ANNEX 3

Part A. Summary of Country Reports on Production and Field/Pot Test of Plant Growth Promoter (PGP) from Chitosan by Radiation Processing

(1) Bangladesh (Ms. Salma SULTANA, BAEC)

Chitosan was processed from shrimp shells and the production of oiligochitosan was achieved following the FNCA guideline of production. The molecular weight of oligomers is from 7,000-10,000 dalton. The effect of different levels of oligo chitosan application on yield and yield components of rice, mungbean and tomato were investigated. Yield increased up to 10% by applying oligo-chitosan twice at 50 ppm at tillering and booting stages in rice. Moreover, yield increased up to 30% by applying oligo-chitosan twice at 50 ppm at vegetative and flower initiation stages in mungbean, while fruit yield increase up to 41% when oligo-chitosan was sprayed one time at 75 ppm during vegetative stage in tomato.

(2) China (Dr. Jing PENG, Peking University)

The oligo-Chitosan prepared by radiation technique has been commercialized in China. It has been used in the field test of cucumber. After treatment, the amount of straight cucumber and average weight gain could be increased. PGP has been widely used in China to increase the yield, enhance the quality of products, improve the ability to stress, facilitate the mechanized farming and to promote the new agricultural system. PGR is considered as Pesticide in China. In the prospects of PGP application, the PGP will be widely used in agriculture, forestry, and horticulture to improve the efficiency of fertilizers to reduce environment pollution and the efficiency of water. Combination of PGPs will be used such as PGP+PGP, PGP + fertilizer, PGP + insecticide or fungicide or herbicide.

(3) Indonesia (Dr. Darmawan DARWIS, BATAN)

Oligochitosan Plant Growth Promoter (PGP) was prepared by irradiating chitosan using gamma ray with a dose of 75 to 100 kGy. The evaluation of contribution of oligochitosan to phosphorus uptake of soybean plants has been carried out. The results show that oligochitosan increase total phosphorus uptake of soybean plant significantly. Combination of oligochitosan with biofertilizer shows more phosphorus uptake of soybean plant. Oligochitosan in 0.5% in acetic acid solution concentration, 2L/Ha shows

optimum total P uptake in soybean plant. The same results were also shown by yield of soybean seed. The yield of soybean seed is 2.8 ton/Ha for the plant treated with fertilizer formulation of ½ recommended NPK + oligochitosan + liquid fertilizer while the yield of soybean seed for control is 2.1 ton/ha.

The oligochitosan PGP produced by our institute was introduced to the IAEA Deputy Director General and Head of The Department of TC, DR. Kwaku Aning and his team under their visit to CAIRT BATAN. Introduction and socialization of Oligochitosan PGP to Ministry of Research and Technology and members of Parliament from South Kalimantan was done at CAIRT BATAN on December 27, 2011. Training on the application of oligochitosan for plant growth promoter to the farmers and agricultural staffs from Kerinci District, South Sumatra Province was done at CAIRT BATAN on 19-21 December 2011. This training was attended by 6 participants including local farmer, Agriculture Department District staff and farmer supervisor

(4) Japan (Dr. Naotsugu NAGASAWA, JAEA)

Oligo-chitosan and oligo-alginate, obtained by gamma-irradiation are effective as plant growth promoter and plant elicitor. The average molecular weights of oligochitosan and oligoalginate are below 10 kDa by GPC. The chitosan and alginate fraction with Mw in range of 1-3kDa (Dp: 5-16) significantly increased the plant growth of barley and soybean. Alginate irradiated in 4% solution was used to investigate the changes in its molecular structure. The generation of reducing end, carboxyl end and non-reducing 4,5-unsaturated end residue were identified by 1H and 13C-NMR analysis.

In collaboration research with FNCA biofertilizer project group (PL: Prof. Yokoyama ;Tokyo University of Agriculture and Technology), study for synergy effect of biofertilizer and oligochitosan were conducted. Oligo-chitosan has positive effects on developing nodule number in soybean pot experiments. In case of nitrogen fixation activity, root nodules treated the oligo-chitosan showed a tendency of higher nitrogen fixation activities than those of untreated root nodules. The combination with oligo-chitosan and Live Coat (Cell-nae-genki) was not more practical, when treated at same time. However, when treated with oligo-chitosan at one day before transplant to soil contaminated by the pathogen, suppression effect against tomato bacterial wilt was much higher than those in the individually-treated.

Oligo-chitosan as plant activator (trade name: oligo-glucosamine-L(OG-L)) was commercialized in Japan. To expand commercialization of oligochitosan, PGP, OG-L, we introduced OG-L in exhibition and / or seminar (19 times from April, 2009 to January, 2012).

(5) Kazakhstan (Mr. Bekmuratov TIMUR, Institute of Nuclear Physics)

Commercial applications of radiation processing are very interesting for Kazakhstan. Most interesting technologies for the country are modification of materials and production of track membranes. One material being developed using radiation technology by the Institute of Nuclear Physics is the hydrogel wound dressing. It is very important for the country to exchange information and knowledge with members of FNCA, in the field of - radiation modification of materials, nuclear medicines and radiation oncology. For implementation of radiation processing of polymers (chitosan and SWA production) we need to do market survey review of existing technologies, to choose raw materials and to discuss those technologies with agricultural scientists.

(6) Mongolia (Dr. Amartaivan TSENDDAVAA, Nuclear Research Center, NU of Mongolia)

Mongolia joined FNCA last year. Every activity in the electron beam application project is in the initial state. Joining to these activities, we see three things for future plan:

- Facility possibility: Mongolia has 22 MeV electron accelerator, which has been used for fundamental research till now. First challenge of irradiation of materials would be using 22 MeV electron beam. In the case of beam energy is too high for radiation processing, we will try to decrease electron energy to around 10 MeV. But it would be also first challenge for the facility.
- Project team: Project team will be established many members including biologist, farmer, chemist as well as engineers in the accelerator.
- Choice of raw materials: For PGP production, Mongolia has no raw materials such as shrimp, crabs. Prof. Hien from Vietnam suggested to supply some chitosan for R&D. For future activity, chitosan export from China should be considered. Field and pot test decided to conduct using potato, tomato and wheat.

(7) Malaysia (Dr. Kamaruddin BIN HASHIM, Nuclear Malaysia)

Oligochitosan as plant growth promoter and elicitor has been applied for rice, agarwood plant, vegetable and tissue culture. For field trial on rice plantation, Nuclear Malaysia engaged in research collaboration with FELCRA Bhd, a government owned company. The field trials produced good informative results which revealed the potential of oligochitosan as plant growth promoter and elicitor in agriculture industry. The results revealed that oligochitosan increased the yield of rice to as much as 26%. Direct seedling method produced high yield of rice compare to planting method.

Field trial on agarwood plant where the resin of this plant is being use as perfume, showed the effectiveness of oligochitosan on the growth of plant and at the same time as elicitor preventing disease infection which retard the plant growth. Tissue culture study on banana and pineapple indicated that the existence of oligochitosan in the media increase the growth of the tissue plant. Through commitment, consistent promotion and marketing of oligochitosan by the researchers to potential costumers and end users, local company, Nuclear Malaysia managed to find local company, Avid Focus Resources, as partner to commercialize and market oligochitosan, as indicate in the Non Disclosure Agreement between Nuclear Malaysia and the company.

(8) Philippines (Ms. Charito ARANILLA, PNRI)

The Philippine Nuclear Research Institute studies two natural polymers, chitosan and carrageenan, modified by radiation processing as plant growth promoters. Production of oligochitosan from commercial grade chitosan, was done according to the established FNCA guideline. Preliminary pot experiments were conducted by collaborators from Phil. Rice Research Institute (in combination with fertilizer) and BIOTECH-UPLB (in combination with BioN) using rice and tomato, respectively. Initial data indicate no statistical significant difference in the yield and yield components. However, an increase of 12.4% in the yield of tomato was observed. For oligocarrageenan, production was done with synergy effect of H_2O_2. Initial pot test experiments on rice and mungbean showed statistically significant difference between control and oligocarrageenan treated samples. Increase in yield was more than 25% for both crops. Future works will be more field test applications of oligochitosan and oligocarrageenan, specifically on rice and corn.

(9) Thailand (Dr. Phiriyatorn SUWANMALA, TINT)

Chitin, prepared from local shrimp shells, was changed into chitosan by chemical reactions. Radiation-induced degradation was used to reduce the molecular weight of the prepared chitosan, yielding oligochitosan. Effects of oligochitosan on growth and productivity of Thai chili plants were investigated. The experiment was carried out with randomized complete block design (RCBD) with ten replications. The foliar spraying of oligochitosan (molecular weight ~ 15,000 Da) with the concentration of 20, 30, 40 and 80 ppm mixed with fertilizer was applied. The growth and productivity of these oligochitosan-treated chili plants were compared with those of untreated chili plants. The effects of oligochitosan on Thai chili's growth and productivity were investigated in term of plant height, total number of chilies, total weight of chili, total number of green

chilies, total number of red chilies, harvest time and weight per chili. The results showed that the application of oligochitosan, at the concentration of 80 ppm, mixed with the fertilizer displayed significant effects, statistically, on chili height, total weight of chili, total number of chilies, total number of green chilies, total number of red chilies and weight per chili. The results showed that productivity was increased up to 34%. The oligochitosan exhibited the ability to protect not only aphid inlection but also the ability to shorten the harvest time of chili plants. The treatment of chili plants by oligochitosan clearly displayed positive effects on chili's growth and productivity. These results suggest its potential use in agriculture purposes as growth promoter for Thai chili plants.

Farmers from the southern part of Thailand are interested in making chitosan from shrimp shells. They contacted TINT and requested our R&D staffs to transfer this technology to them. The project was initiated and the course was held during 14 – 16 September 2010 in Chumporn province, in the southern part of Thailand. With approximately 75 participants attending, the workshop was successful. Some participants have applied the lesson learned from the workshop for real applications. One participant has started making chitosan from shrimp shells (instead of commercial chitosan he normally purchases and uses) for treating the water in his soft-shell crab farm. Another participant has applied radiation to reduce the molecular weight of chitosan, for commercial purposes.

(10) Vietnam (Dr. Nguyen Quoc HIEN, VINATOM)

Oligochitosan produced by gamma irradiation of chitosan solution (3%) containing small amount of hydrogen peroxide (H2O2) has been commercialized as biotic elicitor and growth promoter for plant. Results of field test on rice indicated that 4 times spraying per crop is better in term of disease resistance and increase of rice yield (~20%). Therefore it is suggested that further field test with rice seed treatment and together with leaf spraying should be carried out. A guideline of field test of oligochitosan on rice will be soon conducted.