Annex 3

Presentation Summaries of FNCA 2025 Workshop on Mutation Breeding Project

October 28 – 30, 2025
Cibinong, Indonesia

BANGLADESH

Dr. A.N.K Mamun, Bangladesh Atomic Energy Commission

BINA dhan 25 is a mutant of BRRI dhan 29 becoming more popular to farmer as a premium rice, higher market price, export quality, early mature, day neutral, higher yield (7.14 to 8.50 t/ha) The average weight of 1000 grain is 19.7-gram, amylose content is 25.1% and protein content is 6.6%. Moreover, it can cultivate relatively low fertilizer and low irrigation system and it is developed through carbon ion beam irradiation. It was released for commercial cultivation in the year 2022. Meanwhile, a quite number of advanced mutant lines are selected for further research. Among them, some are under field trial and some are under way to release for commercial cultivation.

CHINA

Dr. Tan Yuanyuan, Zhejiang University

Next-generation sequencing was widely used in mutation breeding. In the presentation, we used multiple amplicon sequencing to identify the mutations in *OsNramp5* gene that is involved in Cd intake from soil to rice root. Primers were designed and the amplification fragment can cover the whole CDS region of *OsNramp5*. Here we tried two strategies by pooling the M_1 flag leaves or M_2 seeds for sequencing. Three flag leaves of each plant were selected and 90 leaves were pooled for DNA extraction and sequencing. One mutant from about 27,000 plants was identified by sequencing the flag leaves, but the mutation could not be passed down to next generation. The endosperm portion from 80-100 seeds was cut and pooled for sequencing. Only one mutant from about 45,000 seeds was identified by sequencing the seed, and the mutation could pass down. The M_3 plants were grown in Cd contaminated pot soil or field. It is found that Cd concentration in seeds was lower than 0.2 mg/kg, significantly decreased in mutant compared with the wild type. To utilize the mutation in rice breeding, a CADMA-HRM marker was also developed for genotyping.

INDONESIA

Dr. Winda Puspitasari, National Research and Innovation Agency

Through the e-Asia joint research program based on FNCA network, Indonesia has gained the opportunity to integrate remote sensing technology into mutation breeding programs to accelerate the development of improved rice mutant varieties. In the initial phase, a

comprehensive database was established using data acquired from unmanned aerial vehicles (UAVs) and field observations to construct a predictive model. In the subsequent phase, this model will be applied for the selection of early and advanced generations of rice mutant lines, thereby enhancing the efficiency and precision of the breeding process. Moreover, crosses between mutant variety and its parental variety have been conducted to genotype and characterize novel traits arising from induced mutations. In addition, the sorghum mutation breeding program has successfully developed three mutant lines, which have been officially registered under the names of Sorgamma, Gamma Sorbico 1, and Gamma Sorbico 2.

JAPAN

Dr. HASE Yoshihiro, National Institutes for Quantum Science and Technology

Efficient mutagenesis is critical for mutation breeding. However, it is very difficult to accumulate beneficial mutations without impairing the original growth ability, because a large part of newly-induced mutations is deleterious for growth. We considered this point using heat tolerance of rhizobia as a model case. Wild-type cells grow optimally at 32~34 degree C, but their growth is markedly retarded at 36-degree C. We performed experimental evolution combined with repeated gamma irradiation, in which wild-type cells were subcultured for three months with a gradual increase in temperature from 32 to 37-degree C. Additionally, they were exposed to gamma rays 10 times in total during the experimental period. Novel heat-tolerant mutant lines were successfully obtained. The mutant lines formed colonies at 36 degree C, at which the wild type could not form any visible colonies, while the mutant lines showed a good growth comparable to the wild type at 32-degree C. The 40 Gy was the most effective dose to facilitate adaptation to high-temperature environment in our experimental conditions. The two most tolerant lines had a mutation in the same genes possibly reflecting a strong relationship with high-temperature tolerance. These results suggest that experimental evolution with an appropriately increased mutation frequency is effective to accumulate beneficial mutations without impairing the original growth ability.

MALAYSIA

Mr. Faiz Bin Ahmad, Malaysian Nuclear Agency

Rice breeding in Malaysia plays a vital role in strengthening national food security, improving productivity, and developing resilient varieties suited to climate change. The decline in Malaysia's rice self-sufficiency ratio to approximately 56.2% in 2023 highlights the urgent need to develop new climate-resilient rice varieties. Mutation breeding is one of the key approaches used to develop such varieties, in combination with advanced molecular and biotechnological methods. Ion beams and gamma rays are two powerful physical mutagens widely applied in mutation breeding to create genetic variation and develop improved rice mutant lines. Several advanced rice mutant lines have been developed through direct mutation (using ion beam or gamma ray) and indirect mutation by crossing mutant cultivars with popular mega varieties. These promising mutant lines

have been evaluated in multi-location trials across major granary areas in Malaysia, with several lines selected for further local verification trials nationwide. Furthermore, advanced genome sequencing has been applied to these mutant lines and their parental varieties to identify genes associated with targeted traits. Innovation in disease detection is also crucial for screening, selection, and field monitoring of rice mutant genotypes. Moving forward, the dissemination and commercialization of the mutant cultivar NMR152 will be expanded through collaborations with seed-certified companies.

MONGOLIA

Dr. Bayarsukh Noov, Institute of Plant and Agricultural Science

The induced mutation considered useful efficient tool for the improvement of specific plant traits like yield, stress tolerance, disease resistance, quality and increase breeding efficiency. Thus, development of early maturity, drought and heat tolerant wheat varieties with potential stable yield under changing climate condition through application of mutation techniques has been needed for stable food production.

There are no mutagen sources such as ion beam (Carbon 320 MeV) or gamma-ray (cobalt 60) for mutation induction for wheat and barley in Mongolia. The wheat varieties Darkhan-181, Darkhsn-222 and Buryatskii Ostitya were treated by carbon ion beam and gamma ray to shorten growth duration, drought resistance, grain quality and yield stability. The ion beam treatment of 5, 10, 20, and 30 Gy was applied at National Institutes for Quantum Science and Technology Japan.

Totally, 1,764 rows of 50 progenies planted in M1-M4 for the breeding initial materials.

In the yield trial, 4 mutants including early maturity line Darkhan-247, late maturity line Darkhan-245, 246, 243 have been tested in 3 replications and evaluated for green traits, quality and resistance to disease and pests. The new advanced mutant Darkhan-247 had 1.0 t/ha over yield than both check variety Darkhan-131 and Khalkh gol-1. Late maturity Darkhan-243,245, 246 gave 0.3-1.0 t/ha higher yield than control Darkhan-144.

Climate change will further influence pathogen spread and severity. One leaf rust race determined on wheat in Darkhan-Uul province, and this indicates increased yield loss in Mongolia. Among the advanced wheat varieties studied on the demonstration and yield trial the 90%-95% susceptibility for the specific race of stem rust have been observed. Only two cultivars including Lider-80 and Yunion originated from Russia and one advanced breeding line, Darkhan-242, were resistant. Thus, the wheat mutation breeding should focus not only on the yield but also biotic stresses for stable yield.

THE PHILIPPINES

Mr. Christopher C. Cabusora, Philippine Rice Research Institute

This year's report highlights the development of new submergence-tolerant rice mutants, dubbed "Next Submarino" varieties, aimed at addressing the challenges of flooding in Philippine rice

ecosystems. Building on the success of NSIC Rc194 (*Submarino 1*) and NSIC Rc590 (*Submarino 2*), which possess the *Sub1* gene from FR13A, the study applies mutation breeding to improve resilience, maturity, and yield stability while meeting farmers' and consumers' preferences for yield and quality grain.

A total of 15 promising mutant lines were evaluated under controlled and field submergence conditions. Results showed several highly tolerant lines—such as PR38560-SM-2, PR48421-IVM-2-5-6, and PR42837-SM-18-B-RTD-1-23-DRT2-Sub1—exhibiting survival rates of 90–100% and yield advantages up to 20% over the tolerant check variety, NSIC Rc 590. Molecular marker analysis confirmed the presence of the *Sub1* gene in selected lines, while in the other lines, a new submergence tolerant gene may be present. These mutants also demonstrated resistance to rice blast disease and stable yield under stress.

The study concludes with forward strategies, including grain and nutritional quality assessment, national cooperative testing, and gene sequencing to confirm novelty. The "Next Submarino" lines are envisioned as future varieties and donors for breeding rice adapted to flood-prone and multiple-stress environments in the Philippines.

THAILAND

Ms. Kakanang Punyalue, Rice Department

Rice improvement for resistant to rice gall midge by using gamma radiation was started on 2017. RD53 seeds were irradiated at a dose rate of 300 Grays at the Office of Atoms for Peace. M_1-M_7 seeds were planted and selected for phenotypic characteristics and rice gall midge resistance via screening at Phare Rice Research Center. In observation yield trials of M_8–M_9, 44 rice lines were selected. The resulting promising line RD53'17CoG$_{300}$-PRE-380-1-1-1-1-1-1 was subjected to steps of rice breeding program during 2022–2024. The results revealed that RD53'17CoG$_{300}$-PRE-380-1-1-1-1-1-1 is photoperiod insensitive and glutinous, with the yield potential of 5,750 kilograms per hectare. Its average grain yield was 4,745 kilograms per hectare. Its growth duration is 132 days and the height is 118 cm. Its outstanding characteristics is its high resistance to Phare rice gall midge, medium to shattering, good cooking quality with soft texture and fragrance.

VIET NAM

Dr. Le Duc Thao, Agricultural Genetics Institute

In 2025, we continue screening of new soybean and peanut lines in the M_5-M_7 generations; developing and producing new mutant soybean and peanut varieties; screening rice lines carrying mutations for yield and quality traits; sequencing and designing molecular markers related to the above characteristics; and evaluating adaptation capacity in different ecological regions.

- On peanut, evaluated by molecular markers to resist bacterial wilt and late blight disease in M_4 generation with 394 mutant peanut lines including: 130 lines from L14, 134 lines from L27,

130 lines from L29, the amplified bands in the mutant lines were indistinguishable from those of the original varieties. Screening in M_5 to M_7 generations, we selected 48 lines from dry seed irradiation and 51 lines from germinated seed irradiation

- On soybean, evaluated by molecular markers to resist Rust disease and Powdery mildew disease in M_4 generation with 397 mutant soybean lines including: 130 lines from DT90, 132 lines from DT95, 135 lines from DT2008. Screening in M_5 to M_7 generations, we selected 60 lines from dry seed irradiation and 54 lines from germinated seed irradiation.
- On rice, combining irradiation mutagenesis and molecular markers for selecting high-yielding and good-quality rice varieties. 04 promising lines were selected, having a short growth duration (105-110 days in the rainy season), yield of 5.9-6.3 t/ha, good pest and disease resistance, slender grain, high quality cooked rice (delicious, soft, fragrant, and moderately sticky), high translucency, and low amylose content (below 16%).

[Summary Shared by Member Country]

KOREA

Prof. Si-Yong Kang, Kongju National University

The main content of my presentation is an introduction to the status of ion beam breeding in Korea and the results of my recent research using proton beams. In Korea, proton irradiation has been serviced since 2013 at the KOMAC, KAERI. This project intends to exploit the various advantages of the proton beam irradiation to enhance efficiency of mutation induction in useful plants. This research focus on a series of comparative study of proton ion-beam and gamma ray on Brassica family species, i.e *Arabidopsis* and *Brassica rapa* subsp *Triloculraris* (a rapid cycle brassica; RC-Br) for application of mutation breeding. In first, we compare the mutation induction rate and genomic information between both radiations analysed by phenotypic and genotypic variation of mutants. we also select useful or promising mutant lines with improved traits; unique traits and disease resistance. To select useful mutants with biotic or abiotic tolerance, we select JA-sensitive lines from a RC-Br mutant pool generated by proton beam irradiation, focusing on altered JA-sensitivity in seed germination and root elongation. The results of this research will be contributed to improve mutation breeding using ion-beam irradiation as well as genomic research of plants.