International Journal of Advanced and Applied Sciences, 11(8) 2024, Pages: 127-134

Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Breeding of local white glutinous corn (*Zea mays ceratina* L.) with multigamma irradiation methods to obtain superior mutant cultivars

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ARTICLE INFO

Article history:
Received 14 April 2024
Received in revised form
1 August 2024
Accepted 4 August 2024

Keywords:
Multigamma irradiation
High-yielding varieties
Drought stress resistance
Pest and disease tolerance
White glutinous corn

ABSTRACT

This study aims to enhance local white glutinous corn through breeding with multigamma irradiation to develop high-yielding varieties that are resilient to extreme weather, drought stress, and pests. The research addresses the significant decline in white sticky corn production due to adverse conditions and a lack of superior seeds. Methods included observation, sampling, irradiation at 3000 rads for 30 minutes, and rigorous selection processes. The results showed that the newly developed corn varieties adapted well to harsh conditions and exhibited a substantial increase in production, averaging 12.16 tonnes per hectare compared to the parent variety's 7.15 tonnes per hectare, reflecting a 41.20% production increase. This method significantly outperformed conventional breeding techniques, which yielded between 2.50 and 3.21 tonnes per hectare.

1. Introduction

Corn is a valuable and strategically important crop, especially for its role as an alternative to rice, providing a significant source of carbohydrates and protein (Nurhafidah et al., 2021; Muntean et al., 2022; Hairuddin et al., 2023). It is also a key raw material for the food and animal feed industries (Rani et al., 2021; Amzeri, 2018). Corn is nutritionally important due to its rich content, including protein, carbohydrates, fiber, sugar, fat, water, and other essential nutrients such as phylic acid, iron, niacin, calcium, selenium, potassium, amino acids, and cornstarch, which is used in baking (Helilusiatiningsih et al., 2022; Sari et al., 2017). For every 100 grams of corn kernels, the nutritional content is as follows: 21.0 g of carbohydrates, 3.4 g of protein, 4.5 g of sugar, 2.4 g of fiber, 1.5 g of fat, 96.0 kcal of energy, and 73% water. It also contains 13.0 μg of Vitamin A, 0.09 mg of Vitamin B1 (Thiamine), 0.06 mg of Vitamin B2 (Riboflavin), 1.68 mg of Vitamin B3 (Niacin), 0.79 mg of Vitamin B5 (Pantothenic acid), 0.14 mg of Vitamin B6 (Pyridoxine), 23.0 μg of Vitamin B9 (Folate), 5.5 mg of Vitamin C, 0.09 mg of Vitamin E, 0.4 μg of Vitamin K, 3.0 mg of calcium, 0.45 mg of iron, 26.0 mg of magnesium, 77.0 mg of phosphorus, 218.0 mg of potassium, 1 mg of sodium, and 0.62 mg of zinc (Simanihuruk et al., 2020). Additionally, white sticky rice corn (Srikandi) contains 10.44% protein, 0.41% lysine, and 0.09% tryptophan (Edy, 2020).

Local white glutinous corn is one of the important types of food that needs to be developed because the nutritional content is very high and has many health benefits. The nutritional content in 100 g of white glutinous corn flour includes Carbohydrates=73.7 g, protein=9.2 g, fat=3.9 g, Phosphorus=256 mg, calcium=10 mg, iron=2 mg, vitamins A=30 RE, vitamin B1=0.38 mg, vitamin B2=0.04 mg, vitamin C=3.0 mg, fiber=0.40g, niacin=60.0 mg, energy=345.0 kcal, and the amylopectin content was almost 100%, whereas in ordinary corn it was only 72%. The benefits of white glutinous corn are as follows: 1) launch the digestive process, 2) improve the immune system, 3) maintain dental health, 4) maintain eye health, 5) source of energy, 6) ward off free radicals, 7) overcome anemia problems, 8) maintain healthy skin, 9) prevent thrush, 10) maintain bone health, 11) treat cholesterol, 12) increase stamina, 13) prevent diabetes, 14) treat hemorrhoids, 15) maintain heart health, 16) good for pregnant women, 17) prevent Alzheimer's, 18) source of vitamins, 19) support fetal growth, 20) maintain skin moisture, 21) tighten skin, 22) prevent wrinkles, 23) treat acne problems, 24) prevent fine lines on the skin, 25) brightens the skin, and 26) maintains blood sugar levels.

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https://doi.org/10.21833/ijaas.2024.08.014
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White glutinous corn has physical characteristics similar to other types of corn, but it is more nutritious and offers greater benefits compared to other varieties. Corn ranks second after rice in contributing to Indonesia's gross domestic product, following rice and biofuels (Tahaei et al., 2022). According to the Food and Agriculture Organization of the United Nations, in 2016, 41% of the corn in Indonesia was used for food, and 28% was used for animal feed, with the rest allocated for other purposes. The total corn demand that year reached 23.84 million tons, but domestic production was only 23.58 million tons, leaving a shortfall of 0.26 million tons. In 2008, maize productivity in Indonesia was 4.00 tons per hectare (t/ha), but by 2015, it had decreased to 3.79 t/ha. In 2012, productivity reached 4.90 t/ha, slightly dropping to 4.85 t/ha in 2013. In 2016, maize productivity rose to 5.303 t/ha but again declined to 5.227 t/ha in 2017. As a result of these fluctuations, the government has had to import corn to meet domestic demand. Farmers growing local white glutinous corn typically achieve low yields, with productivity often below 2.0 t/ha.

The low maize production in Indonesia is caused by various factors, including The availability of superior seeds that are still relatively lacking, drought stress, pest and disease attacks, inadequate and optimal cultivation techniques (Rinanti et al., 2021), planting land, crop processing and maintenance is not optimal (Sutresna et al., 2021; Khalafi et al., 2021; Jamidi et al., 2022; Swapna et al., 2020), pest and disease control are not optimal (Wahyudin and Fitriatin, 2017), irrigation system is not good, and post-harvest processing is inadequate. One of the important activities that must be carried out to increase corn production to the maximum is utilizing modern technology to obtain superior generations or varieties of seeds. One of the best ways to obtain selected high-yielding maize seeds in a relatively short time is through multigamma (nuclear) irradiation.

The background to the research is that white sticky corn production has decreased significantly due to the influence of drought, pests, and diseases and a lack of superior seeds. This study aims to improve local white glutinous corn varieties with Multigamma (Nuclear) Irradiation Techniques to obtain selected high-yielding white glutinous corn seeds that can adapt to drought stress, extreme climate change, pest and disease tolerance, and high production.

2. Materials and methods

Samples of locally developed white glutinous corn seeds were obtained from local corn farmers in Timor, East Nusa Tenggara, Indonesia. Sample irradiation was carried out by the Bioscience Laboratory of the University of Nusa Sandalwood in the Radioactive Division. The planting of local white glutinous corn produced by multigamma irradiation is centered in four provinces, namely Kupang Province of East Nusa Tenggara, Tana Toraja Province of South Sulawesi, Mamuju Province of West Sulawesi, and Palu Province of Central Sulawesi.

The research equipment includes 1) a standard multigamma irradiation source for irradiating local white glutinous corn seed samples, 2) a radiation dose counter to measure the dose used, 3) a protein content analyzer, 4) a tractor for tillage, 5) a digital scale for weighing mass per 100 corn kernels, 6) Other supporting tools such as crowbars, hoes, tractors, pest sprayers, buckets, plastic pipes, and so on.

The methods used in this study include observation, sampling, irradiation, careful selection, comparative analysis, and interpretation.

The stages of carrying out the research include: 1) Observation to collect physical and chemical characteristics of local white glutinous corn of the parent variety and selection of samples developed with multigamma irradiation, 2) Cultivating the planting area, 3) Irradiating samples of white glutinous corn seeds at a dose of 3000 rads during 30 minutes, 4) Watering the planting area, 5) Planting corn seeds by planting at a depth of (3-4) cm, spacing of 20 cm x 75 cm, placing 2 seeds per hole, 6) Observing the age and ability to grow seeds at the age of 7 days after planting (d a p) on randomly selected samples (30 seeds), 7) Embroidery, 8) weeding and fertilization with NPK and Urea at a dose of 2: 1, 9) During growth, plant conditions were observed which included: Adaptation to dry land, pest-disease tolerance, and individual plant selection. The first selection at the age of 30 d a p, the second selection at the age of 60 d a p, and the final post-harvest selection on seeds, 10) Harvesting and drying, 11) Mass weighing per 100 corn kernels, 12) Analysis of protein content (analysis service), 13) Comparing physical and chemical characteristics of superior mutant cultivars with their parents, 14) Interpretation

Several mathematical formulations for data analysis include Pasangka and Refli (2021; 2022), Pasangka and Irvandi (2021), Pasangka et al. (2022), Pasangka and Pasangka (2023), Malelak et al. (2023), and Pasangka and Wahid (2021).

Percentage of growth of local white glutinous corn seeds in the parent (control sample) and selected superior mutant cultivars (treatment sample).

Parent varieties (control sample):

$$PG_{CS} = \left(\frac{T_{AS}-A_{CS}}{T_{AS}}\right) \times 100\% \quad (1)$$

where, PG_{CS} is the percentage of growth in the control sample (%), T_{AS} is the total number of seeds planted, A_{CS} is the number of seeds that did not grow in the control sample.

Selected superior mutant cultivars (Treatment sample).

$$PG_{TS} = \left(\frac{T_{AS}-A_{TS}}{T_{AS}}\right) \times 100\% \quad (2)$$

where, PG_{TS} is the percentage of growth on treatment (%), T_{AS} is the total number of seeds planted, A_{TS} is *the* number of seeds that did not grow on the treatment sample.

The average production in the control sample at four planting locations was calculated using the equation.

$$A_{PCS} = \left(\frac{P_{L1}+P_{L2}+P_{L3}+P_{L4}}{4}\right) \tag{3}$$

where, A_{PCS} is the average production of the control sample, P_{L1}, P_{L2}, P_{L3}, and P_{L4} are the production of the control sample, and selected superior cultivars in four planting locations.

The average production of selected superior mutant cultivars in the four planting locations was calculated using the following formula:

$$A_{PTS} = \left(\frac{P_{L1}+P_{L2}+P_{L3}+P_{L4}}{4}\right) \tag{4}$$

where, A_{PTS} is the average production of selected superior mutant cultivars (t/ha).

The average percentage increase in the production of selected superior mutant cultivars was calculated by equation:

$$I_{PAP} = \left(\frac{A_{PTS}-A_{PCS}}{A_{PTS}}\right) \times 100\% \tag{5}$$

where, I_{PAP} is the percentage increase in average production (%).

3. Results and discussions

3.1. Observation, measurement, and calculation results

Based on the results of observations, measurements, and calculations on the characteristics of local white glutinous corn developed by the multigamma (nuclear) irradiation method to obtain selected high-yielding varieties that can adapt to drought stress, extreme climate change, pest-disease tolerance, and high production. The real results are presented in Figs. 1-6 and Tables 1-3 as follows. Fig. 1 shows one example of the growth of selected high-yielding local white glutinous corn from multigamma irradiation 35 d a p.

Fig. 2 shows one example of the growth of local white glutinous corn from the parent variety 35 d a p. Selected superior cultivars of local white glutinous corn fruit at 55 d a p are shown in Fig. 3. The parent variety of a local white glutinous corn fruit at the age of 65 d a p is shown in Fig. 4. Fig. 5 shows one example of local white glutinous corn cobs of selected superior cultivars after harvest (68 d a p), and Fig. 6 shows an example of local white glutinous corn cobs of parent variety after harvest (95 d a p).

Table 1 contains the Number of local white glutinous corn seeds that did not grow in the control sample and the treated samples based on.

Fig. 1: An example of the growth of selected high-yielding local white glutinous corn from multigamma irradiation at 35 d a p

Fig. 2: An example of the growth of local white glutinous corn from the parent variety at 35 d a p

Fig. 3: An example of selected superior cultivars of local white glutinous corn fruit at 55 d a p

Fig. 4: An example of a local white glutinous corn fruit from the parent variety at the age of 65 d a p

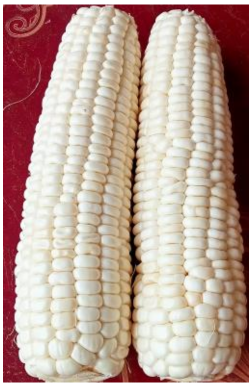

Fig. 5: An example of local white glutinous corn cobs of selected superior cultivars after harvest (68 d a p)

Fig. 6: An example of local white glutinous corn cobs of parent variety after harvest (95 d a p)

Table 1: Number of local white glutinous corn seeds that did not grow in the control sample and the treated samples based on the observed results

SG No.	The number of seeds in every group	The number of seeds that don't grow					
		Control sample	SSC1	SSC2	SSC3	SSC4	SSC5
I	30	7	2	3	3	2	3
II	30	8	3	2	4	5	3
III	30	6	1	4	1	2	4
IV	30	6	1	2	2	1	1
V	30	7	3	1	1	3	1
	Average = 30	6.8	2.00	2.40	2.20	2.60	2.40
	Total average	6.8			2.32		
	Growth percentage	77.33%	93.33%	92.00%	92.67%	91.33%	92.00%
	Total average growth percentage	77.33%			92.27%		

SG = sample group

Data on the results of observations, measurements, and calculations, which show various characteristics of both the treatment samples (multigamma irradiation) and the control samples, are in Table 2.

Table 2: The results of observations, measurements, and calculations of the physical and chemical characteristics of local white glutinous corn of the parent variety and selected superior cultivars

No.	Descriptions	Parent variety	Selected superior cultivars
1	Average growing time	8 d a p	4 d a p
2	Growth percentage	77.33%	92.27%
3	Flowering age range	(55-60) d a p	(40-50) d a p
4	Average flowering age	58 d ap	46 d a p
5	Plant height range	(155-195) cm	(135-175) cm
6	Average plant height	1776.15 cm	150.25 cm
7	Adaptation to dry land	Less adaptive	Adaptive
8	Tolerant to pest-disease	Less tolerant	Tolerant
9	Harvest age range	(90-95) d a p	(65-68) d a p
10	Average harvest age	93 d a p	66 d a p
11	Cob length range	(10.25-13.15) cm	13.75-16.55) cm
12	Average cob length	12.15 cm	15.25 cm
13	Cob diameter range	(3.20-3.55) cm	(4.56-5.25) cm
14	Average cob diameter	3.35 cm	4.68 cm
15	Cob skin layer	Layered to the tip of the cob	Layers of skin arranged towards the tip of the cob
16	Leaf number range	(13-19)	(12-18)
17	Average number of leaves	16	15
18	Mass range per 100 seeds	(55.18-62.30) g	(67.45-78.85) g
19	Average mass per 100 seeds	58.15 g	72.68 g
20	Dried seed color	White is a bit dull	Bright white
21	Protein content	10.15%	12.36%
22	Seed production range	(6.93-7.46) t/ha	(11.96-12.35) t/ha
23	Average seed production	7. t/ha	12.16 t/ha
24	Maximum seed production potential	7.46 t/ha	12.35 t/ha
25	Percentage of production increase	-	41.20%

Data on local white sticky corn production levels resulting from multigamma irradiation (treatment samples) and data on production levels of parent cultivars (control samples) are listed in Table 3.

Table 3: Production levels at the four planting locations in the control sample (parent variety) and the treatment sample (selected superior cultivars)

No.	Planting location	Parent variety (t/ha)	Selected superior varieties
1	Kupang Province of East Nusa Tenggara Timur	7.46	12.35 t/ha
2	Tana Toraja Province of South Sulawesi	6.94	11.96 t/ha
3	Mamuju Province of West Sulawesi	6.93	12.18 t/ha
4	Palu Province of Middle Sulawesi	7.25	12.16 t/ha
	Average production	7.15	12.16 t/ha
	Percentage increase in production		41.20%

3.2. Data collection for calculating seed growth percentage

To calculate the percentage of seed growth in the parent variety (control sample) and selected superior mutant cultivars (treatment sample), five groups of samples were taken randomly, with 30 seeds observed in each group. The treatment sample consisting of five groups with five variations of observations is listed in Table 1.

3.3. Statistical calculation results

The number of seeds selected at random for observation =30 seeds, the average number of seeds that did not grow in the control sample=6.8, and the average number of seeds that did not grow in the treated sample=2.32 seeds. By using Eq. 1, Eq. 2, and the data in Table 1, the percentage of seed growth in the control sample and the treatment sample can be calculated as follows.

Based on Eq. 1 and Eq. 2, the percentage of growth in the control sample and treatment sample were obtained at 77.33% and 92.27%.

By using Eq. 3, Eq. 4, and Eq. 5, the average production in the control sample and the treatment sample, as well as the percentage increase in the production of high-yielding local white glutinous corn were obtained successively at 7.15 t/h, 12.16 t/h, and 41.20%.

The target of this research is to develop local white sticky corn using the multi-gamma irradiation method, with the main hope that the production results achieved using this treatment will be relatively high. Therefore, the statistical method used is only focused on calculating the growth percentage, which is one of the main superior characteristics of mutant cultivars, calculating average production after multi-location tests, and calculating production percentages.

- Calculation process:

○ Growth percentage of control sample

$$PG_{CS} = \left(\frac{T_{AS} - A_{CS}}{T_{AS}}\right) \times 100\% = \left(\frac{30 - 6.8}{30}\right) \times 100\%$$
$$= 77.33\%$$

○ Growth percentage on treatment sample

$$PG_{TS} = \left(\frac{T_{AS} - A_{TS}}{T_{AS}}\right) \times 100\% = G_{TS}$$
$$= \left(\frac{30 - 2.32}{30}\right) \times 100\% = 92.27\%$$

○ The average production on control sample

$$A_{PCS} = \left(\frac{P_{L1} + P_{L2} + P_{L3} + P_{L4}}{4}\right)$$
$$= \left(\frac{7.46 + 6.94 + 6.93 + 7.25}{4}\right)$$
$$= 7.15t\ ha^{-1}$$

○ The average production on treatment sample

$$A_{PTS} = \left(\frac{P_{L1} + P_{L2} + P_{L3} + P_{L4}}{4}\right)$$
$$= \left(\frac{12.35 + 11.96 + 12.18 + 12.16}{4}\right)$$
$$= 12.16t\ ha^{-1}$$

○ The average percentage increase in the production of selected superior mutant cultivars

$$I_{PAP} = \left(\frac{A_{PTS} - A_{PCS}}{A_{PTS}}\right) \times 100\% = \left(\frac{12.16 - 7.15}{12.16}\right)$$
$$= 41.20\%$$

3.4. Growing time and percentage of seed germination, adaptation to extreme weather and drought stress, pests and diseases

The average growth time of local white glutinous corn seeds produced by multigamma irradiation was 4 d a p, while the parent variety had a growing time of 8 d a p with an average growth percentage of 92.27 % for selected superior mutant cultivars and 77.33% for the parent variety. Fig. 1 and Fig. 3 show two examples of local white glutinous rice growth selected high-yielding cultivars as a result of multigamma irradiation at the age of 35 d a p and 55 d a p, respectively, growing fertile, smooth leaves and large fruits. Fig. 2 and Fig. 4 show two examples of the growth of local white glutinous corn from the parent variety that grew less fertile, with slightly striped leaves and medium-sized fruit. This situation shows that local white glutinous corn cultivars selected from multigamma irradiation grow faster, have higher seed growth percentages, are more adaptive to extreme weather and drought stress, are tolerant of pests and diseases, and have higher production potential compared to the parent variety.

3.5. Flowering and harvesting age

The selected local white glutinous corn cultivars have a flowering age range (40-50) d a p with an average flowering age of 46 d a p, while the parent variety (55-60) d a p with an average flowering age of 58 da p. The harvest age of selected high-yielding local white glutinous corn ranged between (65-68) d a p with an average harvest age of 66 d a p, while the harvest age of the parent variety was (90-95) d a p with an average harvest age of 93 d a p. This case shows that local white glutinous corn of selected superior mutant cultivars as a result of multigamma irradiation have a faster flowering and harvesting age than the parent variety.

3.6. Production rate and percentage of production increase

The mass of 100 seeds from selected high-yielding local white glutinous corn ranged from 67.45 g to 78.85 g, with an average mass of 72.68 g. In comparison, the mass of 100 seeds from the parent variety ranged from 55.18 g to 62.30 g, with an average mass of 58.15 g. The production of selected superior cultivars of local white glutinous corn ranged from 11.96 t/ha to 12.35 t/ha, with an average of 12.16 t/ha, while the parent variety's production ranged from 6.93 t/ha to 7.46 t/ha, with an average of 7.15 t/ha. This represents a 41.20% increase in production. These results show that local white glutinous corn cultivars developed through multigamma irradiation have higher yields compared to the parent variety.

The use of multigamma irradiation in developing local white glutinous corn has shown significant increases in production compared to conventional methods like crossbreeding. This development process is relatively quick, involving short steps such as irradiating seed samples, planting to obtain mutant cultivars, initial purification, multilocation testing, and final purification. The resulting superior cultivars can maintain high production levels over a long period, meaning that even future generations of these cultivars will continue to produce high yields. The superior cultivars developed through irradiation have characteristics that are significantly different from the parent variety, highlighting new findings in research using this method for local white glutinous corn. In contrast, cultivars developed through conventional methods (crossbreeding) showed a decline in production in the F3 generation.

The development of local white glutinous corn using the multigamma irradiation method has produced significantly higher yields compared to conventional methods, such as crossbreeding, which typically result in yields between 2.50 t/ha and 3.21 t/ha. Although these results show some increase in production, overall yields remain relatively low, even though the plants can adapt to drought and pest conditions. Among farmers, corn seeds developed through conventional methods tend to have a short productive life, with production starting to decline by the third generation. In contrast, seeds developed through multigamma irradiation maintain high production levels over several generations. For example, Pasangka's (2010) research on local Timorese yellow corn produced superior generations that farmers cultivated until 2023. The average yield during the first cultivation of purified mutants was 55 t/ha, and by 2023, production remained relatively high, with an average yield of 46.5 t/ha. During the plant growth process, careful observations were made on both the treated and control samples. To prevent cross-pollination between the treated samples (plants exposed to multigamma irradiation) and the control samples (parent plants without irradiation), they were planted in locations far apart but under identical conditions. These conditions included the same soil type, irrigation system, planting distance, fertilizer application, lighting, and temperature. The same selection techniques were used for both groups, and all other variables were kept constant.

Throughout the growth period, adaptive traits such as resistance to drought, pests, and diseases were observed, along with the selection of plants showing strong growth. This process was applied to both the irradiated plants and the control plants.

Although several superior cultivars were produced from the multigamma irradiation, only one cultivar with the best traits was selected through strict evaluation. Other varieties showed high production but had weaknesses, such as poor pest resistance, inability to adapt to dry environments, and weak stems, causing them to fall during early flowering or long harvest times. Some varieties could only thrive in specific environmental conditions.

The selected cultivar demonstrated strong adaptability to various environmental factors, both biotic (living organisms) and abiotic (non-living conditions), bloomed relatively early, and had a short young harvest period (65-68 d a p). It also showed significant production increases, with large, long ears of corn and robust growth. During multi-location testing and purification, strict selection was conducted to ensure the superior cultivar maintained consistent genetic traits.

The observations revealed that a superior cultivar of local white glutinous corn developed through multigamma irradiation was able to adapt well to environments with limited water and pest and disease attacks, while also achieving a relatively high increase in production. In contrast, the parent cultivar showed poor adaptation to water shortages and was highly susceptible to fruit caterpillar attacks, resulting in lower production.

The superior cultivar obtained through multigamma irradiation and strict selection was able to grow in a wide range of biotic and abiotic environments. This included different soil types (such as clay, rocky, low-water, and salty soils), extreme weather conditions (unstable soil and air temperatures ranging from low to high), and resistance to pests and diseases, all while maintaining high production levels.

For example, Table 3 shows production results from four research locations (multilocation tests), which were nearly identical across sites. The highest yield was in Kupang, East Nusa Tenggara, where the production reached 12.35 t/ha despite challenging conditions, including water scarcity, limestone clay with slight salinity, and hot weather (average temperature of 32°C). In Tana Toraja, South Sulawesi, the planting site had high elevation, cold weather (average 16°C), and black clay soil. The sites in Mamuju (West Sulawesi) and Palu (Central Sulawesi) had similar conditions with sandy clay soil and an average temperature of 25°C.

Production levels across all locations were consistently high and similar, demonstrating that the multigamma-irradiated seeds can adapt to a variety of environmental conditions, both biotic and abiotic.

4. Conclusion

The selected superior mutant cultivars of local white glutinous corn, developed through multigamma (nuclear) irradiation, adapt well to extreme weather, drought, and are tolerant to pests and diseases. These cultivars show a significant increase in production compared to the parent variety. The average production of the selected superior mutant cultivars is 12.16 t/ha, while the parent variety produces 7.15 t/ha, representing a 41.20% increase in production.

List of symbols

cm	Centimeter
g	Gram
t/ha	Ton per hectare
k cal	Kilocalorie
mg	Milligram
A_{CS}	Number of seeds that did not grow on control sample
A_{PCS}	Average production of control sample
A_{PTS}	Average production of selected superior mutant cultivars
A_{TS}	Number of seeds that did not grow on treatment sample.
I_{PAP}	Percentage increase in average production
PG_{CS}	Percentage of growth on control sample
PG_{TS}	Percentage of growth on treatment
P_{L1}, P_{L2}, P_{L3}, P_{L4}	Production of control sample and selected superior cultivars in four planting locations
T_{AS}	Total number of seed planted
d a p	Days after planting
SG	Sample group

Acknowledgment

This work was supported and funded by Decentralization Research, Directorate of Research and Public Service, Department of Education and Culture of Indonesia Government and Technology Research through University of Excellence Applied Research of Nusa Cendana University with grant number: 171/UN15.19/LT/2023 (Professor's Research). Especial thanks to authorized officials who had funded this research and special thanks to all colleagues in the research who have worked well together to write this manuscript.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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