Annex 3

Session Summary
of FNCA Workshop on Radiation Processing and Polymer Modification for Agricultural, Environmental and Medical Applications

26th – 27th October, 2020

Zoom Web-Meeting

Session 2: Project Overview and Confirmation of Agenda

1) Project Overview (Dr Tamada Masao)

The radiation processing and polymer modification project was launched newly from 2018 by merging electron accelerator and biofertilizer projects. This project conducts the following seven R&D subjects which meet the needs in participating countries of Bangladesh, China, Indonesia, Japan, Kazakhstan, Malaysia, Mongolia, the Philippines, Thailand, and Vietnam:

1. Degraded chitosan for animal feeds
2. Hydrogel for medical application
3. Environmental remediation
4. Synergistic effect of plant growth promoters (PGP), super water absorbents (SWA) and biofertilizer (BF)
5. PGP and SWA inclusive process development
6. Mutation breeding of BF microbe using gamma irradiation
7. Sterilization of BF carrier using gamma irradiation

Achievements obtained in the project will be evaluated in the 3rd year to determine continuation of three years as a new phase at the coordinators meeting on March 2021. However, due to a considerable impact of COVID-19 pandemic this phase will be extended by one year and evaluated in March 2022. Thus, the workshop is held by a web meeting to share the information for achievements under limited research activity, current problems, and planning 2021.

Session 3 and 4: Progress Report on Biofertilizer

1) Dr Md. Kamruzzaman Pramanik, Bangladesh Atomic Energy Commission, Bangladesh

R&D Subject

- Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer
- Hydrogel for Medical Application

Short Summary

i) Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer

An experiment was set up and initiated on ***"Synergistic/ combined effect of chitosan (as PGP) and***

***Azopirillum spp. (as biofertilizer)* on rice plants"** at the field level. The field was located in Rangpur and the experiment was carried out on the rice variety BRRI-129 and replica plots were used for each type of treatment. The experiment was implemented up to seedling and then postponed due to COVID-19 situation.

ii) Hydrogel for Medical Application

Last year, an experiment was set up to incorporate chitosan in PVA to attribute the hydrogel with antimicrobial properties upon irradiation by gamma ray. The gel containing chitosan showed antimicrobial activity on both Gram positive and Gram negative bacteria. Animal trial was supposed to be performed this year. Due to COVID-19 situation, experiment on animal trial was not conducted.

Results

None

Future Plan

i) Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer

To observe the synergistic effect of PGP and Bioferfilizer on rice plan: The experiment will be carried out at field level. Irradiated chitosan and Azospirillum species will be used as PGP and biofertilizer, respectively on the rice variety BRRI-19. Six treatments (viz, T1: 100% chemical fertilizer, T2: 50% chemical fertilizer, T3: 50% chemical fertilizer +100 ppm chitosan, T4: 50% chemical fertilizer +100 ppm chitosan+ biofertilizer, T5: 50% chemical fertilizer + biofertilizer and T6: Control) will be applied and several parameters including tiller height and number, panicle length and grain yield will be assessed to determine synergistic or combined effect of chitosan and biofertilizer on the selected rice variety.

ii) Hydrogel for Medical Application

To observe the effect of chitosan incorporated radiation-processed hydrogel on burn injury, a plan has been made for experimental burn injury model. As rabbit shares remarkable similarity in metabolic and pathological alterations of burn with human, this animal has been selected as trail animal. Hot metal tools (coin) method for burn induction will be applied and blocks or disks of chitosan incorporated hydrogel will be used as wound dressing. Wound healing rate will be observed up to two to three weeks and the result will be compared with that of plain hydrogel.

2) Prof Ruifu Zhang, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, China

R&D Subject

- Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer
- Mutation Breeding of BF Microbe using radiation

Short Summary

In 2020, I planned to conduct two experiments, one is the breeding of a biofertilizer strain of *Trichoderma guizhouenase NJAU4742* by X-ray to get improved mutants for stress tolerance, plant

growth promotion and fungal pathogens suppression, the startup strain *Trichoderma guizhouenase NJAU4742* is used for production of biofertilizer in China. The second experiment I plan to do is to evaluate the synergy of Super Water Absorbents (SWA) and biofertilizer in greenhouse pot experiments, but due to the difficulty to get SWA during the COVID-19 pandemic, this experiment was not conducted this year.

Results

To get enhanced *Trichoderma guizhouenase* 4742 strains for different characters: Stress tolerance and antagonism, breeding of this strain with X-ray radiation was carried out, Irradiation dose was: 84 Gy, 84 Gy and 82 Gy for three times, and the total was 250 Gy, After irradiation, the spores of *Trichoderma guizhouenase* NJAU4742 was coated on different screening media.

About 3,500 different mutants were isolated and screened, after irradiation, the salt tolerance of different mutants were significantly improved, especially for the mutants of M4 and M5.

For acid tolerance, some mutants which can tolerance the low pH of 2.5 were obtained.

For fungal pathogen antagonist, mutants with improved biocontrol ability for *Fusarium moniliforme*, *Fusarium oxysporum*, *Phytophthora capsici* and *Rhizoctonia sclerotiorum* were obtained.

Future Plan

- Evaluation of these breeding strains in greenhouse and field experiments;
- Synergistic Effect of Super Water Absorbents and Biofertilizer

3) Mr Nana Mulyana and Dr Darmawan Darwis, National Nuclear Energy Agency (BATAN), Indonesia

Short Summary

The decrease in the carrying capacity of agricultural land due to limited macro nutrients, salinity and other pollutants such as heavy metals has a negative impact on efforts to develop sustainable development goals (SDGs). This study aims to obtain N-fixing bacterial isolates and P-solubilizing that are able to adapt to high salinity conditions, lignocellulolytic fungi with optimum capabilities that can be used in the development of community empowerment-based bioremediation. The mangrove forest of Hurun Bay Lampung was used as a place for taking bacterial isolates from the rhizosphere of *Rhizophora apiculata* and *Sonneratia alba*, then obtained 2 bacterial isolates (SB33, SB36) N-fixing and P- solubilizing which are effective in high salinity conditions. The use of Co-60 gamma irradiation to obtain fungi *Trichoderma reesei* and *Phanerochaete chrysosporium* with higher lignocellulolytic capabilities and heavy metal uptake. The results showed that fungi *Trichoderma reesei* exposed to gamma rays at a dose of 750 Gy had a specific cellulase activity 1.5 times higher than that of the control (wildtype). Fungi *Phanerochaete chrysosporium* exposed to 600 Gy gamma rays had good growth ability in medium containing heavy metals Pb and Cd. In the 500 ppm Pb and 50 ppm Cd medium, the fungi *Phanerochaete chrysosporium* 600 Gy had a biomass weight of 3.0 and 3.6 times higher than the control (wildtype). In 1% alkaline lignin medium and 5% Gmelina wood

(*Gmelina arberoa* Roxb.) substrate, fungi *Phanerochaete chrysosporium* 600 Gy had 2.34 and 2.07 times higher lignin peroxidase (LiP) activity than the control (wildtype). The results of this study are expected to be an alternative solution in utilizing mangrove biodiversity, plant biomass substrates and gamma irradiated mutated molds to support the development of food security and security through community empowerment-based land bioremediation.

4) Dr Phua Choo Kwai Hoe, Malaysian Nuclear Agency, Malaysia

R&D Subject

- Environmental Remediation
- Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer
- Mutation Breeding of BF Microbe using radiation
- Sterilization of BF Carrier using radiation

Short Summary

Malaysia's biofertilizer market is currently focusing on liquid multifunctional biofertilizer products. Malaysia focuses on carrier sterilization, commercialization of biofertilizer, synergistic effects of biofertilizer with oligochitosan, mutagenesis of biofertilizer microorganisms by using gamma irradiation, seed treatment biofertilizers, biofertilizer toxicity test, and bioremediation.

Results

Malaysia successfully commercialized four biofertilizer products (Bioliquifert, GoGrow BioNPK Biofertilizer, M99 Biofertilizer, and BioNiK Phos). A total of 400,000 L Bioliquifert were distributed to paddy growers in West Malaysia from January to October 2020. Total sales was RM 6,800,000.00. GoGrow BioNPK Biofertilizer was launched on 4–5 November 2019, Nuclear Malaysia Innovation Day. BioNik Phos is a commercial biofertilizer developed through Ugandan Biofertilizer Project. M 99 Biofertilizer as a single microbe multifunction activity product will launch on 10 November 2020. This product won 5 awards. Effect of M99 biofertilizer, radiation processed chitosan (RPC), and chemical fertilizer on *Brassica* sp. plant in greenhouse showed the presence of a synergistic effect between M99 and RPC. Experiments on the effects of biofertilizer C2, oligochitosan, and liquid smoke on fertigated chili plants at PUSPEN (Cure & Care Rehabilitation Centre) were initiated in September 2020.

Improvements in the multifunctional activities of *Acinetobacter* sp. were conducted through gamma irradiation. The mutation effects on the phosphate solubilisation gene (*pqq* genes) were obtained. Isolation of full sequences of *pqq* genes is currently in progress. Development of biofertilizer-treated seeds using encapsulation is currently in progress. Biofertilizer toxicity test was performed to determine the toxicity level of the biofertilizers by using Zebra fish embryo. Five types of biofertilizers (AP1, AP2, AP3, M99, and M100) were safe to use. There were 12 publications, 1 trademark and 3 copyrights produced.

Future Plan

Current biofertilizer projects (commercialization, synergy effects, mutagenesis and seed treatment) will be continue and carrier sterilization and bioremediation projects will start in 2021.

5) Ms Sunjidmaa Otgonbayar, Institute of Plant and Agricultural Sciences, Mongolia

R&D Subject

- Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer

Short Summary

In 2001 the IPAS successfully launched its biofertilizer product under the trade name of Rhizobacterial fertilizer, which reduces the input cost of fertilizers and increases crop yield. The Rhizobacterial fertilizer is a low cost and environment friendly product and can be used to enhance the yield of all crops as well as soil fertility. Oligochitosan is a low molecular weight chitosan and it can be obtained by γ-ray irradiation to chitosan /from Indonesia/.

Results

In case of experimental plants control group number of fruit is both oligochitosan and biofertilizers show similar effect. In synergy effect group number was 1.3 times higher than control. This is very similar results on sweet pepper. Biofertilizer and Oligochitosan are significantly effective for plant growth promotion, but best result is found in synergy effect which significantly higher than expected result.

Future Plan

- To determine and isolate bacterial local strains
- Carrier material irradiation
- Synergy effect of oligochitosan and Bacterial fertilizer on wheat, cabbage and 1st seed of potato.

6) Ms Julieta A. Anarna, National Institute of Molecular Biology and Biotechnology, University of the Philippines Los Banos, The Phillipines

R&D Subject

- Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer

Short Summary

The use of microbes as biofertilizer is an important part for sustainable production of agricultural crops whether conventional or incorporation in organic practice. For this year report we had conducted three field experiments two for co-inoculation of Bio N (Azospirillum) and Mykovam (Mycorhiza) using corn and tomato as the test crop and the other experiment was carageenan and Bio N compared with chemical fertilizers (analysis is ongoing). Production, promotion and extension of the biofertilizer technology is continuously conducted.

Results

Evaluation of combined inoculation of Bio N and Mykovam with chemical fertilizer was conducted

using corn and tomato as the test crop. The experiments were conducted under field condition layout using RCBD with three replication and with the following treatments T1 – Control , T2 – Full Chemical fertilizers ,T3 – Full Chemical fertilizer + Bio N, T4 - 1/2 Chemical fertilizer + Bio N, T5- Bio N + Mykovam andT6 – ½ Chemical fertilizer + Bio N + Mykovam. The results showed that mean weight of corn from the plants treated with ½ chemical fertilizer combined with Bio N and Mykovam were comparatively similar to the fully fertilized plot.Combination of Bio N and Mykovam yield 8.8 tons per hectare. For tomato, comparison of yield and cost of fertilizer applied on tomato cv.Diamante max was evaluated. Results showed the highest yield of 8.6 tons per hectare obtained from plants treated with full dosage of chemical fertilizer (6 bags Complete (14-14-14) + 6 bags UREA (46-0-0) that cost P 11,400.00 ($220). Plants treated with 50% chemical + Bio N and plants treated with Mykovam obtained the yield of 7.60 and 7.80 tons per hectare respectively with lesser cost of fertilizer due to 50% reduction of chemical fertilizer. Results of the experiment shows the potential of this combination, nitrogen fixing microorganisms (Bio N) and mycorhiza (Mykovam) assumed can furnish the most complete array of elements needed by crops resulting to less use of chemical fertilizers and improving farmers income.

Future Plan

1. Continue on the conduct of experiments for the combined inoculation of different biofertilizers and bio-organic fertilizers to lessen farmers' dependence on chemical fertilizers by formulation of the best combination of biofertilizers and BOF
2. Promotion and extend biofertilizers technology to the farmers
3. Improvement of Bio N production (lifespan, carrier, lessen dosage of gamma irradiation)

7) Dr Kunlayakorn Prongjunthuek, Department of Agriculture, Thailand

R&D Subject

- Sterilization of BF Carrier using radiation

Short Summary

The effect of PGPR bio-fertilizers on growth and yield of sweet corn Hi-Brix 3 variety was studied by using 2 isolates of *Azospirillum* sp. and 2 types of carrier (autoclaved and irradiated) during 2016–2019. The results showed similar for the 4 years. In loamy soils, T1, T4, T5 and T6 made Hi-Brix 3 sweet corn with high fresh pod weight between 10,263–22,631 kg/ha. For sandy loam, the T4 showed the highest weight of fresh pod was 11,250–13,375 kg /ha.

Results

The objective of this research was to study the effects of PGPR bio-fertilizers on growth and yield of Hi-Brix 3 sweet corn using PGPR biofertilizer with 2 isolates of *Azospirillum* sp. and 2 carrier types (autoclaved and irradiation). RCB with 4 replications and 7 treatments were conducted at clay loam and sandy loam during the year 2016–2019. The results showed that using both types of PGPR biofertilizer in the clay loam experiment plots, the results were similar for the 4 years. There were four

methods that made sweet corn of Hi-Brix 3 varieties with fresh pod weight 10,263–22,631 kg/ha is T1 125-31.25-62.5 kg N-P_2O_5-K_2O/ha (recommended rate), T4 PGPR biofertilizer type 1 in combination with 125-31.25-62.5 kg N-P_2O_5-K_2O/ha, T5 PGPR type 2 with 125-31.25-62.5 kg N-P_2O_5-K_2O/ha (recommended rate) and T6 PGPR type 1 with 93.75-0-46.88 kg N-P_2O_5-K_2O/ha (75% of recommended rate). The experimental results of sandy loam showed that the results of the 4 years were in the same, T4 applied PGPR biofertilizer type 1 with 375-62.5-31.25 kg N-P_2O_5-K_2O/ha (recommended rate), Hi-Brix 3 sweet corn gave the highest fresh pod weight 11,250–13,375 kg /ha. Furthermore, it was also found that both types of PGPR biofertilizer resulted in the sweetness of sweet corn Hi-Brix 3 varieties of both experimental plots were 8–18 ^{o}brix and the population of *Azospirillum* sp. *Azotobacter* sp. and *Beijerinkia* sp. in soil increased 5–68% compared with T1 and all three genera of bacteria were effective. For nitrogen fixation between 0.005–0.636 μmol C_2H_2 hr^{-1}, it was pointed out that the use of PGPR biofertilizer.

Future Plan

Study of the use of irradiated carrier with PGPR bacteria isolated from climate change affected areas. To be used in the development of new PGPR biofertilizer that can be used in all areas. It's also cheap with a small packaging size, but is usable in equivalent to old products. The study was conducted in the main economic crops in the country such as rice, sugarcane, cassava, corn, vegetables, herbs and cut flowers.

8) Dr Tran Minh Quynh, Vietnam Atomic Energy Institute, VietNam

R&D Subject

- Mutation Breeding of BF Microbe using radiation
- Sterilization of BF Carrier using radiation

Short Summary

Vietnam is the only country that less influenced by the COVID-19 pandemic in the region though the social distancing, quarantine and isolation have also significantly affected to the application of the mutant strains in practice as well as commercialization of BF product. Fortunately, Forum for Nuclear Cooperation in Asia (FNCA) motivated us to accelerate our works in screening of high cellulase producing strains from gamma radiation mutation of *Trichoderma koningiopsis*. Up to now, we also completed the field tests to evaluate the effects of Rapol V biofertilizer on the growth of tomato plants. We believed that our BF products can be approved for its use in agriculture production in Vietnam soon.

Results

A fungal strain *Trichoderma koningiopsis* VTCC 31435 was kindly supplied by Vietnam Type Culture Collection, Vietnam National University, Hanoi. After activation, the fungus were cultured on potato dextrose agar (PDA) plate at 28 °C for 7 days, then the spores were collected on saline solution (0.9%) containing Tween 80 and gentle shake to obtain a spore suspension with density of about 108-109

CFU/ml. The suspension samples were irradiated under gamma source at the dose ranging from 300 to 2,500 Gy for isolating the higher cellulase producing strains. The results revealed that the highest mutation rate was obtained by gamma irradiation at dose of 700-1,500 Gy. Four stability mutants with high cellulase producing were collected after screening. CMCase and FPase assays indicated the CMCase and FPase activities of the mutants were about 1.51-2.48 and 1.2-1.87 time, compared with the parent. Therefore, these mutants can be applied for decomposing of rice straw.

From last year, the Rapol V, a plant growth promoting BF was prepared from the polymeric carrier composed of radiation modified starch and sodium alginate. Early this year, influences of this BF on the growth of tomato plants grown in both alluvial and exhausted soils were evaluated. The results showed that the combination of these beads based biofertilizer with NPK as regulation much increased the tomato production. More fruits with heavier weight gathered from the treated plants in compare with the control, which cultured by NPK only. The highest marketable yield of tomato fruits obtained with the plants fertilized with Rapol V at 25 kg/ha. Our results also revealed that the use of Rapol V can save at least 20% NPK without reduction of the yield of tomato fruit.

Future Plan

1. Study on the prolonged stability of radiation induced mutant *Trichoderma* strains for further applications
2. Perform the field tests to evaluate capacity of the *Trichoderma* mutants for rice straw decomposing in practice
3. Investigation the long-term effects of Rapol V biofertilizer on the vegetable fertilized with reduced chemical fertilizer (NPK) and promote the use of Rapol V in agriculture production to minimize the agricultural pollution.

Session 6 and 7: Progress Report on Polymer Modification

1) Dr Salma Sultana, Bangladesh Atomic Energy Commission, Bangladesh

R&D Subject

- Hydrogel for Medical Application
- Plant Growth Promoters

Short Summary

i) Hydrogel for Medical Application: Dressing Material for Animal Wounds Using Kappa Carrageenan-PVA Hydrogels

A series of hydrogels were prepared by radiation polymerization, with γ-radiation from ^{60}Co γ-source at room temperature, from an aqueous mixture of polyvinyl alcohol (PVA) and kappa-carrageenan (KC) irradiated at 25 kGy radiation dose. Carrageenan has exhibited its potential for wound healing in the past. Animal trials of these hydrogels were performed by applying on the burn-wounds of rabbits and the wound contraction percentages were determined. Wound contractions for the hydrogels appeared to be more rapid than a burn-wound-healing ointment.

ii) Plant Growth Promoters

The plan which we were supposed to accomplish in 2020 that is now postponed due to COVID-19 pandemic situation. For COVID-19, the last week of March to June, 2020 there was lockdown in our country. Lockdown period, we couldn't attend our office and that's why our all research activities were postponed.

Results

i) Hydrogel for Medical Application: Dressing Material for Animal Wounds Using Kappa Carrageenan-PVA Hydrogels

By applying the KC-PVA hydrogel as wound on rabbit the wound contraction (%) was found higher with comparison to other two rabbits (positive and negative control) with increasing of time (day) and it reached highest at day 24 that was 85.44% and other two values for positive and negative control were found 70.08% and 65.44% respectively. So it can be concluded that wound contractions for the hydrogels appeared to be more rapid than a burn-wound-healing ointment.

ii) Plant Growth Promoters

None

Future Plan

i) Hydrogel for Medical Application: Dressing Material for Animal Wounds Using Kappa Carrageenan-PVA Hydrogel

We have already discussed with Bangabandhu Medical College and Hospital, Dhaka, Bangladesh for the application of the Wound dressing on the Out and in Patients there.

We have been able to draw attention and convince our higher authority about the product.

We are trying to grow awareness through some awareness programs among the Doctors and Mass people (The benefactor)

ii) Plant Growth Promoters

We have already discussed with our higher authority and collaborator (BARI) regarding Field-level trial. We have been able to extend our collaboration with BINA as part of to commercialize PGP. From BINA it would be very much easy for us to reach the farmers. We have been trying on building up awareness about using the environment friendly agricultural practice.

2) Dr Hongjuan Ma and Ms Feng Ye, Shanghai Institute of Applied Physics, Chinese Academy of Sciences, China

R&D Subject

- Environmental Remediation

Short Summary

Waste water treatment using EB irradiation entered the stage of large-scale commercial application in China. Several demonstration projects will be developed in the field of waste water treatment in pharmaceutical factories and also landfill leachate. Multiple polymeric fibrous metal ions adsorbents

were prepare with irradiation induced graft polymerization. Uranium extraction from seawater and uranium mine wastewater treatment move on to pilot stage.

Results

Waste water treatment using EB irradiation entered the stage of large-scale commercial application. The world's largest electron beam treatment industrial wastewater project was completed and put into operation. The project realized the online operation of 7 electronic accelerators, with a daily wastewater treatment capacity of 30,000 tons. The demonstration project already shows three years' stable operation. Waste water treatment using EB irradiation got several orders for the treatment of wastewater from pharmaceutical factories and also landfill leachate. Cooperation with many companies on pilot scale up of metal ions adsorption materials prepared with irradiation induced graft polymerization is under development. Uranium extraction from seawater moved on to pilot stage. A high uranium adsorption capacity of 17.57 mg-U/g-adsorbent in natural seawater and ultra-long service life of at least 30 cycles were obtained. Uranium production costs could be reduced to $80.70–86.25 per kg of uranium, which is similar with the uranium spot price. Several types of fibrous adsorbents totaling 30 kg were synthesized for the uranium extraction from seawater. The exceptional durability of the fibers suggests the possibility of economically producing nuclear fuel from the ocean. Fibrous adsorbents prepared with irradiation induced graft polymerization show more removal efficient than commercial resins. Uranium mine wastewater treatment moves on to pilot stage.

Future Plan

Waste water treatment using EB irradiation is under designing for more various industries such as printing and dyeing, papermaking, chemical, pharmaceutical, etc., as well as wastewater treatment in industrial parks with complex water quality.

One demonstration project for metal ions treatment will be carried out.

100 g uranium will be extracted from seawater.

3) Dr Tita Puspitasari, National Nuclear Energy Agency (BATAN), Indonesia

R&D Subject

- Degraded Chitosan for Animal Feed

Short Summary

The project of degraded chitosan (oligochitosan) for animal feed applications is still ongoing. The internal budgeting was cut sharply due to the limited budget of our institution. Finally, the additional funding has granted as IDR 168 Million or USD 11,450 for the first year of 2020/2021, starting from July 2020 to June 2021 from Educational Fund Management Institutions (LPDP) through Ministry of Research and Technology/BRIN of Indonesia. The lab activities for molecular weight measurement using Gel Permeation Chromatography (GPC) was affected by the prolonged COVID-19 situation due to that we must work from home.

Results

Regarding the limited budget of our institute, the proposal of the application of oligochitosan for animal feed on the Indonesian domestic chicken has been submitted to Ministry of Research and Technology/BRIN of Indonesia for 5 years funding as National Research Priorities. Furthermore, the proposal has been accepted and the funding has been granted as IDR 168 Million or USD 11,450 for the first year of 2020/2021, starting from July 2020 to June 2021. The activities have to support the National Research Priorities on Modern Biotechnology for the Formation of Superior Local Chicken Strains and Supporting Technology for High Productivity and Disease Resistance with the target is to get candidates for Superior Local Chicken Seeds with Egg Production ≥ 60% and Body Weight ≥ 1 kg (Age 10 weeks). The coordinator of the project is Agricultural Research and Development Agency, and make collaboration with many institute including BATAN.

The activity in the first year is testing the physical-chemical properties of oligochitosan as additive to animal feed, especially the analysis of the molecular weight of oligochitosan. The molecular weight of oligochitosan will be measured and verified by using our new equipment of Gel Permeation Chromatography (EcoSEC Elite HLC-8420GPC-Tosoh). The chitosan were irradiated in various methods such as solid, paste, liquid, and combining with H_2O_2. The activities still on going and the result haven't completed yet.

Future Plan

Continuing the molecular weight measurement of oligochitosan irradiated in various methods.

Taking into account the funding of the second year of 2021/2022 supported by the Ministry of Research and Technology/BRIN of Indonesia in terms of national priorities research program to continue the in-vivo test in Indonesian domestic chicken.

4) Mr Alexander Borissenko and Mr Murat Kassymzhanov, JSC "Park of Nuclear Technologies", Kazakhstan

R&D Subjects

- New agricultural products – hydrogels based on potassium polyacrylate and their physical and chemical properties (Production of radiation cross-linked water super absorbents)

Short Summary

The aim of the work is development and synthesis of hydrogels with target parameters for agrotechnical complex.

Area of application: use of super absorbents in agriculture allows to decrease the need in moisture for 50% and more and also to increase periods between irrigations in 2-5 times. The approximate cost of 1kg of product – KZT 2,900 (USD 6.81). Maximum capacity of the product at Radiation Sterilization Complex- 1,400 tons/year. Planned number of being created work places— 10.

Results

The work to implement the production of radiation cross-linked super absorbents based on potassium polyacrylate are still continued.

All necessary permitting documents are received for production implementation.

It is planned to establish a separate subsidiary enterprise of the whole technological line for SWA production. In this regard, the negotiations with private investors on buying out 75 % of ownership interest are underway.

The negotiations with large agricultural organizations are in the process for establishing cooperation and sale of products for 40,000 hectares of area. The negotiations are ongoing to conduct test in the sector of drilling boreholes for using SWA as a solution thickener.

Under cooperation with State Forest Nature Reserve “Semey Ormany”, the experiments with the use of radiation cross-linked super absorbents aimed to increase the survival percent of seedlings planted by open pit methods at the problem areas of “Semey ormany” reserve were conducted.

Work with SFNR “Semey Ormany”

On April 20, 2018 the mechanized planting of two year seedlings of common pipe was carried out with the use of radiation cross-linked waterabsorbing super absorbents at the block 104 of the natural forestry of Semipalatinsk branch of RSE SFNR “Semey Ormany”.

The experimental area comprised of 2 testing fields placed in the suburban forestry of the Semipalatinsk branch of RSE State Forest Nature Reserve “Semey Ormany”: testing field # 1with the area of 8,474 m^2; testing field #2 with the area of 8,113 m^2. As a result of the first month (May 2018), the seedling percent at experimental areas comprises 98 ± 1%.

The inventory of two year common pine seedlings planted on experimental areas carried on October 02, 2020 with the use of radiation cross-linked water absorbing super absorbents showed that: 925 of 2,556 planted seedlings (36.2%) are survived at the Field #1(Washmill (Baltushka) + gel), 748 of 1,942 planted seedlings (38.5%) were survived at the Field #2 (pure gel). At the control field, 405 of 2,000 (17.8%) are survived. *During the inventory, only viable plants with preserved healthy top sprout of coniferous crops are considered.*

Conclusions

Over the past two years of observations, the experimental area where SWA were used, have gone ahead in two times by its survival rate and the growth of some seedlings reaches up to 40 cm that is 10 cm higher than seedlings at the control area.

Sale of 75% of “BetaSorb” ownership share will make possible the engagement of private investors in the use of radiation technologies and accelerating techniques and also provide confidence to investors in our interest in development of “BetaSorb” activity by maintaining 25% of ownership interest in JSC “Park of Nuclear Technologies”.

5) Dr Taguchi Mitsumasa, National Institutes for Quantum and Radiological Science and Technology (QST), Japan

R&D Subject

- Hydrogel for Medical Application

Short Summary

For medical applications, gelatin was gelled and applied to cell culture experiments. On the gelatin hydrogel, the cells grew three-dimensionally, unlike plastic dishes. Furthermore, the microfabrication technique was developed using 3.0 MeV protons for biocompatible polymeric materials such as water-soluble polysaccharide derivatives. Microstructured hydrogels were obtained by the proton microbeam.

Results

The functionalization of biocompatible materials is expected to be widely applied for advanced bio-/medical-technologies such as regenerative medicine, diagnosis, drug delivery, and drug discovery. Hydrogel has been expected as a biocompatible scaffold, which supports to keep an organ shape during cell multiplying and, control gene expression and cell fate. Gelatin has high biodegradability and biocompatibility. It has been used as a base material of the hydrogel. The authors fabricate hydrogels, without the use of toxic chemicals, by using ionizing radiation. The stiffness and stability of hydrogel were investigated under cell culture conditions. HeLa cell adhesion and growth on the fabricated hydrogels were investigated to validate the applicability for the cell scaffolding material. A surface microstructure (minute shape, depth of flute) of the hydrogel is important to control gene expression. The authors developed the microfabrication technique for biocompatible polymeric materials, such as the water-soluble polysaccharide derivatives by using a 3.0 MeV focused proton beam from the single-ended accelerator. Microstructured hydrogels were obtained using the proton beam, and adhesion and proliferation of cells on them were investigated.

Future Plan

Investigate the control technique of the cell function.

Develop new bio-devices for regenerative medicine, diagnostics, and drug discovery.

6) Ms Maznah Mahmud, Ms Sarada Idris, Ms Norhashidah Talip and Dr Marina Talib, Malaysian Nuclear Agency, Malaysia

R&D Subject

- Degraded Chitosan for Animal Feed (Tilapia) (Ms Sarada Idris)
- Hydrogel for Medical Application and Biofertilizer (Ms Maznah Mahmud)
- Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer (Ms Norhashidah Talip)
- Plant Growth Promoters and Super Water Absorbents, inclusive Process development (Ms Maznah Mahmud)

Annex 3

Short Summary

i) Degraded Chitosan for Animal Feed (Tilapia)

0.1% Chitosan in water was irradiated under gamma irradiation (25 kGy) to produce low molecular weight (LMw) chitosan as a dietary supplement for tilapia. The study consisted of 4 treatments (control, 2.5 g, 5.0 g and 7.5 g chitosan/1 kg feed) fed 3 times daily to the tilapia. The addition of LMw chitosan (5 g) showed the best result on final weight, growth rate, feed conversion ratio, protein efficiency ratio and survival rate.

ii) Hydrogel for Medical Application and Biofertilizer

This study was carried out to see the new potential technique and materials for development of ready to use cell culture for 3D cells cultivation. The gamma ray induced formation of PVP crosslinked-network with carrageenan entangles between the crosslinked chains. The hydrogel able to swell and retain its integrity until day 8 in culture media. The cells agglomerate and form spheroid (3D cells) with different diameter ranging from 130 um - 220 um. The κCA-PVP-PEG hydrogel shown its potential as media for 3D cell cultivation. Study on enhancement of hydrogel integrity should be carried out further as to increase its capability to swell and retain its integrity for longer time and at different media conditions.

iii) Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer

Experiments were carried out around July 2020. 5 parameters were carried out in this study; 1) Control, 2) SWA only, 3) SWA with Oligochitosan, 4) SWA with Oligocarrageenan and 5) SWA with VitaGrow (commercial PGP). Chinese Kale was used in this study. For plants heights, synergistic of SWA with Oligochitosan gave the highest value at 20.85 cm. While, for the length of the roots, treatment of SWA only gave highest result.

iv) Plant Growth Promoters and Super Water Absorbents, inclusive Process development

One guidebook on the operational procedure of oligochitosan production in Nuclear Malaysia has been produced. This “Confidential Classified-Document’’ covers irradiation procedure, all analyses at QA and QC stages and overall mixing procedure for oligochitosan production in Nuclear Malaysia. Due to long Movement Control Order (MCO) and Conditional Movement Control Order (CMCO) ‘work from home mode’ which held from March to June we were able to just carry out one pot test on Chinese kale to see the effect of different PGPs which were Oligochitosan, Oligocarrageenan and VitaGrow (local commercial PGP) on Chinese kale. Results from pot test showed that application of PGPs on Chinese kale indicate insignificant effect on growth and yield of Chinese kale. The uncontrollable factors such as low sunlight and heavy rainfall during the test may contribute to the low productivity. Heavy rainfall and rain often caused damage to the plants, fertilizers drain-away and PGP run-off.

Results

i) Degraded Chitosan for Animal Feed (Tilapia)

The influence of different levels of LMw chitosan on the tilapia weight gain, feed conversion ratio (FCR), protein efficiency ratio (PER) and survival rate are discussed.

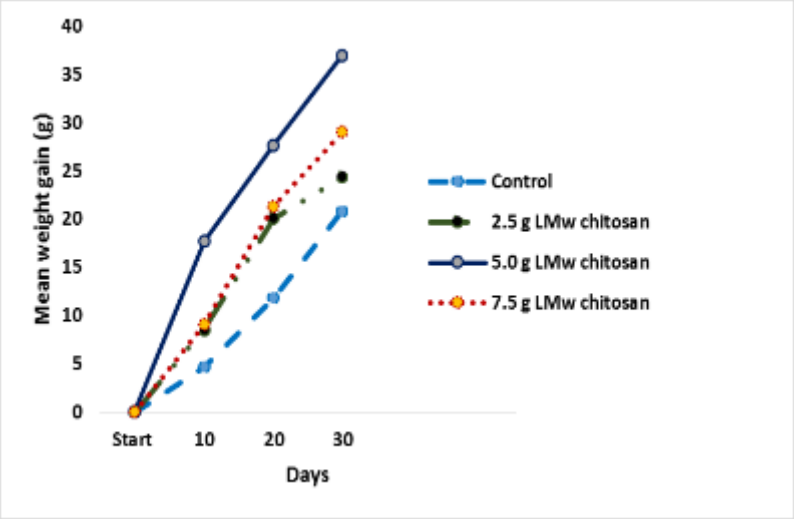

Figure 1. Weight gain of the tilapia fed with chitosan

There were significant differences in weight gain of tilapia between diets containing LMw chitosan and without chitosan during 30 days of experiment. A general tendency of increasing weight gain was observed in all treatments with the addition of LMw chitosan in the diets. This study showed the best growth is tilapia fed with 5 g LMw chitosan, followed by 7.5 g and 2.5 g. Minimum growth was observed in tilapia fed with commercial feed without chitosan.

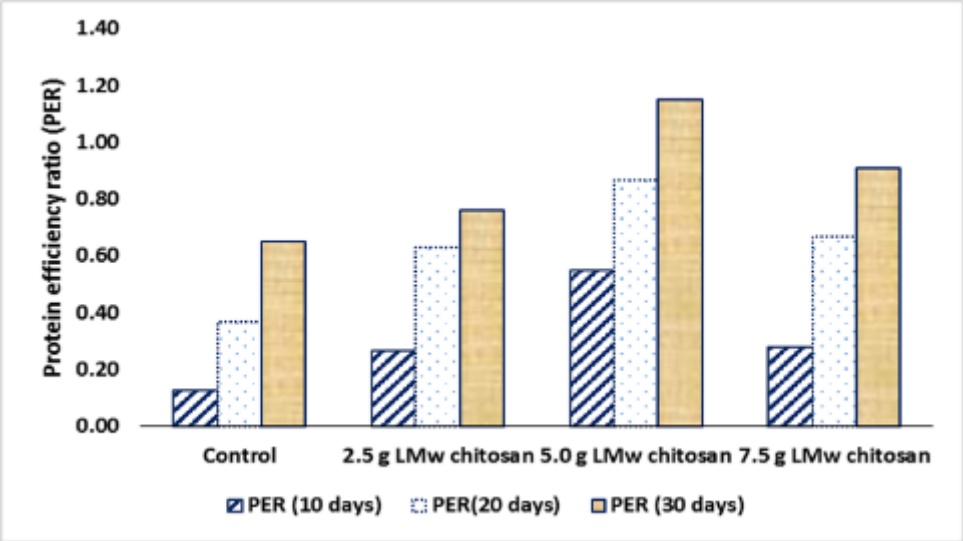

Figure 2. Feed conversion ratio (FCR) of the tilapia fed with chitosan

The value of feed conversion ratio (FCR) revealed that tilapia fed with 5 g LMw chitosan took less food (1.06 g) to produce 1.00 g of fish compared to the tilapia fed with commercial fish pellet (1.69), 2.5 (1.62) and 7.5 (1.14) g LMw chitosan. The study conducted in 30 days revealed that FCR of tilapia fed with 5.0 g LMw chitosan has positive correlation with the tilapia weight gain.

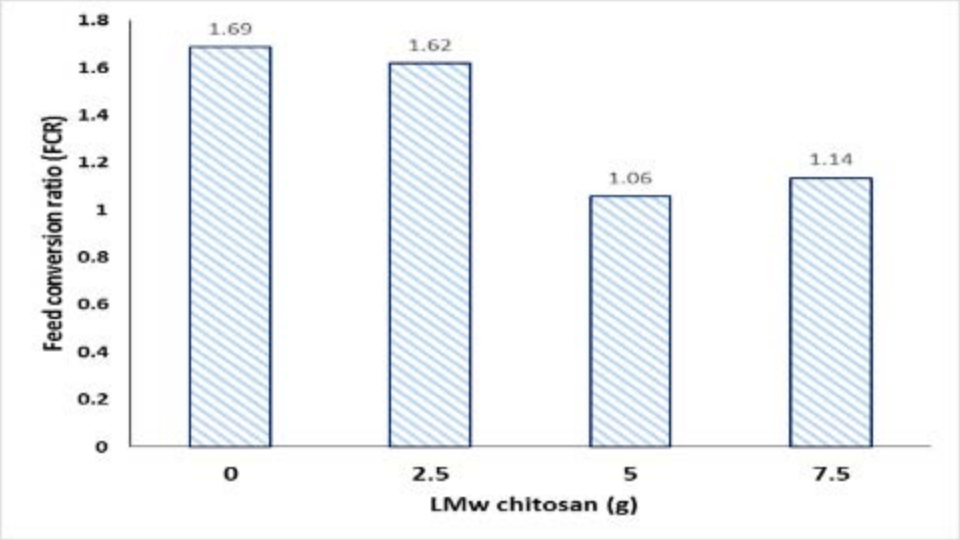

Figure 3. Protein efficiency ratio (PER) of the tilapia fed with chitosan

The best protein efficiency ratio (PER) value for tilapia fed experimental and control diets was from diet of 5 g LMw chitosan. This result revealed that the addition of 5 g LMw chitosan in the diet significantly improve the protein efficiency ratio (PER) hence optimizing the protein consumed. The survival rate of feeding trial in control and 7.5 g LMw chitosan showed more than 50 % mortality, whereas 100 % survival rate was recorded for 2.5 g and 5.0 g LMw chitosan. This result indicated that the optimum level of-chitosan to be added in commercial tilapia food pellet is less than 0.05 % to avoid mortality and preserved suitable condition in the tank.

ii) Hydrogel for Medical Application and Biofertilizer

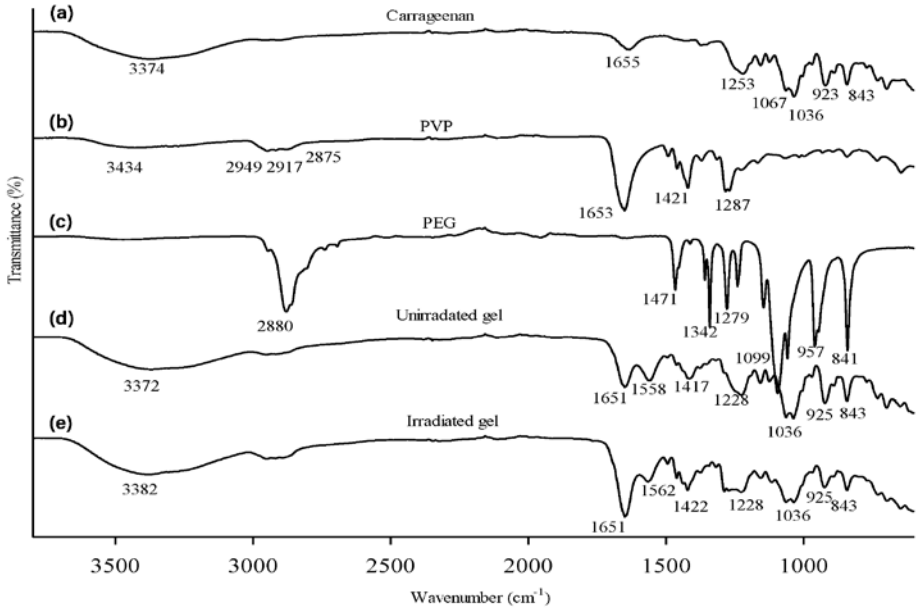

Figure 1. IR spectras of irradiated and unirradiated κCA-PVP-PEG

The insignificant difference in peak patterns and peak position when FTIR spectrum of unirradiated κCA-PVP-PEG hydrogel was compared with the irradiated hydrogel. This finding suggested that κCA and PEG chains are entangled within the cross-linked PVP to form an interpenetrating network (IPN). The irradiation of κCA with gamma-rays resulted in radical formation on the κCA macromolecule chains and these sites of radical formation become the points of initiation for side chains with PVP (Abad et al., 2003). Although κCA known to degrades rapidly with irradiation, the unchanged FTIR spectra of hydrogels after irradiation also indicated that grafting of κCA to PVP or the IPN formation had diminished the degradation of κCA in other words PVP preserved the κCA against gamma-irradiation.

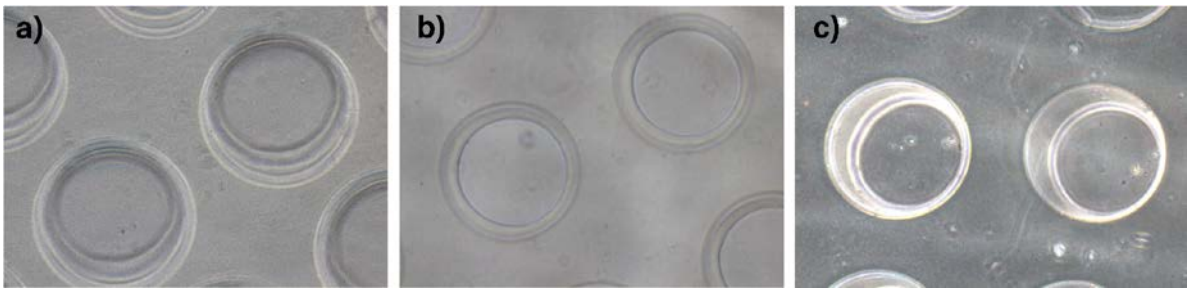

Figure 2. The morphology of microwells on the surface of κCA-PVP-PEG at (a) day-1 (b) day-5 and (c) day-10 in cell culture media.

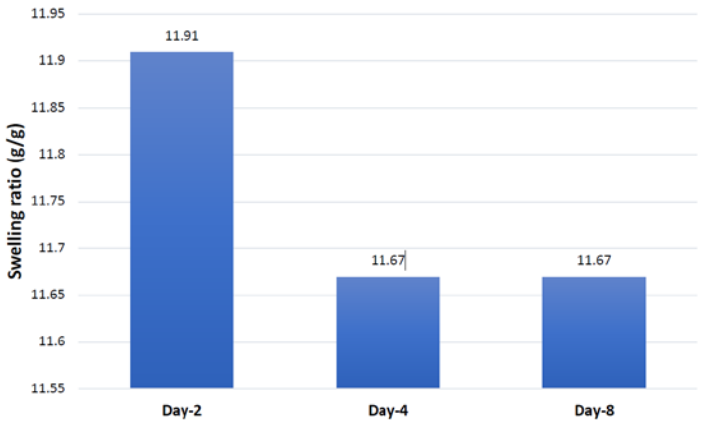

Figure 3. Swelling ratio of κCA-PVP-PEG hydrogels soaked in cell culture media at day-2, day-4 and day-8.

The swelling ratio was slightly higher at day-2 and stabilised afterwards, shown in Figure 3. This might be due to the outwards movement of water molecules from κCA-PVP-PEG hydrogels networks as cell culture media have higher solutes thus created a concentration gradient. However, the equilibrium was reach at day-4 and the swelling ratio remain unchanged until day-8 which indicated no further swelling or deswelling occurred. This also suggested that the κCA-PVP-PEG hydrogels remained physically intact in cell culture media until day 8.

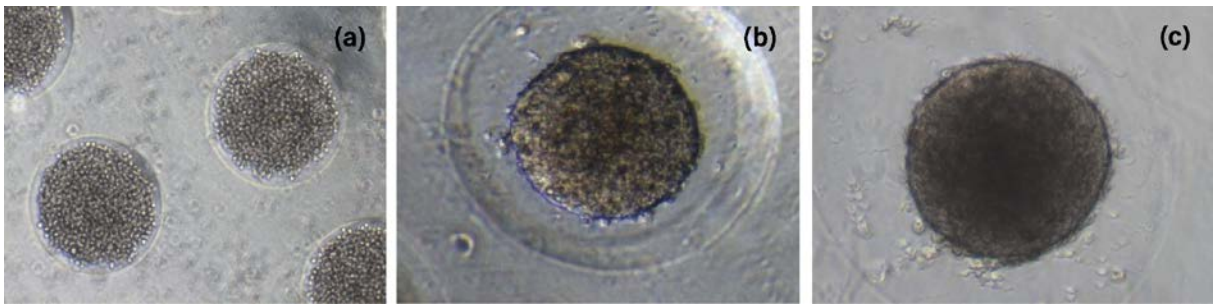

Figure 4. HTB43 spheroid formation at (a) day-1 (b) day-5 and (c) day-10.

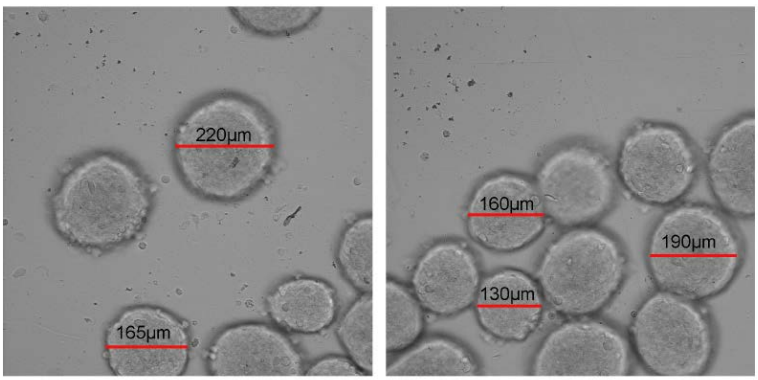

Figure 5. Harvested HTB43 spheroid at day-10 with size range between 130 µm to 220 µm

Figure 4 shows images of spheroids at day-10, captured using Cell Reporter system (Molecular Devices, USA). It is shown that spheroids formed from κCA-PVP-PEG hydrogels exhibited different sizes that ranged from 130 to 220 µm shown in Figure 5. The different sizes might be influenced by different number of cells received by each microwell during seeding process. Other factors that might have the effect towards spheroids sizes are the amount of nutrient supplied and the time of spheroids shaking.

The κCA-PVP-PEG hydrogels serve the purposed of being the potential scaffold for 3D cell culture.

iii) Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer

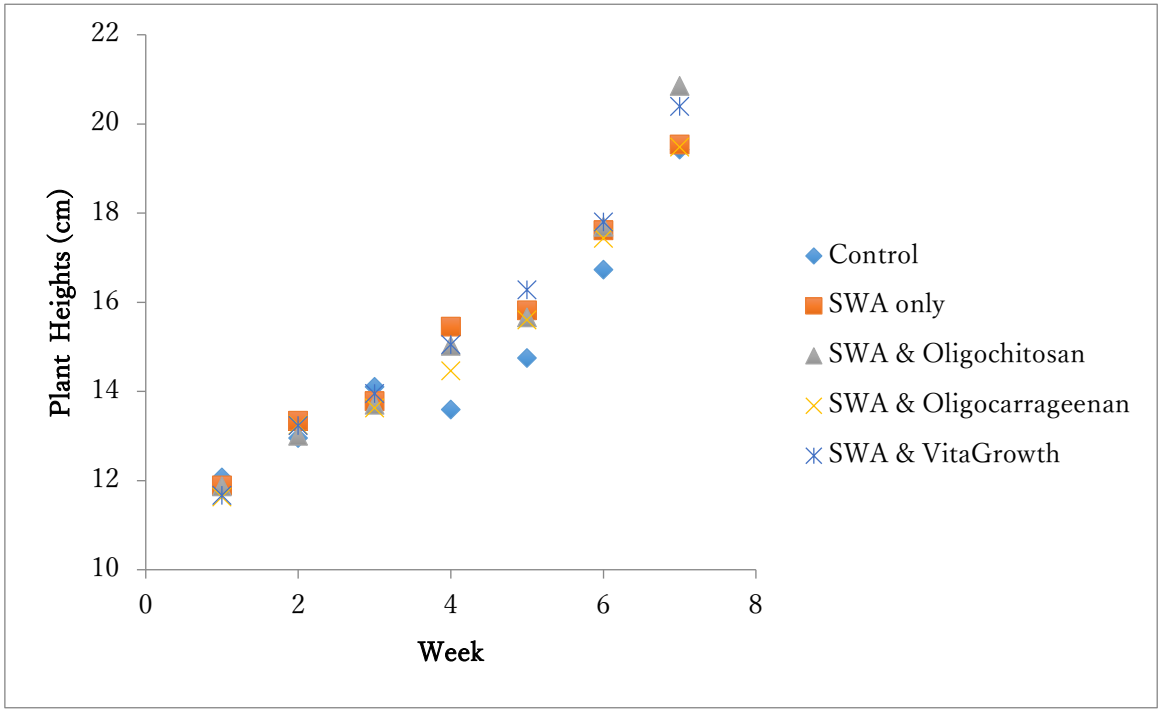

Figure 1. Synergistic effect of SWA and PGP of growth on Chinese Kale.

Figure 1 shows the synergistic effects of SWA and PGP on growth of the plant (Chine Kale). Experiments were carried out for 7 weeks. Data of plant's growth were collected every week. At early stages of plant's growth, at first three weeks, growth of all treatments were at the same rate. The difference in growth rate started at the 4th week where control stated as the lowest growth compared to other treatments. At 7th week, synergistic effects of SWA and Oligochitosan shows highest value at 20.85 cm in height.

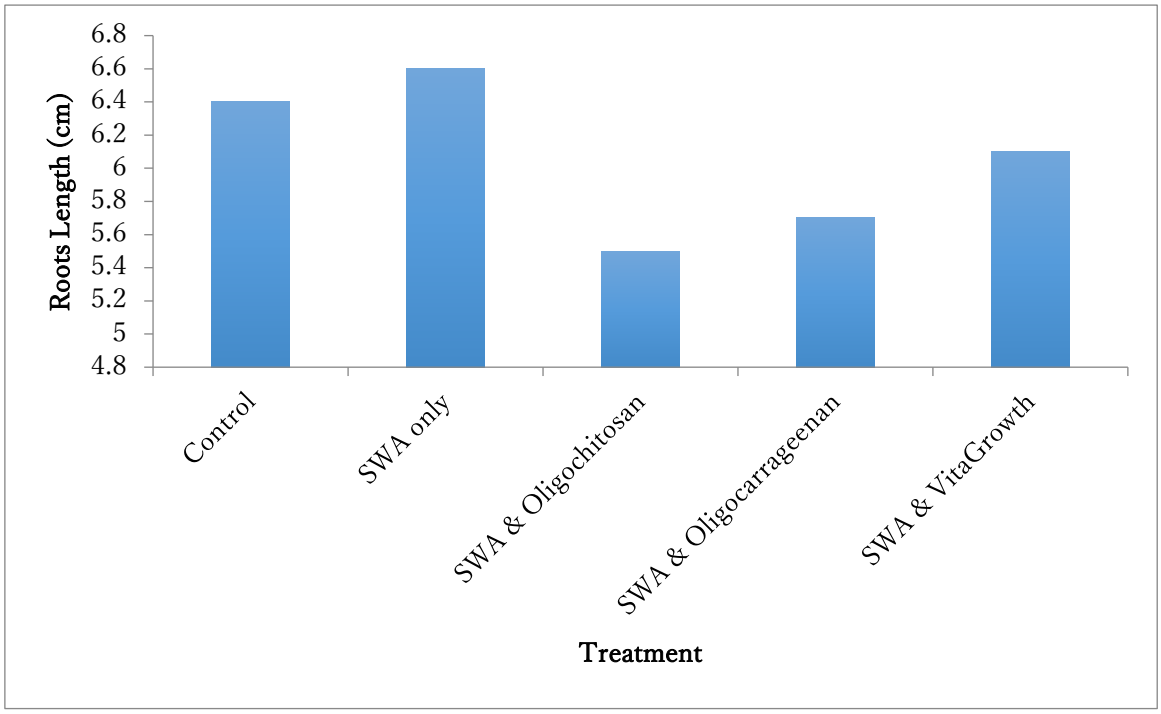

Figure 2: Synergistic effect of SWA and PGP on roots length on Chinese Kale.

Figure 2 shows the synergistic effects of SWA and PGP on roots length of the plants (Chinese Kale). The lengths of the roots were taken on the day of harvesting (week 7). As can be seen, the length of the roots does not effected with the synergistic of SWA and PGP where, treatment with SWA only gave the highest value, 6.6 cm.

iv) Plant Growth Promoters and Super Water Absorbents, inclusive Process development

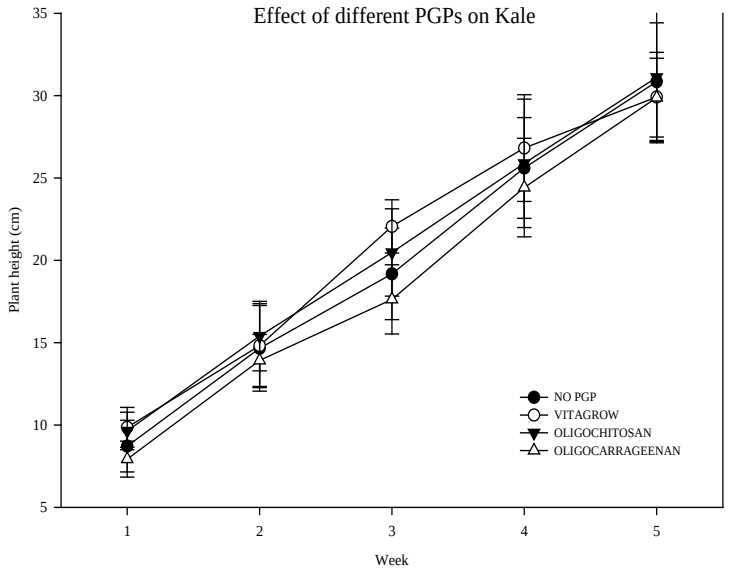

Figure 1. The growth of Chinese kale from week 1 to week 5 after treated with different PGPs and Control (without PGP).

This experiment was carried out to observe the potential of Oligocarrageenan as PGP and to measure the efficiency of radiation-degraded polysaccharides (oligoCarrageenan and OligoChitosan) compare to the commercial PGP (VitaGrow). The pot test was carried on Chinese kale with treatment of 3 different PGPs which were Oligochitosan, Oligocarrageenan and VitaGrow (local commercial PGP) and Control (without PGP). The concentration of PGPs applied during this experiment was fixed at 100 ppm.

Figure 1 shows the insignificant different on growth of Chinese kale from week 1 to week 5 after treated with PGPs compare to Control (no PGP). Chinese kale treated with Oligocarrageenan showed the lowest rate of plant growth from week 1 to week 5. The rate growth of Chinese kale treated with oligocarrageenan consistently increase at same the same from week 1 to week 5. Others treatment showed lower rate after week 4. In final week, all treatments showed insignificant different on plant height.

Table 1. Results of Chinese kale after treated with different PGPs with Control (without PGP).

TREATMENT	N	Average plant height (cm)	Total yield (g)	Average no.of leaves (unit)
Oligochitosan	10	31.11 ± 3.97^{A}	610.9	9.5 ± 0.97^{a}
NO PGP	10	30.85 ± 3.57^{A}	814.4	10.5 ± 1.35^{a}
Vitagrow	10	29.92 ± 2.71^{A}	652	9.4 ± 1.96^{a}
Oligocarrageenan	10	29.88 ± 2.39^{A}	692.8	9.4 ± 1.07^{a}

Table 1 shows results on average plant height, average number of leaves and total yield. The insignificant different results on average plant height and number of leaves after treated with PGPs compare to Control. Results also show that PGPs does not increase the yield of Chinese kale. But Oligocarrageenan indicates higher result on yield compare to VitaGrow and Oligochitosan. Due to the unpromising results obtained from this experiment we plan to repeat the pot test with same experimental design and parameters.

Future Plan

i) Degraded Chitosan for Animal Feed (Tilapia)

Tilapia farming has great potential in Malaysia. As chitosan has been found to be useful as a growth promoter and an immunostimulant to enhance protection of fish against bacterial disease, the future plan is to introduce degraded chitosan into the real tilapia farming. In addition, degraded chitosan is also plan to be further explore in other aquatic/animal.

ii) Hydrogel for Medical Application and Biofertilizer

1. Apply for grant and complete the study has planned
2. Collaboration with potential counterpart from university: get latest information and technology on 3D cells from university counterparts.
3. Find new formulation of cell culture dish which able to stand in media up to 14 days and more because some cells require longer time of incubation to reach certain size.
4. Get funding and get new cell lines: get potential cell lines such as breast cancer cell lines
5. Request for articles from the related-field-researchers through available 'social networking site' e.g Research Gate.

iii) Synergistic Effect among Plant Growth Promoters, Super Water Absorbents and Biofertilizer

We found out that the results for roots length were not as expected even though the synergistic effects of SWA and PGP on growth of the plant were significant. This may due to the location of the pot test study. The green house was located behind a big building and close to a big tree. We assumed that the plants were not getting enough sun light throughout the study. In future we would like to repeat the experiments to confirm the results obtained this year.

iv) Plant Growth Promoters and Super Water Absorbents, inclusive Process development

1. Repeat pot test application of PGP on Chinese kale. The experimental design and parameters will be remained the same as in previous test.
2. The data collection will be covered the germination rate, survival of seeds, plant height, number of leaves, and total yield.
3. Establishment on:
   i. Development of oligocarrageenan: study will cover the solubility of oligocarrageenan in different Na salt solutes and effect of different EtOH content on stability of oligocarrageenan.
   ii. Effect of different storage conditions on oligocarrageenan stability.
   iii. Up-scaling the operational procedure of oligocarrageenan in 2 years time.

7) Dr Charito T. Aranilla, Philippine Nuclear Research Institute (PNRI), The Philippines

R&D Sibject

- Hydrogel for Medical Application
- Plant Growth Promoters and Super Water Absorbents, inclusive Process development

Short Summary

i) Hydrogel for Medical Application

In vivo hemostatic efficacy evaluation of CMC granules and KC/PEO/PEG hydrogel dressing were done in four rat bleeding models, namely, femoral bleeding, aortic bleeding, deep wound, and caudal pole nephrectomy. The KC/PEO/PEG dressing was more efficient than the commercial Celox gauze in controlling bleeding time with a 100% survival rate. The CMC granules was as efficient as Celox

granules in controlling bleeding time but with better survival rate, less adhesion, inflammation, granular deposits and easier removal.

ii) Plant Growth Promoters and Super Water Absorbents, inclusive Process development

Microbial biodegradation studies of Cassava Starch/PAAc super water absorbent was monitored using MODA for a period of 85 days. Incorporation of starch in PAAc hydrogel greatly improved it biodegradability. Pot experiments using Completely Randomized Design with Minimum Applied Depletion has been performed in lettuce. Physiological parameters such as plant height, number of leaves, root length, number of roots and fresh weight were recorded. The application Carrageenan PGP technology has been expanded in crops such bananas, sugarcane and cacao.

Results

i) Hydrogel for Medical Application

In this study, the developed hemostats were tested in Sprague-Dawley rats. KC/PEO/PEG dressing and CMC granules were applied in the animals without sustained compression and monitored for a period of 7 or 14 days. Comparisons were made against commercial chitosan-based agent, Celox (CLX). Primary outcomes observed were bleeding time, incidence of re-bleeding, animal survival, and gross and microscopic changes. The KPP-D group showed the shortest bleeding time for all bleeding models, significantly faster than all the other treatment groups. KPP-D also registered the highest survival rate (100%) with no display of gross abnormalities. CMC-G showed comparable bleeding time with CLX products but had better survival rate at 98% compared to 96%. Incidence of re-bleeding was greater in CLX treated groups as well as more occurrence of granular adhesions that impacted mortality outcome. Findings indicate the efficacy of KPP-D in the treatment of severe hemorrhage due to traumatic injury and in intraoperative cases. While CMC-G was more suited for external trauma.

ii) Plant Growth Promoters and Super Water Absorbents, inclusive Process development

The cassava S-PAAc SWA (10%starch/20%AAc at 38% DN and 15 kGy) had the highest biodegradability with a rate of 42% in 85 days compared to pure PAAc (20% AAc at 50% DN and 15 kGy) and Control. The control used was cellulose which showed around 10% biodegradation within 3 weeks and a steady incremental increase henceforth. This slow degradation could be attributed to the crystalline structure of cellulose. The S/PAAc SWA showed an initial biodegradation curve at 3 weeks which could be attributed to starch trapped within the cross-linked network (as in an interpenetrating gel model). Afterwards, a steady and fast increase was observed. The biodegradation of pure PAAc may be due to the low molecular-weight fragments from the soluble fraction which are more susceptible to microbial degradation. The incorporation of starch induced by radiation processes resulted in higher biodegradation rate of the SWA which is useful for environment friendly SWA products.

Future Plan

i) Hydrogel for Medical Application

There is a requirement to source for a technology taker or industry partner prior to submission of proposal for another pre-clinical study, using swine models. With that, technology promotions will be conducted in collaboration with the Institute's Business Development Unit.

Upon securing a letter of interest from the technology taker, the proposal for efficient evaluation in swine bleeding models will be submitted to Department of Science and Technology for approval and funding.

ii) Plant Growth Promoters and Super Water Absorbents, inclusive Process development

For SWA, pot experiments will be continued using okra and sweet corn. For the field experiments, suggested crops to be used were okra, lettuce and cucumber.

8) Dr Phiriyatorn Suwanmala, Thailand Institute of Nuclear Technology (Public Organization), Thailand

R&D Subject

- Plant Growth Promoters and Super Water Absorbents, inclusive Process development

Short Summary

SWA beads, with uniform size and shape, have been successfully prepared, offering a simplified process and a practical application for end-users. SWA beads show swelling degree as high as 450 times of its original dry weight. The production for SWA beads does not require three major energy-consuming processes (cutting, drying and grinding), thus reducing both cost and time.

Results

Researchers from TINT successfully prepared a new generation of SWA – SWA beads – via radiation-induced graft polymerization of acrylic acid onto cassava starch beads. A newly designed process was able to fabricate SWA in uniform size (1-2 mm) and shape (spherical bead). The spherical shape of SWA beads is similar to that of fertilizers, thus making them more practical for real-life agricultural applications. Also, SWA beads can be sown along with seeds at the beginning of the planting process. The prepared SWA beads offer swelling degree as high as 450 times of its original dry weight.

The newly designed process for SWA beads can also overcome the major problems associated with the production process of the original SWA hydrogel. Without the three major energy- and time-consuming processes (cutting, drying and grinding), the production process for SWA beads thus results in a major reduction of energy, time and, most importantly, cost.

Table 1: Differences between the traditional production process for SWA hydrogels and the new production process for SWA beads, to produce the same amount of product (as estimated from laboratory scale).

	SWA	**SWA beads**
Product amount	1,000 Kg	1,000 Kg
Time for material preparation	1 day	2 days
Irradiation dose	20 kGy	10 kGy
Time for "cutting" and "drying"	40 days (50 Kg / 2 days)	No need (naturally dried in 2 days)
Time for "grinding" and "size sorting"	10 days (100 Kg / day)	No need
Total production time	43 days	5 days
Monomer solution	Completely utilized (simultaneous irradiation)	Reusable (not exposed to irradiation)
Manpower	Much more	Much less
Energy (heat)	Much more (Air oven @ 60^{o}C)	Much less

Future Plan

- Study the loading and releasing efficiency of fertilizers encapsulated inside SWA beads
- Perform field test of SWA beads in order to (1) compare with previous results from the original SWA hydrogel and (2) determine the optimum content for SWA beads for each specific plants
- Perform the feasibility study of commercial production of SWA beads
- Perform the up-scaling production of SWA beads
- The degraded chitosan for animal feeds will be performed in 2021.

9) Dr Nguyen Ngoc Duy, Vietnam Atomic Energy Institute, Viet Nam

R&D Subject

- Degraded Chitosan for Animal Fee
- Hydrogel for Medical Application
- Environmental Remediation

Short Summary

Selenium nanoparticles with size ~41.8 nm were synthesized by the γ-irradiation method using oligochitosan (OCS) as a stabilizer. The SeNPs/OCS product in powder was also prepared by the spray drying technique with high purity. OCS and SeNPs/OCS products were able to recover the total white blood cell of γ-ray irradiated mice.

The cell scaffolds from the mixture of gelatin/CM-chitosan and gelatin/CM-chitin were prepared by radiation-crosslinking by gamma-ray at a dose of ~25 kGy.

Results

SeNPs were spherical morphology with an average diameter calculated to be of 41.8, 50.9, and 51.9 nm for different storage time (0, 30, and 45 days) at 4°C, respectively. At 27°C, SeNPs size increased faster than that at 4°C with the increase from 41.8 nm (0 days) to 115.1 and 125.8 nm for the storage time of 30 and 45 days, respectively. SeNPs/OCS powder prepared by spray drying had an orange color and high purity. The particle size of SeNPs slightly increased from 41.8 to 43.8 nm when the SeNPs/OCS solution changed into powder form. The level of total WBC in all three groups of irradiated mice, which were even orally supplemented with OCS, SeNPs/OCS, and Phosphate Buffer Saline (PBS) was significantly decreased during 10 days after irradiation. However, the recovery of total WBC in irradiated mice orally supplementing OCS and SeNPs/OCS for 20 days was already observed. The oral supplementation of SeNPs/OCS was the better recovery of WBC than that of mice received OCS. For the irradiated mice supplemented with OCS at the dose of 20 μg.day−1, the total WBC was fully recovered to the normal level after 20 days, especially in the test group received SeNPs/OCS the time for the recovery of total WBC was less than 20 days.

The CM-chitosan and CM-chitin exhibited a significant amelioration of features of the gelatin-derived scaffold material in the same manner. Both the prepared scaffolds from gelatin/CM-chitosan and gelatin/CM-chitin accounted for a swelling degree ~7–9 g/g in PBS, compressive modulus ~46–66 kPa, a porosity ~70–73 %, a pore size ~100–300 mm. They exhibited also an acceptable biodegradability in the collagenase enzyme, and non-cytotoxicity for adipose-derived stem cells (hADSCs) with RGR of ~97%, which all met the fundamental requirements for hADSC culture-scaffold materials.

Future Plan

Study on treatment of textile dyeing wastewater by electron beam irradiation combine biological method at a large scale.

The production of oligochitosan for use as an additive to increase the immune system in aquaculture at a pilot-scale.

Commercialization of oligochitosan in livestock and aquaculture.

Session 8: Discussions on this year's activities amid the COVID-19 pandemic

The participants reported changes in the status of radiation facilities and research activities from March/April to October 2020. The status in each member country is as below.

- Bangladesh

The COVID-19 situation is not yet good and many restrictions still continue as of October 2020. The radiation facilities in BAEC is available but research activities are limited due to the pandemic. We expected our experiment will start after winter season.

- China

In this spring irradiation facilities were not available, but now the facilities are restarted.

- Indonesia

The radiation facilities are available. However, some sections are slowing down their work under the influence of the COVID-19.

- Japan

The radiation facilities were shut down for several months and some supplies related to PCR diagnostic were difficult to purchase. As of October 2020, the situation is back to normal.

- Kazakhstan

Absent in this session due to the schedule.

- Malaysia

From March to June, Malaysia was totally locked down and all facilities were closed due to the pandemic. As of October, Malaysia still have problem with the COVID-19 and partially locked down. Some facilities are still shut down.

- Mongolia

Absent in this session due to the schedule.

- The Philippines

During total lock down started in March, all offices and facilities were closed. From June, workers can go to their office 15 days/month. As of October, electron beam facilities are available. Gamma facilities are closed due to the upgrading. Another small gamma irradiator is available instead.

- Thailand

March to May, radiation facilities were available but there were no customer because of lock down. From June, the situation is back to normal.

- Viet Nam

The government of Viet Nam well controlled the spread of COVID-19. The radiation facilities are available.