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Perfomance of Agronomic Characters in Several Wheat Varieties Resulting from Gamma Irradiation

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ABSTRACT

Wheat is a cereal crop that can grow well in tropical areas only at high altitudes. However, the limited area of the highlands means that wheat development is directed at the lowlands, so plant breeding efforts are needed to obtain genotypes that are adaptive in the lowlands, one of which is through gamma ray irradiation. This research aims to identify the performance of agronomic characters of several wheat genotypes resulting from gamma irradiation planted in the lowlands. This study used a Randomized Block Design (RBD) with 2 factors, namely the first factor was wheat variety (Dewata/L, Basribey/I, and G-21/F) and the second factor was irradiation dose (0 Gy, 100 Gy, 200 Gy and 300 Gy). The data analyzed using F test at 5%. The treatment means were further compared and separated by using the Duncan Multiple Range Test (DMRT) at 5%. The research results showed that the wheat variety treatment had a significant effect on plant height and leaf area of wheat, while the gamma ray irradiation treatment and the combination of the two treatments had no significant effect on all parameters observed, but showed diversity in agronomic characters.

Keywords: Adaptive mutants; Lowland; Mutation induction; Wheat breeding

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is a staple food for most of the world's population. Wheat is a staple for more than a third of the world's population because wheat has high nutritional diversity, so the prospects for wheat are very large, seen from the potential for large areas of land that can be planted with plants that contain 70% carbohydrates and 3% protein (Chen et al., 2018). This non-rice cereal crop has also been identified as suitable for the agricultural climate in Indonesia(Wahyu et al., 2013). The energy source of wheat is very high, because there is a high gluten content in wheat grains. Apart from that, it also contains 1.5 to 2.0% fat, 1.5 to 2.0% minerals and a number of vitamins (Irawan et al., 2016).

National wheat needs are almost entirely met from imports, so that Indonesia is now the second largest wheat importing country with total imports of 7.1 million tons/year and this figure has increased from the previous year which was only 6.7 million tons/year. Based on data from the Food and Agriculture Organization FAO (2013) wheat imports reached 10.3 million tonnes, which of course requires quite a bit of foreign exchange. However, the reality of wheat imports in 2016 for consumption needs based on Central Statistics (BPS) data was 8.3 million tons. If the increase in wheat imports reaches 5% or 6%, total wheat imports in 2017 are estimated to reach around 8.71 million tons to 8.79 million tons.

The enormous need and increasingly limited import capabilities require immediate domestic wheat development in both the highlands and lowlands. The development of subtropical wheat in Indonesia is concentrated only in the highlands, which are also limited in area. The limited area of the highlands which are mostly planted with vegetables and other horticultural crops has greatly influenced the development of wheat in Indonesia. The height of different places will result in differences in the overall climate components of that place (Mardi et al., 2022). Therefore, the wheat breeding program in Indonesia is directed at developing superior tropical varieties that are able to adapt to various altitudes including the lowlands and until now the amount of wheat genetic material is still small (Nur et al., 2015).

The main obstacle faced in the development of wheat is environmental stress in the lowlands, especially high temperature stress (Wahyu et al., 2013). The impact of heat stress on plants is very complex, resulting in changes in growth and development, changes in physiological function, and reduced grain formation and yield (Mondal et al., 2013). Each genotype has a different ability to withstand high temperature stress. This means that genotypes that can adapt to high temperature stress are possible, and if wheat varieties are found that can adapt to the lowlands with high temperature stress characteristics, they can be developed (Puspita et al., 2016). Various plant breeding efforts must be made to increase the tolerance of wheat plants to abiotic environmental stresses such as high temperatures through genetic improvement. Improving plant adaptation to the environment can be achieved with two approaches, namely changing the growth environment and developing plant genotypes with high yields and stress tolerance(Nur et al., 2015).

Exploiting genetic diversity through mutation induction is one of the methods needed in plant breeding programs to develop plant varieties that have certain characteristic advantages. Mutation induction is one way to increase plant diversity (Asida, 2013). The aim of mutation induction is to increase the mutation frequency rate so that variants with a high level of diversity are obtained which will be selected according to the desired character (Setiawan et al., 2015). Mutation induction can be carried out using physical, chemical and biological mutagens. Gamma ray irradiation is a type of physical mutagen that is commonly used to increase genetic diversity in various plants (Suprasanna & Nakagawa, 2013). Mutations are expected to cause diversity in the traits to be selected so that superior traits can be selected selectively while good traits in the original varieties are maintained (Sari et al., 2016). Plants resulting from mutants, especially gamma ray irradiation, will be superior to the original plants, such as resistance to water stress, faster generative phase or flowering phase so that the harvest time will be shorter and other advantages. Most of the superior varieties resulting from mutation induction are produced through mutation induction with gamma rays (Wayan et al., 2019).

Based on the description above, it is necessary to carry out research aimed at identifying the performance of agronomic characters of several wheat genotypes resulting from gamma ray irradiation planted in the lowlands.

MATERIAL AND METHOD

This research was carried out at the Growth Center Land, Jalan Peratun No. 1 New Memories, Percut Sei Tuan District, Deli Serdang Regency, North Sumatra with an altitude of ± 25 meters above sea level, in August - November 2023.

The materials used in this research were wheat seeds of the Dewata/L (V1), Basribey/I (V2), and G-21/F (V3) varieties. The tools used in this research were polybags, plastic boards, wood, paranets, bamboo.

This research used a factorial Randomized Block Design (RBD) with 2 factors. The first factor is wheat variety (V), consisting of Dewata/L (V1), Basribey/I (V2), and G-21/F (V3), while the second factor is irradiation dose (R), consisting of 0 Gy (control), 100 Gy (R1), 200 Gy (R3) and 300 Gy (R4). Each treatment was repeated 3 times.

The research began with preparation of planting media which was carried out by mixing soil and compost (1: 1) then placing it in a 40 x 25 cm polybag. Next, wheat seeds are planted in polybags by making holes in the soil 3-5 cm deep. The number of seeds planted is 2 seeds/polybag. Watering is done 2 times a day in the morning and evening. Weeding is done manually by pulling out weeds that grow by hand. Pest control is carried out manually using hands and chemically using Regent 50 SC.

The parameters observed were plant height, leaf area, number of productive tillers, flowering age, and harvest age. All the recorded data for various parameters were analyzed using F test at 5%. The treatment means were further compared and separated by using the Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULT AND DISCUSSION

Plant Height

The results of the analysis of variance showed that wheat variety treatment had a significant effect on the height of wheat plants aged 10 WAP. However, the gamma ray irradiation treatment and the combination of the two treatments had no significant effect on wheat plant height. The average height of wheat plants can be seen in Table 1.

Table 1. Plant height of several wheat varieties with gamma ray irradiation in the lowlands

Variety	Irradiation dose				Mean
	0 Gy	100 Gy	200 Gy	300 Gy	
	cm				
Dewata/L	61.09	65.03	68.54	58.87	63.38 a
Basribey/i	59.73	49.40	48.97	51.73	52.46 b
G-21	59.73	64.61	62.16	66.93	63.36 a
Mean	60.18	59.68	59.89	59.17	

Note: The numbers followed by different letters Duncan's Multiple Range Test at the level of α = 5%

Based on Table 1, it can be seen that the variety treatment has a significant effect on the growth of wheat plant height, where the highest average is found in the Dewata/L variety, reaching 63.38 cm, which is not significantly different from the G-21 variety, namely 63.36 cm, but is significantly different from the Basribey/ variety. I is 56.30 cm. One of the reasons for differences in plant height is the genetic characteristics of the varieties. According to Zulaiha et al. (2012), differences in plant height between varieties are influenced by genetic structure and the growing environment, namely sunlight and water, while diversity in appearance shows that genetic factors have a real influence on adaptation, thereby influencing plant growth and yield. Apart from that, the Dewata/L variety is included in the superior wheat varieties, so it produces more optimal growth and tends to be adaptive for planting in lowlands with high temperatures. Nur et al. (2015) reported that the Dewata variety is an introduced line from India with high temperature tolerant characteristics. This proves that plants adapt to maintain optimal appearance in environments with high temperature stress.

Leaf Area

The results of the analysis of variance showed that the wheat variety treatment had a significant effect on the leaf area of wheat aged 10 WAP. However, gamma ray irradiation treatment and the combination of the two treatments had no significant effect on wheat leaf area. The average wheat leaf area can be seen in Table 2.

Table 2. Leaf area of several wheat varieties with gamma ray irradiation in the lowlands

Variety	Irradiation dose 0 Gy	100 Gy	200 Gy	300 Gy	Mean
			cm^2		
Dewata/L	25.40	24.18	30.08	31.81	27.87 a
Basribey/i	25.62	22.89	19.08	18.89	21.62 b
G-21	25.62	27.61	27.39	28.82	27.37 a
Mean	25.55	24.89	25.51	26.52	

Note: The numbers followed by different letters Duncan's Multiple Range Test at the level of α = 5%

Based on Table 2, it can be seen that the wheat variety treatment showed a real influence on the growth of wheat leaf area, where the highest average was found at Dewata/L reaching 27.87 cm2 and the lowest average was found at Basribey/I, namely 21.62 cm2. There is a real influence on the growth of wheat leaf area because the three varieties show growth characteristics that are adaptive to high temperature stress because they are planted in lowland areas. This is in line with Sari et al. (2016) that significant characters have better characteristics so that they can adapt to environments affected by high temperatures and make it possible to use them as genotypes for further planting. According to Wu (2017) Low water potential in plants causes a reduction in the size of plant parts such as stems and leaves for the accumulation of reserve food materials. In line with De Simone et al. (2014) Drought stress causes premature aging of wheat leaves. The ability of plants to remain photosynthetically active or to resist premature leaf aging is said to be a green defense mechanism in wheat.

Number of Tillers

The results of the analysis of variance showed that wheat variety treatment, gamma ray irradiation and the combination of the two treatments had no significant effect on the number of tillers. The average number of tillers can be seen in Table 3.

Table 3. Number of tillers of several wheat varieties with gamma ray irradiation in the lowlands

Variety	Irradiation dose 0 Gy	100 Gy	200 Gy	300 Gy	Mean
			tiller		
Dewata/L	5.33	8.58	7.00	10.20	7.78
Basribey/i	6.61	4.75	4.90	6.00	5.57
G-21	6.61	7.83	5.04	6.50	6.50
Mean	6.19	7.05	5.65	7.57	

Note: The numbers followed by different letters Duncan's Multiple Range Test at the level of α = 5%

Table 3 shows that the highest average number of productive tillers was in Dewata/L, namely 7.78 tillers and the lowest was in Basribey/I, namely 5.57 tillers. Meanwhile, the highest average number of productive tillers with gamma ray irradiation treatment was at an irradiation dose of 300 Gy, namely 7.57 tillers and the lowest at 200 Gy, namely 5.65 tillers. Both treatments had no significant effect on the number of productive tillers of wheat plants.

Based on Table 3, it can also be seen that neither single nor combination treatments had a significant effect on the number of tillers, but did result in different numbers of tillers. The combination of Dewata/L treatment with a gamma irradiation dose of 300 Gy produced the highest number of productive tillers, namely 10.20 tillers. It is suspected that apart from the irradiation dose, the characteristics of each type of wheat plant also have their own level of sensitivity to gamma rays. Sensitivity to radiation can be measured based on the LD (lethal dose) value, namely the dose that causes death of the irradiated plant population. The level of plant sensitivity is influenced by the type of plant, growth phase, size and material to be mutated, and varies greatly between plant types and between genotypes (Baddeley, 2013).

The number of tiller formed from genotypes that are able to adapt to the lowlands ranges from 5-7 tillers. The potential number of wheat tillers planted in the highlands for the Dewata variety can reach 8 tillers. Although the average results show no significant difference, it can be assumed that the decrease in the number of tillers could occur due to high temperature stress in the lowlands. In line with (Al-Karaki (2012) Al-Karaki that high temperature and drought stress are very important environmental factors that have an impact on the rate of growth and development of wheat. In line with Muhammad et al. (2016) in plants, depending on the time, stage, and severity of water stress, drought stress causes various morphological, physiological, biochemical, and molecular abnormalities that lead to decreased plant growth and development. According to Khan et al. (2023) the tillering, branching, flowering, anthesis, and grain filling stages are the most critical stages in responding to drought. Drought stress at these stages can cause yield losses of up to 69%.

Flowering Age and Harvest Age

The results of analysis of variance showed that wheat variety treatment, gamma ray irradiation and the combination of the two treatments had no significant effect on flowering time and wheat harvest time. The average age of flowering and harvest time of wheat can be seen in Table 4.

Table 4 shows that the longest flowering age in the wheat variety treatment was Basribey/I, namely 65.11 days and the fastest was Dewata/L, namely 62.18 days.

Table 4. Flowering age and harvest age of several wheat varieties with gamma ray irradiation in the lowlands

Treatment	Flowering Age	Harvest Age
	day	
Variety		
Dewata/L	62.18	98.58
Basribey/i	65.11	99.97
G-21	63.77	98.58
Irradiation dose		
0 Gy	64.26	99.29
100 Gy	63.51	98.90
200 Gy	62.87	98.34
300 Gy	64.10	99.64

Meanwhile, the gamma ray irradiation treatment resulted in the longest flowering age in the control treatment, namely 64.26 days and the fastest at a radiation dose of 200 Gy, namely 62.87 days. Based on the results obtained, it can be seen that the two treatments did not have a real effect on flowering time. This is because high temperature stress in the lowlands has inhibited the vernalization process which usually occurs in wheat plants. This process is a stimulus that comes from the wheat plant itself to flower, but can occur if the temperature is low. This was explained by Nasution (2018) that wheat plants require a vernalization process, namely a treatment with low temperatures to stimulate the plant to flower and produce seeds.

Table 5 also shows that the longest harvest age in the wheat variety treatment was Basribey/I, namely 99.97 days, and the fastest was Dewata/L and G-21/F, namely 98.58. Meanwhile, the gamma ray irradiation treatment which produced the longest harvest life was at a radiation dose of 300 Gy, namely 99.64 and the fastest at a radiation dose of 200 Gy, namely 98.34. Based on the results obtained, it can also be seen that the two treatments did not have a real effect on the harvest time of wheat plants. In general, there are several things that influence the harvest life of a wheat plant, namely the variation in the genotype of the wheat plant itself which then forms its respective characteristics. In accordance with Widowati et al. (2016) who stated that wheat harvest age is influenced by genotype. Apart from that, the flowering and harvest time of wheat plants is also influenced by altitude and climate. As the altitude increases, the wheat harvest period also increases. The existence of differences in climate elements from season to season or even from time to time will affect the potential wheat yield. Direct and indirect rainfall influences wheat yield. The direct influence is through the availability of water for wheat plants and the planting period, while the indirect influence is through humidity, temperature and light intensity (Tarigan et al. 2013);Tarigan et al. 2023).

Generally, the age of flowering is related to the age of harvest, so that if the age of flowering is faster, the age of harvest will also be shorter. According to Fakhrunisa et al. (2018), the difference between the age at which flowering begins and the age at which harvest begins is caused by genetic factors, namely plant age. Flowering days were significantly positively correlated with plant height and number of leaves. This indicates that the amount of vegetative growth will extend the flowering time. The positive correlation between plant height and flowering time supports the results of Unigwe et al. (2016) which also showed a positive correlation. This will affect how long each genotype takes to carry out its growth stages, resulting in differences in harvest age. The speed of harvest is also influenced by the type of variety and altitude (Iizumi & Ramankutty, 2015)

CONCLUSION

The variety treatment had a significant effect on plant height and leaf area of wheat, while the gamma ray irradiation treatment and the combination of the two treatments had no significant effect on all parameters observed, but showed diversity in agronomic characters.

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