# Chapter VI

# Discussion

## 6.1 Field survey

The study investigated the main status of current farming practices in rice production and other cropping systems with fertilizer management for rice based cropping systems in Cambodia.

### 6.1.1 Nutrient management

Based on the secondary data, Beong Tranh Khang Tboung commune is characterized as one of areas with relatively low agricultural productivity given that it is positioned on the Prateah Lang soil group, which is the sandy-textured top soil overlying a loamy or clayey textured subsoil (White *et al*., 1997a,b). The group of soil represents a major rice production soil type, and its surface layer, is structure less, hard dry with vary color from pale brown, gray or while to lighter shades brown gray. As almost clay absent in the top soil is very easy disperse and it very infertile soil. Most soils are deficient in N and P, and some may be K, S and Mg-deficient according to results of both the pot and field experiments (Lor *et al*., 1996; Pheav *et al*, 1996). Other macro-and micro-nutrients disorders are evident when the main fertilizers N, P, K, S and Mg are applied. In addition, a number of problem soils exhibit iron (Fe) toxicity, acidity, and/or high salt concentrations in some areas (White et al., 1997a; Seng *et al*., 2001). The high fields have the highest sand content, and therefore the poorest water- and nutrient-holding capacities. The low fields are the most fertile soil, but some soils are still poor in terms of N and P contents regardless of the field level (White *et al*., 1997a,b).

A study in Takeo Province of Cambodia by Ieng *et al*., (2002) indicated that in the rainfed lowland areas farmers generally use chemical fertilizers such as phosphorus (P), potassium (K) and sulfur (S) but at rates less than the recommended rates for each soil type (White *et al*., 1997a; Dobermann and White, 1999; Seng *et al*., 2001). These farmers tend to overuse N relative to present rates of P, K and S. However, nutrient balances in many of the impoverished rainfed lowland rice soils in other provinces of Cambodia are poorly understood, and rice yield responses to application of commercially available fertilizers is considered by farmers to be uneconomical (Nesbitt, 1997b), probably due to their limited first-hand experiences (poor timing of fertilizer application, poor matching of the fertilizer types with each soil), combined with abiotic and biotic constraints.

The productivity of rice soils in Cambodia varies greatly, with unfertilized rice yielding from 0.60 to 1.40 t/ha (White *et al*., 1997). But, the result from the field survey revealed that rice yield was slightly high. The average of rice yield was 1.51 t/ha. The rice yield vary form year to year and from study to study (Table 6.1).

Table 6.1 Rice yield (t/ha) reported for whole of Cambodia, and for province of Takeo in various studies

| | Wet season | Sources |
|---|---|---|
| Cambodia | 1.81 | MAFF(1999-2000) |
| Takeo | 2.20 | MAFF(1999-2000) |
| Takeo | 1.34 | Janh et al,(1996) |
| Takoe | 1.81 | Ieng at al (2002) |
| Takeo | 1.51 | This survey |

The rate of fertilizer application in study area varied from household to household depending on soil types and farmer’s practices and available cash to purchase fertilizer. The survey result showed that farmers apply farmyard manure form 200-660 kg/ha mixing with inorganic fertiliser including urea (46-0-0) and 16.16.8.13 they broadcast and incorporate into the soil to 15-20 cm depth just before transplanting as a basal dose. More urea and 16-16-8-13 were used than 16-20-0 and DAP. The high price of fertilizer is found one reason for less use of 16-20-0 and DAP. Most of the farmer reported that urea and 16-16-8-13 are the best fertilizers for enhancing rice growth and increasing rice yield. Farmer used urea (46-0-0) at rate between 15 to 50 kg/ha and 16-16-8-13s applied at rates ranged between 50 to 100 kg/ha.

Nevertheless the way they apply fertilizer differs in terms of stage production and type of fertilizer used. Farmers use urea (46-0-0) by splitting 50% for basal and the remaining 50% using as topdressing. About forty percent of farmers use urea (46-0-0) fertilizer for topdressing at tillering stage, while sixty percent of farmer use urea fertilizer for topdressing at panicle initiation. The rainfed rice farmers showed tendency apply N as basal application, and then forgo a later application or apply second dressing at wide ranged of different time from tillering to booting.

The amount of applied fertilizer is still low for the rainfed lowland soils. Farmers primarily apply N and P. Most rainfed lowland farmers apply fertilizer only once or twice for early-maturing rice. According to Nuth (2001), an N-P-K proportion of 50: 23:30 or equivalent to 80 kg of urea (46-0-0), 50 kg DAP (18-46-0) and 50 kg of fertilizer (K) is generally recommended for Prateah Lang soil group. But, in a condition of sufficient water supply recommended N-P-K application rate is 100:40:80 kg/ha. Nevertheless, White *et al*., (1997) suggest that inorganic fertilizer should apply in small frequent doses after cow manure application and soil been flooded for a week.

Most of farmer in study areas harvest crops by leaving the stubble about 15 to 20 cm. In case of some short duration varieties there is a tendency to harvest the complete plant (i.e. cut the plant close to the ground leaving no more than 5 cm of straw on the field). Therefore a larger proportion of the nutrients are removed from the field. This results in the relative infertility and nutrient deficient status of a large proportion of Cambodian rice soils. The importance of rice straw management in maintaining soil fertility with exception of N, P and Ca, over 60% of the nutrient are contain in the straw at harvest (Table 6.2). Removing the straw removes these nutrients from the soil system. Thus straw has important role to play in maintaining soil fertility and nutrient balance, event when fertilizer are being used.

Table 6.2.Macro and micro nutrient in rice grain and straw harvest

| | N | P | K | S | Ca | Mg |
|---|---|---|---|---|---|---|
| | ---------------------------------- | | %---------------------------------- | | | |
| | | | Nutrient concentration | | | |
| Grain | 0.72 | 0.19 | 0.28 | 0.10 | 0.04 | 0.10 |
| Straw | 0.32 | 0.04 | 0.79 | 0.10 | 0.39 | 0.17 |
| | | | Nutrient per ton of grain yield(kg/t) | | | |
| Grain | 7.9 | 1.9 | 2.8 | 0.9 | 0.4 | 1.0 |
| Straw | 4.8 | 0.6 | 11.8 | 1.4 | 5.9 | 2.6 |
| Total | 12.6 | 2.4 | 14.7 | 2.4 | 6.3 | 3.6 |
| | | | Percent of nutrient in grain or straw harvest | | | |
| Grain | 62 | 76 | 19 | 41 | 7 | 28 |
| Straw | 38 | 24 | 81 | 59 | 93 | 72 |

(Source: Linquist and Pheng, 2001)

In brief, the high consistency in nutrient management practiced by framer with formal recommendation has efficiency contributed a great deal of impact on improving rice productivity of farmers in the commune.

In spite of this there is remains two importance points that also deserve special consideration. First, attention should be paid on preserving the health of soil in long run by minimizing the negative effects to be originated from the used of inorganic fertilizers. This has precisely opened an opportunity for researcher to involve themselves in training framer on integrated nutrient management in which the incorporation of organic fertilizer, such as residue, compost.

### 6.1.2 Farmers knowledge about soil and fertilizer

Farmers were not aware of soil type on their farms. This may be due to effect of farmer training course conducted in these. However, all farmers recognized different in texture (sand or clay), compaction, and ease information of their soil. Other study by Seng *et al*., (2001) indicated that most of farmer in the rainfed lowland areas, were unaware of CIAP fertilizer recommended applicable for soil type due to lack of advised. This provides further evident that the development of farmer own decision rule for fertilizer used had occurred in parallel with the development of CAIP fertilizer recommendation. Almost farmers applied urea to their rice crop, at rate about 34 kg/ha. The rainfed rice farmers showed a grate tendency to apply N as basal application and than forgo a later application or apply a second dressing at wide rand deferent time from tillering to booting.

The farmer in the study areas almost all farmer applied inorganic fertilizer in their field. They reported that fertilizer is very important for obtaining satisfactory yield, and that without inorganic fertilizer they expected insufficient rice for family consumptions.

Very few farmers accessed in formation directly from government and NGOs. Most farmers applied fertilizer according to their own decision-making rule or following with their neighbor.

Farmer considerate a number factor when they applied fertilizer to their field. Over 90% reported that they never applied fertilizer when the field no standing water. The framer reported that, if fertilizer applied to field with no standing water, weed growth is stimulated; rice growths are suppressed and in some cased soil harden. The farmer also report that, if their field is submerged (i.e. water level is greater than the level water standing water need by the crop) they do not apply fertilizer because nutrient will run off with the water. Most of the farmer notes that it was preferable not apply fertilizer in either situation in order to avoid losing money.

These results suggest that there may be a need for research that defined how fertilizer rate and timing can be varied from the general recommendation (Seng *et al*., 2001) to achieve the greatest return form an investment in fertilizer submerging or drought coincide with schedule time for application. However farmers have already their rule s for dealing with these kinds of situation but their efficacy has not been adequate test.



### 6.1.3 Fertilizer related constraints in rice cultivation

Interview with farmers identified several problems affecting for rice production. They report that their soil become very poor and the rice yield become very low due to insufficient money to buy fertilizer for their crop. They stated that they need credit to buy fertilizer, but it is very difficult to get. Also the price of fertilizer increases during growing season approached but the price of rice decrease after the harvesting.

Poor quality of fertilizer is the other problem, because the yield of rice sometime do not increased as expected with fertilizer application, and the soil in their field became hard. Farmers attributed this to effect of adulterated fertilizer. However, it may also be due to the used of inappropriate types or rate of fertilizer or inappropriate timing of fertilizer application.

In the other survey of fertilizer use by farmers, Hongen and Soun (1991) reported that concerned about adulteration of fertilizer were ranged higher than the cost or availability of fertilizer in the market. In effect, the possibility of getting adulterated fertilizer increase the price of fertilizer product as well as decreasing the respond which might be expected from using them. All of these factors combined to increase the cost of production, decrease the value of production and increase the risk of lose associate with fertilizer used.

## 6.2 Field experiment

The present study sought to make a contribution to the understanding of effect of fertilizer and crop residue relations in rainfed lowland ecosystems that are prevalent in Cambodia. It has addressed gaps in knowledge of nutrient balances, the residual value of fertilizer, and the effect of crop residue incorporation into soils for subsequent rice crops.

The experiment was conducted on an acid sandy rainfed lowland soil, which comprises about 30 % of the rice growing regions of Cambodia. Soils with broadly similar properties, in comparable rainfed sub-ecosystems can be found in Laos and Northeast Thailand. The present research results may also inform the development of nutrient management practices for Cambodian farmers.

### 6.2.1 The effects of fertilizer, rice straw and residue incorporation

The results in study showed that fertilizer application significantly affected plant growth. Growing plant without fertilizer produce low panicle number, shorter plant and extended 50% of flowering day. The number of days to 50% flowering has been shown to be sensitive indicator of P deficiency in rice (White *et al*., 1998). Plant took long to flower when grown in treatments without P than in treatment with P and days to 50% flowering was closed related to the P concentration in shoot at flowering (White *et al*., 2000).

With rice straw addition alone, the rice yield increased marginally 0.28 t/ha (rice-rice, pattern), but still in the range (0.2 to 0.4 t/ha) obtained by Ponnamperuma (1984) and Alberto *et al*., (1996). The small increase of yields could be due to the very low P content in rice straw combined with modest amount of straw was returned (Zhu and Xi, 1990; Dobermann and Fairhurst, 2000). In general, crops produced low biomass and nutrient uptake (0.8 to 1.0 kg P/ha) in the nil-P soils so the amount of P returned from this source have not significant effects on rice yield and biomass of subsequent crop/crops. However, significant yield increases would be expected if rice straw around 5 to 9 t/ha per cropping season (Oh, 1984; Songmuang *et al*., 1997; Seng *et al*., 1999) is incorporated alone or with inorganic fertilizers into the soils depending on fertility capacities of the soils.

Seng *et al*., (1999) found that when straw was added with optimum rate of inorganic P fertiliser, rice yields increased particularly when the soils were exposed to loss of soil-water saturation because straw incorporation aided P availability by maintaining low redox potential, and apparently maintained inorganic and organically-bound P in more plant available forms. However, if the soils already have high residual P levels or are treated with high P fertilizer rates, the contribution of P from rice straw incorporation would have marginal or insignificant effects on plant biomass and grain yield. The results of present experiments showed complementary effects of returned straw with/without inorganic fertilizer by increasing rice yields on a sandy soil of Cambodia. Seng *et al*., (1999) also reported the advantage of straw particularly, under temporarily loss of soil-water saturation. Organic acids produced during decomposition of straw are reportedly harmful to rice (van Mensvoort *et al*., 1985). However, if fresh or dry rice straw is incorporated at least 2 to 3 weeks before transplanting rice, breakdown of the readily decomposable potentially toxic organic acids occurs. This would substantially eliminate toxic effects of organic substances (Ponnamperuma, 1984). However, delayed transplanting is not feasible in many rainfed lowlands. The use of late duration rice varieties is recommended as a strategy where delayed transplanting is not feasible because the negative effect of straw prevents excessive vegetative growth at an early stage. This recommendation is supported by Seng (2000), who found no evidence of yield reduction in a long-duration traditional rice variety with rice straw addition of 5 t/ha.

In this experiment results also found that the incorporation of crop residues (rice straw) significantly increases the grain yield of Rice-rice pattern. Secondly the incorporation of mungbean residue has no effect on yield of, but the incorporation of rice straw significantly increase the yield of mung bean (Rice-mung bean pattern). The third cropping pattern the incorporation of maize residue has no effect on rice yield, but increases yield of maize crop significantly.

The residue of rice straw effect on the grain yield of wet season rice was found low. However, crop residues either as rice straw or crop biomass incorporated into the soil provide advantages for improving long-term P reserves and for current crop nutrition directly by supplying available P for plant requirements, and indirectly by increasing P availability in the soil through solubilization or reduced P sorption capacity of the soil (Tomar *et al*., 1986).

In addiction, when incorporation of residue (rice straw) alone increased rice grain yield about 0.5t/ha. When residue were applied in combinations with fertilizer grain yield increased from 0.5 to 2.4 t/ha. According to Willet (1995) and Rangeland and Boonpuckdee(1998) showed that for some soils in North earth of Thailand there was little to no responses to either fertilizer or on-farm residue applied alone. But a good respond if applied in combination with fertilizer.

Crop residue incorporation is also beneficial to improve soil structure, but the effects of applying crop residues may vary with soil textures. In the sandy soils, application of crop residues can increase soil organic matter, improve soil-water retention capacity and reduce the leaching of nutrients (Oh and Lee, 1971; Lefroy and Konboon, 1998).

Organic residues either as rice straw or fallow crops contribute to build-up of organic P in soil (Pheave *at el*., 2002), and increase availability of P during a loss of soil water saturation (Seng *et al*., 1999).

Sengxua *et al*., (2002) indicated that applying only N, P, and K. fertilizer increase the yield in short term, but in the long term a greater amount of nutrient are extracted. Most of inorganic fertilizers were not replenished other macronutrient and micronutrient so these become deplete with continual cropping and remove of grain and crop residue. A depletion of soil nutrient may occur rapidly in the coarse textured soil.

The rates and turnover processes of residues and release of nutrients from the above organic sources to the main wet season rice production has yet to be fully investigated, but preliminary results indicated that applications of crop residues substantially increased subsequent rice growth and crop nutrient uptake, while greater yields were obtained with the combined use of inorganic fertilizer plus organic residues.

There remains a need to understand in depth both the short and long-term effects of residue incorporation on microbial biomass turnover in the field condition under rainfed lowland environment.



**6.2.2 Cropping systems**

The two crops were grown in the early wet season (EWS) and wet season (WS) for experiment at CARDI. The EWS crops (crop2 and crop4) yield very low for all three crops included: rice, mung bean, and maize, due to drought during crop growth and water longing in flowering for maize and mung bean. There was difficult protect the crop pest damage (bird) in early wet season, due to very few was grown around that area during conducted experiment.

The early wet season crops was planted in early of March and harvested at the middle of June. Subsequently, the wet season rice crop was sown in the mid of July and harvested in December. The early wet season mung bean and maize crop were affected by water logging conditions during flowering stage. It was found that with early land preparation and improved water management, mung bean crop could be grown successfully in that area. These changes will reduce the problem of excess moisture for fine and dry seedbed preparation allowing drainage for mung bean. But, these practices involve increased labour and inputs, which many farmers in this area cannot afford (Bayasake *et al*., 2002). However, as there were irrigation systems available for rice cultivations in the early wet season and wet season, farmers could earn more income by growing a rice crop than a mung bean and maize crop.

The early wet season rice crop was also planted at the early of March and harvested at the middle of June. There is low production of early wet season rice crop as the rainfall was inadequate for a crop establishment in this area insufficiency of irrigation water availability for the early wet season and wet season crops. The water availability depends on the rainfall in the Phnom Penh district.

Based on the experiment results among three cropping patterns, when the gross margin is compared within these three systems, the highest gross margin (7,101,680 Riel) was obtained in the rice-mung bean system. While, the moderate gross margin (6,590,240 Riel) was obtain in the rice-rice system and lowest gross margin (4,882,090 Riel) was obtain in the rice-maize system.



Mung bean-rice double cropping system is found most suitable option for rainfed lowlands particularly where supplementary irrigation is available. The rice yield is higher in rice-rice pattern but due to low price of rice it is not found profitable against mung bean-rice pattern. Rice-maize pattern lowest profit than other two systems, due to maize could product suitable yield and the cost of input especially seed very high price (6000 Riel/kg), but when selling price of this produce very low

(510 Riel/kg), Therefore, the maize production received a negative gross margin for all treatment.

Growing legume prior to rice is preferred rather than the reverse scenario, because legume after rice would have increased problems associated with damage from drought, insects, pests.

On the other hand, introducing of mung bean and maize into the rice based cropping system is more difficult, as often heavy rainfall and drought in the early wet seasom cause crop failure. There are possibilities of growing early wet season mung bean crops in rainfed lowland, if farmers used improved measures for crop protection and water management.

The residual effect of mung bean on the grain yield of wet season rice was low. However, the residuals of the legume crop could contribute to improved soil fertility. The additional benefits of legumes to the double cropping systems in Cambodia such as contributions to soil nutrition require further investigation. This increased knowledge is a vital step to examine the effect of early wet season and dry season crop on the yield of the WS rice crop in Cambodia.

The introduction of a double-cropping system in the coarse-textured soil rainfed lowlands has been suggested to take advantage of the bimodal rainfall pattern with two growing (wet and dry) seasons per year. The double-cropping system is proposed on the assumption that farmers would adopt sequential improvements to an existing system rather than an entirely new system (Fujisaka, 1991). The rice-based double cropping system offers alternatives to farmers with limited resources to increase rice yields. The second crop in this system can be a cover fallow that: 1) provides fodder for animals grazing the pastures (Nye and Greenland, 1960); 2) accelerates all nutrient recycling of residues from previous and current crops (Roder *et al.*, 1995); 3) contributes to the control of weeds and pests (Buckles, 1999); and 4) improves soil-water and nutrient retention capacities (Roder *et al.*, 1995): preventing the leaching of nutrients particularly in coarse-textured soils.

Different varieties of rice and legumes are an important component in the development of cropping systems throughout Cambodia. Early maturing legume and rice varieties are available in Cambodia (Javier, 1997) and need to be examined. Continued testing of varieties in a range of locations will assist in improving the adaptation of these cropping systems in Cambodia.