Test of Samosir local varieties of shallots with gamma-ray radiation on changes morphology characters, physiology and production

Yelfi Yana Linda Br Jabat¹, Rosmayati² and Jonathan Ginting²

¹Student of Agrotechnology Department, Faculty of Agriculture, University of Sumatra North, Jl. Prof. A. Sofyan No. 3, Medan, 20155, Indonesia
²Faculty of Agriculture, University of North Sumatra, Jl. Prof. A. Sofyan No.3, Medan ,20155 , Indonesia

Email: sijabat.yelfi1@gmail.com

Abstract. Shallots are one of the vegetable commodities that are in demand by the public, but their production does not meet market demand. One of the reasons is the difficulty of suitable seeds for the area. This condition can be overcome by obtaining superior seeds in the Samosir area through irradiation on shallot bulbs. The research objectives were to produce high production, and to identify changes in the morphological and physiological characters of the local Samosir variety shallots. Treatments were arranged in a non-factorial Randomized Block Design. Shallots bulbs were irradiated with several doses of gamma-ray irradiation (0, 1, and 2Gy) using a Co⁶⁰ irradiation sources. The results showed that there were morphological and physiological differences between the irradiation treatments. The number of leaves with the highest value at 2 Gy 20.147 g and the lowest at 18.894 g control. The heaviest wet weight in the control was 20.355 g and the lowest was at 2 Gy 18.45 g. At 1 Gy and 2 Gy can significantly increase the content of chlorophyll-a 2 Gy 2.484, chlorophyll-b 2 Gy 1.579, and total chlorophyll-(a+b) 2 Gy 4.056. This proves that the dose of gamma-ray radiation affects the morphological and physiological characters of shallots.

1. Introduction
Shallots are one of the commodities of horticultural crops that are of interest to the Indonesian and international community, because they can be processed into various types of food (salads) and cooking spices (sambel, rendang seasoning, etc.), it's just that the production does not meet market demand, especially the market in Samosir Regency. Farmers are less interested in planting shallots because of the difficulty of suitable seeds for the area.

In several shallot-producing regencies, North Sumatra, it is known that Samosir Regency occupies some of the lowest positions in terms of productivity, production, and planted area. The data shows that in 2015 the shallot production in the area was 1,352.70 tons, with a total planting area of 210 hectares and productivity of 64.41 quintals/ha. This condition is unfortunate considering that Samosir shallots used to be the prima donna [1].

There are several causes of a decrease in the production of samosir shallots, including biotic stress factors (pests and diseases), environmental stresses (drought and climate), and genetic factors originating from the plant itself which is unable to survive and adapt to its environment [1].
Shallots are one type of plant that is difficult to produce flowers and seeds, especially in lowland areas, this causes vegetative propagation using bulbs to be an alternative and commonly used by farmers. The use of plant material in the form of tubers which is continuously and hereditary is used because it is considered more efficient in growing faster and easier to obtain, compared to using True Shallot Seed (TSS), this is one of the sources of problems faced by farmers because it causes low genetic diversity [2,3].

Gamma-ray irradiation is a mutation technique that belongs to physical mutation. These rays have short wavelengths and large energies [4]. Its use is considered safer than chemical mutations because it does not leave residues [5].

Gamma-ray irradiation with low doses can stimulate cell division, plant growth, and organism development has given gamma-ray treatment [6].

Based on the description above, it causes researchers to be interested in researching the test of local varieties of shallots of Samosir with gamma-ray radiation on changes in morphological characters, physiology, and production of local shallots of Samosir. This study wanted to see the extent to which there were differences in the morphological, physiological, and production characteristics of local varieties of shallots of Samosir which were irradiated and not irradiated by gamma-rays.

2. Materials and methods
This research was carried out on farmers' land in Dosroha village, Simanindo, Samosir Regency, North Sumatra with an altitude of ± 900 meters above sea level, from February 2021 to May 2021. Materials and tools used include: onion bulbs of local variety Samosir, Gamma irradiator Chamber 4000A with Co60 radiation sources, fertilizers, insecticides, fungicides, planting tools in the field, measuring instruments, and stationery.

Gamma-ray irradiation is carried out at BATAN (National Nuclear Energy Agency). Bulbs to be irradiated measuring 3 g. Irradiation using gamma rays to do with the level of dose of 0, 1, and 2 Gy to be emitted through the irradiator gamma Chamber 4000A with Co ray source60. Planting of each tuber is done by plotting plots with a size of 90 X 120 cm and totaling 3 plots/beds, the spacing used is 15 cm x 15 cm, the number of bulbs planted per dose is 48 bulbs, and 25 of them are used as samples, so that the total number of plants obtained is 1,115 plants.

The application of organic fertilizer is carried out a week before planting, applied in the planting hole individually. NPK fertilizer was applied at the age of 2 WAP and 4 WAP at a dose of 0.5 g/plant for each application. Foliar fertilization was given with s-print fertilizer at a dose of 5 ml/l of water from the age of 4 WAP to 7 WAP. Pest control was carried out by spraying trivia insecticide, fungicide Amistartop 325 C was used for disease attack. Parameters observed were the number of leaves (wap), tuber fresh weight (g), and leaf chlorophyll content (mg g-1).

Data from each dose were averaged. The test was carried out by comparing the average yield data from the control treatment (0 Gy) with each other gamma-ray irradiation doses. Then the data obtained were analyzed using the Bnt-Test at the level of 5% and 1%.

3. Results and discussion
3.1. Number of leaves per clump (strands)

| Table 1. The average number of leaves (leaf) aged 6 WAP due to Administration of several doses irradiation of gamma rays. |
|---------------------------------------------------------------|
| Treatment | Number of leaves (strand) |
|-----------|--------------------------|
| R0        | 18.894 a                 |
| R1        | 19.78 ab                 |
| R2        | 20.147 b                 |

Description: The figure is followed by a letter that is the same in the same column differ not real of paragraph at the level of α = 0.05 and 0.01 by testing different real-smallest.
Data on the average number of leaves (strands) of shallot plants treated with gamma-ray radiation doses in various treatments can be seen in Table 1 and Figure 1. From the data, it can be seen that the gamma ray irradiation treatment had no significant effect at ages 2 and 4 ms and a significant effect on age 6 ms. Gamma-ray irradiation treatment aged 6 ms treatment of 1 gy (19.78 strands) was not significantly different from the control (18.89 strands) and 2 gy (20.15 strands), and the control was significantly different from 2 gy. These results indicate that the higher the radiation dose, the lower the number of leaves. This is thought to be due to one of the effects of radiation, namely the occurrence of physiological damage which results in suppressed plant growth (number of leaves). Human (2017) stated that radiation can cause death (lethality), sterility (sterility), and other physiological damage (physiological disorders) [7]. In addition, irradiated plants mostly cause leaf anomalies which include stunting, thickening, changes in shape and structure, shrinkage, leaf curling, and leaf union.

### 3.2. Bulb fresh weight (g)

**Table 2.** Average fresh weight of tubers (g) due to the administration of several doses of gamma ray irradiation.

| Treatment | Bulb fresh weight (g) |
|-----------|-----------------------|
| R₀        | 20.355                |
| R₁        | 19.079                |
| R₂        | 18.45                 |

Description: The figure is followed by a letter that is the same in the same column differ not real of paragraph at the level of $\alpha = 0.05$ and 0.01 based test bedan of paragraph smallest.
Figure 2. shows that the higher the dose of -ray irradiation gamma, the lower the fresh weight of the tuber follows regression curve.

From the data it can be seen that the gamma-ray irradiation treatment had no significant effect on the fresh weight of the tubers. Observation of the fresh weight of tubers per clump showed that the fresh weight of tubers decreased with increasing doses of gamma-ray radiation. In the control treatment, the fresh weight of tubers was 20.355 g, the dose of 1 gray was 19.079 g and the dose of 2 gray was 18.45 g. The decrease in fresh weight of tubers was related to the diameter of tubers produced due to gamma-ray radiation treatment. Observation of fresh weight showed that there was a decrease in diameter with increasing radiation dose. Brown and Caligari (2013) stated that gamma ray radiation with doses of 2 gy, 4 gy and 6 gy on onion bulbs planted caused physiological damage which included growth inhibition, reduced number of flowers and decreased tuber yield. The effect of radiation will increase with increasing radiation dose [8].

3.3. Chlorophyll content of leaves (mg. g⁻¹).

Table 3. Average content of chlorophyll a, chlorophyll b and total chlorophyll due to the administration of several doses of gamma ray irradiation.

| Treatment | Chlorophyll-a | Chlorophyll-b | Chlorophyll-(a+b) |
|-----------|---------------|---------------|-------------------|
| R₀        | 1.62 a        | 1.12 a        | 2.62 a            |
| R₁        | 2.09 b        | 1.32 b        | 3.41 b            |
| R₂        | 2.48 c        | 1.58 c        | 4.06 c            |

Note: Numbers followed by the same letter in the same column are not significantly different at the level of α=0.05 and 0.01 based on the smallest significant difference test.
Figure 3. Pasa chlorophyll a, chlorophyll b and total chlorophyll shows that the higher the gamma ray irradiation dose, the higher chlorophyll content followed the regression curve.

From the data, it can be seen that the gamma-ray irradiation treatment had a significant effect on the chlorophyll content of the leaves of the shallot plant, it can be seen in Table 3. From the data, it can be seen that the gamma-ray irradiation treatment had a significant effect on the chlorophyll content of the leaves. Where the chlorophyll content of the leaves shows that the higher the dose of gamma-ray irradiation is given, the more the values of chlorophyll a and b and total chlorophyll (a+b) are in red onion leaves. This is in line with research on garlic radiation material. Sutarto et al. (2004) stated that radiation treatment affects the chlorophyll content of garlic [9]. An increase in the content of chlorophyll a, chlorophyll b, and total chlorophyll of shallots can be caused by changes in plant metabolic activity resulting in enlargement of the thylakoid membrane as an effect of irradiation. As mentioned by Mugiono (1996) that the formation of Leaf chlorophyll is influenced by genetic factors, so that changes in the amount of leaf chlorophyll indicate that there has been a change in the genetic composition of the plant cells [10]. Chlorophyll mutation is an important parameter to evaluate the occurrence of mutations in plants due to Gamma Ray radiation [11]. The higher the frequency of chlorophyll mutations, the more likely there will be variations in other growth parameters.

4. Conclusion
The results of the study concluded that there were significant differences in morphological and physiological characters between irradiated and unirradiated shallot plants. In general, the higher the dose of gamma-ray irradiation given, the more it suppresses plant growth. Gamma-ray irradiation significantly increased the average number of leaves and the content of chlorophyll a, chlorophyll b, and total chlorophyll at the irradiation dose of 2 Gy. However, observing the fresh weight of tubers in the treatment without irradiation showed the heaviest weight compared to 1 Gy and 2 Gy.

Reference
[1] Ginting J, Rahmawati N and Mariati M 2015 Perubahan Karakter Agronomi Bawang Merah (Allium ascalonicum L.) Aksesim Simanindo Samosir Akibat Pemberian Berbagai Dosis Irradiasi Sinar Gamma I. Agroekoteknologi Univ. Sumatera Utara 3 340–339
[2] Bisognin D 2012 Breeding vegetatively propagated horticultural crops”, Crop Breed Appl. Biotechnol 11 35–43
[3] McKey D, Elias M, Pujol B and Duputié A 2010 The evolutionary ecology of clonally
propagated domesticated plants, *New Phytol.* 186 318–32

[4] Kovacs E and Keresztes A 2002 Effect of gamma and UV-B/C radiation on plant cells *Micron* 33 199–210

[5] Dwimahyani I and Widiarsihi S 2011 The effects of gamma irradiation on the growth and propagation of in-vitro chrysanthemum shoot explants (cv. Yellow Puma) *Atom Indones.* 36 45–9

[6] Zaka R, Chenal C and Misset M T 2004 Effects of low doses of short-term gamma irradiation on growth and development through two generations of Pisum sativum *Sci. Total Environ.* 320 121–9

[7] Human S 2007 *Riset dan Pengembangan Sorgum dan Gandum untuk Ketahanan panganPusat Aplikasi Teknologi Isotop dan Radiasi.* (Jakarta Selatan)

[8] Brown J and Caligari D S 2013 *An Introduction to Plant Breeding* (Oxford (GB): Blackwell Publishing)

[9] Sutarto I, Dewi N and Arwin 2004 Pengaruh iradiasi sinar gamma 60 co terhadap pertumbuhan tanaman bawang putih (Allium sativum L.) varietas lumbu hijau di dataran rendah *Risal. sinar Ilm. Penelit. dan Pengemb. Apl. Isot. dan radiasi, Jakarta.*

[10] Mugiono 1996 Pengaruh Iradiasi Sinar Gamma Terhadap Mutasi Klorofil Dan Variasi Genetic Ketahanan Penyakit Elas Pada Padi Gogo. *J. Zuliat* 7 1

[11] Brunner H 1987 Methods of Inducing of Mutations *Jt. FAO/IAEA Program. IAEA-Laboratories-Seibersdoef. Austria.*