CHAPTER 5

CONCLUSION

5.1 Suitable cultivation practices for methane mitigation and rice production under rice straw management systems

Burning of agricultural residues in fields is a common practice in developing countries. It is used to clear remaining straw and stubble after harvest and to prepare the field for the next crop cultivation. In Southeast Asia, burning is the major disposal method for rice straw (IPCC 1996). This research showed that the immediately change of soil temperature in burning field induced endothermic reaction from soil to water and induced water transport from ground to soil surface which may due to forces from water evaporate caused by burning heat, (Figures 3.9 and 3.12). In addition, the soil water in the deeper level moved up to soil surface by capillary force and hence results in soil temperature dropped at the initial stage of burning. Thereafter the increment of soil temperature up to 28 °C (an average soil temperature = 26 ^{o}C) occurred at 5, 10 and 20 cm depth of soil on account of heat transfer from soil surface to soil depth by heat conduction process while, air temperature in burning period changes from 32 ^{o}C up to 43 ^{o}C. Normally, the burning was done before noon or in evening that result to a slightly change of soil temperature (±2^{o}C). Therefore, rice straw burning in the rice field, although lead to soil surface temperature change but its effect is minor to soil temperature change by depth. As the result, effects to microbial community and quantity in surface soil are insufficient, as show in Figures 3.26 and 3.27. In addition, timing of burn is the key to control the violence of burning impact. We found the increasing of water content in 10 cm soil depth and the reducing of soil water content at soil depth 20 and 30 cm when the field burned around noon. In the other hand, the water content did not change when the field burning was done in the evening (Figure 3.13). Since the evening has more moisture on the field and the diurnal pattern of temperature and soil water content are on the way down therefore the change of temperature during field burn dose not high.

In fact, the rice straw management incorporated into the soil can avoid air pollution from open field burning. Although the addition of organic carbon into the soil with anaerobic condition in paddy field encourage the rising of methane emission. However, the application of water drainage during early flowering period can reduce methane emission significantly. In irrigated paddy fields, drainage practices are often performed in order to remove harmful substrates produced in reduced soil and to supply O_2 to the rhizosphere to vitalize the roots. In general rice fields typically are drained several weeks before harvest. Mid-season drainage practices have recently attracted attention because the practice itself can reduce CH_4 emissions from paddy fields (Towprayoon et al., 2005; Yagi et al., 1996). Guo and Lin (2001) proposed that the duration of aeration and the nitrogen fertilizer dressing time and rate are the key factors which control N_2O and CH_4 emission. From our experiment, the mid-season drainage in irrigated rice field showed more effect on GHG mitigation in the carbon-rich (unburned rice straw) rice field than low carbon (burned rice straw) rice field as show in figure 3.31. The GHG reduction were 23.83%, 14.51% and 10.98% in S, I and B plots, respectively.

The soil carbon and soil nitrogen changed according to the cultivation practice, especially the rice straw management. Soil carbon in rice straw incorporation field (I and S plot) was higher than soil carbon in burned rice straw field (B plot) due to the effect of rice straw application. On the other hand, soil nitrogen content was higher in burned plot than the other two plots. This phenomenon supported well in the result of emission of nitrous oxide. This research reveals that higher methane emission can be found in the rice straw incorporated paddy field while higher nitrous oxide emission can be found in the field with burned rice straw. The average annual GHGs emissions were 1.26, 1.29 and 1.34 kg/m^2 in B, I and S plot, respectively.

In terms of rice production, it was found that B plot produced higher grain yields than the others. The grain yield in I plot and S plot were 13% and 14% lower when compare to B plot. However, mid-season drainage did not show significant difference in yield production to local drainage However, considering the increase of soil carbon and reducing air pollution with acceptable yield reduction is a key factor in solving environmental problems. Therefore, the suitable cultivation practice for methane mitigation, air pollution avoidance and rice production under rice straw management system is unburned rice straw with mid-season drainage.

5.2 The carbon budgets in paddy soil with different rice straw management systems

The time scale of carbon budget in this experiment covered from the beginning of land preparation until harvesting. The data collections were performed in double crop of rice cultivation in 2007. The net carbon budget equals the carbon input (seedling, rice straw, stubble and rice plant) minus the carbon output (grain, rice straw removal, CH_4 emission, carbon release in gas phase from burning and microbial respiration), assuming that losses due to leaching is negligible. The rice straw and stubble application (I plot) had a positive impact on carbon budget after continuous incorporate residues. Our experiment showed that soil carbon can increase by incorporating rice straw and stubble practices. On the contrary, the rice straw burning is the main cause of carbon loses from system as shown in B plots. The carbon budget presented the most negative in both crops of rice straw burning practice (-180 g/m^2 and -150 g/m^2).

In the aspect of greenhouse gases inventory, CH_4 emissions are important part of carbon removal from rice ecosystem because the higher GWP 21 times of CO_2. Therefore, with regard to mitigation aspect, we have introduced the option of mid-season drainage into the experiment. The measurement GHGs emissions were conducted for the two crops consecutively throughout the rice cultivation in wet season and dry season. Local cultivation practice with rice straw and stubble incorporate (LI) plot was the large source of methane emission but can be reduced by huge implementing of mid-season drainage before the flowering stage, as shown in result of mid season drainage practice with rice straw and stubble incorporate (MI) plot. Study of carbon budget showed that the burning rice straw practice induces the soil carbon loss from rice field higher than unburned practice. The incorporate residues can slow down the carbon loss from soil. Moreover, in the long term, the continuous incorporation of residues tends to increase soil carbon. In conclusion, the study provides a preliminary sustainable cultivation for irrigated rice field and proposes to increase soil carbon by incorporated rice straw into the soil and diminish methane emission by apply the mid-season drainage before the flowering stage as mitigation option. The burning plot although obtained high yield, the carbon can be lost from the soil and create pollution for the surrounding area.

Recommendations

In general, the amount of carbon removed by the crop harvest and high decomposition rate was higher than the carbon supply, and therefore, the estimated carbon budget became negative and could not be compensated by only straw or stubble incorporation. Integrated use of other materials along with rice straw may be a preferred strategy in carbon sequestration in rice fields. Currently, Thailand requires alternative energy to substitute fossil energy for power production. Rice straw is one of the potential biomass for renewable energy because of its large quantity produced country wide. Annually, 8.5–14.3 Mt rice straw burning contributes 5.0–8.6 MtCO_2-eq which could be converted to 786–1325MW of power production, yielding a total greenhouse gas (GHG) avoidance of 7.8–13.2 MtCO_2-eq at plant efficiency 20-27% (Suramaythangkoor and Gheewala, 2008).

The present study suggests the suitable rice straw management in terms of greenhouse gas emissions and potential for carbon storage. However, the long term monitoring of carbon budget and soil carbon content are needed to clarify the soil carbon storage as the potential of biosequestration in paddy field. In addition, study of crop models encompass with long term soil carbon storage studies are necessary in order to see the positive impact of the rice straw management.