BRIN – National Research and Innovation Agency, Indonesia

Indonesia's Success Stories in the Application of Nuclear Technology

for Sustainable Agriculture

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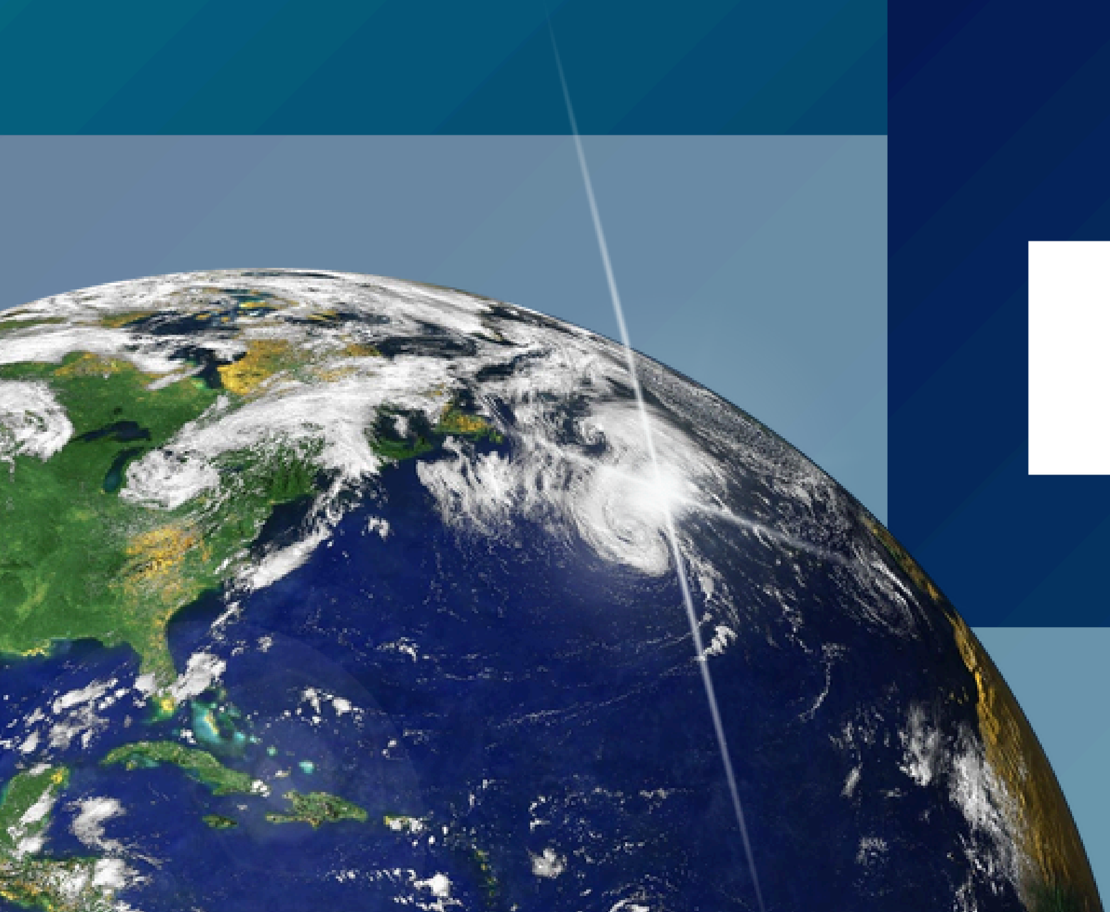
Meeting Global Challenges with Nuclear Science

Global food demand continues to rise as climate change affects production. Conventional breeding takes years. Nuclear technology helps create stronger plants faster.



How Radiation Helps Our Food

Scientists use radiation safely.	New plant varieties can fight drought, pests, and disease.	helps farming for a long time and keeps enough food for people.

How Mutation Breeding Works

Mutation breeding changes genes naturally, producingdiversecrops safelywithoutforeignDNA. It accelerates genetic improvementacceptedby farmers and consumers

Step	Activity	Output
1	Radiation treatment on seeds	DNA variation
2	Growing and selecting plants	Visible new traits
3	Field testing and evaluation	Stable, high-yield crops
4	Variety release and adoption	Approved new varieties

Research in Indonesia

UnderBRIN,nuclearresearch combines radiation with genomics and metabolomics. Scientists study traits such as plant height, maturity time, and drought tolerance. They use NGS and bioinformatics to see gene changes, then run multi-location field tests to confirm performance. This makes breeding faster, more precise, and adaptable.

- **Steps:** mutation induction → selection → characterization (genes & metabolites) → multi-location testing → release. **Tools:**
- radiation, genomics, metabolomics, NGS, bioinformatics. **Result:** modern mutant varieties that work in the lab and in the
- field.

Success in Rice Breeding

Indonesia has successfully used nuclear technology to develop more than thirty new rice varieties. These varieties provide higher yields, resist pests, and mature faster, directly supporting food security and farmers’ welfare.

Variety Development

Since 1982, over thirty mutant rice varieties have been released through nuclear breeding programs, showing consistent improvement in productivity, adaptability, and resilience across various regions of Indonesia.

Key Examples

Prominent varieties such as Sidenuk, Mira-1, Bestari, Mustajab, Isora, and Pikatan demonstrate outstanding performance in yield potential, growth stability, and tolerance to environmental stress and diseases.

Main Advantages

These mutant rice lines feature high yield capacity (up to 10 tons per hectare), early harvesting age, and strong resistance to major pests, ensuring reliable production and reduced losses.

Saving and Improving Local Rice

Indonesia'slocalrice varieties, such as Rojolele,Lampai Sirandah, and Dayang Muratan, have been improved using nuclear techniques. These varieties now offer higher yields, better taste, and stronger pest resistance while keeping their traditional identity. The program connects modern technology with cultural preservation and regional collaboration.

Preserved Heritage

Maintain flavorand cultural identity.

Improved Quality

Higher yield and pest resistance.

Local Collaboration

Joint workwithregions and farmers.

Expanding to Other Crops

Nuclear technology in Indonesia is not limited to rice. It has been successfully applied to other important crops, helping improve food production, industrial value, and plant resilience through the creation of high-yield, pest- resistant, and nutrient-rich varieties.

Soybean Improvement

Kemuning and Sugentan varieties, early and high-yielding.

Sorghum Development

Drought-tolerant types with high biomass potential.

Fruit and Industrial Crops

Pirama banana, sugarcane, and ornamentals improved.

Collaboration and International Recognition

Indonesia's success in nuclear agricultural research is strongly supported by international collaboration. Partnerships with IAEA and FAO have strengthened research capacity, expanded global networks, and brought international recognition through awards and the establishment of an Collaborating Center.

- Global Partnership
- Outstanding Achievement Awards (2015 & 2021)
- IAEA Collaborating Center (2017–2026)

Sharing Knowledge and Technology

Indonesia promotes active knowledge sharingand technologytransfer toensurethat nuclear innovations reach farmers effectively. Collaborationamong researchinstitutions, government, and international partners helps build skills, encourage innovation, and strengthen sustainable agricultural development.

Capacity Building

Regular training and workshops improve scientists' and farmers' understanding of nuclear-based agriculture.

Technology Transfer Models

Linear, systemic, and collaborative approaches connect research, policy, and field application efficiently.

Partnership Network

Joint efforts by BRIN, IAEA/FAO, universities, and the private sector expand knowledge and adoption.

Future Outlook and Key Messages

Future Outlook

Indonesia will combine nuclear mutation breeding with genomics and bioinformatics to develop climate-smart crops, supported by IAEA and FAO collaboration for sustainable and resilient agriculture.

Key Messages

Responsible use of nuclear technology enhances food security, supports farmers, and protects nature, proving that science can drive peace, prosperity, and sustainability in agriculture.

Online training in collaboration with Indonesian Nuclear Society Association (HIMNI). Weekly activities

Online training in collaboration with the Ministry of Agriculture

Journal club, sharing knowledge about mutation breeding and biotechnology, up to date technology

Local Superior Variety
Ex BATAN dan PemDa Klaten (2019)

Rojolele Srinar

Potential 9,75 t/Ha
Average 8,42 t/Ha
Sticky rice
Pandan aroma
Amilose content 20,83%
Medium resistance to WBC biotype 1,2,3
Medium resistance to Tungro inoculum Garut dan Purwakarta
Resistance to Blast race 073, Medium resistance to race 173

Rojolele Srinuk

Potential 9,22 t/Ha
Average 8,07 t/Ha
Sticky rice
Pandan aroma
Amilose content 15,9 %
Medium resistance to WBC biotype 1
Medium resistance to Tungro inoculum Garut dan Purwakarta
Medium resistance to Blast race 073

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https://doi.org/10.17221/66/2024-CJGPB

Detection of genomic loci associated with days to heading in tropical japonica rice through QTL-seq

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Abstract: This study investigated the genetic basis of days to heading (DTH) in tropical japonica rice using F_2 populations derived from late-maturing Rojolele and early-maturing Rojolele Srinuk varieties. Phenotypic analysis of DTH showed continuous distribution and positive skewness. Whole genome sequencing (WGS) derived single nucleotide polymorphism (SNP) from early and late-heading bulks were used to identify three candidate regions with strong association to DTH: *qDTH3.1* and *qDTH3.2* on chromosome 3, and *qDTH7.1* on chromosome 7, with the latter linked to the *Oryza sativa Pseudo-Response Regulator 37* (*OsPRR37*) gene. InDel markers validated *qDTH7.1*'s significant linkage to DTH, particularly marker ID14, which is effective for marker-assisted selection of early DTH in Rojolele background.

Keywords: bulked segregant analysis; flowering time; genetic regulation; *Oryza sativa*; whole genome sequencing

Using QTL-seq, we aimed to identify the genetic determinants of DTH regulation in Rojolele and its progeny. The insights from this investigation will be useful for enhancing the agronomic performance of Rojolele and facilitate the integration of superior japonica varieties into tropical cultivation, which will contribute to food security and agricultural sustainability in Indonesia and other tropical regions.

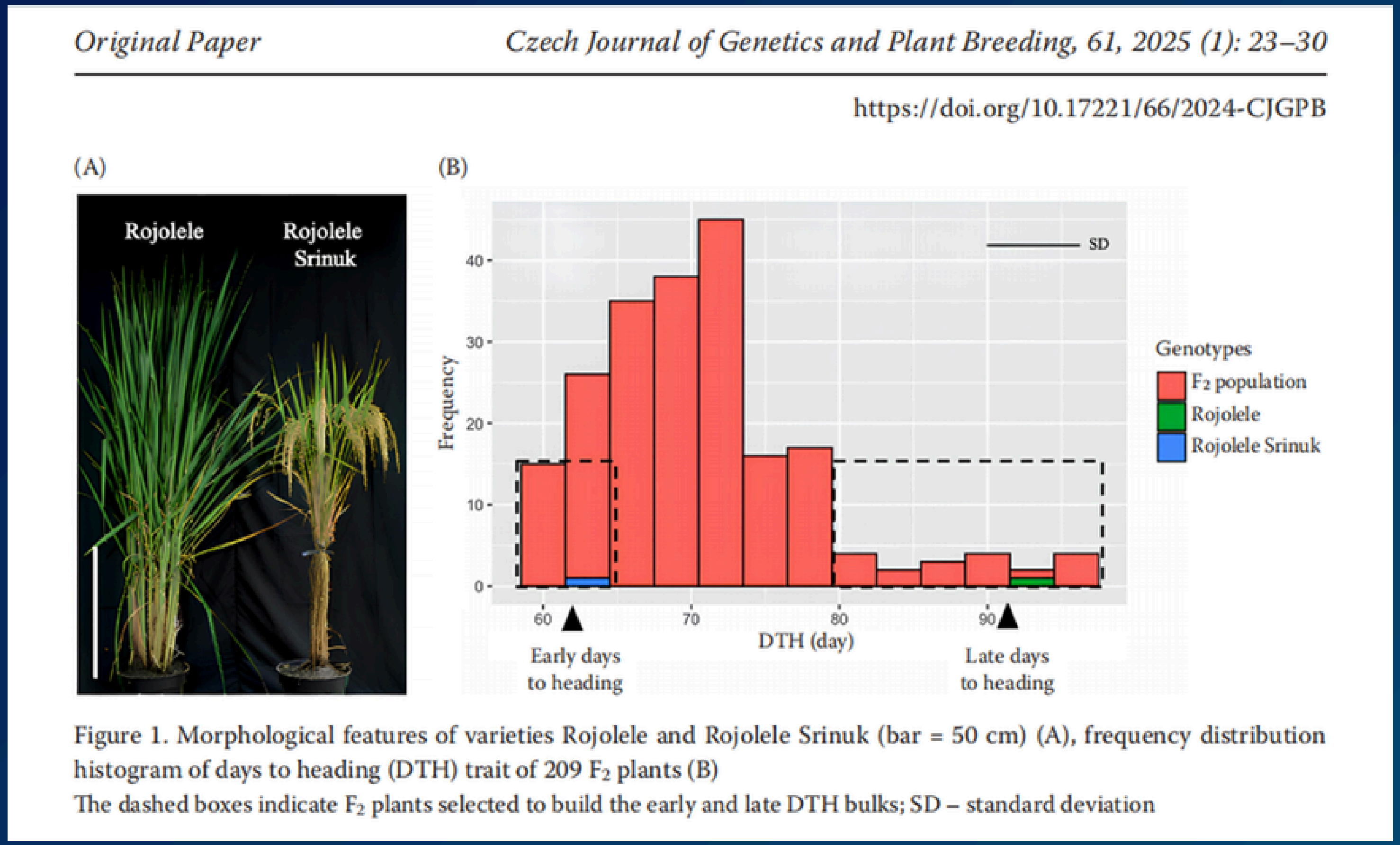
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Figure 1. Morphological features of varieties Rojolele and Rojolele Srinuk (bar = 50 cm) (A), frequency distribution histogram of days to heading (DTH) trait of 209 F_2 plants (B)
The dashed boxes indicate F_2 plants selected to build the early and late DTH bulks; SD – standard deviation

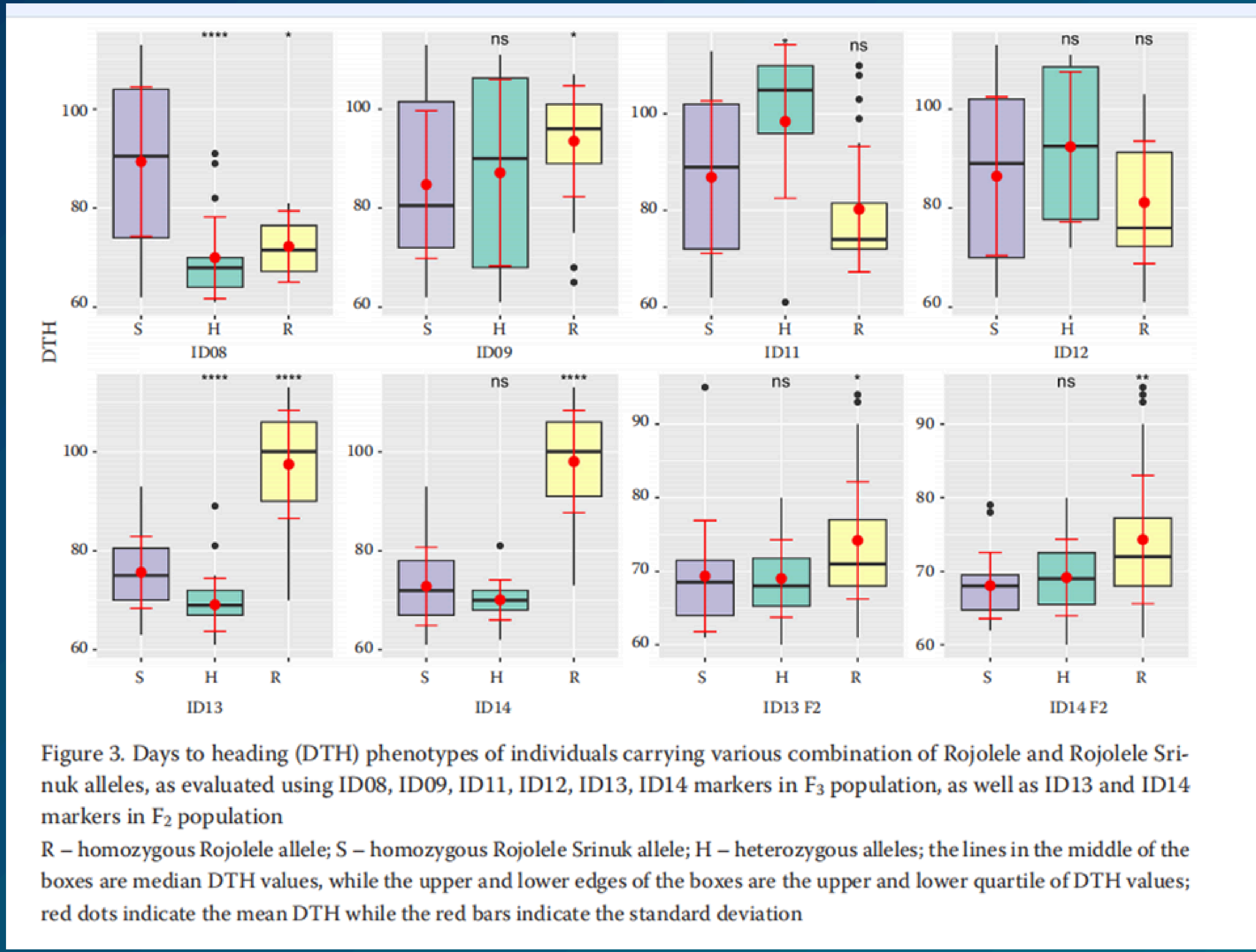

Figure 3. Days to heading (DTH) phenotypes of individuals carrying various combination of Rojolele and Rojolele Srinuk alleles, as evaluated using ID08, ID09, ID11, ID12, ID13, ID14 markers in F_3 population, as well as ID13 and ID14 markers in F_2 population
R – homozygous Rojolele allele; S – homozygous Rojolele Srinuk allele; H – heterozygous alleles; the lines in the middle of the boxes are median DTH values, while the upper and lower edges of the boxes are the upper and lower quartile of DTH values; red dots indicate the mean DTH while the red bars indicate the standard deviation

QTL-seq is a cost-effective method for identifying rice chromosome segments linked to specific traits. WGS data from QTL-seq is also useful for the design of new markers and identification of underlying genes based on allelic variations

CONCLUSION

The qDTH7.1 locus in rice chromosome 7, which co-located with the OsPRR37 gene, has significant association with DTH in tropical japonica back ground. Validation using InDel markers from qDTH7.1 locus, particularly ID14, confirmed its potential utility in marker-assisted selection for DTH. Further gene expression studies are needed to elucidate the precise regulatory mechanisms of DTH in tropical japonica rice.

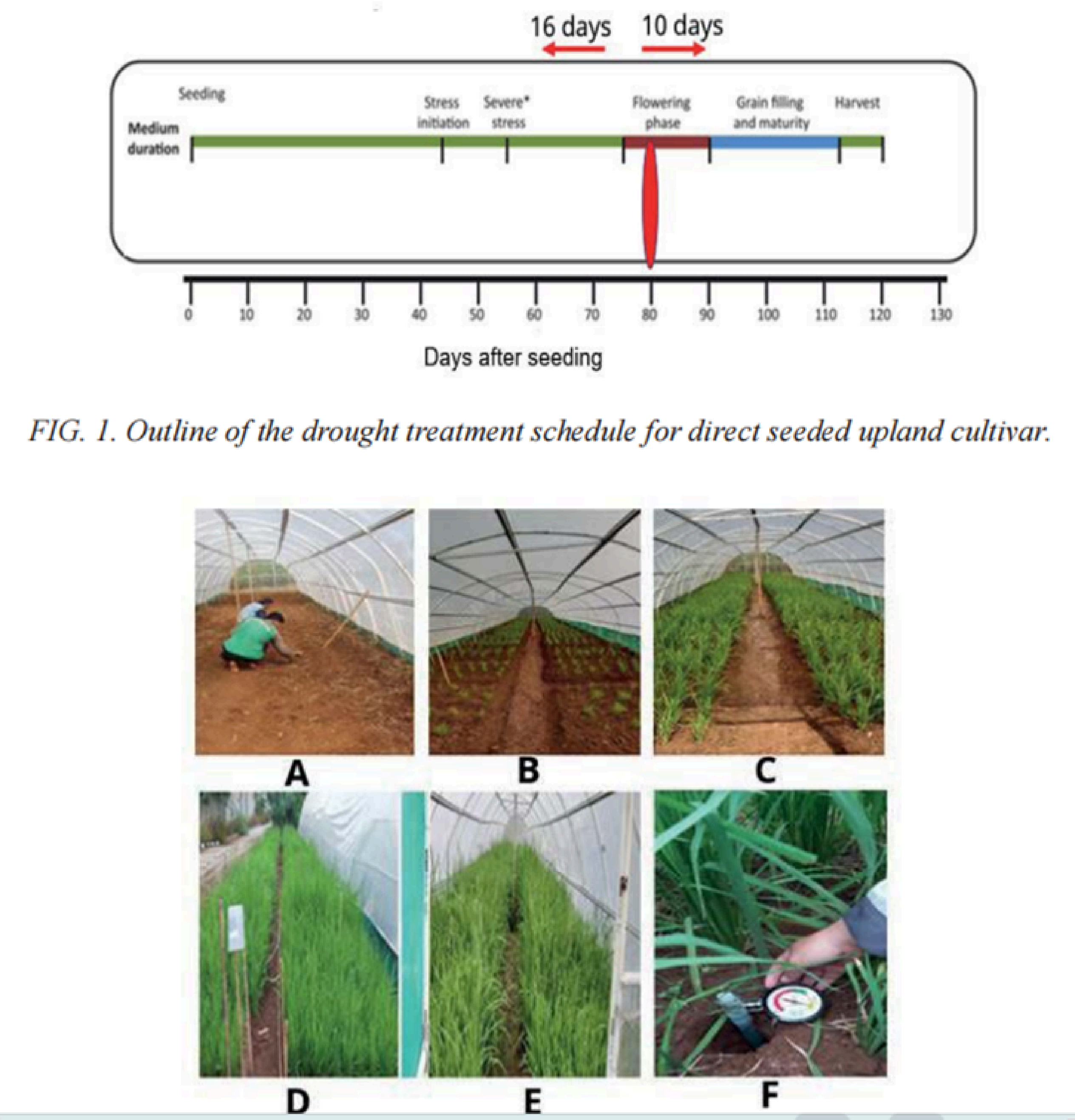

FIG. 1. Outline of the drought treatment schedule for direct seeded upland cultivar.

2-4. MUTATION BREEDING AND PRE-FLOWERING STAGE FIELD SCREENING FOR DROUGHT TOLERANCE IN UPLAND RICE

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Abstract

A simple protocol is presented for field screening drought tolerance in upland rice at the pre-flowering stage. The method is based on a plastic house (rainout shelter) field test in which drought is imposed during the critical period for rice in the reproductive phase, which is 16 days before flowering and 10 days after flowering. The experiment was an augmented block design with control plants (parent and check varieties) in each block. The plots were irrigated only when susceptibility check showed leaf rolling with a score of 9 (as per the International Rice Research Institute) and the groundwater potential reached more than –35 kPa at 30 cm soil depth. Information on the responses of standard genotypes (parent, tolerant and susceptible) is given to which test plants are compared. After this phase, the plants are watered again. Enough water should be applied to saturate the root zone.

Key words: Drought, upland rice, pre-flowering stage.

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Application of selection index for rice mutant screening under a drought stress condition imposed at reproductive growth phase

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Abstract. *Sarwendah M, Lubis I, Junaedi A, Purwoko BS, Sopandie D, Dewi AK. 2022. Application of selection index for rice mutant screening under a drought stress condition imposed at reproductive growth phase. Biodiversitas 23: 5446-5452.* Drought is a condition of limited availability of water that can reduce rice growth and productivity, and may threaten food security. Therefore, efforts are needed to produce drought-tolerant rice genotypes. This study aimed to select drought tolerant of the M3 mutant upland rice population at the reproductive growth phase. This research was carried out in dryland at BATAN, Indonesia, from September 2020 to February 2021, using an augmented design. The study employed 360 genotypes of mutant upland rice and 5 check varieties, namely Salumpikit, IR20, IR64, Limboto, and Situgintung. The selection index was constructed based on multivariate analyses such as correlation, path, and Principal Component Analysis (PCA). The coefficient of the selected main component can be used as a selection index. Before selecting the character values of each genotype, the values were standardized to obtain the same degree of value. The results showed that grain weight per hill (W.G.), panicle density (P.D.), panicle length (P.L.), and the number of filled grains per panicle (NFG) could be used as selection criteria for mutant upland rice tolerant to drought at reproductive growth phase. The selection index formula was I = (5*0.44*WG) + (2*0.41*PD) + (0.23*PL) + (0.42*NFG). Selection of genotypes of mutant upland rice based on weighted index selection resulted in 89 genotypes with high yields and good agronomic characteristics so that they could be tested in further research.

Keywords: Augmented design, drought, mutant rice, selection index, upland rice

Study of Salinity Tolerance in Several Mutant Rice Lines Using Morphophysiological and Biochemical Approaches

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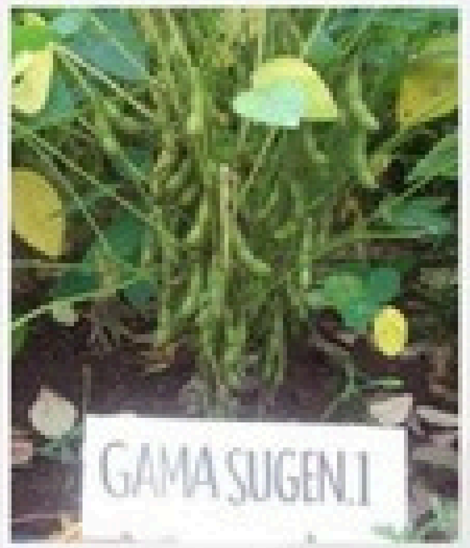
Abstract. Salinity is one of the main constraints in rice production. Atomita 2 is a rice variety resulting from breeding released in 1983, which was initially indicated to be tolerant to salinity. However, specific findings related to salinity tolerance in the mutation-based Atomita 2 rice variety have not been disclosed. This study aims to determine the potential mutant line of the Atomita 2 rice variety that is tolerant to salinity stress and identify morphological, physiological, and biochemical characters in the M4 generation against salinity stress. This research was conducted in a greenhouse and consisted of two experiments: (1) Initial screening to determine potential mutant lines of rice variety Atomita 2 tolerant to salinity stress, (2) Identification of morphophysiological and biochemical characteristics of mutant lines of rice variety Atomita 2 to salinity stress. The first experiment showed that salinity selection using 60 mM NaCl resulted in 38 surviving genotypes. The results of the second experiment showed that several morphological, physiological, and biochemical characters were identified to show differences in the response of each genotype to salinity stress. A decrease in plant height, number of tillers, weight of 100 grains, and grain weight was a morphological response due to increased salinity stress. The reduction in photosynthesis rate, stomatal conductance, transpiration rate, and SPAD score is a physiological response of rice plants to salinity stress. Changes in APX and CAT enzyme activities, MDA, and proline content indicated the biochemical response of rice to NaCl stress.

Key words: antioxidant enzyme, mutant strains, reactive oxygen species

Soybean Mutant Varieties

Mutiara 1
- High productivity
- Super big seeds

Rajabasa
- Tolerant in acid soil
- High productivity



Gamasugen 1
- Super early maturity
- High yield

Gamasugen 2
- Super early maturity
- High yield

Mutiara 2
•High yield
•Black soybean

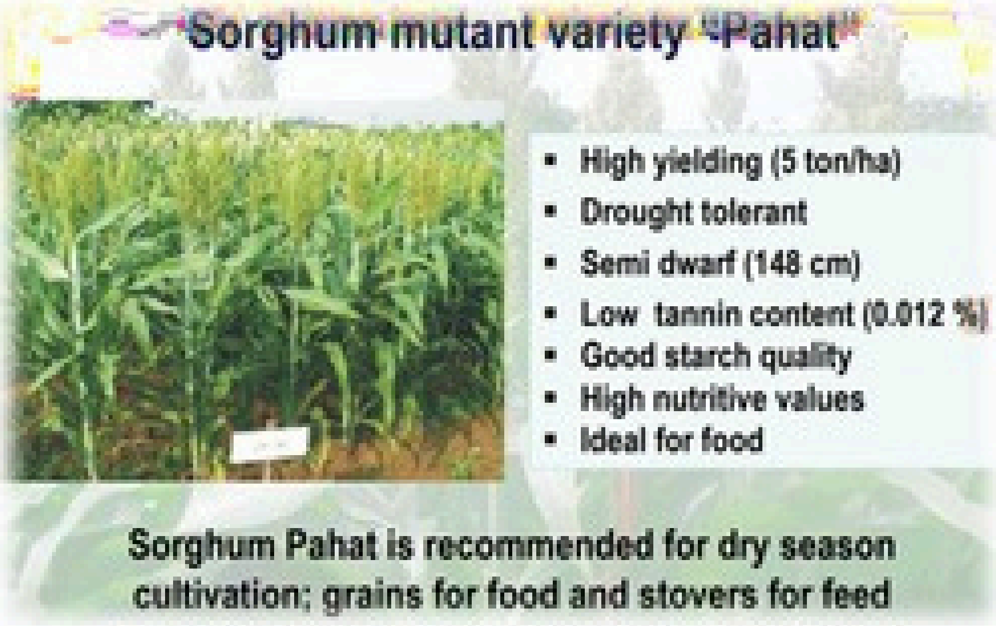
Mutiara 3
•High yield
•Black soybean

Drought tolerant soybean mutant varieties; Kemuning 1 dan Kemuning 2

Research on Assembling Superior Sorghum Varieties

Sorghum plant breeding targets;

Seed productivity
Nutritional content and food suitability
Biomass production
Brix percentage
Stay green and brown midrib
Pest and disease resistant
Abiotic stress tolerant

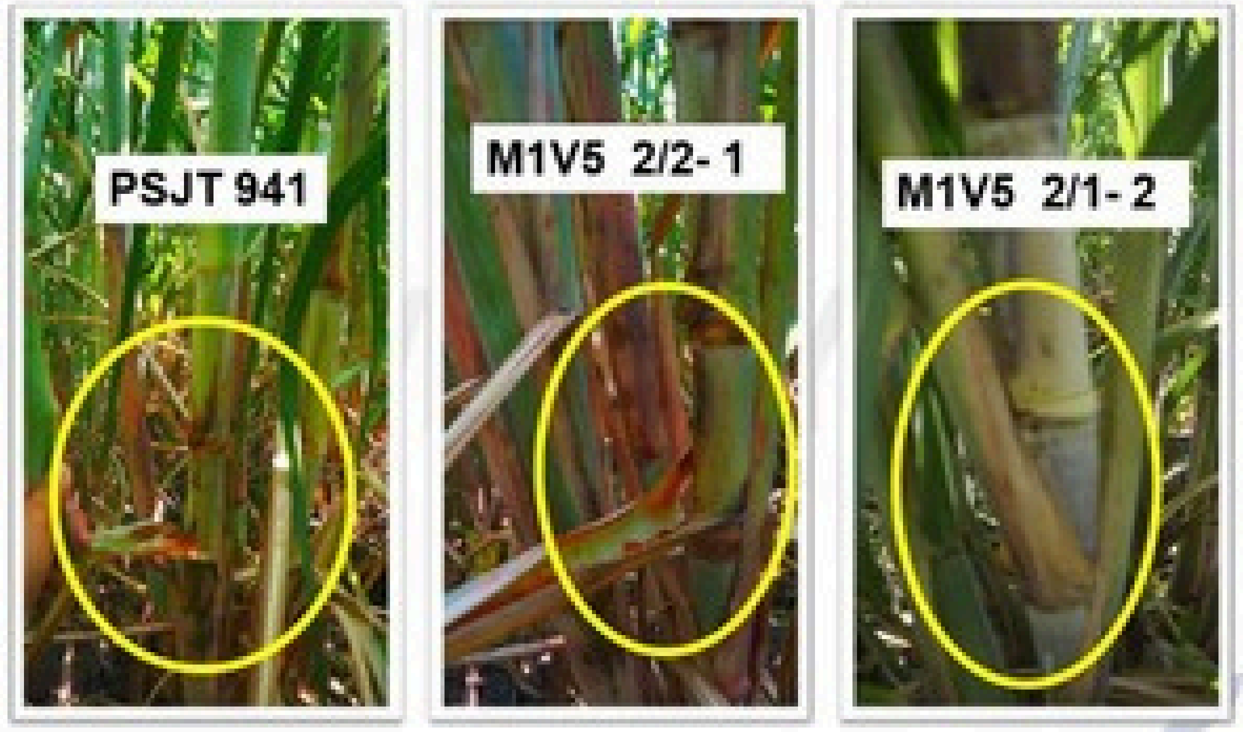


Mutation Breeding Research in Vegetative Plants

BRIN

The results of mutation breeding in Chrysanthemum (>30 varieties), research collaboration with the Ornamental Crops Research Institute, Ministry of Agriculture

Banana varieties are the result of mutation breeding, resistant to Fusarium wilt disease and high vitamin C content



Mutation breeding in sugarcane to improve agronomic properties, especially early ripeness and easy removal of old and dry leaves, research collaboration with national sugar companies

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Thank You

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