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Effect of gamma rays on phenotypic of garlic cultivar doulu

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Abstract. This research aims to determine the effect of gamma-ray irradiation on the phenotypic of the garlic cultivar Doulu. The study was conducted in April-August 2018. Radiation on the bulb garlic is carried out at the centre of Safety and Meteorological Technology (PTKMR), BATAN, Jalan Lebak bulus Raya No. 49 Jakarta. Bulb planting is done at the research Hall of vegetable crops, Tongkoh village, Berastagi, North Sumatera. The draft used in this study is non factorial group random draft with 6 radiation dose treatment of 0 Gy (Control), 2 Gy, 4 Gy, 6 Gy, 8 Gy and 10 Gy. Each of the treatment levels is repeated as much as 4 and consists of 10 cloves of garlic. The observed quantitative data parameters are growing age, crop height, number of leaves, number of cloves, heavy bulbs, diameter of bulb, heavy cloves and diameter of cloves. The qualitative data parameters observed are bulb structures and bulb forms. Qualitative Data obtained is analyzed using various prints with advanced test of the smallest real difference (LSD). The results shows the irradiation of the influential gamma rays in the height of the plant, the number of leaves, the number of cloves, the weight of bulbs, the diameter of the bulb, the weight of cloves, and the diameter of garlic cultivars Gamma-ray irradiation produces a variety of bulb structures and bulb shapes. The parameters observed were structure and shape bulb based on IPGRI. Results showed that there were differences in the structure and shape of garlic bulbs.The structure of bulb are regular two-fan groups, regular multi-cloved radial, regular quadruple , regular two-cloved , and Irregular. The shape of bulb are Flat , Flat globe, Rhomboid, Broad oval, Globe and Ovate.

1. Introduction

Garlic (*Allium sativum* L.) is one of the agricultural commodities needed by the world population, mainly used as a flavoring or deodorizer for some types of food. The development of garlic plants in Indonesia is currently experiencing a very sharp decline. Some local garlic cultivars are very difficult to find both on farmers ' land and in the domestic market. One of the main causes is the presence of imported garlic which is the quality of the tompios is better recognized compared with the local garlic bulbs at an affordable price by consumers [1]. Some superior varieties of garlic are commonly cultivated among others varieties Bagor (Ngajuk), Lr (Batu), Jatibarang and local Sanur [2].In North Sumatra there is a local garlic that is the cultivar Doulu, where the cultivar is not widely reported. According to [3] the garlic cultivar Doulu is widely known by the public because it has a spicy flavor and sharp

smell.Based on the research of [3]it is stated that the garlic cultivar Doulu grows well at a height of 917-1500 m above sea level and has morphological characteristics, namely plant height 40-45 cm, green leaf color, the number of leaves 7-9 strands, The orientation of the leaf spreads, the bulb shape Flat Globe, the color of bulb is the white and purple , the diameter of the bulb ranged from 2.2 – 3.9 cm, irregular bulb structure, color of purplish white clove, and the number of cloves 6 – 18 cloves. In addition, garlic is scattered in the village of Doulu, brand, and Tongging, and Dairi regency in the villages of Situngkir and Silalahi.

In order to develop local crop potential, it is necessary to improve local varieties character. In the field of biology and plant breeding, artificial mutations are often used to increase genetic diversity in the assembly of new varieties. Mutations are a process whereby a gene changes or any type of material change that causes a phenotype change that is inherited from one to the next generation. By using mutagen or mutation-causing materials, a new diversity can be created in the effort to obtain superior varieties according to the purpose of breeding [4].

The genetic diversity in garlic can be increased through the breeding of mutations [5]. [6] reported that gamma-ray radiation in garlic produces 16 mutants on MV 2 and MV 3 ' whereas [7] gets a mutant garlic from the result of gamma beam radiation at a dose of 1-4 Gy. In Indonesia, [8] reported that gamma-ray radiation in garlic at a dose of 2-12 Gy can affect the height of the plant.

Garlic can be found in the form of herbaceous (to grow upright and can reach a height of 30-60 cm. The shape is flatter, shaped pointed at the end of the stem or the leaf petals thin but strong. The stem of garlic is a long-lasting stem (can reach 30 cm) and is composed of a thin but strong leaf. The leaves of this little bulbs later serve as small bulbs wrapping themselves[10].Garlic bulbs are similar in shape to gasing. Each bulb has 3-36 cloves [9]. Clove consists of two parts, namely two adult leaves and a vegetative shoots. One of the two strands of the leaf, the mature leaves located on the outside, serves as a cylindrical and small hollow-hole protective leaf. This protective leaf becomes thin dry, strong and serves as a protector for a leaf and vegetative shoots next to it. Another leaf is younger and is in a protective leaf, then thickened as a food supply [10]. The root of garlic is located on the stem, precisely on the base of the bulb or root shaped bulb discs. Garlic flower is a compound flower, stemmed, round shape, and produces seeds for generative purposes. Garlic flowers are often invisible at all and often flowers are not formed because they are still in the stage of Flower shoots [11].In Indonesia, the garlic clones can be grouped into 3 groups, namely Lumbu Hijau, Lumbu yellow, and white Lumbu. Green Lumbu and yellow Lumbu are suitable to be planted on high ground, while white Lumbu is more suitable in lowland. Some other local cultivars are quite potentiate, among others Sanur, Layur, Bogor, Kresek, and many more local clones that have not been evaluated [12]. The area of garlic spreading in Indonesia namely North Sumatra, West Java, Central Java, East Java, Bali, Lombok and East Nusa Tenggara.

Radiation is the beam of energy from an energy source into its environment. Radiation can interact with the material it has on the ionization process, excitation, etc. Gamma rays are electromagnetic wave radiation with very short wavelengths emitted by an unstable atomic nucleus that is radioactive. In general, the gamma rays used for radiation are the result of the decay of Cobalt-60 atomic nuclei. Cobalt-60 is a type of metal that has the same characteristics as iron/nickel [13]. Once the nucleus of the atom emits a α particle, β- (electron), β + (positron), or after an electron capture, the nucleus that is still in the state of the shot will descend to its underlying state by emitting gamma radiation. Irradiation dose is the

amount of radiation energy absorbed into the material. For each type of material required special dose to obtain the desired results. The unit used today is Gray (Gy). One Gray = 1 Joule/kg. The use of irradiation dose depends on several things, such as the microbial population (boletus or bacteria) before irradiated, microbial resistance to radiation, the environment of time-radiating and the purpose of the use of irradiated doses. In order for each ingredient to be able to receive an irradiation dose precisely, it is performed irradiation dose measurement using dosymmetry [14].

Gamma-ray radiation will cause genome mutations, chromosomal mutations (including mutation of genes) and cytoplasmic mutations and assert that ionizing radiation (Gamma-ray irradiation) will produce ions and radicals in the form of hydroxy (OH). A dose that is too low leads to reduced mutants formed while excessively high doses will turn off the material that was mutated or resulted in sterility [15]. Gamma radiation affects the genetic crop in real and produces high production so that intensively has been carried out the breeding program since 1972 with the help of techniques from the International Atomic Agency (IAEA) that is centered in Vienna. Gamma-ray radiation results in mutations of structural changes in both genes and chromosomes. The result of this mutation was the emergence of diversity. Such diversity arises not only between the energy levels absorbed by garlic, but also appears in plants with the same level of energy absorption, so it is necessary to do the best selection of individuals, then planted to produce Garlic plants are excellent production, age and resistant to biotic and abiotic conditions .

According to Bhaihaki [16], a diversity of plants can be known through the observation of crop characters. The character of the plant is generally divided into two qualitative and quantitative characters. The diversity contained in a plant is caused by the two factors of diversity, namely the diversity caused by the environment and caused by inherited or genotyping properties. If the diversity of the appearance of a plant character is mainly caused by genotyping factors, the character will be inherited by the next generation [17].The diversity of phenotype that appears to be produced by genotyping and or environmental differences. The diversity of phenotype occurring is due to the diversity of genotypes and environmental diversity. The diversity of phenotype reflects environmental diversity [18]

2. Method

The study was conducted in April – August 2018. Radiation on the bulb garlic is carried out at the Center for Safety and Meteorology Radiation Technology (PTKMR), BATAN, Jalan Lebakbulus Raya No. 49 Jakarta on 16 April 2018. Bulb planting is done at the research Hall of vegetable plants, Tongkoh village, Berastagi, North Sumatera on 20 April 2018.The tools on this research are Gamma Ray irradiators, hoe, flush tools, metered, ruler, wheelbarrow, scales, sample plastics, scissors, paper labels, pens, writing books. The material used in this research is the bulb garlic as much as 240 cloves, manure, non-organic fertilizer (TSP, Urea, and KCl), straw, soil as a planting medium. The draft used in this study is non factorial group random. The given radiation dose is: G0 = control without gamma beam radiation; G1 = dose 2 Gy; G2 = dose 4 Gy; G3 = Dose 6 Gy; G4 = Dose 8 Gy; G5 = dose 10 Gy. The parameters were observed in this research are quantitative properties namely: germination (day), plant height (cm), number of leaves (strands), diameter of bulbs (cm), heavy bulbs (cm), heavy bulbs (gr), heavy cloves (GR), the number of cloves (fruit) and diameter of cloves (cm) and Qualitative parameters are the structure and shape of the bulb using key determinations of International Plant genetic Resources Institute (IPGRI).

3. Results and discussion

The results of the research on quantitative parameters were obtained that the impact of Gamma rays is not noticeable towards the growing age and very noticeable effect on the height of the plant (cm), the number of leaves (strands), the diameter of the bulbs (cm), heavy bulbs (GR), the number of cloves Fruit), heavy clove (gr) and diameter clove (cm) garlic cultivars Doulu (Table 1).The growing age observation is done by noting the seeds that are growing every day. The highest growing age obtained at the treatment of 8 Gy radiation dose is 25.95 and the lowest growing age is in the treatment of 2 Gy. The height of the plant is observed 2 weeks after planting (WAP) and repeated every 7 days. The highest plant height obtained at 2 Gy radiation dose treatment is 51.18 cm and the lowest in the treatment 10 Gy is 3.53 cm. Number of leaves at 10 WAP is obtained at the treatment of 6 Gy radiation dose i.e. 6.95 and lowest obtained at 10 Gy treatment i.e. 2.85. Diameter of the highest bulbs obtained at the treatment of 2 Gy radiation dose is 3.43 cm and the lowest in the treatment 10 Gy is 0.36 cm.

Table 1. Analysis of the variance of quantitative parameters of garlic, Doulu, which is radiated by Gamma rays

Parameter	Degree of freedom	Mean	F count	F Table	
				0,05	0,01
Germination	5	47,56	1,98^{ns}	2,90	4,55
Plant height	5	1564,48	50,71**		
Number of leaves	5	13,89	31,29**		
Diameter of bulbs	5	7,37	74,10**		
Height of bulbs	5	356,50	42,85**		
Height of cloves	5	2,03	31,23**		
Diameter of cloves	5	0,51	61,25**		
Number of cloves	5	79,88	34,36**		

*Description : ns= not significance ** = very significance*

The highest bulb weight obtained in the control treatment is 22.64 gram and the lowest at the treatment of 10 Gy radiation dose is 0.46 gram. The highest weight of cloves obtained in the treatment of control is 1.83 gr and the lowest at a dose of radiation 10 Gy ie 0.26 gr. Diameter of the highest clove is obtained from the treatment of dose 2 Gy radiation ie 0.86 cm and the lowest obtained in the treatment 10 Gy ie 0.04 cm. The highest number of cloves obtained from the treatment of 2 Gy is 10.73 and the lowest obtained from the G5 treatment is 0.55 (Table 2).

Table 2. A quantitative Parameter of garlic Doulu cultivars

No	Treatment Dose of Radiation (Gy)	Mean of Parameters							
		germination (day)	Plant height (cm)	Number of leaves	Weight of bulbs (gr)	Diameter of bulbs(cm)	Weight of coves (gr)	Diameter of cloves (cm)	Number of cloves
1	0	18,73	48,40 cd	7,1b	22,64c	3,30b	1,83c	0,78cd	10,28b
2	2	17,7	51,18 d	6,83b	21,04c	3,43b	1,80c	0,86e	10,73b
3	4	20,35	43,91 cd	6,95bc	15,11b	3,00bc	1,53bc	0,77c	9,43b
4	6	20,5	42,83 c	6,25b	11,55b	2,98b	1,33b	0,82e	9,6bc
5	8	25,95	15,32 b	3,65ab	1,62a	0,80a	0,32a	0,22b	2,4a
6	10	25,4	3,53 a	2,85a	0,46a	0,36a	0,26a	0,04a	0,55a

Description: The rate of the rating followed by the same letter on the same column and row of each treatment is no different from the 5% level based on the LSD test

2. The structure and shape of the garlic bulb Kultivar Doulu irradiated Gamma rays

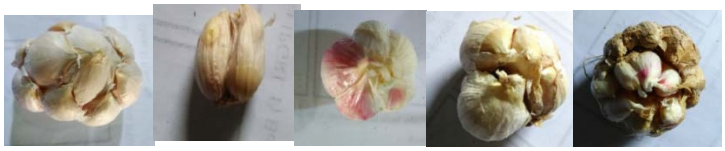
The parameters observed in this research are the structure and shape of the bulb garlic cultivar Doulu, which is irradiated by Gamma rays. The bulb structure is very diverse. The structures found are regular two-fan groups, regular quadruple, irregular, regular multi-cloved radial, regular quadruple and regular two-cloved [16]. The original bulb structure or the unirradiated treatment is irregular or irregularities (Fig. 1).The bulb structure at radiation dose treatment of 2 Gy was obtained three structures, namely regular two-fan groups (a), regular quadruple (b) and irregular (c), shown in Figure 2.

Figure 1. Bulb structure of control treatment is irregular

(a) (b) (c)

Figure 2. The bulb structure (a)regular two-fan Groups (b) regular quadruple (c) irregular

The bulb structure on the treatment of 4 Gy radiation doses is regular two-fan groups, regular two-cloved, regular multi-cloved radial, regular quadruple, and irregular shown in Figure 3.



(a) (b) (c) (d) (e)

Figure 3. (a) Regular two-fan groups (b) regular two-cloved (c) Regular multi-cloved radial (d) regular quadruple (e) irregular

The bulb structure at the treatment of radiation dose 6 Gy is regular two-fan groups, regular multi-cloved radial, regular quadruple and irregular shown in Figure 4.

(a) (b) (c) (d)

Figure 4. (a) Regular two-fan groups (b). Regular multi-cloved radial (c). Regular quadruple (d). Irregular

The bulb structure at the radiation dose of 8 Gy is regular two-fan groups, regular quadruple, and regular two-cloved shown in Figure 5. The bulb structure at the treatment of 10 Gy radiation dose is regular two-cloved, and regular two-fan groups are shown in Figure 6. The results of bulbs in garlic can be seen in the appendix. The bulb shape on the control treatment is the flat globe shown in Figure 7.

(a) (b) (c)

Figure 5. The bulb structure; (a) A flat globe (a). Regular quadruple (c) Regular two-cloved

(a) (b)

Figure 6. Structure of bulbs; (a) regular two-cloved (b) flat globe

Figure. 7. Bulb form at dose 0 Gy (Control): Flat Globe

Bulb forms on the treatment of 2 Gy radiation doses are flat globe, globe and rhomboid shown in Figure 8. The bulb shape on the treatment of 4 Gy radiation doses is the flat globe, Rhomboid, Broad oval and globe shown in Fig. 9

(a) (b) (c)

Figure 8. The bulbs shape; (a) flat globe (b) Globe (c) rhomboid.

(a) (b) (c) (d)

Figure 9. The Bulb shape ; (a) flat globe (b) rhomboid (c) Broad Oval (d) Globe

The bulb shape at the treatment of 6 Gy radiation dose is flat globe and rhomboid. Shown on Figure 10.The bulb shape at the treatment of 8 Gy radiation dose is flat globe, Broad oval, and flat shown in Figure 11.The bulbs shape on the radiation dose of 10 Gy is the globe and flat globe displayed on Figure 12

(a) (b)

Figure 10. Bulbs shape ; (a) flat globe (b)rhomboid

(a) (b) (c)

Figure 11. Bulbs shape ; (a) flat globe: (b) broad Oval and (c) flat

(a) (b)

Figure 12. The Bulbs form; (a) Globe (b) flat globe

The effect of Gamma-ray irradiation on phenotypic of garlic

Phenotypic characters observed in this study were the first generation of mutants (MV1). Gamma irradiation can cause a change in descent when fired at plants. The interaction of gamma rays with chromosomes can cause the structure of the chromosomes to break, break or switch pairs. Changes that occur can affect the nature of the plant being radiated. One function of radiation is solving the chromosomal yarn in the onion seeds and influencing the synthesis of auxin that will accelerate cell division to accelerate the seed growth process. Abnormalities until the death of an irradiated plant caused by the formation of free radicals such as H+, which is very lability ion in the reaction process due to radiation, resulting in a lot of impact in various directions that resulted in changes or mutations of either DNA, cell level, or tissue, even resulting in death in plants [1]. In this research based on the variegation test showed no influence of gamma-ray irradiation on the age of growing garlic. This is because the seeds can still retain its original properties and radiation has no stimulating influence on the seeds so it does not grow faster. The unreal effect on gamma irradiation treatment resulted from the occurrence of diplontic selection toward recovery or repair of the function of the enzyme system that is disrupted due to gamma-ray irradiation. Diplontic selection is the occurrence of a competition between the mutated cells with the normal cells around, where the end of the cells of the mutation loses competing until a certain time limit so that the plant tissue re-grows normally [19].

Based on a variegated test shows there is a very real influence of gamma-ray irradiation towards high garlic plants. Gamma-ray irradiation treatment resulted in decreased crop height as the radiation dose increased. According to [20] this is due to the disruption of the metabolism of plants that radiation can lead to the disruption of protein synthesis that plays a role in plant growth. Highest crop height gained on 2 Gy treatment compared to plant control. Excessively high dosing will inhibit cell division causing cell death, which affects the plant growth process, decreasing the growing power of plant and plant morphology. The high decline of plants or plants becomes dwarf due to the effect of high doses as a result of physiological disorders or chromosomal damage caused by mutagen (gamma-ray radiation) is given. Gamma rays are included in the pegion radiation and interact with atoms or molecules to produce free radicals (loss of one electron from its free electron pair) in the cell. These radicals can damage or modify the components is very important in plant cells and causes a partial alteration of the morphology, anatomy, biochemistry and physiology of the plant depending on the dose of its radiation [21]

The highest bulbs diameter obtained 2 Gy radiation dose. Radiation treatment resulted in declining the diameter of the bulbs along with increasing radiation dose treatment. Based on the variegated test shows there is a very real influence of gamma-ray irradiation to the weight of garlic bulbs. The highest bulb weight obtained by the control plant. Among the treatment of radiation dose 2 Gy showed the highest weight of the bulbs among other radiation dose. Gamma-ray irradiation treatment results in decreased weight of the bulb alongwith increasing doses radiation treatment radiation affects the characteristics of cloves and bulb. Gamma-ray irradiation raises physiological damages that include inhibitory growth and decreased bulb yield [22].The highest number of leaves in 10 WAP is obtained at a dose 4 Gy radiation. Based on various print tests, there is a gamma irradiation effect on the number of leaves. The higher the dose of radiation decreases the number of leaves. This is due to physiological damage caused by gamma-ray irradiation. The highest clove weight obtained plant control. Among the treatment of radiation dose 2 Gy showed the highest weight of cloves among others. Gamma radiation at the right dose can lead to mutations, both chromosomes and genes. The administration of excessively high doses will inhibit cell division, decreasing the growing power of crops and plant morphology. But the radiation dose is not too low enough to rotate the plant because the frequency of mutations that are too low only produces a few sectors that were mutated [20]

The highest diameter of the clove is obtained by 2 Gy radiation dose. According to [1] diameter large and small garlic cloves are influenced by the difference in ability and absorption of seedlings to gamma rays as well as adaptation of seedlings with the environment. For all seedlings are subjected to damage to the chromosome threads and in less than 24 hours the structure form each seedling back but unlike the initial state. 2 Gy radiation dose produces the largest average of this because the uptake and re-establishment of this dose is better compared to other dosages. The absorption of different doses causes the formation and rearrangement of the chromosomes difficult because the content is absorbed various.

The given gamma beam radiation will pass through the fruit with controlled speed and dose. And when the radiation is stopped, then there is no residual energy in the fruit. Irradiation does not cause the fruit or seeds to be radioactive or contaminated by radiation. The quality of the macronutritions (proteins, lipids, carbohydrates) is not altered by radiation and similarly to minerals also proved to remain stable. Controlled Gamma-ray radiation at doses below 1 kGy that is fired may slow down the physiological process of the fruit/seed, thereby slowing down the reduction of fruit/seed mass than without readiation. When gamma-ray radiation is given to a clove of garlic, the photon particles are derived from gamma rays with the energy that has the power to hit a molecule and catapult the electron so that the ionic pair forms (ionization). This ionization process causes the physical characteristics and functions of the cell molecules to change. DNA is involved in all metabolic and clonogenic processes of cells. Ionization of DNA will result in biologic amplification. Radiation produces highly active chemical species in foods that react with DNA. Ionizing radiation has enough energy to remove electrons from the atom to form ions or free radicals. The free electrons will mashed chemical bonds within the DNA molecule of the seed. During the irradiation process, the material will absorb radiation energy. Radiation will break down the chemical bonds of the DNA of contaminants. So that contaminant organisms are unable to repair damaged DNA, consequently the growth will be obstructed [23]Gamma-ray irradiation also gives a change in the qualitative parameters of garlic cultivar Doulu, which is in the parameters of bulb structures and bulb forms. Gene mutations can occur in two-way forms, i.e. from dominant (often-emerging properties) to recsive (properties that do not appear to be covered by

dominant properties) or vice versa. A frequent mutation is a gene mutation versus a dominant gene mutation. The dominant heterozygous gene (genotype form occurs in the individual) has a new direct mutation can be seen its change in its descendants ([24]. The resesive gene mutation is more common than the dominant gene. The mutation of this gene relates to the qualitative nature controlled by a slight gene so that breeding the mutation will be faster than the genetic character controlled by many genes [24].

References

[1] Ayu, K. C. A, Pasangka B., dan Bukit, M., (2016), Penerapan Radiasi Multigamma Untuk Pengembangan Bawang Putih Lokal Timor. 1(1).
[2] Yulipriyanto, H., (2010), *Biologi Tanah dan Strategi Pengolahannya*, Yogyakarta, Graha Ilmu.
[3] Gultom, T., (2016), Pengaruh Pemberian Kolkisin Terhadap Jumlah Kromosom Bawang Putih (*Allium sativum*) Lokal Kultivar Doulu, *Jurnal Biosans. 2(3).*
[4] Harsanti, L.,Yulidar, (2015), Pengaruh Irradiasi Sinar Gamma Terhadap Pertumbuhan Awal Tanaman Kedelai *Glycine max* (L.) Merill) Varietas Denna 1, *Prosiding Pertemuan dan Presentasi Ilmiah.*
[5] Sutarto, I., Nurrohma, Kumala, D. dan Arwin, (2004), Pengaruh Radiasi Sinar Gamma Co-60 Terhadap Pertumbuhan Tanaman Bawang Putih (Allium Sativum L) Varietas Lumbu Hijau Di Dataran Rendah. *Risalah Seminar Ilmiah Penelitian dan Pengembangan Aplikasi Isotop dan Radiasi*.
[6] Choudry, A., Dyansagar, V. R ., (1982), Morphological Mutant Of Garlic, *J. Indian Bot. Soc.* 61: 85 - 92.
[7] Marchesi. G., A. Fouchi dan Coombi,R., (1982), The Response Of Three Garlic Boitypes To Treatment with Mutagens. *Sementi Ellete*. 28: 17 -20.
[8] Sumiyarsih, S., Aliudin, (1990), Pengaruh Sinar Gamma Co-60 Terhadap Pertumbuhan dan Struktur Anatomi Daun Pada Bawang Putih, *Bull. Penel. Hort.* 19 (4) : 57-61.
[9] Husain. N. A., (2015), Studi Etnobotani dan Identifikasi Tumbuhan Berkhasiat Obat Berbasis Pengetahuan Lokal di Kabupaten Enrekang, Fakultas Pertanian. Universitas Hasanuddin Makassar.
[10] Wibowo, S., (1989), *Budidaya Bawang Putih*, Penebar Swadaya, Jakarta
[11] Syamsiah, I. S., Tajuddin, (2003), *Khasiat dan Manfaat Bawang Putih Raja Antibiotik Alami*. Agromedia, Jakarta Selatan.
[12] Rachmadi, M.,(2000), *Pengantar Pemuliaan Tanaman Membiak Vegetatif*, Universitas Padjajaran, Bandung.
[13] Sinaga, Q. (2016), Survei Penyebaran Dan Morfologi Kultivar Bawang Putih Lokal Di Sumatera Utara, Skripsi, Fmipa, Unimed, Medan.
[14] Makhziah, S., Koentjoro, Y., (2017), Pengaruh Radiasi Sinar Gamma Cobalt-60 Terhadap Sifat Morfologi dan Agronomi Ketiga Varietas Jagung (*Zea mays* L.), *Jurnal Ilmu Pertanian Indonesia (JIPI)*. 22 (1): 41 - 45.
[15] Hemon, A. F., (2009), Induksi Mutasi Dengan Iradiasi Sinar Gamma Dan Seleksi In Vitro Untuk Mendapatkan Embrio Somatik Kacang Tanah Yang Toleran Polietilena Glikol, *Jurnal Agrotropika.* 14(2): 67 – 72.
[16] Baihaki, A., (2000), *Teknik Rancangan Dan Analisis Penelitian Pemuliaan*, Universitas Padjajaran, Bandung.
[17] Rachmadi, M.,(2000), *Pengantar Pemuliaan Tanaman Membiak Vegetatif*, Universitas

Padjajaran, Bandung.
[18] Reijenders, Suwandi, dan Stallen, (1991), Pengaruh Lokasi Ketinggian Tempat Terhadap Pertumbuhan Dan Perkembangan Bawang Putih cv. Lumbu Putihdan Lumbu Kuning. Laporan Penelitian. ATA 395 Project.
[19] Ginting, J., Rahmawati, Nini, dan Mariati. 2015. Perubahan Karakter Agronomi Bawang Merah (Allium ascalonicum L.) Aksesi Simanindo Samosir Akibat Pemberian Berbagai Dosis Iradiasi Sinar Gamma, *Jurnal Online Agroekoteknologi*. 3(1) : 340 – 339.
[20] Ngurah, G. S., Gde, I. A. K., (2016), Efek Induksi Mutasi Radiasi Gamma Co-60 Pada Pertumbuhan Fisiologis Tanaman Tomat *(Lycopersicon Esculentum* L.), *Jurnal Keselamatan Radiasi dan Lingkungan*. 1(2) e-ISSN: 2502–4868.
[21] Sutarto, I., Nurrohma, Kumala, D. dan Arwin, (2004), Pengaruh Radiasi Sinar Gamma Co-60 Terhadap Pertumbuhan Tanaman Bawang Putih (Allium Sativum L) Varietas Lumbu Hijau Di Dataran Rendah. *Risalah Seminar Ilmiah Penelitian dan Pengembangan Aplikasi Isotop dan Radiasi*.
[22] Ulfa, A. B., Mariati, dan Ferry, E.T.S, (2015),Karakter Pertumbuhan Bawang Merah *(Allium ascalonicum L.)* Varietas Lokal Samosir Pada Beberapa Dosis Iradiasi Sinar Gamma, *Jurnal Online Agroteknologi.* 3(1) : 426 – 434
[23] Akrom, M., Hidayanto, E., dan Susilo, (2014), Kajian Pengaruh Radiasi Sinar Gamma Terhadap Susut Bobot Pada Buah Jambu Biji Merah Selama Masa Penyimpanan. *Jurnal Pendidikan Fisika Indonesia*. 10 : 86-91.
[24] Kusuma, A.D. dan Ita, D.(2013), Pengaruh Radiasi Gamma Terhadap Perubahan Morfologi Pertumbuhan Stek Tanaman Kembang Sepatu (*Hibiscus rosa-sinensis*), *Majalah Ilmiah Aplikasi Isotop dan Radiasi.*4(2).