Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	**Mutation Breeding of Major Crops for Low-input Sustainable Agriculture under Climate Change**
Country & Name of Project Leader:	Bangladesh, Dr. A. N. K. Mamun
Background of the Project	Aus, aman and boro are three rice cultivating seasons in Bangladesh. Among these aus is the least cultivated and grown in comparatively small scale due to prevailing drought and less availability of surface water for irrigation. Modern varieties of aus rice cover a significant area of the country conversely local cultivars cover a small area. Aus rice requires much fewer inputs than aman and boro.Due to continuous declination of groundwater level, nowadays more emphasis is given on the extension of aus cultivation throughout the country.
Purpose of the Project	Develop new rice varieties with Higher yield, Early mature, Rain-fed, Low input, Salinity, Drought, High Temp, Flood/submerge tolerant
Outputs of the Project	Finally about 15 advanced promising mutant lines are selected form carbon ion beam and gamma induced population of B11 and Lombur rice land races. Most of them are selected for higher yield, early & late maturity, lodging resistant, draught tolerant and suitable for cultivation in rain feed condition, photoperiod insensitive, bold grain and also long grain and fine grain. Most of them are suitable for both cultivation in Aus and Aman seasons.
Project outcomes/ achievements (Please include economic impact and publication if any)	Two promising advanced lines with higher yield, early lodging resistant, draught tolerant, photoperiod insensitive and suitable for cultivation in rain feed condition, sent for regional/multiplication trials.
Factors not considered in the planning process that may have led to better outcomes for the project.	Training for young scientist may have better outcomes for the project.
Factors during project implementation that inhibited outcomes for the project.	Covid-19 pandemic is inhibiting/inhibited our planned schedule of research activities outputs and outcomes.
Lessons learned from the	Selection of mutant lines/varieties with desire agronomic trait

Project	from carbon ion beam irradiated population of rice.
Recommendations to ensure sustainability of project outcomes	Ensure cultivation of new mutant varieties at grass root/farmer levels with the help of agriculture extension peoples
Future direction, such as continuation, change/ revision, termination	Continuation
Special Notes	FNCA mutation breeding project helping us to develop new rice varieties with desire agronomic traits Carbon and carbon ion beam irradiation facility under FNCA project also open a new window in our mutation breeding research activities. We released three rice varieties under this project to farmers named BINA Dhan-14, BINA Dhan-18 and BINA Dhan-19 are now very very popular.

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	**Breeding New Rice Varieties for Sustainable Agriculture under Climate Change**
Country & Name of Project Leader:	China, Qingyao Shu
Background of the Project	Rice is the most important major staple food crop in China, its sustainable production is of pivotal importance to food security, environment protection and overall welfare in China, particularly under climate change. To achieve sustainable rice production in the historical process of rapid urbanization under climate change in China, it is necessary to breed new varieties with increased performance (yield, quality and tolerance to biotic and abiotic stresses).
Purpose of the Project	The project aims to 1) breed new rice varieties that are well adapted to rice production under climate changes in China; 2) develop genetic resources, techniques and methods that could be used for breeding new varieties with increased performance (yield, quality and tolerance to biotic and abiotic stresses) in rice production under climate change.
Outputs of the Project	(1) One hybrid rice variety (i.e. Jiang Liang You 7901) was officially released for commercial production; (2) Three herbicide-resistant mutant lines have been developed and being used in production; (3) Genomic variations induced by high energy ion beams have been identified and elucidated; (4) One mutant gene has been cloned.
Project outcomes/ achievements (Please include economic impact and publication if any)	The project has increased rice productivity in Zhejiang and neighboring areas in China and laid basis for generating economic impact soon; The findings of genomic variations induced by high energy ion beams deepen understanding of mutation induction.
Factors not considered in the planning process that may have led to better outcomes for the project.	Mutation induction is always very much dependent on “luckiness” because the mutation frequency is very low. In this project, we failed to identify mutant resistant to a number of diseases.
Factors during project implementation that inhibited	

outcomes for the project.	
Lessons learned from the Project	
Recommendations to ensure sustainability of project outcomes	More efforts will be invested to expand the use of mutant variety so to generate more impact.
Future direction, such as continuation, change/ revision, termination	Mutation techniques will be used when appropriate in practical breeding.
Special Notes	

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	Soybean Improvement through Induced Mutations and Related Biotechnology
Country & Name of Project Leader:	Indonesia Sobrizal
Background of the Project	Soybean is one of the main crops for food and industry in Indonesia. As the main source of plant-based protein, soybean has the highest priority after rice and corn in terms of food security. In the last decade, national soybean production was relatively low. The national soybean production was 986,000 tons from a harvested area of 785,500 ha in 2017 and it was 995,000 tons with a harvested area of 790,000 ha in 2018. This figures were below from the national demand which is estimated to reach 2.8 million tons per year, which lead to an inevitable imports of soybeans. To increase soybean production through plant breeding programs, a wide genetic diversity of plants is needed as the basic in selection activities to obtain genotypes that have the desired character. One method to increase the genetic diversity of soybeans is the application of induced mutations. The use of induced mutations has contributed significantly to the release of more than 2700 mutant plants worldwide, both in plants propagated through seeds and vegetatively. The combination of mutation techniques and biotechnology to support selection can increase efficiency in plant breeding.
Purpose of the Project	The project of soybean breeding aims to obtain - improvement of yield potential in abiotic stress, such as dryland and acid soil - improvement of agronomic characters, such as early maturity and characters related to yield component - improvement of seed quality, such as seed size and seed nutrition
Outputs of the Project	High yielding soybean varieties
Project outcomes/ achievements	- Increase farmer's income - Contribute to soybean availability for food and industry

(Please include economic impact and publication if any)	Unfortunately, we have no data for real economic impact.
Factors not considered in the planning process that may have led to better outcomes for the project.	Dissemination of new varieties has not been carried out to farmers maximally.
Factors during project implementation that inhibited outcomes for the project.	The government's policy to import soybeans from abroad causes the increase in domestic soybean productivity to be very slow.
Lessons learned from the Project	The involvement of stakeholders from various sector is needed to achieve the expected outcomes.
Recommendations to ensure sustainability of project outcomes	
Future direction, such as continuation, change/ revision, termination	Soybean breeding is important to increase the production and and greater resilience to climate change.
Special Notes	

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	Mutation Breeding -Ion beam breeding research for development of useful crop genetics resources
Country & Name of Project Leader:	-Republic of Korea -Si-Yong Kang
Background of the Project	Establishment of new creating methods of useful mutants using various radiation sources is important for the development of genetic resources. It is necessary to elucidate differences in the effects on mutations among gamma ray, heavy ion and proton radiations.
Purpose of the Project	To increase ion beam breeding research in Korea, it is necessary to study basic research of proton irradiation (e.x, 100 MeV, KOMAC) of plant materials as well as to set new beam line of 200 MeV heavy ion accelerator (RAON).
Outputs of the Project	-identified proper irradiation condition and bio-effects of proton beam on main plant species -compared the mutation induction rate and molecular mechanism with other radiations
Project outcomes/ achievements (Please include economic impact and publication if any)	Two research papers related to proton beam breeding conducted by our research team were published in two international journals in 2021.
Factors not considered in the planning process that may have led to better outcomes for the project.	
Factors during project implementation that inhibited outcomes for the project.	The heavy ion beam accelerator (RAON) was planned to be completed in 2021, but it has been delayed.
Lessons learned from the Project	
Recommendations to ensure sustainability of project outcomes	In the category of mutation breeding research, it is necessary to set up various research titles to meet the research conditions and needs of the participating countries.
Future direction, such as continuation, change/ revision, termination	Continuation
Special Notes	

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	**Mutation Breeding of Major Crops for Low-input Sustainable Agriculture Under Climate Change**
Country & Name of Project Leader:	Malaysia Dr Sobri Hussein
Background of the Project	This project is initiated with 4 different types of variety (MR 219, MR 211, Pongsu Seribu2 & MR264) as starting material. The project on rice mutation breeding for sustainable agriculture is progressing well as per scheduled. Nuclear Malaysia managed to produce 12 most potential mutant lines through ion beam (irradiated at AVF-Cyclotron at the National Institute of Quantum Science and Technology) and gamma radiation. Three mutant lines (MINT 1, MINT 2, MINT 3, MINT 4, MINT 5, MINT 6, MINT 7, MINT 8, MINT 9 7 NMR191) were produced through ion beam radiation while another 2 mutant lines (NMR151 and NM152) were derived from gamma radiation. **On 29 Jan 2021,** the Malaysia's Ministry of Agriculture and Food Industries (MAFI) have certified NMR152 as national new rice variety after NMR152 undergone the strict technical evaluation by the technical committee BKKIPB (Ref no: MDI/PR/JKTBKKIPB/P/2021(14)). Due to the great reputation and high demand from the farmers, NMR152 was officially launched by the honorable Prime Minister of Malaysia on **20 November 2021.** With the launching, the mutant rice variety - NMR 152, is now officially named after the name of the 9th Prime Minister of Malaysia as 'IS21' (**I**smail **S**abri 20**21**) .
Purpose of the Project	1. To evaluate advanced mutant lines of rice with low agriculture input. 2. To develop new mutant rice that tolerates the global climate change. 3. To obtain certification for NMR151 & NMR152 & NMR 191. 4. To produce the best agronomy package for the farmers.
Outputs of the Project	● Government of Malaysia through MOSTI has **awarded RM 2,021,200.00 million research grant** to further develop rice mutation breeding project (Project code RD0120A1407-2020). ● Two mutant lines were **successfully granted** with Certificate of Registration of New Plant Variety and Grant of Breeder's Right by Department of Agriculture Malaysia in Feb 2020 with registration number; **PBR0156** (for NMR152) and **PBR 0159** (for NMR151). ● Documentation of Standard Operation Procedure (SOP) for

	Certified Seed in Malaysia. (Still in progress) **Publications:** Hasan, N. A.1,2*, Mohd, Y. R.2,3, Harun, A. R.4, Faiz, A.4, Sobri, H.4 and Yusof, S.4.Screening of phenotypic performance, drought, and salinity tolerance in the mutagenized population of Oryza sativa cv. MR219 generated through ion beam irradiation.International Journal of Agricultural Technology. Vol. 17(5):1735-1752. 2021. N A Hasan1,2,*, M Y Rafii2,3, A R Harun4 , F Ahmad4 , N N Jaafar2 and A I Akmal Shukri2Agro-morphological response of rice (Oryza sativa L.) (cv MR 284) to chronic gamma irradiation. IOP Conf. Series: Earth and Environmental Science 756 (2021) 012009 IOP Publishing doi:10.1088/1755-1315/756/1/012009. Zarifth S,K., Mohd Rafii Y., Mahmud T, M, M.,Mohd R, I. & Abdul Rahim H. Growth Performance and Antioxidant Enzyme Activities of Advanced Mutant Rice Genotypes Under Drought Stress Condition. Agronomy 2018, 8, 279; doi:10.3390/agronomy8120279. Oladosu Y, A. Genotype-Environment Interaction and Stability Analyses in Advanced Rice Mutants for Grain Yield and Straw Qualit. University Putra Malaysia. PhD Thesis 2018. Asma I,K. Yield Physico-Chemical and Nutritional Characteristics of MR219 Rice Mutants and Their Effects on Glycemic Index and Responses in BALB/c Mice. University Putra Malaysia. Master of Science Thesis 2018. Sobri Bin Hussein[1], Abdul Rahim Bin Harun[1], Shakinah Binti Salleh[1], Khairuddin Bin Abdul Rahim[1], Faiz Bin Ahmad[1], Phua Choo Kwai Hoe[1], Shyful Azizi Bin Abdul Rahman[1], Ahmad Nazrul A.W[1], Latiffah Binti Nordin[1], Atsushi Tanaka[2], Anna Ling Pick Kiong[3], Mohd Rafii Bin Yusop[4], Kogeethavani R[5]. Mutation Breeding of Rice for Sustainable Agriculture in Malaysia. 15- 19 Oct 2017. Kyrenia Cyprus.
Project outcomes/ achievements (Please include economic impact and publication if any)	**Achievements:** ● **Awarded gold medal** in Nuclear Malaysia Technology Preview & Showcase 2021 ● **Awarded Director General Special Award 2021**(Nuclear Malaysia Technology Preview & Showcase 2021) ● IAEA Award_**Outstanding Achievement Award 2021**

- FNCA Award_ **Breakthrough Prize 2021**

Impact

- NMR152 successfully increased the farmers' income between 40% to 50% in **Peninsular Malaysia.**
- Increase factory income up to **3.8%** (Sykt HMN (M) Sdn Bhd).
- Upon registration of NMR152 as certified seed with Ministry of Agriculture and Food Industries (MAFI) that signified the inclusion of the mutant variety into National Subsidy Scheme, approximately **50,000 farmers** in the country were benefited from this FNCA project.
- This project was invited to participate in the flood relief mission in **east coast** of Malaysia. As a result, mutant variety successfully increased the farmers' income between 50% to 80%.
- Farmers received **high quality seed** as an outcome of research collaboration between Malaysian Nuclear Agency and Industrial partners (Innovation technology from both parties).
- **High demand** from the local farmer's due to officially launch by the honorable Prime Minister of Malaysia.

Economic impact

Total sale for 2020 : **RM 1.30 Million**
Total sale for 2021: **RM 2.45 Million**

Online Media

https://www.bernama.com/bm/am/news.php?id=1942919
https://www.bernama.com/en/news.php?id=1943052
https://www.youtube.com/watch?v=zn_bEVByra0
https://www.youtube.com/watch?v=jqOg7NufC58
https://www.youtube.com/watch?v=hxHYlE_8a6c
https://www.nst.com.my/news/nation/2021/11/747049/pm-local-researchers-mobilise-efforts-agro-food-innovation?fbclid=IwAR03s210r0vueNEU6rRlWrHm-l2CazkQJmSWin2W__NQ8T6KNKxCl-9MeGY
https://bit.ly/30MukHG?fbclid=IwAR3Dlb-Pvbrji1EXQYlaf1NoRAErlMarntuThiEU8CPdGbtWn8BpP4tBj6E
https://www.utusan.com.my/terkini/2021/11/pm-lancar-benih-padi-is21-berdaya-tahan-produktiviti-tinggi/
https://www.utusan.com.my/gaya/2020/07/beras-teknologi-nuklear/
https://www.hmetro.com.my/amp/mutakhir/2021/11/779463/baka-padi-baharu-is21-mampu-tingkatkan-pengeluaran-padi-negara

	https://www.hmetro.com.my/amp/mutakhir/2021/11/779462/masalah-pesawah-dan-petani-adalah-masalah-kerajaan-pm https://www.sinarharian.com.my/ampArticle/173485 https://www.astroawani.com/berita-malaysia/kenaikan-harga-baja-dan-racun-kjaan-bantu-kurangkan-beban-pesawah-petani-pm-331892?amp=1 https://umno-online.my/2021/11/20/kenaikan-harga-baja-dan-racun-kjaan-bantu-kurangkan-beban-pesawah-petani-pm/amp/ https://www.thesundaily.my/local/govt-to-help-alleviate-burdens-of-farmers-pm-updated-FM8583474 https://www.thevibes.com/articles/news/47677/govt-to-ensure-reduced-fertiliser-pesticide-prices-ismail-sabri
Factors not considered in the planning process that may have led to better outcomes for the project.	● The availability of man power during covid-19 pandemic and Natural disaster such as the country worst flood on Dec 2021.
Factors during project implementation that inhibited outcomes for the project.	• Much of the research work was affected due to **Covid-19 pandemic.** • The farming activities particularly in large scale plantations that highly rely on foreign workers were affected due to **MCO** (Malaysian movement control order **2020 - 2021**). • Certification of other new potential varieties in the pipeline would still require long period. • The project requires much more research fund in order to release new rice variety. • Global climate change is one of the major challenges in the sustainable agriculture in rice mutation breeding. • Field trials/evaluations are subjected to rice growing season/schedule in all granary areas. • Major plant disease such as *Pyricularia oryzae* , *Xanthomonas oryzae* pv. Oryzae, *Nilaparvata lugens* and stem borer still affecting rice industry in Malaysia (2020-2021).
Lessons learned from the Project	● Climate change and natural disaster is fuelling a decline in rice crop production

	- Lacking of new varieties in the market - Insufficient supply of high quality seeds - Certification of new variety required long period - At leat 5 to 10 years is required to produce new rice variety - Huge amount of research fund is required to produce new variety (RM1 Million to RM 5 Million)
Recommendations to ensure sustainability of project outcomes	The most potential lines such as **NMR151** and **NMR 191** should be verified by rice technical committee members and related agencies to complete registration procedures before release to the farmers as one of the national varieties.
Future direction, such as continuation, change/ revision, termination	- Moving forward, Malaysia Nuclear Agency will continue with its efforts in obtaining the approval and registration of other potential mutant lines (NMR151 and NMR191) as the national new rice variety. - The project has addressed the national agenda and policy in getting new rice variety that resistance to biotic and abiotic stress for sustainable production and increase well being and livelihood of the farmers. - In view that there are still many other potential mutant lines that can be further developed, the efforts of mutation breeding should be continued as it remains relevant in the area of plant breeding and has been proven to be able to create variation within a crop variety.
Special Notes	Global climate change is one of the major challenges in the sustainable agriculture in Malaysia. This project have **highly impacted** the **socio-economic status of the farmers** as the mutant rice are adaptable to current global climate change conditions while have proven to increase the yield and income of the farmers.

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	Improvement of major crops through low input Sustainable agriculture under climate change in Mongolia
Country & Name of Project Leader:	Mongolia, Bayarsukh. Noov
Background of the Project	Mongolia is experiencing dramatic climate change. Last 70 years the absolute air temperature raised by 2.1^{0}C and the precipitation decreased in Mongolia. By the year 2020 the average air temperature will raise by 2.2-3.0^{0}C and in further 25 years warming will intensify by two times and evaporation increase by seven to ten times. Due to the above changes the yield potential of existing plant varieties reduced due to climate change, the cropping zone boundaries has been changing towards North, pest and disease distribution, frequency increased and soil erosion and degradation increased, respectively. The wheat is dominant crop and cultivated in about 80% of agricultural land in Mongolia. In Mongolia, the breeding of high potential wheat varieties was always major subject in breeding program. During 50 years of study the over 90 cereals crop varieties developed including 72 varieties of spring wheat, nine-durum wheat, four of oats and 2 common millet varieties. Among them a new spring wheat varieties Orkhon, Khalkh Gol –1, Darkhan-34, Darkhan-74, Darkhan-144, Darkhan-131 and the barley variety Alag-Erdene, Burkhant-1 and common millet Burgaltai are officially certified and commercialized. Barley is second cultivar planting after wheat in Mongolia. Mostly used for animal feed, brewing beer and human consumption. There we need to develop short duration varieties adapted Mongolian condition. The application of mutation breeding technique in Mongolia has conducted since 1970s at the Institute of Plant and Agricultural Science (IPAS). The mutation breeding mainly focuses on the development of new mutant wheat varieties and barley, rapeseed and rice mutant on enhancement of wheat genetic diversity for

	breeding. Through mutation breeding Mongolia increased volume of wheat mutant lines with target improving traits and developed number of new mutant varieties Darkhan-172, Darkhan-173 transferred to state variety test for registry and Darkhan-141 officially registered as promising new variety. The existing commercial wheat varieties have not good grain quality, drought tolerance, and disease and pests resistance and cannot sustain stable yield under climate change. The induced-mutation considered useful efficient tool for the improvement 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 needed for stable food production.
Purpose of the Project	Improvement of major crops productivity and drought tolerance through application of mutation technique combined biotechnology and marker assisted selection following tasks identified: - Enhancement of genetic diversity in wheat, barley through application of mutation techniques - Development of high yielding, drought tolerance, disease resistant wheat and barley varieties
Outputs of the Project	To develop new varieties of crops by mutation breading using gamma rays and ion beams (high yields using less fertilizer and chemicals) resistance to various environmental stress, e.g. diseases, insects, drought, flood, etc.
Project outcomes/ achievements (Please include economic impact and publication if any)	The improved new mutagen source for mutation breeding of Mongolia, such as ion beam (He 50MeV, Carbon 320 MeV) mutagen. Totally, 1917 rows of 60 progenies planted in M2-M4 for the breeding initial materials. In 2021, the ion beam treatment applied at the Department of Radiation-Applied Biology Research, National Institutes for Quantum and Radiological Science and Technology Japan. We received seeds after sowing. According to the biometrical measurements taken in the

	M_2 generation, the growth period of Darkhan-144 15Gy dose variant was 3 days earlier than control, in Omskaya-36 100Gy was 2 day earlier than control. Yield increased by 25.0g in the 100Gy dose (helium ion beam treatment) of Omskaya-36 variety. Other mutant progenies could not pass control by yield. 100Gy dose of Omskaya-36 variety productive stem is higher than control. Seed number per spike of Toboliskaya 125 Gy variant increased by 6. According to the biometrical measurements taken in the M_3 generation, the growth period of 20Gy dose of Omskaya-36 variety was 2 days earlier than control, other mutant progenies were similar to control. Plant height is fluctuated 83-111 cm. All doses of ion beam treatment of Toboliskaya variety plant height reduced by 7-16 cm. Productive stem number of Darkhan-144 20Gy variant was higher (by 12) than control. Also yield of this progeny was high (by 14 g higher than control). In 20Gy dose of Toboliskaya variety seed number per spike was higher than control and seed weight per spike also higher than control variety. The 363 spikes 42 plants and 95 rows selected by the spike form, maturity, and stress tolerance and transferred to the next level study. In 2021, at the agronomy trail we are studied 10 mutant lines of early, mid and mid-late maturity. AL-647, AL-649 mutant lines matured by 5 days earliar than check variety Darkhan-144 and gave higher yield by 0.4-3.1 t/ha. In the yield trial, two mutant lines including early maturity Darkhan-225 and mid maturity variety Darkhan-234. The 1000 kernel weight and seed volume weight of mutant advanced line Darkhan-225 were higher than control Darkhan-131 variety. Mid late maturity mutant advanced line Darkhan-234 were high 1000 kernel weight than control Darkhan-34 variety.
Factors not considered in the planning process that may have led to better outcomes for the project.	Through this project Mongolia could increase volume of mutant lines with target improved traits and this is important achievement for Mongolia. Also we are improved to Mongolian mutation breeding

	new mutagenesis, such as carbon and helium ion beam mutagens.
Factors during project implementation that inhibited outcomes for the project.	Mongolia doesn't have irradiation facility and physical mutation induction very much dependent on the international collaboration. Thanks to our colleague from Japan for great help for irradiation our seed materials during project implementation period. However, international transportation and customs clearance of seed materials became more difficult these days. In particular, in 2020 we are not able to send any seed for irradiation because of the COVID19 pandemic outbreak. The strong financial support is needed from government to implement successful mutation breeding.
Lessons learned from the Project	
Recommendations to ensure sustainability of project outcomes	
Future direction, such as continuation, change/ revision, termination	Future direction of mutation breeding of Mongolia will continue mutation breeding in combination with biotechnology under the Cereal crop breeding research project funded by the Science and Technology Fund of Mongolia by the financial support.
Special Notes	We are very much appreciating the ion beam irradiation service provided by the Department of Radiation-Applied Biology Research, National Institutes for Quantum and Radiological Science and Technology Japan. We would like to request Japan to continue this service to member states.

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	Development of Rice Varieties Adapted to Adverse Rice Environments Through Induced Mutation
Country & Name of Project Leader:	Philippines Nenita V. Desamero/Christopher C. Cabusora
Background of the Project	Climate change poses a huge threat in Philippine rice agriculture. Changes in climate patterns, causes phenomena leading to yield losses amounting to billions of pesos. Climate resilient rice varieties are one of the long-term solutions considered to mitigate these losses due to climate change. The project utilizes various plant breeding strategies, such as induced mutation techniques to generate and develop rice lines, and eventually varieties, with durable and multiple tolerance to adverse growing conditions.
Purpose of the Project	To generate rice varieties with single of combined tolerance to climate change-related environmental stresses (drought, saline, submergence, high temperature).
Outputs of the Project	a. 33 Released rice varieties adapted to rainfed-drought prone and saline-prone rice ecosystems. ▪ 2 Varieties developed from seed mutation by gamma ray ▪ 4 Varieties developed from induced mutation through anther culture ▪ 1 Variety developed from somaclonal induced variation through tissue (seed) culture ▪ 1 Variety developed from combining tissue culture and gamma irradiation (*in vitro* mutagenesis) ▪ 25 Varieties developed from conventional breeding b. Breeding lines as novel sources of genes for traits important to rice breeding.

	▪ 206 lines for combined abiotic tolerance (drought, saline, submergence) ▪ 4 doubled haploid lines for resistance to rice tungro disease
Project outcomes/ achievements (Please include economic impact and publication if any)	▪ Disseminated saline tolerant rice varieties to regions of the Philippines experiencing sea water intrusion, and drought tolerant varieties to rainfed regions. ▪ Publications: Enhancing Phenotypic and Genetic Variability in Drought-Tolerant Traditional Rice Variety Salumpikit Through In Vitro Mutagenesis *Rice-Based Biosystems Journal, Vol. 6: 1-11, February 2020.* Enhanced Yield and Yield Component Traits of the Mutants Derived from Rice cv. Samba Mahsuri-Sub1 and Pokkali Through Induced Mutation *Global Scientific Journals (GSJ), Vol. 7, Issue 6, 649-653.* Characterization of a Novel Floral Mutation Induced by Gamma Irradiation of Philippine Rice Variety NSIC Rc9 *International Journal of Sustainable Agricultural Research* *2012 Vol. 8, No. 1, 00 43-55, December 2020.* Diversity Assessment of the Traditional Rice Varieties Collected in Northwest Luzon *Rice-Based Biosystems Journal, Vol. 8, pp. 85-94, February 2021.* Field Performance of Improved Somaclones from *In vitro* Culture Rice Variety PSB Rc 68 Under Complete Submergence *Rice Based-Biosystems Journal, Volume 9, pp. 63-74, August 2021.*

Factors not considered in the planning process that may have led to better outcomes for the project.	▪ Budget streamlining ▪ More investments in molecular-based characterization/research
Factors during project implementation that inhibited outcomes for the project.	▪ COVID-19 Pandemic ▪ Community Lockdowns ▪ Mandatory quarantines
Lessons learned from the Project	▪ Implementation of the project without compromising the safety and health of the people involved/working in the project.
Recommendations to ensure sustainability of project outcomes	▪ Promotion of stress tolerant varieties ▪ Sustainable and sufficient funding
Future direction, such as continuation, change/ revision, termination	▪ Molecular research: gene mapping, gene sequencing ▪ On-site validation/screening of generated breeding lines.
Special Notes	

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	**Program:** Rice Breeding for Flood Prone Areas **Project:** Rice Breeding for Flash-flood Tolerance
Country & Name of Project Leader:	Thailand / Peera Doungsoongnern, Malinee Chanwan, Nila Rasidee, Udompan Kalasi
Background of the Project	The flood-risk rice growing area of Thailand is approximately 62,246 hectares. (Chinucha *et al.,* 2014). The pattern of flooding could be divided into 2 types of flood. The first is prolonged deep flooding, and the second is flash flood, which features a short period flooding (1-2 weeks). While deep water flood is fairly predictable, flash flood is extremely unpredictable and may occur at any stage of rice growth especially at vegetative period. Thus, submergence tolerance in rice is highly desirable and expected to enhance food security. The submergence tolerance of rice plants refers to the ability of rice to survive submersion. After the water recedes back to normal. The rice plant can recover and be able to grow and yield.
Purpose of the Project	To create lines/varieties that have flash flood resistance, high yield potential, good grain quality, desirable market characteristics for both consumption and processing, and suitable harvesting period for the flooded rice fields of Thailand.
Outputs of the Project	Seventy hundred twenty (720) lines of nine parents/varieties (4,500 lines) are mutant rice lines. The lines are submergence tolerant line under artificial ponds flood submerge (4 times) during M_4 to M_7.
Project outcomes/ achievements (Please include economic impact and publication if any)	Twenty-two elite lines were experimented On-Station Yield Trial (paddy field). The average yield is about 3,002 kg/ha and nine lines had yielded more than parent (ck.). RD31-B-390-3-4B brought highest yield (3,870 kg/ha).
Factors not considered in the planning process that may have led to better outcomes for the project.	In-depth study of genetics will help to understand and increase research success.
Factors during project	Lack of continuity in supporting research budgets.

implementation that inhibited outcomes for the project.	
Lessons learned from the Project	To acquire skills, techniques, and methods with high efficiency to use in assessing the flood resistance of rice in different generations.
Recommendations to ensure sustainability of project outcomes	Take the test at a higher level in many conditions at risk of flash flooding to confirm the results of the previous preliminary experiment. This will lead to the selection of species that are well adapted in a variety of areas. before propagating to farmers.
Future direction, such as continuation, change/ revision, termination	-
Special Notes	Working with FNCA, we had the opportunity to use a mutation induction technique using electron beam for the development of flood-resistant rice varieties. It is a new method that yields different results from the previous method, resulting in experience and continual development of work. The method is expected to be able to successfully develop rice varieties in accordance to the objectives of this research project.

Mid-term Report of the Project
(Summary of the Project performance and result)

Project Title	Improvement of rice and groundnut varieties through mutantation breeding in Vietnam
Country & Name of Project Leader:	Vietnam- Le Duc Thao
Background of the Project	Vietnam has achievements in breeding mutant plant varieties for production applications. The application of mutations to creat population of new materials has been identified as an important technique.
Purpose of the Project	Creating the materials mutant lines of the rice and peanut for breeding
Outputs of the Project	- 50 promising line for rice - 10 promising line for peanut
Project outcomes/ achievements (Please include economic impact and publication if any)	- Selected 82 mutant rice lines in the M4 generation - Selected 27 mutant peanut lines in the M5 generation - 01 article
Factors not considered in the planning process that may have led to better outcomes for the project.	Lack of continuity, regularity of research funding
Factors during project implementation that inhibited outcomes for the project.	Limited research funding
Lessons learned from the Project	To need closure combination of traditional breeding and biotechnology for more effective in breeding.
Recommendations to ensure sustainability of project outcomes	Often after the end of the project, the team has difficulties to maintain and continue to evaluate the materials. FNCA project should have a small budget to support groups to ensure continuity of activities.
Future direction, such as continuation, change/ revision, termination	The project has not ended and we will continue screening to select new varieties, and in 2022, we continue to irradiate on peanuts, oranges and soybeans.
Special Notes	