# Evaluation of gamma irradiation on seed germination and growth characteristics of Thailand upland rice (*Oryza sativa* L.) Jaw Haw Cultivars

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**Abstract.** This study aim to determine the effects of gamma irradiation on seed viability of upland rice (*Oryza sativa* L.). Long harvesting age and low productivity are the inhibiting factor in upland rice breeding. The objectives of this research were to increased productivity of upland rice using gamma irradiation at dose of 20,40,60,80,100 Gy and without radiation. Dry seeds of upland rice were irradiated with Cobalt-60 Gammacells-220 irradiator at the dose of 20-100 Gy. The effects of gamma irradiation on the growth were compared with the control plants. An increase in germination percentage, vigor, index, shoot length, root length and shoot length was found at the low dose of irradiation treatment. Results showed that irradiation doses had a significant effect on seed germination and growth. Irradiation at the dose of 80 Gy indicates a more significant reduction in seed viability when compared to the dose of 40 Gy. The results indicated that Jaw Haw Cultivars is very potential radiation significantly the increase the growth parameter. In conclusion, the lower doses of irradiation may be used to increase the germination percentage and index in upland rice.

## 1. Introduction

Upland rice (*Oryza sativa* L.) is rice cultivated on dry land which nutrient content 63% of total energy sufficiency and 37% of protein [1]. Long harvesting age and low productivity are some of the weaknesses local rice Jaw Haw Cultivars, one of upland rice variety needs 5 months for harvesting. It means that it needs longer time compared to white rice. The production of upland rice is still low production because of the decrease of harvested are caused by land conversion, varied soil and climate conditions, high pest and disease rate, and not optimal application of cultivation technology. The long growing period, the low productivity as well as the sensitivity to natural enemy caused upland rice cultivation is very rare. The most crucial problem was the lack of availability of varieties and superior seeds [2].

Gamma radiation was recognized as an effective tool to generate future resources in molecular particularly for rice and developed in other graminaceous crops [3]. Gamma ray irradiation could enhance the rice plant's tolerance to salt stress by changing expression levels and protein structures in membrane transport gene [4]. Gamma irradiation has influence on plant growth and development by inducing genetically, cytological, biochemical, physiological and morphogenetic changes in cells and tissues depending on the levels of irradiation [5]. Low dose of gamma radiation may increase the enzymatic activation and awakening of the young embryo which results in stimulating the rate of cell division and affect vegetative growth [6,7]. Gamma irradiation treatment on the crop can stimulate germination which can be developed in stress-tolerance varieties as well as increasing production yield [8]. Using irradiation techniques for enhancing germination and growth rate could increase the quality of the valuable plant. The main objective of this study is to use gamma irradiation for enhancing Jaw Haw Cultivars growth factor (germination percentage, germination index, vigor index, root length and shoot length). From the the result of the study, it can be used to increasing in production yield and reducing long-term harvesting costs.

## 2. Materials and methods

### *2.1. Plant materials*

Upland rice Jaw Haw Cultivars were used in this study and seed were collected from Chiang Mai Field Crops Center Chiang Mai-Maejo, Chiang Mai, Thailand. Seeds were put into 6 plastic bags contained 100 seeds in each experimental condition.

### *2.2. Gamma irradiation*

Irradiation of dry seed of Jaw Haw Cultivars was done using a Cobalt-60 radioactive by utilizing the Gammacells-220 irradiator at Program in Applied Physics, Faculty of Science, Maejo University, Chiang Mai, Thailand (figure 1). This research was arranged based on factorial completely random design (CRD) with 6 level of gamma irradiation dose: without radiation, radiation at dose of 20, 40, 60 ,80 and 100 Gy. The control seeds were not exposed to gamma rays.

### *2.3. Radiation sensitivity test*

Seed bioassay was performed in Biotechnology Division, Faculty of Science, Maejo University. Two folded 9 cm. in diameter filter paper was cut and placed in sterile Petri dishes for use as a seedbed. Total 5 replicates of 20 seeds were placed in a Petri dish for each treatment. Sterile water (5 cc) was dropped to the dishes and then placed into an incubator at 250 $^{o}$C for 12 hrs.

### *2.4. Planting*

The seeds were sowed in a sandy soil pot (soil:sand=3:1) for 14 days in the greenhouse at Faculty of Agriculture, Maejo University, Chiang Mai, Thailand (figure 2). Irrigation was done by watering the plants every day. Assessment of the seedling growth was evaluated on germination percentage, germination index, germination vigor, shoot length and root length. Germination percentage is measured by considering germinated seed after initiation of radical and plumule elongation. The shoot and root length were measured in centimeters by a scale and the root/shoot length ratio was calculated using the estimates of seedling growth. Data for germination, the shoot and root length was noted after 14 days of germination.

### *2.5. Determination of plant growth parameter*

Observation of seedling growth was conducted on germination percentage, germination index ,vigor index, root length and shoot length were used for germination assessment [9,10]. Observation data were subjected to one-way analysis of variance (one-way ANOVA) at a 1 percent level of probability for laboratory and field study, to determine the differences in an average of all tested parameters between irradiated and non-irradiated. Statistical analysis was performed using Statistical Analysis System Software version 17.0.

**Figure 1.** Cobalt-60 Gammacells-220 irradiator.

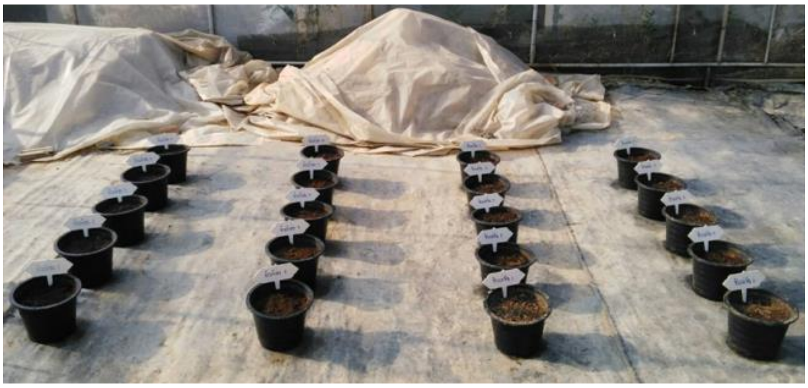

**Figure 2.** Seeds planting in the greenhouse.

*2.6. Seed germination*

Table 1 showed that the irradiation dose gives a very significant effect on germination percentage and a germination index of the seeds. The germination percentage, index and vigor index were highest at 40 Gy of irradiation treatment compared with others. However, it was found that increasing the dose of radiation more than 60 Gy significantly reduced the seed germination percentage in Jaw Haw Cultivars. Seedling vigor (Vigor Index) were decreased with increasing radiation doses (table 2). It was higher at a lower dose and lower at a higher dose. The number of leaves per seedlings at 14 days was not significant between treatments in Jaw Haw Cultivars. The dry weights of the plants at 80 Gy and 20 Gy are significantly higher than other treatments. The same results were observed by Moussa [11].

*2.7. Seedling and root length*

The shoot and root length are generally used to determining the effects of various physical and chemical mutagens. Maximum root length (3.47 cm) was observed in control treatment followed by treated seed of 60 Gy and 40 Gy (2.76 cm and 2.74 cm) and it was lowest (2.49 cm) in the treated seed of 20 Gy (figure 3). The maximum reduction in root and shoot length occurred with increasing radiation doses. A similar result was reported by Talebi and Talebi [12] in rice.

**Figure 3**. Root and shoot length of Jaw Haw Cultivars after 14 days of planting.

**Table 1.** Germination percentage and index affected by gamma rays in upland rice (*Oryza sativa* L.) Jaw Haw Cultivars.

| Dose (Gy) | Germination parameters | |
|---|---|---|
| | Germination percentage (%) | Germination index (%) |
| 0 (control) | 95.0 ± 1.19 a | 246.32 a |
| 20 | 92.0 ± 0.03 a | 233.82 a |
| 40 | 95.0 ± 1.19 a | 246.32 a |
| 60 | 93.0 ± 0.02 a | 238.82 a |
| 80 | 78.0 ± 0.02 c | 197.01 c |
| 100 | 83.0 ± 0.02 b | 212.89 b |

Means within a column followed by the same letter are not significantly different (p< 0.05), The data showed are mean ± SD of five replicates. Different letters a, b, c, d and ab denote significant difference (p < 0.05) between different treatments.

**Table 2.** Germination parameters affected by gamma rays in upland rice (Oryza sativa L.) Jaw Haw Cultivars.

| Dose (Gy) | Vigor index | Shoot length (cm) | Root length (cm) | Root / Shoot length ratio |
|---|---|---|---|---|
| 0 | 93.85± 0.53 b | 2.51 ± 1.22 a | 3.47 ± 1.19 a | 1.38 |
| 20 | 96.03± 0.79 ab | 2.09 ± 1.05 ab | 2.49 ± 0.03 b | 1.19 |
| 40 | 101.12± 0.00 a | 2.51 ± 1.07 a | 2.74 ± 1.19 b | 1.09 |
| 60 | 91.84± 0.49 b | 2.10 ± 0.94 ab | 2.67 ± 0.02 b | 1.27 |
| 80 | 83.48± 0.53 c | 1.83 ± 0.94 b | 2.59 ± 0.02 b | 1.41 |
| 100 | 86.66± 0.49 c | 1.97 ± 0.86 b | 2.55 ± 0.02 b | 1.29 |

Means within a column followed by the same letter are not significantly different (p < 0.05), The data showed are mean ± SD of five replicates. Different letters a, b, c, d and ab denote significant difference (p < 0.05) between different treatments.

## 3. Discussions and conclusion

The results from the study showed that lower doses (20-60 Gy) had stimulating effects on seedling growth parameters, such as germination, shoot length and root length, while higher doses of more than 60 Gy significantly reduced seed germination under laboratory and greenhouse experiments. It may be concluded that low doses of irradiation may promote better germination, growth, and development by breaking the barriers including dormancy in *Oryza sativa* L. (Jaw Haw Cultivars).

**Acknowledgments**
We are grateful for the financial support provided by National Research Council of Thailand (Grant no. MJU.1-61-015) and Faculty of Science and Faculty of Agricultural Production, Maejo University, Chiang Mai, Thailand.

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