Chapter IV

Discussion

According to the analysis of chemical composition in latex sera collected from the concentrate latex factory during August, 2000 to October, 2001, both CS and DS contain nitrogen mostly in the form of NH_4^+ ranging from 0.5% to 0.9%. The concentration of nitrogen and other elements in CS and DS were higher than that present in Hoagland solution and therefore diluted from 1-9% before testing with rice seedlings. As shown in the process of latex concentrate that ZnO was added to fresh latex as preservative it was well aware that Zn content in serum was exceeded the standard (5 ppm) of effluent from factory of Thailand (Department of Environmental Quality Promotion, 1994). The first step was to test the feasibility of using latex serum with rice seedlings, because seedlings are most susceptible to environment. Hydroponic culture was selected as the method to investigate the possibility of using control serum and deproteinized serum as fertilizer for rice, because large number of treatments can be conducted at the same time. SPR 1 was selected as one of the test cultivar to represent for high fertilizer responsive rice, whereas KDML 105 represent for low fertilizer responsive rice. These two rice cultivars produce good quality grain and widely grown in the central part of the country and the Eastern region, where rubber plantation and factories exist. Due to the variation of nitrogen among lots of latex serum, the greatest variation of total nitrogen and NH_4, which are most useful in controlling application rates on agriculture land should be considered before using (Sommer, 1977). Due to the low nitrogen content of latex serum so it considerable not saving in shipping costs; it was not economical unless turning it in the form of solid fertilizer with high content of nitrogen.

4.1 Utilization of latex serum as fertilizer for rice seedlings in hydroponics culture

At early growth stage, the rice seedlings need water and depend on nutrients mobilized from seed endosperm as the major source of nutrients. Growth of rice seedlings in tap water was therefore observed with long but poorly branched root. Therefore, evaluation of plant growth by measuring the root length may not be the appropriate method. Root dry weight should be also measured.

Growth of rice seedlings, both SPR 1 and KDML 105 were best in diluted latex serum 1-3%. Too high concentration of both CS and DS suppressed development of seedlings. Their roots were darkened, poorly branched and appeared much less healthy than those other treatments, probably due to excessive nutrients that promote growth of microorganisms and they became more competitive than the rice seedlings. Application of chemical fertilizer ($N:P_2O_5:K_2O$=15-15-15) and Hoagland solution even more toxic to seedlings as they became yellow and wilting at 6-8 days after application, probably due to excessive nutrients that caused toxic to rice seedlings. The proper N content for rice seedlings was 4-40 mg/L as reported by Matsuo et al. (1995) in the Kasugai solution. The 1-3% diluted CS and DS contain about 65-195 mg/L (Table 3.1) of total nitrogen which should provide about 56-58 mg/L of NH_4^+ at 1% dilution. The nitrogen content of Hoagland solution calculated was 238 mg/L, which was higher than suitable range for the rice seedlings.

These results indicated the possibility of both sera at low concentration to use as fertilizer for seedlings of SPR 1 and KDML 105. Although latex serum could promote shoot, root and leaf number of the rice seedling, it resulted in a rise of unpleasant odours due to high nutrient content such as sulphur, which is a good growth medium source for a variety of micro-organisms (John, 1968 and 1973; Wood and Lim, 1989). The culture solutions should be renewed once a week in order to maintain pH and sufficient supply of nutrient for the plants.

4.2 Utilization of CS and DS as fertilizer for rice plants in Pot Experiment I

At the maximum tillering stage, rice plants applied with CS9 showed the average height and tiller/hill lower than that of chemical fertilizer about 0.83 and 0.67 fold, respectively but at maturity, the rice plants applied with serum showed higher straw weight of 1.26 fold over chemical fertilizer control. These results indicated the availability of serum as slow-mobilization nitrogen source for paddy rice. According to earlier maturing stage of chemical fertilizer treated plants, the weight loss of chemical fertilizer treated plants may be occurred during the harvesting time by sunlight. The number of tillers/hill increased over untreated control was observed when increasing concentration of CS from CS1 to CS9. This confirms the findings of John et al. (1977), who estimated the number of tillers increases from 4 to 7 tillers by increasing the concentration of serum applied from 1% to 5% by the use of serum in Malaysia. They also indicated that the tiller numbers of rice plants receiving latex serum were somewhat lower than those of complete nutrient solution. It was different from this study that increasing level of serum to CS9 can increase tiller numbers more than chemical fertilizer and produced new tillers till the end of planting. By the end of planting, CS applied plants of CS9 had higher shoot dry weight than those of chemical fertilizer but root dry weight was lower. This indicates that latex serum promoted more shoot growth of SPR 1 than root growth.

Due to the late tiller production, the average flowering day of CS9 treated plants were later than chemical fertilizer treated plants. This means that if only CS9 was applied, it may postpone the harvesting day.

Although at the maximum tillering stage CS9 produced tillers less than that of chemical fertilizer, it produced more panicles/hill and grain yield than that of chemical fertilizer control. This may be due to the production of late tillers that produced the grains. Although grain yield of SPR 1 applied with CS9 were higher, the 100-grain weight was found to be lower. As seen in CS1 to CS9, increasing level of CS, mean 100-grain weight was gradually decreased. This could be due to too much nitrogen at later stages of growth increases sterility of spikelets. It was also observed that percentage of filled grain of CS treated plants was decreased with increasing concentration of latex serum. However, this is not significant among treatments. Follett, Murphy and Donahue (1981) reported that late season nitrogen application tend to increase grain protein more than preplant application but the former have less effect on yield. This indicates that if serum application was performed at early season the grain yield could be better.

Therefore, it is evident that CS at 9% could substitute Ammonium Phosphate fertilizer (16-20-0) at 30 kg/rai. These findings supported by the report of Tan, Pillai and Barry (1975) in that effluent from rubber factories can be used to irrigate fields of oil palm, Napier grass (*Pennisetum purpureum*) and Star grass (*Cynodon plectostachyus*) without ill-effect.

In case of KDML 105 the overall vegetative growth at 70 days after germination of KDML 105 was in contrary to SPR 1 that the application of CS9 were not significantly different in height and tillers/hill from those of chemical fertilizer control. This may be due to the late planting of KDML 105 at the end of October. Being photoperiod sensitive, KDML 105 may accelerate shoot growth and tillering to proceed to reproductive stage. The confirmation of slow-mobilization of nitrogen from shoot to grain of latex serum was seen in shoot dry weight of KDML 105, which was finally more than that of chemical fertilizer about 1.6 fold at maturity in spite of the same height and tillers/hill at maximum tillering stage. Besides higher shoot dry weight, rice plants applied with CS9 had more panicles/hill than chemical fertilizer treated plants. As same as SPR 1, although the shoot dry weight of CS9 treated plants was higher about 1.6 fold, the root dry weight was higher about 1.05 fold only as compared to chemical fertilizer. This confirmed that CS promoted shoot growth more than root growth. By increasing concentration of CS, rice plants tended to increase height gradually, on the contrary, DS applied plants exhibit no difference in height among treatments. This could be due to lower protein concentration in DS resulted from protease treatment and the inhibition of nutrient absorption by surfactant added in the process of deproteinized concentrated latex. The increasing short peptides and free amino acids may promote growth of water and soil microorganisms better than rice plants. Lower overall growth was observed for tillers/hill, straw weight, panicles/hill and grain weight of all DS applied plants. Lower concentration of DS3 and DS5 were more efficient than DS7 and DS9.

Even though KDML 105 has the limitation of photosensitivity; plants applied with CS9 showed delayed flowering about ten days comparing to chemical fertilizer treated plants.

Although the rice plants applied with CS9 produced more panicles/hill than those of chemical fertilizer significantly, it produced lower grain weight and percentage of filled grain approximately 25%. This could be due to too much nitrogen accumulation in the leaves at the reproductive stages of growth that increased sterility of spikelets. As seen in CS1 to CS9, increasing percentage of unfilled grain were observed with increasing level of CS. These results support by the findings of Tanaka et al (1964) who reported that increasing nitrogen fertilizer to rice plants, straw weight and grain weight will increase to one point, after this point grain weight will be decreased.

4.3 Effects of CS and DS on nutrient content of straws, seeds and soils

The significant higher nitrogen content in straws and seeds of SPR 1 and KDML 105 treated with both control and deproteinized sera comparing to chemical fertilizer indicated that transformation of N from latex serum to the rice plants occurred at high efficiency so that more than 2 fold of N accumulated in straws and seeds. The other nutrient content in straws and seeds which were affected by utilization of latex sera is S (Table 3.9 and 3.10). For all other elements there was no obvious change among treatments. The high accumulation of N and S in straws and seeds of rice fertilized with latex sera may result from an increase in protein content which should increase benefit in terms of animal feeds and human nutrition.

Phosphorus content in the straws and seeds was higher when chemical fertilizer was applied (C2). Since the role of phosphorus in the rice plants is to activate root growth, flowering, ripening and good grain development (De Datta, 1981) the low P content of the rice grain and straw of CS treated plants may be due to the low content of P in latex serum. So application of latex serum with more phosphorus fertilizer in the early reproductive stage should give better grain yield.

From Table 3.11 and 3.12, it was found that pH of soils after application with either control or deproteinized sera was increased especially CS9 and DS9 from 4.2 to 5.1-5.8. It is noted that application of latex serum decrease soil acidity significantly and should be considered as sustainable development of soil properties. Since the soil used in this research is classified as acid soil (pH 4.2 before planting), it is interesting to observe about one pH unit change after harvesting comparing to 4.6 in chemical fertilizer treatment. The correlation between K and pH was observed and suggested that KOH may be the factor that was involved. These results also confirmed previous study (Tan et al., 1975) that application of latex serum resulted in a slightly increase in soil potassium.

N content of the soil after crop harvesting of SPR 1 and KDML 105 was increased with increasing level of both sera (Table 3.11 and 3.12). It was significantly higher than that of chemical fertilizer applied soil.

All other nutrients in soil showed increasing trends after planting , as the rice plants can absorb nutrients via leaves and roots, and secreated back to the soil after harvesting.

Zinc concentration in the soils was increased significantly when applying with CS and DS, however its did not exceed the natural average of 81 ppm reported in the soil of China extracted by hydrochloric acid (Herawati, 1998). Cu content in the soil after harvesting of SPR 1 and KDML 105 was 5.34 and 4.34 ppm, respectively, close to 2.78 ppm of the soil from China extracted by HCl without ashing (Herawati, 2000)

Utilization of conventional latex serum (CS) as fertilizer for both rice cultivars showed higher plant growth and grain yield comparing to deproteinized serum (DS). The increasing N content in straws, seeds and soils, in parallel with soil pH also indicated that application of CS9 or diluted latex serum at 9%, which is equivalent to 117 kgN/rai can replace ammonium phosphate fertilizer ($N:P_2O_5:K_2O$=16-20-0) at 30 kg/rai, but require longer time for maximum tillering and flowering especially in non-photosensitive rice, SPR 1 (16 days), and to the less extent in photosensitive cv. KDML 105 (10 days), comparing to the use of ammonium phosphate fertilizer.

To overcome this slow effect of latex serum, the application of ammonium phosphate fertilizer together with CS was performed at various combinations. By defining that 100F is application of 30 kg/rai ammonium phosphate fertilizer (16-20-0) and 100S is 117 kgN/rai of latex serum.

4.4 Utilization of CS in combination with ammonium phosphate fertilizer as fertilizer for rice plants in Pot Experiment II

The purpose of this study was to investigate the appropriate ratio of latex serum and chemical fertilizer for rice plants comparing to untreated control (T1), 100F (T2) and 100S (T3). Among the three combinations of 25F+75S (T4), 50F+50S (T5) and 75F+25S (T6) tested, T5 is considered the best treatment and most economic. With only half strength of chemical fertilizer (50F) and latex serum (50S), the synergistic effect was observed in both plant growth and grain yield (2.2 fold over 100F) in both rice cultivars (Table 3.13-3.16, Fig. 3.15-3.18). Although flowering delay of 5 days was still observed in SPR 1, but KDML flowering was 3 days earlier than the use of chemical fertilizer only. Although SPR 1 took more time to flowering but it produced more panicle/hill than that of chemical fertilizer about 1.82 fold. Moreover grain weight/hill was higher about 2.17 fold and the 100-grain weight was highest. In this study, it was found that latex serum in combination with chemical fertilizer, rice plants did not produce the late tillers anymore.

The percentage of unfilled grain of KDML 105 tends to increase when increasing level of latex serum with decreasing level of chemical fertilizer. Rice plants applied with low concentration of latex serum with high concentration of chemical fertilizer had more spikelets resulted in high percentage of unfilled grain. These results supported Matsushima (1980) who reported that the reduction in the percentage of ripened grains is often due to an excessive number of spikelets.

4.5 Effects of CS in combination with ammonium phosphate fertilizer on nutrient content of straws, seeds and soils

The major nutrient element (N, P, K) and all other minor elements in straws and seeds of T5 in both rice cultivars were similar to those of control T2 (Fig. 3.19-3.22 and Table 3.17-3.21).

In soil, combination of latex serum with chemical fertilizer had no profound effect on soil pH, whereas use of latex serum only has more benefit for acid soil (Table 3.21 and 3.22). It is therefore interesting to understand the effect of full strength latex serum (100S) in the presence of additional chemical fertilizer.

N content of rice straws of 100S was highest due to fresh straw at harvesting period. Rice plants received much more chemical fertilizer went into maturity stage earlier than those receiving lower concentration. So N content was lower in the straws of both rice cultivars applied with high concentration of chemical fertilizer (75F+25S) than those applied with low concentration of chemical fertilizer. Sulfate tended to increase when applied the rice plants with 100S and 25F+75S. Rice plants supplemented with 50F+50S had sulfate content in the straw closed to that of chemical fertilizer. It was clearly indicated that 50F+50S did not affect Zn concentration in the straws of both rice cultivars.

N content in the seeds was in the same trend as the straws. Phosphorus content tended to increase with increasing level of chemical fertilizer. Zn concentration in the seeds was not affected by 50F+50S treatment. Zn content in the seeds of SPR 1 was 30.6 ppm, slightly higher than 23.38 ppm of rice samples from Japan (Herawati et al., 1998). However, Cu content in the seeds was 26 ppm, higher than 3.99 ppm of rice samples from China (Herawati et al.,1998; 2000) Soil supplemented with latex serum was increased in N content in KDML 105 planted soil and also increased K content in the soil of both rice cultivars. Treatments did not affect Cu and Zn concentration in the soil indicating the environmental-friendly of latex serum, which can be fertilized the rice plants.

4.6 Utilization of fixed amount latex serum (100S) and variable chemical fertilizer as fertilizer for rice plants in Pot Experiment III

The design of Pot Experiment III is to evaluate the effect of fixed amount of latex serum in comparison with 100S (T3) plus varied amount of chemical fertilizer: 100S+10F (T7), 100S+25F (T8) and 100S+50F (T9). The results indicated that 100S+50F was the best treatment as shown by drastic increase of tillers per hill, shoot and root dry weight and maximal grain yield of 1.8-2.8 fold over T2 in KDML 105 and SPR 1 (Table 3.23-3.26 and Fig. 3.23-3.26).

In this experiment the total nitrogen applied was 117+4.8=121.8 kgN/rai, which was very high for KDML 105, and resulted leafy-tall plants (Fig. 3.26). Ntamatungiro et al. (1999) reported that nitrogen fertilizer represents a major input to the crop, because high grain yield can be obtained only when adequate amount of N is accumulated in rice plant throughout the growing season. However in photoperiod-sensitive variety such as KDML 105, too high elongation in excess of 150 cm could be observed in the field in excess N-fertilizer (Songmuang and Tawonmas, 1997). Excessive amount of nitrogen in the late stage of growth increases tiller number per hill, panicles per hill, but usually decrease in percentage of filled grain due to sterility of spikelets (Matsushima, 1980). In the 100S+50F (T9) rotten neck was observed in KDML 105, resulted in inhibition of the flow of water and nutrients to the kernels and stop grain filling. An increased incidence of blast disease was also observed.

It can be seen that the tiller number per hill of SPR 1 applied with chemical fertilizer was almost constant at 49 days after germination and increase again at 63 days after germination (Fig. 3.23). Then after secondary applying chemical fertilizer at the beginning of panicle initiation stage the rice plants became healthy and produce new tillers. These results indicate that the nutrient is not enough for the growth and development of the rice plants leaded to low grain yield of T2. Even at the rate of 100S+10F, the rice plants generate tillers/hill, panicles/hill and grain weight closed to that of chemical fertilizer but it showed delay of flowering about 19 days.

This study also showed that the average flowering day of 100S+50F was about 6 days later than that of chemical fertilizer. However, the 100S+50F applied plants produced more grain yield of 2.84 fold over that of chemical fertilizer. Addition of chemical fertilizer to 100S resulted in earlier flowering, but may exceed the N-requirement of the rice platns.

Comparing to the Pot Experiment II (Fig. 3.18b and 3.25b) the number of tillers of KDML 105 receiving 100S+25F and 100F+50S from this study still increased after 70 days after germination so the maximum tillering stage of these treatments was one week later than that of other treatments.

4.7 Effects of fixed amount latex serum (100S) and variable chemical fertilizer on nutrient content of straws, seeds and soils

Fig. 3.27-3.28 show that application of 100S plus increasing amount of 10, 25, 50F resulted in the high nutrient content of straw such as nitrogen, phosphorus and potassium, that can be used to feed cattle. This result agrees with previous study by Tan et al (1975) who reported that rubber factory effluent treated grass can be safely fed to cattle. Moreover it is the good source of nutrient for the next crop production, it straw compost was incorporated in the soil. Snidvong n adyudhya (1993) reported that the rice plants can absorb about 44-56% N from rice straw of the first crop after applied to the soil and 12-15% in the second, and 3-4% in the third crop. So latex serum is the sustainable nutrient source for rice plants. However, Yasuda (1987) reported that an increase in straw weight and a decrease in grain yield were caused by increased nitrogen content in rice plants, as well as by decreased percentage of ripened grains. He also explained that the threshold level of nitrogen content for appearance of damage due to excessive nitrogen was 1.2 g% in straw. From this study nitrogen content in the straw of T3, T7 and T8 of both rice cultivars was higher than 1.2 g% indicating the excessive N, and resulted in low grain yield. Sulfate in the straws of both rice cultivars increased with increasing level of chemical fertilizer to 100S, not the same as in the seeds. Phosphorus in the straw and the seeds of KDML 105 supplemented with 100S+50F was high. This indicates the good grain quality due to the higher food value because of phosphorus content of the grain (De Datta, 1981). K content in the soils supplemented with latex serum plus chemical fertilizer and soil pH increased as compared to untreated control. This result confirms the results obtained from Pot Experiment II and III.

The future uses of organic wastes as soil amendments for agricultural production will be driven by disposal and environmental considerations, as well as by scientific advances (Benckiser and Simarmata, 1994). So the effect of application of latex serum as rice fertilizer in the fields and its environmental impact is necessary to be investigated.