Effect of gamma irradiation on harvest date of local upland red rice cultivar

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Abstract. Rice is a carbohydrate source and main staple food in Asia including Indonesia. The aim of the study is to assess the effect of gamma irradiation on the harvest date of upland rice. Common problems in cultivation of upland red rice are low production and long harvest life. One of the solutions is through the breeding mutation. The research was conducted in Field Experiment Faculty of Agriculture, Halu Oleo University. The research used a split plot design, as main plot was the irradiative treatment and the sub plot was the different of cultivar in three replications. The irradiative treatment consist of two levels, i.e. $b_0$=without gamma irradiation, $b_1$=treatment with gamma irradiation. The cultivar tested are ($v_1$) = Labandiri, ($v_2$) = Jangkobembe, ($v_3$) = Ranggohitam, ($v_4$) = Paedarra. The research reveals that gamma irradiation treatment could accelerate the plants to reach the age of flowering, simultaneity of flowering, seed filling period, and harvest date.

1. Introduction

Rice (Oryza sativa L.) is a carbohydrate source and main staple food in Asia including Indonesia [1,2,3,4]. Rice demand in Indonesia has increased [5,6,7,8,9]. The population increased and wetland conversion, causes rice supply cannot be fulfilled sustainably [5,10]. Several programs have been created to increase production of in Indonesia, including increasing productivity [4,11,12], development upland rice [13,14] and breeding program [15-19], and also decreasing level of rice consumption and promote the source of local food [20].

Rice aside from being a source of carbohydrates, is also containing proteins, fats, fibre, minerals, and also anthocyanins [21,22,23], mainly for red rice. Red rice is a functional food with a high health value [24]. Anthocyanin is a phenolic compound that included in flavonoid group and functions as an antioxidant [25]. It plays an important role for plant itself and human health. Common problems in the cultivation of upland red rice are mostly because of low level production and length of harvest date. One of the solutions is through the breeding mutation, to increase upland rice production and shortage the harvest time.
Age and yield are characters that could improve through mutation induction [26]. General mutation induction has done by gamma-ray irradiation [27,28]. Gamma ray is most widely used in plant breeding [29,30], because it is a mutagen that has high energy with good penetration, mutation induction can produce genetic diversity [31] faster than conventional breeding, so it is faster to obtain the desired plant [32]. In some plants, age and yield characters could improve through mutation induction. Improvement of age and yield characteristics of local red upland rice through gamma ray irradiation [33,34], is expected to increase the genetic diversity of plants that can be selected to obtain candidates for early matured red rice upland rice with high yields.

2. Materials and methods
This research was conducted in Field Experiment Faculty of Agriculture, Halu Oleo University. The research used a split plot design, as main plot was the irradiative treatment and the subplot was the different of cultivar in three replications. The irradiative treatment consists of two levels, i.e. b₀=without gamma irradiation, b₁=treatment with gamma irradiative. The cultivar tested are (v₁) = Labandiri, (v₂) = Jangkobembe, (v₃) = Ranggohitam, (v₄) = Paedara. Several generative characters included flowering time, flowering uniformity, anthesis period and harvest date were examined. Data analysed using ANOVA (analysis of variances) and further test using DMRT (Duncan’s Multiple Range Test).

3. Results and discussion

3.1. Result

3.1.1. Flowering time and uniformity. The results showed that the irradiation treatment caused the acceleration of flowering plants and the speed at which the plants reached a flowering uniformity (Table 1). The highest age of flowering acceleration occurred in Labandiri cultivars (3.56 days), Paedara (0.22 days), and Ranggohitam (4.67 days). Cultivars that achieved the fastest flowering simultaneity occurred in Paedara cultivars, with an average time to reach flowering uniformity in 7.11 days, then followed by Jangkobembe with an average of 7.56 days, Labandiri an average of 8.67 days and Ranggohitam an average of 11.22 days.

| Treatment                          | flowering Time (Day) | Average |
|-----------------------------------|----------------------|---------|
| v₁                                 | v₂                   | v₃      | v₄     |         |
| Without Gamma irradiation         | 109.44               | 109.89  | 115.00 | 107.44  | 110.44  |
| Gamma irradiation                 | 105.89               | 109.67  | 110.33 | 109.11  | 108.75  |
| Different                          | (3.56)               | (0.22)  | (4.67) | 1.67    | (3.56)  |

| Treatment                          | flowering Uniformity | Average |
|-----------------------------------|----------------------|---------|
| v₁                                 | v₂                   | v₃      | v₄     |         |
| Without Gamma irradiation         | 8.67                 | 7.56    | 11.22  | 7.11    | 8.64    |
| Gamma irradiation                 | 7.89                 | 9.67    | 10.78  | 10.44   | 9.69    |
| Different                          | (8.97)               | 27.94   | (3.96) | 46.88   | (8.97)  |

\[v₁\text{=Cultivar Labandiri; } v₂\text{=Cultivar Jangkobembe; } v₃\text{=Cultivar Ranggohitam; } v₄\text{=Cultivar Paedara}\]

3.1.2. Anthesis period and harvest date. The result showed that irradiation treatment has significantly effect on the anthesis period and harvest date (Table 2). Based on Table 2, it appears that the Jangkobembe cultivar has the fastest anthesis period, since panicles first time appear until the harvest date needed 35.22 days. Then followed by the Paedara cultivars with an average time of filling seeds
35.56 days and Ranggohitam with an average time of 37.56 days. While the longest seed filling time occurred in Labandiri cultivars with an average time of 39.56 days.

### Table 2. Effect of Irradiation on the anthesis period and harvest date

| Treatment              | Anthesis Time (Day) | Harvest Date (Day) |
|------------------------|---------------------|--------------------|
|                        | v1      | v2      | v3      | v4      | Average | v1      | v2      | v3      | v4      | Average |
| Without Gamma irradiation | 39.56  | 35.22  | 37.56  | 35.56  | 36.97  | 140.33 | 137.56 | 141.33 | 135.89 | 138.78 |
| Gamma irradiation      | 32.44  | 30.78  | 38.33  | 34.56  | 34.03  | 130.44 | 130.78 | 137.89 | 133.22 | 133.08 |
| Different              | (7.11) | (4.44) | 0.78   | (1.00) | (2.94) | 9.89   | 6.78   | 3.44   | 2.67   | 5.69   |

Different (7.11) 6.78 3.44 2.67 5.69

v1=Cultivar Labandiri; v2=Cultivar Jangkobembe; v3=Cultivar Ranggohitam; v4=Cultivar Paedara

It appears from Table 2 that the Paedara cultivar has the fastest harvest date compared to the other three cultivars. The average harvest date of Paedara cultivars is 135.89 days. It is then followed by Jangkobembe with a harvest date of 137.56 days and Labandiri with a harvest date of 140.33 days while the Ranggohitam cultivar with the longest harvest date averaged 141.33 days.

### 3.2. Discussion

In general, the acceleration of flowering age due to a gamma irradiation of 3.56 days with the acceleration of the Ranggohitam cultivar by 4.67 days or 4.46% faster. Then in the Labandiri cultivar at 3.56 days (3.23%) and Jangkobembe at 0.22 days (0.21%). The irradiation treatment can accelerate the occurrence of simultaneous flowering, especially in the Labandiri and Ranggohitam cultivars, which respectively accelerate to 8.97% and 3.97%.

Based on Table 3 it also appears that the irradiation treatment can shorten the time of filling the seeds so that it reaches the harvest faster with an average acceleration of 2.94 days. The highest seed filling acceleration occurred in Labandiri cultivars, with an average of 7.11 days. It is then followed by Jangkobembe cultivars with an average acceleration of 4.44 days and Paedara with an average acceleration of 1.00 days.

The irradiation treatment led to an acceleration of harvest date in all cultivars tested. The highest harvest date acceleration occurred in Labandiri cultivars with a harvest date of 130.44 days and an average harvest date acceleration of 9.89 days, followed by Jangkobembe with a harvest date of 130.44 days and an acceleration of the harvest date of 6.78 days. Then the Ranggohitam cultivar with an average harvest date of 130.78 days and an average harvest date of 3.44 days and Paedara with a harvest date of 133.22 days and an average harvest date of 2.67 days.

### 4. Conclusions

It concluded from the research, that the gamma irradiation treatment could accelerate the plants to reach the age of flowering, simultaneity of flowering, seed filling period, and harvest date. The most potential cultivars to be developed based on the acceleration of harvest date in Labandiri cultivars with a harvest date of 130.44 days and an average harvest date of 9.89 days, then followed by Jangkobembe with a harvest date of 130.44 days and an acceleration of the harvest date of 6.78 days. Then the Ranggohitam cultivar with an average harvest date of 130.78 days and an average harvest date of 3.44 days and Paedara with a harvest date of 133.22 days and an average harvest date of 2.67 days.
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