from erosion.

6.5 Information access

This section will analyze how farmer had access to the information sources need to be supported for their coffee production. The section is divided into three sub-topics: Technology, credit, and market aspects.

6.5.1 Information approaching on improved technological aspects

There were many credible information sources relating to agricultural knowledge that was common in the study site with focus special on coffee production that farmers can access. They were not only directly obtained from extension agents but also from the contact farmers provided, television, radio, neighbors, technical extension bookcase or even salesman. Respondents were asked during the survey about their common sources of information on coffee techniques that they frequently seek. The respondents' identification of their personnel common sources of information is described in Table 24. Result indicated that all the contact farmers receive information from the extension staff compared to 3.0 percent of the non-contact farmers, 19.4 percent of the contact farmers reported listen to radio compared to 21 percent of the non-contact farmers, it seems that the contact farmers were eager to obtain the information from television at 61 percent higher the non-contact farmers at 29 percent.

The non-contact farmers tend to get information from salesman, television, radio, and from contact farmers. Between radio and television, television was more preferred by farmers but they said that the contents were presented too fast and difficult for them to understand, especially the technical items. High percentage of farmers listen to radio or TV on extension programs seem as an indicator of the farmer's interest in seeking agricultural information and farmers are eager to learn new knowledge. It illustrates that the extension staff were not only provide information directly to the farmers, but also indirectly provide information through other channels. Of which, the highest percentage of the non-contact farmers reported getting information from the contact farmers of 34.3 percent. This was attributed to the impact of the extension system and it affirms the sustainability of the extension system in DakLak province as Vietnamese Government can not afford to employ the number of extension workers needed to cover the whole rural population. As mentioned above, the extension staff could not cover all the farmers frequently in their area during each of their visit. Therefore, the villagers were requested to nominate somebody among themselves to be the contact farmers. The extension education must be through the contact farmers, who help to disseminate the information and ideas to their neighbors and voluntary serve as a liaison between extension workers and farmers.

Table 24 shows the highest percentage of the non-contact farmers informed receiving the technologies from the contact farmers 34.3 percent, it is clear that the contact farmers were able to participate along with the extension agents in agricultural development and dissemination process of the improved coffee techniques. This indicates scope for increasing their participation to full and active partnership in technology development at the study area. The result finding is likewise to the experiences stated by Benor *et al.* (1984) that technical advise spreads from the extension agent through the contact farmers, who follows the extension agents' advise to large number of farmers by other to see what the contact farmers try in their fields and the results they achieve or the contact farmers talk about the practices he has been taught to their neighbors, relatives, friends, and help them understand and adopt the recommendations. In this way, a large proportion of farmers can quickly reach.

Scoones and Thompson (1994) stated that the key identified farmers could serve as resource persons for workshop based on farmer-to-farmer interaction and discussion. Such workshops are intended to identify common knowledge, information and experiences, verified and validated by a group of farmers. The role of outsiders is to facilitate the process and synthesize valuable outcomes or sharing ideas.

Table 24 Source of information on coffee production

Source of information	Contact farmer (n = 31)		Non-contact farmer (n = 99)	
	Average No.	Percentage	Average No.	Percentage
Extension agents	31	100.0	3	3.0
Contact farmers	0	0.0	34	34.3
Radio	6	19.4	21	21.1
Television	19	61.3	29	29.3
Neighbor or relative	0	0.0	27	27.3
Extension bookshelves	10	32.3	15	15.3
Salesman	0	0.0	20	20.2

Source: Survey, 2002.

The Relatives, contact farmers or salesman were the main information sources for the non-contact farmers. Those sources, however, did not pay attention much to the contact farmers groups since the contact farmers said paying more attention on getting information direct from the extension staff or indirect from TV, radio or extension bookshelves.

Results in Table 25 indicates that 100 percent of the contact farmers had access to the extension staff within every month through both visit by the farmers themselves to the extension office or during the extension programs were organized at their villages. Both groups often listen to the extension programs on radio and TV within every week and every month. Farmers get information from the extension bookshelves within every week because of opening every one-day a week.

Furthermore, the non-contact farmers somehow get information from salesman within every two months at the time of buying the material inputs like fertilizers, pesticides or other relevant inputs.

Table 25 Frequency contact information from different sources by coffee farmers

Sources of Information	Contact farmers (n = 31)			Non-contact farmers (n = 99)		
	EW	EM	ETM	EW	EM	ETM
Extension agents	-	100	-	-	3.0	-
Contact farmers	-	-	-	20.2	14.1	-
Radio	6.5	12.9	-	8.1	13.1	-
Television	29.0	-	-	29.3	-	-
Neighbor or relatives	-	-	-	-	27.3	-
Extension bookshelves	32.3			15.3	-	-
Salesman	-	-	-	-	-	20.2

Source: Survey, 2000. EW: Every week, EM: Every month, ETW: Every two month.

6.5.2 Credit access on coffee production

Agricultural economic development in the rural areas of Vietnam depends on a number of factors, like extension system, infrastructure, communication, market, credit facilities etc. Parallel to the need for appropriate agricultural technologies, the provision of credit is indispensable for farmers to increase the efficiency in agricultural production and their family's income. Swanson *et al.* (1997) stated that access to credit is one of the ways to improve farmers' access to improved technologies and increase productivity, farmers' ability to purchase inputs, are particularly important. There were two major types of credit in the study area, namely the formal credit source called the Vietnamese Bank for Agriculture and Rural Development (VBA), and from the non-formal sources such as, friends, relatives, other farmers, private money lenders, traders, women credit fund etc.

Table 26 Access to credit from different sources by coffee farmers

Credit sources	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
VBA	28	90.3	60	60.1
Women refund credit	13	41.9	9	9.1
Money lenders	-	-	23	23.2
Traders	-	-	32	32.3
Relatives/other farmers	-	-	20	20.2
Average	1.32		1.45	

Source: Survey, 2002.

Table 26 indicates that 100 percent of the contact farmers versus 95 percent of the non-contact farmers took loans for coffee production from different available credit sources. High percentage farmers of both groups borrowed from the VBA. Up to 90.3 percent of the contact farmers compared to the non-contact farmers 60 percent, those farmers somehow also borrowed from other credit sources. The interest rate was being used of the VBA in one percent month^{-1} for loan duration within one year and the loan size depend on farmers' size, ranged from 340 to $1300. Just few farmers complained about difficulties in approaching the credit channels, especially the VBA sources because most of their land was granted the red books so that they had right to use their land as collateral for loans with reasonable interest rate. The data clearly shows that the loans provided by formal credit sources had played an important role to meet the credit demand of the coffee farmers in the study area.

Nevertheless, a high percentage of the non-contact farmers still depend on the informal credit sources like moneylenders, traders, and relative at 23.2, 32.3 and 20.2 percent respectively. These sources require high interest rates ranged from two to five percent month^{-1}. For those who did not borrow any money, some were afraid of having no ability to pay back the loan because of the fluctuation of coffee price on the world market. The others had either the capability for self-financing or they did not

have any plans for investment on coffee. The rest of the farmers who did not have access to the VBA said that they did not know how to pass the procedures of the bank to borrow loans or they did not know how to make yearly plan production activities. It is at present very risky for them because the low price of coffee, their capacity to return loans is very low, and finally took time to get loans for their urgent needs and indefinitely. The opinions were that they did not understand how the formal monetary system works, planning production activities, and the service as a handy, flexible, or long term of informal sources. The result indicates similar to the experience stated by Watts (1984) that the private moneylenders were the preferable source by the non-contact farmers even though exorbitant rate was charged. Ekasingh *et al.* (2001) also stated that the most important credit sources for farmers come from the Agricultural Bank and Agricultural Cooperatives (BAAC) and merchants. However, credit from BAAC was found not to be adequate for farmers' needs and thus farmers had to borrow from merchants with further higher interest rate but easily obtained procedures like lending farm inputs to farmers charging the interest in the higher priced inputs or directly lending actual money to farmers.

In average, the contact farmers borrowed from 1.32 credit sources compared with the non-contact farmers 1.5. It means that the non-contact farmers based more on external sources with higher interest rate compared with the contact farmers, who had more opportunities to access the formal credit sources, which were introduced by the extension agents. Aside from that, the contact farmers were organized themselves into groups to set up the refunding credit so each participants of the groups had a change to borrow from their groups' sources, the farmers then required to repay both loan and interest to the groups at the appropriate time but generally within a year of borrowing.

6.5.3 Market access on coffee production

The most important factor that influenced the coffee production was the institutional arrangement, the roles of public and private sectors within the study area. One of the institutional arrangements was the market for coffee productivity and its inputs. The main inputs for coffee production included fertilizers, pesticides, oil for

irrigation and other facilities were bought in credit or indebt from local merchants or the traders outside the commune. Since coffee growers had little capacity to process and sell their own coffee to the big markets so that the local marketing channels operated by private middlemen, who were currently the most important channels at the study area. They acted as village collectors by directly collecting coffee from other farmer and selling it to inter-village middlemen. Farmers reported that their coffee price was still very low as compared to the free market because their productivity has to go through many middlemen.

Other farmers took their products themselves to the processing plants or traders. Those farmers were quite satisfied with the marketing arrangements. However, they complained about the instability in prices. Great uncertainty and sharp fluctuations in the price of coffee affected the ability of farmers to allocate resources efficiently. As the fluctuation of coffee price in the world market, farmers in this commune often sell a part of their productivity afterward to invest back for the next crop or return the debt for the bank. The rest of storage was held in the storehouse waiting for higher price. As green coffee is susceptible to changes the color or even flavor affecting at elevated temperatures or in conditions of high relative humidity. As a consequence, the mould growing on beans was a particular hazard, black beans arising, and insect damage. Resulting holes in the beans also occur during unsanitary storage and caused price reduction and less competition in the market. Resulted coffee growers suffer much loss from reduced value and low price.

Table 27 Marketing channels for coffee production

Market channels	Contact farmer		Non-contact farmer	
	Average No.	Percentage	Average No.	Percentage
Middlemen at farm gate	0	0.0	27	27.3
Agents within commune	9	29.0	56	56.6
Outside commune trades	22	71.0	16	16.2

Source: Survey, 2002.

Table 27 indicates the agents within the commune like traders, shop retailers, collectors, and outside commune, such as bigger agents or traders were the main marketing channels for coffee farmers in this commune. Farmers reported that selling for outside commune agents got higher price selling for agents at their own commune. There were differences in approaching the market channels between two groups, the non-contact farmers often sell their products to agents within commune and middlemen at the farm gate respectively 56 percent and 27 percent whilst the contact farmers found further agents outside the commune. Based on the farmers' reporting, it can be concluded that there was a significant impact from the extension agents for the contact farmers through introducing the information sources or how to access to the market channels. With better market information, farmers can shorten the marketing channels i.e. through middlemen lead to reducing market costs and increasing their income. There is, however, 71 percent of the contact farmer informed sold their productivity with higher price for the agents outside the commune. It thus can be concluded that the contact farmer group was proved to have contributed to increasing economic return in term of marketing price else.

6.6 Farmers' constraints on coffee production

Table 28 presents the common constraints faced by farmers on coffee production. Both groups of farmers commonly reported seven main types of constraints. Of which, pricing for their output and irrigation systems were illustrated as the most difficult faced by both groups of farmers, whilst only 6.5 percent of the contact farmers reported lack of the technical knowledge compared with 70 percent of the non-contact farmers. It means the non-contact farmers seem to be lack of knowledge or information on how to apply the fertilizers, how to prune, and how to control the pests and diseases outbreak on their coffee gardens as well as inadequate knowledge on how to make a strategic plan on agricultural production activities for getting credit from the bank or access the marketing for their productivity.

Table 28 Common constraints of respondents on coffee production

Constraints	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
Technical knowledge	2	6.5	70	70.7
Pests & diseases outbreak	4	13.0	45	45.5
Low output's price	28	90.3	95	96.0
Credit sources access	0	0.0	25	25.3
Irrigation system	25	80.6	94	94.9
Marketing for outputs	5	16.1	50	50.5
Biennial bearing	3	9.7	56	56.6

Source: Survey, 2002.

Another aspect which most the non-contact farmers 56.6 percent reported about the biennial bearing rhythm whilst less percentage of the contact farmers 9.7 percent reported to have faced with this issue. Wrigley (1988) proved that robusta coffee is very prone to biennial bearing, which can only be reduced by careful pruning. In a high-yielding year the trees sacrifices the production of next year's bearing wood for the demands of the developing crop so that the next year's crop is small as the tree concentrates on vegetative growth, which produces another good crop for the following years, thus, rhythm of biennial bearing is established. Clifford and Willson (1985) explained that the overbearing could lead to exhaustion of nutrients within the tree, which are restrict the vegetative growth, thereby reducing the number of buds available to flower in the following years. Vegetative shoot often cause die-back phenomenon when the nutrients in the leaves and stem have been transfer to the fruits. It is, therefore, important to maintain the balance between cropping and vegetative growth by considering amount of cropping wood to be pruned away at the beginning of the good years and to be maintained the balance of nutrients application.

As the mass development of coffee plantation planted in large-scale area during the past years, and most coffee areas were grown by unselected seedlings resulting in a high proportion of trees, which produced low yield, small bean size, susceptible to leaf-rust diseases, non-uniform ripening, and the tree has not produced as its potential yield. The coffee gardens of the non-contact farmers seem to have more pests and diseases outbreak than the contact farmers. This can be explained by less pruning, imbalanced fertilizers application, or wrong pesticides and insecticides application of those farmers compared to the contact farmers.

Because of the limited capacity of industrial processing plans to take over the coffee productivity. Therefore, most coffee farmers were currently processing it by sun dry to remove the unwanted mucilage, pulp, skin, and parchment to obtain the dry coffee beans by using of local-made dehusking that cause high rate of broken beans and off-flavours. Adding with black beans, mould beans, and excess moisture beans often resulted from sun-based drying in bad weather conditions so that the coffee growers suffer much loss from reduced value and low price at the farm gates else.

In brief, the important constraints faced by both groups of farmers were low price of their outputs and inadequate water but the non-contact farmers faced more problems on lack of knowledge, credit and market access on coffee production.

6.7 Adoption of recommended technologies

This section will explore the adoption of technologies with special focus on the contact farmers, who were trained the technological packages on coffee production by measuring the acceptability index among the individual recommended practices.

6.7.1 Adoption analysis

Hildebrand and Poey (1985), cited in Norman *et al.* (1995) stated that the measurement of adoption of technologies disseminated from the extension agents

through index of acceptability (I_a) as considered an important indicator to quantify the impact or the return from the extension investment.

Dejene (1989) stated that an extension agent is ultimately responsible for teaching farmers how to adopt improved recommendation technologies that lead to improve yield, income and general well-being and finally giving feedback to researchers on the farmers' responses to the recommended practices. Of which, the yield attained by farmers as the result of adoption of improved practices. Hussain *et al.* (1994) stated that the farming system under study, the adoption of new technologies and practices are being recommended by the extension service is considered as a necessary condition for increasing productivity.

The concept of adoption in this study is used to refer to the farmers' decision of whether to use agricultural technologies irrespective of the levels at which the technology are used. Mosher (1978) found that extension activities had a marked impact on farm production only within those localities in which production could be increased by adopting and extending the use of technologies already recommended from the extension agents.

6.7.2 Adoption rate and index acceptability

As mentioned above, there was 31 farmers (23.8 percent) in the study area have participated on the extension programs called the contact farmers. These farmers were interviewed deeply about their practical application followed the recommended technological components from the extension agents. They were asked if they were using the recommended technologies for their coffee garden or not. If so, on what proportion area has applied for their coffee gardens, results are shown in Table 29.

Table 29 Index acceptability on recommended technological components

Technological components	Contact farmers (n = 31)				Index acceptability (percent)	Rank
	Farmers Adoption		Adoption Scale			
	%	Rank	%	Rank		
Fertilization	77.4	3	61.2	2	47.4	2
Grafting	87.0	2	0.99	5	0.86	5
Pruning	100	1	83.7	1	83.7	1
Pest and disease control	64.5	4	55.8	3	36.0	3
Irrigation	58.0	5	51.1	4	29.7	4

Source: Survey, site observation, 2002.

The adoption was operationalized using parameters like different adoption rate, such as percentage of the contact farmers adopted components of coffee technology packages related to fertilization, propagation, pruning, pest and disease management, and irrigation. The proportion of total coffee area was covered by recommended technologies (quantity of fertilizer, water resource, pesticide, insecticide, grafted areas etc.), and finally overall adoption index through average number of technology components adopted by the contact farmers. Doss and Morris (2001) defined that the rate of adoption as the proportion of farmers to a given technologies regardless of the level use and the intensity or scale of adoption defined in terms of the level usage of the technologies on the proportion of the farmers' land followed the given technologies.

The result from survey indicated that almost the techniques were applied by farmers, of which, pruning was the favorable component. This technique needs not only the time but also the farmers' skills and it requires farmers have to repeat the practices in the fields. Then, followed by grafting, fertilization, pest and disease management, and irrigation. However, overall index of acceptability were completely different among the recommended components. IA illustrates that pruning was ranked

first, followed this was fertilizer application, pests and diseases management third, irrigation fourth, and finally grafting respectively.

There were 100 percent of farmers followed the pruning component guided by the extension agents as they said that they were trained how to prune coffee in the field practically, which parts of the tree will be cut, and which parts will be remained for the next crop and how to shape the tree proportional whilst it has been rarely practiced before because they regretted to cut off the secondary branches, and they somehow did not know that the robusta coffee rarely flowers more than once at any previous season node again. Some did not prune because of high time-consume, skilled labor requirement, and ignorance of benefit from pruning.

The grafting technique was also concerned and accepted by most farmers at 87 percent, but the application of this technique on the field was very limited with the I_a was less than one percent (in Table 29). There were many reasons that farmers explained for less I_a value of grafting component. First, the farmers need some time to practice, as it was difficult to graft with a highly successful ratio due to incompatibility of scion and rootstock. Second, there were not available of good scion to graft the low yield trees. Finally, most farmers said that they regretted cutting the trees, which can produce fruits for next crop. Another reason, where a large number of farmers who were following the technology and they have applied on a small portion of the area, this indicate that farmers still testing the technology and they have not yet convinced that it should be adopted the technology as a component of a more complex cropping system. An additional survey in the following year may be valuable in assessing the adoption, or some modification may be necessary to promote the adoption.

The fertilizer technique was also applied and accepted by almost farmers, 77.4 percent with the I_a value at 47.4 percent (in Table 29). The adoption rate of fertilizers application was concerned mainly on influence by the knowledge that reducing the amount of fertilizer, the balance nutrients application than their normal practices or not apply fertilizers at the susceptible time like heavy rain or sunshine to reduce the

loss from drainage and evapo-transpiration process. Some farmers did not apply or just a parcel of their coffee area as they said that the recommendation ratio was low compared to coffee trees' requirement. Aside from this, the fertilizer application was divided many times, thus, it needs more farmers' labors.

As robusta is very prone to pests and diseases pressure so fungicides and insecticides need to be used often on coffee production. It is, therefore, not surprising that the I_a index 36 percent was not so high compared to other components. The farmers actual followed the extension recommendation at 64.5 percent (in Table 29). The adoption of pests and diseases management was mainly influenced by the knowledge that determining the amount of pesticides, the dose and the kinds of labels which used compared to their normal practices or not applying at the susceptible time like the development of beneficial insect or even at the heavy rain. Farmers said that they would like to follow the extension agents but in a certain area to see what was going on to their coffee gardens. The rest of the bigger area, they used more pesticides or another labels with higher dosage to control pests and diseases.

Compared with the other techniques, irrigation was the less applicable by farmers at 58 percent. The adoption rate of irrigation management was concerned mainly on influenced by the knowledge that reducing the amount of water than their normal practices or irrigate in the susceptible time to promote the uniform flowering and successful pollination process. With I_a index was 29.7 percent, the farmers reported that they used more water than the amount of recommendation from the extension agents. Some reported that the coffee gardens were evaporated fast as no shading and less intercropped with other crops. Others reported the more they irrigated the higher the yield got.

Table 29 illustrates a wide variation in adoption of the several components within the contact farmer group. This implies that farmers did not adopt the technologies as a package that was promoted by the extension agents, but rather in a selective and piece-meal manner. Result from the survey found that there were 38.7 percent of household in total of 31 adopted all five technological components,

followed 32.3 percent adopted four components, 13 percent adopted three components, 6.5 percent adopted two components, and 9.7 percent adopted one component. The result is similar to the findings regarding selective adoption were reported in a study in Mexico (Bylerlee *et al.*, 1986), and Floyd *et al.* (2003) studied in Nepal found that only 10 percent of households were multiple-technology adopters mean adopting technological package while 60 percent adopted two and less than 30 percent did not follow any of the technologies. Pretty and Röling (1997) stated that there was a few farmers able to adopt the whole modern packages of production without considerable adjustments. Parts of the problem was that the most agriculture research and extension still occurs on the research station, where scientists experience conditions quiet different from those experienced by farmers.

In brief, the Acceptability Index analysis showed that the adoption of technological components was not uniform among farmers, and it indicated having a good chance of acceptance by the farmers. Pruning received the highest adoption of 83.7 percent, followed by fertilization 47.4 percent, pest management 36 percent, irrigation 29.7 percent, and grafting 0.86 percent.

6.8 Farm performance

The level of output is the main factor determining the benefit of coffee farm enterprise, through the yield level is depended on many socio-economics and biophysical components of the system, both within and outside its boundary. This section attempts to analyze the benefits accrued from coffee production of two groups of farmers, of which, the yield variability and yield gap were recorded to prove the stability of the systems and the gross margin analysis was also used to compare the profitability of those farmers who had access to the extension agents with the non-contact group.

6.8.1 Yield variability

Table 30 shows an annual series set of data on coffee yield ha^{-1} of two groups of farmers for the last four years from 1998 to 2001. In average, the contact farmers harvested 3.04 ton of dry bean ha^{-1} compared to 2.65 ton ha^{-1} of the non-contact farmer. The growth rate was different from both groups of farmer; the contact farmers maintained continuing increased coffee yield through years as compared to the yield fluctuation of the non-contact farmers group had. The non-contact farmer group harvested 2.4 ton ha^{-1} in 1998 in average increased up to 2.9 ton ha^{-1} in 1999. It was, however, down to 2.5 ton ha^{-1}, and increased a little bit in 2001 at 2.80 ton ha^{-1}.

Table 30 Variability of coffee yield of contact, non-contact farmers (dry bean ton ha^{-1})

Year	Contact farmer (n = 31)		Non-contact farmer (n = 99)	
	Yield	Growth rate percentage	Yield	Growth rate percentage
1998	2.75	-	2.40	-
1999	3.02	1.09	2.90	1.2
2000	3.11	1.03	2.50	0.9
2001	3.29	1.04	2.80	1.1
Mean	3.04	-	2.65	-
SD	0.23	-	0.24	-
CV	7.40	-	9.05	-

Source: Survey, 2002, SD: standard deviation, CV (percent): coefficient of variation

Table 28 shows the value of CV of two groups of farmer obtained from four years period recorded at 7.4 percent and 9.05 percent respectively. As the proposal of McConnell and Dillon (1997), who use the coefficient of variation (CV percent), which expresses the standard deviation (SD) of a sample of observation on variables as a percentage of the sample's mean value to measure the stability of different activities or systems. The larger the value of CV obtained, the higher degree of

instability of activities proved. It illustrated us that the coffee yield of the contact farmer group was more stable than the non-contact farmer within the past four years.

6.8.2 Yield distribution

Coffee yield of farmers harvested in the year 2001 are presented in Table 31. On a category basis, yield of the contact farmers ranged from two to more than four tons ha^{-1} with an average of 3.3 ton ha^{-1} of dry coffee bean compared with the non-contact farmers an average of 2.8 ton ha^{-1} varied from two to four ton ha^{-1}. Huge variation in coffee yield among the farmers occurs, with yields ranged from two ton to more than four ton ha^{-1}. The overall means of coffee yield of the two groups of farmers were significantly difference ($p<0.01$). This seems to be a large potential for narrowing the yield gap among the farmers.

Table 31 Yield gap distribution among contact and non-contact farmers

Coffee yield dry bean ha^{-1}	Contact farmers (n = 31)		Non-contact farmers (n = 99)	
	Average No.	Percentage	Average No.	Percentage
<1	0	0.0	0	0.0
1 – 2	1	3.2	0	0.0
>2 – 3	1	3.2	96	96.9
>3 – 4	28	90.3	3	3.03
> = 4	1	3.2	0	0.0
Average***	3.3		2.8	

Source: Survey, 2002. *** Indicates significantly difference at 0.01 determined by two-tailed Student's t-test.

The result from survey shows that the farmers who applied high amount of inputs, especially chemical fertilizers, do not necessary had higher yield than the other farmers using less even at lower levels of inputs used, the yield also differed from among farmers using the same amount of these inputs. This implies that advise farmers through the extension programs in making better decisions in input use and

crop management will significantly improve the overall efficient attempt in coffee production. Most the contact farmers of 90.3 percent harvested yield in the interval of more than three ton ha^{-1} $year^{-1}$ compared with the non-contact farmers just 3.03 percent, the rest of the non-contact farmers harvested in the interval from more than 2 to 3 ton ha^{-1} $year^{-1}$.

6.8.3 Farm performance efficiency analysis

Output is one of the most important indicators to assess the performance of a system. It is primarily a measurement of the relative adaptability of a system or activity in a particular agro-ecological environment. On commercial farms, it is an indicator of relative efficiency of resource use and management performance. On non-commercial farms, productivity plays a very important role in achieving family sustainability. Production beyond what a family can consume or store or barter becomes irrational or may even be undesirable (McConnell and Dillon, 1997).

To better understanding about the efficiency of coffee production and to compare the performance of both groups of farmers, a gross margin (GM) analysis was performed. It was computed by simple subtracting the total revenue (TR) earned, deriving from the coffee yield multiplied by the unit price of coffee, with the total variable cost (VC) included the cost of fertilizers, irrigation, pesticides, manure, bio-fertilizer. Adding fix costs that consists of land tax, and the depreciation costs obtained from tractor, well, establishment, irrigation pump, interest of fix cost.

The result was demonstrated in the Table 32 with the average price of inputs and coffee productivity based on local traders, while other like intercropped products were based on local market price. According to traders at the commune, the prices of all kinds of inputs and outputs were quite stable in the past four years except the coffee price that fluctuated from 0,4 to \$0,7 kg^{-1} during the past four years.

Table 32 Costs and economic return for contact, non-contact farmers, $ ha^{-1} year^{-1}.

	Items	Contact farmer (n = 31)	Non-contact farmer (n = 99)	Calculate t
A	Return			
	Coffee	2,155	1,829	6.418***
	Intercropped products	211	112	4.954**
	Total gross return	2,366	1,941	10.0285***
	Cost			
B1	Total variable costs	526	604	-3.9048**
	Chemical fertilizers	230	299	-6.017**
	Manure fertilizer	25	14	2.156*
	Bio-fertilizer	46	28	3.505***
	Irrigation	206	229	-7.735***
	Pest control	19	34	- 17.1727***
B2	Total labor cost	436	358	13.081***
B3	Total fixed cost	310	310	6.553ns
B	Total cost	1,272	1,269	6.333*
C	Gross margin (A – B1)	1,840	1,336	43.883***
D	Farm return (A- B)	1,095	669	16.375***

Source: Survey, 2002.

***, **, *, ns Indicates statistically difference at 1%; 5%, and 10% levels and non-significant difference determined by two-tailed Student's t-test., the result is attached in Appendix IV.

Coffee is a crop that requires very high production cost. The average total production costs of two groups were not much difference, $1,272 ha^{-1}year^{-1} for the contact farmers, and $1,269 ha^{-1} for the non-contact farmers within one year production. These costs included variable cost, fixed cost and family labor. Of which, farmers spent much particularly on variable costs, respectively 41.3 percent and 47.5 percent of the total cost, followed as second cost derived from labor at 34.3 percent and 28.1 percent, fixed cost was ranked as third with the same at 24.3 percent for both

groups. For the fixed cost, according to the economic-technical norm for robusta coffee production was proposed by Department of Agriculture and Rural Development, of which, coffee producers had to invest at least for one ha of coffee included machines, pump, wells and other necessary equipment or whether they had to rent these equipment with equivalent or higher price to support them during normal yearly maintenance activities (DARD, 2001). Moreover, through group discussion and directly observation found that there was not so much difference among farmers on investing the fixed costs needed to maintain their coffee gardens, and because of a high percentage of farmers who could not remember how much they did invest on their coffee gardens. Therefore, the estimation was based on the standard of investment for coffee production from DARD. The same depreciation value of $310 has given to all the farms with size of one hectare. It included the land tax and the other equipment deprecation cost like coffee garden establishment, machine, pump, and wells.

Total cost of two groups of farmer is shown in Table 32, a part, in term of labor cost, it indicates that the labor intensive of the contact farmer group was higher compared to less intensive labor of the non-contact farmer group, it seems that the non-contact farmers depended more on the external inputs compared with the contact farmers, the contact farmer group spent about $80 higher than the non-contact farmer group in term of labor. This higher cost resulted from the intensifying of pruning, basal-bund making and post-harvesting activities. Fertilizer has been known as the largest variable cost that farmers had to spend every year with an average of $230 ha^{-1} $year^{-1}$ for the contact farmers and $299 for the non-contact farmers, followed by irrigation cost with a little bit higher for the non-contact farmers compared to the contact farmers, respectively at $206 and $229. Finally, the farm performance should be paid attention with family farm return from the farm of two groups by subtracted the total cost from the income obtained. For this, if a farmer owns one hectare of 10 to 12 year-old coffee garden, he or she would earn approximately $1,095 a year in net profit in case of invested in one year production about $1,272 for the contact farmers compared with net profit earning of $669 of the non-contact farmer who invested $1,269. The difference in gross margins and farm return between two groups of

farmers resulted, in part, from the lower variable costs, higher coffee yield and intercropped products of the contact farmers compared with the non-contact farmers, who used higher external inputs. Assuming that data acquired from the farmers are adequately reliable, thus, it can be concluded that, in the context of the study area, the contact farmers were proved to have significantly contributed to increasing economic return for farmers.