Minutes of the FNCA Workshop
"Radiation Processing of Natural Polymers"

9th - 12th February, 2015
Yogyakarta, Indonesia

1) Outline of Workshop

ⅰ) Date	9th - 12th February, 2015
ⅱ) Venue	Melia Purosani Hotel , Yogyakarta, Indonesia
ⅲ) Host Organisation	National Nuclear Energy Agency (BATAN),Indonesia Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT)
ⅳ) Participants	Nineteen (19) participants from eight (8) FNCA member countries: Bangladesh, Indonesia, Japan, Kazakhstan, Malaysia, the Philippines, Thailand and Vietnam.
ⅴ) Programme	**Annex 1**

2) Workshop Programme

Open Seminar on "Application of Radiation Processing for Sustainable Development and Agriculture"

An open seminar on application of radiation processing for sustainable development and agriculture was held at Melia Purosani Hotel, Yogyakarta. Forty nine people including those from research institutes and universities, farmers and students participated in the seminar. Dr Djarot Sulistio Wisnubroto, Chairman of National Nuclear Energy Agency (BATAN) and Dr Sueo Machi, FNCA Coordinator of Japan gave their opening remarks. The summary of open seminar is attached as **Annex 3**.

Opening Session

The workshop was attended by the experts on applications of electron accelerator and radiation processing of natural polymer from the FNCA participating countries namely Bangladesh, Indonesia, Japan, Kazakhstan, Malaysia, the Philippines, Thailand and Vietnam. The list of participants of the workshop is attached in **Annex 2**.

Dr Anhar Riza Antariksawan DDG of BATAN and Dr Sueo Machi each gave a welcoming speech and hoped for a fruitful discussion during the workshop. The participants then briefly introduced themselves.

Session 1 : Overview of FNCA

Dr Sueo Machi reported on the progress of FNCA projects during the 15th Ministerial Meeting in 2014. In addition to the major decisions made during that meeting, the highlights and achievements of on-going FNCA projects were enumerated.

Dr Masao Tamada, Director General of Takasaki Advanced Radiation Research Institute, Japan Atomic Energy Agency (JAEA) introduced Achievement and Challenges of the Project on Radiation Processing of Natural Polymers. PGP and SWA synthesized by radiation processing of natural polymers have been researched in terms of their technology transfer to the end-users. The PGP guideline dealing with its detail directions is a major product in 2014. All outputs and outcomes in FY2012 - 2014 as phase 4 in our project will be evaluated in coordinator meeting, March, 2015.

Session 2: Country Report on Production and Field/Pot Test of Plant Growth Promoter (PGP) from Chitosan by Radiation Processing

Eight (8) FNCA member countries presented reports, detailing their activities for 2014 on oligochitosan PGP/elicitor obtained by radiation processing. Member counties shared the results of PGP from chitosan and carrageenan in terms of weight gain and disease reduction of plants. The summaries of the reports are attached as **Annex 4 Part A**.

Session 3 : Results of Field Tests of PGP

Dr Nguyen Quoc Hien, Head of R & D Department, Vietnam Atomic Energy Institute (VINATOM), and Ms Maznah Mahmud, Research Officer, Malaysian Nuclear Agency (Nuclear Malaysia) gave lead speeches for this session. Ms Maznah reported on the trial, which was done in Kampung Bukit Kechil, Utan Aji, Perlis, Malaysia starting on October 2014. There were 4 types of treatment applied in this trial:

i. T1 – liquid biofertilizer + liquid smoke
ii. T2 – liquid biofertilizer + liquid smoke + oligochitosan
iii. T3 – Control, Farmer's normal practice
iv. T4 – liquid smoke + oligochitosan

Oligochitosan treatment was applied in 2 stages i. seed stage ii. field stage. The oligochitosan is 10kDa and pH 5.4.

For seed treatment, 100ppm of oligochitosan was used for seed-soaking, 30 minutes and later seeds were air-dried. During seedling stage, oligochitosan was sprayed with 100ppm 3 times (once a week).

In field, plants were treated with spraying of 100ppm oligochitosan. The spraying was done on day 25th, 45th, 55th and 75th.

Ÿ As the results:

i. MR 219-4 indicated 15% more yield compare to MR 219 and MR 219-9 after treated with T2.
ii. For MR 219 – treatment of T1 and T4 indicated 15% higher than T2 and 25% higher than T3
iii. For MR 219-4 – the T3 treatment highest compare to T1, T2 and T4.
iv. For MR 219-9 – all package treatments indicated positive effect on MR 219 (not significantly different among 3 treatments) compare to T3.

Ÿ Conclusion:

Oligochitosan indicated good effect on MR 219, MR 219-4 and MR 219-9 after included in the packages treatment.

Session 4: Strategy for Commercial Application of PGP

Dr Nguyen gave a speech that Vietnam has succeeded commercial application of oligochitosan as elicitor for rice plant. Mr Sergey Kotov, Leading Manager, JSC "Park of Nuclear Technologies", Kazakhstan reported that Kazakhstan has only EB machine for radiation processing, and the meeting recommended degradation of chitosan to be carried out by EB irradiation to solid chitosan in thin flat packing.

Dr Naotsugu Nagasawa from JAEA reported current status of the preparation of a guideline on chitosan PGP application for rice, chilli and other crops. A draft of the guideline will be delivered to the PLs of participating countries for revising. Finalised guideline will be uploaded to FNCA website in May, 2015.

Session 5: Work Plan of Project Activity on Plant Growth Promoter (PGP) by Radiation Processing of Natural Polymers in 2015-2017

Dr Tamada and Dr Nagasawa delivered lead speeches for the session. Dr Tamada gave a review and summary of the activities of the group from 2012-2014 and presented possible activities in the next phase 2015-2017. Dr Nagasawa introduced a new method for generating nanofiber chitin using ultrahigh pressure water jet. The generated nanofiber is being studied for effect of radiation to get oligochitin. According to the regulation in Japan, agricultural products considered to be organic must not undergo any chemical processing. The method being explored may be promising.

During the group discussion, the member states shared their experiences and situations on product registration and commercialisation of PGP. Among the members, Japan, Vietnam Malaysia and Thailand have already commercialised and Indonesia semi commercialised their products. Bangladesh and Philippines have a clear plan and strategy towards commercialisation, while new member state, Khazakstan, will be given assistance to accelerate the activities of the country. Building towards commercialisation, it was emphasized by Dr Machi to strengthen the linkage with agriculture sectors such as agricultural institutes for selection of plants and conducting field tests on the application of oligochitosan for selected plants. It was also strongly recommended to study the synergy between oligochitosan and bio-fertilizers in collaboration with FNCA biofertilizer project leaders.

As agreed upon in the previous workshop, Vietnam and Malaysia will be formulating the guideline for the application of oligochitosan on rice, while Indonesia and Thailand will formulate the guideline for chili. FNCA countries will use these guidelines for effective application of oligochitosan PGP.

Session 6: Country Report on Production and Application of Hydrogel Super Water Absorbent by Radiation Cross-linking and Grafting of Natural Polymers

Eight (8) member countries presented their reports on research activities on SWA. At this session, the current situation of the progress on SWA project was discussed. Every country has its specific problem which they are currently solving. Some specific advices are made for them. Dr Sultana, Principal Scientific Officer, Bangladesh Atomic Energy Commission (BAEC) is importing raw material, the coconut dust, from Vietnam. Indonesia is watering the plant only once a week because they are trying to solve their main problem for sandy soil – very frequent irrigation. In Japan the market for SWA is very small, no irrigation is used, so there is no need for application of SWA. Kazakhstan has problems with irrigation and ability to use raw material, carboxymethylcellulose (CMC) with is at very low price, made on its territory. Dr Machi advised for Malaysia to try using SWA in rubber tree, which is very important for Malaysia. The Philippines also needs to check the target wheat for application. Dr Nguyen in his report mentioned that there is no economic effect of SWA production in Vietnam even with the price of $2.5.The summary of the reports of each country is attached as **Annex 4 Part B**.

Session 7: Summary on Results of Field/Laboratory Tests of SWA

Dr Darmawan Darwis, Head of Radiation Processing Department, Center for Isotopes and Radiation Application, National Nuclear Energy Agency (BATAN) delivered a lead speech for this session.

The activities of super water absorbent (SWA) in FNCA member states have different progress for each member country. Some of them are still in pot scale or semi field scale like Bangladesh, China, Indonesia, Japan, Malaysia, Mongolia and Philippines. Kazakhstan is still in ongoing lab scale research, whereas Thailand and Vietnam have done field test. The plants used for evaluation are diverse such as tomato, zea mays, chilli and soybean.

The advantages of SWA in agriculture are reducing irrigation frequency, increasing water-holding capacity, increasing water use efficiency, enhancing soil permeability and infiltration rates, reducing compaction tendency, stopping erosion and water run-off, and increasing plant performance (especially in structure less soils in areas subject to become drought).

There are some considerations regarding raw material selection for SWA preparation such as: It should be available in bulk, indigenous material in each country is more favourable; non-toxic; easy to be processed; relatively cheap; biodegradable; and the product can be function well. Followings are the details of each country's status:

- Bangladesh carried out pot test of SWA on tomato and mary- gold flower.
- Indonesia has done semi field test of SWA combining with oligochitosan for shallot.
- Japan already commercialised CMC gel for lamination of *whashi* (a style of Japanese paper) but the commercialisation was stopped due to the bankruptcy of the company.
- Kazakhstan has just started R&D in lab.
- Malaysia has done greenhouse test of SWA on rice.
- The Philippines performed semi-field test with soybean.
- Thailand has done field test of SWA on rubber tree and baby corn.
- Vietnam stopped commercialisation of SWA due to it cannot compete with market demands.

Good cooperation with Ministry of Agriculture to perform field test was recommended.

Session 8: Strategy for Commercial Application of SWA in Collaboration with Agriculture Sector

Dr Suwanmala reported on following points about strategy for commercial application of SWA in collaboration with agriculture sector as follows:

Strategy

1. Choose material abundantly available in the country. So this will reduce the production cost as well as give value-added to the material itself.
2. Determine the characteristics of SWA produced in term of :
    - Swelling degree (different pH and condition of solution)
    - Water retention
    - Degradability
    - Particle size
3. Collaboration/cooperation with agriculture institutes to determine crops and marginal land area.

Challenges

1. Facing during production process :
    - Drying takes long time at low temperature. If drying temperature too high can induce crosslinking.
    - Grinding needs special equipment because dry SWA very hard to be crushed
    - SWA requires appropriate packaging in order to protect SWA from absorbing moisture.
2. Procedure of application
    - As an alternative – do refer to the commercialised product. But sometimes, types of plant and soil conditions do affect the performance of SWA. Also, collaboration with agriculture institutes will help on getting information on how to use SWA on specific plant at specific land area.
3. Price – most of SWA produced among member countries are higher cost compare to the commercialised SWA.

Recommendations in order to enhance the need of SWA from the market :

1. Make a promotion by participating in exhibitions
2. Researchers have to be close to the farmers in order to know are their needs
3. Collaboration research institute with agriculture institutes.

Session 9: Work Plan on Super Water Absorbent (SWA) Project in 2015-2017

Ms Tita Puspitasari, Researcher, BATAN summarised results on field or laboratory test of SWA. SWA needs legal registration as soil conditioner for commercialisation. Participating countries suggested considering the requirement of SWA in each member state for legal registration and the necessary data to clear the legal regulation

in each country. Although the technology for controlling the SWA properties such as water content and biodegradability is investigated well, further research is recommended to be carried out to reduce the production cost for better cost effective.

Dr Ferhat Aziz, Deputy Chairman of BATAN gave remarks on the workshop. He reported that an article on the workshop appeared in the local newspaper and also that three Ministers of Indonesia have gathered to declare their supports on BATAN's activities on nuclear technologies. He finally wished for prosperity of FNCA and congratulated Dr Machi on holding this workshop. In return, Dr Machi expressed his gratitude for BATAN's warm hospitality offered throughout the workshop and expressed admiration for the progress on their field testing.

Session 10: Coordination of the FNCA Project with RCA/IAEA Project on Radiation Processing

The outcomes, outputs and achievements of the project RCA/IAEA RAS/1/104 on Supporting Radiation Processing for the Development of Advanced Grafted Materials for Industrial Application and Environmental Preservation are listed and presented by Ms Mahmud. Three projects selected to be collaborated are radiation processing, mutation breeding, and cancer therapy. There is no indication overlapping between FNCA and RCA projects, furthermore the projects should be more synergic. Since some member countries have different groups of FNCA and RCA projects, the information between them should be exchanged by the project leaders of the member groups.

Session 11: Summary and Conclusion

Dr Machi made an introductory speech in this session. Dr Tamada presented a summary of PGP and SWA activities and evaluation for phase 4 covering the years 2012-2014. Major outputs for PGP sub-project include very promising increase in yield and productivity in various crops, such as rice and chilli, and preparation of FNCA Guidelines on Plant Growth Promoter to promote the technology transfer to end users. For the SWA sub-project, major outputs are increase in germination percentage of various crop seeds mainly in pot tests and field test in sandy-type soil showed decrease in watering frequency thus saving significant volume of water. A total of eighteen (18) published papers were generated from this project. The socio-economic and scientific impact was given a high score and the overall project outlook is to continue the project. Work plan for phase 5 will focus on optimization of water content and biodegradability of SWA, conduct of pot and field tests and preparation of new FNCA guidelines on SWA. Updating the PGP guidelines is one of

the activities to be taken in the next phase. Information exchange to solve the obstacles (legal registration, budget for field test etc.) in technology transfer and further collaboration with other FNCA group and agricultural sector are also included in the workplan.

Closing Session

The workshop was officially closed by Dr Machi. He first expresses his appreciation to Dr Darwis and his staff that have contributed for this workshop. He informed that the next country will be decided at the Coordinators Meeting.

Technical Visit (11 February)

First, the participants visited Playen vilage, Gunung Kidul District, Yogyakarta Province to see demo plot of oligochitosan on paddy. And the technical visit was then continued to demo plot of SWA and oligochitosan on shallot, chilli and eggplant at Bantul District, Yogyakarta Province.

3) Conclusion and Recommendation

1. The meeting noted following points:
   (1) Most of FNCA Coordinators of the participating countries recommend the project should be extended for another 3 years after the implementation for 6 years because the project meets national priority of securing food by the sustainable agriculture.
   (2) Most of Project Leaders recommend continuing the project, base on the project evaluation in terms of the socioeconomic as well as scientific impact.
   (3) Vietnam has succeeded commercial application of oligochitosan as elicitor for rice plant with 10-20% yield increase and sugarcane. The oligochitosan is produced by the VINATOM Ho Chi Minh Radiation Center and distributed by the private company to end-users.
   (4) Thailand has achieved the commercial application of oligochitosan as plant growth promoter and elicitor. Oligochitosan is produced by using the pilot plant with capacity of 15,000 liter/month installed at the Thai Irradiation Center by the TINT, and the product is used for chili, Mariam plum and others.
   (5) Malaysia produced oligochitosan using pipe reactors in Malaysia Nuclear Agency (Nuclear Malaysia) to be commercially sold by two private companies for application on a variety of plants such as rice, chili,

agarwood and fig, and further field tests will be carried out to extend the application for additional plant.

(6) The Philippines has achieved promising results by pot tests on rice, mung beans, peanut by oligocarrageenan produced from seaweeds aiming commercial application by 2018.

(7) Indonesia has made the semi-field test of oligochitosan on a variety of plants including chili, rice, rubber tree, tomato, potato, shallot etc. to achieve highly promising results of increasing yield ranging from 25 to 300%. BATAN is aiming to achieve full commercial application of the oligochitosan by 2017.

(8) Bangladesh tested the effect of oligochitosan on spinach in plots and found that 100 ppm oligochitosan, gives three times more yield in comparison with the control. In case of amaranth, 70 ppm oligochitosan gave 10% increase of yield.

(9) Kazakhstan was advised to use 5 MeV to irradiate chitosan in the solid state in thin layer to produce oligochitosan, since it does not have Co-60 source.

(10) Thailand has implemented field tests of SWA on baby corn achieving yield increase of 45%, bamboo, and rubber tree with promising results.

(11) Bangladesh is pot testing SWA application on tomato plant and marry-gold flower plant with good results.

(12) Indonesia is testing in the field of sandy soil for shallot and chili with highly promising results in collaboration with the Institute of Assessment for Agriculture Technology of Jogyakarta of Ministry of Agriculture.

(13) Malaysia tested vegetable spinach, kailan and green mustard in the green house to obtain promising results.

(14) The Philippines produced SWA from AAc grafted seaweed which is the cheapest and has very high water absorption capacity (900g/g SWA), and pot test for plants will be done in 2015.

(15) Vietnam discontinued the commercial production of SWA from AAc grated starch due to high production cost.

(16) Regarding registration of oligochitosan, VINATOM in Vietnam registered the oligochitosan as the elicitor, JAEA in Japan commercialised oligochitosan production as the activator which does not need registration, in Thailand registration is not required, and BATAN is in the process of registration hoping early clearance.

2. The meeting recommends following points:

(1) The project on Radiation Processing of Natural Polymers which has been carried out for 6 years should be extended another 3 years.

(2) The sub-project on the plant growth promoter (PGP)/elicitor from chitosan/carrageenan should be aiming to achieve the goal of

commercialisation by JFY 2017.

(3) The sub-project on the super water absorbent (SWA) should conduct the field tests for selected specific crops at specific location to meet the need of the Member Countries.

(4) Strengthening the collaboration with agriculture institutes and experts in order to better implement the field tests for specific plants and disseminate results to stakeholders in agricultural sector.

(5) Enhancing the linkage with the team of FNCA Project on Bio-fertilizer to study possible synergetic effect between elicitor effect and bio-fertilizer.

(6) Government should financially and/or administratively support the field test of oligochitosan/oligocarrageenan and SWA since it costs much for field work.

(7) Possible new activity of EB application project should be discussed in JFY 2017 in the priority areas such as sustainable agriculture, human health, energy and environmental protection.

3. At the visiting field test sites, the participants learned following points: In Playen Village, Gunung Kidul District, Yogyakarta.

(1) Rice grown with oligochitosan (OC) has wider leaves, more tillers of 25 than the control of 18 tillers. The effect of OC is clearly observed. Oligochitosan is sprayed one a week.

(2) Sorgum with oligochitosan has larger bunch and yield. The difference of size of the bunch is clearly seen in the fields.

(3) Playen village community is very pleased to have the field tests of BATAN.

In Bantul District, Yogyakarta.

(1) Chili crops grown in sandy soil with OC and SWA look much better than control which is infected with yellow virus. Chili is infected at the rate of 90% without OC and only 3% with OC.

(2) In Bantul, shallots with OC and SWA in sandy soil is grown much better than control.

(3) For shallots the frequency of watering is reduced from 2 times per day to 1 time per 3 days, which saving labor work load and water.

(4) These field tests are carried out in collaboration with These field tests are carried out in collaboration with AIAT (Assessment Institute for Agricultural Technology of Yogyakarta) very successfully, especially in :

(a) Egg plants grown with OC have higher yield of 150kg/700m^2 than control of which yield is 100kg/700m^2.

(b) Egg plants with OC look healthier and fruits are larger than control.

4) Attachments

- Annex 1: Programme
- Annex 2: List of Participants
- Annex 3: Summary of Open Seminar
- Annex 4: Part A: Summary of Country Reports on Production and Field/Pot Test of Plant Growth Promoter (PGP) from Chitosan by Radiation Processing
- Part B: Summary of Country Reports on Production of Super Water Absorbent (SWA) by Radiation Processing
- Annex 5: Current Status of R&D in Each Country