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Study Of Various Agronomic Characters And Analysis Of Sorgum (Sorghum Bicolor (L) Moench) Nira Content Local Varieties In Suspected Mutant By Gamma Irradiation

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Abstract: Sorghum is a cereal crop that has the potential to be developed, especially on marginal land because it has high adaptability. The importance of selecting the right sorghum variety is emphasised to achieve optimal production yields in Indonesia as each variety has unique characteristics, such as plant height, resistance to pests and diseases, and tolerance to land conditions. Other characteristics to consider are sugar content, flavour, and harvest time. The sugar content in sorghum juice can be used as a substitute for sugar and syrup in food, while the brix value is an indicator of the quality of the juice. The mutation method in plant breeding is one of the steps to produce sorghum varieties that are resistant to extreme environmental conditions. This study aimed to test the nira content in sorghum plants. The research was written using two components and factorial Randomised Group Design (RGD) with three replications, namely: The first factor was sorghum varieties Local Bandung (A0), Local Demak (A1), Local Jember (A2) while the second factor was gamma irradiation dose B0 (0 Gy), B1 (300 Gy), B2 (500 Gy) with a total of 135 plants. The results showed that the provision of some sorghum varieties and doses of gamma irradiation on the parameters of plant height, plant diameter, sucrose test analysis, fructose test analysis, glucose test analysis had a real and very real effect. The interaction of several varieties of sorghum and the dose of gamma-ray irradiation had a real and very real effect on the parameters of the number of leaves, sucrose test analysis, fructose test analysis, and glucose test analysis while for other parameters it had no real effect.

Keywords: Sorghum, Gamma Irradiation, Nira.

INTRODUCTION

Sorghum is one type of cereal crop that has great potential to be developed in Indonesia because it has a wide adaptation, is drought tolerant, can produce on marginal land, and is relatively resistant to pests or diseases. The growth of sorghum in Indonesia faces significant challenges, including difficult access to quality local seeds. This situation has caused farmers to be less enthusiastic about cultivating sorghum consistently (Halil et al., 2020). Sorghum production in Indonesia is still far behind when compared to other countries in Asia or globally. One of the efforts that can be made to increase sorghum production is to use superior varieties, considering that the genetic variation of sorghum offers various advantages. Development through plant breeding programmes is needed to obtain quality sorghum seeds (Duang et al., 2023).

Research in sorghum plant breeding using gamma radiation is carried out with the aim of improving some plant characteristics to be superior to the original variety. One method to increase genetic diversity is through mutation (Sobrizal, 2017). Sorghum stem juice is also often used as a raw material for making bioethanol. The brix content of sorghum stem juice is one indicator of the quality of the juice. The higher the brix value of the juice, the sweeter the flavour. For pure sucrose solutions, the brix degree value indicates the

percentage of sucrose content in the solution, while for pure unprocessed nira, the brix value can include other solids besides sucrose (Syamsul et al., 2018).

Each type of plant has a different nira composition, generally consisting of water, sucrose, reducing sugars, other organic materials, and inorganic materials. Water is the largest component in nira, reaching about 75-90%. Sucrose content is the largest solid in the range of about 12.30-17.40%. Reduction sugar ranges from 0.50-1.00%, and the remaining components are organic and inorganic compounds (Rachmanto et al., 2019). Therefore, this article presents the results of research on the growth, development, and nira content of sorghum local varieties suspected to be mutants due to gamma irradiation..

METHOD

This research was located in the experimental field of Muhammadiyah University of Jember at Jl. Karimata 49, Sumbersari District, Jember where the research was conducted from June to December 2023. The research was written using two components and factorial Randomised Group Design (RAK) based on three replications, namely: Bandung Local sorghum variety (A0), Demak Local (A1), Jember Local (A2) while the second factor was gamma irradiation dose B0 (0 Gy) without irradiation, B1 (300 Gy), B2 (500 Gy). Observation parameters consisted of Plant Height, Number of Leaves, Stem Diameter, Leaf Area, Flowering Age, Sucrose Test Analysis, Fructose Test, and Glucose Test.

RESULTS AND DISCUSSION

Plant Height

Table 1. Duncan test results of gamma irradiation mutant local sorghum varieties on plant height at 14, 42, 56, and 70 DAP.

Sorghum Variety	Plant Height (cm)	
	14	42
A0 (Local Bandung)	33,16 a	147,09 a
A1 (Local Demak)	33,02 a	147,13 a
A2 (Local Jember)	32,69 b	146,44 b
Gamma Irradiation Dose	56	70
B0 (0 Gy)	181,56 a	214,80 b
B1 (300 Gy)	179,53 b	215,51 a
B2 (500 Gy)	178,64 b	214,64 b

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 1 shows that the treatment of sorghum varieties and the dose of gamma irradiation is significantly and very significantly different from the observation parameters of plant height at the age of 14, 42, 56, and 70 hst. At the age of 14 hst and 42 hst local varieties of Bandung (A0) and local Demak (A1) were significantly different from the treatment of local varieties of Jember (A2), with an average value of plant height at the age of 14 hst local Bandung 33.16 cm, local Demak 33.02 cm. While the age of 42 hst local Demak average 147.13 cm, local Bandung 147.09 cm.

Age 56 hst, the B0 (0 Gy) level is significantly different from B2 (500 Gy) and B1 (300 Gy), while age 70 hst, the B1 (300 Gy) level is significantly different from B0 (0 Gy) and B2 (500 Gy), with an average value of plant height at 56 hst B0 (0 Gy) 181.56 cm, while age 70 hst B1 (300 Gy) 215.51 cm.

It is suspected that A0 (Local Bandung) and A1 (Local Demak) got the highest average value due to genetic differences between the sorghum varieties. Each variety shows a unique response to the growth ability

of sorghum plants. Factors such as the availability of adequate water and nutrients for plants directly affect the way plants respond in terms of growth (Surtinah et al., 2016). The difference in the dose of gamma irradiation B0 (0 Gy) and B1 (300 Gy) gave the best results in increasing the growth of sorghum plants to the effect of the dose of irradiation used. This is in accordance with research conducted by Pangesti et al., (2023) concluded that the higher the dose of irradiation used, the less plant growth. These results indicate that irradiation treatment on plants can inhibit the activity of enzymes responsible for stimulating budding, resulting in inhibited plant growth.

Stem Diameter

Table 2. Duncan test results of gamma irradiation mutant local sorghum varieties on stem diameter at 14, 28 and 56 DAP.

Sorghum Variety	Diameter of Plant (mm)	
		56
A0 (Local Bandung)		22,82 b
A1 (Local Demak)		23,78 a
A2 (Local Jember)		23,94 a
Gamma Irradiation Dose	14	28
B0 (0 Gy)	2,68 a	12,46 a
B1 (300 Gy)	2,33 ab	12,01 b
B2 (500 Gy)	2,17 b	12,19 ab

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 2 shows that the treatment of sorghum varieties is significantly different from the observation parameter of stem diameter at the age of 14, 28 and 56 hst. At the age of 56 hst, the levels A1 (Local Demak) and A2 (Local Jember) were significantly different from A0 (Local Bandung). Local varieties of Jember and local Demak gave the highest average value with the results of level (A2) 23.94 mm and level (A1) 23.78 mm.

Age 14 hst, level B0 (0 Gy) was significantly different from level B2 (500 Gy) and not significantly different from B1 (300 Gy), while age 28 hst, level B0 (0 Gy) was significantly different from level B1 (300 Gy) and not significantly different from level B2 (500 Gy). The B0 (0 Gy) level gave the highest average value of the other treatments at the age of 14 hst of 2.68 mm, and the age of 28 hst of 12.46 mm.

It is suspected that the use of variety A2 (Local Jember) has a diverse morphological response associated with having genetic characteristics that are typical of each variety. It is in accordance with the level of soil moisture and the availability of nutrients that are sufficient for plants directly affect the way plants respond in terms of stem diameter size (Erwin et al., 2022). It is suspected that B0 (0 Gy) which is not given a dose of irradiation affects the development of plant stems, this is in accordance with the opinion of Mudibu et al. (2012) because the response of different plants when given gamma-ray irradiation with a certain dose can have a positive effect and can also have a negative effect on agronomic and morphological characters.

Sucrose Test Analysis

Table 7. Duncan test results of gamma irradiated mutant local sorghum varieties against Sucrose Test.

Sorghum Variety	Sucrose Test (µg/mL)
A0 (Local Bandung)	0,63 b
A1 (Local Demak)	0,66 a
A2 (Local Jember)	0,38 c
Gamma Irradiation Dose	
B0 (0 Gy)	0,69 a

B1 (300 Gy)	0,57 b
B2 (500 Gy)	0,40 c

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 7 shows that the treatment of sorghum varieties had a very significantly different effect on the sucrose test parameter. The level of local Demak (A1) was significantly different from local Bandung (A0) and significantly different from local Jember (A2). The local sorghum variety Demak (A1) gave the highest average value of the other treatments of 0.66 µg/mL. While the B0 (0 Gy) level is significantly different from the B1 (300 Gy) level and is significantly different from B2 (500 Gy), the B0 (0 Gy) level gives the highest average value of the other treatments of 0.69 µg/mL.

Table 8. Duncan test results of interaction of gamma irradiation mutant sorghum varieties on sucrose test.

Sorghum Variety X Gamma Irradiation Dose	Sucrose Test (µg/mL)
A0B0 (Local Bandung x 0 Gy)	0,81 a
A0B1 (Local Bandung x 300 Gy)	0,63 c
A0B2 (Local Bandung x 500 Gy)	0,45 g
A1B0 (Local Demak x 0 Gy)	0,78 b
A1B1 (Local Demak x 300 Gy)	0,59 e
A1B2 (Local Demak x 500 Gy)	0,61 d
A2B0 (Local Jember x 0 Gy)	0,49 f
A2B1 (Local Jember x 300 Gy)	0,49 f
A2B2 (Local Jember x 500 Gy)	0,15 h

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 8 shows that the interaction of the treatment of sorghum varieties and the dose of gamma irradiation was significantly different from the sucrose test parameters. At the A0B0 level (Local Bandung x 0 Gy), it was significantly different from the other treatments, giving the highest average value of 0.81 µg/mL.

It is suspected that the sucrose content in each type of sorghum is influenced by a number of factors, including plant age which also plays a role in determining the level of sweetness. Apart from the plant age factor, other things that affect the sucrose content in sorghum stems include variations in plant varieties, environmental conditions where plants are grown, and agricultural management techniques applied to the sorghum (Hasibuan et al., 2022).

Fructose Test Analysis

Table 9. Duncan test results of gamma irradiated mutant local sorghum varieties on Fructose Test.

Sorghum Variety	Fructose Test (µg/mL)
A0 (Local Bandung)	0,65 a
A1 (Local Demak)	0,65 a
A2 (Local Jember)	0,64 b
Gamma Irradiation Dose	
B0 (0 Gy)	0,56 b
B1 (300 Gy)	0,69 a
B2 (500 Gy)	0,68 a

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 9 shows that the treatment of sorghum varieties differed significantly on the fructose test parameter. At the A0 level (Local Bandung) and A1 (Local Demak) were significantly different from the A2 level (Local Jember). The local varieties of Bandung (A0) and local Demak (A1) gave the highest average value of the other treatments of 0.65 µg/mL. Meanwhile, the B1 (300 Gy) and B2 (500 Gy) levels were significantly different from the B0 (0 Gy) level. Level B1 (300 Gy) and B2 (500 Gy) gave the highest average value of the other treatments with the results (B1) of 0.69 µg/mL and (B2) of 0.68 µg/mL.

Table 10. Duncan test results of interaction of gamma irradiation mutant sorghum varieties on Fructose Test.

Sorghum Variety X Gamma Irradiation Dose	Fructose Test (µg/mL)
A0B0 (Local Bandung x 0 Gy)	0,56 g
A0B1 (Local Bandung x 300 Gy)	0,61 f
A0B2 (Local Bandung x 500 Gy)	0,77 a
A1B0 (Local Demak x 0 Gy)	0,66 e
A1B1 (Local Demak x 300 Gy)	0,76 b
A1B2 (Local Demak x 500 Gy)	0,53 h
A2B0 (Local Jember x 0 Gy)	0,47 i
A2B1 (Local Jember x 300 Gy)	0,69 d
A2B2 (Local Jember x 500 Gy)	0,75 c

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 10 shows that the interaction of sorghum varieties and the dose of gamma irradiation was significantly different for the fructose test parameter. At the A0B2 level (Local Bandung x 500 Gy) significantly different from the other treatments gave the highest average value of 0.77 µg/mL.

It is thought that the higher the level of sweetness of the plant, the better the quality. This factor also underlines that the level of softness and sweetness is the main clue to the quality of fructose, both fresh and after processing. Sugar production in plants is also affected by the amount of carbohydrates produced from the photosynthesis process (Sarjani et al., 2021).

Analysis of Glucose Test

Table 11. Duncan test results of gamma-ray irradiation mutant local sorghum varieties on Glucose Test.

Sorghum Variety	Glucose Test (µg/mL)
A0 (Local Bandung)	0,24 c
A1 (Local Demak)	0,31 a
A2 (Local Jember)	0,26 b
Gamma Irradiation Dose	
B0 (0 Gy)	0,32 a
B1 (300 Gy)	0,23 c
B2 (500 Gy)	0,27 b

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 11 shows that the treatment of sorghum varieties differed significantly on the glucose test parameter. Level A1 (Local Demak) was significantly different from level A2 (Local Jember) and significantly different from A0 (Local Bandung). The local Demak variety (A1) gave the highest average value of the other treatments of 0.31 µg/mL. While at the level of B0 (0 Gy) significantly different from B2 (500 Gy) and significantly different B1 (300 Gy). At the B0 level (0 Gy) gave the highest average value of the other treatments of 0.32 µg/mL.

Table 12. Duncan test results of interaction of gamma irradiation mutant sorghum varieties on Glucose Test.

Sorghum Variety X Gamma Irradiation Dose	Glucose Test (µg/mL)
A0B0 (Local Bandung x 0 Gy)	0,35 a
A0B1 (Local Bandung x 300 Gy)	0,17 h
A0B2 (Local Bandung x 500 Gy)	0,20 g
A1B0 (Local Demak x 0 Gy)	0,31 d
A1B1 (Local Demak x 300 Gy)	0,34 b
A1B2 (Local Demak x 500 Gy)	0,28 f
A2B0 (Local Jember x 0 Gy)	0,30 e
A2B1 (Local Jember x 300 Gy)	0,17 h
A2B2 (Local Jember x 500 Gy)	0,32 c

Notes: The numbers followed by the same letter in the same column are not significantly different in Duncan test (DMRT) at 5% level.

Table 12 shows that the interaction treatment of sorghum varieties and gamma irradiation dose differed significantly on the glucose test parameters. At the A0B0 level (Local Bandung x 0 Gy) significantly different from the other treatments gave the highest average value of 0.35 µg/mL.

It is suspected that other factors such as the type of sorghum, climatic conditions, plant age, and maintenance techniques such as fertiliser application and irrigation also affect the sugar content in sweet sorghum stems. In addition, the sugar content in plants is influenced by the adaptability of plants to the environment where they grow, which ensures that the photosynthesis process can take place optimally (Marles et al., 2019).

CONCLUSION

The response of sorghum plants resulting from the treatment of several sorghum varieties was significantly different from the observation parameters of plant height at 14 hst, stem diameter at 56 hst, very significantly different from the observation parameters of plant height at 42 hst, sucrose test analysis, fructose and glucose test. The response of sorghum plants to gamma irradiation treatment was significantly different in the observation parameters of plant height at age 56, and 70 hst, stem diameter at age 14 hst and 28 hst, sorghum juice levels in the treatment of gamma irradiation doses of 300 Gy and 500 Gy and the interaction of sorghum varieties and gamma irradiation doses had an effect on sucrose test analysis, fructose test analysis and glucose test analysis which greatly influenced the levels of juice produced.

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