Improvement of Local Purple Corn (*zea mays*) Variety with Multigamma Irradiation (Nuclear) Techniques Yielding Superior Generation

Bartholomeus Pasangka[1](✉) and P. Irvandi Gorby[2]

[1] Department of Physical Science, Nusa Cendana University, Kupang, East Nusa Tenggara, Indonesia
bpasangka15@gmail.com, b.pasangka@staf.undana.ac.id
[2] Department of Analytical Mathematics, Nusa Cendana University, Kupang, East Nusa Tenggara, Indonesia

Abstract. This study aimed to use multigamma irradiation techniques (nuclear) to improve indigenous purple corn to produce better generation types that can withstand drought, harsh climates, pests and diseases, and high yields. Observation, sampling, irradiation, careful selection, purification, and interpretation are some research methodologies used. Observations for taking an inventory of the parent variety's physical and chemical characteristics, determining the research location, cultivating the area of planting, irradiating 3000 rads dose to the sample for 30 min, soaking the area of planting, planting seeds, irrigation, observing age and ability to grow grains, embroidery, weeding and fertilizing, keeping plant conditions during growth, harvesting, and drying. Result of research: Selected high-yielding local purple corn cultivars resulting from multigamma irradiation can withstand drought and adverse weather, are pest and disease resistant, and produce much more than the variety of parents. The average production of the selected high-yielding varieties was 11.12 t/ha, while the parent variety was 6.71 t/ha, with an increase in production percentage of 39.66%.

Keywords: development · local red peanut · multigamma irradiation · superior cultivars

1 Introduction

Purple corn (*Zea Mays Indurata* or in Spanish: *Maiz Marado*) has not been cultivated and widely developed Indonesian farmers, but has been cultivated and widely developed by farmers in the Andes mountains of South America [1–3]. Purple corn is one type of food that is very important because of its high nutritional or nutritional content such as: protein, fiber, sugar, carbohydrates, fat, water, calories [4, 5], *phyli*c acid, amino acids, potassium, calcium, selenium, niacin, iron [6, 7], corn starch flour for making cookies [8]. In addition, purple corn seeds contain anthocyanins [2] which cause a purple color in the form of *Chrysanthemin* (*Cyanidan* 3-O-Glucocide and Pelargonidin 3-OBG-Glucocide) which have many benefits, namely protecting the stomach from damage, improve eye

A. Doyan et al. (Eds.): ICSES 2022, APR 8, pp. 5–18, 2023.
https://doi.org/10.2991/978-94-6463-232-3_2

vision, inhibit tumor cells, as an anti-inflammatory compound, antioxidant, prevent obesity and diabetes, improve brain memory ability, ward off free radicals in the body, prevent atherosclerosis, inhibit atherogenesis process by bad fat *oxydyze*, prevent clogging disease blood vessels, protects the integrity of endothelial cells in the lining of the blood vessel walls from damage, relaxes blood vessels preventing atherosclerosis and other diseases of cardiovascular [9, 10]. The results of Syahbuddin's research [11] reported that purple corn of the Purple 1 Srikandi variety contained 51.92 μg/g anthocyanins and low amylose content (6.66–9.37) % so that the texture was fluffier. Another benefit of purple corn is as a raw material for the processed food industry such as ice cream, brownie cakes, boiled water into fresh drinks, and so on [12, 13].

The nutrients or nutritional content in every 100 g of corn kernels are carbohydrates = 21 g, protein = 3.4 g, fiber = 2.4 g, calories = 96 kcl, waters = 73%, sugar = 4.5 g, fat = 1.5 g, vitamin A = 13μg, Thiamine (vitamin B1) = 0.09 mg, Riboflavin (vitamin B2) = 0.06 mg, Niacin (vitamin B3) = 1.68 mg, *Panthothenic* acid (vitamin B5) = 0.79 mg, Pyridoxine (vitamin B6) = 0.14 mg, Folate (vitamin B9) = 23 g, vitamin C = 5.5 mg, vitamin E = 0.09 mg, vitamin K = 0.4 g, Calcium = 3 mg, Iron = 0.45 mg, Magnesium = 26 mg, Phosphorus = 77 mg, Potassium = 218 mg, Sodium = 1 mg, and Zinc = 0.62 mg [14]), protein content in white Srikandi corn was 10.44%, *lisin* 0.410%, and *triptofan* 0.087% [15].

Local purple corn that has started to be developed in Indonesia comes from Manado, North Sulawesi and Palu, Central Sulawesi, with a production potential of up to 7.5 t/ha if planted in the rainy season and 6.4 t/ha if planted in the dry season [16, 17]. In general, purple corn has the same physical characteristics and properties as other types of corn, although the nutrient content in purple corn is higher than that of ordinary corn [9]. Corn is the second largest carbohydrate-producing food ingredient after rice [18, 19], and is the main source of raw materials in the poultry feed industry (50–55)%), animal feed of 55% [20], a source of quality forage, a staple food ingredient in most areas in Indonesia, especially the eastern part of Indonesia, and the second largest contributor after rice to gross domestic income [21], in addition, corn is a biofuel [22]. Behind that, corn is used as a processed material for cooking oil, ethanol, organic acids, and flour [23, 24].

The need of corn for food and animal feed in Indonesia in 2016 was around 41% and 28%, the rest for other uses [25]. The total utilization of corn in 2016 was 23.84 million tons, while corn production in the same year was 23.58 million tons. This means that Indonesia is experiencing a shortage of raw materials for corn by 0.26 million tons [26]. Corn production in 2008 was 4.00 t ha^{-1}, decreased in 2015 which was only 3.79 t/ha [25]. Corn productivity in Indonesia in 2016 was 5.303 t/ha and in 2017 decreased to 5.227 t/ha, productivity in 2012 was 4.90 t/ha and in 2013 decreased to 4.85 t/ha [27]. As a consequence, the government has to import corn to meet domestic needs [28].

The low maize production in Indonesia is brought on by various variables, such as the supply of superior seeds is still lack relatively [29], drought stress, pest and disease attacks, cultivation techniques are not adequate and optimal [30, 31], planting land processing and plant maintenance is not optimal [32–36], pest and disease control is not optimal [37], the irrigation system is not good, and post-harvest processing is not adequate. 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. Breeding with multigamma (nuclear) irradiation techniques is one of the finest approaches to obtain superior generation maize seeds in a short amount of time [38, 39]. This study aims to improve local purple corn (*zea mays*) varieties using Multigamma Irradiation (Nuclear) techniques in order to produce superior generation purple corn seeds that can adapt to a lack of water (drought stress), are pest and disease tolerant, adapt to extreme climates, and produce a high harvest.

This template, modified in MS Word 2007 and saved as a "Word 97–2003 Document" for the PC, provides authors with most of the formatting specifications needed for preparing electronic versions of their papers. All standard paper components have been specified for three reasons: (1) ease of use when formatting individual papers, (2) automatic compliance to electronic requirements that facilitate the concurrent or later production of electronic products, and (3) conformity of style throughout a conference proceedings.

2 Result and Methods

2.1 Research Site

Samples of local purple corn seeds were obtained from farmers in Palu, Central Sulawesi, Indonesia, which have been cultivated for a long time, although production is relatively low. Samples of local purple corn seeds were irradiated at the Mini Nuclear Laboratory of the Physics Department, Nusa Cendana University, Kupang Indonesia. Planting locations to obtain superior generations through purification with a careful selection system individually were carried out in four locations (four provinces) namely East Penfui (Province of East Nusa Tenggara), Tinoring Tana Toraja (Province of South Sulawesi), Mamuju (Province of West Sulawesi), and Palu (Province of Central Sulawesi).

2.2 Research Instruments

The primary instruments are: 1) Multigamma irradiating sample. 2) A radiation dose counter is used to calculate the multigamma radiation dose. 3) Instrument to analyze water content; 4) Land management tractor. 5) Digital scales for weighing the bulk of per 100 seed. 6) Additional tools such as crowbars, hoes, buckets, plastic pipes, pest sprayers, shovels, saws, hammers, sickles, and so on. Irradiation, sampling, observation, cautious selection, purification, comparison, and interpretation were all used in this work.

2.3 Research Step

The research activity was carried out with the following steps: 1) observation for sampling purple corn seeds, inventorying the physical and chemical characteristics of local purple corn parent varieties, and determining the research location, 2) cultivating the planting area, 3) irradiating purple corn seed samples with dose of 3000 rads for 30 min. The multigamma source used consists of several standard radioactive elements that have been set in one kit. The energy consumed from a multigamma source is the total energy which can be adjusted using an absorber or filter and measured by a radiation detector (total energy used is 3000 rads), 4) soaking the planting area, 5) planting corn seeds with two seeds per hole by mixing at a depth of (3–4) cm, and spacing of 15 cm x 75 cm, 6) Irrigationadjusted to rainfall at the planting site, 7) Observing the age and seeds growth ability at 7 days after planting (d a p) on selected samples (control and treatment) randomly (50 seeds) at s, 8) replanting seeds that did not grow, 9) Weeding and fertilizing with NPK and Urea at doses of 2:1, 10) Observing the condition of the plant during growth which includes: tolerance to pests and diseases, adaptation to less water (dry land), and plant selection three times, the first selection when the plant was 30 days after planting, the second selection at the age of 60 days after planting (near harvest), and the final post-harvest selection on seeds, 11) Harvesting and drying, 12) Mass weighing per 100 seeds corn, 13) Protein content analysis (analysis service), 14) Comparing parent varieties and superior generations characteristics (physical and chemical), 15) Interpretation and conclusions. Complete and systematic research steps can be seen clearly in the diagram Fig. 1.

2.4 Statistical Mathematics for Data Analysis

The mathematical equations data analysis required include.

2.4.1 The Mathematical Equation Calculating Growth Percentage

The mathematical equation calculating growth percentage of purple corn seeds in the selected superior generation (treatment sample) and parent variety (control sample) is [40, 41]:

For treatment sample:

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

where: PG_{TS}: treatment growth percentage (%), T_{AS}: the total number of seeds planted, A_{TS}: not growing seeds number on treatment sample.

For control sample:

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

where: PG_{CS}: control sample growth percentage (%), A_{CS}: not growing seeds number on control sample (%).

2.4.2 The Equation to Calculate Selected Superior Generation Products

The equation to calculate selected superior generation products in the average in the four planting locations was:

$$A_{PTS} = \frac{P_{L1} + P_{L2} + P_{L3} + P_{L4}}{4} \tag{3}$$

where: A_{PTS}: the selected superior generation production average (t/ha), PL1, PL2, PL3: superior generation and control samples production in four planting locations.

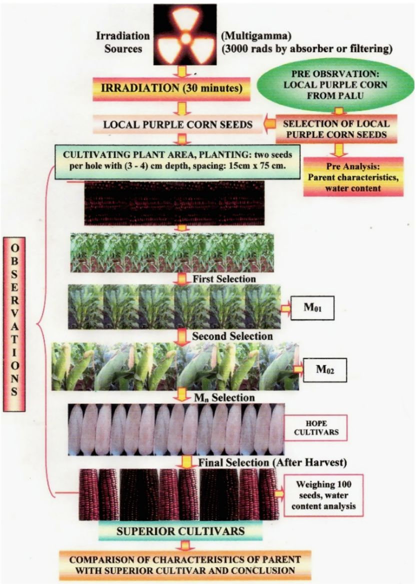

Fig. 1. Research flow diagrams (charts)

The Formula for calculating of control sample average production at the four planting sites was:

$$A_{PCS} = \frac{P_{L1} + P_{L2} + P_{L3} + P_{L4}}{4} \tag{4}$$

where: A_{PCS}: the control sample average production.

Production increasing equation in average percentage:

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

where: I_{PAP}: average production increase percentage (%).

3 Results and Discussion

3.1 Observation, Measurement, and Calculation Results

The characteristics of local purple corn that were developed through breeding with multi-gamma (nuclear) irradiation techniques yielding superior generations that has less water adaptation (dry land), extreme climate, pest and disease tolerance, and high production are shown in the results of observations, measurements, and calculations. Figures 2, 3, 4, and 5 illustrate the actual results of observation.

The fruit shape of local purple maize from superior generations as a result of multi-gamma irradiation and the parent variety can be seen clearly in Figs. 2, 3, 4, and 5.

Fig. 2. An example of local purple corn fruit new superior generation varieties from multigamma irradiation at 55 days after planting (d a p).

Fig. 3. An example of local purple corn of parent variety at 95 d a p

3.2 Data to Calculate the Percentage of Growing Seeds

The seed growth percentage in the control and treatment samples was obtained by looking at data from five (5) groups of 50 seeds each in the control and treatment samples. The treatment samples were from five (5) different groups, each with five (5) different observations, as shown in Table 1.

3.3 Tables 2 and 3 Illustrate the Actual Results of Observation, Measurement, and Calculation

The actual complete data of observation, measurement, and calculation can be shown in Tables 2 and 3.

Fig. 4. An example of local purple corn cob of selected superior generation varieties from multigamma irradiation post-harvest.

Fig. 5. An example of a corn cob of local purple post-harvest parent variety.

3.4 Statistical Calculation

Applying Eq. (1) and the data in Table 1, the estimation control and treatment samples seed growth percentage may be estimated as follows.

The not growing control sample seed average was 9.60 seeds, and the randomly selected observed seeds number was 50 seeds. The average number of seeds that did not germinate in the superior generation chosen was 2.56.

In the control sample, the growth percentage was calculated:

$$PG = \left(\frac{T_{AS} - A_{SG}}{T_{AS}}\right) \times 100\% = \left(\frac{50 - 11.2}{50}\right) \times 100\% = 77.60\%$$

Growth rate in the treatment sample as a percentage:

$$PG = \left(\frac{T_{AS} - A_{SG}}{T_{AS}}\right) \times 100\% = \left(\frac{50 - 3.24}{50}\right) \times 100\% = 93.52\%$$

Treatment samples and control production average was obtained using Eqs. (3) and (4), and the local purple corn selected superior generation production increasing percentage was calculated using Eq. (5).

Control sample average yield at the four planting sites (variety of parent):

$$A_{PCS} = \frac{P_{L1} + P_{L2} + P_{L3} + P_{L4}}{4} = \left(\frac{7.02 + 6.25 + 6.72 + 6.85}{4}\right) = 6.72\,t\,/ha$$

At the four planting sites, the average treated samples output or a selected superior generation from multigamma irradiation:

$$A_{PTS} = \frac{P_{L1} + P_{L2} + P_{L3} + P_{L4}}{4} = \left(\frac{11.27 + 10.98 + 11.13 + 11.15}{4}\right) = 11.12\,t\;\,/ha$$

Increasing percentage in superior generation multi-gamma irradiation production:

$$I_{PAP} = \left(\frac{A_{PTS} - A_{PCS}}{A_{PTS}}\right) \times 100\% = \left(\frac{11.12 - 6.71}{11.12}\right) \times 100\% = 39.66\%$$

Table 1. As a consequence of observation, not growing purple corn seeds number in the control and treatment samples.

No	**Seeds number in each group**	**Not growing seeds number**					
S		**Control sample**	**Selected superior generation**				
G			**1**	**2**	**3**	**4**	**5**
I	50	11	3	2	3	4	3
II	50	13	4	3	5	3	2
III	50	10	2	5	2	3	4
IV	50	9	3	4	2	2	3
V	50	12	5	2	3	5	4
	Average = 50	11.20	3.40	3.20	3.00	3.40	3.20
	The selected superior generation total average	11.20	3.24				
	Control and treatment samples Growth Percentage	77.60%	93.20%	93.60%	94.00%	93.20%	93.60%
	Average total of growth percentage	77.60%	93.52%				

Table 2. Important physical and chemical local purple corn parent characteristics and superior generation varieties based on observations, measurements, and calculations.

No	Description	Parent Variety	Selected Superior generation
1	Time of growth	9 days after planting (d a p)	5 days after planting (d a p)
2	Percentage of growth	77.60%	93.52%
3	Range of flowering age	(76–108) d a p	(42–50) d a p
4	Average flowering age	85 d ap	45 d a p
5	Plant height range	(164.20–2.16) cm	(150–186) cm
6	Average height of plant	178.15 cm	165.23 cm
7	Adaptation for dry land and extreme weather	Less adaptive	Adaptive
8	Tolerant of pests and diseases	Less tolerant	Tolerant
9	Range of harvest age	(130–155) d a p	(70–95) d a p
10	Average age of harvest	135 d a p	75 d a p
11	Cob range of length	(11.75–14.10) cm	13.77–16.58) cm
12	Average length of the cob	12.24 cm	15.65 cm
13	Cob diameter range	(3.28–3.62) cm	(4.52–4.85) cm
14	Average cob diameter	3.55 cm	4.76 cm
15	Cob ski layer	Layered to the tip of the cob	Layers of skin arranged towards the tip of the cob
16	Leaf number range	(12–17)	(12–16)
17	Average number of leaves	15	14
18	Mass range per 100 seeds	(56.14–65.38) g	(68.13–76.87) g
19	Average mass per 100 seeds	65.12 g	75.65 g
20	Dried seeds color	Dark purple	Light purple
21	Protein content	9.27%	11.15%
22	Seed production range	(6.25–7.02) t/ha	(10.98–11.15) t/ha
23	Average seed production	6.71 t/ha	11.12 t/ha
24	Maximum seed production potential	7.02 t/ha	11.15 t/ha
25	Production increase Percentage	–	39.66%

Table 3. Production values in the control (original variety) and treatment samples at the four planting locations (selected superior generation).

No	Planting Location	Initial Variety	Selected Superior Generation
1	East Penfui Province of East Nusa Tenggara Timur)	7.02 t/ha	11.27 t/ha
2	Tinoring Tana Toraja Province of South Sulawesi	6.25 t/ha	10.98 t/ha
3	Mamuju Province of West Sulawesi	6.72 t/ha	11.13 t/ha
4	Palu Province of Central Sulawesi	6.85 t/ha	11.15 t/ha
	Average production	6.71 t/ha	11.12 t/ha
	Percentage increase in production		39.66%

3.5 Time of Growing and Seed Growth Percentage, Adaptation to Drought Conditions, Extreme Weather, Pests and Diseases

Local purple corn seeds produced by multigamma irradiation (high-yielding varieties) had a growing time of 5 d a p, while the time of growth for the parent variety was 9 d a p with a growth percentage of 93.52% for high-yielding varieties and 77.60% for parent varieties. Figure 2 illustrates an example of the local purple maize growth produced by multigamma irradiation at of 55 d a p which was fertile with large and smooth fruit and smooth leaves. An example of the growth of local purple maize variety of parent at 95 d a p with dull leaves slightly wilted, fruit of medium size, and leaves and fruit look smooth can be seen in Fig. 3. These physical characteristics indicate that the selected superior generation of local purple corn seeds from multigamma irradiation grew faster with a higher growth percentage than the parent variety, more adaptive to dry land and extreme weather conditions than the parent variety. The data above shows that both selected superior generation varieties and parent varieties are both tolerant of pests and diseases.

3.6 Flowering and Harvesting Age

An example of a local purple corn cob of superior generation irradiated by multigamma with a size larger than that of the parent variety can be shown by Fig. 5. This shows that purple corn varieties of superior generation have higher production opportunities than the parent variety.

The range of flowering age for the selected high-yielding varieties was (42–50) d a p, while the parent variety was (76–108) d a p, with a general average flowering of 45 d a p for the selected superior generation varieties and 85 d a p for the parent variety. The range of harvesting ages for selected superior generation varieties was (70–95) d a p, while the parent variety was (130–155) d a p, with the average harvest age for selected superior generation about 75 d a p, while the parent variety was 135 d a p. This proves that local purple corn varieties of selected superior generation have a shorter flowering and harvesting age than the parent variety. In other words, selected superior generation varieties flower and harvest faster than their parent varieties.

3.7 Production Rate and Percentage of Production Increase

The mass per 100 seeds of selected superior generation varieties ranged from (68.13–76.87) g with an average mass per 100 seeds of 75.65 g, while the parent variety ranged from (56.14–65.38) g with an average mass per 100 seeds of 65.12 g. The seed production range of the selected superior generation varieties was (10.98–11.15) t/ha with an average production was 11.12 t/ha, while the production range of the parent variety was (6.25–7.02) t/ha with an average production was 6.71 t/ha. The maximum seed production potential is 11.15 t/ha for selected superior generation varieties and 7.02 t/ha for parent varieties with an increase in seed production percentage was 39.66%. This shows that the production of selected superior generation varieties is higher than the production of the parent varieties.

4 Conclusion

When compared to the parent variety, a selected superior generation of local purple corn from multigamma (nuclear) irradiation may adapt well to drought stress, extreme weather, pest and disease tolerance, and greatly enhanced yield. The superior generation varieties' average production was 11.12 t/ha, compared to 6.71 t/ha for the parent variety, representing a 39.66% increase in productivity.

Acknowledgments. The Tana Toraja Regency Regional Government supported this study, which was carried out in partnership with prominent research experts. This amount includes the manuscript's publication charge. Thank in particular to the authorized official who supported this effort, as well as the co-author who contributed to the writing of this manuscript.

Authors' Contributions. The both author and co-author was contributed in research and writing manuscript.

References

1. Agricultural Research and Development Agency, Purple *Corn. Cereal Crops Research Agency, Ministry of Agriculture*, 2021. balitsereal@litbangpertanian.go.id.
2. I. Nursa'adah, N. Basuki, and A. N. Sugiharto, Genetic Variability of Inbred Lines in S3 Generation of Purple Corn (*Zea mays var Ceratina Kulesh*). Journal of Plant Production, 5(3) (2017) 506–514.
3. M. H. Suhadi, Damanhuri, and A. N. Sugiharto, The Preliminary Yield Trials of Top crossing Inbred Maize (zea mays L) Generation S3. PLANTROPICA: Journal of Agricultural Science, 1(2) (2016) 23–30.

4. Agustiar, E. L. Panggabean, and Aswana, Growth Response and Sweet Corn Production (*Zea mays Saccarata Sturt*) Againts Giving Liquid Fertilizer Bayprint and Rice Husk. Agrotekma: Journal of Agrotechnology and Agricultural Science, 1(1) (2016) 38–48.
5. D. P. Sari, B. S. Wilman, and H. Gusmara, The Effect of Palm Oil Sludge and Dosage of NPK Fertilizer on Growth a Field of Sweet Corn (*Zea mays Saccharata*) in Ultisols. Agritrop, 15(1) (2017).
6. A. W. Dewantara, D. Ratna, and S. J. Santosa, Study of Biological Fertilizer Against Intensity of Damage to Grasshopper Pests on Black Corn Plants. Journal of Agricultural Innovation, 22(1) (2020) 29–35.
7. N. Saputri, S. Jokosantosa, and S. A. Bahri, Study of Types of Biological Fertilizers on the Intensity of Cescospora sp. Leaf Spot Disease on Black Corn Plants. Journal of Agricultural Innovation, 22(1) (2020) 50–55.
8. N. M. Rosiana, E. Harmayani, and Y. Pranoto, Change in Characteristics of Physicochemical, Hydrophobicity, and Crystallinity in Corn Starch Acetylation. Journal of Agricultural Technology, 22(2) (2021) 101–108.
9. M. Harli, Ag. Yasin, and Syamsuddin, The Effect of the Integration of Purple Corn Genotype on Two Growing Environment. Journal of Agrisystem, 13(2) (2017) 155–163.
10. https://qualityseeds.co.id, Benefits of Purple Corn. Plant Seed Development Center, 2018.
11. H. Syahbuddin, Popularize Purple Corn in Indonesia. Ministry of Agriculture Introduces Srikandi Variety. Agriculture department, 2020.
12. R. S. Hutasoit, M. Chosin, and N. Setyowati, Growth and Yield of Eight Genotypes of Sweet Corn Cultivated Organically in Lebak Swamp Land. Indonesia Journal of Agriculture Sciences: JIPI, 22(1) (2020) 45–51.
13. H. Pennita, C. Harison, Marwanto, and Rustikawati, Cross print of Growth Characters and Yield Components with Yield on 15 Genotypes of Corn Hybrids. Indonesian Journal of Agriculture Sciences: JIPI: 22(1) (2020) 1–8. https://doi.org/10.31186/jipi.22.1.1-8.
14. B. W. Simanihuruk, Y. O. Lumbantoruan, and H. Gusmara, Dosage of Palm Mud and KCl Fertilizer on Growth and Yield of Corn (*Zea mays L*) on Ultisols in Bengkulu. Indonesia Journal of Agriculture Sciences, 22(2) (2020) 85–92. https://doi.org/10.31186/jipi.22.2.85-92.
15. Edy, Characterization of F_1 and F_2 Genotypes of Corn Varieties of White Srikandi and Local Glutinous Corn in Different Planting Distance. AGROSAINS. Journal of Agronomy Research, 22(1) (2020) 32–38.
16. A. N. Sugiharto, The First Purple Corn in Indonesia, Book Chapter. Maize Research Centre. Brawijaya University Malang Indonesia (2015).
17. W. Zhiwu, C. Kai, Q. Shiyun, L. Zembin, C. Wen, X. Huaying, Z. Suxian, D. Zhaohua, Y. Musa, H. Dermawan, and K. Syahruddin, Cultivation of High Population Corn to Increase Land Productivity and Efficiency in Indonesia. Agroscience, 3(1) (2019) 15–20. https://doi.org/10.33019/agrosaintek.
18. Nurhafidah, A. Rahmat, A. Karre, and H. H. Juraeje, Germination Test of Various Types of Varieties of Corn (*Zea mays*) Using Different Methods. J. Agroplantae, 10(1) (2021) 30–39.
19. E. Kustiani, T. P. Rahardjo, and V. Laamou, Characteristics of several breeding numbers in hybrid maize (*Zea mays L*). Journal of AGRINIKA, 3(2) (2019) 47–94.
20. Amzeri, Overview of the Development of Corn Agriculture in Madura and Alternative Processing into Biomaterials. ENGINEERING SCIENTIFIC JOURNAL, 11(1) (2018) 74–86. http://journal.trunojoyo.ac.id/rekayasa.
21. A. Hudoyo and I. Nurmayasari, Increasing of the Corn Productivity in Indonesia. Department of Agribusiness, University of Lampung, Bandar Lampung Indonesia.
22. Y. Moelyohadi, Root Growth Response of Several Genotypes of Corn (*Zea mays* L) at Low Nutrient Supply Conditions with Water Culture Method. CHLOROPHIL X-1 (2015) 36–42.
23. T. Batacut, Y. R. Firdaus, and M. T. Akbar, Maize Development for Food Security, Industry and Economy. Food Journal, 4(2) (2015) 135–148.

24. A. Saputri, L. SoesantoL, E. Mugiastuti, A. Umayah, and A. Sarjito, Exploration and Virulence Test of Bacillus sp. Corn Endophytes Against Corn Sheath Rot Disease. Indonesian Journal of Agriculture Sciences, 22(2) (2020) 70–78. https://doi.org/10.31186/jipi.22.2.70-78.
25. FAO: Food and Agriculture Organization, (2018) http://faostat3.fao.org/home/E.
26. A. Hudoyo and I. Nurmayasari, Increasing of the Corn Productivity in Indonesia. Department of Agribusiness, University of Lampung. Bandar Lampung Indonesia. Book Chapter (2019).
27. R. Dialista and A. N. Sugiharto, Performance of Sweet Corn (*Zea mays L. Sachharata Sturt*) at 2 Altitude. PLANTROPICA Journal of Agricultural Science; 2(2) (2017) 155–163.
28. H. Walida, K. Anwar, and R. T. Hutasoit, Germination and Growth of Corn (*Zea mays L*) with PGPR Biofertilizer Application. Agroplasma Journal (STIPER) Labuhanbatu, 4(1) (2017) 1–7.
29. S. U. Lestari, R. P. D. Julianto, and A. Sumiati, Increasing the Independence of Farmers through Independent Corn Seed Production. Indonesian Service Access Journal, 1(2) (2017) 9–17.
30. H. Widijanto and Suntoro, Making Demonstration Plots for Corn Cultivation to Increase Planting Period on Dry Land by Utilizing Organic Fertilizer. PRIMA: Journal of Community Empowering and Services: (2019), pp: 28–32. https://jurnal.uns.ac.idprima/index.
31. T. Rinanti, N. Herlina, and A. Rifianti, Effect Population Three Varieties of Sweet Corn (*Zea mays var Saccarata*) on Growth and yield and the development Phase on the Medium Land. Plantropica: Journal of Agricultural Science, 6(1) (2121) 1–10.
32. I. W. Sutresna, I. W. Sudika, and D. R. Anugrahwati, Improving Technology for Cultivation of Free-Split Corn as an Effort to Increase Farmers' Production and Income. Proceedings of the National Seminar for the 45th Anniversary of UNS: 5(1) (2012), http://jurnal.fp.uns.ac.id/index.php/semnas.
33. A. Wahyuddin, Ruminta, and S. A. Nursarifah, Growth and Yield of Herbicide Tolerant Corn (*Zea mays L*) Due to Application of Various Dosage of Potassium Glyphosate Herbicide. Cultivation Journal: 15 (1) (2016).
34. Damanhuri, M. R. A. Asyim, I. Erdiansyah, and I. Khoir, Detasseling Application to Increase Corn (*Zea mays L*) Production. Agritrop Journal of Agricultural Sciences: (2017), pp. 108–113.
35. H. A. Karim, M. H. G. Yasin, H. Kandatong, Hasan, Hikmahwati, and Fitrianti, Productivity Test of Various Hybrid and Non-Hybrid Corn (*Zea mays L*) varieties suitable for the Agroecosystem of Polewali Mandar Regency. Agrovital: Journal of Agricultural Science: 5(1) (2020).
36. ST. Subaedah, Nirwana, and Saida, Sweet Corn Development Partnership Program with Legowo Planting System in Takalar District. Balireso Journal, 5(1) (2020) 75–85.
37. A. Wahyuddin, B. N. Fitriatin, F. Y. Wicaksono, and R. A. Rahadiyan, Response of Corn Plants (*Zea mays L*) Due to Application of Phosphate Fertilizer and Time of Application of Phosphate Solvent Microbial Fertilizer on Utisol Jatinangor. Cultivation Journal: 16(1) (2017).
38. R. P. D. Julianto, A. N. Sugiharto, and E. Santoso, Increasing the Role of Farmers in the Development of Sweet Corn (*Zea mays L. Saccharata*) Varieties through the Participatory Breeding Program. Indonesian Service Access Journal, 1(1) (2016) 34–42.
39. Uslan and N. Jannah, Genetic Diversity of Local Corn (*Zea mays*) Cultivars from South Amarasi, Kupang District, Indonesia by Inter Simple Sequence Repeats Marker. BIODIVERSITAS; 21(3) (2020) 1208–1214.
40. B. Pasangka and Refli, Development and ultivation of Local Kidney Bean (*Phaseolus Vulgaris* L) Through Breeding to Use Multigamma Irradiation Technique (Nuclear). American Journal of Agricultural and Biologycal Sciences, 11 (3) (2016) 117–127.

41. B. Pasangka and I. G. Pasangka, Continuous Development and Cultivation of Soybean as a Result of Multigamma Irradiation through Final Purifying Method, Journal of Research in Science Education.7 (2) (2021) 156–166. https://doi.org/10.29303/jppipa.v7i2.611, http://jppipa.unram.ac.id/index.php/jppipa/index