Radiosensitivity and the Influence of Gamma Rays Irradiation on Local Samosir Shallots

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Abstract
Bulbs of localSamosir Shallot with the weight ranging from 1,3 to1,7 g were irradiated by several doses of gamma rays in order to investigate the radiosensitivity and the effects of irradiatons on the plants. Dry bulbs 2,5 months after harvest were exposed to gamma raysradiation ranging from 0 Gy to 20 Gy to determine their responses to radiation stress and the effective radiation dose for identification of Lethal dose 50 (LD_{50}). Percentage of shoot growth was measured on 35th days after planting. The variation in morphological and agronomic characters were also determined. The results indicated that increasing doses of gamma irradiation had significant effect on shoot growth. Increasing in gamma rays doses from 0 Gy to 11Gy had little effect on percentage of shoot growth.With the increase in radiation dosesabove 11Gy, agreat reduction in percentage of shoot growth was observed in irradiated bulbs as compared to control. The LD_{50} values of local Samosir Shallot determined from linear regression analysis (using *Curve-fit Analysis* software) based on percentage of regenerated shoot growth was 11.60 Gy. There were also siqnificantdifferenciesbetweenregenerated plants growth from irradiated bulbs and control (unirradiated).Treated bulbs produced shorther plant lenght and less leave number.
Key Words: Shallots, gamma ray irradiation, radiosensitivity, $LD_{50,}$ plant growth.

Introduction

Local Samosir shallot (*Allium ascalonicum*) grown at highland surrounding Toba Lakewhich about 930 meter above sea level, is one of the important commodity that since long time ago has been intensively cultivated by the farmers at the region. It is very popular and in great demand for having typical and pungent scent, more red shiny color, more spicy and less water content although smaller bulb size than other varietas of shallots. However, Planting area and shallot production in the area is not growing, even tends to decrease and in several districts that were used to be the centers of shallot cultivation have now converted into coffee cultivation, therefor the production is much lower than comsumpsionneed so that to fulfil the demands of shallot in North Sumatra, the government imports it from abroad and partly from Brebes.

Because of the great prospect and potential market of shallot, the cultivation in Indonesia especially in North Sumatra needs to be increased in the quantity, quality and continuity. To support the development, breeding activities are necessary to produce shallot cultivars that can adapt and yield well in lowland as well as in high land Samosir. Genetic improvement by hybridization is difficult to performed because shallot is an outcrossing and highly heterozygous crop (Eady, l995). It is propagated by seeds, bulbs or sets (small bulbs). Being a biennial species it takes more time to improve this crop by conventional methods such as hybridization, recombination and selection (Lawande*et al*., 2009). The lack of inbred lines also makes it difficult to perform genetic linkage analysis in onion (Cramer and Havey, 1999). In addition, the flowers of Samosir shallot is difficult to form seeds. Alternatively,Samosir shallot breeding can be done by using mutation induction.Mutation induction can increase the genetic diversity of plants (Van Harten, 1988). Induced mutations serve as a complementary approach in genetic improvement of crops (Mahandjiev*et al*., 2001). It can be done by using a chemical mutagen or physical mutagen. One of the most effective physical mutagens to create genetic variation in plants is by using gamma rays irradiation (Human, 2003). Gamma rays has been widely used for producing mutations in crop plants, and frequently used to create variation in gene pools of crop plants.

The effects of gamma radiation oncytological characteristics vary from species to species andamong different genotypes within the same species. Gammaradiation interferes with the process of cell division,resulting in cytological abnormalities and in a reducedfrequency of dividing cells, which is ultimately reflected inreduced seedling growth and other morphological aberrations (Amjad and Anjum, 2002).Gamma rays are known to influence plant growth and development by inducing cytological, genetical, biochemical and physiological changes in cells and tissues (Gunckeland Sparrow, 1961).

The biological effect of gamma rays is based on the interaction with atoms or molecules in the cell, particularly water, to produce free radicals (Kovacs and Keresztes, 2002). These radicals can damage or modify important components of plant cells and have been reported to affect differentially the morphology, anatomy, biochemistry and physiology of plants depending on the radiation dose (Ashraf,2003). Plants responsesto the gamma rayirradiation, besides affected by the kind of culture used, also depended on irradiation dose. Most of the researcher reported a highly correlation between irradiation dose and survival of plants. Higher doses produce very drastic effects, usually causing plant death, and relatively lower doses often result in altered growth characteristics (Amjad and Anjum, 2002).Sunarjono *et al*., (1985) reported that irradiated shallot by gamma rays with 1, 5 and 6 Gy tended to increase bulbs yield compared to control, eventhough the yield in the first generation was decreased. At dose of 1, 2, 4, and 5 Gy could stimulate flowering.Bhamburkar and Bhalla (1980) found that germination percentage, and seedling height and survival were affected, when seeds of three onion varieties were irradiated with gamma rays. They concluded that different varieties of Allium showed varying sensitivity to irradiation. In another experiment,when seeds of Phaseolus vulgaris were irradiated with 0, 4, 8, 12, 16 and 20 krad gamma rays, seed germination, plant height, survival and yield all decreased as the dose of irradiation increased, but the effects were relatively small (Carneiro*et al*., 1987).The purpose of this work is to study radiosensitivity (LD_{50}) of local Samosir shallot and to investigate the change occured caused by ionizing gamma rays radiation of different doses from Co^{60} on the first generation irradiated plants.

Materials and Methods

Sixty four (64) bulbs by doses of irradiated and non-irradiated local Samosir shallot were packaged in 0.1mm thick paper bags of 10 X 22cm dimension and sealed. The bags were subjected to gamma rays irradiation in iradiator Chamber A4000 with Cobalt-60 source at PATIR BATAN, by exposing them to doses of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 16, 17, 18, 19 and 20 Gy. Subsequently, the irradiated bulbs along with unirradiated bulbs (control) were grown in the field condition. The plants were then observed daily for a period of five (5) weeks. Percentage of shoots growth was recorded for the fifth week. Linear regression analysis by using *Curve-fit Analysis* software package was used to estimate the optimum LD_{50} doses by using percentage of shoots growth in the field conditions. The differencies between treated plants growth and the control were also analized by using t-test.

Results and Discussion

Table 1 shows percentage of shoots growthand plants length 5(five) weeksafter planting in control (uniradiated) and irradiated shallots. Shoot growth in terms of shoot emergence (at least 5 mm)was assessed each day until no further shoot growth emergence was noted. The percentage of shoots growthwas measuredas a percentage of all buds planted emergenced shootsthat furthermore was used to identify lethal dose of irradiated local Samosir shallotby gamma rays.

The results indicated that increasing doses of gamma rays irradiation had significant effect on shoot growth for the fiveweek.Shallots irradiated to a dose of 5 Gy at 5 WAP (weeks after planting) observation still grow well and 100% alive. Increasing in gamma rays doses from 5Gy to 11Gy had little effect on percentage of shoot growth. However,with the increase in radiation dosesabove 11Gy, a great reduction in percentage of shoot growth was observed in irradiated bulbs as compared to control. Shallot irradiated with dose of 14 Gy and more, some still grow for a few weeks, but at 5 weeks after planting, nothing was survived (Figure 2). Figure 1shows the performance of samosir shallotsat age 2 WAP irradiated with gamma rays dose of 1 Gyup to 11 Gyalong with the plant control.

Figure1.Profil of 2 weeks regenerated plants from iradiated bulbswith doses of 1 to 11 Gy along withunirradiated plants (left side)

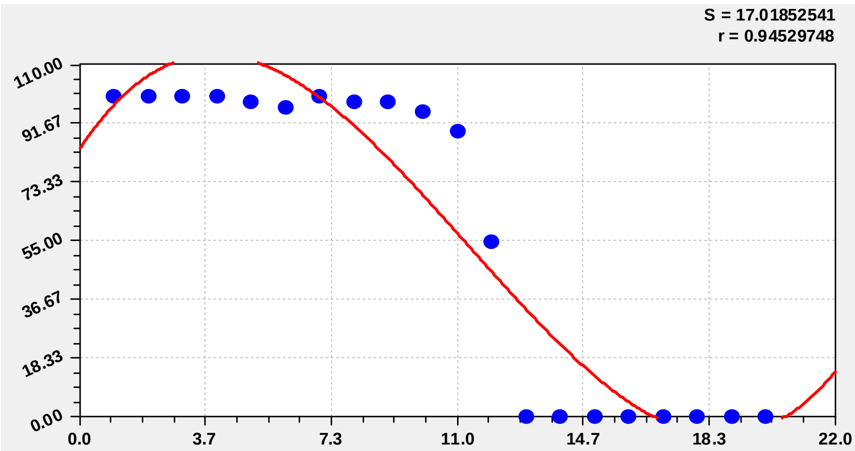
Figure 2. Profil of 5 weeks iradiated bulbs with doses of 13 to 18 Gy

The LD_{50} values of local Samosir Shallot determined from linear regression analysis (Polynomial fit using *CurveExpert*1.3*Analysis* software) based on percentage of regenerated shoot growth was 11.60

Gy. Determination of the lethal dose (LD) is one of the major factor that support the success of irradiation treatments to obtain a variant or mutant form of irradiated plants (Reni *et al.*, 2011).

Table. 1. The percentage of shoot growth andthe length of the plants 5(five) weeksafter planting

Dose of Irradiation (Gy)	**Percentage ofemergenced shoots (%)**	**The length of plants (cm)**
0 (Kontrol)	100,00	29,21±3,51
1	100,00	27,38±*3,09
2	100,00	27,99±3,27
3	100,00	26,26±**2,80
4	100,00	27,89±3,08
5	98.44	25,37±**3,33
6	96.88	22,33±**3,02
7	100,00	19,37±**3,45
8	98,44	18,73±**3,55
9	98,44	19,02±**4,31
10	95,31	11,78±**5,12
11	89,06	12,04±**5,19
12	54,69	7,25±**4,90
13	0	0
14	0	0
15	0	0
16	0	0
17	0	0
18	0	0
19	0	0
20	0	0



DosisIradiasi (Gy)

Figure 3. Grafic the effect of gamma irradiation on the percentage of growth at 5 weeks after planting

The variation in morphological and agronomic characters were also determined,the differencies between treated plants growth and the control were analized by using t-test.Gamma ray irradiation affects the growth of Samosir red shallot. The higher of doses of gamma rays, the fewer survival plants.Eventhough the shallots irradiated to a dose of up to 9Gy performed a good growth viability, but the growth of irradiated plants event at the lowest dose compared to control plants seemed depressed. This was indicated by the length and leaves number of irradiated plants that were shorter and fewer than control plants. Mean shoot length, leave number and tiller number of 6 weeks plants are presented at Table 2. The higher of doses of gamma rays the shorter shoot length, fewer leaves number and tiller number until dose of 8 Gy. However, at 9 Gy, shoot length, leaves number and tiller number of irradiated plants increased slightly.

Tabel 2. Mean shoot lenght and leave number of 6 weeks plants after planting

DOSES	Shoot lenght	Leaves Number	Tiller number
0 Gy	30,25±3,05	18,83±6,26	5,47±1,27
1 Gy	26,87** ±4,45	14,67**±4,96	4,92±*1,29
2 Gy	27,03**±3,12	14,44**±5,03	5,27±1,19
3 Gy	26,53**±3,98	14,81**±5,17	5,11±1,22
4 Gy	26,89**±4,81	15,38**±6,70	5,13±1,25
5 Gy	23,64**±4,55	13,11**±4,90	5,17±1,35
6 Gy	21,59**±4,52	12,56**±4,39	4,80±**1,19
7 Gy	20,37**±3,87	10,90**±3,73	4,59±**1,19
8 Gy	18,46**±3,95	10,26**±4,16	4,67±**1,69
9 Gy	19,81** ±4,54	11,84**±4,04	5,47±1,27

Conclusions

The research conducted revealed the sensitivity (LD50 value) of local Samosir shallot to gammaradiation based on percentage of regenerated shoot growth was 11.60 Gy. Gamma ray irradiation affects the growth of Samosir red shallot .The higher of doses of gamma rays, the fewer survival plants, the shorter shoot length, and fewer leaves number and tiller number.

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