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Application of Various Organic Materials and Urea on Soybean Growth and Production in Nickel Contaminated Soil

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Abstract

The research was conducted at the Experimental Garden of Hasanuddin University (UNHAS) located in Baraya, Makassar, South Sulawesi from March to June 2022. This research was in the form of experiments conducted in soybean plant pots. The media used was soil obtained from post-nickel mining in Sorowako, East Luwu Regency, South Sulawesi. Research in the field is arranged according to a Randomized Block Design (RAK) with 3 replications. The treatment design used a 2-factor factorial design. The first factor is the type of Organic Material or Compost (K) consisting of 4 levels, namely; K0 (without organic matter), K1 (Kirinyuh compost), K2 (gamal compost) and K3 (rice husk compost) and the second factor is Urea (U) fertilization treatment consisting of 4 levels, namely; U0 (without Urea fertilizer), U1 (100 kg ha^{-1} Urea), U2 (200 kg ha^{-1} Urea), U3 (300 kg ha^{-1} Urea). The number of pots used was 4 units per treatment so there were 192 units of observation. The two factors tested resulted in 16 treatment combinations. The results showed that gamal compost (*Gliricidia sepium*) gave the best effect in increasing plant height, number of soybean leaves and weight of 100 soybean seeds. The results showed that urea dose of 100 kg ha^{-1} gave the best effect in increasing plant height and number of soybean leaves. The results showed that there was no interaction between the administration of the type of organic matter and the dose of urea

Keywords: nickel contaminated soil, organic material, soybean, urea

A. Introduction

Nickel mining activities have a significant impact on increasing the amount of heavy metals in the environment which affect the quality of land, air and water. Nickel source rock containing nickel according to international trade standards is found at a depth of 20 – 40 meters below the ground surface. The ground cover and vegetation must be excavated to reach rocks containing 3-5% nickel. The former excavation layer is piled up in the area around the mining area and will be backfilled after the mining activities are completed (Sriwahyuni, 2012).

According to Desi Nadalia (2009); that the impact of the stripping method and nickel cover rock (open pitmining) causes changes in the physical, chemical and biological properties of the soil. These changes are in the form of loss of nutrients and soil organic matter content, soil compaction, pollution, changing the composition of the soil layer, erosion and sedimentation and a decrease in the population of soil microorganisms. The loss of top soil results in plants not being able to grow normally so the soil is not productive.

To overcome these problems, it is necessary to develop a post-mining land reclamation technology, especially for agricultural purposes, namely, by providing organic matter and urea fertilizer. The use of organic matter in the soil surface layer, which was carried out by Renault, C. K., Buffa, L. M., and Delfino, M.A., (2004) showed that organic matter as a soil enhancer in post-mining land can improve plant growth, stimulate plant root growth, and increase the fresh weight of several types of plants.

In addition to organic matter, the application of urea ($CO(NH_2)_2$) fertilizer is also needed to increase plant biomass and reduce the negative impact of Ni (nickel). Because Ni plays a role in the formation of available N (NO_3^- and NH_4^+) in legumes (Eskew, D.I., Welch, R.M. dan Norvell, W.A., 1984), by applying urea to the soil, nitrogen will be more available to plants to reduce the involvement of Ni in the urease structure (Dixon, N. E., Gazzola, C., Blakeley, R. L. and Zerner, B. 1975) which is absorbed by plants which can cause plants to contain heavy metals.

The main problem that occurs is that the concentration of Ni is very high in the soil, which is not suitable for growing food crops (Duarte, B., M. Delgado, I. Ca_ador., 2007). The effects of excessive Ni poisoning on plants have been widely reported, such as growth inhibition (Molas, 2002), decreased production and fruit quality (Gajewska, E., M. Sklodowska, M. Slaba, J. Mazur, 2006). Nickel can be toxic to plants if the content is more than 1 ppm (Marschner, 2002), but some plants can still grow normally in the range of 1-10 ppm (Reeves and Baker, 2000).

On the other hand, the need for food commodities such as soybeans in Indonesia every year always increases in line with population growth and improvement in per capita income. Domestic production is not able to keep pace with national needs, for example soybean production in 2011 amounted to 851,290 tons of dry beans or decreased by 55,740 tons (6.15%) compared to 2010. Imports of soybeans in the same year reached 2.08 million tons with a value of US$1.24 billion. This import is carried out to meet the national soybean needs every year around 2.3 - 2.4 million tons (BPS, 2012). The decline in soybean production was due to an estimated decrease in harvested area of 55.560 ha (0.58%).

Soybean cultivation area is also expanded and productivity needs to be increased. Efforts to increase soybean production are limited by limited land ownership because some of the productive paddy fields have been converted into non-agricultural land. Behind the limited land resources for the expansion of agricultural areas, there is land that is quite potential to be utilized, namely land after nickel mining. Post-mining or post-mining land generally becomes marginalized and not used even though there is a reclamation area in the post-mining land rehabilitation process which is intended for revegetation and reforestation processes (Sariwahyuni, 2012).

The hypotheses of the research conducted are:

1. Organic matter from the gamal plant (*Gliricidia sepium*) can optimize the growth and production of soybean plants on nickel-contaminated media.
2. Urea dose of 100 kg ha-1 can optimize growth and production of soybean plants on nickel-contaminated media.
3. There is an interaction between the type of organic matter and the dose of urea that is given to optimize the growth and production of soybean plants on nickel contaminated media.

The objectives to be achieved from this research are:

1. Determine the type of organic matter that provides optimum growth and production of soybean plants on nickel-contaminated media.
2. Determine the dose of urea that provides optimum growth and production of nickel-contaminated media soybeans.
3. Knowing the interaction between the type of organic matter and the dose of urea that provides optimum growth and production of soybean plants on nickel-contaminated media.

Usefulness of this research; is expected to be a solution in overcoming heavy metal nickel pollution and at the same time to develop soybean plants in post-nickel mining areas, as well as recommendations from the government and nickel mining companies in South and Southeast Sulawesi in optimizing post-mining land.

B. Methology

1. Place and Time of Research

The research was conducted at the Experimental Garden of Hasanuddin University (UNHAS) located in Baraya, Makassar, South Sulawesi from March to June 2022.

2. Materials and Tools

The materials used include; Soybean seeds of Tanggamus variety, organic matter/compost (kirinyuh, gamal and rice husks), urea fertilizer, SP – 36, KCl, EM4, Rhizobium, post-nickel mining soil and labels. While the tools used in this study were pots, projection paper, ruler, envelope, sieve (2 mm), oven, scales, planting tools and watering can.

3. Research Design

This research is in the form of an experiment conducted in a pot. The media used was soil obtained from post-nickel mining in Sorowako, East Luwu Regency, South Sulawesi. Research in the field is arranged according to a Randomized Block Design (RAK) with 3 replications. The treatment design used a 2-factor factorial design.

The first factor is the type of Organic Material or Compost (K) consisting of 4 levels, namely; K0 (without organic matter), K1 (Kirinyuh compost), K2 (gamal compost) and K3 (rice husk compost) and the second factor is Urea (U) fertilization treatment consisting of 4 levels, namely; U0 (without Urea fertilizer), U1 (100 kg ha^{-1} Urea), U2 (200 kg ha^{-1}Urea), U3 (300 kg ha^{-1} Urea). The number of pots used was 4 units per treatment so there were 192 observation units. The two factors tested resulted in 16 treatment combinations (Table 1).

Table 1. Combinations of various types of organic matter and tested doses of urea fertilizer

Urea Fertilizer Dosage (U)	Types of Organic Ingredients (K) 20.000 kg ha^{-1}			
	No Organic Ingredients (K0)	Kirinyuh (K1)	Gamal (K2)	Rice Husk (K3)
0 kg ha^{-1} (U0)	K0U0	K1U0	K2U0	K3U0
100 kg ha^{-1} (U1)	K0U1	K1U1	K2U1	K3U1
200 kg ha^{-1} (U2)	K0U2	K1U2	K2U2	K3U2
300 kg ha^{-1} (U3)	K0U3	K1U3	K2U3	K3U3

4. Procedure

Soil extraction is carried out at the post-mining location by determining the location of the land extraction using the Global Position System (GPS). Soil was taken at a depth of tillage layer between 0 – 20 cm from the soil surface at several different points at random which were considered to represent the pattern of distribution of composite soil sampling points. Soil media obtained was dried and sieved (2 mm). Then the soil was filled into plastic pots as much as 10 kg pot^{-1} and mixed with compost according to treatment with a dose of each treatment, namely 100 gr pot^{-1}.

Soybean seeds of Tanggamus variety were mixed with Rhizobium (±20 g kg^{-1}) before planting and planted directly in pots as many as 3 seeds per pot. A week after planting, thinning is done and 1 plant is left. At the same time, SP-36 and KCl fertilizers were given at the same time at a dose of 100 kg ha^{-1} or 0.6 g pot^{-1}, respectively. Half the dose of urea was given when the soybean plants were 2 weeks old. Soybeans (early generative phase) were harvested after 12.

5. Data Analysis

Analysis of data measured non-destructively which is carried out every week, namely:

1. Plant height was measured from the base of the stem growing on the soil surface to the highest point of the plant.
2. Calculation of the number of leaves, which is counting all the leaves that show a slightly dark green color, because it is suspected that they are already actively carrying out photosynthesis which supports plant growth.

Variables that are measured destructively at harvest are:

1. Measurement of dry weight (BK), put into a paper bag (silkbag) and oven at a temperature of 75 - 105^{o}C for 3-4 days. Dry weight or biomass obtained by weighing each plant part that has reached stable dryness.
2. Seed weight per plant, weighing all the seeds produced in each plant.

3. The weight of 100 seeds, weighing the 100 seeds formed by each plant are needed.
4. Soybean crop production per hectare (ton ha^{-1}), obtained from the conversion of seed weight per plant. Calculated by the formula:
   Production per Ha = (Total Population x Seed Weight Per Plant (Kg))/1000
5. Determination of nickel content is carried out by separating the roots and shoots of plants (stems and leaves) to determine the ability of plants to accumulate nickel metal. Preparation for Ni analysis of plant samples was about 100 g of each plant sample washed with 3% HCl, rinsed with distilled water 2-3 times and oven for 6 hours at 105°C. The dry sample was crushed and weighed 100 mg and then dissolved in a mixture of 2 ml of concentrated HNO3 (65%). This solution was heated in an oven at 200°C for 14 hours, until all samples were completely dissolved. The extract (heating) was added with distilled water and put into a volumetric flask until it reached 50 ml. The nickel concentration of the sample solution was measured using Inductively – Coupled Plasma, Optical Emission Spectroscopy ICP-OES (Perkin Elmer Optima 2000 DV).
6. Analysis of soil Ni content by using a dry soil sample that has been pulverized as much as 0.5 grams dissolved in 10 ml of aquaregia (HCl and Nitric Acid 3: 1) in a beaker and heated to dry. The sample was given 5 ml of nitric acid and distilled water and then heated again until dissolved. After the cold solution was added aquades back up to 50 ml. The sample was centrifuged for 10 minutes at a speed of 3000 – 4000 rpm, the supernatant was taken and the heavy metal content was measured using ICP – OES Spectroscopy.
7. Soil analysis was carried out twice, namely before planting and after harvesting. Soil was taken compositely at 3 (three) points at a depth of 0 – 20 cm around the plant roots and air-dried. Soil analysis included: soil structure, bulk density, C – organic (Walkley & Black), N (Kjeldahl), P (Olsen), K, CEC (1 N NH_4OAc pH 7.0).
8. Chemical analysis of organic matter before planting was carried out in the same way as soil analysis (N, P, K and C-organic).

The data from the observation of the estimator parameters was analyzed for variance (Anova) at the 5% level to determine the effect of treatment. If there is a significant (significant) effect on the treatment, a different test is carried out using BNJ at a level of 5% (Sastrosupadi, 2000).

C. Findings and Discussion

1. Plant Height (cm) Soybean

The results showed that the application of various types of organic compost and urea on nickel contaminated soil and the interaction between the two had no significant effect on plant height at the age of 14 DAP, 28 DAP, 42 DAP, 56 DAP and 70 DAP.

Figure 1 shows that the application of compost organic matter and urea dose on nickel contaminated soil tends to increase soybean plant height without organic matter and urea. The highest average soybean plant height was obtained at the age of 14 DAP in the K2U3 treatment, which was 13.04 cm and the lowest was obtained at the K2U1 treatment, which was 10.67 cm. The highest average soybean plant height at 28 DAP treatment K2U1 was 25.42 cm and the lowest was obtained at K3U1 treatment, which was 18.08 cm. The highest average soybean plant height at 42 DAP treatment K1U1 was 52.94 cm and the lowest was obtained at K0U0 treatment, which was 42.08 cm. The highest average soybean plant height was at 56 DAP in K3U2 treatment, which was 66.56 cm and the lowest was obtained at K0U0 treatment, which was 56.67 cm.

At the end of the observation at the age of 70 DAP, the highest average soybean plant height in the K1U3 treatment was 73.17 cm and the lowest was obtained in the K3U0 treatment, which was 60.83 cm. The application of organic gamal compost (*Gliricidia sepium*) gave the best effect on soybean plant height at the beginning of vegetative growth. This is in line with the results of research by Saraswati (2005) that gamal leaves have a low C/N ratio <15 compared to other organic materials given. contains 0.8 kg Urea, 0.25 kg Phosphate, 0.6 kg Mn and 0.5 Dolomite per 50 kg Gamal leaves (Abeygunawardana, 2005). Because gamal leaves are easy to decompose and quickly provide the nutrients needed for soybeans at the beginning of growth, the application of organic matter for gamal leaves shows the height of soybean plants at the beginning of growth as shown in Figure 1.

The application of urea to soybean plants showed that a dose of 100 kg ha^{-1} showed the best average in soybean plant height compared to other urea doses. This is due to the nature of soybean plants that do not require too high a dose of urea because it can fix N from the air through the roots. The provision of 100 kg ha^{-1} urea, optimally utilized by soybeans for growth.

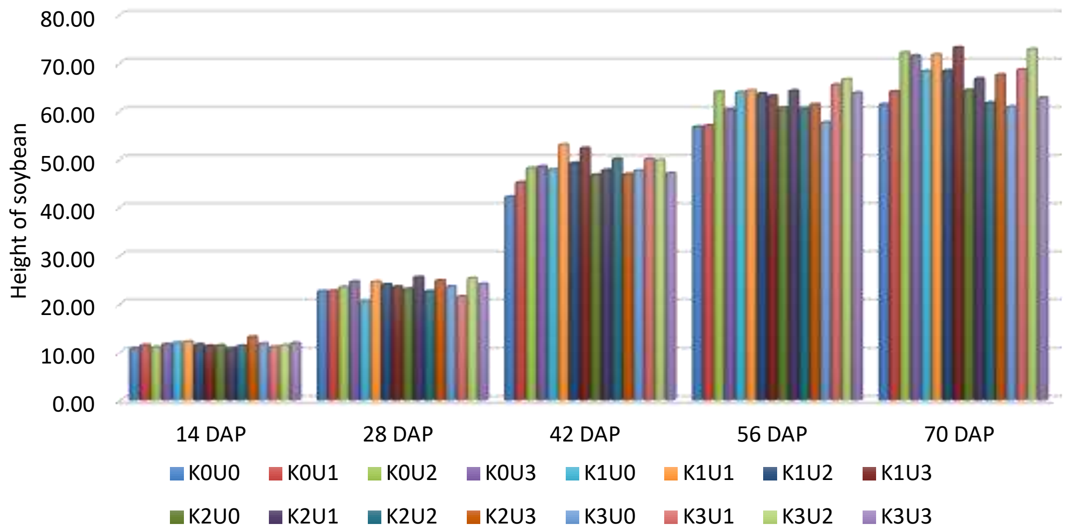

Figure 1. Average height of soybean plants aged 14 DAP, 28 DAP, 42 DAP, 56 DAP and 70 DAP with the application of various types of organic matter and urea on nickel contaminated soil

2. Number of Soybean Plant Leaves

The results showed that the application of organic compost and urea on nickel-contaminated soil had no significant effect and the interaction between the two had no significant effect on the number of leaves of soybean plants at the age of 14 DAP, 28 DAP, 42 DAP, 56 DAP and 70 DAP.

Figure 2 shows that the application of organic compost and a dose of urea on nickel contaminated soil tends to increase the number of leaves of soybean plants without organic matter and urea. The highest average number of soybean leaves was obtained at the age of 14 DAP treatment with K2U1 which was 13.75 strands and the lowest was obtained at K2U3 treatment, which was 11.25 strands. The highest average number of soybean leaves at the age of 28 DAP treatment K2U1 was 25 strands and the lowest was obtained at treatment K1U3 which was 20 strands. The highest average number of soybean leaves at the age of 42 DAP treatment K1U2 was 53.25 strands and the lowest was obtained at treatment K0U1 which was 38.25 strands. The highest average number of soybean leaves at the age of 56 DAP treatment K0U1 was 70.75 strands and the lowest was obtained at treatment K0U0 which was 45.75 strands.

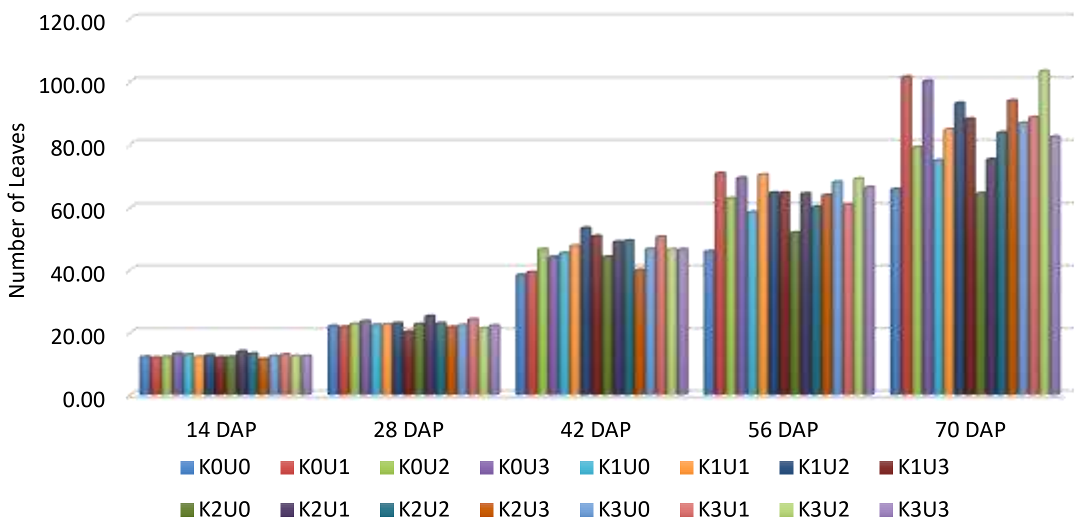

Figure 2. Average number of leaves of soybean plants at observational ages of 14 DAP, 28 DAP, 42 DAP, 56 DAP and 70 DAP with various types of organic matter and urea treated on nickel contaminated soil

At the end of the 70 DAP observation, the highest average number of leaves of soybean plants with K3U2 treatment was 103.17 strands and the lowest was obtained in K2U0 treatment, which was 64.3 strands. If seen from the increase in the number of leaves of soybean plants at the beginning of growth, the addition of organic matter from the leaves of Gamal (*Gliricidia sepium*) showed that the addition of leaves was better than other organic materials. This is because organic matter from gamal leaves contributes more N in the vegetative phase, while kirinyuh has more influence on the increase in the number of leaves in the generative phase. Meanwhile, soybean plants require more N in the vegetative phase for this growth because gamal leaves contain 3.15% N, 0.22% P, 2.65% K, 1.35% Ca and 0.41% Mg (Ibrahim, 2001).

3. Dry Weight (g) Soybean Plant

The results showed that the application of organic compost and urea on nickel-contaminated media had no significant effect on the canopy dry weight of soybeans, as well as the interaction between the two treatments had no significant effect on the canopy dry weight of soybeans.

Figure 3 shows that the application of various types of organic matter with various doses of urea on nickel contaminated soil, tends to increase the weight of seeds per soybean plant than without the application of organic matter and urea. The highest average seed weight per soybean plant when given a dose of 300 kg ha^{-1} (U3) of urea was obtained from plants that were given gamal organic matter (K2), which was 5.95 g. The lowest average seed weight per soybean plant was obtained from plants that were given organic gamal also with a dose of urea 200 kg ha^{-1} (U2), which was 5.17 g.

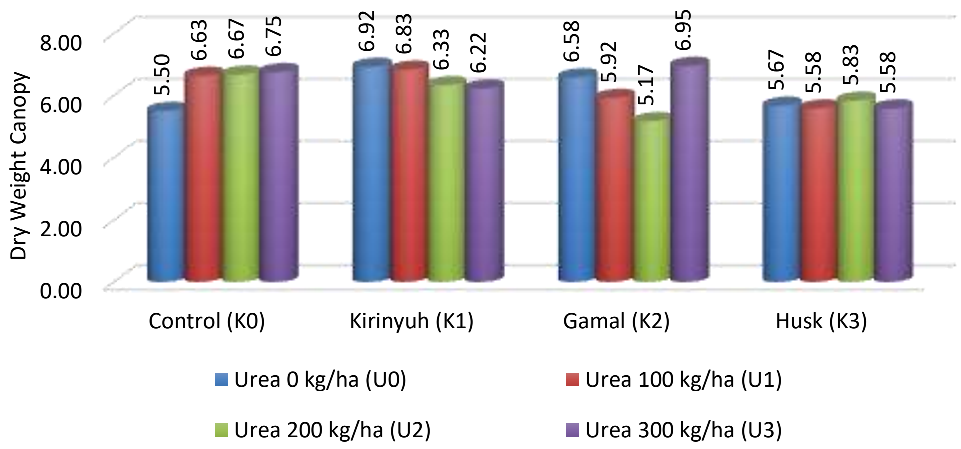

Figure 3. Average dry weight of soybean canopy with various types of organic matter and urea in nickel contaminated soil

The results showed that the application of various types of organic matter and urea to nickel contaminated soil had a significant effect on the dry weight of soybean roots, while the interaction between the two treatments did not significantly affect the dry weight of soybean roots.

Table 2. Average dry weight gram (g) of soybean roots on various types of organic matter and urea dosage

Treatment	Control (K0)	Kirinyuh (K1)	Gamal (K2)	Husk (K3)	Average	NP BNJ 0.05
Urea 0 kg ha^{-1}	7.80	10.70	7.70	6.30	8.13^{a}	
Urea 100 kg ha^{-1}	9.35	12.40	11.90	11.93	11.40^{b}	
Urea 200 kg ha^{-1}	11.75	14.90	11.80	14.00	13.11^{b}	2.58
Urea 300 kg ha^{-1}	10.88	11.77	9.45	7.00	9.78^{ab}	
Average	9.95^{a}	12.44^{b}	10.21^{ab}	9.81^{a}	-	
NP BNJ 0.05			2.58			

Note: The average value followed by the same letter means that it is not significantly different in the BNJ test at a level of 0.05

The results of the BNJ 0.05 test (Table 2) showed that the highest average dry weight of soybean roots was obtained with the application of kirinyuh organic matter (K1), which was 12.44 g and was not significantly different from the application of gamal compost organic matter (K2), which was 10. 21 g, but significantly different in the treatment without the addition of organic matter (K0) which was 9.95 g and organic matter of rice husk compost (K3) 9.81 grams.

Based on the results from table 2, the provision of organic matter from kirinyuh shows that the dry weight of soybean roots is heavier, this is because the C/N ratio of kirinyuh is 0.55 higher than gamal 0.39 and rice husks 0.44 based on the results of chemical analysis of organic matter obtained. given. So that the supply of nutrients utilized by soybeans only reaches the roots and increases the dry weight of soybean roots.

The results of the BNJ test at the 0.05 level (Table 2) also showed that the highest average dry weight of the roots was obtained at various doses of urea 200 kg ha^{-1} (U2), which was 13.11 g, not significantly different from the urea dose treatment. 100 kg ha^{-1} (U1) was 12.33 g and the dose of urea 300 kg ha^{-1} (U3) was 11.74 g, but significantly different in the treatment without urea (U0) which was 8.13 g. Seen from table 2, the results of the BNJ test show that without urea fertilizer the root weight of soybean plants was the lowest, which means that there was an effect of urea application on root dry weight.

4.Seed Weight per Plant

The results showed that the application of organic compost and urea to nickel-contaminated soil and the interaction between the two treatments did not significantly affect seed weight per plant.

Figure 4 shows that the application of organic matter with various doses of urea tends to increase seed weight per soybean plant compared to without the application of organic matter and urea. The highest average seed weight per soybean plant at a dose of 300 kg ha^{-1} (U3) of urea was obtained in plants that were given kirinyuh compost (K1), which was 21 g. The lowest average seed weight per soybean plant was obtained in plants that were given rice husk compost and a dose of urea 300 kg ha^{-1} (K3U3), which was 14.2 g.

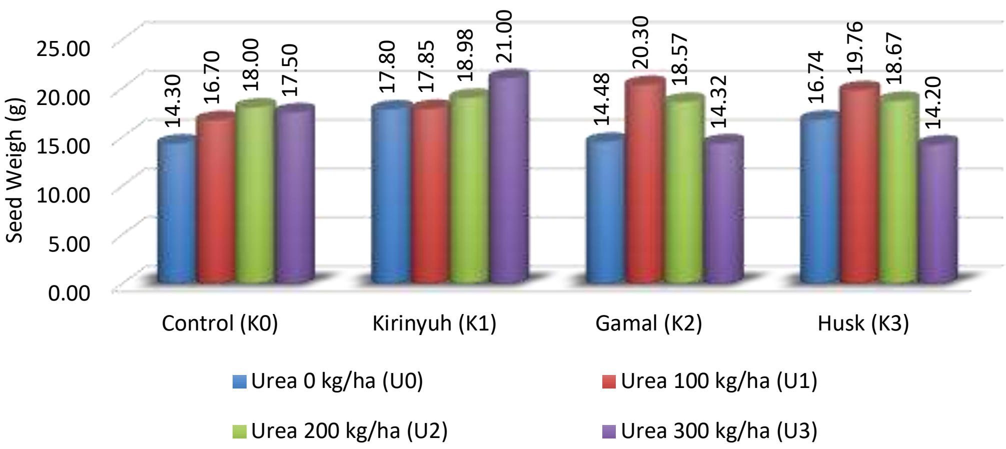

Figure 4. Average seed weight per plant with various types of organic matter and urea in nickel contaminated soil

Judging from the results of soil chemical analysis before planting on nickel-contaminated soil, it was 10.74 ppm, an increase with the addition of kirinyuh organic matter increased to 16% - 28.33% P in the soil (*Test results at the Laboratory of Soil and Environmental Conservation, Faculty of Agriculture, Muslim University of Indonesia*), Soybean which is a plant requires more phosphorus (P) for the formation of its seeds than other legumes showing a heavier seed weight.

5. Weight of 100 Soybean Plant Seeds

The results showed that the application of organic compost and urea on nickel contaminated soil and the interaction between the two treatments did not significantly affect the weight of 100 soybean seeds.

Figure 5 shows that the application of organic matter and urea to nickel-contaminated soil tends to increase the weight of 100 soybean seeds compared to no application of organic matter and urea. The average weight of the highest 100 soybean seeds without urea (U0) was obtained from plants that were given gamal compost (K2), which was 11.73 g. The lowest average weight of 100 soybean seeds was obtained from plants without compost (K0) with a dose of urea 100 kg ha^{-1} (U1) which was 9.03 g.

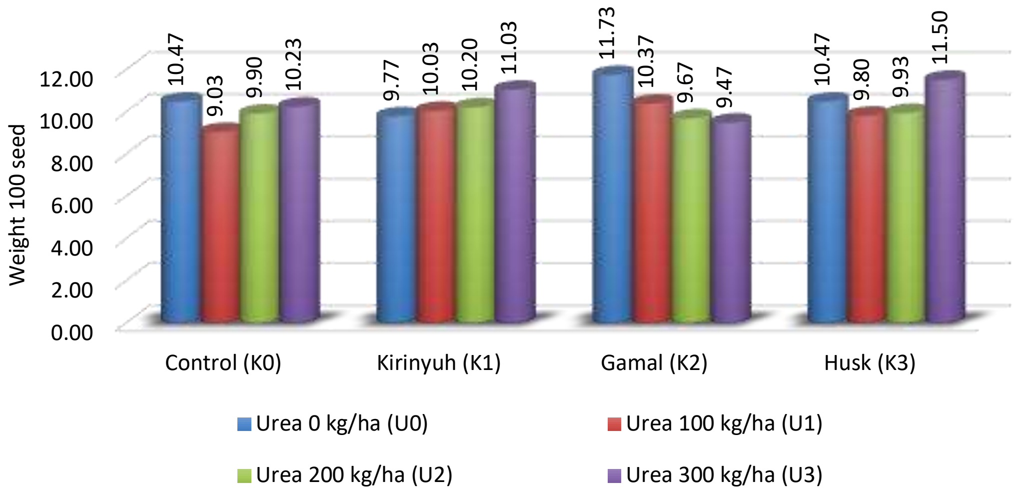

Figure 5. Average weight of 100 soybean seeds with various types of organic matter and urea on nickel contaminated soil

If you see in Figure 5 the application of organic matter from gamal can increase the weight of 100 plant seeds without giving urea this is due to the higher P and K content when compared to the given organic matter. The results of the chemical analysis of organic matter given by gamal had P 0.009 ppm and K 2,229.49 ppm and C/N ratio 0.39. Because the supply of nutrients from organic matter from gamal leaves is faster and can also be directly utilized by soybean plants to form more flowers so that the weight of the seeds will be heavier.

6. Soybean Crop Production (tonnes) per Hectare

The results showed that the application of organic compost and urea on nickel contaminated soil, as well as the interaction between the two treatments did not significantly affect soybean production per hectare.

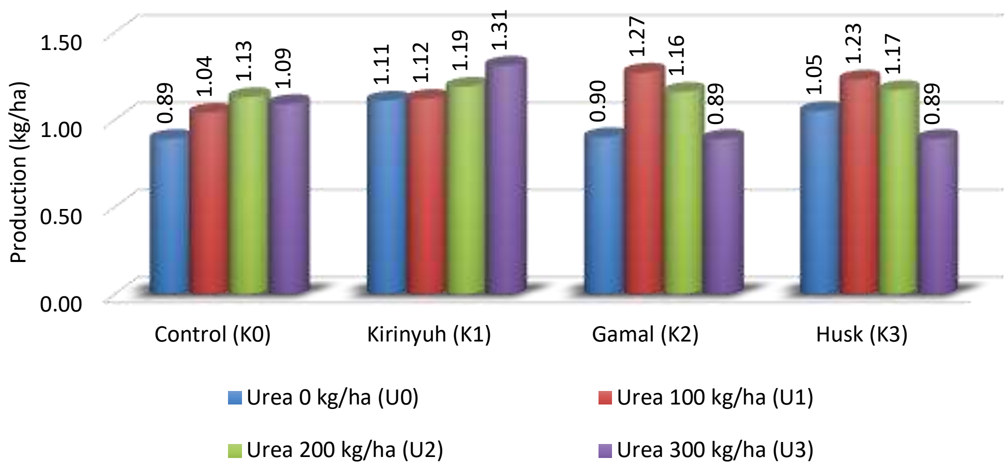

Figure 6. Average soybean production (tonnes) per hectare with various types of organic matter and urea on nickel contaminated soil

Figure 6 shows that the application of organic matter and urea on nickel contaminated soil tends to increase soybean crop production per hectare without the addition of organic matter and urea. The highest average production per hectare of soybean plants given a dose of urea 300 kg ha^{-1} (U3) was obtained in plants that were given kirinyuh compost (K1), namely 1.31 tons ha^{-1}. The lowest average production per hectare of soybean was obtained from plants without compost (K0) and urea (U0), which was 0.89 tons ha^{-1}.

It can be seen in Figure 6, the average soybean production per hectare is below the average yield potential of the Tanggamus variety, which is 1.22 tons ha^{-1}. This is due to environmental conditions growing soybeans, so it cannot grow optimally because the planting media is from post-nickel mining soil. Growth inhibition and decreased production and seed quality (Molas, 2002; Gajewska *et al*., 2006) were caused by the high concentration of available Ni in the soil.

7. Soybean Plant Nickel Content

The results showed that the treatment with various types of organic compost and urea on nickel contaminated soil could reduce the nickel content in the leaves and roots of soybean plants compared to without the application of organic compost and urea.

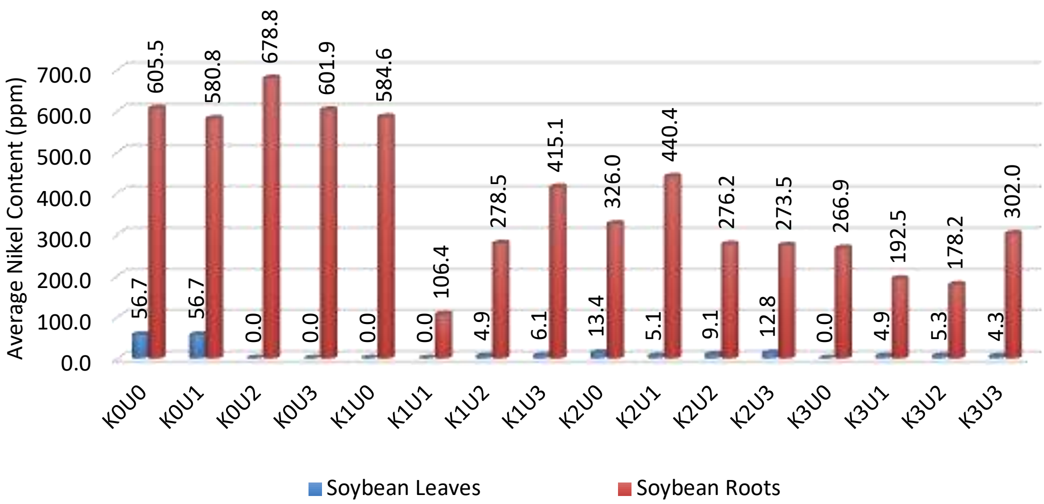

Figure 7. Average Nickel Content (ppm) in Leaves and Roots of Soybean Plants (*Test Results at the Animal Food Chemistry Laboratory, Department of Nutrition and Animal Feed, Faculty of Animal Husbandry, Hasanuddin University*)

Figure 7 shows that the application of various types of organic compost and urea on nickel contaminated soil tends to reduce the nickel content of soybean plants. The highest average nickel content in soybean leaves without organic matter and urea dose 100 kg ha^{-1} (K0U1) is 56.68 ppm while the highest average nickel content in soybean roots without organic matter and urea dose 200 kg ha^{-1} (K0U2) which is 678.77 ppm.

If it is seen in Figure 7 that without organic matter (K0) the Ni content in soybean leaves and roots is still higher, when compared with organic matter there is a decrease, which means that organic matter can help in reducing the nickel content in soybean leaves and roots. This is in line with Verloo (1993); Syekfani (2010) that organic matter can chelate metals dissolved in the soil. Organic matter contains organic acids which are negatively charged so that they can react to form bonds with metal cations. Due to the trapping of heavy metals such as nickel in the given organic material, nickel is not directly absorbed by the leaves and roots of soybean plants.

Administration of urea showed toxicity to soybean shoots and roots as found by Eskew *et al*. (1984), who found toxicity to the use of urea in the leaf tips of soybeans grown without nickel.

8. Nickel Content in Soil

The results showed that the treatment with various types of compost organic matter could reduce the nickel content in the soil compared to no compost organic matter.

Figure 8 shows that the application of various types of organic compost did not affect the nickel content in the soil. The highest average content of total nickel and nickel available in the soil was obtained with the addition of organic gamal compost and without urea (K2U0), namely 3.695 ppm and 806.66 ppm, respectively.

The test results show that the average Ni content in the soil used is still quite high. So it is necessary to do the right method to improve the quality of critical land after nickel mining into a suitable planting medium, including using accumulator plants or phytoremediation. In this way, it can reduce the Ni content in the soil after nickel mining so that it can be planted and the large area after nickel mining is not marginalized.

The use of organic matter is a method used to overcome the chemical feel of the soil because it is contaminated with heavy metal Ni (Djajakirana, 2001). Agronomic manipulations that can be done to increase plant biomass and accumulation. The use of organic matter will improve soil fertility thereby increasing crop yields and giving urea to take advantage of excess nickel in the media.

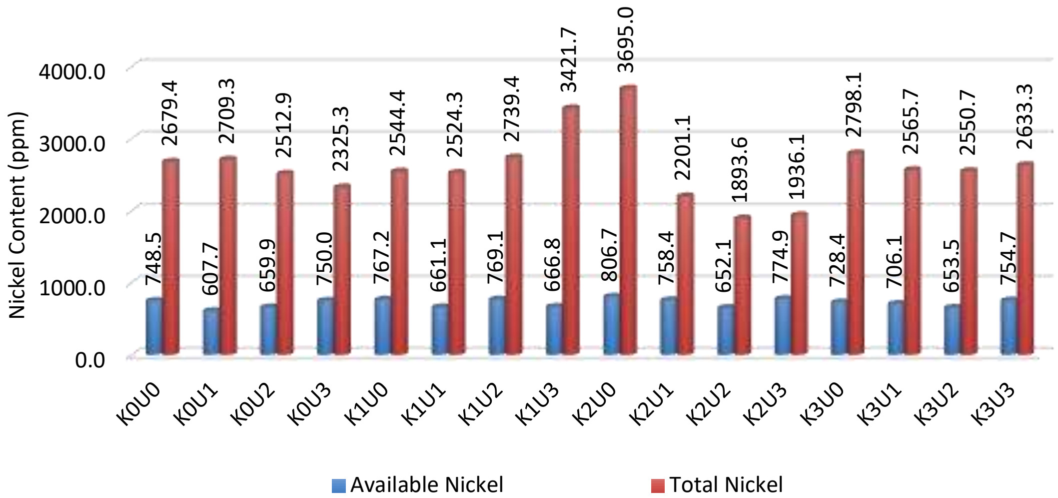

Figure 8. Average Nickel Content (ppm) in Soil (*Test Results at the Animal Feed Chemistry Laboratory, Department of Nutrition and Animal Feed, Faculty of Animal Husbandry, Hasanuddin University*)

D. Conclusion

Based on the results of research conducted, it can be concluded that provision of various types of organic compost tends to increase growth and production and reduce nickel content in soybean plants on nickel contaminated soil. Gamal compost (Gliricidia sepium) gave the best effect in increasing plant height and number of soybean leaves and weight of 100 soybean seeds. Giving various doses of urea can also increase the growth and production of soybean plants which can accumulate nickel in the soil to the leaves. Urea dose of 100 kg ha-1 gave the best effect in increasing the growth of plant height and number of soybean leaves. There is no interaction between the application of organic matter and urea on the growth and production of soybeans.

E. Recommendation

Based on the research that the author did, it is recommended that further research be carried out on the dose of organic matter from Gamal compost (*Gliricidia sepium*) in improving the structure of nickel-contaminated soil in order to optimize soybean growth and it is also recommended to remediate nickel mining areas before planting cultivated plants so that they are not polluted by heavy metals. nickel which has an impact on human health.

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Inheritance Pattern of Qualitative Character Traits in F2 Population of the Bara x Ungara and Dewata x Unggara Crosses

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Abstract

The purpose of this study was to estimate the inheritance pattern of qualitative character traits from the F2 population of the Bara x Ungara and Dewata cross. The study was conducted in the experimental garden of Unhas, Tamalanrea sub-district, Makassar, South Sulawesi. The quantitative character traits observed consisted of four characters, namely, the color of the flower corolla, the coloring of the immature fruit, the branching habit, and the nodal color. The results showed that the population of F2 crosses showed a purplish-green color (34) as the dominant color in immature fruits. Crosses with the Ungara variety exhibited a significant contribution to the color in the immature fruit. The nodal color characters is closely related to the duplication interaction pattern between alleles at different loci

Keywords: *Capsicum frutescens*, F2 generation, pepper breeding, qualitative data

A. Introduction

The development of high anthocyanin chilies is an additional goal to realize food biofortification on health (Ilodibia, C.V., C.E. Ugwoke, T.P. Egboka, E.E. Akachukwu, U.M. Chukwuma, & B.O. Aziagba, 2015; Garg, M., N. Sharma, S. Sharma, P. Kapoor, A. Kumar, V. Chunduri, & P. Arora, 2018; Rehan, A. Sharma, & P. Singh, 2020). The Ungara variety is one of the varieties with high anthocyanin levels. It is characterized by purple leaves, stems, and fruit. According to Herison, C., E. Surmaini, Rustikawati, & Yulian (2018), Tang, B., L. Li, Z. Hu, Y. Chen, T. Tan, Y. Jia, Q. Xie, & G. Chen (2020), and Huang Y., X. Wang, W. Miao, H. Suo, C. Fu, M. Chen, X. Zhaoand, & L. Ou (2021), the purple color on the fruit indicates a high anthocyanin level, so the Ungara variety is good to be used as a biofortification plant. This can be corrected by crossing commercial varieties such as Bara and Dewata. This variety is considered very popular with its productivity and high level of spiciness (Kusmana K. Y. Kusandriani, & D. Djuariah, 2017; Umami K., D.R. Anugrahwati, & I.K.D. Jaya, 2022). Therefore, crosses between these varieties become one of the good assembly lines in forming biofortified varieties that are in demand by general consumers.

Bara x Ungara and Dewata x Ungara crosses have entered F2. The F2 generation population is the population with the highest level of diversity, including qualitative characters (Benowicz A., M. Stoehr, A. Hamann, & A.D. Yanchuk, 2020; Cazzola F., C. J. Bermejo, & E. Cointry, 2020). Qualitative characters are characters that are not or slightly influenced by environmental influences. This character can be an effective approach in estimating the potential diversity of a cross. In addition, this character can be an approach in knowing the pattern of interaction between alleles in controlling a trait (Syukur M., S. Sujiprihati, & R. Yunianti, 2015). Therefore, it is important to estimate the genetic diversity pattern of the population of the Bara x Ungara and Dewata x Ungara crosses. The purpose of this study was to estimate the inheritance pattern of qualitative character traits from the F2 population of the Bara x Ungara and Dewata x Ungara crosses.

B. Methology

The study was conducted in the experimental garden of Unhas, Tamalanrea sub-district, Makassar, South Sulawesi. This experiment was carried out with the concept of observation by planting 200 F2 lines in each cross (Bara x Ungara and Dewata x Ungara). However, the number of plants that germinated and grew well was 255 lines (101 F2 lines from Bara x Ungara cross and 154 F2 lines from Dewata x Ungara cross).

1. Research procedures

The seedling was done using a planting medium consisting of soil, compost, and husk charcoal (1:1:1). Chili seeds were sowed in a seeding tray previously moistened with water until evenly distributed. Each planting holed consisted of one seed. The seeds will be transferred to small polybags 14 days after planting (DAP). Then, the seedling maintained until they were 40 DAP to transfer to the field. Planting was done with a spacing of 60 x 50 cm with a zigzag concept on mulch beds measuring 1 m x 10 m. Each planting hole is planted with one chili seed and given a buffer stake so that the plant does not collapse or break. Maintenance of chili plants includes watering, replanting, fertilizing, weeding, controlling pests and diseases, and harvesting. Watering is carried out twice a day, namely in the morning and evening. Embroidery is carried out on cayenne pepper plants that experience abnormal growth, wilt, and are attacked by pests or diseases. Embroidery time is carried out one week after planting (WAP) and carried out in the afternoon. The Fertilization is focused on chemical fertilizers NPK 15:15:15 which is done regularly once per week. The NPK fertilizer was diluted with a concentration of 5g/liter and 200 ml of the solution was given per plant. Weeding is done to remove weeds that interfere with growth around the plant which is carried out periodically once every three weeks. Control of pests and diseases using a mixture of insecticide Curacron 500 EC with a concentration of 2 cc/liter of water and fungicide Antracol 70 WP with a concentration of 2 g/liter of water. Pesticides and fungicides are applied by spraying on the soil surface and or under the leaves according to the level of attack of these pests and pathogens. The harvesting was carried out according to the common harvest criteria.

2. Data Analysis

The Observations were made on qualitative characters. The qualitative characters observed consisted of four characters, namely the color of the flower corolla, the color of the immature fruit, the branching habit, and the nodal color. All characters were displayed with individual frequency concepts in an Excel table.

C. Result and Discussion

The flower corolla color was shown in Table 1. In common, white was more dominant than other colors in the two populations (B/U = 91 and D/U = 144). Purple as the base color of Ungara was not seen in both populations. Meanwhile, the combination of the two populations occurs at the ends of the purple flower's corolla or purplish white flowers corolla (Nascimento N.F.F., M.F. Nascimento, R.M.C. Santos, C.H. Bruckner, & F.L. Finger, 2013). White as a general color in chili flower corolla that has a strong dominance. It was also reported by Gurung T., B.K. Sitaula, T. Penjor, & D. Tshomo (2020). When looking at the comparison between white and purplish white, there are two assumptions, namely, there is a duplication interaction between alleles, or crossover occurs in some parts of the purple trait. Possible duplication interactions are based on the proportion between white and purplish white. This proportion is close to a 15:1 ratio in the D/U population, so the interaction is thought to follow the pattern of allele duplication interactions between different loci (Sobir and Syukur, 2011). However, in the B/U population, the proportion between the two is 9:1 or does not follow the 15:1 duplication interaction proportion. In addition, the total purple trait did not appear in both populations in sufficient numbers. It indicates that the full purple corolla flower has too little probability. So, the color diversity pattern of the flower corolla is thought to not follow the concept of gene interaction. However, the pattern is thought to be more inclined to crossover blending. The possibility of crossing over is also corroborated by the purple color occurring only at the ends of the corolla flowers. When completely segregated, the color of the corolla flower will be purple in total.

Table 1. Inheritance pattern of flower corolla color in the population of chilies crossing Bara x Ungara and Dewata x Ungara

Population	Fruit corolla color		
	White	Purplish white	Purple
Bara x Ungara (B/U)	91	10	0
Dewata x Ungara (D/U)	144	10	0

The inheritance pattern of immature fruit colors was shown in Table 2. Based on the table, the population of the Bara x Ungara cross showed a purplish-green color (34) as the dominant color in immature fruits. It is followed by light green (22) and purplish white (15). On the other hand, the Dewata x Ungara cross shows that dark green is more dominant than other colors. It is followed by light green (37) and purplish green (31). Based on the results above, the inheritance pattern of immature fruit color shows a high complexity. It is also in line with the report of Herison C., E. Surmaini, Rustikawati, & Yulian, (2018). As a qualitative character, this character has quite a lot of groups. The more groups indicate that the more genes are involved in influencing the character. It was also reported by Jeong H-B., S-J. Jang, M-Y. Kang, S. Kim, J-K Kwon, & B-C Kang (2020), where there are three alleles PSY1, CCS, and PRR2 that affect the color of immature fruit. In addition, according to Andrade N.J.P., A. Monteros-Altamirano, C.G.T. Bastidas, & M . Sørensen (2020) immature fruit color is influenced by the interaction of two genes. These two reasons cause the mapping pattern of the inheritance of immature fruit color traits to be relatively complex. In general, the color of the immature fruit in the Bara variety is dark green, the Dewata variety is white, and the Ungara variety is purple. Crosses with the Ungara variety showed a significant contribution to the color of the immature fruit. The proportion of purple was reflected in both crosses, although the percentage of purple in the fruit was not too dominant. The high complexity of the fruit properties makes the purple color presentation more visible in the cross-population. It is different from the color of the corolla flower which has relatively few classes, so the effect of purple is minor on the character. The relatively dominant purple pattern will correlate with the increase in anthocyanins in chili fruit (Tang *et al*. 2020; Huang Y., X. Wang, W. Miao, H. Suo, C. Fu, M. Chen, X. Zhaoand, & L. Ou, 2021) so that crosses with the Ungara variety are considered effective.

Table 2. Inheritance pattern of immature fruit color in the population of chilies crossing Bara x Ungara and Dewata x Ungara

Population	Immature fruit color					
	DK	LH	PG	W	PW	P
Bara x Ungara	10	22	34	9	15	10
Dewata x Ungara	52	37	31	8	16	10

Notes: DK = dark green, LH = light green, PG = purplish green, W = white, PW = purplish white, P = purple.

The inheritance pattern of branching habits was shown in Table 3. Based on the table, both populations have dense branching habits (B/U = 51 and D/U = 66). It is different from Gurung *et al.* (2020) showed more sparse habits than other branching habits. However, the study worked on the concept of exploration rather than on the results of the cross. Sparse habit and intermediate habit in the population of Bara X Ungara have relatively the same number of individuals, namely 21 and 29, respectively. Meanwhile, the population of Dewata X Ungara has 36 and 52 individuals with sparse and intermediate branching habits, respectively. Based on the inheritance pattern, the dominance of dense characters is very prominent in the population of the Bara x Ungara cross. The Bara variety has a sparse branching habit, while the Ungara variety has a dense branching habit. On the other hand, in the Dewata x Ungara population, relatively dense canopy treatments had almost the same number as intermediate branching habits. It is because the Dewata variety is also dense, so the pattern that occurs is relatively dominated by dense and intermediate characteristics.

Table 3. Inheritance pattern Branching habit in the population of chilies crossing Bara x Ungara and Dewata x Ungara

Population	Branching habit		
	Sparse	Intermediate	Dense
Bara x Ungara	21	29	51
Dewata x Ungara	36	52	66

The color inheritance pattern of the book has very few classes, namely green and purple (Table 4). In common, the book green color predominates in both populations (B/U = 92 and D/U = 141). This pattern is similar to the color of the corolla flower, where the ratio is around 9:1 for the Bara x Ungara cross and 10:1 for the Dewata x Ungara cross. However, the color of the book is relatively small, so the inheritance pattern is relatively easy to predict. Possible interaction patterns on book characters are dominant interactions between alleles at one locus or duplication interactions between alleles at different loci. When viewed from the proportions of the two populations, the green and purple color patterns of the book are relatively close to the duplication interaction between alleles at different loci (Sobir and Syukur 2011). It is because the interaction between alleles in one locus has a ratio of around 3:1, so this pattern is very far from the results in book color (Syukur *et al.* 2015). Therefore, the inheritance pattern of book color is closer to the duplication interaction pattern between alleles at different loci.

Table 4. Inheritance pattern of book color in the population of chilies crossing Bara x Ungara and Dewata x Ungara

Population	Nodal color	
	Green	Purple
Bara x Ungara	92	9
Dewata x Ungara	141	13

D. Conclusion

The results of inheritance on qualitative characters have various patterns depending on the phenotype class possessed by these characters. Nodal color characters and corolla flower colors have relatively few gropus and have relatively the same comparison pattern. However, the color of the book is thought to have an inheritance pattern of duplication interaction, while the color pattern of the flower corolla has a role of crossing over the inheritance. Immature fruit color characters have many classes with complex interactions. Crosses with immature purple fruit relatively affect the inheritance pattern of fruit color and are correlated with an increase in fruit anthocyanins. Meanwhile, the inheritance pattern of the Branching habit shows a role of dominance, especially for the dense Branching habit. This cross pattern of qualitative characters is the basis for not continuing the analysis of the inheritance of quantitative characters, so these two populations are recommended to be analyzed more deeply for quantitative characters.

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Assesment of Viability of Sesame (*Sesamum indicum* L.) Seeds Using Germination Method with Paper Media

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Abstract

Seed viability is the ability of seed to germinate which is demonstrated by a variety of physiological or biochemical phenomena. Paper media can be used for testing seed viability. This study aimed to determine the most effective method of seed germination utilizing paper media for the viability of sesame seeds. The research was conducted at the Seed Laboratory of the Sweetener and Fiber Crops Research Institute, Malang in March – May 2020. The research method used a two-factor factorial Completely Randomized Design. The first factor was the sesame seed variety which consisted of SBR 1 and Winas 1. The second factor was the seed germination method which consisted of a test on top of paper, a test on rolled top papers, a test between of papers and a test between folded paper. Each treatment was replicated four times, resulting 32 experimental units. Sesame seed viability was significantly affected by the manner of seed germination using paper media, according to the findings. In comparison to other treatments, sesame seeds of the Winas 1 variety exhibited the highest percentages of simultaneous growth, germination, vigor index, normal seedling dry weight, hypocotyl length, and radicle length when tested on rolled top paper

Keywords: *Sesamum indicum,* straw paper, sumberrejo 1, winas 1

A. Introduction

Sesame is an oil-producing plant that may be grown in tropical and subtropical areas. Sesame seeds are made up of 50-53% vegetable oil, 20% protein, 7-8 crude fiber, 15% nitrogen-free residue, and 4.5-6.5% ash. Sesame seed oil is rich in unsaturated fatty acids, particularly oleic and linoleic acids, anti-oxidants alanine or lignin, vitamins B and E, and cholesterol-free. In the meantime, protein can be isolated from sesame seed hulls and used as an animal feed ingredient. Therefore, sesame oil production in Indonesia needs to be increased, one of which is through the use of high quality seeds. High-quality seed is the most important factor in agricultural production success because it produces high yields of high-quality products (Wiguna, 2013).

The quality of seeds include physical, genetic, and physiological qualities. Physical quality is determined by the seeds' cleanliness, shape, size, color uniformity, and absence of mechanical or pest-related damage. Genetic quality based on the level of purity. Meanwhile, physiological quality is measured from seed viability, moisture content, and seed storability. Seed viability is the ability of seeds to grow, as evidenced by a variety of physiological and biochemical phenomena, which can be evaluated using these phenomena. Through physiological, biochemical, and cytological approaches, the indication of seed viability demonstrates that the seeds are alive (Widajati, E., Endang, M., Endah, R. P., Tatiek, K., Syhartanto, M. R., Abdul, Q., 2017).

The physiological approach is the evaluation of growth changes, whereas the biochemical approach is the evaluation of the metabolic activity of seeds, such as the ability of enzymes to catalyze the metabolic activities of germination, respiration, ATP synthesis, and son so. Through the condition of chromosomes, cell membranes, mitochondria, etc., a cytological approach can be recognized. The mathematical approach, on the other hand, is a concept based on observations of seed viability benchmarks that have been translated into mathematical formulas and may be used to forecast viability quickly (Widajati *et al*., 2017).

Germination assays can be used to assess the physiology of seeds, although they can only determine the percentage of normal germination on optimal germination media and often employ paper or sand substrates (Hidayat RS and Mayasari, 2019). Commonly employed papers include filters, blotters, and towels (ISTA, 2010). However, the three substrates are highly costly and must be imported for their procurement. Therefore, an alternative substrate medium was produced from straw paper and has been recommended for use in Indonesian seed testing (Sadjad, 1972 in Hidayat RS and Mayasari, 2019). According to Purbojati and Faiza (2006), straw paper has the highest degree of resemblance, at 97.22 percent, followed by stencil paper at 88.87 percent.

Alimoeso and Sutarto (2006) suggested that the approach for determining germination or growth potential could employ the top of paper (on paper), between paper (between paper), or planted paper (between paper fans). The rolled-up paper established with plastic (UKDdp) test method is most commonly used for seed testing with parchment paper. According to Hapsari and Suwarno (2008), stencil paper can be used as a substitute for straw paper when using the UKDdp method to verify seed viability. Based on Suwarno and Deni (2009), the efficiency of testing the viability of large and small seeds can be done by using two sheets of parchment paper for germination variables. The germination method and paper substrate significantly affected the viability of E. pellita seeds utilizing the test method on paper (UDK), which produced higher germination values (Yuniarti, N., Megawati, Budi, L., 2017). The germination of maize seeds of the Anoman, Bisman, and Srikandi varieties was identical using the UDK, Udk, and UKDdp techniques (Nurhafidah., Abdul, R., Abbas, K., Hasyim, H.J., 2021).

Prior to usage, the germination rate of sesame seeds categorised as having a long shelf life or exhibiting dormancy were evaluated for viability testing. Several varieties of sesame which are classified as superior are SBR 1 and Wirnas 1. Local sesame varieties Sumberejo 1 (SBR 1) are the result of negative mass selection. This variety can be grown on dry soil and rice fields with limited water, can be harvested at 105 DAP, and contains between 55 and 58 percent oil. The Wirnas is an excellent sesame cultivar with a potential yield of 2.2 tons per hectare, an oil content greater than 50 percent, drought tolerance, and early maturity. Therefore, this variety can be cultivated on paddy fields using crop rotation.

This study aims to determine the viability response of sesame seeds using parchment paper, to identify a seed germination method using straw paper that is effective against sesame seed viability, and to obtain sesame varieties with the highest viability using straw paper.

B. Methology

This study was conducted between March and June of 2022 at the Seed Laboratory of the Research Institute for Sweeteners and Fibers in Malang, East Java. The materials and equipment used were sesame seeds of the SBR 1 variety in 2015 and Winas 1 variety in 2016, as well as straw paper, petri dishes, plastic, scissors, rubber, and a germinator.

This study employed a Two-Factor factorial Completely Randomized Design (CRD). The initial variable was sesame seed variety, which consists of SBR 1 and Winas 1. The second aspect was the method of seed germination using straw paper, which included tests on paper, rolled paper, between papers, and folded papers. The test on paper was conducted by placing the straw paper in a 9 mm-diameter petri dish. In the test of seeds on rolled paper, seeds sprouted on straw paper, which was subsequently rolled and erected during the germination phase. Seed testing between paper was done by germinating sesame seeds between straw paper. While the seed tests between folded paper, the seeds were germinated on folded paper and a shaped fan-like structure. The experiment included four replications and eight treatment combinations, yielding 32 experimental units. Each treatment was evaluated with 400 seedlings (ISTA, 2010). Germination was conducted in a type 72 IPB germinator at temperatures between 25 and 30 degrees Celsius.

The variables observed were the percentage of simultaneous growth (%), growth speed (% KN/etmal), germination (%), vigor index (%), normal seedling dry weight (g), hypocotyl length (cm), and radicle length (cm). The first observation was carried out on the 3rd day and the second observation on the 6th day after germination (Balittas, 2016). Experimental data were analyzed using analysis of variance (F test) with SAS 9.1 software. The F test results that were significantly different were further tested using the Duncan Multiple Range Test (DMRT) at the 5% level.

C. Result and Discussion

Simultaneous growth and the speed of seed growth are indicators of seed vigor. Seed vigor is the ability of seeds to develop rapidly and generate healthy plants in adverse conditions (Asra, 2014). The speed of seed growth reveals the strength of vigor required to produce seeds that can survive in inadequate environmental conditions (Fatikhasari, Z., Intani, Q.L., Dian, S., Muhammad, A.U., 2022). Table 1 displays the observed parameters for the simultaneous growth (percent) and growth rate (percent/etmal).

Table 1. Percentage of simultaneousness and speed of seed growth on varieties and methods of germination of sesame seeds (*Sesamum indicum* L)

Treatments		Simultaneous Growth (%)	Growth Speed (%/etmal)
Varieties	Germination method		
SBR 1	Test on paper	47.5 c	36.0 d
	Test on rolled paper	94.5 a	44.3 bc
	Paper-to-paper test	94.0 a	56.0 a
	Test between folded paper	82.0 b	43.8 bc
Winas 1	Test on paper	54.5 c	32.5 e
	Test on rolled paper	97.5 a	45.5 bc
	Test on paper	93.5 a	46.5 b
	Test on rolled paper	90.5 ab	42.5 c
Coefficient of Diversity (%) (%)		8,69	14,02

Note: The numbers followed by the same letter indicate that the DMRT test results are not statistically different (α 0.05).

Table 1 demonstrates that the Winas variety with the rolled paper germination test method has the highest percentage of simultaneous growth at 97.5% and is not substantially different from the SBR 1 variety with the inter-paper germination test method. In contrast to the best growth rate parameter, however, the SBR 1 variety's inter-paper germination test result was 56.0%/etmal. This revealed that the use of the germination procedure to the to the tested sesame seed varieties had no significant influence on germination. According to Nurhafidah *et al*. (2021), one of two germination procedures can be used to germinate corn. Tefa (2017) states that the speed of growth is regulated by water content and shelf life.

Germination or absolute viability benchmark that replicates potential viability is the capacity of a seed to develop into a normal plant that produces normally under optimum conditions. The vigor index is a metric that measures the uniformity and speed of germination. Table 2 presents the results of observations about the germination, vigor index, and normal seedling dry weight.

Table 2. Percentage of germination, vigor index and normal seedling dry weight of varieties and germination methods of sesame seeds (*Sesamum indicum* L.)

Treatments		Germination (%)	Vigor Index (%)	Normal Seedling Dry Weight (g)
Varieties	Germination method			
SBR 1	Test on paper	93.0 cd	91.5 a	0.1248 b
	Test on rolled paper	96.5 abc	97.5 a	0.1298 ab
	Paper-to-paper test	94.5 bcd	96.0 a	0.1185 bc
	Test between folded paper	93.0 cd	94.5 a	0.1045 d
Winas 1	Test on paper	91.5 d	85.0 b	0.1105 cd
	Test on rolled paper	98.5 a	98.0 a	0.1418 a
	Paper-to-paper test	96.0 abc	95.5 a	0.1185 bc
	Test between folded paper	97.5 ab	97.5 a	0.1403 a
Coefficient of Diversity (%)		8,69	14,02	

Note: The numbers followed by the same letter indicate that the DMRT test results are not statistically different (α 0.05).

Using the germination test on rolled paper (UDKd), the Winas 1 variety generated the highest percentage of germination, vigor index, and normal seedling dry weight, which were 98.5 percent, 98 percent, and 0.1418 grams, respectively. Seed vigor properties indicate a seed's capacity to grow rapidly, normally, and uniformly. According to Fatikhasari *et al*. (2022), a decline in vigor index and germination is a physiological sign of deteriorating seed quality. In the meanwhile, biochemical indicators include a reduction in enzyme activity, food reserves, and an increase in conductivity levels. Based on Purbojati and Faiza (2006), the best germination and vigor indices for sesame seed germination were 98% and 96.80%, respectively, when straw paper medium was used. Rahayu and Titiek (2015) observed that the use of straw paper substrate did not show a significant difference with filter paper substrate.

The hypocotyl is the part of the embryonic axis between the cotyledons and the primary root which becomes the stem of the sprout. While the radicle, which is the lower end of the hypocotyl in the embryo that will develop into the primary root of the sprout, is presented in Table 3. Table 3 shows that the Winas 1 variety using the germination test on rolled paper (UDKd) resulted in the best hypocotyl and radicle lengths of 3.87 cm and 8.20 cm, respectively. The existence of hypocotyl and plumule development proves that the sprouts formed are normal sprouts. The hypocotyl growth is healthy and flawless, with no tissue injury. Plumule growth is ideal, as it has green leaves, grows well within or exits from the coleoptile, or has complete epicotyl growth and typical buds. According to Wibowo (2020), the type of paper and the interaction between panted paper and paper type influence the parameters of the average length of the radicle and plumule.

Table 3. Hypocotyl length and radicle length on varieties and germination methods of sesame seeds (*Sesamum indicum* L)

Treatments		Hypocotyl Length (cm)	Radicle Length (cm)
Varieties	Germination method		
SBR 1	Test on paper	2,73 b	3,30 d
	Test on rolled paper	3,00 b	6,85 b
	Paper-to-paper test	2,90 b	4,73 c
	Test between folded paper	2,45 b	5,30 c
Winas 1	Test on paper	3,85 a	4,68 c
	Test on rolled paper	3,87 a	8,20 a
	Paper-to-paper test	3,83 a	6,33 b
	Test between folded paper	3,67 a	5,18 c
Coefficient of Diversity (%)		8,69	14,02

Note: The numbers followed by the same letter indicate that the DMRT test results are not statistically different (α 0.05).

Hidayat RS and Marjani (2020) suggested that the process of cell differentiation will follow the development of new cells in the embryo. As a result, the plumule, which consists of the stem and leaves, and the radicle, which is the root, are created. The growth of the radicle from the seed begins with the absorption of water into the seed coat, which causes the skin to swell and break. This is followed by germination, which is signified by the release of the radicle.

D. Conclusion

Sesame seed viability was significantly affected by the method of seed germination using paper media. Compared to other treatments, Winas 1 sesame seeds exhibited the highest percentage of simultaneous growth (97.5%), germination (98.5%), vigor index (98%), normal seedling dry weight (0.1418 g), length of hypocotyl (3.87 cm), and radicle length (8.3 cm).

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Administration Response of Milkfish Rinsed Water on The Growth and Production of Celery (*Apium graveolens* L.)

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Abstract

This study aimed to determine growth and production responses of celery (*Apium graveolens* L.) after the administration of milkfish rinsed water. This study was perfomed in the Experimental Land, Faculty of Agriculture, Cokroaminoto University, Palopo on June – August, 2022. Experimental method used in this study was a completely randomized design, containing six treatments and four replications (24 experimental units). Treatments in this study contained several milkfish rinsed water administration doses, namely P0 = without rinsed water administration (control), P1 = 250 ml/polybag, P2 = 300 ml/polybag, P3 = 350 ml/polybag, P4 = 400 ml/polybag, and P5 = 450 ml/polybag. The results showed that the milkfish rinsed water administration significantly affect plant height, number of leaves, and number of buds, but obtaining no significant effect on wet weight. The best treatment was found in the P3 treatment with average plant height of 25.30 cm, 149.75 leaves, 6.75 buds, and 59.33 g wet weight

Keywords: celery, growth, milkfish, rinsed, water, production

A. Introduction

Celery is an important vegetable with export value. This plant is the second important spice after lettuce based on its popularity and value. This plant has also long been known in Indonesia with various advantages. Besides a cooking spice, celery can also heal various sickness, such as fever, flu, liver and lymph problems. The chemical contents of celery have several activities as antimicrobial, antihypertensive, antioxidant, antidandruff, antidepressant, and anti-inflammation agents (Arzi, Hemanti, Karampour, Nazari, & Baniahmad, 2014).

The celery prospect in Indonesia, either in domestic or foreign markets as an export commodity, faces a problem in its cultivation as celery cultivation is included in a small-scaled cultivation category as side cultivation plant. Based on the Bureau of Statistics on the vegetable plant survey in Indonesia in 2017, harvesting and production land data of celery plants were absent. This condition was also similarly reported by the Research and Development Program for Horticulture Activities in Indonesia (Puslitbang) (BPS, 2017).

Celery can grow well, if supported with good cultivation condition. All conditions that affect its growth factor will determine the cultivation success. These factors are soil, climate, pests, and diseases. Above these factors, a proper cultivation technique also needs further attention (Yunus, 2018). The celery cultivation can be performed both in wide land and narrow land such as a pot or a polybag (Dalimunthe and Lestari, 2019). Intensive maintenance, proper conditions for growth, and appropriate fertilization are ways to improve celery production quality (Yunus, 2018). The liquid fishery wastes contain proteins and lipids that expose high nitrate and ammonia level. According to the General Directorate of Aquaculture (2015), fish waste can be utilized as an organic fertilizer ingredient. A fish waste that can be utilized comes from milkfish. Milkfish contains proteins and lipids, which can be utilized as organic liquid fertilizer to optimize growth and development of celeries. Commonly, fish rinsed water contains various nutrients, such as N (nitrogen), P (phosphorus), and K (potassium), which become the important components of organic fertilizers to regulate the plant growth.

The objective of this study was to determine the administration response of milkfish rinsed water on the growth and production of celery plants, and identify the best rinsed water concentration for growth and production of celery plant improvemen.

B. Methology

This study was carried out in the Experimental Land, Faculty of Agriculture, Cokroaminoto University, Palopo, Jl. Lamaranginang, Batupasi Village, Wara Utara Sub-district, Palopo City. The study was performed on June – August, 2022.

The experimental method used was a completely randomized design, containing six treatments and four treatments. Hence, there are 24 experimental units in this study. The treatments were composed of: P0 = control (without rinsed water administration), P1 = 250 ml/polybag milkfish rinsed water, P2 = 300 ml/polybag milkfish rinsed water, P3 = 350 ml/polybag milkfish rinsed water, P4 = 400 ml/polybag milkfish rinsed water, and P5 = 450 ml/polybag milkfish rinsed water. The observational data were analyzed using an analysis of variance. If there was a significant different, the data were continuously analyzed with the Honestly Significantly Different (HSD) at 5% level.

Planting was performed after the sown seedlings were 1 month old or produced 3-4 leaves. Seedlings were carefully transferred to the treatment polybags filled with soil containing the soil media. The planted seedlings had to be in a similar size and healthy. Seedlings were sufficiently watered every morning or afternoon to sustain the soil humidity. Also, soil was also maintained not too wet and not too dry.

The milkfish rinsed water was produced by chopping the milkfish and cutting it into two parts. This condition was proposed to simplify the rinsed water collection. Water at 7 L was poured in a container with milkfish. The rinsed water was then collected after the first and second time of rinsing. The milkfish used was 1 kg weight in a fresh condition. After the rinsed water was ready, the rinsed water was kept in a bucket. For the last step, the milkfish rinsed water was applied to the celeries after two-week planting.

Observation was started on 2 WAP (weeks after planting), then continued once in two weeks to determine the treatment effect, based on the observational characteristics in celeries. Celeries were harvested after reaching 63 WAP in polybag. The observational parameters were plant height (cm), number of leaves (leaves), number of buds, and weight wet (g).

C. Result and Discussion

Plant Height

Based on the analysis of variance, milkfish rinsed water administration treatments obtained a significant difference on celery height parameter. The average height of celeries after administered with milkfish rinsed water until 63 WAP can be shown below in Table 1.

Table 1. Celery height after milkfish rinsed water application

Treatment	Average plant height (cm) on -th week (WAP)				
	7	21	35	49	63
P0	4.58 a	6.75 a	8.80 a	12.53 a	20.38 a
P1	5.28 a	8.00 a	10.93 abc	16.95 ab	25.08 a
P2	5.03 a	8.00 a	10.80 abc	16.08 ab	21.48 a
P3	4.85 a	8.63 a	11.95 bc	20.48 b	25.30 a
P4	5.23 a	8.88 a	11.98 bc	18.65 b	24.85 a
P5	5.40 a	9.50 b	13.28 bc	16.35 ab	23.13 a

Note: Numbers followed by similar letter in the same column show no significant different based on HSD test at 5% level.

From the table above, the average plant height of celeries was significantly different on 35 and 49 WAP. The highest average height on 63 WAP was obtained by the P3 treatment (350 ml rinsed water) at 25.30 cm, while the lowest average height was obtained by the P0 treatment (control) without rinsed water administration at 20.38 cm.

Number of Leaves

Based on the analysis of variance, the administration of milkfish rinsed water could significantly affect the number of leaves in celeries. The average number of leaves in celeries after the rinsed water administration until 63 WAP is shown in Table 2.

Table 2. Number of leaves in celeries after milkfish rinsed water administration

Treatment	Average number of leaves (leaves) on -th week (WAP)				
	7	21	35	49	63
P0	3.00 a	5.25 a	9.50 a	44.25 a	70.50 a
P1	3.25 a	7.00 abc	14.25 ab	58.50 ab	96.50 ab
P2	3.00 a	6.00 abc	11.75 a	55.00 ab	98.50 ab
P3	3.25 a	8.25 bc	21.00 bc	94.00 c	149.75 c
P4	3.25 a	10.00 cd	19.50 bc	64.00 ab	131.75 bc
P5	3.50 a	11.50 d	22.50 c	74.50 bc	129.50 bc

Note: Numbers followed by similar letter in the same column show no significant different based on HSD test at 5% level.

The table above shows that the average number of leaves in celeries obtained a significant different on 21, 34, 49, and 63 WAP. On the 63 WAP, the average number of leaves in the P3 treatment was 149.75, as significantly different from the P0, P1, and P2 treatments, but insignificantly different from the P4 and P5 treatments.

Number of Buds

Based on the analysis of variance, the administration of milkfish rinsed water could significantly affect the number of buds in celeries. The average number of buds in celeries after the rinsed water administration until 63 WAP is shown in Table 3.

Table 3. Number of buds in celeries after milkfish rinsed water administration

Treatment	Average number of buds on -th week (WAP)		
	35	49	63
P0	1.00 a	2.25 a	3.25 a
P1	1.50 a	3.75 ab	4.75 ab
P2	1.25 ab	3.75 ab	5.25 ab
P3	3.00 c	5.75 c	6.75 b
P4	2.00 abc	4.25 bc	6.00 b
P5	2.75 bc	4.25 bc	5.50 ab

Note: Numbers followed by similar letter in the same column show no significant different based on HSD test at 5% level.

Based on the table above, the average number of buds in celeries shows a significant different on 35, 49, and 63 WAP. The P3 treatment was significantly different from the P4 and P5 treatments, but insignificantly different from the P0, P1, and P2 treatments on all observational period. The highest number of buds produced was obtained from the P3 treatment (350 ml rinsed water) at 7.50 buds, while the lowest number of buds was obtained from the P0 treatment (control) without rinsed water administration at 3.25 buds.

Wet Weight

Based on the analysis of variance, the administration of milkfish rinsed water had no significant difference on the wet weight of celery. The average wet weight of celery after the milkfish rinsed water administrations is shown in Figure 1.

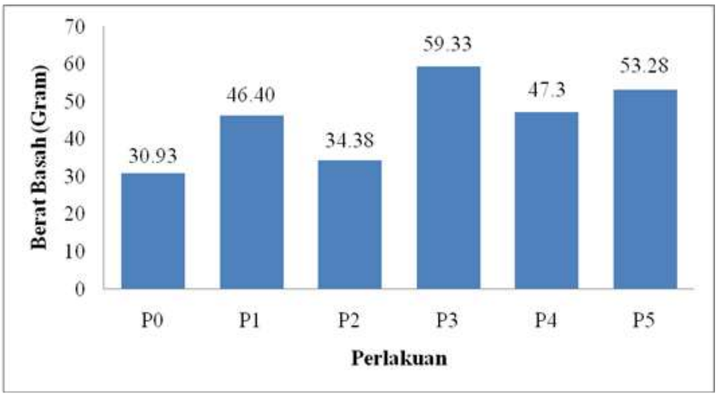

Figure 1. Average wet weight of celery plants after milkfish rinsed water administration

From the figure above, the first highest average wet weight of celery was found in the P3 treatment (350 ml milkfish rinsed water) at 59.33 g, while the second highest wet weight was found in the P5 treatment (450 ml milkfish rinsed water) at 53.28 g, the third highest wet weight was the P4 treatment (400 ml milkfish rinsed water) at 47.3 g, the fourth highest wet weight was the P1 treatment (250 ml milkfish rinsed water) at 46.40 g, and the lowest wet weight was found in the P0 (control) treatment without milkfish rinsed water administration at 30.93 g.

2. Discussions

Based on the study results in celery height, the P3 treatment obtained the highest value by administering 350 ml/polybag milkfish rinsed water at 25.30 cm, compared to other treatments, while the lowest value was obtained from the P0 treatment at 20.38 cm. This condition was thought as the administration of milkfish rinsed water supplied nutrients, such as N, P, and K, that were required by celeries.

In addition, General Directorate of Aquaculture (2015) explained that the addition of N and P matters could improve growth, in this case plant height. Besides nitrogen matter, plant height growth can be affected by phosphorus (P), zinc (Zn), and manganese (Mn). Ca nutrient is required by plants for cell elongation, cell division, upward growth of plants, and bud formation. Iron (Fe) is important for chlorophyll formation in leaves required for photosynthesis, which can continuously be used as a food for plants to grow and develop. Magnesium (Mg) is functioned for assisting the phosphate transportation pathway in plants and accelerating the fruit formation. Manganese (Mn) is functioned in photolysis process (water degradation) to form energy that can be used by plants for metabolisms, such as absorption, transpiration, cell division, flowering, and fruit formation (Nurul, 2012).

The P3 treatment produced the highest number of leaves at 149.75, while the lowest number of leaves was obtained from the P0 treatment at 70.50. According to the Swamp Land Agriculture Research Center (2015), nitrogen has roles in plant vegetative growth, plant coloration, and organ-initiator for photosynthesis. Plants applied with the fish rinsed water showed a positive impact due to abundant calcium (Ca), iron (Fe), nitrogen (N), magnesium (Mg), and manganese (Mn) contents that can promote plant length growth, number of leaves, and fruit formation (Anik, 2012).

Based on the analysis of variance for number of buds in celery, the P3 treatment had the highest number of buds at an average of 6.75, while the lowest number of buds was found in the P0 treatment at an average of 3.25. This condition was caused by the nitrogen content in milkfish rinsed water. Nitrogen is a main nutrient for plant growth to promote the plant vegetative growth, improve protein content in leaf-producing plants, following Patti, P.S., E. Kaya, & C. Silahooy (2013).

The wet weight parameter presents the highest value in the P3 treatment at an average of 59.33 g, while the lowest value was obtained from the P0 treatment at an average of 30.93 g. This condition indicates that a wider root distribution coverage will cause a better nutrient absorption as widening the nutrient absorption area and provide optimal plant parameters. According to Mutyarny (2014), the plant wet weight mainly fluctuates, depending on the plant humidity level.

D. Conclusion

Based on the study results, administration of milkfish rinsed water could significantly affect plant height, number of leaves, and number of buds, but showing no significant different on plant height observation and wet weight. The best milkfish rinsed water administration was found in the P3 treatment, which produced 25.30 cm height, 149.75 leaves, 6.75 buds, and 59.33 g wet weight

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Effect of The Drying Time of Unhulled Rice on The Rice Quality of Variety Inpari-7

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Abstract

High rice consumption necessitates an improvement in rice quality. Rice quality issues can result from pest attacks, unhulled rice transportation, harvesting, and drying. An alternative is to use a drier to enhance the quality of rice. Therefore, research to evaluate the quality of rice dried in a dryer with various drying times is required. The Rice Milling Unit, Harapan Village Unit Cooperative (VUC), Tiroang Sub-District, Pinrang District, located at coordinates 3O48'41"S and 119O42'5E, was the site of this study. This study was set up using a Randomized Block Design (RBD), with the treatment of unhulled rice drying duration, namely drying according to farmers' customs (A0), drying for 10 hours (A1), and drying for 12 hours (A2) using a dryer at an average temperature of 65OC. The results showed that a good percentage of whole grains, broken grains, groats grains, whitewash grains, yellow grains, red grains, unhulled grains, and foreign grains were obtained by drying the grain using a dryer for 12 hours. The novelty of this research is the finding of the right unhulled rice drying time using a dryer

Keywords: carbohydrates, drying floor, head rice, red grains, rice quality

A. Introduction

Rice is one of the food crop products that are consumed daily by the community. Rice is used as the main source of carbohydrates (Wan, J., Wu, Y., Pham, Q., Li, R. W., Yu, L., Chen, M. H., Boue, S. M., Yokoyama, W., Li, B., & Wang, T. T. Y. 2021; Wang, Z., Wei, K., Xiong, M., Wang, J.-D., Zhang, C.-Q., Fan, X.-L., Huang, L.-C., Zhao, D.-S., Liu, Q.-Q., & Li, Q.-F., 2021) because it is easy to obtain, tastes good, and can be combined with other food ingredients

In economics, rice is the source of income for people, the economic stability index, and the main basis for government food policies (Arifin, A., Biba, M. A., & Syafiuddin, S., 2021; Suvi, W. T., Shimelis, H., & Laing, M. 2020), this causes the quality of rice production to be considered. The phenomenon of low rice quality will affect the selling price and consumer interest in consuming rice.

The low quality of rice can be caused by a slow harvesting process (Zhang, N., Wu, W., Wang, Y., & Li, S., 2021; Zhang, N., Wu, W., Li, S., Wang, Y., Ma, Y., Meng, X., & Zhang, Y., 2022), which causes the rice plants to fall down and the rice seeds to germinate. In addition, the slow transport of unhulled rice from ricefields to unhulled rice processing site (An, K., Kim, S., Shin, S., Min, H., & Kim, S. 2021; Said, S. A., Darma, R., & Tenriawaru, A. N., 2021) causes the drying process to be slow and resulting in the unhulled rice turning black and the rice brown. Another phenomenon is the not-right unhulled rice drying process and the presence of Paraeucosmetus pallicornis attacks (Abdullah, T., Aminah, S. N., Kuswinanti, T., Nurariaty, A., Gassa, A., Nasruddin, A., & Fatahuddin, F., 2020; Sjam, S., Surapati, U., Adiwena, Syatri, A., Dewi, V. S., & Rosmana, A., 2018) which cause the skin of the unhulled rice to become spots, so the rice tastes not better when consumed

The community has not understood good unhulled rice drying techniques, so they still rely on natural drying by utilizing sunlight and drying floors. Drying in this way still has several obstacles and shortcomings. One of which is unfavorable weather, which can result in poor drying effectiveness it greatly affects the quality of rice and its shelf life.

Using a dryer is an alternative that can solve the problem of drying rice and can be used in unfavorable weather. Therefore, research is needed to determine the quality of rice dried in dryers with different drying times. The novelty of this study is to find out the proper drying time in the dryer.

B. Methology

This research was carried out at the rice mill unit of the Harapan Village Unit Cooperative (VUC), Tiroang District, Pinrang District (coordinates: 30°48'41" S, 119°42'5" E).

1. Research Methods

The studies were designed based on a Randomized Block Design (RBD) with the treatment of drying time for rice grains, namely drying time according to farmers' habits (Control, A0), drying time of 10 hours (A1), and drying time of 12 hours (A2), drying for 10 and 12 hours using a dryer at an average temperature of 65OC. Each treatment was carried out 3 times. The rice quality components observed were based on the Indonesian National Standard (SNI, 6128/2008), namely: whole grains (%), broken grains (%), groats grains (%), whitewashing grains (%), yellow grains(%), red grains(%), unhulled grains (grains/100 g) (%) and foreign grains (%).

2. Data Analysis

Observational data were analyzed using analysis of variance based on a randomized block design, and Duncan's test was continued if the treatment showed a significant effect.

C. Result and Discussion

The results of the analysis of variance showed that the difference in drying time had a significant effect on the physical quality of rice. Duncan's test results showed that drying for 12 hours resulted in a higher percentage of whole grains and a lower percentage of broken grains and groats, as shown in Figure 1.

Whole rice grains are rice grains that are not broken and expressed as percentages (Müller, A., Nunes, M. T., Maldaner, V., Coradi, P. C., Moraes, R. S. de, Martens, S., Leal, A. F., Pereira, V. F., & Marin, C. K., 2022; Scariot, M. A., Karlinski, L., Dionello, R. G., Radünz, A. L., & Radünz, L. L., 2020) so that they have the best quality of rice and have a negative correlation with grains of broken and groats (Indrasari, S. D., Apriyati, E., Purwaningsih, H., Ardhiyanti, S. D., Kusbiantoro, B., Wening, R. H., & Usyati, N., 2022; Sulistyo, A., Mubarak, A., & Hendris, 2021). Figure 1 shows that the drying of 12 hours with a dryer resulted in the percentage of whole rice grains being 96.61%. Drying of 12 hours using a dryer possibility to be able to reduce the moisture content of unhulled rice up to 14% so that the rice grains have strong bonds between particles and unbroken.

Rice quality requirements SKI 6128/2008 state that drying for 12 hours using a dryer is in quality I, while the floor drying system is categorized as quality IV. Drying for 10 hours using a dryer is not recommended because it does not meet the requirements of SNI. (Badan Stardarisasi Nasional-BSN, 2008).

Broken rice grains are rice grains that are broken and have a size of 0.2 mm to 0.6 mm from the whole rice grains, while the groats rice grains are rice grains with a smaller size of 0.2 mm that are also part of grains of whole rice. The use dryer with a drying time of 12 hours will produce broken rice grains classified as quality I, while the use of a dryer in the form of a drying floor will result in broken rice grains classified as quality II (Badan Stardarisasi Nasional-BSN, 2008).

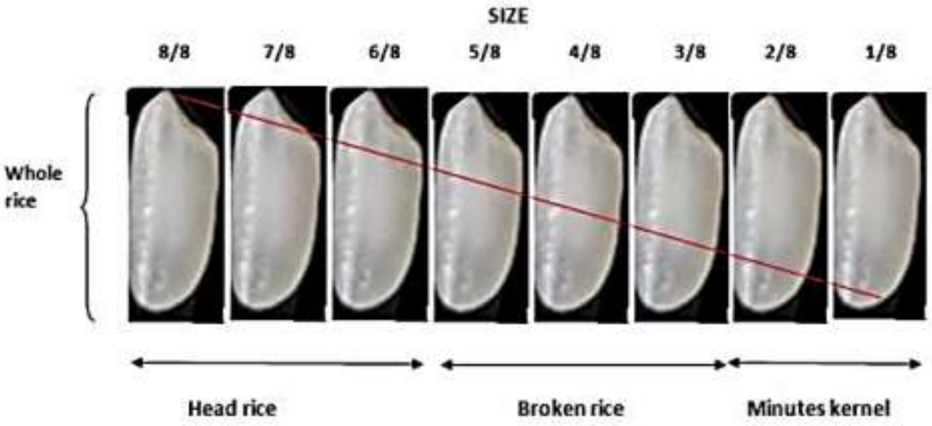

Figure 1. Shape and size for rice (https://www.jica.go.jp)

Figure 2 shows the percentages of broken rice grains and groats rice grains which are higher for drying using a drying floor and dryer for 10 hours. This is probably because of the relatively high unhulled rice water content (>14%), so the pores between the starch crystals bind larger to water, and the bonds between the amylum crystals become weak and break easily (Chumsri, P., Panpipat, W., Cheong, L. Z., & Chaijan, M., 2022; Gabriel, A. A., Solikhah, A. F., & Rahmawati, A. Y., 2021).

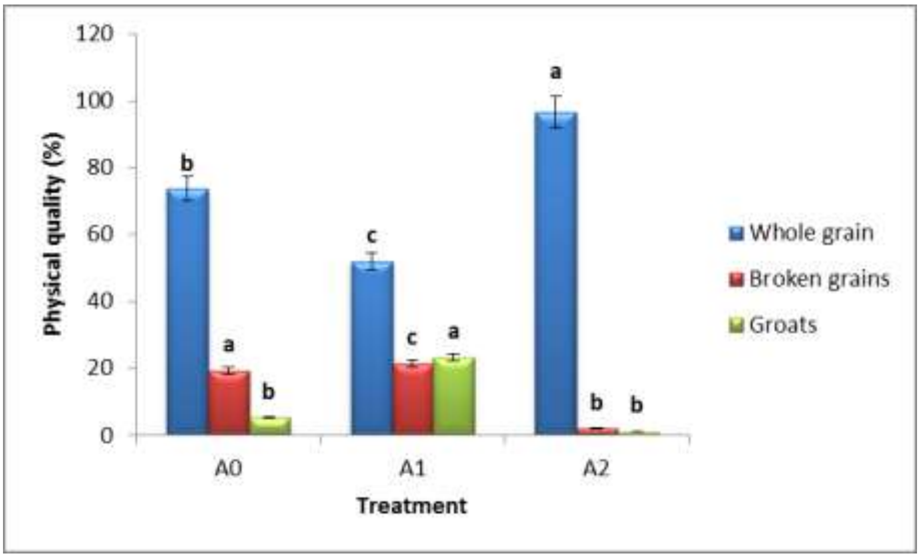

Figure 2. The average percentage of whole rice grains, broken rice grains, and groats rice grains in the treatment of unhulled rice drying time on the quality of rice grains varieties inpari-7. Drying time according to farmers' habits (Control, A0), drying time of 10 hours (A1), and drying time of 12 hours (A2), drying for 10 and 12 hours using a dryer

The microstructure of rice grains shows clusters of irregular starch crystals (Khan, A. H., Min, L., Ma, Y., Zeeshan, M., Jin, S., & Zhang, X., 2022; Lin, G., Yang, Y., Chen, X., Yu, X., Wu, Y., & Xiong, F., 2020). Different rice varieties have different crystal sizes and the influenced by genetic factors and pre-and post-harvest treatment of rice (Cao, C., Shen, M., Hu, J., Qi, J., Xie, P., & Zhou, Y., 2020; Indrasari et al., 2022; Li, Y., Liu, H., Wang, Y., Shabani, K. I., Qin, X., & Liu, X. Y., 2020). Figure. 3 shows microscopically that large rice crystals are composed of smaller crystals. Each starch crystal is encased in a transparent film, which makes the starch crystal tighter and cleaner, making the coated crystals appear smoother. The pores between the crystals are also clearly shown in Figure. 3.

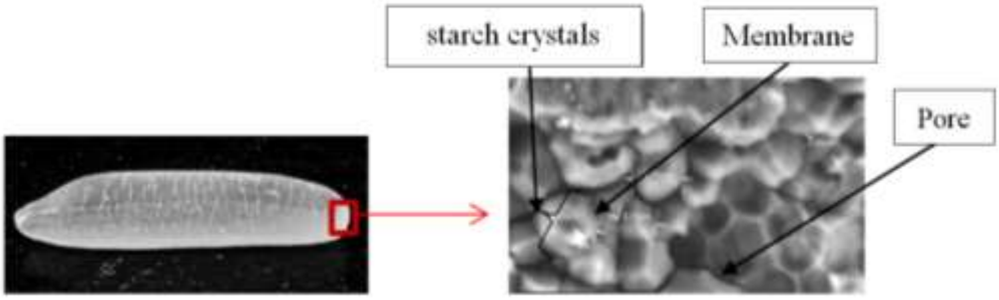

Figure 3. Microstructure of rice grains

The starch crystals in rice are composed of two glucose polymers (amylose and amylopectin) bound by glycosidic bonds (He & Wei, 2020; Jin & Xu, 2020; Zhu, J., Yu, W., Zhang, C., Zhu, Y., Xu, J., Li, E., Gilbert, R. G., & Liu, Q., 2020) The smaller the amylose content or higher the amylopectin content, the fluffier the rice (Bautista & Counce, 2020; Munawar & Sabaruddin, 2021). Furthermore, the fluffier of rice, the smaller the starch crystal density value, so the rice is easily broken (Li, H., Liu, B., Bess, K., Wang, Z., Liang, M., Zhang, Y., Wu, Q., & Yang, L., 2022; Wang, G., Yan, X., Wang, B., Hu, X., Chen, X., & Ding, W., 2022).

The pores between the starch crystals function as channels for liquid absorption from the environment into the rice (Rajabnezhad,S., Ghafourian, T., Rajabi-Siahboomi, A., Missaghi, S., Naderi, M., Salvage, J. P., & Nokhodchi, A., 2020; Sarifudin, A., Keeratiburana, T., Soontaranon, S., Tangsathitkulchai, C., & Tongta, S., 2020). The smaller the pores in rice, the faster absorption of liquids into the rice (Aravind, N. R., Sathyan, D., & Mini, K. M., 2020; Keeratiburana, T., Hansen, A. R., Soontaranon, S., Blennow, A., & Tongta, S., 2020). Thus, the pore size of rice can determine the value of its compressive strength (Jaya N. A., Yun-Ming, L., Cheng-Yong, H., Abdullah, M. M. A. B., & Hussin, K., 2020; Vieira, A. P., Toledo Filho, R. D., Tavares, L. M., & Cordeiro, G. C., 2020). The larger the pore space and the greater the porosity value of rice, the more fragile the rice, so the compressive strength value will be smaller (Nuaklong P., Jongvivatsakul, P., Pothisiri, T., Sata, V., & Chindaprasirt, P., 2020; Rattanachu, P., Toolkasikorn, P., Tangchirapat, W., Chindaprasirt, P., & Jaturapitakkul, C., 2020).

The rice milling process is a process that changes unhulled rice into rice, where unhulled rice experience a physical process to release the husk (husk). So, recommended the water content of unhulled rice reaches 14% (Arsyad & Maryam, 2020; Saeed, A. A. H., Harun, N. Y., Bilad, M. R., Afzal, M. T., Parvez, A. M., Roslan, F. A. S., Rahim, S. A., Vinayagam, V. D., & Afolabi, H. K. 2021; Utami & Ulfa, 2022). If the water content of unhulled rice is lower than 14%, the rice grains will easy to break (Mahanani & Inrianti, 2021; Yang, W., Zheng, Y., Sun, W., Chen, S., Liu, D., Zhang, H., Fang, H., Tian, J., & Ye, X., 2020), so rice produced is more in the form of broken rice grains. Meanwhile, if the water content of unhulled rice exceeds 14%, the grinder machine will work very hard, and the resulting bran will clog the sieve holes during grinding, so the rice produced is easily cracked and broken (Kumoro, A. C., Lukiwati, D. R., Praseptiangga, D., Djaeni, M., Ratnawati, R., Hidayat, J. P., & Utari, F. D., 2019; Permatasari, 2020; Tang, Z., Li, Y., Zhang, B., Wang, M., & Li, Y., 2020).

Rice color is a characteristic of rice that can be directly assessed and can influence consumer decisions in choices. The rice color is a significant sensory parameter. Usually, the whiter the rice color, the higher the price (Arslan, M., Zareef, M., Tahir, H. E., Guo, Z., Rakha, A., Xuetao, H., Shi, J., Zhihua, L., Xiaobo, Z., & Khan, M. R., 2022; Jeesan & Seo, 2020). Muller et al., (2022) and Ziegler, V., Paraginski, R. T., & Ferreira, C. D (2021) stated that the factors that affect the color or browning of rice are temperature, humidity, grain moisture content, and storage time.

Analysis of variance showed that the percentage of whitewashing grains and yellow grains were influenced by differences in the drying time of the unhulled rice, while red grains were not affected by the drying time of unhulled rice. The results of Duncan's test showed that drying for 12 hours gave a percentage of red grain and yellow grains that were different from other treatments with lower percentage values, as shown in Figure 4.

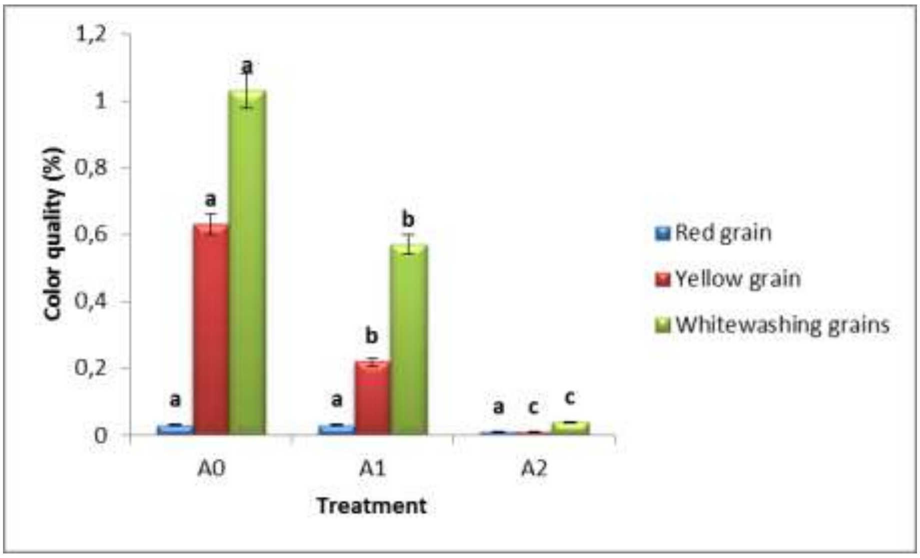

Figure 4. The average percentage of whitewashing grains, yellow grains, and red grains in the treatment of unhulled rice drying time on the quality of rice grains varieties inpari-7. Drying time according to farmers' habits (Control, A0), drying time of 10 hours (A1), and drying time of 12 hours (A2), drying for 10 and 12 hours using a dryer

Yellow grains are whole rice grains, broken rice grains, or groats that are yellow, yellow-brown, or pseudo-yellow caused to physical processes or activities of microorganisms (De, 2020; Ziegler et al., 2021). Generally, rice with water content > 14% will degrade caused of non-enzymatic browning reactions by the reaction between reducing sugars and groups of amine free from amino acids or proteins (Maillard reaction). The Maillard reaction will cause the rice to be yellow to brown (Lang, G. H., Kringel, D. H., Acunha, T. dos S., Ferreira, C. D., Dias, Á. R. G., Zavareze, E. da R., & de Oliveira, M., 2020; Liu, Y., Shad, Z. M., Strappe, P., Xu, L., Zhang, F., Chen, Y., & Li, D., 2022). In addition, the attack of fungus also causes rice that yellow color (Jamali, H., Sharma, A., Roohi, & Srivastava, A. K., 2020).

Grains whitewash are rice grains that are half or more white like chalk (chalky) and have a soft texture caused by physiological factors (Utami & Ulfa, 2022). One of the factors that cause the rice to whitewash is not optimal harvest time, so it produces green grains, and when in the mill obtained grains are whitewashed, and consumers do not like milled rice which has whitewashed grains high percentage of caused easy attack by pests during storage. (Yuriansyah, 2017).

Foreign objects are something that not classified as rice, such as straw, bran, panicles, gravel, soil grains, sand, metal, wood pieces, glass pieces, other grains, dead insects, and other objects (Millati, T., Alhakim, H. M., & Febriana, F., 2021; Yuriansyah, 2017). While, the unhulled rice grain is unhulled rice that has not been or partially exfoliated in the milling process, including broken rice grains that still have husks (Iswanto, P. H., Dr. Ir. Arief RM Akbar, M., & S.TP.Meng Sc, A. R., 2018; Yuriansyah, 2017).

Analysis of variance showed that the difference in drying time did not significantly affect the percentage of milled rice impurities as indicated by the average percentage of unhulled rice grain and foreign objects. The average of percentage unhulled rice grain and rice impurities found in 12 hours of drying was lower than according to farmers' habits and 10 hours of drying time, as shown in Figure 5.

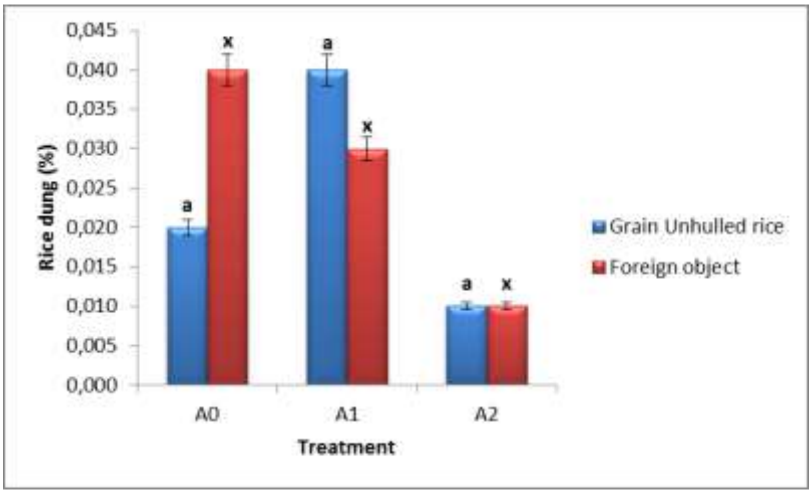

Figure 5. The average percentage of unhulled rice grain and rice impurities in the treatment of unhulled rice drying time on the quality of rice grains varieties inpari-7. Drying time according to farmers' habits (Control, A0), drying time of 10 hours (A1), and drying time of 12 hours (A2), drying for 10 and 12 hours using a dryer

D. Conclusion

The quality of rice using a dryer for 12 hours of drying showed a better percentage of whole grains/head rice, broken grains, groats, grain whitewash, yellow/broken grains, red grains, unhulled grains, and foreign grains compared to other treatments.

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Growth Response of Phalaenopsis Seedling on Various Concentrations of Hyponex Leaf Fertilizer

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Abstract

The aim of the study was to determine and analyze the effect of Phalaenopsis seedling growth at various concentrations of Hyponex foliar fertilizer. This study was conducted in Cempalagi Village, Tempe Sub-district, Wajo Regency. By using a randomized block design consisting of five concentrations of hyponex fertilizer, namely: 1.0 g/liter of water, 2.0 g/liter of water, 2.5 g/liter of water, 3.0 g/liter of water and 3.5 g/liter of water. Results of study showed that the concentration of hyponex fertilizer at 2.5g/liter of water obtained the best results on leaf number, leaf length, leaf thickness, root number and root length of Phalaenopsis orchids

Keywords: *Phalaenopsis*, seedling, hyponex, media tanam

A. Introduction

Ornamental plants have been known since centuries ago, because of its beauty that can be used to beautify a house or room and soothe the soul. Thus, this kind of plant is in high demand in the market. During the covid-19 pandemic, ornamental plants had brought new trends and lifestyles as a result of the implementation of WFH (work from home) policy. Many people suddenly showed great interest in plants to channel hobbies, utilise spare time and some even venture to the ornamental plant business. The reasons behind this probably comes from the assumption that taking care of plants is a safe, fun activity, brings peace to mind, it can even be profitable for ornamental plant businessmen, and this activity can be carried out at home.

One of the ornamental plants favoured by the public is orchid. Aside of the stable prices, orchid plants have beautiful flowers, durable and do not wither quickly and fall off so that it can be enjoyed for a long time. Currently, about 750 families, 43,000 species, and 35,000 hybrid varieties of orchids have been identified from all over the world. Indonesia has about 5,000 species. Of that number, 986 species are spread in the forests of Java Island, 971 species are on Sumatra Island, 113 species grow in the Maluku Islands, and the rest can be found in Sulawesi, Irian Jaya, Nusa Tenggara, and Kalimantan (Indonesia, 2019).

Indonesia has at least 25% of the world's flowering plant species. This means that Indonesia is the seventh largest country with a number of species reaching 20,000 species, of which 40 percent are endemic or native to Indonesia. The plant family that has the most species members is the orchids (Orchidaceae) (Indonesia, 2019).

Phalaenopsis is a genus of orchids that has a variety of types and beauty, with approximately 40-60 species. This orchid is one of the prima donna of the orchid business in Indonesia and around in the world. Another feature of Phalaenopsis is that it is able to bloom throughout the year with an average flowering period of one month (Iswanto, 2001). On June 5, 1990, the moon orchid (*Phalaenopsis amabilis* L.) was officially named the national flower, as Puspa Pesona. This orchid has a characteristic pure white flower with a golden yellow tongue.

Orchid propagation by vegetative means is done by growing certain vegetative parts of the parent plant. Through this propagation technique, orchid seedlings with the same genetic characteristics as their parents will be produced. One of these vegetative propagation means is in-vitro.

Plants that are cultured in-vitro are called plantlets which are ready to be transferred to the growing media and cannot grow if they are directly transferred from in-vitro conditions to the field or greenhouse. Therefore, before being transferred, the plantlets must undergo a period of acclimatization by planting in a pot called the Community Pot. The trick is to remove the seeds from the bottle, then wash them thoroughly, after that they are planted with a total of 30 seeds/pot. Then place the pot on a shelf that is topped with 20% paranet and coated with UV plastic.

After going through a period of acclimatization in commnity pot for three to four months, the seeds that have grown larger are separated individually in small pots called Individual Pots (Seedling). After 4 months then transferred back to a larger pot, treated until blossoming.

In the new growing media outside the bottle, both on community pot and on seedling, orchid seeds no longer receive special treatment. In this condition, a suitable growth medium is needed for growth and development. In addition, plant nutrient needs must be supplied from the outside through fertilization. According to Kusmanto (2010) in Nuryani *et al* (2019), it is stated that to achieve optimal fertilization efficiency, fertilizer must be applied in an amount that meets the needs of the plant, not too much and not too little. If the application of fertilizer is higher than needed, the soil solution will be too concentrated thereby poisoning to plants, on the other hand, if the fertilizer is insufficient, the effect of fertilization on plants may not be visible.

Hyponex fertilizer is a product that can be applied to orchids. This fertilizer is a foliar fertilizer in the form of crystals containing many macro and micro nutrients needed by plants. Orchid plants require elements of nitrogen, phosphorus and potassium in sufficient quantities to grow. The elemental content of the leaf fertilizer is expected to be beneficial on the orchid plants' growth. For this reason, research was carried out to determine the right concentration needed by orchid plants to stimulate their growth. Based on this description, a study titled "Growth Response of Phalaenopsis Seedlings in Various Concentrations of Leaf Hypotex Fertilizer" was conducted.

B. Methology

The research was carried out in the form of a randomized design experiment consisting of five concentrations of hyponex fertilizer, namely: h1 = 1.0 g hyponex fertilizer/liter of water, h2 = 2.0 g hyponex fertilizer/liter of water, h3 = 2.5 g hyponex fertilizer/liter of water, h4 = 3.0 g hyponex fertilizer/liter of water and h5 = 3.5 g hyponex fertilizer/liter of water.

The experiment began by choosing a pot as a container for planting media. Selected pots of the same size of 15 cm in diameter and 15 cm in height. The pots were washed and drained, then the pots were arranged according to the treatment.

Plant preparation

Orchid plants of *Phalaenopsis* seedling aged 1 month which not yet produced flowers or were still in community plot were used. Several factors used as consideration in selecting young plant seeds are healthy roots, stems, leaves, has smooth green without spots leaves color, as well as has wide and thick leaves among the existing seedlings.

Selected plants were then repotted, means the act of dismantling the planting media and the plants themselves thoroughly, to replace the old planting media with suitable planting media. Before planting, the plants were soaked in a fungicide solution of 2 g/liter of water for five minutes, then left the plants to dry.

Planting media preparation

Prepared fungicide solution and bactericide solution (Dithane M-45) of 2 g/liter of water were used to soak media in separate place for five minutes, then washed thoroughly and left to dry. Media filling was done by putting the media in each pot according to the treatment with requirement of up to 1 cm below the pot tip.

Planting

Orchid plants were planted in pots with a mixture of mos : roasted husks: red stone fragments: wood charcoal (1:1:1:1). Followed by planting one plant per pot, the plant then was placed in a place under a plastic shade that has been prepared prior.

Fertilization

Fertilization was performed by spraying, according to the treatment. Every plant was treated with 8 ml green hyponex fertilizer once a week for 3 weeks in the morning by spraying it to the leaves and all parts of the plant.

Watering

Watering was carried every day in the morning and evening or depending on the weather and plant conditions. Pest and disease control are carried out if the symptoms appear.

Observation Parameter

Plant growth were observed at the end of the experiment at the age of 12 weeks after planting. The parameters observed were:

1. Leaf Number (leaves)
2. Longest Leaf Length (cm)
3. Leaf Thickness (mm)
4. Number of Roots
5. Root length (cm)

C. Result and Discussion

1. Result

Hyponex fertilizer suggested better results on the number of leaves, leaf length, leaf thickness, number of roots and root length of *Phalaenopsis* orchids. The results obtained were better with the application of 2.5 g hyponex/liter of water compared to other treatments (Figure 1 and Tables 1,2,3,4).

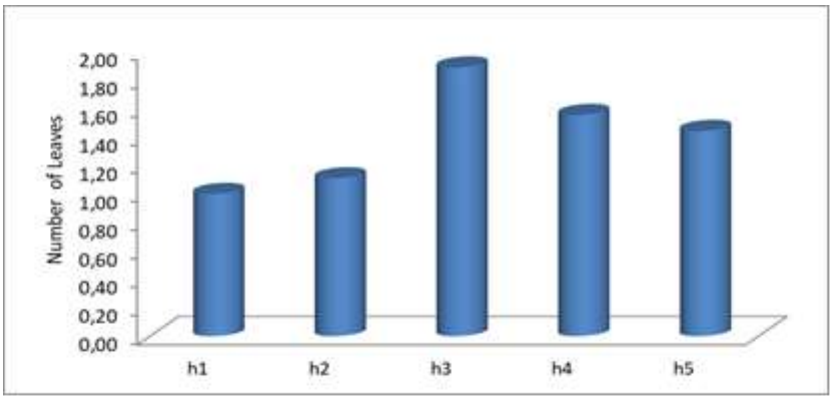

Figure 1. Average number of Phalaenopsis orchid leaves

Table 1. Average leaf length of *Phalaenopsis* orchid plants

Hyponex Concentrations	Average (leaves)	NP LSD ά 0.05
h1	5.67c	
h2	6.87b	
h3	8.03a	0.75
h4	7.20b	
h5	6.97b	

Note: The numbers followed by the same letter mean that they are not significantly different in the LSD test of ά 0.05.

Table 2. Average leaf thickness of *Phalaenopsis* orchid plants

Hyponex Concentrations	Average (mm)	NP LSD ά 0.05

h1	0.044c	
h2	0.047b	
h3	0.067a	0.009
h4	0.055b	
h5	0.054b	

Note: The numbers followed by the same letter mean that they are not significantly different in the LSD test of ά 0.05.

Table 3. Average number of *Phalaenopsis* orchid roots

Hyponex Concentrations	Average (number)	NP BNT ά 0.05
h1	1.11b	
h2	1.22b	
h3	1.89a	0.36
h4	1.44b	
h5	1.44b	

Note: The numbers followed by the same letter mean that they are not significantly different in the LSD test of ά 0.05.

Table 4. Average root length of *Phalaenopsis* orchids

Hyponex Concentration	Average (cm)	NP LSD ά 0.05
h1	1.17c	
h2	1.40b	
h3	2.30a	0.54
h4	1.73b	
h5	1.67b	

Note: The numbers followed by the same letter are not significantly different in the LSD test of ά 0.05.

2. Discussion

The orchid plants' number of leaves were not significantly different at all fertilizer concentration treatments, but it was still seen that the number of leaves tended to be higher when treated a hyponex concentration of 2.5 g/liter of water (Figure 1). The same thing for leaf length, leaf thickness, number and length of roots showed that the application of a hyponex concentration of 2.5 g/liter of water suggested better results which were significantly different from other treatments (Tables1,2,3 and 4). In addition to these results, it was also seen that there were different plant appearances such as better leaf smoothness and freshness at a hyponex concentration of 2.5 g/liter of water compared to other treatments. This is because the hyponex concentration of 2.5 g/liter of water is optimal amount needed to get the maximum effect on plant vegetative growth.

The existence of good vegetative growth allows plant metabolism to take place properly, such as the photosynthesis process by leaves and absorption of water and nutrients by orchid roots that encourage better plant growth. Salisbury and Ross (1995), stated that photosynthetic capacity increased with increasing number of leaves, leaf area and thickness with the assumption that other factors such as light, water, temperature, and nutrients were in optimal conditions.

Moreover, this fertilizer has quite high nitrogen nutrient (200 mg N) which is very good for young or at the seedling stage orchids. Fertilizer application is closely related to the vegetative and generative growth phases. Fertilization treated to young orchid plants should contain a lot of nitrogen with optimal doses. N serves to form amino acids (proteins), nucleic acids, nucleotides, and chlorophyll in plants, so that in the presence of N, plants are greener, accelerate plant growth (height, number of tillers, number of branches) and increase the protein content of crop yields.

The content of nutrient elements in fertilizers that are applied with concentrations that are according to plant needs will allow plants to grow and develop better. Plants treated with hyponex fertilizer with a higher concentration of 3.0 g/liter of water and 3.5 g/liter of water seemed to no longer encourage more active growth, but on the contrary, these concentrations began to suppress the rate of plant growth. This can be seen in all the observation parameters that are slower or lower in growth. Suseno (1981), states that for optimal plant growth, a balance of nutrients is needed. Furthermore, Setyamidjaja (1986), added that optimal fertilization efficiency can be achieved if fertilizer is treated in suitable amount needed by plants. Excess fertilizer can cause acidic planting media so that the soil texture tends to be harder and not friable. As a result, the activity of earthworms and microorganisms in the soil media can be disrupted. Furthermore, if the fertilizer treated exceeds the optimum concentration, it can cause poisoning in plants.

The low growth at the hyponex fertilizer concentrations of 1.0 g/liter of water and 2.0 g/liter of water, was suspected as the result of insufficient nutrient elements treated to orchid plants, resulted in slow growth.

D. Conclusion

Based on the results of the study, it can be concluded that hyponex fertilizer concentration of 2.5g/liter of water suggested the best results on the number of leaves, leaf length, leaf thickness, number and length of root of the *Phalaenopsis* orchid.

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Assessment of Soil Damage for Biomass Production in Slope Area Used as Agricultural Land in Tanggetada District, Kolaka Regency

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Abstract

This study aimed to assess the soil degradation level for biomass production in sloping areas used as agricultural land. This research was conducted in Tanggetada District, Kolaka Regency. This research was conducted using a field survey method with a slope class approach which is used as agricultural land with a slope of 8-15%, 15-25%, 25-45%, and > 45%. The results of the study show that the status of soil damage in sloped areas used as agricultural land in Tanggetada District, Kolaka Regency, for slope classes 8-15%, 15-25%, and 25-45% included in the lightly damaged category while slope classes >45% included in the moderately damaged category. The limiting factors for soil damage status at this location are surface rock, microbial count, bulk density, permeability, and redox

Keywords: soil damage, slope, agricultural land

A. Introduction

Soil is the most crucial component in an ecosystem that functions as a place to grow and can store water and nutrients that plants need. The utilization of land for the development of crops is adjusted to its capabilities. Land use not following its designation will damage soil, especially biomass. Soil damage for biomass production is a change like the soil that exceeds the standard criteria for soil damage caused by management actions that are not environmentally sound.

Over time, the increase in population growth has consequences for converting agricultural land into residential, industrial, infrastructure, and other uses. The increase in population growth also impacts increasing the need for food to meet the needs of life. On the other hand, agricultural land has been dramatically reduced, so people are forced to use land unsuitable for agricultural lands, such as land with steep slopes to grow crops.

The area of Tanggetada District is 44,165 Ha, with an area of land used for agriculture of 13,504.51 Ha. The types of plants cultivated are crops (horticultural food crops and plantation crops (BPS, 2021). Based on the interpretation of land use maps and topographic land maps, Farmers in Tanggetada Subdistrict used farmers as agricultural land with slope classes of 8-15%, 15-25%, 25-45%, and >45% covering an area of 7,302.81 Ha. Using land with steep slopes as agricultural land will cause soil damage for agricultural purposes. Biomass production in a sloping area used as agricultural land in Tanggetada District, Kolaka Regency.

B. Literature Review

1. Soil Biomass

Biomass is organic material derived from plants and animals composed of carbon (C), hydrogen (H), and oxygen (O) atoms. Biomass also includes gases and liquids from non-fossil materials and the degradation of organic matter. Biomass is formed from the interaction of carbon dioxide ($CO2_{)}$, air, water, soil, and sunlight (Basu, 2010). Biomass is an environmentally friendly energy source whose carbon source comes from $CO2_{in}$ the air. Combustion of biomass produces the same amount of $CO2_{as}$ is absorbed by the photosynthesis process (Reed and Das, 1988).

2. Slope

The slope of the slope is a specific height difference in the relief that exists in a landform. The land's slope shows the area's character that must be considered in the direction of land use. Each region's land slope is different but generally can be classified into several groups (Sinery, Rudolf, Hermanus, Samsul dan Devi, 2019). According to Gunawan (2011), the land slope class is classified into five types.

a. Mountainous with a slope of more than 45% (greater than 24°)
b. Hilly with a slope of 25-45% or 14°-24°
c. Wavy with a slope of 15-25% or 8°-14°
d. Sloping with a slope of 8-15% or 5-8°
e. Flat with a slope of 0-8% or 0-5°

The slope of the slope is very influential in the process of weathering and soil development, washing, and transport of soil. Soil erosion by water on sloping areas also causes the soil to erode and be transported, ultimately leaving less fertile soil so that soil and plant productivity decreases (Septianugraha and Abraham, 2014).

3. Soil Damage

Soil damage is a process or phenomenon of a decrease in the capacity of the soil to support life with the loss or decline of the function of the soil, both its function as a source of plant nutrients and its function as a matrix where plant roots are anchored and where water is stored. The process of soil damage is a process or phenomenon of a decrease in the ability of the soil to support life at this time or in the future caused by human activities (Roy, 2012). The land is a resource that is the mainstay in the socio-economic activities of the community, especially in developing countries. However, land resources are not sustainable resources. Land resources have changed due to natural processes and human activities. Changes due to natural processes are caused by changes in the earth's surface due to geomorphology. The ongoing geomorphological process will have a direct or indirect impact on the earth's surface's physical condition. The geomorphological process will result in a decrease in the quality and carrying capacity of the land, which in turn will cause land degradation.

Meanwhile, land degradation caused by human activities occurs due to the use of the environment by humans who ignore environmental balance. Land degradation is the loss or reduction of the potential use of land to support life. The loss or change in appearance causes it not to be replaced by others (Siregar, 2010).

C. Methology

1. Research Location

This research was conducted in March 2022. The study was located in Tanggetada District, Kolaka Regency, Southeast Sulawesi Province, and the sample analysis was carried out at the Analytical Laboratory of Halu Oleo University, Kendari.

2. Research procedure

This research was conducted using a field survey method with a slope class approach which is used as agricultural land with a slope of 8-15%, 15-25%, 25-45%, and >45%, identify the characteristics of the land.

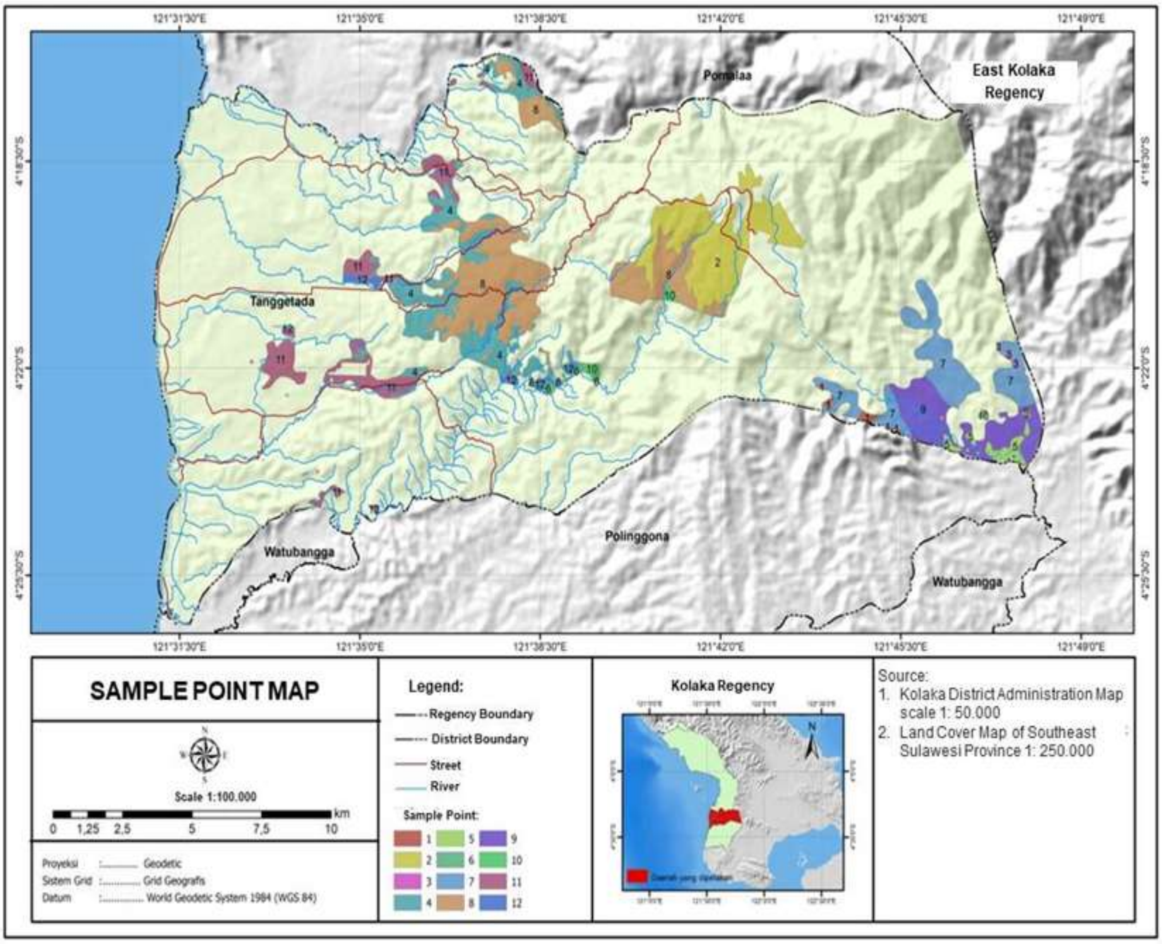

Figure 1. Map of Sample Points

Table 1. Description of Sample Points for Each Slope Class

Slope	Sample	Land Use	Area (Ha)
	1	Dryland farming	33.30
>45%	2	Mixed dry land farming	985.59
		Total	1018.89
	3	Dryland farming	11.10
	4	Mixed dry land farming	964.90
15-25%	5	Dryland farming	110.89
	6	Kebun Campuran	50.12
		Total	1137.00
	7	Dryland farming	734.21
	8	Mixed dry land farming	1487.00
25-45%	9	Dryland farming	569.61
	10	Mixed dry land farming	40.70
		Total	2831.53
	11	Mixed dry land farming	595.86
8-15%	12	Mixed dry land farming	75.80
		Total	671.66

3. Data analysis

Determine standard criteria for soil

Damage Evaluation of soil damage at the research site based on Government Regulation No. 150 of 2000 concerning Control of Soil Damage for Biomass Production Procedures for Measurement of Standard Criteria for Soil Damage for Biomass Production

Table 2. Soil Damage Standard Criteria

No.	Parameters	Critical threshold
1	Thickness	< 20 Cm
2	Surface rock	> 40%
3	Fraction composition	< 18% Colloid, > 80% quartz sand
4	Density	> 1,4 g/cm^3
5	Total porosity	<30 ; >70 %
6	Permeability	<0,7 >8 cm.jam^{-1}
7	pH (H2O) 1:2.5	< 4,5 ; >8,5
8	Electrical Conductivity	> 4,0 mS. cm^{-1}
9	Redox	< 200 mV
10	Microbial Count	<10^{2}cfu/g Soil

Source: Government Regulation No. 150 of 2000

Determination of soil damage status for biomass production

- ***Matching method***

Soil damage identification is carried out by the matching method, namely comparing the results of measurements of each parameter in the field and laboratory with the critical threshold determined in Government Regulation No. 150 of 2000. Matching is carried out at each sample point. Or point of view. Steps to determine the status of soil damage:

1. I calculated the relative frequency (%) of each parameter of soil damage.
2. Giving a score for each parameter based on its relative frequency value
3. Summarizing the score for each parameter of the soil damage criteria
4. Determining the status of soil damage based on the sum of the scores

- ***Scoring Method***

Method *scoring* is carried out by considering the relative frequency of soil classified as damaged in one land unit and then used to determine the category of soil damage status.

Table 3. Soil Damage Status Based on the Relative Frequency of Each Parameter

Relative Frequency of Damaged Soil (%)	Score	Soil Damage Status
0-10	0	Not Damaged
11-25	1	Damaged
26-50	2	Medium Damaged
51-75	3	Severely Damaged
6-100	4	Very heavily damaged

Source: Minister of Environment Regulation No. 7 of 2006

Table 4. Soil Damage Unit Based on Accumulated Value Soil Damage Score

Relative Frequency of Damaged Soil (%)	Class Soil Damage Status	Accumulated Value Soil Damage Score Land Dry
0-10	Not Damaged	0
11-25	Light Damage	1-14
26-50	Moderate Damage	15-24
51-75	Severe Damage	25-34
6-100	Very heavily damaged	35-40

Source: Ministry of Environment Regulation No. 7 of 2006

D. Result and Discussion

The causes of soil damage are caused by the nature of the soil and human activities that cause the land to be disturbed/damaged and unable to function anymore. Activities that use land and other natural resources uncontrollably can cause damage to the soil for biomass production, thereby reducing the quality and function of the soil, which in turn can threaten the survival of humans and other living things.

The analysis of the status of soil damage at the research site is based on the Regulation of the Minister of the Environment No. 7 of 2006 concerning Procedures for Measuring Standard Criteria for Soil Damage for Biomass Production, as well as data that affect the calculation of soil damage analysis. Analysis of soil damage status for each level of the slope is described in the following table:

Table 5. Soil Damage Status on Slope Class 8-15%

No.	Parameter	Sampel		FR	Skor
		1	2		
1	Solum thickness	120	96	0	0
2	Surface rock	6,25	6,25	0	0
3	Fraction composition				
	- Sand	66,12	51,6	0	0
	- Clay	5,76	26,32	0	0
4	Bulk density	1,57	1,27	50	2
5	Total porosity	27,94	50,74	50	2
6	Degree of water	3,21	2,66	0	0
7	Permeability	6,21	6,54	0	0
8	pH (H2O) 1:2.5	0,03	0,026	0	0
9	Redox	231	202	0	0
10	Total Microbes	137	100	0	0
Total Score					4
Soil Damage Status Slightly					Damaged
Limiting Factors					Bulk density and Soil Porosity

Based on observational data on soil damage used as agricultural land on slopes of 8-15%, including mild damage with inhibiting factors for bulk density and soil porosity. The ideal for biomass production is below 1.4 g/cm^3. One factor that affects plant growth is the high and low density of the soil. The denser the soil, the more difficult it will be for plant growth (Haridjaja, O., Hidayat, Y., dan Maryamah, L.S., 2010).

Table 6. Soil Damage Status on slope class 15-25%

No.	Parameter	Sampel				FR	Skor
		1	2	3	4		
1	Solum thickness	114	110	87	109	0	0
2	Surface rock	12.5	6.25	6.25	6.25	0	0
3	Fraction composition						
	- Sand	40.38	27.89	71.64	64.82	0	0
	- Clay	12.41	13.61	7.63	14.04	0	0
4	Bulk density	1.78	1.52	1.37	1.12	50	2
5	Total porosity	23.25	42.71	44.35	57.6	25	1
6	Degree of water	2.31	2.11	0.14	0.21	50	2
7	permeability (Permeability)	6.54	7.1	6.72	5.92	0	0
8	pH (H2O) 1:2.5	0.035	0.018	0.036	0.01	0	0
9	Redox	172	191	213	199	75	3
10	Total Microbes	102	156	112	122	0	0
Total Score							8
Soil Damage Status Slightly							Damaged
Limiting Factors							bulk density, porosity, redox

The status of soil damage on slopes of 15-25% is categorized as lightly damaged with inhibiting factors bulk density, porosity, and redox. The more sloping soil is, the more intensive erosion occurs, which causes loss of organic matter and nutrients in that location. The low content of organic matter will affect the density, soil porosity, redox, and the number of microbes in the soil. The density of the soil is an indication of the density of the soil. The denser the soil, the higher the weight of its contents, which means it is more difficult to pass water or penetrate plant roots. (Hardjowigeno, 1993). Hanafiah (2012) states that porosity reflects the level of ease of the soil to pass water flow (permeability) or the speed of water flow to pass through the soil mass (percolation).

Table 7. Status of soil damage on slope class 25-45%

No.	Parameter	Sampel				FR	Skor
		1	2	3	4		
1	Solum thickness	88	85	83	76	0	0
2	Surface rock	6.25	6.25	6.25	6.25	0	0
3	Fraction composition						
	- Sand	40.98	28.41	69.89	22.34	0	0
	- Clay	11.11	31.75	23.76	33.52	0	0
4	Bulk density	1.44	1.56	1.32	1.45	75	3
5	Total porosity	45.65	41.96	49.89	45.25	0	0
6	Degree of water	0.87	2.3	0.75	0.32	25	1
7	Permeability	6.2	6.22	6.57	6.31	0	0
8	pH (H2O) 1:2.5	0.068	0.002	0.035	0.03	0	0
9	Redox	229	223	212	209	0	0
10	Total Microbes	139	107	105	167	0	0
	Total Score						4
	Soil Damage Status Slightly						Light damage
	Limiting Factors						Bulk density and permeability

The status of soil damage on slopes of 25-45% is included in the category of light damage with inhibiting factors for bulk density and permeability. The value of density and permeability have implications for the ability of plant roots to reach water in the soil. This occurs due to intensive land use activities without any processing in the tillage layer, thus increasing soil density and bulk density. Arifin (2010) states that continuous intensive soil management without resting the soil and without adding organic matter damages the soil structure. This results in a decrease in soil permeability.

The increase in soil density is due to agricultural activities, which also affects the increase in soil density. Overall, the survey results show that the value of soil fill density increases with increasing soil depth, both in locations that produce high production and locations with low production. This follows Hardjowigeno (2003) statement that the higher bulk density causes the soil density to increase, and aeration and drainage are disturbed.

Table 8. Status of soil damage on slope class >45%

No.	Parameter	Sampel		FR	Skor
		1	2		
1	Solum thickness	54	73	0	0
2	Surface rock	50	50	100	4
3	Fraction composition				
	- Sand	22.62	21.85	0	0
	- Clay	14.88	37.22	0	0
4	Bulk density	1.56	1.42	100	4
5	Total porosity	22.11	29.67	100	4
6	Degree of water	0.15	0.13	100	4
7	permeability (Permeability)	5.31	6.11	0	0
8	pH (H2O) 1:2.5	0.025	0.032	0	0
9	Redox	178	169	100	4
10	Total Microbes	93	86	100	4
Total Score					24
Soil Damage Status Slightly					Moderate damage
Limiting Factors					Surface rock, bulk density, permeability,

	redox, and total microbes

Soil damage status on slopes >45% has moderate damage status with inhibiting factors: surface rock, bulk density, permeability, redox, and Total microbes. Soil with a slope of > 45% will experience high erosion, affecting the soil properties that affect biomass production. Andrian, Supriadi dan Purba M., (2014) and Kasmawati, Hasanah U., dan Rahman, A., (2016) stated that the more sloping the slope of the soil, the greater the water flow velocity on the surface so that the erosion of parts of the soil is more significant. Dela & Mardiatno (2012) stated that the flow velocity would increase with the more excellent slope value, and the carrying capacity of the crushed soil particles would be higher so that the erosion process would be even greater. One of the inhibiting factors at this location is the number of microbes. Microbes are one of the critical factors in the soil ecosystem because they can affect the cycle and availability of nutrients for plants and the stability of soil structure. Biomass formation is also influenced by many other factors, namely temperature and humidity (Joergensen, R.G., P.C Brookes and D.S Jenkinson, 1990). The ideal microbial count for biomass production is more significant than 10^2cfu/g soil. Soil with high micro-organisms will accelerate the process of biomass decomposition that plants can utilize.

E. Conclusion

Based on the results of the assessment of the status of soil damage on sloped areas used as agricultural land in Tanggetada District, Kolaka Regency, for the slope class 8-15%, 15-25%, and 25-45%, including the category of mild damage while the slope class >45% belongs to the damaged category. Currently. The limiting factors for soil damage status at this location are surface rock, number of microbes, bulk density, permeability, and redox.

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The Effect of BAP Concentration on *In-Vitro* Mutant Taro Regeneration

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Abstract

Plant regeneration through invitro culture is strongly influenced by the use of growth regulators. BAP is a class of cytokinins that affect cell division which is very well used to stimulate plant growth. The aim of the study was to determine the effect of BAP concentration on the regeneration of various *in vitro* mutant taro. The study was carried out at the Plant Tissue Culture Laboratory, Faculty of Agriculture, Hasanuddin University, Makassar. The method used was factorial completely randomized design with 2 factors as the environmental design. The first factor was the BAP concentrations of 0.0 mg/L, 1.0 mg/L, 1.5 mg/L, 2.0 mg/L and 2.5 mg/L. The second factor was mutant plants consisting of control plants (diploid), mutant 1 (*Putative-Tetraploid),* mutant 2 (Mixoploid), mutant 3 (Mixoploid), and mutant 4 (*Putative-Tetraploid*). The results showed that the best regeneration was obtained by BAP concentration of 0 mg/L with control plants on the parameters of root length (2.41 cm), number of roots (11.66 pieces) and plantlet formation rate (13 days). The BAP concentration of 1 mg/L was shown by mutant plant 1 on the parameters of the number of shoots (26 pieces) and number of leaves (16 pieces). BAP concentration of 0 mg/L in mutant 4 had a shoot height of 1.83 cm. The results of ploidy flow cytometry analysis of mutant plants *with Putative-Tetraploid* parental traits after regeneration resulted in detectable diploid chromosomes that were different from the parent types in all BAP concentration treatments

Keywords: BAP, taro, mutant, in vitro

A. Introduction

One commodity that currently has high prospects with increasing international market demand, especially in Japan, is taro satoimo (*Colocasia esculenta* var. antiquorum). The Satoimo taro commodity belongs to the genus Araceae which is easy to cultivate and has a fairly high level of productivity. The high demand for satoimo taro commodity from Japan opens wider opportunities in satoimo taro cultivation (Amelia & Yumiati, 2016).

Satoimo (*Colocasia esculenta* (L.) Schott var antiquorum) is a type of taro that is classified as small corm taro or known as Japanese taro which is traded internationally. About 50% of Japan's population of ±120 million people, consume satoimo as a staple food other than rice. Thus, the current demand for Japanese taro reaches ± 360,000 tons per year, while production capacity in Japan continues to decline to 250,000 tons per year due to limited land and climatic factors that do not allow farming throughout the year (SEAMEO, 2013). This condition opens up opportunities for Indonesian exports to Japan and has encouraged local governments in Indonesia, including Kepahiang, Cisarua, Bantaeng, Malang, and Buleleng to encourage farmers to develop satoimo as an export commodity (Maretta, D., Handayani, D. P., Rosdayani, H., dan Tanjung A., 2016). The productivity of Japanese taro in several districts in South Sulawesi province during 2019-2020 can be seen in the table 1.

Table 1. Planted Area, Harvest Area, Productivity and Production of Japanese Taro in South Sulawesi Province

No	District/City	Planted Area (ha) MT 2020/2021	Harvest Area (ha)	Productivity (kw/ha)	Production (ton)
1.	Maros	27.49	27.49	167.33	460
2.	Gowa	25.11	25.11	156.11	392
3.	Takalar	16.75	16.75	277.01	464
4.	Jeneponto	19.75	19.75	312.52	635
5.	Bone	20.90	20.90	342.11	715
6.	Soppeng	15.60	15.60	971.15	1.515
7.	Wajo	3.25	3.25	455.38	148
8.	Luwu	10.25	10.25	190.24	195
9.	Luwu Utara	19.60	19.60	119.90	235
10.	Luwu Timur	19.30	19.30	696.89	1.345
11.	Enrekang	20.00	20.00	341.50	698
12.	Toraja Utara	10.00	10.00	280.30	380
13.	Makassar	1.00	1,00	28.82	32
	Total	209.00	209.00	345	7.214

Source: Food Security Service of South Sulawesi, 2021

The development of Japanese taro cultivation has resulted in the need for continuous availability of sufficient seeds, but is often constrained by season, land availability, and long planting duration. Therefore, plant tissue culture has been developed to produce plants in large quantities and in a short time, free of pests and diseases, does not depend on the season and requires less initial seeds (Maretta *et al*., 2016). One of the important stages in tissue culture is shoot multiplication which is the most basic method that must be mastered to be able to produce plants in large quantities. Growth regulators and other compounds such as appropriate vitamins in *in-vitro* culture are needed so that they can produce plantlets in large quantities efficiently.

One of the growth regulators that plays a role in shoot multiplication is Benzylaminopurin (BAP). BAP is one of the cytokinin group hormones with the ability to induce tiller shoots which is higher than other types of cytokinins such as kinetin and 2-ip, because BAP is not easily damaged and is more stable in the media so that the amount available in the media is more than other type of cytokinin. The BAP-driven growth includes faster cell division and enlargement (Ilham, M., Sugiyono dan Prayoga, L., 2019).

The use of BAP and several other compounds in culture media may stimulate shoot proliferation because of the synergism between these compounds (Lestari, 2011). Paulos, M., V.R. Joshi & S.R. Pawar (2015) reported that the average number of shoots in-vitro of Banana (*Musa paradisiaca* cv Grand Naine on MS medium with BAP concentration of 5 mg/L produced 2.6 shoots at 30 days after induction (Maretta *et al*., 2016). In addition, a research conducted by Wulansari, A., Martin AF, Rantau DE, Ermayanti TM (2014) reported that BAP and vitamins including thiamine and adenine can trigger shoot growth in taro which can support the multiplication of *in vitro* taro shoots.

Based on the description above, it is necessary to conduct research on the regeneration of various Japanese taro mutants at various concentrations of BAP *In-Vitro*.

B. Methology

1. Research Design and Procedures

The research was conducted at the Plant Tissue Culture Laboratory, Department of Agricultural Cultivation, Faculty of Agriculture, Hasanuddin University, Makassar, South Sulawesi. The study was conducted in May-November 2022. The method used was complete randomized design with 2 factors as the environmental design with BAP as the first factor and mutant plants as the second factor. While the levels of BAP (Z) used were concentrations of 0.0 mg/L (z0), 1.0 mg/L (z1), 1.5 mg/L (z2), 2.0 mg/L (z3) and 2.5 mg/L (z4). While the treatment of mutant plants (M) was diploid control (mo), 1 c1t1 putative-Tetraploid mutant, (m1), 2 c2t1 mixoploid mutants (m2), 3 c3t1 mixoploid mutants (m3), 4 c2t2 putative-Tetraploid mutants (m4). Thus, the treatment consisted of 25 treatment combinations. Each treatment was repeated 3 times with each replication using 3 shoot heads so that there were 225 experimental units. All media used were added with 0.2 mg/L IBA.

The research procedure begins with sterilizing bottles and equipment using an autoclave at a temperature of 121 ^{0}C with a pressure of 17.5 psi for one hour. Furthermore, the preparation of regeneration media was carried out by dissolving MS (according to the composition) + 30 g/L sucrose +0.2 mg/L IBA + BAP (according to the treatment concentration) which was then made up to 1000 ml using distilled water. Furthermore, the pH was adjusted to 5.8 by adding NaOH or HCl. Subsequently, the solution was put into a pot and 7 grams of agar was added. The media was heated on an electric stove while stirring until it was close to the boiling point of 98°C. After the media boiled, the media was removed and poured into culture bottles of 25 ml each. Culture bottles were covered with aluminum foil and tied with rubber bands. The media was sterilized by autoclaving at a pressure of 10 psi for 15 minutes. Culture bottles containing the media were placed on the culture rack for 1 week to determine the sterility of the media. In the planting process, Japanese taro mutants were taken from culture bottles and then cut into pieces and planted into regeneration media. The regeneration medium used was MS media with the addition of a combination of BAP + IBA according to treatment. The shoots were kept in an incubation room at a temperature of 25-26°C with 16 hours/day irradiation and an irradiation intensity of ±1,000-2,000 lux. Shoots were incubated for 4 months and observed every week.

Parameters observed were number of roots (cm), root length, number of shoots (fruit), shoot height (cm), number of leaves (pieces) and plantlet formation rate (days). In plants with the best growth, polyploidy level analysis was performed using Flowcytometry (CyFlow (R) Space, Partec, Germany). Samples were taken from the leaves of ± 25 mm^2 of the treated plants. The sample was then ground using a razor blade in a petri dish with 0.2 ml of extraction buffer (solution A from Partec Kit), then incubated for 10 minutes at room temperature. The supernatant from the sample was then filtered using 30 µm nylon mesh and placed in a cuvette, then was added with 1 ml of DAPI solution. The sample was then incubated for 1 minute. The sample was then inserted into a tool called Flowcytometry. The tool will read the light intensity from the sample to show the number of ploidy changes that occur which are shown through the graph displayed in the tool.

2. Data Analysis

The data obtained were analyzed using analysis of variance (ANOVA) and further tested with the DMRT (Duncan's Multiple Range Test) test at a significance level of 5% using STAR Software (Statistical Tool for Agricultural Research). Furthermore, the treatments with the best results were analyzed for chromosomes using Flowcytometry.

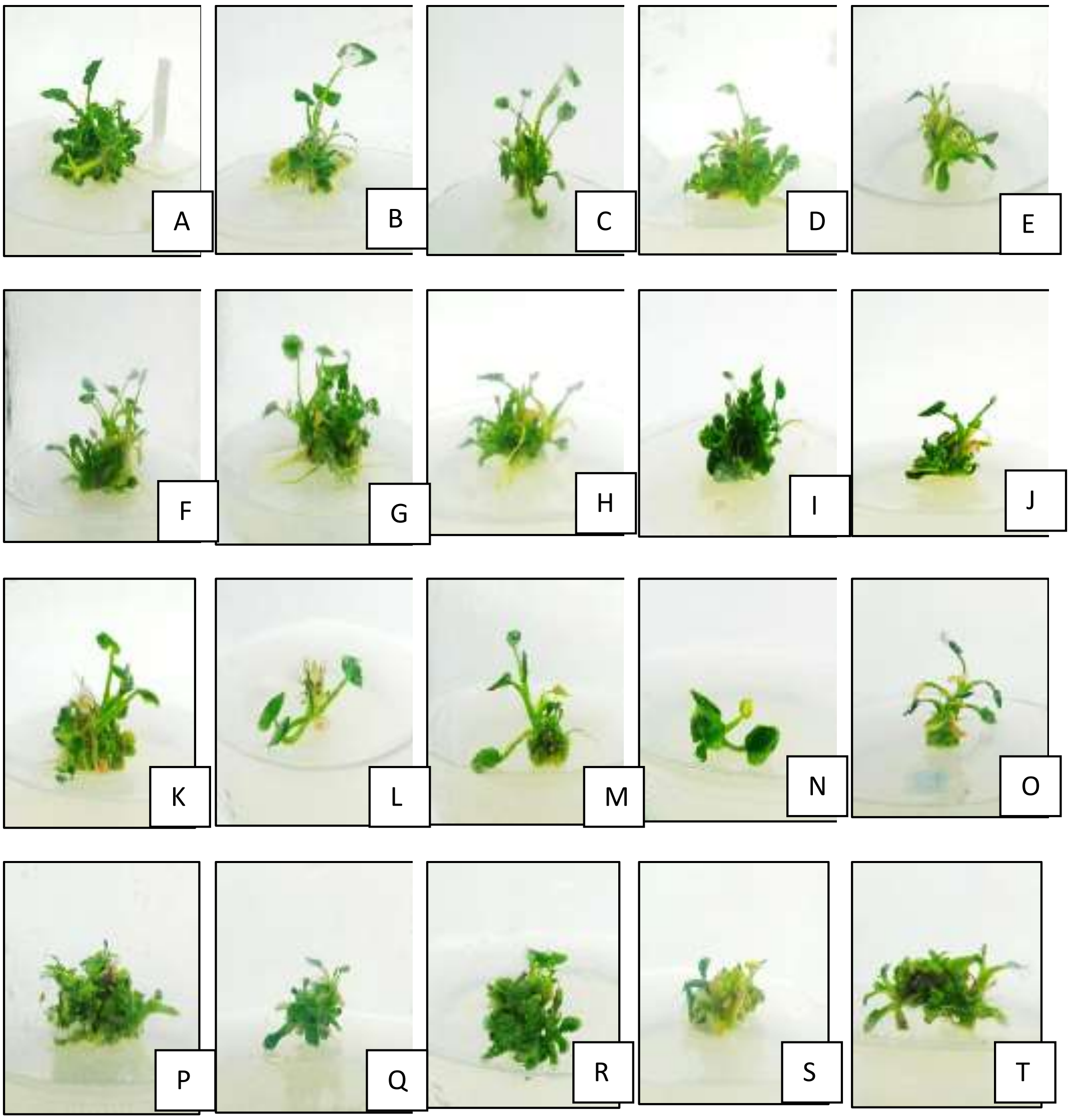
C. Result and Discussion

The results of the mid-square analysis of variance in the mutant taro regeneration experiment using BAP *in vitro* are shown in Table 2. The results of the analysis showed that the concentration of BAP and mutant plants significantly affected all parameters including root number, root length, number of shoots, shoot height, number of leaves, and plantlet formation rate.

Table 2. Mid-Square Analysis of Varian on Several Observation Parameters in Regeneration Experiments of Mutant Taro Using BAP *In Vitro*

SK	DB	Middle Square					
		JT	TT	JA	PA	JD	KMP
M	1	209.963**	0.525**	23.638**	1.108**	84.219**	474.560**
Z	3	76.77**	0.194**	37.233**	1.627**	69.566**	3277468**
MxZ	3	81.57**	0.108**	12.530**	0.332**	30.905**	34.015**
Error	16	3.051	0.010	0.123	0.005	0.692	14.002
KK		10.35%	8.97%	12.85%	9.31%	11.79%	12.28%

Description: **: very significant effect, *: significant effect, tn: no significant effect, SK: source of diversity, DB: degrees of freedom, KK: coefficient of diversity, M: mutant plant, Z: concentration of BAP, JT: number of shoots, TT: shoot height, JA: number of roots, PA: root length, JD: number of leaves, KMP: plantlet formation rate.



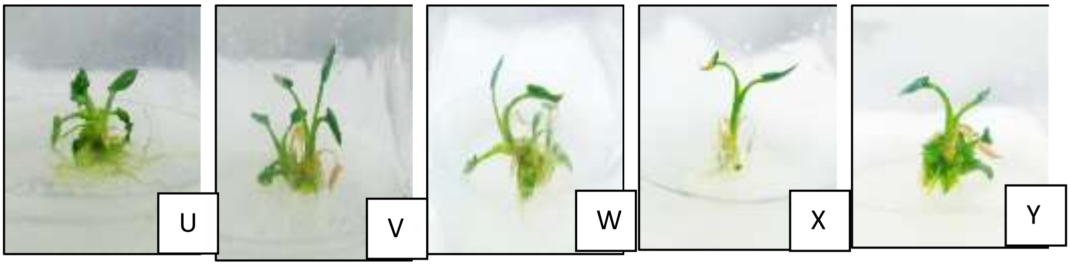


Figure 1. **Appearance of Various Taro Plants with Various Concentrations of BAP *In-Vitro* after 16 MST**

Description: (A) z0m0 (BAP mg/L control plant); (B) z1m0 (BAP 1 mg/L, control plant); (C) z2m0 (BAP 1.5 mg/L, control plant); (D) z3m0 (BAP 2 mg/L, control plant); (E) z4m0 (BAP 2.5 mg/L, control plant); (F) z0m1 (BAP 0 mg/L, mutant plant 1); (G) z1m1 (BAP 1 mg/L, mutant plant 1)); (H) z2m1 (BAP 1.5 mg/L, mutant plant 1); (I) z3m1 (BAP 2 mg/L, mutant plant 1); (J) z4m1 (BAP 2.5 mg/L, mutant plant 1) ; (K) z0m2 (BAP 0 mg/L, mutant plant 2); (L) z1m2 (BAP 1 mg/L, mutant plant 2); (M) z2m2 (BAP 1.5 mg/L, mutant plant 2); (N) z3m2 (BAP 2 mg/L, mutant plant 2); (O) z4m2 (BAP 2.5 mg/L, mutant plant 2); (P) z0m3 (BAP 0 mg/L, mutant plant 3); (Q) z1m3 (BAP 1 mg/L, mutant plant 3); (R) z2m3 (BAP 1.5 mg/L, mutant plant 3); (S) z3m3 (BAP 2 mg/L, mutant plant 3); (T) z4m3 (BAP 2.5 mg/L, mutant plant 3); (U) z0m4 (BAP 0 mg/L, mutant plant 4); (V) z1m4 (BAP 1 mg/L, mutant plant 4); (W) z2m4 (BAP 1.5 mg/L, mutant plant 4); (X) z3m4 (BAP 2 mg/L, mutant plant 4); (Y) z4m4 (BAP 2.5 mg/L, mutant plant 4).

The difference in morphology of various mutant taro plants to the level of BAP concentration can be seen in Figure 1.

The treatment of BAP concentration and mutant plants was found to affect the morphological characteristics of the regenerated plants under in vitro conditions. The results of ANNOVA analysis from observations to cultures aged 16 WAP showed that the interaction of BAP concentration treatment and mutant plants had a very significant effect on the morphology of taro *Safira*.

Table 3. The Effect of BAP Concentration on Root Amount of *In Vitro* Mutant Taro *Safira*

Mutant Plant	BAP concentration				
	z0 (0 mg/L)	z1 (1.0 mg/L)	z2 (1.5 mg/L)	z3 (2.0 mg/L)	z4 (2.5 mg/L)
m0 (Control)	11.66_p^a	4.33_q^b	2.16_r^a	1.50_s^b	2.00_{rs}^a
m1 (Mutant 1)	3.50_q^c	8.66_p^a	2.00_r^a	3.00_q^a	1.16_s^b
m2 (Mutant 2)	2.55_p^e	2.66_p^c	1.66_q^{ab}	1.16_q^a	1.27_q^b
m3 (Mutant 3)	1.66_p^d	1.27_{pq}^d	1.33_{pq}^b	1.00_q^a	1.16_{pq}^b
m4 (Mutant 4)	4.33_p^b	3.78_p^b	1.66_q^{ab}	1.50_q^b	1.44_p^{ab}

Description: numbers followed by the same letter in rows (abcd) and columns (pqrs) means that they are not significantly different in the DMRT test with a level of = 0.05

The DMRT test = 0.05 in Table 3 shows that the interaction of treatment media without BAP (z0) with control plants (mo) had the highest average number of roots, namely 11.66 pieces, which was significantly different from all treatments of mutant plant species (m1, m2, m3, m4). Control plants (mo) without BAP treatment (z0) had a significantly different average root length with all BAP concentration treatments (z1, z2, z3, z4). The difference in the number of roots was due to the different levels of BAP or cytokinin content in the regeneration medium, thus affecting the number of shoots formed. According to Hattu, W., Parera Dj, F., dan Raharjo S. H. T., 2018), the use of BAP may inhibit root initiation, elongation, and development. In addition, the type of explant affects the number of roots formed. Sinaga (2020) reported that in taro *Kaliurang,* root growth in diploid clones was better than that of tetraploid clones.

Table 4. The Effect of BAP Concentration on Root Length (cm) of *In Vitro* Mutant Taro *Safira*

Mutant Plant	BAP concentration				
	z0 (0 mg/L)	z1 (1.0 mg/L)	z2 (1.5 mg/L)	z3 (2.0 mg/L)	z4 (2.5 mg/L)
m0 (Control)	2.41_{p}^{a}	1.16_{q}^{a}	0.98_{r}^{a}	0.63_{s}^{b}	0.56_{s}^{a}
m1 (Mutant 1)	1.16_{pq}^{c}	1.10_{qr}^{a}	1.00_{r}^{a}	1.25_{p}^{a}	0.33_{s}^{b}
m2 (Mutant 2)	0.60_{p}^{e}	0.72_{p}^{b}	0.70_{p}^{b}	0.33_{q}^{a}	0.38_{q}^{b}
m3 (Mutant 3)	0.76_{p}^{d}	0.55_{q}^{c}	0.40_{r}^{c}	0.55_{q}^{a}	0.33_{r}^{b}
m4 (Mutant 4)	1.66_{p}^{b}	0.66_{q}^{bc}	0.63_{qr}^{b}	0.58_{qr}^{b}	0.53_{r}^{a}

Description: numbers followed by the same letter in row (abcde) and column (pqrs) mean not significantly different in DMRT test with level α = 0.05

The DMRT test at α = 0.05 in Table 4 shows that the interaction of treatment media without BAP (z0) on control plants (mo) showed the best average root length of 2.41 cm which was significantly different from all mutant plant treatments (m1, m2, m3, m4). Control plant (mo) without BAP treatment (z0) had an average root length that was significantly different from all BAP concentration treatments (z1, z2, z3, z4). It is suspected that this is due to the different ZPT content in the growth medium of taro plants and also to differences in endogenous auxin in mutant plant tissues. Widiastoety (2014) states that the formation of explant roots is related to the levels of endogenous cytokinins and auxins in plant tissues, followed by the process of elongation and division of meristematic cells. According to Pamungkas (2015), higher BAP concentrations will reduce root length in explants.

Table 5. The Effect of BAP Concentration on Number of Shoots of *In Vitro* Mutant Taro *Safira*

Mutant Plant	BAP concentration				
	z0 (0 mg/L)	z1 (1.0 mg/L)	z2 (1.5 mg/L)	z3 (2.0 mg/L)	z4 (2.5 mg/L)
m0 (Control)	24.16_{p}^{a}	22.50_{p}^{b}	11.66_{r}^{a}	10.33_{r}^{c}	16.05_{q}^{b}
m1 (Mutant 1)	10.33_{q}^{c}	26.00_{p}^{a}	12.66_{q}^{a}	24.16_{p}^{a}	11.83_{q}^{c}
m2 (Mutant 2)	22.83_{pqr}^{a}	20.22_{r}^{b}	21.11_{qr}^{a}	24.50_{p}^{a}	23.89_{pq}^{a}
m3 (Mutant 3)	13.00_{p}^{c}	7.66_{s}^{d}	11.33_{qr}^{a}	19.83_{p}^{cb}	8.50_{rs}^{d}
m4 (Mutant 4)	16.00_{qr}^{b}	11.61_{s}^{c}	13.50_{rs}^{a}	21.16_{p}^{c}	16.89_{q}^{b}

Description: numbers followed by the same letter in row (abcde) and column (pqrs) mean not significantly different in DMRT test with level α = 0.05

The DMRT test at α = 0.05 in Table 5 shows that the interaction of media with BAP treatment at a concentration of 1.0 mg/L (z1) on mutant plants 1 (m1) showed the highest average number of shoots, which was 26 fruit which was significantly different from the treatment on mutant plants (m0, m2, m3, m4). In the treatment of mutant plant 1 (m4) without BAP treatment of 1.0 mg/L (z1), the average shoot height was not significantly different from the BAP concentration of 2.0 mg/L (z3) which was 24.16 pieces and significantly different from the BAP concentration treatments (z0, z2, z3, z4). It indicated that the mutant plants had more shoots than the control plants. This is in line with Sinaga (2020), the difference in the characters of diploid and tetraploid taro *Kaliurang* is seen in the higher number of tetraploid shoots compared to the diploid. Furthermore, the different BAP concentrations also affected the number of shoots formed. According to Lestari (2011), BAP functions to encourage the formation, multiplication, and growth of shoots in various plants so as to increase their effectiveness in plant propagation.

Moreover, Gowen (1995) states that *in vitro* shoot formation is influenced by the presence of high levels of cytokinins in culture media, and the most effective type of cytokinin is BAP.

Table 6. The Effect of BAP Concentration on Shoot Height (cm) of *In Vitro* Mutant Taro *Safira*

Mutant Plant	BAP concentration				
	z0 (0 mg/L)	z1 (1.0 mg/L)	z2 (1.5 mg/L)	z3 (2.0 mg/L)	z4 (2.5 mg/L)
m0 (Control)	1.00^{a}_{ps}	1.33^{a}_{pq}	1.50^{a}_{p}	1.25^{a}_{qr}	1.11^{a}_{rs}
m1 (Mutant 1)	1.16^{a}_{pq}	1.33^{bc}_{p}	1.00^{bc}_{q}	1.00^{bc}_{q}	1.08^{a}_{q}
m2 (Mutant 2)	1.02^{a}_{q}	1.50^{b}_{p}	1.02^{b}_{q}	1.00^{bc}_{q}	1.08^{a}_{q}
m3 (Mutant 3)	0.66^{b}_{r}	1.01^{dc}_{p}	0.83^{c}_{qr}	0.90^{c}_{pq}	0.80^{b}_{qr}
m4 (Mutant 4)	1.83^{a}_{p}	1.44^{b}_{q}	1.16^{b}_{r}	1.16^{ab}_{r}	1.11^{a}_{r}

Description : numbers followed by the same letter in row (abcde) and column (pqrs) mean not significantly different in DMRT test with level α = 0.05

The DMRT test at α = 0.05 in Table 6 shows that the interaction of media without BAP treatment (z0) on mutant plant 4 (m4) showed the highest average shoot height of 1.83 cm which was significantly different from all treatments of mutant plant species (m0, m1 , m2, m3). In the treatment of mutant plants 4 (m4) without BAP treatment (z0), it showed a significantly different average shoot height with all BAP concentration treatments (z1, z2, z3, z4). The presence of ZPT cytokinin content in the media may cause cell elongation and enlargement which tends to lead to the formation of shoots. According to Lestari (2011), the use of BAP and several other compounds in culture media may stimulate shoot proliferation due to the synergism between these compounds. The difference in shoot growth at the same concentration is thought to be caused by differences in the content of endogenous hormones in the explant tissue, which will give different organ growth. Furthermore, the composition of the media for each type of plant is not the same or specific due to different genotypes and plant physiological conditions (Lestari, 2011).

Table 7. The Effect of BAP Concentration on Number of Leaves of *In Vitro* Mutant Taro *Safira*

Mutant Plant	BAP concentration				
	z0 (0 mg/L)	z1 (1.0 mg/L)	z2 (1.5 mg/L)	z3 (2.0 mg/L)	z4 (2.5 mg/L)
m0 (Control)	9.05^{b}_{qr}	12.00^{b}_{p}	8.16^{a}_{rs}	6.83^{a}_{s}	9.94^{b}_{q}
m1 (Mutant 1)	6.66^{c}_{q}	16.00^{a}_{p}	3.50^{c}_{r}	4.00^{bc}_{r}	4.00^{c}_{r}
m2 (Mutant 2)	15.72^{a}_{p}	7.33^{c}_{r}	5.94^{b}_{s}	5.33^{b}_{s}	14.22^{a}_{q}
m3 (Mutant 3)	2.00^{d}_{s}	7.16^{c}_{p}	5.83^{b}_{p}	3.33^{c}_{qr}	3.50^{c}_{q}
m4 (Mutant 4)	7.66^{c}_{p}	7.33^{c}_{p}	3.16^{c}_{q}	3.83^{c}_{q}	3.89^{c}_{q}

Description : numbers followed by the same letter in row (abcde) and column (pqrs) mean not significantly different in DMRT test with level α = 0.05

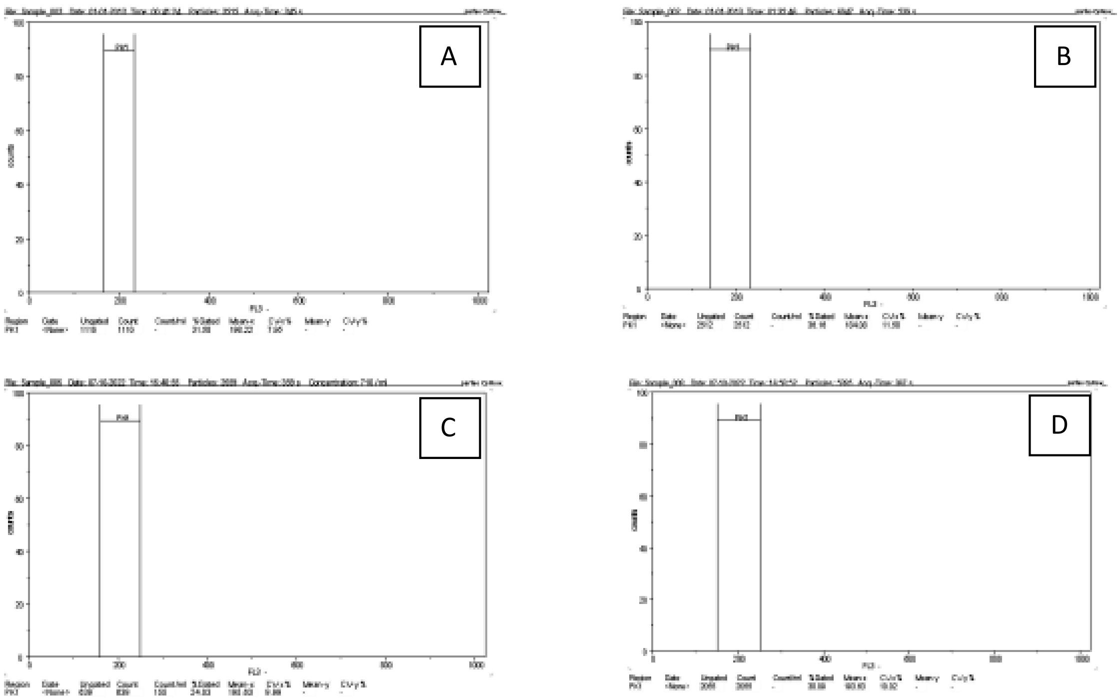
The DMRT test at α = 0.05 in Table 7 shows that the interaction of media treatment with BAP concentration of 1.0 mg/L (z1) on mutant plant 1 (m1) showed the highest average number of leaves, which was 16 pieces which were significantly different from all treatments in mutant plants (m0, m2, m3, m4). In the treatment of mutant plant 1 (m1) at the concentration of BAP of 1.0 mg/L (z1), the average number of leaves was significantly different from all treatments with BAP concentration (z0, z2, z3, z4). All types of mutants were able to produce leaves although grown in media without cytokinins. This condition occurred due to the use of MS media which had met sufficient nutrient intake for the explants to form leaves. According to Joni Y., Efendi, D., dan Roostika, I. (2014), MS media is known to have a high nitrogen content. The high nitrogen content may increase the cytokinin content in plants. The difference in the number of leaves is thought to be caused by the type of mutant plant that contains different endogenous cytokinins so that the addition of the same BAP will produce a different number of leaves. According to Hartmann and Kester (1983), different plants may respond to cytokinin and auxin hormones in different concentrations. This is caused by differences in the concentration of the endogenous hormone content of the plant itself. Cytokinins first accumulate in the roots, then in the xylem fluid, and finally in the leaves.

Table 8. The Effect of BAP Concentration on the plantlet formation rate (HST) of *In Vitro* Mutant Taro *Safira*

Mutant Plant	BAP Concentration				
	z0 (0 mg/L)	z1 (1.0 mg/L)	z2 (1.5 mg/L)	z3 (2.0 mg/L)	z4 (2.5 mg/L)
m0 (Control)	13.27_{r}^{b}	15.33_{r}^{b}	18.83_{r}^{c}	30.00_{q}^{c}	39.33_{p}^{d}
m1 (Mutant 1)	16.16_{r}^{ab}	16.00_{r}^{b}	20.33_{r}^{c}	33.33_{q}^{c}	47.00_{r}^{c}
m2 (Mutant 2)	19.55_{r}^{ab}	17.66_{r}^{ab}	22.66_{sr}^{bc}	41.33_{q}^{b}	5366_{p}^{b}
m3 (Mutant 3)	21.00_{s}^{a}	23.66_{rs}^{a}	29.33_{r}^{a}	52.33_{q}^{a}	60.0_{r}^{a}
m4 (Mutant 4)	19.66_{r}^{ab}	20.00_{r}^{ab}	27.66_{q}^{ab}	50.66_{p}^{a}	53.22_{p}^{b}

Description : numbers followed by the same letter in row (abcde) and column (pqrs) mean not significantly different in DMRT test with level α = 0.05

The DMRT test = 0.05 in Table 8 shows that the interaction of media concentrations without BAP treatment (z0) on control plants (mo) showed the average plantlet formation rate of 13.27 days which was significantly different from all treatments in mutant plants (m1, m2, m3, m4). In control plants (mo) without BAP treatment (z0), it had an average plantlet formation rate that was not significantly different with BAP concentration of 1.0 mg/L (z1) which was significantly different from other BAP concentrations (z2, z3, z4). It is presumably due to control that a plant with diploid cells has a faster cell division orientation compared to polyploid mutant plants. Comai (2005) states that polyploid plants have a larger nucleus size which causes the cell division process to be more complicated and take longer. This condition is also associated with the activation and suppression of gene expression. In addition, Gantait S., N. Mandal, S. Bhattacharyya, & PK Das (2011) reported that the growth of tetraploid plants was considered slower than diploid plants which also occurred in ornamental plants *Gerbera jamesonii* Bolus cv.



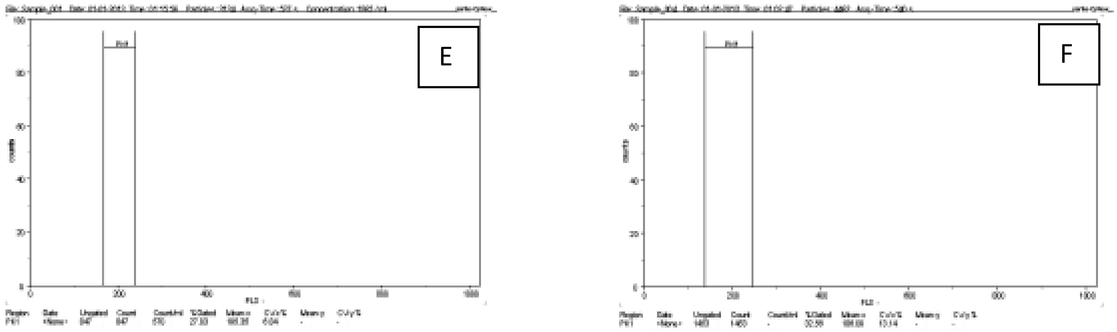


Figure 2. Graph of Ploidy Degrees with Flow Cytometry of mutant 4 taro resulted of regeneration of various BAP concentrations *In Vitro*

Description: (A) z0m0 (BAP 0 mg/L, control mutant plant); (B) z0m4 (BAP 0 mg/L, mutant plant 4); (C) z1m4 (BAP 1 mg/L, mutant plant 4); (D) z2m4 (BAP 1.5 mg/L, mutant plant 4); (E) z3m4 (BAP 2 mg/L, mutant plant 4); (F) z4m4 (BAP 2.5 mg/L, mutant plant 4).

Flow cytometry analysis is a modern method for determining the ploidy level in plants. Flow cytometry has proven to be a fast and efficient method for estimating the ploidy level in almost all plant tissue regeneration, and is particularly suitable for studies involving large sample sizes (De, K.K., Saha, A., Tamang, R., Sharma, B., 2010; Eeckhaut T. Leus, L. Van Huylenbroeck, J., 2005). Jones, J.R. G.T. Ranney, & T.A. Eaker (2008) used flow cytometry to determine the ploidy level and genome size of 200 diverse species and Rhododendron cultivars which are now a valuable database for plant breeders. Flow cytometry was also used to determine the ploidy level of polyploid adventitious shoots induced from three *Rhododendron* hybrids.

According to the ploidy analysis using flow cytometry on samples of mutant taro plants with putative-tetraploid parental traits at various BAP concentrations (figure 2), it shows that all samples regenerating at various BAP concentrations did not produce putative-tetraploid traits like its parent type yet produced plants with a detectable diploid chromosome. The percentage (%) gated at 0 mg/L (z0) BAP concentration in control plants (m0) was 31.58%, BAP concentration of 0 mg/L (z0) in mutant 4 (m4) was 36.16%, BAP concentration (z1) of 1 mg/L in mutant 4 (m4) was 24.03%, BAP concentration of 1.5 mg/L (z2) in mutant 4 (m4) was 38.09%, BAP concentration of 2 mg/L (z3) in mutant 4 (m4) was 27.03%, BAP concentration of 2.5 mg/L (z4) in mutant 4 (m4) was 32.56%. Chromosomal differences detected after regeneration were due to the putative-tetraploid parental trait which showed the dominant chromosome, namely 4n (tetraploid) with a percentage of 35.50% but did not show much difference with chromosome 2n (diploid) with a percentage of 29.94% and 3n (triploid) with a percentage of 15.39 % so that this allows the occurrence of ploidy selection. Variations found in regenerated plants tend to be caused by variations that are inherited by the plant of parent type. This is supported by Esfahani *et al.* (2020) that polyploidy induction and high percentage of mixoploid yields are generally considered to be drawbacks of the procedure because the unstable polyploidy state often returns partially or completely to the diploid state after successive cell divisions of two different developmental cycles of cells in the mixoploid shoots leading to competition during its growth. According to Kainth & Grosser (2010), diploid cells have a faster division rate than autotetraploid cells, allowing the resulting mixoploid shoots to turn back into diploids.

D. Conclusion

MS media containing different concentrations of BAP caused different growth in mutant taro. Mutant plant parent types (diploid, mixoploid, putative-tetraploid) at the same media concentration also produced different growth. Diploid cells have a faster division rate than polyploid cells. The interaction of BAP treatment that showed the best regeneration was the concentration of 0 mg/L in the control plants with the parameters of root length (2.41 cm), number of roots (11.66 pieces) and plantlet formation rate (13 days). Concentration of BAP of 1 mg/L in mutant plant 1 showed the parameters of the number of shoots (26 pieces) and number of leaves (16 pieces). Concentration of BAP of 0 mg/L in mutant plant 4 had a shoot height of 1.83 cm.

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Characterization of M8 Wheat Mutant Adaptability to Low Land

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Abstract

The wheat requirement in Indonesia is still fulfilled by import, which increases annually. To reduce the import dependence, Indonesia is required to elevate the domestic wheat production appropriate to the Indonesian agroclimatic condition by wheat plant breeding mutation. This study was aimed to characterize several mutant wheat commodities, that are adaptive to lowland condition. The experiment was arranged in a completely randomized block design with 16 observed-wheat genotypes (G). The wheat genotypes used were: 1) (G1) N1 200 2.4.B.6, 2) (G2) N 200 2.3.3, 3) (G3) N 200 2.5.2, (G4) N 350 3.6.2, (G5) N 350 3.7.1, (G6) N 300 3.6.1, (G7) N 350 3.1.3, (G8) N 250 3.7.1, (G9) M 200 1.7.1, (G10) S 300 7.9.1, (G11) S 300 2.1, (G12) D 200, and several comparative varieties, such as (G13) *Guri-3*, (G14) *Selayar*, (G15) *Nias*, and (G16) *Dewata*. The results obtained that the lowland-adapted M8 wheat mutant with high productivity level was found in N 200 2.4.B.6 (2.75 $t.ha^{-1}$), N 200 2.3.3 (2.69 $t.ha^{-1}$), and D 350 3.6.2 (2.35 $t.ha^{-1}$). Characters with the highest heritability level were number of tillers, number of productive tillers, seed weight per panicle, and production. Meanwhile, characters, that were correlated with production, were plant height, number of tillers, number of productive tillers, harvesting age, seed-filling period, number of spikelets per panicle, percentage of empty florets, number of seeds per panicle, and seed weight per panicle

Keywords: characteristics, lowland, wheat

A. Introduction

Wheat (*Triticum aestivum* L.) is an important food commodity in the world and the second most important food, after rice, both as a caloriandor proteomic source. The protein level in wheat is 13% and the carbohydrate level is 69% (Suriani & Farid, 2014). Wheat is required as the main ingredient for wheat flour in Indonesia, which continues to increase along with the wheat flour needs (Silahturrohmah, S., Roviq, M., & Barunawati, N., 2019). The wheat import tends to fluctuate annually due to high demand and a growing number of inhabitants. The wheat requirement in Indonesia has massively been obtained from the import activity, whereas 11.43 million tons in 2017, 10.09 million tons in 2018, 10.69 million tons in 2019, and 10.29 million tons in 2020 (BPS, 2021). To reduce import dependence, Indonesia needs to improve domestic wheat production.

Domestic wheat production needs to be supported by available wheat varieties appropriate to the agroclimatic condition in Indonesia. Different height levels may affect the whole climate component difference in the following location (Mardi & Wahyu, 2022). Therefore, wheat development prior to the agroclimatic condition in Indonesia is necessary. This development program has also been conducted by the Agricultural Research and Development Center through the multilocation test of wheat plants from India and CIMMYT (International Maize and Wheat Improvement Center) in 2003. Based on the adaptation test, two wheat varieties adaptable to highland/low temperatures in Indonesia were found, namely variety Selayar and Dewata varieties, which were released at the end of 2003 (Talanca & Andayani, 2015). However, wheat plant cultivation in the highlands is uneconomical due to high competition with other horticultural plant commodities. Therefore, wheat plant cultivation in the lowland is necessary to conduct (Wicaksono, F. Y., Nurmala, T., Irwan, A. W., & Putri, A. S. U., 2016). Furthermore, evaluation and genotype selection from the mutated wheat product should be proceeded to obtain high-temperature-adapted wheat, based on the location height.

One of the frequent physical mutagenic activities is gamma-radiation. The mutation induction technique is extremely good for plants without parental sources. According to Witjaksono (2003), the wheat plant in Indonesia is included in the lowest genetic variation, as gaining the new superior character with a hybridization technique is difficult to conduct. The genetic variation increase and improvement can be performed by cross-breeding and genetic mutation induction. The previous study applied several wheat varieties to identify, namely M1 by *300-Gy* gamma-radiation, M2 by determining the population variety, M3 by high-temperature stress selection, M4 by optimal environmental selection, and M5 by high-temperature stress selection (Nur, 2013). Meanwhile, the previous activities of wheat mutant lines to produce a higher production were found in N.350.3.8.9 (2.31 t. ha^{-1}) and N.200.2.4.B.6 (2.66 t. ha^{-1}) (Nasaruddin Farid, Yunus, dan Hari, 2018).

The results assembled varieties need to maintain their genetic purity to get maximum results. Variety identification during the assemblage is necessary to be performed for differing the lines produced by the available variety. However, the variety identification method can only be performed conventionally, more inefficient, time-consuming, complicated observation, and relatively expensive price, if applied in routine testing. Therefore, a cheap and fast way without specific tools should be developed to assist seed purity identification with reliable accuracy. Based on the description above, a further study regarding the characterization of mutant wheat adaptability to lowlands was performed

B. Methodology

This study was conducted in the Experimental Field, Faculty of Agriculture, Hasanuddin University, Tamalanrea Sub-District, Makassar, South Sulawesi at 22.4 m above sea level throughout July-October, 2022. The experiment was arranged in a completely randomized block design with 16 observed-wheat genotypes (G) as the treatments and three replications. Thus, there were 48 trial plots observed in this study. Each plot was represented by five plant samples, thereby 240 samples from the plots were observed in this study. The wheat genotypes used were: 1) (G1) N1 200 2.4.B.6, 2) (G2) N 200 2.3.3, 3) (G3) N 200 2.5.2, (G4) N 350 3.6.2, (G5) N 350 3.7.1, (G6) N 300 3.6.1, (G7) N 350 3.1.3, (G8) N 250 3.7.1, (G9) M 200 1.7.1, (G10) S 300 7.9.1, (G11) S 300 2.1, (G12) D 200, and several comparative varieties, such as (G13) *Guri-3*, (G14) *Selayar*, (G15) *Nias*, and (G16) *Dewata*.

The parameters observed were plant height, number of tillers, number of productive tillers, panicle length, number of spikelets, number of empty spikelets, the weight of seeds per panicle, the weight of 1000 grains, leaf chlorophyll content, number of stomata, and productivity, seed color, growth behavior, number of flag leaves, panicle color, culm length, and bottom husk. Data analysis was performed by analysis of variance with the Least-Significant Different (LSD) test at a 0.05 confidence level. To find out the relationship between the characters, regression and correlation studies were carried out, while the genetic diversity of mutant genotypes was carried out by heritability analysis

C. Result and Discussion

The LSD test results from Table 1 indicate that the N200.2.4.B.6 (g1) obtained the highest plant height (57.00 cm), which was significantly different from the comparative varieties, namely Guri-3 (a) and Selayar (b). Based on the number of tillers, the N 200 2.4.B.6 (g1) also had the most tillers (5.60 tillers) and was significantly different from the comparative varieties, namely Selayar (b), Nias (c), and Dewata (d), while the number of productive tillers showed that the N 200 2.4.B.6 (g1) had the most productive tillers (4.53 tillers) and was significantly different from the comparative varieties, such as *Guri-3* (a) and *Dewata* (d).

Table 1. Plant height, number of tillers, and number of productive tillers in M8 wheat genotypes

Genotypes	Plant height	Number of tillers	Number of productive tillers
(g1) N 200 2.4.B.6	57.00 **ab**	5.60 **bcd**	4.53 **ad**
(g2) N 200 2.3.3	47.70	4.60 d	3.93 d
(g3) N 200 2.5.2	42.43	2.73	2.27
(g4) N 350 3.6.2	48.93	4.20 d	3.67
(g5) N 350 3.7.1	48.93	2.67	2.40
(g6) N 300 3.6.1	46.47	2.40	2.13
(g7) N 350 3.1.3	49.00	2.67	2.13
(g8) N 250 3.7.1	48.47	1.87	1.67
(g9) M 200 1.7.1	48.97	3.53	3.00
(g10) S 300 7.9.1	50.70	2.53	2.00
(g11) S 300 2.1	48.03	3.00	2.60
(g12) D 200	45.33	2.80	2.07
(g13) Guri-3 (a)	50.00	5.07	3.93
(g14) Selayar (b)	46.87	4.53	4.27
(g15) Nias (c)	55.40	4.27	4.20
(g16) Dewata (d)	53.73	3.40	3.27
NP LSD 5%	6.28	0.58	0.49

Note: Numbers followed by the same letter in the column (abcd) indicate a highly significant difference from the comparative varieties of *Guri-3* (a), Selayar (b), Nias (c), and Dewata (d), based on the LSD test level = 0.05

The number of productive tillers was affected by an environmental factor, namely air temperature, whereas higher air temperature tended to inhibit the number of productive tiller growth. This condition followed Andriani & Isnaini (2011), that the number of tillers depended on the variety and environmental conditions. Each tiller has the potential to produce one panicle. The number of tillers importantly contributes to the harvesting product. This condition was similar to Rachmadani, S., Damanhuri, D., & Soetopo, L. (2017), that the number of tillers could directly affect the product per plant as part of the selection criteria to gain a highly potential wheat genotype. The higher number of productive tillers, the more seed produced in the plants.

Based on the LSD test results from Table 2, the N 350 3.1.3 (g7) obtained the fastest flowering day (43.33 DAP) and was significantly different from the comparative varieties, namely Guri-3 (a) and Selayar (b), while seed-filling rate showed that the N 200 2.4.B.6 (g1) obtained the fastest seed filling (27.47 days) and was significantly different from the comparative varieties, namely Guri-3 (a), Selayar (b), and Dewata (d). The flowering day in the wheat plant can also be affected by the environment, mainly temperature. High temperatures can accelerate the flowering process. Wheat planted in lowland flowers faster than in highland (<400 asl). This condition was caused by the lowland environmental condition is more supportive for wheat growth, based on the temperature, humidity, and sunlight level. Wahyu, Y., Samosir, A. P., & Budiarti, S. G (2013) performed a study on wheat and stated that the flowering day of wheat in the lowland was about 43-70 DAP. A faster harvesting day was thought due to temperature stress in the lowland. Besides environmental conditions, the factor of land height can also affect the flowering day and harvesting period. Wahyu *et al* (2013) stated that extremely high air temperatures could affect the harvesting period in several wheat varieties in the low-elevated area.

Table 2. Flowering Day, Harvesting Period, and Seed Filling Rate in M8 wheat genotypes

Genotype	Flowering Day		Harvesting Period		Seed Filling Rate	
(g1) N 200 2.4.B.6	44.80		72.93	**ab**	27.47	**abd**
(g2) N 200 2.3.3	46.47		73.93	ab	28.13	ab
(g3) N 200 2.5.2	46.73		77.67		30.93	
(g4) N 350 3.6.2	47.67		77.20		29.53	a
(g5) N 350 3.7.1	46.87		76.93		30.07	a
(g6) N 300 3.6.1	46.33		78.33		32.00	
(g7) N 350 3.1.3	43.33	**ab**	75.80	a	32.80	
(g8) N 250 3.7.1	43.60	b	73.07	ab	29.47	a
(g9) M 200 1.7.1	44.20		77.13		32.93	
(g10) S 300 7.9.1	47.87		76.93		29.07	a
(g11) S 300 2.1	47.93		79.93		32.00	
(g12) D 200	47.07		78.80		31.73	
(g13) Guri-3 (a)	46.47		79.53		33.07	
(g14) Selayar (b)	46.80		78.07		31.27	
(g15) Nias (c)	44.80		74.87		30.07	
(g16) Dewata (d)	44.47		75.33		30.87	
NP LSD 5%	**2.96**		3.51		2.97	

Note: Numbers followed by the same letter in the column (abcd) indicate a highly significant different from the comparative varieties of *Guri-3* (a), *Selayar* (b), *Nias* (c), and *Dewata* (d), based on the LSD test level = 0.05

The LSD test results from Table 3 present that the N 250 3.7.1 (g8) obtained the highest panicle length (8.47 cm) and was significantly different from the comparative varieties of *Guri-3* (a), *Selayar* (b), and *Dewata* (d). The number of spikelets per panicle data presents that the N 200 2.4.B.6 (g1) has the highest value and (13.20 spikelets) and was significantly different from the comparative varieties of Guri-3 (a) and Nias (c). Furthermore, the number of seeds per panicle data indicates that the N 200 2.4.B.6 (g1) had the highest value (28.13 seeds) and was significantly different from the comparative varieties.

Panicle length is a product component that has a direct connection to the number of spikelets. Based on Kirby (2002), the longer panicle found, the more spikelets formed as a potential of a greater number of seeds produced. The panicle length also showed an interaction after the temperature stress treatment (Syuryawati, Rahmi YA, Zubachtirodim, 2007).

Table 3. Panicle Length, Number of Spikelets per panicle, and number of seeds per panicle in M8 Wheat genotypes.

Genotype	Panicle Length		Number of Spikelets per Panicle		Number Of Seeds Per Panicle	
(g1) N 200 2.4.B.6	8.40	ad	13.20	**ac**	28.13	**abcd**
(g2) N 200 2.3.3	8.23	d	12.60	a	24.90	abd
(g3) N 200 2.5.2	7.60		12.00		23.80	a
(g4) N 350 3.6.2	8.00		13.00	ac	24.80	ab
(g5) N 350 3.7.1	8.03		12.87	ac	22.07	
(g6) N 300 3.6.1	7.50		11.80		23.33	a
(g7) N 350 3.1.3	8.33	ad	12.13		20.33	
(g8) N 250 3.7.1	8.47	**abd**	12.60	a	23.40	a
(g9) M 200 1.7.1	7.93		12.27		21.27	
(g10) S 300 7.9.1	8.10		12.53		20.13	
(g11) S 300 2.1	7.80		11.80		18.03	
(g12) D 200	7.77		12.00		20.87	
(g13) Guri-3 (a)	7.83		11.67		19.60	
(g14) Selayar (b)	7.93		12.33		20.13	
(g15) Nias (c)	8.03		11.73		21.87	
(g16) Dewata (d)	7.69		13.13		21.13	

NP LSD 5%	0.49	0.88	3.70

Note: Numbers followed by the same letter in the column (abcd) indicate a highly significant difference from the comparative varieties of *Guri-3* (a), Selayar (b), Nias (c), and Dewata (d), based on the LSD test level = 0.05

The LSD results in Table 4 present that the N 200 2.4.B.6 (g1) obtained the greatest number of seeds per panicle (28.88 seeds) and was significantly different from the comparative varieties of Guri-3 (a), Selayar (b), and Dewata (d). The seed weight per panicle data indicates that the N 200 2.4.B.6 (g1) obtained the highest weight (0.79 g), as also found in the weight of 1000 seeds (28.84 g), which was significantly different from all comparative varieties, while the production value showed that the N 200 2.4.B.6 (g1) was the most productive variety (2,75 t.ha^{-1}) and significantly different from all comparative varieties. Commonly, one spikelet per wheat panicle has three florets, each of which is filled with one wheat seed. Therefore, the greater number of spikelets, the greater number of florets formed. This condition was similar to Wahyu *et al.* (2013), who stated that a greater number of empty florets per panicle represents a lower number of seeds produced per panicle.

The increased number and percentage of empty florets in the lowlands was caused by the drought or no rainy weather during the seed filling period, followed by the increased temperature that caused the pollen development failure and seed production inhibition. The number of empty florets affects directly the decreased seed weight per panicle and wheat production per grove. The percentage of empty florets in the lowest value is quite tolerable, following Nur (2013), who mentioned that the genotype selection with low empty floret level should be performed to obtain a highly temperature-tolerant genotype in lowland cultivation.

Table 4. Number of Empty Florets, Weight per Panicle, Weight of 1000 seeds, and Production of M8 Wheat Genotypes

Genotype	Number of Empty Florets (%)		Seed weight per Panicle (g)		Weight of 1000 Seeds (g)		Production (ton. ha^{-1})	
(g1) N 200 2.4.B.6	28.88	**abcd**	0.79	**abcd**	28.84	**d**	2.75	**abcd**
(g2) N 200 2.3.3	34.13	abd	0.73	abcd	28.18	d	2.69	abcd
(g3) N 200 2.5.2	33.92	abd	0.66	abcd	25.24		1.22	
(g4) N 350 3.6.2	36.48	bd	0.73	abcd	24.88		2.35	abcd
(g5) N 350 3.7.1	42.86		0.59	abc	26.41		1.21	
(g6) N 300 3.6.1	33.62	abd	0.78	abcd	22.29		1.43	
(g7) N 350 3.1.3	44.09		0.50		28.81	d	0.87	
(g8) N 250 3.7.1	37.94		0.53	a	22.44		0.74	
(g9) M 200 1.7.1	42.12		0.61	abc	25.00		1.62	a
(g10) S 300 7.9.1	46.22		0.52	a	27.73	d	0.82	
(g11) S 300 2.1	48.96		0.35		27.56	d	0.83	
(g12) D 200	42.05		0.57	ab	27.47	d	0.98	
(g13) Guri-3 (a)	43.80		0.42		27.67		1.24	
(g14) Selayar (b)	45.47		0.46		26.65		1.74	
(g15) Nias (c)	37.96		0.49		28.63		1.82	
(g16) Dewata (d)	46.32		0.54		22.57		1.45	
NP LSD 5%	1.65		0.10		3.88		0.34	

Note: Numbers followed by the same letter in the column (abcd) indicate a highly significant different from the comparative varieties of *Guri-3* (a), *Selayar* (b), *Nias* (c), and *Dewata* (d), based on the LSD test level = 0.05

In Table 5, the highest heritability level is presented from the number of productive tillers' character (91.28%). Heritability level depends on the genotype and environment variance. Heritability is a variance proportion caused by the genetic factors against the phenotype variance. Heritability level is one of the genetic parameters considered for character selection (Wirnas, D., I. Widodo, Sobir, Trikoesoemaningtyas, D. Sopandie , 2006; Suharsono & Jusuf, 2009; Sungkono Trikoesoemaningtyas, D. Wirnas, D. Sopandie, 2009; Syukur M., S. Sujiprihati, A. Siregar, 2010; Yunianti R., S. Sastrosumarjo, S. Sujiprihati, M.Surahman, S.H. Hidayat, 2010; Barmawi *et al.*, 2013). Based on the highest heritability level, characters that can be considered as selection characters to choose the best family are the number of tillers, number of productive tillers, seed weight per panicle, and production.

Correlation denotes the amount of relationship occupied in the observed parameters. The correlation coefficient analysis results from Table 6 indicate the correlation of productivity character with other characters. This condition means that plant height, number of tillers, number of productive tillers, chlorophyll index, harvesting period, seed-filling period, number of spikelets per panicle, percentage of empty florets, production per grove, number of seeds per panicle, seed weight per panicle are significantly correlated with the production, as each of which has the correlation values of 0.39, 0.75, 0.78, 0.56, -0.33, -0.37, 0.33, -0.53, 0.99, 0.58, and 0.62, respectively.

Table 5. Heritability Level in M8 Wheat mutants.

No	Characters	Heritability	Classification
1	Plant height	37.90	Medium
2	Number of Tillers	90.48	High
3	Number of Productive tillers	91.28	High
4	Flowering day	28.99	Medium
5	Harvesting Period	41.83	Medium
6	Seed filling rate	36.49	Medium
7	Length of Panicle	37.51	Medium
8	Number of Spikelets per Panicle	37.46	Medium
9	Number of Seeds per Panicle	48.67	Medium
10	Percentage of Empty Florets	48.40	Medium
11	Weight Seeds per Panicle	82.12	High
12	Weight of 1000 Seeds	37.59	Medium
13	Production	90.67	High

Note: $0 < h^2 \leq 20$ (low), $21 < h^2 \leq 50$ (medium), $50 < h^2 \leq 100$ (high)

Correlation analysis is an overview of the kinship level between one character to the others, but the value of correlation cannot explain the causal relationship of the kinship level among characters. Therefore, the role of cross-print analysis is important to elaborate the correlation coefficient. The results of the cross-print analysis can describe how significant the direct and indirect effects of a character to the main character (Rohaeni & Permadi, 2012). The use of correlation analysis and cross-print analysis in determining the selection character has also been performed in many studies, including Milligan SB, Gravois KA, Bischoff KP, Martin FA. (1990), Akhmadi (2016), Anshori (2019), Fadhli, Farid M, Rafiuddin, Effendi R, Azrai M, Anshori MF (2020), Farid BDR M, Nasaruddin, Anshori MF, Chaerunnisa ANJ (2020), and Farid M, Nasaruddin, Musa Y, Ridwan I, Anshori MF. (2021).

Table 6. Correlation analysis

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	**1.00**	0.41 **	0.47**	-0.24*	-0.34**	-0.22tn	0.35**	0.34**	-0.12tn	0.26*	0.07tn	0.18tn	0.39**
2		**1.00**	0.93**	-0.01tn	-0.08tn	-0.12tn	0.12tn	0.09tn	-0.23tn	0.23*	0.14tn	0.30*	0.75**
3			**1.00**	-0.01tn	-0.15tn	-0.16tn	0.10tn	0.15tn	-0.17tn	0.20tn	0.12tn	0.24*	0.78**
4				**1.00**	0.57**	-0.15tn	-0.24*	0.05tn	0.22tn	-0.23tn	-0.02tn	0.00tn	-0.02tn
5					**1.00**	0.53**	-0.42**	-0.31*	0.40**	-0.45**	-0.32*	-0.05tn	-0.33**
6						**1.00**	-0.20tn	-0.44**	0.38**	-0.53**	-0.38**	-0.07tn	-0.37**
7							**1.00**	0.26*	-0.08tn	0.15tn	0.03tn	0.19tn	0.20tn
8								**1.00**	0.08tn	0.31*	0.34**	-0.06tn	0.33**
9									**1.00**	-0.88**	-0.67**	0.12tn	-0.53**
10										**1.00**	0.71**	-0.13tn	0.58**
11											**1.00**	-0.12tn	0.62**
12												**1.00**	0.10tn
13													**1.00**

Description :

1. Plant height
2. Number of Tillers
3. Number of Productive Tillers
4. Flowering day
5. Harvesting Period
6. Seed Filling
7. Penicle Lenght
8. Number of Spikelets
9. Number of seeds per panicle
10. Number of Empty Florets
11. Weight per Panicle
12. Weight of 1000 seeds
13. Production

D. Conclusion

The results showed that the genotypes of M8 wheat mutants in lowland obtained the highest production in the N 200 2.4.B.6 (2.75 t. ha-1), N 200 2.3.3 (2.69 t.ha^{-1}) and N 350 3.6.2 (2.35 t.ha^{-1}). Characters that had high heritability level in M8 wheat mutant were number of tillers, number of productive tillers, weight seeds per panicle, and production. Furthermore, characters that were highly correlated with production were plant height, number of tillers, number of productive tillers, harvesting period, seed filling period, number of spikelets per panicle, percentage of empty florets, number of seeds per panicle, and seed weight per panicle.

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Growth and Production of Several Corn Varieties at Various NPK Fertilizer Dosages

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Abstract

Increasing corn production in Indonesia is one of the government's concerns to ensure the strengthening of food towards self-sufficiency. Improvement of fertilization methods and the use of superior varieties are parts of the intensifications to increase crop productivity. The purpose of this study was to determine the effect of NPK fertilizer doses, types of varieties, and their interactions on the growth and production of corn. This study was conducted from July to October 2022 at Bajeng Cereal Research Center (KP) Experimental Garden, Bajeng Sub-district, Gowa District, South Sulawesi at 27.2 m asl, specifically 5°18'21.5” S, 119°28' 38.6” E. The study used a split-plot design with fertilizer doses N:P: K as the main plot (P), namely N:P: K 60% = 120:90:60, N:P: K 80% = 160:120:80, N:P: K 100% = 200:150:100, N:P: K 120% = 240:180:120, and N:P: K 140% = 280:210:140. The varieties were used as subplots (V), namely *Sinhas 1* (V1), *Jakarin 1* (V2), *Nasa 29* (V3), *JH 36* (V4), *Bisi 18* (V5), *ADV* (V6), and *Pioner* (V7). The results of the study showed that the combination of the fertilizer doses of N:P:K 100% = 200:150:100 with Pioner variety (P3V7) obtained the highest average yield of 11.81 t. ha^{-1} among other combinations of N:P: K fertilizer doses with varieties

Keywords: Corn, N P K, Yield

A. Introduction

Corn is one of the most important food crops after rice. Corn has a strategic role and economic value, and has the opportunity to be developed. Corn is the main source of carbohydrates and protein after rice. Corn is also used as a raw material for food and animal feed industries and as an export commodity. The wide use of corn in various industries causes the demand for corn to increase.

Based on data on corn production in Indonesia for the last 7 years, corn production has always been below the target since 2016, in 2016 corn production was 23.18 million tons and lower than the target of 24 million tons. Corn production in 2017 and 2018 was also below the target of 25.2 million tons and 26.5 million. In 2019, corn production was only 27.61 million tons of the target of 27.8 million tons, and in 2020 corn production was 28.63 million tons, still lower than the target of 29.05 million tons (Directorate General of Food Crops of the Republic of Indonesia, 2020). Based on data from the Ministry of Agriculture of the Republic of Indonesia, the volume of corn imports throughout mid-2019 reached 0.58 million tons. The mid-2019 achievement was closed to the previous year's imports of 0.74 million tons. In line with the increased national maize production, efforts are needed to significantly increase corn productivity to meet demand, increase exports, and reduce imports. The yield of corn can be increased by selecting varieties and doses of fertilizer.

A method to increase corn yields is through the use of quality seeds from superior varieties to produce high production. However, the use of superior varieties is also not enough to support high production, it is necessary to apply fertilizer to meet the nutrition needs of the plants. The use of early maturing superior varieties that are responsive to the application of macronutrients N, P, and K has succeeded in significantly increasing crop production (Agricultural Research and Development Agency, 2021).

The synthetic fertilizer commonly used by farmers is NPK which contains nutrients N, P, and K which are essential nutrients for plants. Increasing the dose of N fertilization in the soil can directly increase protein content (N) and corn production, but meeting only N without P and K elements may cause plants to fall easily, be sensitive to pest attacks and decrease production quality (Pusparini, Yunus and Harjoko, 2018). However, farmers provide inorganic fertilizers excessively which has a negative impact on the environment

Considering these explanations, it is necessary to study the appropriate dosage of NPK fertilizer to optimize the growth and productivity of corn plants.

B. Methology

This study was carried out at the Experimental Garden of the Bajeng Cereal Research Institute (KP), Bajeng Sub-District, Gowa Regency, South Sulawesi at 27.2 m asl, with coordinates of 5°18'21.5"S, 119°28'38.6"E. The study was conducted from July to October, 2022. This study used a split-plot design in a randomized block design, with fertilizer doses of N:P: K as the main plot (P), that is N:P: K 60% = 120:90: 60, N:P: K 80% = 160:120:80, N:P: K 100% = 200:150:100, N:P: K 120% = 240:180:120, and N:P:K 140% = 280:210:140. Varieties was used as subplots (V), namely *Sinhas 1* (V1), *Jakarin* 1 (V2), *Nasa 29* (V3), *JH 36* (V4), *Bisi 18* (V5), *ADV* (V6), and *Pioner* (V7). Based on these treatment combinations, 35 combinations were used with three replications, resulting in 105 experimental units.

Parameters observed in this study were plant height, number of leaves, stem diameter, cob weight, number of rows of seeds, and productivity. Observational data were analyzed using analysis of variance, analysis of heritability, and analysis of genetic diversity. If there is a treatment effect on the analysis of variance, a further test is carried out to differentiate the means between treatments using the Honest Significant Difference (HSD) test at a 95% confidence level.

C. Result and Discussion

Table 1 shows that the interaction between fertilizer dose of N:P:K 100% = 200:150:100 (P3) with *JH 36* (V5) suggests plant height with an average of 211.65 cm and was significantly different from *Nasa 29* (V3), *Sinhas 1* (V1), *Jakarin* (V2), *Bisi 18* (V5), *ADV* (V6), and *Pioner* (V7) and were not significantly different from the fertilizer dose of N:P:K 80% = 160:120:80 (P2) with *Pioner* (V7). In the fertilizer dose of N:P:K 60% = 120:90:60 (P1) the plant height of ADV (V6) was significantly different from *Pioner* (V7), *JH 36* (V4), and *Sinhas 1* (V1), and not significantly different from *Bisi 18* (V5), *Nasa 29* (V3), and *Jakarin* (V2).

Table 1. Plant height (cm) at various doses of fertilizer and varieties

Variety	Treatment					Average	NP (V) LSD 0.05
	P1	P2	P3	P4	P5		
V1	172.33$^{c}_{r}$	183.93$^{c}_{qr}$	198.88$^{ab}_{p}$	195.48$^{bc}_{pq}$	201.00$^{ab}_{p}$	190.33	
V2	198.23$^{ab}_{p}$	178.50$^{c}_{q}$	201.74$^{ab}_{p}$	201.27$^{ab}_{p}$	203.47$^{ab}_{p}$	196.64	
V3	201.50$^{ab}_{p}$	199.98$^{b}_{p}$	196.92$^{b}_{p}$	189.60$^{bc}_{p}$	192.23$^{b}_{p}$	196.05	
V4	208.07$^{a}_{p}$	206.27$^{b}_{pq}$	**211.65$^{a}_{p}$**	194.60$^{bc}_{q}$	205.80$^{a}_{pq}$	205.28	8.68
V5	195.47$^{ab}_{qr}$	200.40$^{b}_{pqr}$	207.09$^{ab}_{pq}$	209.23$^{a}_{p}$	190.27$^{b}_{r}$	200.49	
V6	206.08$^{ab}_{p}$	198.67$^{b}_{p}$	197.67$^{b}_{pq}$	185.68$^{c}_{q}$	200.58$^{ab}_{p}$	197.73	
V7	193.84$^{b}_{r}$	**220.15$^{a}_{p}$**	210.10$^{ab}_{pq}$	202.23$^{ab}_{pq}$	210.05$^{a}_{pq}$	207.27	
Mean	196.50	198.27	203.43	196.87	200.49		
NP (P) LSD 0.05				**8.83**			

Note: Numbers followed by the same letters in columns (a,b,c,d) and rows (p,q) indicate that they are not significantly different on the HSD test $_{0,05}$.

Plant height is affected by N in the vegetative phase, this is in line with the opinion of Bloom (2015), Leghari, S.J., N.A. Wahocho, G.M. Laghari, A.H. Laghari, G.M. Bhabhan, K.H. Talpur, T.A. Bhutto, S.A. Wahocho, & A.A. Lashari (2016), and Ueda, Y., Konishi, M., Yanagisawa (2017), nitrogen fertilization correlated with net photosynthate, amount of chlorophyll pigment, leaf area, seed weight, seed number, and plant biomass. Yovita (2022) reported that plant height, cob height, cob diameter, number of seed rows, 1000 seed weight, and cob weight had a significant effect on productivity, so these characters were used as a standard.

The further test results of the HSD test in table 2 show that the interaction that suggests the highest average number of leaves is the fertilizer dose of N:P:K 100% = 200:150:100 (P3) with *Bisi 18* (V5) and is significantly different from the fertilizer dose of N:P:K 80% = 160:120:80 (P2) with *Nasa 29* (V3), *ADV* (V6), and *Sinhas 1* (V1) and not significantly different with fertilizer dose of N:P:K 80% = 160:120:80 (P2) for *Pioner* (V7).

Table 2. Number of leaves (strands) at various fertilizer doses and varieties

Variety	Treatment					Average	NP (V) HSD 0.05
	P1	P2	P3	P4	P5		
V1	10.27$^{a}_{pq}$	10.80$^{ab}_{p}$	11.03$^{a}_{p}$	11.17$^{a}_{p}$	8.87$^{c}_{q}$	10.43	
V2	10.04$^{a}_{p}$	10.67$^{ab}_{p}$	11.60$^{a}_{p}$	11.03$^{a}_{p}$	10.70$^{ab}_{p}$	10.81	
V3	10.70$^{a}_{p}$	11.23$^{ab}_{p}$	12.20$^{a}_{p}$	11.03$^{a}_{p}$	10.83$^{ab}_{p}$	11.20	
V4	11.27$^{a}_{p}$	10.54$^{b}_{p}$	11.90$^{a}_{p}$	11.03$^{a}_{p}$	11.10$^{ab}_{p}$	11.17	1.13
V5	10.31$^{a}_{p}$	10.74$^{ab}_{p}$	**12.27$^{a}_{p}$**	10.83$^{a}_{p}$	10.40$^{abc}_{p}$	10.91	
V6	10.32$^{a}_{pq}$	10.00$^{b}_{pq}$	10.67$^{a}_{p}$	10.67$^{a}_{pq}$	10.13$^{bc}_{q}$	10.36	
V7	10.37$^{a}_{p}$	**12.27$^{a}_{p}$**	11.90$^{a}_{p}$	10.93$^{a}_{p}$	11.87$^{a}_{p}$	11.47	
Mean	10.47	10.89	11.65	10.96	10.56	10.91	
NP (P) HSD 0.05				1.09			

Note: Numbers followed by the same letters in columns (a,b,c,d) and rows (p,q) indicate that they are not significantly different on the HSD test $_{0,05}$.

The number of leaves has a significant effect on the production of corn plants, this is in line with the opinion of Surtinah (2018), who reports that leaves that function as a place for photosynthesis contribute to production, leaves that actively carry out photosynthesis effects a large contribution to the accumulation dry material that furtherly be sent to the sink as a result of production.

The LSD test results in table 3 show that the interaction between fertilizer dose of N:P:K 60%= 120:90:60 (P1) with *Nasa 29* (V3) shows the best average stem diameter with a value of 25.60 mm and significantly different from *JH 36* (V4), *Bisi 18* (V5), *Pioner* (V7), *Sinhas 1* (V1), and *ADV*

(V6) and not significantly different with the interaction of fertilizer dose of N:P:K 140%= 280:210:140 with *ADV* (V6), and the interaction of fertilizer dose of N:P:K of 100%=200:150:100 (P3) with *Nasa 29* (V3).

Table 3. Stem diameter (mm) at various fertilizer doses and varieties

Variety	Treatment					Average	NP (V) HSD 0.05
	P1	P2	P3	P4	P5		
V1	20.24^{bc}_{p}	19.82^{bc}_{p}	19.40^{bc}_{p}	18.92^{a}_{p}	19.83^{cd}_{p}	19.64	
V2	19.88^{c}_{pq}	17.97^{cd}_{q}	20.13^{bc}_{pq}	15.21^{b}_{r}	21.25^{bc}_{p}	18.89	
V3	$\mathbf{25.60^{a}_{p}}$	16.09^{d}_{s}	$\mathbf{22.17^{a}_{p}}$	19.20^{a}_{r}	21.39^{bc}_{q}	20.89	
V4	22.08^{b}_{p}	21.98^{a}_{p}	21.20^{ab}_{p}	20.80^{a}_{p}	22.79^{ab}_{p}	21.77	3.34
V5	20.55^{bc}_{p}	19.52^{bc}_{p}	20.49^{abc}_{p}	19.41^{a}_{p}	$19.02d_{p}$	19.80	
V6	18.72^{c}_{pq}	20.05^{ab}_{pr}	18.52^{c}_{r}	20.68^{a}_{q}	$\mathbf{23.55^{a}_{p}}$	20.30	
V7	20.75^{bc}_{q}	19.60^{bc}_{q}	19.91^{bc}_{q}	18.89^{a}_{p}	23.07^{ab}_{p}	20.44	
Mean	21.12	19.29	20.26	19.01	21.56	20.25	
NP (P) HSD 0.05	3.40						

Note: Numbers followed by the same letters in columns (a,b,c,d) and rows (p,q) indicate that they are not significantly different on the HSD test $_{0,05}$.

The size of the stem diameter is thought to be influenced by N which supplies nitrogen needs in corn plant tissues. Nitrogen is an essential element for plant growth and development because nitrogen is important in cell division. This is in accordance with Gardner, F.P., R.B. Pearce & R.L. Mitchelll (1991) who stated that nitrogen is important nutrition in the building blocks of amino acids, amides, nucleotides, and nucleoproteins and is essential for cell division, and cell enlargement and therefore also important for plant growth.

The HSD test in table 4 shows that the interaction between the fertilizer dose of N:P:K 140% = 280:210:140 (P5) with *ADV* (V6) suggests the highest average peel cob weight of 26.08 kg and is significantly different from other varieties. The interaction between the fertilizer dose of N:P:K 100% = 200:150:100 with *Pioner (V7)* is significantly different from the fertilizer dose of N:P:K 120% = 240:180:120 (P4) with *Jakarin* (V2).

Table 4. The average cob weight (kg) at various doses of NPK fertilizer and varieties

Variety	Treatment					Average	NP (V) HSD 0.05
	P1	P2	P3	P4	P5		
V1	10.38^{f}_{r}	10.49^{f}_{r}	6.59^{g}_{s}	12.15^{d}_{q}	13.63^{e}_{p}	10.65	
V2	14.61^{e}_{p}	10.68^{f}_{s}	12.93^{d}_{r}	6.44^{f}_{t}	14.35^{d}_{q}	11.80	
V3	17.65^{d}_{p}	13.77^{e}_{q}	11.98^{f}_{r}	12.03^{d}_{r}	10.76^{g}_{s}	13.24	
V4	21.53^{c}_{p}	15.20^{g}_{q}	12.37^{e}_{r}	11.53^{e}_{t}	11.86^{f}_{s}	14.50	0.23
V5	22.10^{b}_{s}	24.18^{a}_{q}	16.79^{c}_{t}	23.81^{a}_{r}	25.64^{b}_{p}	22.50	
V6	23.80^{a}_{r}	16.62^{c}_{t}	24.36^{b}_{q}	23.15^{b}_{s}	$\mathbf{26.08^{a}_{p}}$	22.80	
V7	23.61^{a}_{r}	22.82^{b}_{s}	25.28^{a}_{t}	16.06^{c}_{t}	24.30^{c}_{q}	22.41	
Mean	19.10	16.25	15.76	15.03	18.09	16.84	
NP (P) HSD 0.05	0.25						

Note: Numbers followed by the same letters in columns (a,b,c,d) and rows (p,q) indicate that they are not significantly different on the HSD test $_{0,05}$.

The weight of the peeled cob has a great effect on the production of corn plants. According to a hybrid corn study by Priyanto, S.B., A. Muhammad, & T.M. Andi (2018), one of the characteristics that have a very significant correlation with yield is the weight of the peeled cobs. This proves that the weight of the cobs affects the yield where the grain yield increases significantly along with the increase in the weight of the cob. The increase in the weight of cobs with husks and cobs without husks on corn plants will be in line with the yields obtained. This is in line with the study by Pratikta, Sri, and Ketut (2013) which states that cob weight affects corn production because the greater the cob weight, the greater the corn production.

The results of the HSD test in table 5 show that the interaction between the fertilizer dose of N:P:K 80% = 160:120:80 (P2) with *Jakarin* (V2) suggests an average number of seed rows at 18.11 rows are significantly different from other varieties, but not significantly different with the interaction of fertilizer dose of N:P:K 100% = 200:150:100 (P3) with *ADV* (V6) and N:P : K 120% = 240:180:120 (P4) with *Bisi 18* (V5).

Table 5. The average number of seed rows (rows) at various N:P:K fertilizer doses and varieties

Variety	Treatment					Average	NP (V) HSD 0.05
	P1	P2	P3	P4	P5		
V1	14.07^{a}_{p}	15.11^{ab}_{p}	15.27^{a}_{p}	$16.27^{a`}_{p}$	15.84^{a}_{p}	15.31	
V2	14.78^{a}_{q}	$\mathbf{18.11^{a}_{p}}$	16.18^{a}_{pq}	14.96^{a}_{q}	16.13^{a}_{pq}	16.03	
V3	14.31^{a}_{p}	16.11^{ab}_{p}	16.20^{a}_{p}	16.00^{a}_{p}	16.02^{a}_{p}	15.73	
V4	14.13^{a}_{p}	15.42^{ab}_{p}	15.62^{a}_{p}	15.82^{a}_{p}	16.73^{a}_{p}	15.55	2.39
V5	9.25^{b}_{r}	13.47^{b}_{q}	15.80^{a}_{pq}	16.73^{a}_{p}	15.60^{a}_{pq}	14.17	
V6	15.69^{a}_{p}	16.18^{ab}_{p}	16.44^{a}_{p}	15.83^{a}_{p}	16.02^{a}_{p}	16.03	
V7	14.84^{a}_{p}	15.78^{ab}_{p}	15.47^{a}_{p}	15.56^{a}_{p}	15.69^{a}_{p}	15.47	
Mean	13.87	15.74	15.85	15.88	16.01	15.47	
NP (P) HSD 0.05			**2.37**				

Note: Numbers followed by the same letters in columns (a,b,c,d) and rows (p,q) indicate that they are not significantly different on the HSD test $_{0,05}$.

The highest number of seed rows in this study was 18.11 rows, the more seeds contained on the cob will affect corn production. Sitepu & Adiwirman (2017) reported that the greater the number of seed rows, the higher the production of corn plants.

The HSD test results in table 6 show that the interaction of fertilizer dose of N:P:K 100% = 200:150:100 (P3) with Pioner (V7) indicates the highest average productivity of 11.81 t.ha-1 and not significantly different from *ADV* (V6), but significantly different from *JH 36* (V4), *Bisi 18* (V5), and *Sinhas 1* (V1). Interaction of the ffertilizer dose of N:P:K 80% = 160:120:80 (P2) with *Pioner* (V7) is not significantly different from the interaction of the fertilizer dose of N:P:K 120% = 240:180:120 (P4) with *Bisi 18* (V5).

Table 6. The average productivity ($t.ha^{-1}$) at various N:P:K fertilizer doses and varieties

Variety	Treatment					Average	NP (V) HSD 0.05
	P1	P2	P3	P4	P5		
V1	4.75^{c}_{q}	4.68^{d}_{q}	3.02^{d}_{r}	5.90^{bc}_{p}	6.14^{b}_{p}	4.90	
V2	6.76^{b}_{p}	4.86^{d}_{q}	6.07^{c}_{p}	2.94^{d}_{r}	6.11^{b}_{p}	5.35	
V3	7.81^{b}_{p}	6.46^{c}_{q}	5.97^{c}_{qr}	5.33^{c}_{rs}	4.65^{b}_{s}	6.04	
V4	9.71^{a}_{p}	6.55^{bc}_{q}	5.18^{c}_{r}	5.45^{c}_{r}	5.08^{b}_{r}	6.39	0.96
V5	9.97^{a}_{r}	10.36^{a}_{qr}	8.63^{b}_{s}	11.22^{a}_{pq}	11.80^{a}_{p}	10.40	
V6	10.32^{a}_{r}	7.98^{b}_{s}	11.53^{a}_{p}	10.45^{a}_{qr}	11.43^{a}_{pq}	10.34	
V7	10.25^{a}_{q}	10.89^{a}_{pq}	$\mathbf{11.81^{a}_{p}}$	7.09^{b}_{r}	10.67^{a}_{q}	10.14	
Mean	8.51	7.40	7.46	6.91	7.98	7.65	
NP (P) HSD 0.05			0.99				

Note: Numbers followed by the same letters in columns (a,b,c,d) and rows (p,q) indicate that they are not significantly different on the HSD test $_{0,05}$.

Based on the results of the variance of productivity, the combination of fertilizer doses of N:P: K 100% = 200:150:100 with *Pioner* (P3V7) showed the highest productivity results among other treatment combinations at 11.81 t. ha^{-1}. To support crop production, nutrients, especially N, P, and K during the growth and breeding phases are necessary. Mulyani (2008) reported that N plays a role in the formation of carbohydrates, proteins, and fats as well as other organic compounds and P plays a role in the formation of the generative parts of plants. K plays a role in stimulating the transfer of carbohydrates from leaves to plant organs. The use of inorganic fertilizers sufficiently can also increase crop production. This is in line with the study by Stephen O, Animasaun DA, Bello AA, Agboola OO (2014), the use of inorganic fertilizers to increase productivity is effective in just a few years, according to consistent use on a long-term basis.

D. Conclusion

Based on the results, it can be concluded that the combination of fertilizer dose of N:P:K 100% = 200:150:100 with *Pioner* (P3V7) suggested the highest productivity compared to other combinations of fertilizer dose of N:P:K and other varieties with a yield of 11.81 $t.ha^{-1}$. The variety with the highest production compared to other varieties was *Bisi 18* (V5) with a value of 10.40 $t.ha^{-1}$.

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The Effect of Rice Straw Mulch and Plus Organic Fertilizer Residue on The Growth of Glutinous Corn (*Zea mays ceratina* Kulesh)

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Abstract

This study aimed to determine the effect of rice straw mulch and plus organic fertilizer residue on the growth of glutinous corn. This study was conducted from May to July, 2022 at the Field Laboratory, Faculty of Agriculture, Halu Oleo University, Kendari, Southeast Sulawesi. This study used a randomized block design with split-plot design treatments. Main plots were residue of rice straw mulch (M): without residue of rice straw mulch (M0), 4 t ha-1 residue of rice straw mulch (M1), and 8 t ha-1 residue of rice straw mulch (M2). Main subplots were residue of plus organic fertilizer (P): without residue of plus organic fertilizer (P0), 2.5 t ha-1 residue of plus organic fertilizer (P1), 5 t ha-1 residue of plus organic fertilizer (P2), and 7.5 t ha-1 residue of plus organic fertilizer (P3). Each experimental unit was repeated three times. Measured variables were plant height, number of leaves, leaf area, , plant fresh weight, plant dry weight, and flowering age. The data were analyzed using ANOVA, if the analysis result was significant (Fhit> Ftab), then analyzed further using DMRT on $\alpha=0.05$. The research results showed a single effect in 8 t ha-1 residue of rice straw mulch (M2) or 7.5 t ha-1 residue of plus organic fertilizer (P3) by producing the highest growth of glutinous corn

Keywords: growth, mulch, plus organic fertilizer, residue

A. Introduction

Corn (*Zea mays* L.) is a staple food widely used for food ingredients such as the flour and oil industries and is used for the animal feed ingredient industry. Corn as a food ingredient, can provide more excellent nutritional value compared to other types of grains. Corn generally consists of starch, protein, fat, vitamins, minerals, and organic matter. Glutinous corn is known for special character of glutinous or sticky. Glutinous corn has good taste, is more legit, fluffier and softer. The savory taste of glutinous corn is caused by high amylopectin content, ranging from 90-99% (Suarni, S., Aqil, M., Subagio, H., & Timur, B. P. T. P. J., 2019).

Soil fertility is a problem that needs to be resolved to promote the growth of corn plants, especially in dry land. Naturally, marginal dry land has low soil fertility, based on the acid soil, low nutrient reserves, exchangeable bases, and low base saturation, while having high to very high aluminum saturation (Arsyad, A.R., Junedi, H., & Farni, Y., 2012). According to Sipayung, N.Y., Gusmeizal, & Sumihar, H. (2017), low soil quality can be caused by infertile soil, such as low nutrient content and soil microorganisms. Efforts to maintain soil organic matter levels to reach ideal conditions should provide good actions, environmentally awareness, and sustainability condition. Adding organic matter to the soil has a strong effect to improve soil properties, including soil nutrients (Roidah, 2013).

Mulching is one of efforts to overcome the problem of soil fertility sustainably. Mulch is a covering material above the soil surface for cultivated plants. Mulch is important to reduce the evaporation rate of groundwater due to solar radiation and evaporation so that decreased soil temperature and maintained water humidity to optimize plant growth (Gustanti, Y., Chairul, & Zuhri, S., 2014). Using mulch can modify the microclimate so plants can grow well (Hamzah, H., Jumiati, J., & Hasriani, H., 2022). Rice straw is local raw material that can be utilized as mulch and processed into organic fertilizer. Rice straw is abundant during the harvest season and has not been used properly by farmers. According to Setiyaningrum, A., Darmawati, A., Budiyanto, S. (2019), several advantages of rice straw mulch, including retaining soil aggregates from splashing rainwater, suppressing weed growth, ensuring better plant growth because there is no competition for nutrients, and being more economical because it can be obtained free of charge (Fahmi, 2014). In addition, rice straw contains about 40% N, 30-35% P, 80-85% K, and 40-45% S. Setiyaningrum *et al.* (2019) added that rice straw also contained 4-7% Si, 1.2-1.7% K2O, and 0.07-0.12% P2O5. Through its content, the residue of decomposed straw mulch will increase soil fertility and is very beneficial for plant growth.

Another way to increase plant growth is nutrient addition through fertilization. Fertilization aims to increase plants' nutrients because the nutrients in the soil are not always sufficient to support optimal plant growth (Supartha, 2012). The fertilizer can be organic or inorganic fertilizers. However, imbalance chemical fertilizer without organic matter addition will bring serious consequences and damage the soil (Setiawati, M.R., Sofyan, E.T., & Nurbaity, A., 2017). An alternative solution is by using organic fertilizers to help increase soil fertility and provide unavailable to plants. Applying organic fertilizers can improve soil physical properties, fertilize the soil, add soil nutrients and humus, and affect the life of soil microorganisms (Marlina, N., Midranisah, M., Syafrullah, S., & Harapin, H., 2022). Plus organic fertilizer is a modified fertilizer added with certain microbes (Plant Growth Promoting Rhizobacteria) to enhance and maximize the role of the fertilizer (Sutariati and Wahid, 2012).

Using organic materials, such as mulch and organic fertilizers leaves a residual effect on the soil. Organic matter residue is material left in the soil after certain treatments. The decomposition of straw mulch and organic fertilizer takes a long time because most of the organic matter will be stored as residue that can be reused in the next growing season (Yalang, A., Barus, H., & Rauf, A., 2016). Straw mulch residue in the cultivated area will protect the soil from rain, maintain soil moisture, and increase soil nutrient content. The residue produced by organic fertilizers can increase soil fertility. The residual effect of organic fertilizers can improve the quality and properties of the soil for several years after application. It also increases the N content and other nutrients derived from plant materials (Murwindra, R., Astegi, A., Dwi, P.M., Edi, K., Jumriana, R.N., & Nofri. Y., 2021). Using residue from rice straw mulch and plus organic fertilizer is one of the strategic efforts to overcome soil fertility problems and increase crop growth.

Based on the description of the background above, it is necessary to determine the residual effect from using plus organic fertilizer and rice straw mulch on the growth of glutinous corn.

B. Methodology

This study was carried out at the Experimental Garden II and the Agronomy Laboratory of the Faculty of Agriculture, University of Halu Oleo, from May to July, 2022. The materials used included glutinous corn variety Kumala F1, marker labels, raffia rope, tarpaulin, waring net, paper envelopes, plastic, and zipper packs. The equipment were hoes, machetes, a watering can, tape measure, calipers, analytical scales, cameras, ovens, and stationery.

1. Research Design

The environmental design used a randomized block design with split-plot design treatment. The main plots were rice straw mulch residue (M) which consisted of 3 levels, namely without rice straw mulch residue (M0), 4 t ha-1 residue of rice straw mulch (M1), and 8 t ha-1 residue of rice straw mulch (M2). Subplots were plus organic fertilizer residue (P) which consisted of 4 levels, namely without plus organic fertilizer residue (P0), 2.5 t ha-1 residue of plus organic fertilizer (P1), 5 t ha-1 residue of plus organic fertilizer (P2), and 7.5 t ha-1 residue of plus organic fertilizer (P3). There were 12 treatment combinations, and each treatment was repeated three times to obtain 36 experimental units.

2. Prosedure

Before carrying out the experiment, the first step was preparing the materials and equipment for land and beds, planting the glutinous corn variety of Kumala F1, and maintaining the plant. The land had previously been planted with soybeans treated with rice straw mulch and organic fertilizer. Land processing was carried out after the harvest of the first crop without any land renewal. Machete was used to clear weeds and crop residues, followed by loosening the beds using a hoe without changing the shape and position of the plots from the previous experiment. The trial plot was 200 cm x 150 cm, and the ditch spacing between treatment plots was 30 cm. Re-sorted glutinous corn variety Kumala F1 seed with the characteristics of large seeds were used to minimize growth.

Prepared a planting hole of ± 2 cm with a distance of 40 cm x 60 cm. Put 2 seeds in the planting hole to minimize not growing, then pour soil on the top. After the plants were 2 WAP old, sorting was done by cutting one plant that did not grow well to obtain one plant in each planting hole. Plant maintenance was essential to maximize the growth of cultivated plants. Maintenance carried out were watering, weeding, hilling, and controlling pests and diseases. Observational variables were plant height, number of leaves, stem diameter, leaf area, plant fresh weight, plant dry weight, and flowering age.

3. Data analysis

The observation results were analyzed using variance (ANOVA), if Fcount > Ftable = 0.05, then it was analyzed further using Duncan's Multiple Range Test (DMRT) at the 95% confidence level.

C. Result and Discussion

The analysis results of the effect of rice straw mulch residues and plus organic fertilizer on glutinous corn growth are presented in Table 1.

Table 1. The analysis results of the effects of rice straw mulch residues and plus organic fertilizer on glutinous corn growth

No	Observational variable	Treatment		
		Straw Mulch (M)	Plus Organic Fertilizer (P)	Interaction (M X P)
1.	Plant Height (cm)			
	- 2 WAP	tn	*	tn
	- 4 WAP	tn	**	tn
	- 6 WAP	tn	**	tn
	- 8 WAP	tn	**	tn
2.	Number of Leaves (leaves)			
	- 2 WAP	tn	*	tn
	- 4 WAP	tn	**	tn
	- 6 WAP	tn	**	tn
	- 8 WAP	tn	**	tn
3.	Stem Diameter (cm)			
	- 2 WAP	tn	**	tn
	- 4 WAP	tn	**	tn
	- 6 WAP	tn	**	tn

	- 8 WAP	tn	**	tn
4.	Leaf Area (cm^2)			
	- 2 WAP	*	**	tn
	- 4 WAP	tn	**	tn
	- 6 WAP	tn	*	tn
	- 8 WAP	tn	tn	tn
5.	Fresh Weight (g)	tn	*	tn
6.	Dry Weight (g)	tn	**	tn
7.	Flowering age (day)	*	**	tn

Note: tn (no significant effect), * (significant effect), ** (very significant effect)

Table 1 shows no interaction effect between rice straw mulch residue and plus organic fertilizer residue on all variables observed. Independent rice straw mulch treatment significantly affected leaf area at 2 WAP and flowering age. The independent treatment of plus organic fertilizer showed a significant effect on plant height at 2 WAP, the number of leaves at 2 WAP, leaf area at 6 WAP, and plant fresh weight, and had a very significant effect on plant height at 4, 6 and 8 WAP, the number of leaves at 4, 6 and 8 WAP, stem diameter at 2, 4, 6 and 8 WAP, leaf area at 2 and 4 WAP, plant dry weight, and flowering age.

Decomposed rice straw mulch has a lower ability to maintain soil moisture, but it can contribute to soil nutrient availability if the decomposition process occurs perfectly; its effect will be seen at the end of the vegetative or early reproductive phase. Organic matter is slowly decomposing in the soil, so nutrients are slowly available (Kuziemska, B., Wysokińsk, A., & Trębicka. J., 2020). The mulch residue used in this study is assumed to be in the decomposition process, which means not yet undergone complete decomposition. Thus, its role in independently increasing plant growth and interacting with plus organic fertilizer residues was insignificant (Table 1) except at flowering age (Tables 1 and 7). This condition was in contrast to the plus organic fertilizer residue, which significantly affected plant growth, fresh and dry weight, and flowering age. Yalang *et al.* (2016), stated that the residue of organic mulch could be a nutrient reserve used for planting in the next period and organic fertilizer had a residual effect which means the nutrients gradually become available to plants. Therefore the treatment only has independent effect, especially plus organic fertilizer residue.

The results of Duncan's multiple range test (DMRT) on the effect of plus organic fertilizer residue on plant height, stem diameter, number of leaves, leaf area, plant fresh and dry weight, and flowering age are presented in Tables 2, 3, 4, 5, 6, and 7.

Plant Height

The DMRT results on the independent effect of plus organic fertilizer residue treatment on the plant height are presented in Table 2.

Table 2. The independent effect of plus organic fertilizer residue treatment on the plant height at the age of 2, 4, 6, and 8 WAP

Plus Organic Fertilizer Residue	Plant Height (cm)			
	2 WAP	4 WAP	6 WAP	8 WAP
0 t ha^{-1} (P0)	37.74^{b}	81.82^{b}	112.70^{c}	139.44^{c}
2.5 t ha^{-1} (P1)	38.15^{b}	90.07^{a}	118.85^{b}	148.18^{b}
5 t ha^{-1} (P2)	41.54^{ab}	92.06^{a}	123.30^{ab}	153.74^{ab}
7.5 t ha^{-1} (P3)	44.51^{a}	95.77^{a}	126.82^{a}	159.71^{a}
DMRT α = 0.05	2 = 4.60 3 = 4.83 4 = 4.97	2 = 5.59 3 = 5.87 4 = 6.05	2 = 5.93 3 = 6.22 4 = 6.41	2 = 8.68 3 = 9.11 4 = 9.39

Note: Numbers followed by different letters in the same column are significantly different based on 95% confidence level of DMRT test

Table 2 shows the effect of plus organic fertilizer residue on plant height. The highest plant height at 2 WAP obtained by P3 was significantly different from P0 and P1, but not significantly different from P2. The P0 obtained the lowest plant height, significantly different from P3, but not significantly different from P1 and P2. The highest plant height at 4 WAP obtained by P3 was significantly different from P0, but not significantly different from P1 and P2. The lowest plant height obtained by P0 was significantly different from the other treatments. The highest plant height at 6 WAP obtained by P3 was significantly different from the P1 and P0, but not significantly different from the P2. The P0 obtained the lowest height and was significantly different from the other treatments. The highest plant height at 8 WAP obtained by P3 was significantly different from the P1 and P0, but not significantly different from the P2. The P0 obtained the lowest height and significantly differed from the other treatments.

Application of a higher dose of plus organic fertilizer residue results in higher growth of plant height. It is suspected that plus organic fertilizer residue from the previous application at a higher dose (7.5 tons per hectare) can still provide nutrients for plant growth. According to Zamrodah (2016), the residual effect of organic fertilizers can become nutrient reserves that can be used for the next planting period. Subowo (2010) stated that more organic matter caused a longer period for soil microorganism to decompose, so the organic matter residues could be utilized for subsequent planting. Haumein (2020) stated that the higher the organic fertilizers applied to the soil, the higher residue released. According to Armiyarsih, Sasli, I., & Haris, T. (2020), amino acids produced due to the decomposition of organic matter in the soil will break down into ammonium ($NH4+$) or nitrate ($NO3-$) that can contribute to the availability of nitrogen for plant height growth. Plant height is largely driven by the availability of nitrogen and phosphate nutrients (Rhezali and Lahlali, 2017). According to Hartanti, I., Hapsoh, & Yoseva, S. (2014), N nutrients trigger plant growth during the vegetative phase. It supports by Sinuraya and Melati (2019), that the N element plays a role in cell division and elongation, thereby affecting plant height growth.

Stem Diameter

The DMRT results on the independent effect of plus organic fertilizer residue treatment on the stem diameter of glutinous corn are presented in Table 3.

Table 3. The independent effect of plus organic fertilizer residue treatment on the stem diameter of glutinous corn at the age of 2, 4, 6, and 8 WAP.

Plus Organic Fertilizer Residue	Stem Diameter (cm)			
	2 WAP	4 WAP	6 WAP	8 WAP
0 t ha^{-1} (P0)	0.41^{c}	0.95^{d}	1.22^{c}	1.31^{c}
2.5 t ha^{-1} (P1)	0.43^{bc}	1.10^{cd}	1.32^{b}	1.41^{b}
5 t ha^{-1} (P2)	0.45^{b}	1.14^{bc}	1.34^{b}	1.45^{ab}
7.5 t ha^{-1} (P3)	0.48^{a}	1.20^{a}	1.44^{a}	1.53^{a}
DMRT α = 0.05	2 = 0.029 3 = 0.031 4 = 0.032	2 = 0.037 3 = 0.039 4 = 0.040	2 = 0.090 3 = 0.094 4 = 0.097	2 = 0.080 3 = 0.084 4 = 0.086

Note: Numbers followed by different letters in the same column are significantly different based on 95% confidence level of DMRT test

Table 3 shows the highest impact of the independent effect of plus organic fertilizer residue on stem diameter at 2 WAP obtained by P3 was significantly different from the other treatments. The P0 obtained the smallest stem diameter, significantly different from P2 and P3, but not significantly different from P1. P3 obtained the biggest stem diameter at 4 WAP. It was significantly different from the other treatments. The smallest stem diameter obtained by P0 was significantly different from P2 and P3, but not significantly different from P1. The P3 obtained the biggest stem diameter at 6 WAP and significantly differed from the other treatments. The smallest stem diameter was obtained by the P0, which was significantly different from the other treatments. P3 obtained the biggest stem diameter at 8 WAP and was significantly different from the P1 and P0, but not significantly different from the P1. The smallest stem diameter obtained by P0 significantly differed from the other treatments.

The residue is thought to provide nitrogen, phosphorus, and potassium nutrients affecting soil chemical properties. Applying organic matter as a soil conditioner can increase N, P, and K uptake in the soil Maftu'ah, E., Maas, A., Syukur, A., & Purwanto, B.H. (2013). Plus organic fertilizer contains macronutrients such as N, P, and K to nourish plants and ensure optimal plant growth. The presence of N, P, and elements in the planting medium will increase cell division and enlargement, so young leaves can reach perfect shape faster (Leonardo, A., Yulia, E., & Indra, S., 2016). Puspadewi, S., Sutari, W., & Kusumiyati (2016) stated that N, P, and K are macronutrients absorbed by plants, especially during the vegetative phase. The availability of N, P, and K is especially needed in stimulating plant height growth, stem diameter enlargement, and leaf formation.

Number of Leaves

The DMRT results on the independent effect of plus organic fertilizer residue treatment on the number of leaves of glutinous corn are presented in Table 4.

Table 4. The independent effect of plus organic fertilizer residue treatment on the number of leaves of glutinous corn at the age of 2, 4, 6, and 8 WAP

Plus Organic Fertilizer Residue	Number of Leaves (strands)			
	2 WAP	4 WAP	6 WAP	8 WAP
0 t ha^{-1} (P0)	3.39^{c}	5.17^{c}	8.14^{c}	8.67^{b}
2.5 t ha^{-1} (P1)	3.61^{b}	5.47^{b}	8.78^{b}	8.72^{b}
5 t ha^{-1} (P2)	3.69^{ab}	5.64^{b}	9.03^{b}	8.78^{b}
7.5 t ha^{-1} (P3)	3.86^{a}	6.03^{a}	9.44^{a}	9.42^{a}
DMRT α = 0.05	2 = 0.20 3 = 0.21 4 = 0.22	2 = 0.23 3 = 0.24 4 = 0.25	2 = 0.40 3 = 0.42 4 = 0.43	2 = 0.25 3 = 0.26 4 = 0.27

Note: Numbers followed by different letters in the same column are significantly different based on 95% confidence level of DMRT test

Table 4 shows the effect biggest impact of plus organic fertilizer residue on the number of leaves at 2 WAP obtained by P3 and was significantly different from the P0 and P1, but not significantly different from P2. The least number of leaves obtained by P0 treatment and was significantly different from the other treatments. The P3 obtained the highest number of leaves at 4 WAP, significantly different from the other treatments. A least number of leaves was obtained by P0 and significantly differed from the other treatments. The P3 also obtained the highest number of leaves at WAP, significantly different from the other treatments. The P0 obtained the lowest number of leaves, significantly different from the other treatments. P3 obtained the highest number of leaves at 8 WAP and significantly differed from the other treatments. The lowest number of leaves was obtained by P0, which was significantly different from P3, but not significantly different from P1 and P2.

According to Pane, M.A., Damanik, M.M.B. & Sitorus B. (2014), applying organic matter to soil can increase cation exchange capacity and soil pH. Sari, V.I., Sudradjat, & Sugiyanta (2015) added that increased soil pH indicates improving soil chemical properties, namely providing nutrients. According to Fauzi and Puspita (2017), N is a nutrient that compiles protein and chlorophyll to support leaf formation. Therefore, sufficient nitrogen availability accelerates plant growth, especially stems and leaves. The 7.5 ton per ha residue of plus organic fertilizer increases the number of leaves. Leaves are the main terminal for photosynthesis to produce and assimilate plant growth and development.

Leaf Area

The DMRT results on the independent effect of straw mulch residue and plus organic fertilizer residue treatment on the leaf area of glutinous corn are presented in Table 5.

Table 5. The DMRT results on the independent effect of straw mulch residue and plus organic fertilizer residue treatment on the leaf area of glutinous corn at 2, 4 and 6 WAP

Rice Straw Mulch Residue	Leaf Area (cm^2)					
	2 WAP	DMRT α = 0,05	4 WAP	DMRT α = 0,05	6 WAP	DMRT α = 0.05
0 t ha^{-1} (M0)	73.30^{b}		tn		tn	
4 t ha^{-1} (M1)	87.88^{a}	2 = 8.00				
8 t ha^{-1} (M2)	78.88^{b}	3 = 8.18				
Plus Organic Fertilizer Residue						
0 t ha^{-1} (P0)	67.26^{b}		102.14^{c}		1320.50^{b}	
2.5 t ha^{-1}(P1)	77.87^{ab}	2 = 11.13	114.57^{bc}	2 = 19.50	1401.62^{b}	2 = 263.87
5 t ha^{-1}(P2)	86.37^{a}	3 = 11.68	128.22^{ab}	3 = 20.47	1534.56^{ab}	3 = 277.09
7.5 t ha^{-1} (P3)	87.89^{a}	4 = 12.04	141.64^{a}	4 = 21.09	1696.73^{a}	4 = 285.46

Note: Numbers followed by different letters in the same column are significantly different based on 95% confidence level of DMRT test

Table 5 shows the biggest impact of the independent effect of straw mulch residue on the leaf area at 2 WAP was obtained by M1, which was significantly different from the other treatments. The smallest leaf area was obtained by M0 and was not significantly different from the M2, but significantly different from the M1. Meanwhile, the independent effect of plus organic fertilizer residue on leaf area at 2 WAP showed P3 obtained the widest leaf area, which was significantly different from P0, but not significantly different P1 and P2. The narrowest leaf area was obtained by P0 and was significantly different from P2 and P3, but not significantly different from P1.

The independent effect of plus organic fertilizer residue leaf area at 4 WAP showed that P3 obtained the widest leaf area, which was significantly different from P1 and P0, but not significantly different from the P2. The narrowest leaf area was obtained by P0 was significantly different from P2 and P3, but not significantly different from P1. Widest leaf area at 6 WAP was obtained by P3, significantly differed from P1 and P0, but not significantly different from P2. The narrowest leaf area was obtained by P0 and significantly differed from P2 and P3, but not significantly different from P1.

Winarti (2021) stated that organic fertilizer residues could decompose and release nutrients, including N. The N availability in the soil determines the amount of N that can be absorbed. Adequate N availability will form broader leaves and higher chlorophyll content, so plants can produce sufficient assimilations to support vegetative growth. The sufficient N will ensure that leaves grow and become broader. Leaf size determines the effectiveness of the photosynthesis process. Broad leaves allow high sunlight absorption so that more chemical energy is collected to support the photosynthesis process to produce higher photosynthates or assimilates. In this situation, the plant will grow and develop plant organs such as roots, stems and leaves to the fullest. Photosynthesis results are broken down through respiration to produce energy causing the leaves to be longer and broader. The N element determines leaf chlorophyll, which captures sunlight for maximum photosynthesis and assists plants in spurring vegetative growth, such as the number of leaves and leaf area (Asra, G., Simanungkalit, T., & Rahmawati, N., 2015). Rahmah, A., Izzati, M., Parman, S. (2014) stated that nitrogen was used to support plant vegetative growth, including leaf development. According to Hardian, M., Basuni., & Sahwan, M. (2021), the growth of plant leaves and stems can be hampered due to N deficiency.

Plant Fresh Weight and Dry Weight

The DMRT results on the independent effect of plus organic fertilizer residue treatment on the fresh weight and dry weight of glutinous corn are presented in Table 6.

Table 6. The independent effect of plus organic fertilizer residue treatment on the fresh weight and dry weight of glutinous corn

Plus Organic Fertilizer Residue	Fresh Weight (g)	DMRT α = 0.05	Dry Weight (g)	DMRT α = 0.05
0 t ha^{-1} (P0)	63.28^{b}		18.72^{c}	
2.5 t ha^{-1}(P1)	70.01^{b}	2 = 10.31	21.02^{bc}	2 = 2.97
5 t ha^{-1}(P2)	75.32^{ab}	3 = 10.83	22.88^{ab}	3 = 3.12
7.5 t ha^{-1} (P3)	81.27^{a}	4 = 11.16	25.05^{a}	4 = 3.21

Note: Numbers followed by different letters in the same column are significantly different based on 95% confidence level of DMRT test

Table 6 shows that the biggest impact of the independent effect of plus organic fertilizer residue on obtained by P3 with the heaviest fresh weight, which was significantly different from the P1 and P0, but not significantly different from P2. The smallest fresh weight obtained by P0 and was significantly different from P3, but not significantly different from P1 and P2.

The P3 obtained the heaviest dry weight, which was significantly different from the P1 and P0, but not significantly different from the P2 treatment. Smallest dry weight obtained by P0 which was significantly different from P2 and P3, but not significantly different from P1.

Plus organic fertilizer residue at a dose of 7.5 t ha^{-1} is thought to create good soil structure and texture conditions along with providing macro and micro elements to encourage optimal growth. Biologically, organic matter can affect the activities of macroflora and microfauna organisms and can physically improve soil structure (Jenira, H., Sumarjan, & Armiani, S., 2016). A better root system supports optimal growth to optimize using groundwater, implicating increasing glutinous corn's fresh and dry weight. Roidah (2013) and Armiyarsih *et al.* (2020) stated that optimal plant growth was followed by increased fresh and dry weight due to improved soil conditions. Applying organic matter as a soil conditioner can increase N, P, and K uptake in the soil (Maftua'ah *et al.*, 2013). This will maximize photosynthesis to produce and accumulate assimilate. The large accumulation of photosynthate implicates high plant dry weight. Suryati, Dhiya, Sampurno, Anom, & Edison. (2014), stated that plant dry weight reflected on plant nutritional status as dry weight depends on cell number and size; generally, plants consist of 70% water. Dry matter (organic substances) can be obtained by drying water. Using organic matter such as compost increases plant dry weight (Gusta, A.R., Kusumastuti, A. , & Parapasan, Y., 2015; Armiyarsih *et al*., 2020). The highest fresh and dry weight of glutinous corn was obtained by residues of plus organic fertilizer at a dose of 7.5 ton per hectare (Table 6). Haumein (2020) stated that higher amount of organic fertilizers applied to the soil could withdraw residue, as organic fertilizers require a longer decomposition process used for plant growth in the second planting period.

Flowering Age

The DMRT results on the independent effect of straw mulch residue and plus organic fertilizer residue treatment on the flowering age of glutinous corn are presented in Table 7.

Table 7. The independent effect of straw mulch residue and plus organic fertilizer residue treatment on the flowering age of glutinous corn

Rice Straw Mulch Residue	Flowering age (day)	DMRT α = 0.05
0 t ha^{-1} (M0)	44.17^{b}	
4 t ha^{-1} (M1)	42.83^{b}	2 = 1.10
8 t ha^{-1} (M2)	42.67^{a}	3 = 1.13
Plus Organic Fertilizer Plus		
0 t ha^{-1} (P0)	44.10^{c}	
2.5 t ha^{-1} (P1)	43.33^{bc}	2 = 0.89
5 t ha^{-1} (P2)	42.78^{ab}	3 = 0.93
7.5 t ha^{-1} (P3)	42.00^{a}	4 = 0.96

Note: Numbers followed by different letters in the same column are significantly different based on 95% confidence level of DMRT test

Table 7 shows that the effect of rice straw mulch residue on flowering age was the fastest in M2, which was significantly different from M0 but not significantly different from M1. Longest flowering age was obtained by M0, which was significantly different from M2 but not significantly different from the other treatments. Meanwhile, the effect of organic fertilizer residue plus on flowering age showed that the fastest flowering age obtained by P3 was significantly different from P0 and P1, but not significantly different from P2. Longest flowering age was obtained by P0, which was significantly different from P2 and P3, but not significantly different from P1.

Dewantari, R. P., Nur, E.S., & Setyono, Y.T. (2015) stated that the treatment without mulch caused a significant change in soil water content, resulting in a water deficit. Water stress will increase leaf temperature, close stomata, and decrease photosynthesis. The soil's good physical properties due to residue from a straw mulch (Rizki, T., Hadid, A., & Mas'ud, H., 2015; Wahjunie, E.D., Sinukaban, N., & Damanik, B.S.D., 2012) and residue of plus organic fertilizer containing rhizobacteria are thought to increase nutrient availability and the activity of microorganisms producing plant growth promoting hormones to encourage plant growth rate. The plant growth rate increased along with the increasing dose of fertilizer (Zulkifli, T.B.H., Tampubolon, K., Nadhira, H., Berliana, Y., Wahyudi, D., Razali, & Musril, 2020). Plant growth rate shows the ability to produce biomass per unit of time. An increase in biomass due to water and nutrients absorbed by plants supports the development of plant organs, including reproductive organs such as plant flowers. Therefore, the residue of plus organic fertilizer at a dose of 7.5 t ha^{-1} accelerates the glutinous corn flower formation. Soil properties can be improved using ameliorant materials such as organic materials/fertilizers (Priyadi, Jamaludin, & Mangiring, W., 2020). Biologically, organic matter can affect the activities of macroflora and microfauna organisms and can physically improve soil structure (Jenira *et al*., 2016). The bacterial population increases because organic matter contains C organic and N as a source of microbial nutrition, which increases soil fertility (Tobing, S., Mubarik, N.R., & Triadiati., 2014). Therefore, increasing the dose of plus organic fertilizer and straw mulch can maximize the fertility of dry land to support glutinous corn growth.

D.Conclusion

The interaction effect of rice straw mulch residues and plus organic fertilizer residues on plant growth did not have a significant effect. Rice straw mulch residue significantly affected leaf area and flowering age. In contrast, plus organic fertilizer residue significantly affected plant height, the number of leaves, stem diameter, total leaf area, fresh weight, dry weight, stem diameter, and flowering age. The 8 t ha^{-1} residue of rice straw mulch at a dose of or 7.5 t ha^{-1} plus organic fertilizer residue by producing the best plant growth.

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