CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

This chapter presents conclusions and recommendations of this research. The conclusions were derived based on the findings of factors affecting and assessing profitability of chemical fertilizers adoption in maize cropping systems. The recommendations are also given for the improvements of the adoption of chemical fertilizers in maize cropping systems in study area in future.

7.1 Conclusions

Based on the information of survey, maize is grown for commercial purposes by the majority of households and a very small percent for semi commercial. Almost all of the households grow maize under rain-fed condition and there are no irrigated areas as well in study area. Major cropping systems they preferred were maize-fallow, maize-niger and maize-wheat in this area.

In the survey of 167 households in study area, 79 percent of the households adopted chemical fertilizers in maize cropping systems. But they did not apply chemical fertilizer according to the government recommended rate because almost all of the households used compound fertilizers. As a result, even though they were chemical fertilizer adopters their maize yields were still low. A major constraint for the adoption was lack of knowledge about the technology and this technology is still new to maize farmers.

Households in Yatsauk township were with significantly higher experience in maize cultivation. But they showed significantly higher extension officers' visits and also mechanical threshing in Yatsauk township. None of the households used local maize variety in Yatsauk township and crop rotations were performed by households in both Yatsauk and Pindaya township. Although 59.5 percent of households had adopted chemical fertilizers in Pindaya; inadequate trainings, demonstrations and less motivation has been noticed as major reasons with regards to non adoption of chemical fertilizers in that township.

Regarding the cost of inputs in maize production; cost of seed varied according to the farmers' selection which depends on their wealth. Mostly the richest farmers were used to apply CPDK 888 F_1 seeds for their cultivation while the others were used to apply low cost seeds which were not in good quality. If weather condition is normal and when households get high price because of export demand, the households who use CPDK 888 F_1 will gain more profit than the households who use other varieties. At that time, if farmers apply enough chemical fertilizer as recommended fertilizer rate, they will get highest potential yield and gain profit 2 times higher than the farmers who did not use recommended fertilizer rate. Average cost of production by households who borrowed money was 25 percent higher than the households who did not borrow money in study area. Therefore, less profit appeared in households who borrowed money because of very high interest rate that ranged from 1.25 to 10 percent for one month. Moreover, 13.5 percent of the cost of production was interest cost in maize production and 33 percent and 53.5 percent were under input, labor and other machinery cost respectively. According to

the high yield and price in study area, the most profitable region was created in Yatsauk; that 16 percent higher than in Pindaya. Comparing to non adopters in Yatsauk townships, chemical fertilizer adopters obtained higher gross margin. But they could get higher gross margin if they used their own money instead of borrowed money for maize production.

Using logistic regression model, it was found that REGION (Yatsauk) was highly significant in chemical fertilizers adoption. Thus, one of the possible explanations was that accessibility and modernization which exist households in Yatsauk but not so much in Pindaya enable to purchase input use in maize production especially chemical fertilizers. In Yatsauk, households can travel without difficulty from their villages to the urban area because of good transportation and only 77 kilometer far away from the capital of Shan State while there is 100 kilometer far away from the capital to Pindaya township.

It was also found that households' awareness in livestock rearing was also an important factor in study area. Households earned through livestock rearing such as buffaloes, cows, goats, pigs and chicken.

In addition, land-labor ratio was another factor that motivates to adopt chemical fertilizers in maize production. Households facing increased land pressure were 1.4 times more likely to adopt chemical fertilizers than the non adopters.

Coefficient of experience in maize cultivation was negatively significant; which implies that the more experience the farmers, the less the probability of adopting chemical fertilizers. It means that the risk aversion factors increase with the increase of

experience. This characteristic incites them to be more skeptical to innovation and resistant to change; as a result they belong to late adopters.

Extension officers' visit was another significant factor in the adoption of chemical fertilizers. Extension service was shown to be the strongest force behind the decision of farm households to adopt chemical fertilizers.

According to the results of multinomial logit model, it was also found that REGION (Yatsauk) was again highly significant in all three levels of adoption of chemical fertilizers. However, there were differences from the result of logit model as age of the household head and numbers of oxen were significant in the model. However, in the multinomial logit model, among adopters, the relatively aged farmers had a greater tendency to adopt chemical fertilizers in high level but the age of the household head was not significant in the adoption of low and medium level of chemical fertilizer use. Therefore, comparatively aging farmers were aware of using enough chemical fertilizer in maize fields. Oxen negatively affected to the adoption of chemical fertilizer in the medium level of fertilizer use. The greater number of oxen will decrease the probability of chemical fertilizer adoption. This reveals that households who owned oxen were less likely to apply chemical fertilizers as they had enough animal manure to apply in their maize fields.

7.2 Discussion

According to the sampled (167) survey households in the study area, most of the cropping activities are concentrated during the rainy season and almost all of the

households rely on only rain-fed condition. The surveyed households grew maize-fallow (20 percent), maize-niger (38 percent) and maize-wheat (21 percent) cropping systems. Households in Yatsauk adopted maize-niger cropping system and households in Pindaya adopted maize-wheat cropping system (Figure 4.5). In Yatsauk, households adopted mechanical threshing method and large scale farm and tended to commercialized production when they had high level of income and low population density compared with the households in Pindaya (Pandey, 1999).

Surveyed households grew 5 kinds of maize varieties such as, CPDK 888 F_1, CPDK 888 F_2, CPDK 888 Thantae, Yezin hybrid 3 and local variety. In these, the highest seed cost was among farmers using CPDK 888 F_1 and these households also had highest chemical fertilizers cost in maize field. However, the profitability of using this variety was not the highest in the survey year since abnormal weather condition especially in rainfall. If weather condition is normal as the previous year, yield will be the highest by using CPDK 888 F_1 and the maximum profit will be gained when other production costs are constant according to the sensitivity analysis (Figure 5.20, 5.24). In the study area, Yatsauk township is the more profitable region than Pindaya because households in Yatsauk adopt maize production technologies such as using high yielding hybrid maize, chemical fertilizers and mechanical threshing. In the study area, maize price fluctuated every year because of world price of maize according to the Figure 5.22.

By using different varieties, different cost of production occurred and average cost of production per kilogram of maize grain for the households in Yatsauk township was 122.59 kyats and 143.38 kyats while it was 99.02 kyats and 127.91 kyats for Pindaya

township excluding and including the opportunity cost of family labor respectively. There is no evidence yet to indicate that increased land area under cultivation reduces the unit cost of production. This may be due to the cost of input in case of chemical fertilizers. By using CPDK 888 F_1 variety, households had a lower unit cost of production (127.4 kyats kg^{-1}) compared with those using other varieties as CPDK 888 F_2 (154.8 kyats kg^{-1})and CPDK 888 Thantae (187.4 kyats kg^{-1}). In both townships, every household who borrowed money had more cost of production per kilogram of maize than the households who did not borrow money in case of both adopters and non adopters. It was because of very high interest rate in the study area.

In addition, comparing to non adopters in Yatsauk townships, chemical fertilizer adopters obtained higher gross margin but they could get higher gross margin if they used their own money instead of borrowed money for maize production (Table 5.9). If a household had to apply loans to purchase fertilizer and when the interest rate was high, fertilizer use may not be profitable. Interest cost was relatively high by households who borrowed money in maize production. Therefore, making credit available to farmers is an important way of increasing the adoption of improved maize technologies and improving the level of production (Salasya *et al.*1998).

Different profitability levels were experienced among the households in the study area by using different maize varieties. Although households use high yielding variety as CPDK 888 F_1; they obtained lower yields than national yield and also got less profit in the survey year. But, if farmers use high yielding maize variety and recommended fertilizer rate, they got the highest potential yield and highest profit compared with the

farmers who did not use this high yielding variety and enough chemical fertilizer in their maize field (DAR, 2004) and this findings proved the result of sensitivity analysis in Figure (5. 26) and Table 5.10.

As a result of logit regression model, there are five independent variables that affected the chemical fertilizer adoption in the study area. The independent variable REGION (Yatsauk) was significantly influenced in adoption of chemical fertilizer because of more accessibility and modernization in Yatsauk as far away 77 km from capital while it was 100 km far away from capital to Pindaya. Ransoml *et al.* (2002) suggests that the strategy for improving the adoption of new technologies in accessible areas may be quite different to that used in remote areas.

Another variable livestock was also significant in adoption technology. The farmers who owned livestock can sell the livestock and purchase chemical fertilizers to apply in their fields. Degu *et al.* (2000) approved that Total Livestock Units (TLU), agro-ecological zone, extension services and use of credit significantly influenced the probability of adoption of maize and fertilizer packages in Ethiopia.

Extension officers' visit to the maize field was significantly and positively affected the adoption of chemical fertilizers in maize. The farmers who were visited by extension officers are more inclined to apply chemical fertilizers because they can get the knowledge of fertilizer technology from extension officers (Adunga 1997).

The variable on years of experience in maize cultivation was significant but negatively related with the adoption of chemical fertilizers in maize. It means that the farmers who had less experience in maize growing were likely to adopt the fertilizer

application technology. The previous experience of farmers can be expected to either enhance or diminish their level of confidence. It has been argued that with more experience, farmers could become risk-averse regarding the adoption of chemical fertilizers (Bisanda *et al*. 1998).

The last predictor variable is average land-labor ratio, which showed positive relationship with the adoption of chemical fertilizers in maize. Land to labor ratio was positively and significantly related to inorganic fertilizer uptake, confirming the hypothesis that as land pressure increases, farmers resort to more productive ways of intensification (Hardwick *et al*. 2004).

By the multinomial logit result, REGION (Yatsauk) was also positively related with all levels of chemical fertilizer adoption. It means that the probability of the adoption of chemical fertilizers in Yatsauk township has increased because of its accessibility of transportation and modernization compared with the remote area of Pindaya (Ransoml *et al.* 2003).

Age of the household head also positively influences the adoption of chemical fertilizers, in the case of high level of fertilizers used. It seems that among the adopters, the relatively aged farmers who have more resources have a greater tendency to accept a high level of fertilizer use (Damisa and Igonoh 2007).

Oxen negatively affected the adoption of chemical fertilizer in the medium level of fertilizer use. The greater number of oxen will decrease the probability of chemical fertilizer adoption. This reveals that households who owned oxen are less likely to apply chemical fertilizers as they have enough animal manure to apply in their maize fields. It

was argued that the number of oxen per household, used as a proxy for its wealth was important factor in positively influencing fertilizer adoption decision (Adunga 1997).

Although rainfall is very low in the month of July in the study area, surveyed farmers responded that they faced drought condition for 2 months in survey year. There was no moisture in maize field when they applied chemical fertilizer at that time. Therefore, maize plants were not able to absorb chemical fertilizers from the soil because chemical fertilizer could not be dissolved in the soil due to the drought condition. So, the results can be that the uses of chemical fertilizers are not profitable or even if the farmers gained the profit, profit would be less than typical year.

On the other hand, in situations where the expected rainfall (weather) condition is bad, farmers are unwilling to use fertilizer. This is because farmers are not insured against losses as a result of bad weather and forced to pay the cost of fertilizer they received on credit (Fufa and Hassan 2006).

When households develop crop rotation in maize field especially in acid soil condition they need to apply low dose of chemical fertilizers (N 154 kg ha^{-1}, P_2O_5 62 kg ha^{-1}, K 31.5 kg ha^{-1}) instead of recommended rate (N 200 kg ha^{-1}, P_2O_5 250 kg ha^{-1}, K 100 kg ha^{-1}) for that soil (DAR 2010).

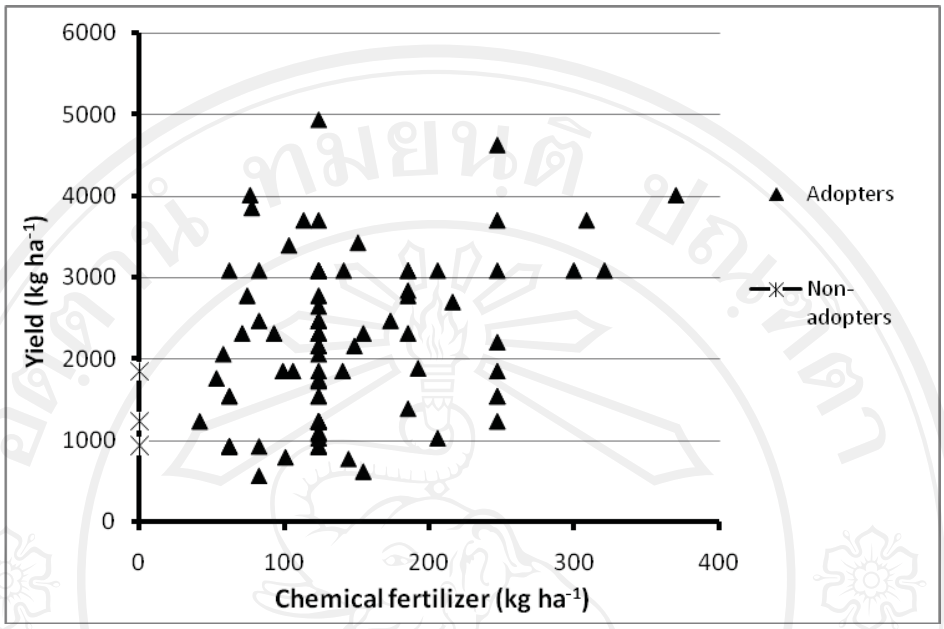

Figure 7.1 Yield and chemical fertilizer in two group in Yatsauk.

In Figure 7.1, there were 25 (29 percent) of 85 adopters' households got yield less than 2,000 kg ha^{-1} in Yatsauk. Almost of these non adopters got less than 2,000 kg ha^{-1} and among them 33.3 percent yield less than 1000 kg ha^{-1}. However, 71 percent of adopters' households got the yield more than 2,000 kg ha^{-1}. The majority of the adopters applied 125 kg ha^{-1} chemical fertilizer. With this rate of fertilizer, farmers yield range between less than 1,000 to 5,000 kg ha^{-1} because of their different use of chemical fertilizer composition (Figure 7.3).

In Figure 7.2, among the adopters in Pindaya, the majority of farmers applied 125 kg ha^{-1} chemical fertilizer and 31 (66 percent) of 47 households used chemical fertilizer rate of 125 kg ha^{-1} or less than that. Among the adopters, even if they used 250 kg ha^{-1} chemical fertilizer they were able to get higher yield (4,631 kg ha^{-1}) but even they used

more than 350 kg ha^{-1} they were not able to get higher yield because of chemical fertilizer composition differences. In non adopters, there was 72 percent of the households got yield less than 2,000 kg ha^{-1} but 28 percent of the households got more than 2,000 kg ha^{-1}. It may be due to the use of compost in Pindaya township.

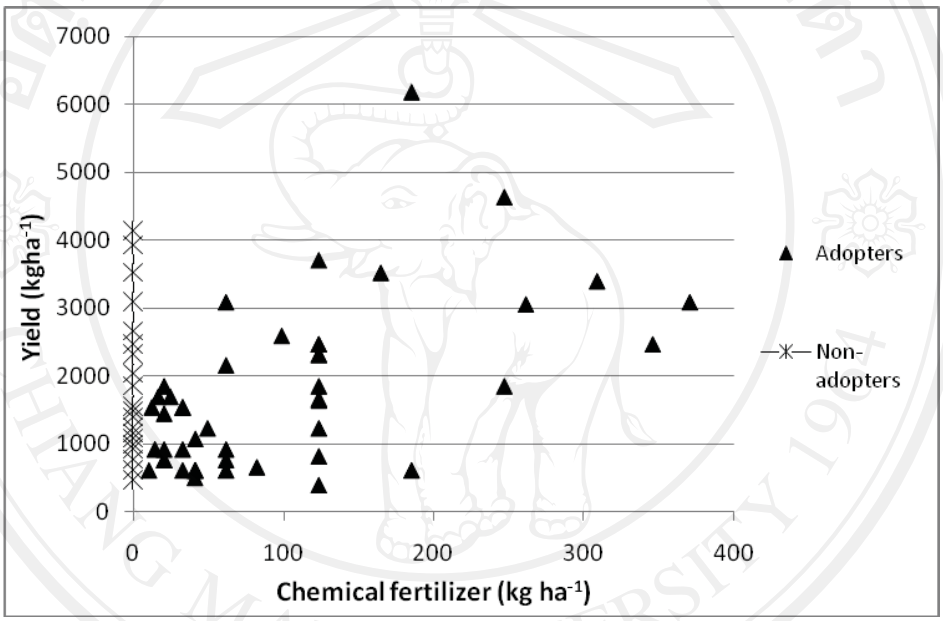

Figure 7.2 Yield and chemical fertilizer in two group in Pindaya.

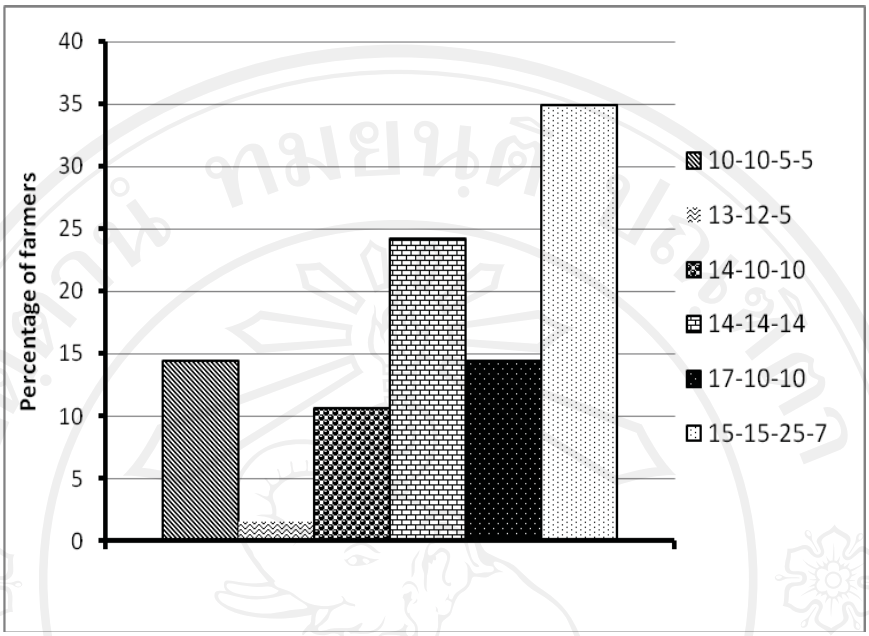

Figure 7.3 Percent of farmers used different fertilizer ratio in the study area.

According to the survey data, farmers used various compositions of chemical fertilizers because of different brand such as Hlae Yinn, Golden buffalo, Red arrow, Thee Sone, Aung Kabar and Armo brand; and they could not follow N: P: K recommended fertilizer rate. In Figure 7.3, there were six kinds of chemical fertilizer ratio that farmers used in the study area. 34.9 percent of farmers applied N: P: K: S fertilizer as a ratio of 15: 15: 15: 7 and 14.4 percent of farmers used fertilizer as 17: 10: 10 and also another 14.4 percent used as 10: 10: 5: 5. There were 24.2 and 10.6 percent of sampled farmers applied chemical fertilizer according to the ratio of 14: 14: 14 and 14: 10: 10 respectively but only 1.5 percent of farmers used 13: 12: 5 ratio of chemical fertilizer. Therefore, the limitation is recognized as this study cannot identify N: P: K levels that applied in maize fields.

Ekasingh *et al* (2004) reported that in Thailand, the most common fertilizers used in maize production were urea (46-0-0), Triple 15 (15-15-15) and 16-20-0 and the average yield of maize was 3.67 ton ha^{-1} in 1998-99. In Thailand, when farmers borrowed from local merchants some had to pay 3 to 5 percent interest a month on top of the higher price of the highest inputs they bought through credit. In Myanmar, the interest rate was very high ranged from 1.25 to 10 percent a month that was dependent on various source of money when farmers borrowed money. Most of the farmers used compound fertilizer as (14-14-14) and (15-15-15-7) to apply in maize fields in the study area and maize yield was 2.2 and 1.7 ton ha^{-1}in the surveyed area in Myanmar.

7.3 Recommendations

Based on the findings of this study, policy implications and future research direction can be derived as follows.

1. Among all maize varieties, growing of CPDK 888 F_1 hybrid maize, Yezin hybrid 3 and local varieties are profitable than other maize varieties because of higher yield than others. Sensitivity analyses showed that growing CPDK 888 F_1 give more profit than others. This may be due to higher yield of this variety. In addition, total cost of production using CPDK 888 F_1 was not the highest within all these varieties. Therefore, government should make efforts to introduce hybrid maize variety to the farmers.
2. The most important factor influenced the adoption of chemical fertilizers is REGION (Yatsauk). The households who live in more accessibility for

transportation and modernization region are more likely to adopt chemical fertilizers. Therefore, it was recommended that better market opportunities and road infrastructures are necessary to exchange input and output easily especially in remote area of Pindaya. The government should make efforts to improve such facilities in this region.

3. Another factor influenced the adoption of chemical fertilizers was found to be livestock ownership. The number of livestock that rearing by households in Yatsauk is larger than in Pindaya. So, households should tend to rear more livestock in Pindaya. Households who owned oxen are less likely to apply chemical fertilizers as they have enough animal manure to apply in their maize fields but it was significant in only medium level. So, manure is not likely to be enough to apply in maize field. So, households should rear more oxen in both regions.
4. Extension officers' visit to the maize field was found important factor affecting adoption of chemical fertilizer. The households who were visited by extension officers will get knowledge for chemical fertilizer application technology in the study area. So, there is urgent need to effort the extension officers to visit to maize fields. The government needs to make demonstration and yield trial in the village to convince farmers about the proper use of chemical fertilizer in maize cultivation. So, agricultural extension officers are the key role in demonstration for adoption the technologies.

5. Formal credit was not available to most of the maize farmers. With rising input prices, providing credit to farmers becomes increasingly important. In collaboration with the government and other stakeholders, the low cost credit system needs to be addressed to the credit problems faced by small-scale farmers; especially for poor farmers.
6. The government needs to improve the awareness on advantages of chemical fertilizer application in maize cropping systems, especially among the non experienced households and to develop the awareness of lime application which improve soil fertility particularly in maize fields.
7. Generally, the households should apply recommended rate of chemical fertilizer in maize field since the application of adequate chemical fertilizer in maize field is the most profitable one when weather condition is normal.
8. Even though the surveyed households grew different cropping system (maize-fallow, maize-niger and maize-wheat) as crop rotation, they faced soil problem in their maize field. Therefore, the households should follow integrated nutrient management practice and soil conservation practices in order to improve soil fertility; especially in Pindaya township, households should grow niger crop after maize as crop rotation.
9. The government should support farmers with respect to seeds, chemical fertilizers and also subsidize credit in maize production in order to attempt to extend maize area and to catch higher maize yield.

10. Finally, researchers should find appropriate methods to reduce the cost of production in maize cropping systems that farmers have to face today; especially for high quality seeds and to reduce the cost of labor in weeding practices in maize production.