LITERATURE REVIEW

Organic matter and soil productivity

Organic matter plays an important role in maintaining soil fertility. Frye et al. (1985) reported that organic matter has beneficial effects on the chemical properties of soils. It is an important mobilizer of plant nutrients. Acids produced during decomposition of organic matter facilitate the release of plant nutrients from mineral soil and as the organic matter decomposed, plant nutrients are mineralized to be made available for plant use. About 25-30% of nitrogen contained in organic matter can be absorbed by rice plant during one crop season (Inoko, 1984). Consequently, continuous application of organic matter accumulates nitrogen and other nutrients in the soil. Generally, the higher the organic matter content, the higher the nitrogen supply capacity in the soil (Wen, 1984). In wetland rice 50-80% of nitrogen comes from soil organic matter (Broadbent, 1979a) and organic matter also increases all available nutrients except zinc (Ponnamperuma, 1980) due to its high cation exchange capacity.

In addition, the application of organic matter is useful in maintaining or increasing the organic substances or nitrogenous compounds in the soil, which decompose slowly but steadily. Subsequently, the nutrients supplied from organic matter are used slowly and remain in the soil for a period of time in contrast with chemical fertilizer which are used rapidly but less effectively (Kumazuwa, 1984). Miller et al. (1965) reported that the slow-release pattern of nitrogen and sulphur mineralization from organic matter offers a definite advantage over soluble fertilizer.

The beneficial effect of organic matter on soil physical properties is known to increase water infiltration. Miller and Arstat (1971) investigated the furrow infiltration rate with different rates of organic matter in the soil. They found that the infiltration rate of higher organic matter in the soil was maintained at a high level throughout irrigation period, while that of the control with low organic matter in the soil decreased rapidly with time.

The effect of organic matter on water holding capacity seems to depend on soil texture. Available moisture content usually increases with organic matter in coarse textured soils. The beneficial effects of organic matter application result largely from an increase in moisture holding capacity due to the higher level of available nutrients in the organic matter (De Datta, 1984). The reduction in soil organic matter represents a reduction in soil structural stability (Wall, 1990). As the organic matter of surface soil increases, the degree and stability of aggregation also increases (Frye et al. 1985).

Biologically, organic matter regardless of the sources has high microbial population and stimulates general microbial activity in soils. In wetland rice, organic matter is the substrate for anaerobic microbial activity (Nenu, 1985).

Since organic matter can influence soil productivity as described above, it will also likely to affect plant growth and development. Volk and Leoppert (1982) reported that the yield potential increased by an average of 21% for 1% increase in soil organic carbon. According to the experiment conducted by Vacharotayan and Takai (1983) at Rangsit, Surin and Phisanulok rice experimental stations in Thailand, the organic matter in the form of rice straw compost could increase the yield of RD7 paddy rice variety. At Surin and Phisanulok, paddy soils showed a high response to rice straw compost and even better yield could be obtained if a higher rate such as 15-18 t/ha of rice straw were applied.

Crop residues in rice-soybean cropping system

Generally in rice-soybean cropping system, main crop residues are straw and soybean residues. Straw is burnt before planting soybean for controlling weeds. Therefore, straw may not be the source of organic matter in this system. After soybean had been mechanically threshed, soybean residues consisting of dry stems, branches, leaves and pod shells are usually left as a pile in the field. The ratio of soybean residue and yield was found to be about 1.4:1 and contained about 1.3% of total nitrogen, 0.1% of phosphorus (P) 2.71% of potassium (K), 39.8% of organic carbon and the amount of the residue left varied from 1.2-2.5 t/ha dry matter (Ongprasret, 1988). Usually in the North, farmers manage their soybean residues by leaving them in the field and then incorporate them into the soil by plowing or burning before planting the following rice crop.

Therefore, use of soybean residues in rice-soybean cropping system may become important, not only as a substitute for nitrogen fertilizer but also to improve physical and chemical properties in rice soils. However, the amount of soybean residues remained in the field is low and often times they are burnt and used for other purposes. Thus, the use of soybean residues alone may not return nutrients and organic matter to the soil at the level that can improve or even maintain soil productivity in this intensive system. Bhromsiri (1988) indicated that 5-6 t/ha of soybean residues were needed in order to achieve an equivalent of applying chemical fertilizer at the rate of 50 kgN/ha for rice.

Considering the soybean residues that the farmers have, the use of soybean residues integrated with inorganic fertilizer should be taken into account when determining the fertilizer requirement of a rice crop and the long term effect on soil fertility.

Green manure as a source of organic matter and nitrogen

Green manure crops are planted and incorporated into the soil in order to provide large quantity of nitrogen and organic matter to the main crops grown later in the same field.

Among the green manure crops, *Sesbania rostrata* has shown great potential in wetland rice because of its tolerance in a range of adverse edaphic conditions, such as salinity and water logging. It grows fast even in flooded conditions and can fix nitrogen at a high rate since it is able to nodulate along its stem as well as in its roots. The nodules can fix nitrogen and release it into the soil after being incorporated (Dreyfus et al., 1981). Rinaudo et al. (1988) found that one third of nitrogen fixed was transferred to the crop and two thirds remained in the soil.

Ibus et al. (1988) reported that at 45-60 days of growth in flooded and dry conditions, *Sesbania rostrata* could yield 20-30 and 30-35 t/ha of biomass with 100 and 200 kgN/ha, respectively.

A similar study in Senegal by Gines et al. (1986) revealed that at 45 days after planted in three 100 square-meter trial plots in farmers' field, *Sesbania rostrata* could produce 12-17 t/ha of biomass (1.5-3.0 t/ha dry matter) and total nitrogen of 62-88 kg/ha.

According to experiments conducted in Northeast Thailand, *Sesbania rostrata* showed encouraging growth and appeared to be an alternative source of organic matter (Regland et al., 1986). Herrera et al. (1989) reported that the nitrogen contribution of *Sesbania rostrata* at 40-60 days after planting in Ban Khu Khut, Ubol Rachathanee was 50-76 kgN/ha and produced 1.72-2.26 t/ha of dry matter. Incorporation of *Sesbania rostrata* at 21 days before rice transplanting increased grain yield by 1.05 t/ha.

However, planting *Sesbania rostrata* requires not only 45-60 days before incorporation and transplanting rice but also conventional land preparation with one plowing and one harrowing for good emergence and growth. Moreover, additional labor for broadcasting or seeding, harrowing and water availability are needed. Usually *Sesbania rostrata* grows well in the rainy season (June-September).

Under intensive cropping system in irrigated lowland conditions of Northern Thailand, less fertile soils such as San Sai series are used for rice-soybean cropping systems. The decline in yield has been seen both in farmers' fields and in the long-term trials. Soil productivity under such condition should be maintained by replenishing organic matter to the soil. Returning crop residues to the soil and incorporating green manure can be alternate nitrogen sources to supplement inorganic fertilizer and sources of organic matter. To design a proper organic matter management system, there needs to be evaluate of available sources of organic matter currently used by farmers, the feasibility with existing farmers' resources and environment as well as the effect of the new system on soil and crops.