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Induction of Variegata Red Majesty Using EMS Mutagen and Gibberellins in Vitro

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Abstract

This study aims to determine how the interaction occurs between the best concentration of EMS with gibberellin in inducing aglaonema variegata and regeneration of aglaonema Red Majesty in vitro. The research was conducted at the Tissue Culture Laboratory of the Faculty of Agriculture, Hasanuddin University and took place from January to June 2022. The study used the method of Separate Plots Design in a Completely Randomized Design as the environmental design. The results showed that the best mutant genetic diversity and in vitro regeneration at 0.3 percent EMS concentration with 15 ppm gibberellin (variegata), and 45 ppm (chimera) and 0.6 percent EMS concentration with 0 ppm gibberellin (variegata) had different characters compared to the control treatment and other treatments

Keywords: Red Majesty, EMS, gibberellins, in vitro, variegata

A. Introduction

Aglaonema is a plant that has an appeal, especially in the beauty of its leaves and is used as an ornamental plant. Aglaonema has around 30 species which have different leaf patterns and colors for each species (Akbar M.R., B.S. Purwoko, I.S. Dewi, W.B. Suwarno, Sugiyanta & M.F. Anshori, 2021). This ornamental plant nationally only has a production of 816,468 trees, while the demand for both export and domestic markets is very large (Indonesian Ministry of Agriculture, 2019). Aglaonema that is highly valued in the market and is on the rise is a mutated Aglaonema such as variegata whose price can reach IDR 1.5 million per leaf (Lakamisi, 2010). According to Kaviani B., Sedaghathoor, S., Motlagh, M. & Rouhi, S. research (2018), the more unique the color of the aglaonema leaves, the higher the demand and selling price. However, the obstacle to obtaining naturally occurring mutations and variegata aglaonema is very rare because the normal frequency and mutation ratio is between 1:1,000,000.

Artificial mutations are a solution to increase the prospective value of aglaonema. Artificial mutation is a change that occurs in a gene due to the administration of a mutagen (Suteja H.N., N. Rostini. & S. Amien , 2019). Artificial mutations can be done through the multiplication of tissue culture (in vitro). Tissue Culture is a technique that is used to propagate a plant usinbpg isolated plant parts (explants) in an optimal, controlled and aseptic environment in glass bottles (Ziraluo and Piter, 2021). Mutation induction through tissue culture propagation is considered very effective in accelerating the desired in vitro selection and increasing plant diversity in a short time commercially without changing the characteristics of the original cultivar (Maluszynski M., Ahloowalia, B.S. & Sigurbjörnsson, B. 1995).

The most widely used chemical mutagen in plants is the chemical compound Ethyl Methane Sulfonate (EMS) because it has been shown to be effective in causing changes in N bases in DNA or RNA or point mutations so as to produce wide genetic diversity (Wijiono, 2016). This is supported by the research of Putra and Purwani (2017), which states that the use of the EMS mutagen can cause mutants by producing high genetic diversity so that they are used in making mutant plants. In an effort to maximize the formation of mutations, the addition of gibberellic acid (GA3) is useful for in vitro shoot regeneration, growth, biomass and fiber elongation in xylem and is able to play a role in replacing auxin (Chakraborty D., Mandal & Datta, S.K., 2000). The successful use of the gibberellin mutagen in inducing variegata plants is also supported by Dewi's research (2015) which states that the gibberellin hormone can increase the length of epidermal stem cells, plant height, density of stomata on the underside of leaves, and total chlorophyll content.

To obtain optimal results, it is necessary to have a combination of the two mutagen compounds combined with tissue culture techniques (in vitro). This is based on Yoosumran's research (2018) using EMS with several concentrations could produce some different characteristic mutations on Dendranthemum grandiflora plants in vitro and Rajagukguk, S., Dwiyani, R. & Astawa (2018), which used GA3 with a concentration of 20 ppm on grape shoots in vitro capable of having the highest effect on the percentage of sprouting and leafy.

B. Methodology

The research was conducted at the Tissue Culture Laboratory, Hasanuddin University, Makassar, South Sulawesi, Faculty of Agriculture, Hasanuddin University. The study was conducted using a Split Plot Design with Ethyl Methane Sulfonate (EMS) as the main plot and gibberellin (GA3) as a subplot in a completely randomized design (CRD). The EMS levels used were 0% (e0), 0.3% (e1), 0.6% (e2) 0.9% (e3). While the Gibberellin treatment used 4 levels, namely 0 ppm (g0), 15 ppm (g1), 30 ppm (g2), 45 ppm (g3). Thus the treatment consisted of 16 treatment combinations with each treatment being repeated 3 times and each repetition using 3 bottles of culture so that there were 144 experimental units

1. *Research procedures*

Preparation of control media (without gibberellin) begins by dissolving 30 gram/L sucrose into 500 ml of water, adding MS according to the dosage for 1000 ml solution, 1.5 mg/L IBA, 2 mg/L BAP, and making it up to 1000 ml by adding distilled water . To make the treatment media almost the same as the control media, the difference is only given the addition of Gibberellin (GA3) according to the predetermined concentration and sufficient media to reach 1000 ml by adding distilled water. Then adjust the pH to 5.8 by adding NaOH or HCl. All media added 2 ppm BAP and 1 ppm IBA

The soaking process using EMS was carried out in a sterile Laminar Air Flow. Soaking was carried out for 1 hour 45 minutes, by immersing the shoots in EMS solutions of various concentrations. Planting is done by sticking the explants into the media so that there is perfect contact between the two. Each media that has been planted is stored in the incubation room for 2-3 months. The explants used were from aglaonema Red Majesty plantlets which had been soaked by EMS.

2. *Data Analysis*

Data analysis used analysis of variance (ANOVA) and continued with the Least Significant Difference Test (LSD) 5% (0.05) using STAR Software to determine the relationship between characters and the amount of genetic diversity formed.

C. Result and Discussion

Plants treated with 0.3% EMS concentration and 15 ppm Gibberellin produced leaves with dominant white spots (variegata) (table 1 and Fig. 1). Plants treated with 0.3% EMS concentration with 45 ppm Gibberellins produced leaves with a dominant dark green color and a few yellow spots (chimera). The treatment of 0% EMS with 0 ppm Gibberellins produced plants with good growth and normal leaf length and width. While the EMS immersion treatment of 0.3%, 0.6% and 0.9% with 0 ppm Gibberellin resulted in variations in color, leaf shape and leaf width which were smaller than the control, the higher the EMS concentration resulted, the leaf length and leaf width became smaller and the growth was slower. slow. In Haswin's opinion (2021), stated that treatment with mutagens at high concentrations resulted in an effect or change on the morphology of the plant. Moreover, using EMS in high concentrations can reduce plant survival rates (Nasri, F., Zakizadeh, H., Vafaee, Y. & Mozafari, A.A., 2021). This is because EMS is a compound that can be toxic so that it can inhibit growth in plants by inhibiting plant chlorophyll production.

Treatment of 0% EMS concentration with 15 ppm, 30 ppm and 45 ppm Gibberellins, produced plants with good growth and larger length and width of leaves than the control. The higher the concentration of Gibberellin, the greater the plant height and leaf area. This is supported by the results of Purwoko B.S., Sulistiyani, D.S. & Gunawan, L.W. (1997), exogenous addition of Gibberellins (GA3) to anthurium plants at concentrations (10, 20, and 30 mg) can cause an increase in leaf area. While the EMS treatment of 0.3% and 0.6% with 15 ppm, 30 ppm and 45 ppm Gibberellins produced variations in leaf color, leaf shape and leaf width which were different from the control. The higher EMS concentration resulted in shorter plant height and at a dose of 0.9% at 0 ppm, 30 ppm and 45 ppm Gibberellins, resulted in browning of leaves and stems until there was death. According to Bhagwat and Duncan (1998), in general, the frequency of mutases can increase with an increase in the concentration of the given mutagen. This is supported by Harten (1998), low concentrations can stimulate changes in plant physiology. In addition, the results of Qosim's research (2012) suggested that EMS treatment was able to encourage cell division in plants, whereas higher EMS concentrations had the potential to cause cell death in plants.

Table 1. Comparison of Aglaonema Red Majesty Plants Control with Treatment on Scoring Evaluation

Treatment	Character			
	Leaf Shape	Leaf Edge	Leaf Color	Dominant Spot Color
E0G0	Oval	Pointed	Pink	Light Green
E0G1	Oval	Pointed	Pink	Dark Green
E0G2	Ellipse	Pointed	Pink	Dark Green
E0G3	Scroll Ellipse*	Pointed	Dark Green*	Light Green
E1G0	Ellipse	Blunt*	Green*	Light Green
E1G1	Ellipse *	Blunt *	Light Green*	Pink and White *
E1G2	Ellipse*	Blunt *	Indian Red*	Light Green*
E1G3	Ellipse*	Blunt *	Dark Green*	Yellow*
E2G0	Oval	Pointed	Pink	Green
E2G1	Ellipse*	Pointed	Dark Green*	Broken White*
E2G2	Ellipse*	Pointed	Green*	Pink and White*
E2G3	Scroll Ellipse*	Tapering*	Green*	Yellowish Green*
E3G0	Ellipse*	Pointed	Broken White*	Pink*
E3G1	Oval	Pointed	Green*	Brownish Yellow*
E3G2	Ellipse*	Blunt*	Pink	Dark Green
E3G3	Oval	Pointed	Reddish Brown*	Light Green

Note: *= In contract to control

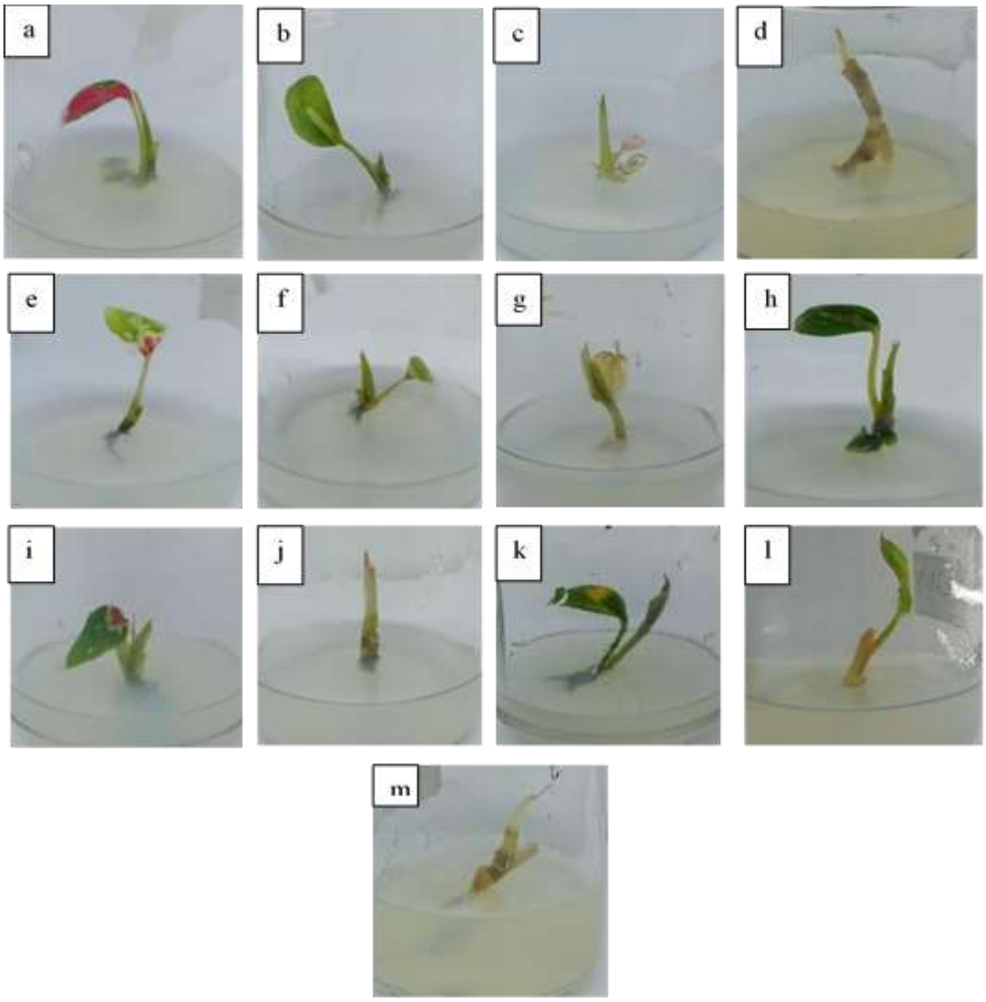

Figure 1. The visual appearance of the leaves based on the results of the leaf morphological analysis scoring. EMS concentration 0 % with 0 ppm Gibberellin (a), EMS 0.3 % with 0 ppm Gibberellin (b), EMS 0.6 % with 0 ppm Gibberellin (c), EMS 0.9 % with 0 ppm Gibberellin (d), EMS 0.3 % with 15 ppm Gibberellin (e), EMS 0.6 % with 15 ppm Gibberellin (f), EMS 0.9 % with 15 ppm Gibberellin (g), EMS 0.3 % with 25 ppm Gibberellin (h), EMS 0.6 % with 25 ppm Gibberellin (i), EMS 0.9 % with 25 ppm Gibberellin (j), EMS 0.3 % with 45 ppm Gibberellin (k), EMS 0.6 % with 45ppm Gibberellin (l), EMS 0.9 % with 45 ppm Gibberellin (m).

The results showed that the fastest germination rate occurred at concentrations without EMS with gibberellin concentrations of 45 ppm giving the fastest average sprouting speed (8.78 days). The longest germination rate (23 days) was in the 0.9% treatment with a concentration of 0 ppm gibberellins. The administration of higher concentrations of EMS and gibberellin resulted in a longer germination speed (Table 2). This is in accordance with the opinion of Priyono & Susilo (2002), the high concentration of EMS given causes more EMS absorption so that the toxicity of EMS will increase and cause growth inhibition. According to Qosim W.A., Yuwariyah W., Y. Hamdani, J.S. Rachmadi M. & Perdani, S.M. (2015), the timing of the emergence of shoots can be caused by a decrease in cell potential in the explant tissue. The meristematic cells in the explants have the potential to form new sprouts, but the administration of mutagens can induce physiological changes in these cells. This change depends on the susceptibility of the meristematic cells that form the explants, causing changes in potential and triggering the growth of cells in the explant tissue which causes differences in the response of the explants. In addition, according to Barani . Akbari, N., & Ahmadi, H. (2013), states that the speed of sprouting is faster with increasing concentrations of Gibberellin (GA3) because GA3 treatment generally responds to cell division.

Table 2. Average Germination Speed (Days) Interaction Treatment of EMS and Gibberellin Concentrations

Gibberellin	EMS				NPG BNT
	e0 (0 %)	e1 (0.3 %)	e2 (0.6 %)	e3 (0.9 %)	
g0 (0 ppm)	18.00^{a}_{r}	18.77^{a}_{r}	20.33^{a}_{q}	23.00^{a}_{p}	1.32
g1 (15 ppm)	16.00^{b}_{s}	18.00^{a}_{r}	19.44^{ab}_{q}	21.89^{ab}_{p}	
g2 (30 ppm)	10.33^{c}_{r}	17.67^{a}_{q}	18.44^{bc}_{q}	21.67^{bc}_{p}	
g3 (45 ppm)	8.78^{d}_{s}	14.77^{b}_{r}	17.89^{c}_{q}	20.55^{c}_{p}	
NPE BNT		1.35			

Note: The same letters in the column (abcd) and in the row (pqrs) indicate no significant difference in the BNT Test level α = 0.05

On the speed of rooting and the speed of forming plantlets, the treatment of EMS and gibberellin concentrations on aglaonema plants had a very significant effect at the 0.05 level, so that it could have a positive effect on the observed variables. Based on the analysis of the mean test (Table 3) for the speed of rooting and the speed of forming plantlets, the fastest average was obtained (31.66 days) at 0.3% EMS concentration with 45 ppm Gibberellin concentration. Rooting speed and plantlet formation were the longest (84.22 days) at 0.9% EMS concentration with 0 ppm gibberellin medium. Giving EMS and gibberellin concentrations affected the speed of rooting of aglaonema explants and the speed of forming plantlets. The results of Pratiwi and Ermavitalini's research (2019), the lower the EMS concentration used, the EMS can function as auxin which helps accelerate root formation and vice versa if the EMS concentration is high it will inhibit growth and can even cause death. In addition, George and Sherrington (1984), administration of Gibberellin (GA3) aims to stimulate the formation of the hormone auxin and can induce explants so as to assist in inducing root formation.

Table 3. Average Speed of Rooting (Days) and Speed of Forming Planlets (Days) in Interaction Treatment of EMS and Gibberellin Concentrations

Gibberellin	EMS				NPG BNT
	e0 (0 %)	e1 (0.3 %)	e2 (0.6 %)	e3 (0.9 %)	
g0 (0 ppm)	36.67^{a}_{r}	33.55^{a}_{r}	54.44^{a}_{q}	84.22^{a}_{p}	5.16
g1 (15 ppm)	35.77^{a}_{r}	32.33^{a}_{r}	50.44^{a}_{q}	78.00^{b}_{p}	
g2 (30 ppm)	34.89^{a}_{qr}	32.11^{a}_{r}	39.11^{b}_{q}	66.89^{c}_{p}	
g3 (45 ppm)	33.66^{a}_{qr}	31.66^{a}_{r}	37.89^{b}_{q}	68.53^{c}_{p}	
NPE BNT		5.12			

Note: The same letters in the column (abcd) and in the row (pqrs) indicate no significant difference in the BNT Test level α = 0.05

In observing the number of shoots, the treatment of various EMS concentrations had a significant effect and the gibberellin treatment had no significant effect so that there was no interaction that had a positive effect on the observed variables. Based on the analysis of the mean test (Table 4), the highest average number of shoots (1.32) was obtained at the concentration without EMS and the lowest number of shoots (1.08) was obtained at the EMS concentration of 0.9%. The use of GA3 had no significant effect because the EMS concentration exerted a stronger suppression on the increase in the number of shoots and only accelerated the growth of aglaonema shoots. Poerba Y.S., Imelda, M., Wulansari, A & Martanti, D. (2009) argued that EMS is a mutated substance that is toxic in in vitro culture, whereas the concentration of EMS given increases, it can reduce growth power, number of shoots, shoot height, and the percentage of rooted cultures.

Table 4. Average Number of Shoots at Various EMS Concentrations

Gibberellin	EMS				Average
	e0 (0 %)	e1 (0.3 %)	e2 (0.6 %)	e3 (0.9 %)	
g0 (0 ppm)	1.11	1.11	1.11	1.11	1.11
g1 (15 ppm)	1.22	1.11	1.00	1.00	1.08
g2 (30 ppm)	1.44	1.11	1.11	1.11	1.19
g3 (45 ppm)	1.50	1.22	1.11	1.11	1.11
Average	1.32 a	1.14 b	1.08 b	1.08 b	
NP (E) BNT α = 0.05		0.16			

Note: The same letters in the column (abcd) indicate no significant difference in the BNT Test level α = 0.05

On the observation of shoot height, the EMS concentration treatment with Gibberellins (GA3) on aglaonema plants had a very significant effect, so that it could have a positive effect on the observed variables. Based on the analysis of the mean test (Table 5), the highest average shoot height (4.50 cm) was obtained at a concentration without EMS with 45 ppm and the lowest average shoot height (2.52 cm) was obtained at an EMS concentration of 0.3% with 0 ppm Gibberellin. This happens because Gibberellin has a good response. According to research by Chakraborty et al., (2000), GA3 has a conducive ability to regenerate shoots in vitro on growth promotion, biomass production and xylem fiber length. In addition, the addition of EMS treatment at high concentrations causes inhibition of plant growth, including the increase in shoot height. According to Harahap M.S.A., Nilahayati., Handayani, R.S., Nazimah, &Hafifah. (2022), growth inhibition in M1 generation plants occurs due to damage to plant physiology as a result of mutagen action, where the high doses of mutagen substances given will also increase the chances of growth inhibition in M1 generation plants. The impact of this is causing a decrease in plant height, leaf size, number of leaves and plant weight.

Table 5. Average Shoot Height (cm) in EMS and Gibberellin Immersion Concentration

Gibberellin	EMS				NPG BNT
	e0 (0 %)	e1 (0.3 %)	e2 (0.6 %)	e3 (0.9 %)	
g0 (0 ppm)	3.78^{b}_{p}	3.41^{c}_{q}	2.64^{c}_{r}	2.52^{c}_{r}	0.19
g1 (15 ppm)	3.90^{b}_{p}	3.55^{bc}_{q}	2.82^{bc}_{r}	2.83^{b}_{r}	
g2 (30 ppm)	3.97^{b}_{p}	3.74^{ab}_{q}	2.93^{b}_{r}	3.02^{b}_{r}	
g3 (45 ppm)	4.50^{a}_{p}	3.90^{a}_{q}	3.62^{a}_{r}	3.53^{a}_{r}	
NPE BNT			0.22		

Note: The same letters in the column (abcd) and in the row (pqrs) indicate no significant difference in the BNT Test level α = 0.05

In observing the number of leaves, the treatment of EMS and Gibberellin concentrations had a very significant effect so that there was an interaction that had a positive effect on the observed variables. Based on the analysis of the mean test (Table 6), the treatment that gave the highest average growth of the number of leaves (1.22 leaves) was obtained from the concentration without EMS with 15 ppm Gibberellin. Meanwhile, the treatment that gave the lowest average number of leaves (not forming leaves) was obtained from the 0.9% EMS treatment with 0 ppm gibberellins, 30 ppm and 45. According to Pratiwi et al. (2013) the application of mutagen substances can result in increased activity of several enzymes due to stimulation of amino acid biosynthesis such as polyphenol oxidase, catalase and pyroxidase which can inhibit growth in leaves. This is supported by Listiani L., Lestari, A., Widyodaru, N., & Sandra, E. (2021), the results of the study showed that EMS administration to Anthurium jenmanii lemon had no impact on the number of leaves formed.

Table 6. Average Number of Leaves (strands) in the Interaction Treatment of EMS and Gibberellin Concentrations

Gibberellin	EMS				NPG BNT
	e0 (0 %)	e1 (0.3 %)	e2 (0.6 %)	e3 (0.9 %)	
g0 (0 ppm)	1.11^{a}_{p}	1.00^{a}_{p}	1.11^{a}_{p}	0.00^{b}_{q}	0.28
g1 (15 ppm)	1.22^{a}_{p}	1.11^{a}_{p}	1.11^{a}_{p}	1.00^{a}_{p}	
g2 (30 ppm)	1.11^{a}_{p}	1.11^{a}_{p}	1.11^{b}_{p}	0.00^{b}_{q}	
g3 (45 ppm)	1.00^{a}_{p}	1.11^{a}_{p}	1.11^{c}_{p}	0.00^{b}_{q}	
NPE BNT		0.25			

Note: The same letters in the column (abcd) and in the row (pqrs) indicate no significant difference in the BNT Test level α = 0.05

The treatment of EMS concentration on the parameter number of roots had a very significant effect while gibberellins did not have a significant effect so that there was no interaction that could have a positive effect on the observed variables. Based on the analysis of the mean test (Table 7) the number of roots, which gave the highest average (3.31 strands), namely the EMS concentration of 0.3% and the EMS concentration which gave the lowest average number of roots (2.58 strands), namely and the EMS concentration of 0.9%. Giving EMS concentration affects the number of aglaonema roots. This is in line with the research of Qosim (2012), that low concentrations in the application of EMS will have properties as an auxin substance in plants and a decrease in plant quantitative, such as the number of roots occurs as a result of random mutations. EMS can cause point mutations at DNA junctions due to changes in nucleotide base pairs that cause changes in amino acids.

Table 7. Average Number of Roots (strands) at Various EMS Concentrations

Gibberellin	EMS				Average
	e0 (0 %)	e1 (0.3 %)	e2 (0.6 %)	e3 (0.9 %)	
g0 (0 ppm)	2.66	3.11	3.00	2.33	2.77
g1 (15 ppm)	2.50	3.55	2.77	2.44	2.81
g2 (30 ppm)	2.33	3.11	2.89	2.77	2.77
g3 (45 ppm)	3.00	3.44	3.11	2.77	3.08
Average	2.62 b	3.31 a	2.94 ab	2.58 b	
NP (E) BNT α = 0.05		0.48			

Note: The same letters in the column (abcd) indicate no significant difference in the BNT Test level α = 0.05

In observing root length, the EMS concentration treatment with Gibberellins on aglaonema plants had a very significant effect so that it could have a positive effect on the observed variables. Based on the analysis of the mean test (Table 8) of root length, which gave the longest average (1.45 cm), namely 0.3% EMS concentration with 0 ppm Gibberellin and the treatment that gave the least root length (0.4 cm), namely 0.9% EMS concentration with 15 ppm Gibberellin. Giving the right concentration of EMS and Gibberellins can affect the length of aglaonema roots. This is in line with Qosim's research (2012), that low concentrations in the application of EMS will have properties as an auxin substance in plants and vice versa if the dose used is high it will cause growth inhibition and even the plant can become lethal. Furthermore, according to Sekioka and Tanaka (1981), stated that GA3 has a function as an auxin in shoot induction and has a cytokinin ratio of GA3 which plays an important role in determining differentiation in plant tissue.

Table 8. Average Root Length (cm) in Interaction Treatment of EMS and Gibberellin Concentrations

Gibberellin	EMS				NPG BNT
	e0 (0 %)	e1 (0.3 %)	e2 (0.6 %)	e3 (0.9 %)	
g0 (0 ppm)	0.80^{a}_{q}	1.45^{a}_{p}	0.44^{a}_{r}	0.50^{a}_{r}	0.14
g1 (15 ppm)	0.60^{b}_{q}	1.10^{b}_{p}	0.43^{a}_{r}	0.41^{a}_{r}	
g2 (30 ppm)	0.56^{b}_{q}	1.00^{b}_{p}	0.52^{a}_{q}	0.45^{b}_{q}	
g3 (45 ppm)	0.55^{b}_{q}	0.83^{c}_{p}	0.53^{a}_{q}	0.56^{a}_{q}	
NPE BNT	0.13				

Note: The same letters in the column (abcd) and in the row (pqrs) indicate no significant difference in the BNT Test level α = 0.05

D. Conclusion

The results showed the effectiveness of EMS and Gibberellin in inducing aglaonema variegata of the Red Majesty type. The best mutant genetic diversity and in vitro regeneration at 0.3% EMS concentration with 15 ppm gibberellin (variegata), 45 ppm EMS (chimera) and 0.6% with 0 ppm gibberellins (variegata) differed from the control and other treatments. The accuracy in EMS and Gibberellin concentrations has a significant effect on the observed parameters.

E. References

Akbar, M.R., B.S. Purwoko, I.S. Dewi, W.B. Suwarno, Sugiyanta & M.F. Anshori. (2021). Agronomic and yield selection of double haploid lines of rainfed lowland rice in advanced yield trials. Biodiversitas, 22: 3006-3012.

Barani, M. Akbari, N., & Ahmadi, H. (2013). The Effect of Gibberelic Acid (GA3) on Seed Size and Sprouting of Potato Tubers (*Solanum tuberosum* L.). African Journal of Agricultural Research. Vol 8(29):3898-3903.

Bhagwat, B. & Duncan, E.J. (1998). Mutation Breeding of Banana cv. Highgate (Musa spp., AAA Group) for tolerance to *Fusarium oxysporum f. sp. Cubanse* using chemical mutagens. Scientia Horticulturae. Vol. 73(1): 11-22.

Chakraborty, D., Mandal & Datta, S.K. (2000). Retrieval of new coloured chrysanthemum through organogenesis from Sectorial chimera. Curr Sci. 789:1060–1061.

Dewi, S. (2015). Perkembangan Kultur Daun *Aglaonema Sp.Var Slam Peari*, *Aglaonema sp var Lady Valentine dan Aglaonema sp var Lipstick* Dengan Perlakuan Zat Pengatur Tumbuh IAA Dan BAP. Departemen Biologi. Fakultas Sains dan Teknologi Universitas Airlangga. Berk. Penel. Hayati:17: 197-203.

George, E.F. & P.D. Sherrington. (1984). Plant Propagation by Tissue Culture. Penebar Swadaya. Jakarta.

Harahap, M.S.A., Nilahayati., Handayani, R.S., Nazimah, & Hafifah. (2022). Potensi Peningkatan Keragaman Genetik Tanaman Kedelai (*Glycine max* (L.) Merr.) Akibat Pemberian Mutagen EMS (Ethyl Methane Sulfonate) pada Fase Vegetatif. Jurnal Ilmiah Mahasiswa Agroekoteknologi, Vol. 1(3): 73-76.

Harten, A.M. (1998). Mutation Breeding. United Kingdom: Cambridge University Press.

Haswin, D.W. (2021). Induksi Mutasi Tanaman *Monstera adansonii* Pada Berbagai Mutagen Kimia Dengan Aplikasi Tetes. Thesis-S2. Universitas Hasanuddin.

Kaviani, B., Sedaghathoor, S., Motlagh, M. & Rouhi, S. (2018). Influence of plant growth regulators (BA, TDZ, 2-iP and NAA) on micropropagation of Aglaonema widuri. Iranian Journal of Plant Physiology, 9(2): 2709-2718.

Kementrian Pertanian (Indonesian Ministry of Agriculture). (2019). Berita Utama. Direktorat Jendral Hortikultura.https://hortikultura.pertanian.go.id/geliat-aglaonema-pada-masa pandemi/#:~:text=Berdasarkan%20data%20statistik%20tahun%202019,produksi%20a glaonema%20nasional%20mencapai%20816.468%20pohon.

Lakamisi, H. (2010). Prospek Agribisnis Tanaman Hias Dalam Pot (POTPLANT). Jurnal Ilmiah agribisnis dan Perikanan (agrikan UMMU-Ternate), 3(2): 55-59.

Listiani, L., Lestari, A., Widyodaru, N., & Sandra, E. (2021). Pengaruh Pemberian Mutagen Kimia Ethyl Methane Sulphonate (EMS) terhadap Keragaman Fenotipe Tanaman Hias Anthurium jenmanii Lemon Secara In Vitro. Jurnal AGROHITA: Jurnal Agroteknologi Fakultas Pertanian Universitas Muhammadiyah Tapanuli Selatan, 6(2), 139-148.

Maluszynki, M., Ahloowalia, B.S. & Sigurbjörnsson, B. (1995). Application of in vivo and in vitro mutation techniques for crop improvement. 85, 303-3015.

Nasri, F., Zakizadeh, H., Vafaee, Y. & Mozafari, A.A. (2021). In Vitro Mutagenesis of Chrysanthemum morifolium Cultivars Using ethylmethanasulphonater (EMS) and Mutation Assesment by ISSR and IRAP Markers. Plant Cell, Tissue and Organ Culture. https://doi.org/10.1007/s11240-021-02163-7.

Poerba, Y.S., Imelda, M., Wulansari, A & Martanti, D. (2009). Induksi Mutasi Kultur In Vitro Amorphophallus muelleri Blume dengan Irradiasi Gamma. J. Tek. Ling. Vol. 10(3): 355-364.

Pratiwi, N. M., Pharmawati, M., & Astarini, I. A. (2013). Pengaruh Ethyl Methane Sulphonate (EMS) Terhadap Pertumbuhan dan Variasi Tanaman Marigold (Tagetes sp.). Agrotop, 3(1): 23-28

Pratiwi, R.A.O. & Ermavitalini, D. (2019). Pengaruh Ethyl Methane Sulphonate (EMS) terhadap Morfologi Akar Kecambah Padi (*Oryza sativa*) Varietas Lallodo. Jurnal Sains Dan Seni ITS, 8(1): 2337-3520.

Priyono, & Susilo, A.W. (2002). Respons Regenerasi In Vitro Eksplant Sisik Mikro Kerk Lily (*Lilium longflorum*) terhadap Ethyl Methane Sulfonate (EMS). Jurnal Ilmu Dasar. Vol. 3(2): 74-79.

Purwoko, B.S., Sulistiyani, D.S. & Gunawan, L.W. (1997). Pengaruh Aplikasi GA3 Terhadap Pembungaan Tanaman *Anthurium andreanum* cv. AVO CUBA. Jurnal Agronomy Indonesia, 25(3).

Putra, B.S & Purwani, K.I. (2017). Pengaruh Mutagen Kimia EMS (Ethyl Methane Sulphonate) Terhadap Daya Berkecambah Benih Tanaman Tembakau var. Marakot. Jurnal Sains dan Seni ITS, 6(2) DOI:10.12962/j23373520.v6i2.26705

Qosim W.A., Yuwariyah W., Y. Hamdani, J.S. Rachmadi M. & Perdani, S.M. (2015). Pengaruh Mutagen Etil Metan Sulfonat Terhadap Regenerasi Tunas Pada Dua Genotip Manggis Asal Purwakarta dan Pandeglang. J. Hort. 25(1):9-14

Qosim, W. A. (2012). Pengaruh Mutagen Etil Metan Sulfonat Terhadap Kapasitas Regenerasi Tunas Hibrida Phaleonopsis in vitro. Qosim, W. A. 2012. Pengaruh Mutagen Etil Metan Sulfonat Terhadap Kapasitas Regenerasi Tunas Hibrida Phaleonopsis in vitro. J. Hort, 22(4): 360-365.

Rajagukguk, S., Dwiyani, R. & Astawa. (2018). Pengaruh Konsentrasi GA3 Terhadap Induksi Tunas Tanaman Anggur (*Vitis vinivera* l.) Secara In Vitro. e-jurnal Agroekoteknologi Tropika, Vol. 7(2): 285-294.

Sekioka, T.A. & Tanaka, J.S. (1981). Differentiation in Callus Culture of Cucumber (*Cucumis sativus* L.). Hort. Sci. Vol. 16: 451.

Suteja, H.N., N. Rostini. & S. Amien. (2019). Pengaruh Perlakuan Ethyl Methanesulphonate Terhadap Perkecambahan Dan Pertumbuhan Kentang Granola (biji). Jurnal Kultivasi, Vol. 18(1): 784-792.

Wijiono, R. (2016). Pengaruh Lama Perendaman Dan Konsentrasi Mutagen EMS (Ethyl metanol sulfonate) Terhadap Pertumbuhan Kedelai (*Glycine max* L.) Varietas Daring. Skripsi. Universitas Islam Negeri Maulana Malik Ibrahim. Malang.

Yoosumran, V. Ruamrungsri, S. Duangkongsan, W. & Kanjana, S. (2018). Induced Mutation of Denranthem grandiflora through Tissue Culture by Ethyl Methanesulphonate (EMS). International Journal of Agricultural Technology, vol. 14(1): 73-82.

Ziraluo, Y. & Piter, B. (2021). Metode Perbanyakan Tanaman Ubi Jalar Ungu (*Ipomea batatas* Poiret) Dengan Teknik Kultur Jaringan Atau Stek Planlet. Jurnal Inovasi Penelitian, 2(3): 1037-1046. https://doi.org/10.47492/jip.v2i3.819.

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Yield Evaluation of Several Tomato Strains from the Cross-Breeding Product of Mawar x Chung

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Abstract

The unavailability of high-yielding varieties can cause low production of tomatoes. Excellent variety construction in plant-breeding programs is possible as an effort to solve the tomato cultivation problem. This study aimed to evaluate the yield of several tomato strains from the cross-breeding product of *Mawar* × *Chung*. This study was conducted at the experimental garden, Faculty of Agriculture, Hassanuddin University from April to July 2023. From the results, a strain with high productivity level was obtained from the KM 10.10.6 (g6), which produced an average of 1432.64 g and was significantly different from both parent plants. This strain also had high heritability levels of plant height, dichotomic height, number of branches, flowering period, harvesting period, number of fruit bunches, number of fruits, fruit length, fruit diameter, fruit weight and productivity. Moreover, this strain had four characteristics that positively correlated to production, namely plant height, stem diameter, number of branches, and number of fruits

Keywords: double cross, three-way cross, heritability, diversity

A. Introduction

Tomatoes are one of the horticulture commodities with high economic value and are much favoured by the public. Tomatoes are a source of vitamins and minerals that can be consumed as fresh fuit, seasoning or processed as food ingredients in tomato sauce and juice (Wasonowati, 2011). Tomatoes also contain an antioxidant compound called lycopene. Lycopene is a pigment that causes tomatoes to be red, lycopene belongs to carotenoids that can prevent and treat various diseases, such as lung cancer, prostate cancer, cervical cancer, pancreatic tumor, and throat tumor (Cahyono, 2008).

According to the market price, tomato is affordable for all community background, thus opening more significant opportunity for market absorption (Dalimartha, 2011). Indonesia's tomato production in the last 3 years has elevated from 1,020,333 tons in 2019 to 1,084,993 tons in 2020 and 1,114,399 tons in 2021 (BPS, 2022). Increasing demand for tomatoes is supported by relatively affordable price, thus providing an excellent opportunity to increase tomatoes productivity. Therefore, an effort to boost domestic tomato production becomes crucial.

In the amount of average production level, the tomato has a low productivity level inproportional to its potential. The low productivity level of tomato is caused by the lack of high-yielding varieties (Asmara P.E.S., E. Ambarwati & A. Purwantoro, 2011). A variety construction in plant breeding program is considerable to obtain a new excellent variety of tomato plants. Excellent variety construction in plant breeding program is preferable due to being environmental-friendly with high sustainability level in biofortification products of agriculture, which has an important role in plant productivity and excellent variety construction improvement (Jambormias and Riry, 2009; M., S. Sujiprihati & R. Yunianti, 2018). A variety construction is proposed to gain a new variety with better hereditary traits that can produce higher quantity product in better quality (Merintan and Purmaningsih, 2016).

The improvement potential of tomato plant products in plant breeding program is conducted by measuring and comparing the conformity among genotypes in tomato plants (Sari, R.E.P., D. Saptadi Kuswanto, 2018). Diversity level can be improved through plant-crossing with far genetical distance (Fadhilah, A. N., M. Farid, I. Ridwan, M.F. Anshori & A. Yassi, 2022). In plant-crossed breeding product, genetical diversity occurs as the plant has different genetic characteristics from both parent plants. Each generation level has different conformity levels, whereas next generation has a higher conformity level than previous generation (Sari et al., 2018). Farid, M., M.F. Anshori, I. Ridwan, N.E. Dungga & I. Ermiyanti (2022) have performed a half-diallele crossing on several tomato varieties with extremely far genetic distance. Crossing between *Mawar* and *Chung* tomato varieties are considered a hybrid product with a high productivity level and lycopene content. Following the description above, a further experiment was necessary to evaluate the product of several tomato strains from the cross breeding of *Mawar* × *Chung*.

B. Methodology

The research was conducted at the Experimental Garden of the Faculty of Agriculture, Hasanuddin University, in Tamalanrea District, Makassar City, South Sulawesi. At an altitude of 22.4 m asl with an average temperature of 24 °C in the morning and 32 °C during the day. This research was conducted from August to December 2021.

The materials used in the research were 10 genotypes resulting from crosses and 4 parental varieties of cayenne pepper seeds, namely G1 (U/B//D/K), G2 (U/D//B/U), G3 (U/D//D /K), G4 (U/K//D/B), G5 (U/D//D/B), G6 (U/B//D/U), G7 (U/B//D/B), G8 (U/D//B), G9 (U/B//D), G10 (D/U//B), G11 (Bara), G12 (Dewata 43 F1), G13 (Ungara IPB), G14 (Katokkon), soil, manure, rice husk charcoal, compost, polybags measuring 10 cm x 15 cm and 30 cm x 35 cm, furadan, patent fertilizer, AB Mix, NPK Mutiara 16-16-16, herbicide with active ingredients paraquat dichloride, insecticide with the active ingredient profenopos, fungicide with the active ingredient propineb and zinc, rapia rope, stake, plastic scrap, plastic bag and research board.

This research was arranged using a randomized block design consisting of 10 genotypes resulting from crosses and 4 parental varieties of cayenne pepper. The experiment was repeated 3 times and each experimental unit consisted of 4 plant samples, so there were 168 experimental units. Observation of cross character evaluation of cayenne pepper was carried out by measuring the observed variables for each plant sample. The diversity of plant characters that appear is determined based on the measurements that have been made. The observed variables included plant height, dichotomous height, plant habitus, stem diameter, flowering age, harvest age, fruit weight, fruit length, fruit diameter, fruit stalk length, and yield. The data obtained was analyzed for variance (Anova), cluster analysis using the STAR (Statistical Tool for Agricultural Research) program and if there is a real or very significant effect, then proceed with the BNT test (α = 0.05). Meanwhile, to see the relationship of each parameter, a correlation analysis was carried out.

C. Result

The LSD test results in Table 1 present the best plant height character in MC 27.12.5 strain (g11) at an averperiod value of 156.00 cm, which was significantly different from the comparative varieties, namely *Mawar* (a) and *Chung* (b). This strain also presents the best stem diameter character at 19.60 mm. Meanwhile, the best dichotomic height character was obtained from the MC 27.7.3 strain (g9) with an average value of 69.00 cm and was significantly different from the comparative varieties.

Table 1. Plant height, dichotomic height, and stem diameter of tomato strains as the cross-breeding products of *Mawar* × *Chung*

Genotypes	Plant height	Dichotomic height	Stem diameter
(g1) MC 9.2.4	88.00	34.00	13.80
(g2) MC 11.4.1	136.00 ^{ab}	48.00 ^{b}	14.90
(g3) MC 35.7.1	142.00 ^{ab}	39.00 ^{b}	15.30
(g4) MC 38.8.8	91.00	40.00 ^{b}	13.30
(g5) MC 27.12.2	132.00 ^{ab}	41.00 ^{b}	19.50
(g6) MC 10.10.2	166.00 ^{ab}	67.00 ^{ab}	16.00
(g7) MC 38.1.1	102.00 ^{b}	55.00 ^{ab}	14.70
(g8) MC 8.3.1	102.00 ^{b}	34.00	15.50
(g9) MC 27.7.3	139.00 ^{ab}	69.00 ^{ab}	14.20
(g10) MC 9.4.1	150.00 ^{ab}	44.00 ^{b}	12.90
(g11) MC 27.12.5	156.00 ^{ab}	44.00 ^{b}	19.60
(g12) MC 9.2.6	97.00 ^{b}	35.00	16.20
(g13) MC 11.4.4	123.00 ^{ab}	45.00 ^{b}	14.50
(g14) MC 27.12.3	124.00 ^{ab}	38.00 ^{b}	15.60
(g15) MC 10.7.8	127.00 ^{ab}	51.00 ^{ab}	14.80
(g16) MC 8.3.2	129.00 ^{ab}	45.00 ^{b}	15.80
(g17) MC 35.7.5	127.23 ^{a}	38.23 ^{b}	13.63
(g18) MC 9.2.7	87.00 ^{ab}	33.00	13.30
(g19) MC 27.12.6	129.00	41.00	15.60
(g20) MC 11.4.5	130.00	46.00	14.70
(g21) MC35.7.6	134.00	39.00	14.50
(g22) MC 27.12.4	123.00	36.00	14.50
(g23) Mawar (a)	103.14	43.63	9.47

(g24) Chung (b)	86.46	29.79	10.83
NP LSD (5%)	7.56	6.92	6.90

Note: Values in the same columns followed by the same letters (ab) present a significantly different condition with comparative varieties of *Mawar* (a) and *Chung* (b), following the LSD test of 0.05.

Table 2 presents the LSD test results of the best number of branches character in MC 10.10.2 strain (g6) at 34.00, which was significantly different from both comparative varieties, *Mawar* (a) and *Chung* (b). The best flowering period character was obtained from the MC 27.7.3 strain (g9) at 29.00 DAP and was significantly different from both comparative varieties. Meanwhile, the best harvesting period character was found in the MC 9.2.6 strain (g12) at 62.00 DAP and was significantly different from the comparative variety of *Chung* (b).

Table 2. Number of branches, flowering period, and harvesting period of tomato strains from the cross-breeding product of *Mawa*r × *Chung*.

Genotypes	Number of branches	Flowering period	Harvesting period
(g1) MC 9.2.4	16.00	31.00	68.00
(g2) MC 11.4.1	22.00 [a]	39.00	68.00
(g3) MC 35.7.1	18.00 [a]	36.00	90.00
(g4) MC 38.8.8	17.00	34.00	71.00
(g5) MC 27.12.2	25.00 [ab]	36.00	67.00
(g6) MC 10.10.2	34.00 [ab]	31.00	70.00
(g7) MC 38.1.1	20.00 [a]	36.00	69.00
(g8) MC 8.3.1	16.00	30.00	73.00
(g9) MC 27.7.3	18.00 [a]	29.00	62.00
(g10) MC 9.4.1	25.00 [ab]	36.00	69.00
(g11) MC 27.12.5	29.00 [ab]	36.00	95.00[b]
(g12) MC 9.2.6	20.00 [a]	31.00	65.00
(g13) MC 11.4.4	16.00	53.00	68.00
(g14) MC 27.12.3	21.00 [a]	41.00	67.00
(g15) MC 10.7.8	20.00 [a]	50.00	71.00
(g16) MC 8.3.2	17.00	30.00	69.00
(g17) MC 35.7.5	16.23	36.90	85.00
(g18) MC 9.2.7	12.00	31.00	68.00
(g19) MC 27.12.6	24.00	37.00	71.00
(g20) MC 11.4.5	17.00	52.00	68.00
(g21) MC35.7.6	17.00	36.00	69.00
(g22) MC 27.12.4	20.00	39.00	71.00
(g23) *Mawar* (a)	10.92	54.53	96.93
(g24) *Chung* (b)	17.70	49.13	87.90
NP LSD (5%)	6.95	4.27	5.03

Note: Values in the same columns followed by the same letters (ab) present a significantly different condition with comparative varieties of *Mawar* (a) and *Chung* (b), following the LSD test of 0.05.

The LSD test results in Table 3 indicate that the best number of flowers per bunch, number of fruits per bunch, and number of fruit bunches are shown in MC 10.10.2 strain (g6) at 12.00, 9.70, and 37.00, respectively. These values are significantly different from both comparative varieties of *Mawar* (a) and *Chung* (b).

Table 3. Number of flowers per bunch, number of fruits per bunch, and number of fruit bunches in strains produced from *Mawar* × *Chung* cross-breeding program

Genotypes	Number of flowers per bunch	Number of fruits per bunch	Number of fruit bunches
(g1) MC 9.2.4	6.00	5.70	24.00 a
(g2) MC 11.4.1	9.33	7.33	25.00 a
(g3) MC 35.7.1	7.67	6.00	26.00 a
(g4) MC 38.8.8	6.70	6.30	19.00 a
(g5) MC 27.12.2	8.70	6.30	23.00 a
(g6) MC 10.10.2	12.00	9.70	37.00 ab
(g7) MC 38.1.1	8.67	7.67	35.00 ab
(g8) MC 8.3.1	7.30	7.00	28.00 a
(g9) MC 27.7.3	8.70	7.33	22.00 a
(g10) MC 9.4.1	9.30	7.30	30.00 a
(g11) MC 27.12.5	8.70	6.30	30.00 a
(g12) MC 9.2.6	6.00	6.00	30.00 a
(g13) MC 11.4.4	7.30	6.30	17.00 a
(g14) MC 27.12.3	7.00	5.30	15.00 a
(g15) MC 10.7.8	8.33	7.67	35.00 ab
(g16) MC 8.3.2	7.70	7.00	30.00 a
(g17) MC 35.7.5	6.90	4.60	17.23 a
(g18) MC 9.2.7	6.00	5.33	23.00
(g19) MC 27.12.6	7.30	5.70	21.00
(g20) MC 11.4.5	7.33	7.00	18.00
(g21) MC35.7.6	9.30	4.67	22.00
(g22) MC 27.12.4	8.67	5.33	14.00
(g23) *Mawar* (a)	4.56	3.83	6.38
(g24) *Chung* (b)	6.82	5.73	25.57
NP LSD (5%)	3.88	3.87	7.05

Note: Values in the same columns followed by the same letters (ab) present a significantly different condition with comparative varieties of *Mawar* (a) and *Chung* (b), following the LSD test of 0.05.

The LSD test results in Table 4 present that the best number of fruits character was obtained from the MC 10.10.2 strain (g6) at 191.00 and significantly different from both comparative varieties of *Mawar* (a) and *Chung* (b). The best character of fruit length was also obtained from the MC 10.10.2 strain (g6) at 44.26 mm, that was significantly different from the comparative varieties of *Mawar* (a) and *Chung* (b). This strain showed the best fruit thickness at 29.98 mm.

Table 4. Number of fruits, fruit length, and fruit thickness in strains produced from *Mawar* × *Chung* cross-breeding activity.

Genotype	Number of fruits	Fruit Length	Fruit Thickness
(g1) MC 9.2.4	86.00 a	27.12 b	25.40
(g2) MC 11.4.1	102.00 ab	34.22 ab	25.76
(g3) MC 35.7.1	95.00 ab	32.72 b	28.22
(g4) MC 38.8.8	127.00 ab	27.00 b	22.08
(g5) MC 27.12.2	101.00 ab	36.38 ab	26.06
(g6) MC 10.10.2	191.00 ab	44.26 ab	29.98

(g7) MC 38.1.1	105.00 ab	29.76 b	23.90
(g8) MC 8.3.1	121.00 ab	30.78 b	24.44
(g9) MC 27.7.3	91.00 a	27.64 b	26.16
(g10) MC 9.4.1	102.00 ab	37.24 ab	27.70
(g11) MC 27.12.5	196.00 ab	31.38 b	26.28
(g12) MC 9.2.6	88.00 a	27.22 b	25.40
(g13) MC 11.4.4	100.00 ab	31.06 b	24.02
(g14) MC 27.12.3	167.00 ab	30.38 b	24.80
(g15) MC 10.7.8	85.00 a	38.70 ab	22.82
(g16) MC 8.3.2	129.00 ab	30.80 b	24.50
(g17) MC 35.7.5	86.23 a	27.33 b	23.37
(g18) MC 9.2.7	81.00	27.12	23.88
(g19) MC 27.12.6	172.00	30.42	25.40
(g20) MC 11.4.5	101.00	31.10	24.50
(g21) MC35.7.6	95.00	31.78	26.02
(g22) MC 27.12.4	120.00	27.18	23.46
(g23) *Mawar* (a)	14.00	26.47	20.15
(g24) *Chung* (b)	85.07	16.62	16.38
NP LSD (5%)	7.05	6.91	6.92

Note: Values in the same columns followed by the same letters (ab) present a significantly different condition with comparative varieties of *Mawar* (a) and *Chung* (b), following the LSD test of 0.05.

The LSD test results in Table 5 describe that the best fruit diameter, fruit weight, and number of cavities characters are presented in the MC 10.10.2 strain (g6) at 49.46 mm, 40.94 g, and 10.60, respectively. In this strain group, fruit diameter and weight were significantly different from the comparative variaties, namely *Mawar* (a) and *Chung* (b).

Table 5. Fruit diameter, fruit weight, number of cavities in strains from the *Mawar* × *Chung* cross-breeding product

Genotypes	Fruit diameter	Fruit Weight	Number of Cavities
(g1) MC 9.2.4	31.70 b	8.48	7.80
(g2) MC 11.4.1	38.70 b	26.98 b	9.60
(g3) MC 35.7.1	37.04 b	29.17 b	7.80
(g4) MC 38.8.8	31.63 b	22.32 b	7.80
(g5) MC 27.12.2	36.30 b	27.07 b	9.20
(g6) MC 10.10.2	49.46 ab	40.94 ab	10.00
(g7) MC 38.1.1	34.40 b	24.95 b	9.60
(g8) MC 8.3.1	35.66 b	11.34 b	6.80
(g9) MC 27.7.3	32.60 b	23.14 b	7.00
(g10) MC 9.4.1	42.32 b	30.90 ab	8.40
(g11) MC 27.12.5	41.00 b	30.83 ab	10.00
(g12) MC 9.2.6	32.78 b	22.90 b	7.80
(g13) MC 11.4.4	35.36 b	25.12 b	9.40
(g14) MC 27.12.3	34.88 b	23.89 b	7.40
(g15) MC 10.7.8	43.66 b	29.32 b	10.00
(g16) MC 8.3.2	36.14 b	11.79 b	9.00
(g17) MC 35.7.5	33.33 b	9.12	7.10
(g18) MC 9.2.7	31.54	8.46	7.40
(g19) MC 27.12.6	35.48	25.31	7.60

(g20) MC 11.4.5	37.28	25.27	9.60
(g21) MC35.7.6	36.92	12.98	7.40
(g22) MC 27.12.4	32.06	8.06	5.60
(g23) *Mawar* (a)	36.97	23.50	7.31
(g24) *Chung* (b)	21.88	3.40	2.03
NP LSD (5%)	6.92	6.88	3.87

Note: Values in the same columns followed by the same letters (ab) present a significantly different condition with comparative varieties of *Mawar* (a) and *Chung* (b), following the LSD test of 0.05.

As presented in Table 6 and the LSD test results, the total dissolved solids (brix) obtained the best value at the MC 9.2.6 strain (g12) with an averperiod of 7.94. The best number of seeds per fruit was obtained from the MC 38.1.1 strain (g7) at 75.20, while the best productivity level was shown in the MC 27.12.5 strain (g11) at 1432.64 g, which indicates a significant different value between the comparative varieties, namely *Mawar* (a) and *Chung* (b).

Table 6. Total dissolved solids (brix), number of seeds per fruit, and productivity level of different tomato strains from the *Mawar* × *Chung* cross-breeding product

Genotypes	Total dissolved solids	Number of seeds per fruit	Productivity level
(g1) MC 9.2.4	7.18	64.20	360.46 ab
(g2) MC 11.4.1	6.28	66.20	558.59 ab
(g3) MC 35.7.1	6.00	68.20	658.35 ab
(g4) MC 38.8.8	6.70	74.40	422.22 ab
(g5) MC 27.12.2	6.08	70.60	1133.13 ab
(g6) MC 10.10.2	5.94	63.40	1432.64 ab
(g7) MC 38.1.1	6.92	75.20	472.49 ab
(g8) MC 8.3.1	6.28	56.40	694.15 ab
(g9) MC 27.7.3	6.32	63.80	505.59 ab
(g10) MC 9.4.1	6.18	74.60	698.18 ab
(g11) MC 27.12.5	6.98	70.60	719.90 ab
(g12) MC 9.2.6	7.94	65.60	434.61 ab
(g13) MC 11.4.4	6.00	64.40	437.94 ab
(g14) MC 27.12.3	6.86	66.00	909.52 ab
(g15) MC 10.7.8	5.16	72.60	504.06 ab
(g16) MC 8.3.2	6.38	59.00	816.73 ab
(g17) MC 35.7.5	6.50	60.23	435.12 ab
(g18) MC 9.2.7	6.60	63.60	283.03
(g19) MC 27.12.6	7.02	68.80	1079.52
(g20) MC 11.4.5	6.68	64.80	557.11
(g21) MC35.7.6	5.24	64.00	501.66
(g22) MC 27.12.4	6.32	56.60	860.15
(g23) *Mawar* (a)	3.44	63.67	186.78
(g24) *Chung* (b)	3.73	48.53	331.08
NP LSD (5%)	3.15	18.81	12.91

Note: Values in the same columns followed by the same letters (ab) present a significantly different condition with comparative varieties of *Mawar* (a) and *Chung* (b), following the LSD test of 0.05.

The heritability analysis results in Table 7 showed that the productivity character obtained the highest heritability rate (99.93%), while stem diameter presents the lowest heritability rate. Following the height category, characters that can be considered as selective characters are plant height, dichotomic height, number of branches, flowering period, harvesting period, number of fruit bunches, number of fruits, fruit length, fruit diameter, fruit weight, and productivity level.

Table 7. Heritability value of tomato strains from the *Mawar* × *Chung* heritability product

No.	Character	Heritability	Category
1.	Plant height	95.99	High
2.	Dichotomic height	83.37	High
3.	Stem diameter	-7.05	Low
4.	Number of branches	53.50	High
5.	Flowering period	89.96	High
6.	Harvesting period	91.62	High
7.	Number of flowers per bunch	8.35	Low
8.	Number of fruits per bunch	-5.24	Low
9.	Number of fruit bunches	72.61	High
10.	Number of fruits	98.85	High
11.	Fruit length	56.00	High
12.	Fruit thickness	7.29	Low
13.	Fruit diameter	54.87	High
14.	Fruit weight	82.97	High
15.	Number of cavities	20.08	Middle
16.	Total dissolved solids (brix)	-6.15	Low
17.	Number of seeds per fruit	-2.53	Low
18.	Productivity	99.93	High

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

The correlation analysis results in Table 8 are focused on productivity as the main character. These results describe the characters that are significantly and positively correlated to productivity are plant height, stem diameter, number of branches, and number of fruits, while characters that have no significant correlation to productivity character are dichotomic height, flowering period, harvesting period, number of flowers per bunch, number fruits per bunch, number of fruit bunches, fruit length, fruit thickness, fruit diameter, fruit weight, number of cavities, total dissolved solids (brix), and number of seeds per fruit.

Table 8. Correlation Analysis

	TT	TD	DIB	JC	UB	UP	JBG	JBH	JT	JBHT	PB	TB	DB	BB	JR	KB	JBP	PROD
TT	1.00																	
TD	0.54*	1.00																
DIB	0.37tn	0.04tn	1.00															
JC	0.70**	0.46*	0.56**	1.00														
UB	0.16tn	0.02tn	-0.05tn	-0.07tn	1.00													
UP	0.42tn	0.23tn	0.19tn	0.10tn	-0.16tn	1.00												
JBG	0.77**	0.69**	0.24tn	0.73**	-0.02tn	0.11tn	1.00											
JBH	0.37tn	0.77**	0.11tn	0.53*	-0.02tn	-0.07tn	0.63**	1.00										
JT	0.16tn	0.30tn	0.15tn	0.35tn	-0.26tn	-0.01tn	0.33tn	0.60**	1.00									
JBHT	0.25tn	-0.13tn	0.75**	0.48*	-0.02tn	0.12tn	0.08tn	-0.11tn	-0.13tn	1.00								
PB	0.67**	0.49*	0.29tn	0.70**	0.18tn	-0.11tn	0.77**	0.68**	0.49*	0.08tn	1.00							
TB	0.67**	0.37tn	0.30tn	0.64**	-0.31tn	0.20tn	0.60**	0.39tn	0.34tn	0.06tn	0.59**	1.00						
DB	0.75**	0.51*	0.29tn	0.74**	0.19tn	0.05tn	0.76**	0.68**	0.54**	0.07tn	0.94**	0.59**	1.00					
BB	0.62**	0.60**	0.37tn	0.75**	0.26tn	0.10tn	0.57**	0.66**	0.39tn	0.23tn	0.72**	0.56**	0.73**	1.00				
JR	0.36tn	0.47*	0.37tn	0.44*	0.41tn	-0.09tn	0.39tn	0.63**	0.52*	0.10tn	0.64**	0.18tn	0.67**	0.67**	1.00			
KB	-0.44*	-0.28tn	0.11tn	-0.02tn	-0.31tn	-0.08tn	-0.54**	-0.20tn	-0.08tn	0.19tn	-0.57**	-0.12tn	-0.48*	-0.13tn	-0.19tn	1.00		
JBP	0.07tn	0.20tn	0.09tn	0.32tn	0.19tn	-0.01tn	0.11tn	0.23tn	0.43*	0.20tn	0.27tn	0.06tn	0.24tn	0.61**	0.51*	0.03tn	1.00	
PROD	0.54**	0.00tn	0.79**	0.65**	-0.03tn	0.29tn	0.31tn	0.02tn	0.03tn	0.90**	0.26tn	0.30tn	0.31tn	0.32tn	0.14tn	0.06tn	0.09tn	1.00

Note: TT: plant height, TD: dichotomic height, DIB: stem diameter, JC: number of branches, UB: flowering period, UP: harvesting period, JBG: number of flowers per bunch, JBH: number of fruits per bunch, JT: number of fruit bunches, JBHT: number of fruits, PB: fruit length, TB: fruit thickness, DB: fruit diameter, BB: fruit weight, JR: number of cavities, KB: total dissolved solids (brix), JBP: number of seeds per fruit, PROD: productivity.

The analysis of variance results showed that different genotypes had a highly significant effect on the characteristics of plant height, dichotomic height, number of branches, flowering period, harvesting period, number of fruit bunches, number of fruits, fruit length, fruit diameter, fruit weight, and productivity. In contrast, stem diameter, number of flowers, number of fruits, fruit thickness, number of cavities, brix content, and number of seeds per fruit had no significant effect in each genotype.

Different genotypes have a significant effect on plant height and dichotomic height. Almost all genotypes obtained significantly different results to the comparative varieties, except in the MC 9.2.4 (g1), MC 38.8.8 (g1), MC 27.12.6 (g19), MC 11.4.5 (g20), MC 35.7.6 (g21), MC 27.12.4 (g22) for plant height character and MC 9.2.4 (g1), MC 8.3.1 (g8), MC 9.2.6 (g12), MC 9.2.7 (g18), MC 27.12.6 (g19), MC 11.4.5 (g20), MC35.7.6 (g21), MC 27.12.4 (g22) for dichotomic height character. Different results are influenced by genetic differences in each genotype due to *Mawar* × *Chung* cross-breeding program. These results were in accordance with Nazirwan, A., Wahyudi & Dulbari (2014), who stated that differences in plant height were influenced by genetic factors of each line/number and environment, such as light intensity, temperature, and nutrient availability.

The number of branches affects tomato growth and production. Each branch influences the number of leaves on the plant used in photosynthesis to produce food reserves. The best number of branches in MC 10.10.2 (g6) significantly differed from two parents as comparative varieties. According to Nasrulloh A.T., W. Mutiarawati & Sutari (2016), the number of branches is directly proportional to the number of leaves, so many branches will produce a greater number of leaves, where the photosynthesis process occurs. Along with the results, the number of branches also influences the formation of tomato plant bunches, whereas MC 10.10.2 (g6) also obtained the best number of fruit bunches. This condition was similar to Syuriani E.E., J. Kartahadimaja, M.F. Sari, & B. Purwanto (2021), who stated that a large number of primary branches could positively contribute to the number of flower bunches.

The characteristics of flowering period and harvesting period for each genotype showed different results. Flowering period started from 29 to 53 HST, and harvesting period started from 62 to 95 HST due to genetic differences in each genotype. According to (Ester et al., 2014), the different flowering periods and harvesting periods are thought to be due to the nature of the plant genotype itself. The genetic characteristics of the plant influence the period from which the flowers appear until the fruit ripens. Different flowering periods and harvesting periods of the tomato genotypes were caused by genetic factors that could influence each genotype's growth period, resulting in differences in the harvesting period for each genotype.

A proper fruit shape is determined by the fruit length, thickness, and diameter characters. The results showed that fruit length was 27.00-44.26 mm, fruit thickness was 22.08-29.98 mm, and fruit diameter was 41.54-49.46 mm. These results indicate that almost all strains from the *Mawar* × *Chung* cross-breeding program have relatively medium to large fruit sizes. However, one of the parents is a cherry tomato species. The preferred quality criteria for tomatoes in the modern market are medium-sized tomatoes with a slightly round shape (Irsyad E.P., A. Yoesdiarti & H. Miftah, 2018). The MC 10.10.2 strain (g6) obtained the best fruit thickness, length, and diameter for the fruit shape characters. Rofidah and Respatijarti (2016) added that the characteristics of fruit length and diameter were positively correlated with the fruit weight, so longer fruit produces larger fruit diameter and greater fruit weight.

Different genotypes also significantly affected the number of fruits per plant, as the MC 10.10.2 (g6) obtained the highest number of fruits per plant at 191 units. In line with these results, the MC 10.10.2 (g6) strain also presents the highest number of cavities with an average value of 10.00. According to Hidayat (1995), the number of cavities in each fruit can determine the number of seeds per fruit, which are useful in cultivating and propagating the plant.

The number of fruits per plant is also closely related to the fruit weight characteristics, whereas these two are directly proportional. The MC 10.10.2 (g6) also obtained the best fruit weight at 40.94 g. Haydar A., M.A. Mandal, M.B. Ahmed, M.M. Hannan, R. Karim, M. Razvy, U.K. Roy & M. Salahin (2007) and Hidayatullah S.A. Jatoi, A. Gafoor & T. Mahmood (2008) reported that the number of fruits per plant could highly influence the fruit weight of tomato plants. Moreover, other characteristics were related to fruit weight, namely fruit shape (fruit thickness, length, and diameter) and number of cavities, which are directly proportional. According to Ester (D., A. Adiwirman, & E. Zuhry 2014), the smaller the fruit size and the lower the number of fruit cavities, the lower the fruit weight per plant, and *vice versa*. However, this condition is also influenced by the plant genetics. According to Comlekcioghi (2010), the weight of fruit yield depends on the cultivar that will be developed, following its genetic potential, which can adapt to a particular environment.

The production characters showed that the MC 10.10.2 (g6) obtained the best productivity at 1432.64 g. These results are in line with the results obtained for other characters, namely number of branches, number of flowers per bunch, number of fruits per bunch, number of fruit bunches, number of fruits, fruit thickness, fruit length, fruit diameter, fruit weight, and number of cavities. A genotype that presents the best results in almost all observed characters indicates that the genotype has good genetics and adaptability. The adaptable genotype to the environment influences the growth and yield of tomato plants. Genotypes that can adapt more quickly to their environment tend to respond better to growth and yield than genotypes that slowly adapt, although having the same growth ability (Ginting, 1991).

In the heritability analysis, the characteristics of plant height, dichotomic height, number of branches, flowering period, harvesting period, number of fruit bunches, number of fruits, fruit length, fruit diameter, fruit weight, and productivity are categorized as high heritability rate. These results indicate that genetic factors influence characters with high heritability rates more than environmental factors. The high heritability rate describes a high relationship between genotype and phenotype, which suggests that the environment has less influence than genetic factors (Handayani and Hidayat, 2012). The upregulated heritability rate is caused by the environmental variation decline or genetic variation increase, thus making it easier for a character to be inherited in the next generation, as the genetic factors are more significant than environmental factors (Sutarman, 2013; Mangoendidjojo, 2012; Sami R.A., M.Y. Yeye, I.S. Usman, L.B. Hassan, & M. Usman, 2013; Syukur M., S. Sujiprihati & R. Yunianti, 2015). A high heritability rate also indicates that the selection progress can be achieved, and strains produced can rapidly be prepared to become new superior varieties (Saputry D.H., A. Daryanto, M.R.A. Istiqlal & S. Widiyanto, 2022). As selection progress increases, the results are better than those of the previous generation (Jameela H., A. Sugiharto, A., & A. Soegiantor, 2012).

The correlation analysis is carried out to determine characters closely related to the main character (productivity). Four characters have a significantly positive correlation with the main character, namely plant height (0.54**), stem diameter (0.79**), number of branches (0.65**), and number of fruits (0.90**). These characters can be used as standards or considerations in determining the best tomato genotype in this study. Therefore, strain selection can be based on plant height, stem diameter, number of branches, and number of fruits to produce a high productivity level. This concept has also been reported previously by Sabouri H., B. Rabieim & M. Fazlalipour (2008), Khapte and Jansirani (2014), Kumar V., N. Koshta, N. Sohgaura, & G.K. Koutu (2014), Mustafa M., M. Syukur, S.H. Sutjahjo & Sobir (2019), and Akbar M.R., B.S. Purwoko, I.S. Dewi, W.B. Suwarno, Sugiyanta & M.F. Anshori (2021).

D. Conclusion

A strain produced from the *Mawar* × *Chung* cross-breeding program with the best productivity level was obtained from the MC 10.10.6 (g6) with an average productivity level of 1432.64 g and was significantly different from its two parents. Characters with high heritability values are plant height, dichotomic height, number of branches, flowering period, harvesting period, number of fruit bunches, number of fruits, fruit length, fruit diameter, fruit weight, and productivity level. Four characters are positively correlated with the productivity level, namely plant height, stem diameter, number of branches, and number of fruits.

E. References

Akbar, M.R., B.S. Purwoko, I.S. Dewi, W.B. Suwarno, Sugiyanta & M.F. Anshori. (2021). Agronomic and yield selection of double haploid lines of rainfed lowland rice in advanced yield trials. *Biodiversitas*, 22: 3006-3012.

Asmara, P.E.S., E. Ambarwati & A. Purwantoro. (2011). Uji daya hasil galur harapan tomat (*Lycopersicon esculentum* Mill.). *Vegetalika,* 1 (1); 68-82.

Badan Pusat Statistik (BPS). (2022). *Statistik pertanian*. Badan Pusat Statistik dan Direktorat Jenderal Hortikultura Republik Indonesia, Jakarta.

Cahyono, B. (2008). *Tomat usaha tani dan penanganan pascapanen*. Yogyakarta: Kanisius.

Comlekcioghi, N. A., M. Simsek, Boncuk dan Y.Y. Akakacar. (2010). Genetic characterization of heat tolerant tomato (Solanum lycopersicon) genom types by SRAP and RAPD markers. *Genet. Mol. Res*, 9(4): 74.

Dalimartha, S & A. Felix. (2011). *Khasiat buah dan sayur cetakan ked 2*. Jakarta: Penebar Swadaya.

Ester, D., A. Adiwirman, & E. Zuhry. (2014). Uji daya hasil beberapa genotipe tanaman tomat (*Lycopersicumesculentum* Mill) di dataran rendah. Riau: Universitas Riau.

Fadhilah, A. N., M. Farid, I. Ridwan, M.F. Anshori & A. Yassi. (2022). Genetic parametes and selection index of high-yielding tomato F2 populations. *SABRAO Journal of Breed. and Gen.*, 54 (5): 1026-1036.

Farid, M., M.F. Anshori, I. Ridwan, N.E. Dungga & I. Ermiyanti. (2022). Half diallel of F_1 tomato hybrid and its double cross-compatibility. *Biodiversitas,* 23(4): 1813-1821.

Ginting, M. (1991). Pengujian pupuk komplesal dan hasil tanaman kedelai (*Glycine max* (L) Merill). *Skripsi*. Fakultas Pertanian Universitas Syiah Kuala Darussalam, Banda Aceh.

Handayani, T., & I.M. Hidayat. (2012). Keragaman genetik dan heritabilitas beberapa karakter utama pada kedelai sayur dan implikasinya untuk seleksi perbaikan produksi. *J. Hort.*, 22(4): 327-333.

Haydar, A., M.A. Mandal, M.B. Ahmed, M.M. Hannan, R. Karim, M. Razvy, U.K. Roy & M. Salahin. (2007). Studies on genetic variability and interreleationship among the different traits in tomatto (Lycopersicum esculentum Mill). *Middleeast Journal of Scientific Researc*h. 2 (3-4): 139-142.

Hidayat, E.B. (1995). *Anatomi tumbuhan berbiji*. Bandung: Institut Teknologi Bandung.

Hidayatullah, S.A. Jatoi, A. Gafoor & T. Mahmood. (2008). Path coefficient analysis of yield component in tomato (iLycopersicon esculentum *Mill.*). *Pakistan Journal of Botany,* 40(2): 627-635.

Irsyad, E.P., A. Yoesdiarti & H. Miftah. (2018). Analisis persepsi dan preferensi konsumen terhadap atribut kualitas sayuran komersial di pasar modern. *J. Agribisains*., 4(2): 1-7.

Jambormias, E. & J. Riry. (2009). Penyesuaian data dan penggunaan informasi kekerabatan untuk mendeteksi segregan transgresif karakter kuantitatif pada tanaman menyerbuk sendiri (suatu pendekatan dalam seleksi). *Jurnal Budidaya Pertanian,* 5(1): 11-18.

Jameela, H., A. Sugiharto, A., & A. Soegiantor. (2012). Keragaman genetik dan heritabilitas karakter komponen hasil pada populasi F2 buncis (*Phaseolus vulgaris* L.) hasil persilangan varietas introduksi dengan varietas lokal. *Produksi Taanaman*, 2(4): 324-329.

Khapte, P.S. dan P. Jansirani. (2014). Genetic variability and performance studies of tomato (*Solanum lycopersicum* L.) genotypes for fruit quality and yield. *Trends in Biosci,* 7(12): 1246-1248.

Kumar, V., N. Koshta, N. Sohgaura, & G.K. Koutu. (2014). Genetic evaluation of rils population for yield and quality attributing characters in rice (*Oryza sativa* L.). *J. Agric. Technol*., 1(1): 43-51.

Mangoendidjojo, W. (2012). *Dasar - Dasar Pemuliaan Tanaman*. Yogyakarta: Penerbit Kanisius.

Merintan, S.F. & N.B.S.L Purmaningsih. (2016). Uji daya hasil pendahuluan 19 galur tomat (*Lycopersicon esculentum* Mill.). *Jurnal Produksi Tanaman,* 4(8) : 654-659.

Mustafa, M., M. Syukur, S.H. Sutjahjo & Sobir. (2019). Inheritance study for fruit characters of tomato ipbt78 x ipbt73 using joint scaling test. *IOP Conf. Ser Earth Environ. Sci.,* 382: 012009.

Nasrulloh, A.T., W. Mutiarawati & Sutari. (2016). Pengaruh penambahan arang sekam dan jumlah cabang produksi terhadap pertumbuhan tanaman, hasil dan kualitas buah tomat kulrivar doufu hasil sambung batang pada inceptisol jatinangor. *Jurnal Kultivasi,* 15(1): 26-36.

Nazirwan, A., Wahyudi & Dulbari. (2014). Karakterisasi koleksi plasma nutfah tomat lokal dan introduksi. *Jurnal Penelitian Pertanian Terapan,* 14(1): 70-75.

Rofidah, N.I. & Respatijarti (2016). Korelasi antara komponen hasil dengan hasil pada populasi f6 tanaman cabai merah besar (*Capsicum anuum* L.). *Jurnal Produksi Tanaman*, 7(12) : 50-57.

Sabouri, H., B. Rabieim & M. Fazlalipour. (2008). Use of selection indices based on multivariate analysis for improving grain yield in rice. *Rice Sci.,* 15(4): 303-310.

Sami, R.A., M.Y. Yeye, I.S. Usman, L.B. Hassan, & M. Usman. (2013). Studies on genetic variability in some sweet sorghum (*Sorghum bicolor* L. Moench) genotypes. *Acad. Res. J. Agric. Sci. Res*., 1: 1-6.

Saputry, D.H., A. Daryanto, M.R.A. Istiqlal & S. Widiyanto. (2022). Potensi hasil dan penampilan hortikultura tomat generasi F6 di dataran rendah. *J. Hort. Indonesia,* 13(1): 14-22.

Sari, R.E.P., D. Saptadi & Kuswanto. (2018). Evaluasi keseragaman dan potensi hasil cabai merah F6 (*Capsicum annuum* L.). *Jurnal Produksi Tanaman*. 6(8) : 1900-1905.

Sutarman, L.W. (2013). *Heritabilitas pada tanaman kedelai* (*Glycine max* L.). Digital Library University of Lampung, Bandar Lampung.

Syukur, M., S. Sujiprihati & R. Yunianti. (2015). *Teknik pemuliaan tanaman*. Jakarta: Penerbit Penebar Swadaya.

Syukur, M., S. Sujiprihati & R. Yunianti. (2018). *Teknik pemuliaan tanaman edisi revisi*. Jakarta: Penerbit Penebar Swadaya.

Syuriani, E.E., J. Kartahadimaja, M.F. Sari, & B. Purwanto. (2021). Karakter kuantitatif delapan galur baru tomat (*Lycopersicum esculentum*) generasi F6 di dataran rendah. *Jurnal Planta Simbiosa,* 3(2); 40-49.

Wasonowati, C. (2011). Meningkatkan pertumbuhan tanaman tomat (Lycopersicon esculentum Mill) dengan sistem budidaya hidroponik. *Jurnal Agrovigor,* 4 (1): 21-28.

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Corn (Zea mays L) Development Based on Drone-Based Vegetation Index Trough NPK Fertilization

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Abstract

Maize is one of the most important food crops after rice. This study aimed to obtain one or more doses of fertilizers that provide high growth and productivity, obtain one or more varieties of maize that have increased productivity, and obtain interactions between doses of fertilizers with maize varieties that deliver high growth and productivity. The research was conducted at the Experimental Farm (KP) of the Bajeng Cereal Crops Research Center, Bajeng District, Gowa Regency, South Sulawesi. At an altitude of 27.2 meters above sea level, with coordinates 5018'21.5 "N, 119028'38.6 "E and an average temperature of 28.50C. The research was conducted from September to December 2022. This study used a separate plot design, fertilizer dose as the main plot consisting of 3 fertilizer doses, namely N:P:K equals 160:120:80 kg N.ha-1, N:P:K equals 200:150:100 kg N.ha-1, and N:P:K equals 240:180:120 kg N.ha-1. The subplots were corn varieties: Sinhas 1, Jakarin, Nasa 29, JH 36, Bisi 18, ADV Joss and Pioner. The fertilizer dose with the highest productivity compared to the other five is N:P:K equals 240:180:120, with an average productivity of 6.66 t.ha-1. The variety that produces the highest productivity compared to the two types is ADV Joss, with an average productivity of 9.28 t.ha-1. The combination of N:P:K fertilization dose equals 160:120:80 with ADV Joss variety gave the highest productivity compared to the combination of fertilization dose and other types with an average productivity of 9.38 t.ha-1. The correlation between productivity and parameters such as plant height, number of leaves, cob weight, cob diameter, cob length, cob length, number of seed rows per cob, seed yield, 1000 seed weight, and NDVI showed a positive interaction.

Keywords: fertilization, maize, NDVI, productivity

A. Introduction

Maize is one of the most important food crops after rice. Maize has a strategic role and economic value and has the opportunity to be developed. Maize is the primary source of carbohydrates and protein after rice. Maize is also a raw material for the food and feed industry and is one of the export commodities. The extensive use of maize in various sectors has increased the demand for maize.

For the last seven years, Indonesia's maize production data has been below the target since 2016; in 2016, maize production was 23.18 million tons, lower than the target of 24 million tons. The same thing happened in 2017 and 2018, below the target of 25.2 million tons and 26.5 million. In 2019, maize production was 27.61 million tons, while the target was 27.8 million tons, and in 2020, maize production was 28.63 million tons, still low from 29.05 million tons (Directorate General of Food Crops, 2020). According to Ministry of Agriculture data, maize imports in mid-2019 reached 0.58 million tons. The mid-2019 achievement was close to the previous year's sense of 0.74 million tons. In line with the increasing national maize crop production, efforts need to be made to significantly increase maize productivity so that it can meet the needs, increase exports, and reduce imports. Increased maize yields can be developed by selecting varieties and fertilizer doses.

One way to increase maize yields is to use quality seeds of superior varieties to produce high results. However, more than the use of select types of sources needed to support increased production, fertilizer is also required to meet the needs of plants. Early-maturing high-yielding varieties responsive to N, P and K macronutrient fertilization have significantly increased crop production (Agency for Agricultural Research and Development, 2021).

The synthetic fertilizer commonly used by farmers is NPK, which contains N, P, and K, essential plant nutrients. Increasing the dose of N fertilization in the soil directly increases the protein (N) content and production of corn plants. Still, fulfilling N elements alone without P and K elements will cause plants to lodge easily, be sensitive to pest attacks and decrease production quality (Pusparini, Yunus and Harjoko, 2018). However, in the field, farmers apply inorganic fertilizers excessively, which hurts the environment.

Maize cultivation combined with innovative farming-based technology utilizing drones is an effort to increase maize production. Smart farming is an intelligent agricultural method based on technology and the provision of data that can be measured and integrated into managing agricultural processes to optimize crop production. In other words, smart farming transforms conventional agriculture into modern agriculture.

One of the methods for evaluating corn crops is using drones or an imaging-based Unmanned Aerial vehicle (UAV). The intelligent farming method includes the use of drones in corn cultivation for monitoring and predicting a yield and the process of fertilizing or spraying pesticides. Drone technology in the monitoring and prediction process will provide analysis information related to crop status through image imaging. This can facilitate farmers in the evaluation process on a broader scale. The objectives of this research are to get one or more doses of fertilizer that provide high growth and productivity, get one or more varieties of corn that have increased productivity, and get an interaction between the dose of fertilizer and corn varieties that provide good growth and high productivity.

B. Methodology

The test was conducted at the Experimental Farm (KP) of the Bajeng Cereal Crops Research Institute, Bajeng District, Gowa Regency, South Sulawesi, at an altitude of 27.2 meters above sea level, with coordinates 5○18'21.5 "N, 119○28'38.6 "E and an average temperature of 28.5○C. This research took place from May to October 2023.

1. Research Design and Procedures

This study was arranged in a Separate Plots Design with a group randomized design as the environment. The main plot (PU) was five doses of NPK fertilization as follows:

P1 = 60 % N:P:K (160:120:80 kg.ha-1)
P2 = 80% N:P:K (200:150:100 kg.ha-1)
P3 = 100% N:P:K (240:180:120 kg.ha-1)

The subplots (AP) were seven maize varieties (v), namely Sinhas I (V1), Jakarin 1 (V2), Nasa 29 (V3), HJ 36 (V4), Bisi 18 (V5), ADV (V6) and NK 212 (V7). Based on this combination, there are 21 treatment combinations repeated thrice, resulting in 63 treatment units. The research used a Legowo 2:1 planting system, corn varieties, urea, SP36 and NPK phonska fertilization. Fertilization was done twice, 15 days after planting and 30 days after planting.

Maintenance included replanting, weeding, thinning, fertilizing, and irrigating. Plant growth was observed until harvest. Harvesting is done on corn cobs when they reach physiological maturity, marked by the appearance of a black layer on the back side of the seed or brownish cobs and drying. After treatment, maintenance and observation of quantitative and qualitative parameters were carried out, and the data were processed statistically and descriptively.

Crop photography is conducted directly in the field using an Inspire 2 Unmanned Aerial Vehicle (UAV) Drone that will be equipped with a 20-megapixel RGB camera with a 4/3 in sensor, 20 mm focal length, and 1/16 second capture speed. Each flight will contain about 1000 or 3000-4000 images for mapping 100 ha of land. Flight planning will occur at 12:00-14:00 in clear weather conditions. Then, the image results are analyzed with ArcGIS software.

Normalized Difference Vegetation Index (NDVI) is an index that describes the greenness of a plant. NDVI is a mathematical combination of the red band and the NIR band used as an indicator of the presence and condition of vegetation and is, therefore, commonly used as an indicator of biomass and relative greenness.

Table 1. Classification of Plant Health Based on NDVI Values.

Plant Healt	Value NDVI
Very Good	0,721 - 0,92
Good	0,421 - 0,72
Normal	0,221 - 0,42
Poor	0,11 - 0,22

(Sumber : http://endeleo.vgt.vito.be/dataproducts.html)

2. Data Analysis

Data analysis to determine the effect of treatment on the measured changes was carried out statistically with the help of STAR 2.1 software. Data analysis was conducted using the ANOVA (Analysis of Variance) method using a separate plot design with a randomized group design as the environment. Parameters that showed a significant effect continued with the BNJ and correlation tests. All morphological, biophysical, and physiological character approaches were analyzed independently to determine the best characters in each selection method. The best selection characters in each course in each selection method were explored together with Image-based Phenotyping characters. This aims to determine the best selection of characters in the approach. The software used in in-depth analysis related to Image-based Phenotyping is ArcGIS.

C. Result and Discussion

1. Result

Table 2. Average productivity (t.ha-1) at different doses of N:P:K fertilizer and varieties

Variety	Treatment			Average	NP (V) BNJ 0.05
	P1	P2	P3		
V1	4.64^{c}_{p}	5.08^{d}_{p}	4.43^{d}_{p}	4.72	
V2	3.81^{c}_{q}	5.67^{cd}_{p}	5.70^{cd}_{p}	5.06	
V3	7.49^{ab}_{p}	7.64^{ab}_{p}	8.11^{ab}_{p}	7.75	
V4	4.39^{c}_{p}	5.26^{d}_{p}	3.93^{d}_{p}	4.53	1.11
V5	6.52^{b}_{q}	6.08^{bcd}_{q}	8.47^{ab}_{p}	7.02	
V6	$\mathbf{9.38^{a}_{p}}$	9.26^{a}_{p}	9.19^{a}_{p}	9.28	
V7	6.66^{b}_{p}	7.32^{bc}_{p}	6.79^{bc}_{p}	6.92	
Average	6.13	6.62	6.66	6.47	
NP (P) BNJ 0.05		1.16			

Notes: Numbers followed by the same letter in column (a,b,c,d) and row (p,q) mean not different in the BNJ test at $\alpha = 0.05$.

Table 2 shows that the interaction between the treatment of N:P:K fertilizer dose 160:140:80 (P1) with ADV variety (V6) gave the highest average productivity value with a value of 9.38 t. ha-1 and significantly different from Sinhas 1 (V1), Jakarin (V2), JH 36 (V4), and Bisi 18 (V5) at the same N:P:K fertilizer dose treatment. ha-1 and significantly different from the varieties Sinhas 1 (V1), Jakarin (V2), JH 36 (V4), Bisi 18 (V5) at the same N:P:K fertilizer dose treatment, the interaction between N:P:K fertilizer dose 200:150:100 (P2) with varieties Sinhas 1 (V1), Jakarin (V2), Pioner (V7), the interaction between N:P:K fertilizer dose treatment 240:180:120 (P3) with Sinhas 1 (V1), and JH 36 (V4) interaction. And not significantly different from the interaction between the treatment dose of fertilizer N:P:K 200:150:100 (P2) with the variety ADV Joss (V6) and the interaction between the treatment dose of fertilizer N:P:K 240:180:120 (P3) with the variety ADV Joss (V6).

Table 3. Average NDVI values at different doses of N:P:K fertilizer and varieties

Variety	Treatment			Average	NP (V) BNJ 0.05
	P1	P2	P3		
V1	0.71^{ab}_{p}	0.89^{a}_{p}	0.81^{a}_{p}	0.80	
V2	0.71^{ab}_{pq}	0.52^{b}_{q}	0.73^{a}_{p}	0.65	
V3	0.73^{ab}_{p}	0.76^{a}_{p}	0.81^{a}_{p}	0.77	
V4	$\mathbf{0.89^{a}_{p}}$	0.87^{a}_{p}	0.70^{a}_{p}	0.82	0.16
V5	0.67^{ab}_{p}	0.67^{ab}_{p}	0.73^{a}_{p}	0.69	
V6	0.86^{a}_{p}	0.71^{ab}_{p}	0.86^{a}_{p}	0.81	
V7	0.52^{b}_{q}	0.76^{ab}_{p}	0.81^{a}_{p}	0.70	
Average	0.73	0.74	0.78	0.75	
NP (P) BNJ 0.05		0.16			

Notes: Numbers followed by the same letter in column (a,b) and row (p,q) mean not different in BNJ test at $\alpha = 0.05$.

Table 3 shows that the interaction between the treatment dose of N:P:K 160:120:80 (P1) with the variety JH 36 gave the highest average value with a value of 0.89 and significantly different from the array Jakarin (V2) at the same dose of N:P:K fertilizer, the interaction between the treatment dose of N:P:K 200:150:100 (P2) with varieties Bisi 18 (V5), and Pioner (V7). And not significantly different from the interaction between the treatment dose of N:P:K 160:120:80 (P1) with the variety ADV Joss (V6), the interaction between the treatment dose of N:P:K 240:180:120 (P3) with the types Sinhas 1 (V1) Jakarin (V2), Nasa 29 (V3), JH 36 (V4), Bisi 18 (V5), ADV Joss

(V6), and Pioner (V7).

Table 4. Correlation Matrix between Observation Parameters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1																							
2	0.4**	1																						
3	0.28*	0.43**	1																					
4	-0.03TN	-0.12TN	0.2TN	1																				
5	-0.17TN	0.1TN	0.16TN	0.22TN	1																			
6	-0.17TN	-0.15TN	-0.11TN	0.35**	0.47**	1																		
7	0.04TN	-0.23TN	-0.26*	0.06TN	-0.66**	0.34**	1																	
8	0.31*	0.02TN	-0.01TN	-0.18TN	-0.34**	-0.26*	0.14TN	1																
9	0.32*	0.28*	0.56**	-0.01TN	0.17TN	-0.12TN	-0.28*	0.18TN	1															
10	0.06TN	0.34**	0.03TN	-0.38**	-0.16TN	-0.22TN	-0.01TN	0.14TN	0.19TN	1														
11	0.31*	0.34**	0.29*	-0.08TN	0.17TN	-0.23TN	-0.38**	0.14TN	0.56**	0.33**	1													
12	0.18TN	0.25TN	0.06TN	-0.25*	-0.14TN	-0.54**	-0.31*	0.06TN	0.25TN	0.49**	0.46**	1												
13	0.08TN	0.33*	0.22TN	-0.07TN	-0.11TN	-0.25*	-0.09TN	0.08TN	0.16TN	0.34**	0.13TN	0.45**	1											
14	0.27*	0.22TN	0.21TN	0.11TN	-0.09TN	-0.1TN	0.01TN	0.14TN	0.23TN	0.18TN	0.14TN	0.22TN	0.36**	1										
15	0.14TN	0.18TN	0.07TN	-0.13TN	-0.09TN	-0.38**	-0.23TN	0.11TN	0.34**	0.33**	0.54**	0.56**	0.39**	-0.01TN	1									
16	0.35**	0.48**	0.47**	-0.1TN	0.11TN	-0.16TN	-0.25*	0.2TN	0.82**	0.42**	0.61**	0.38**	0.28*	0.33**	0.43**	1								
17	-0.03TN	0.07TN	0.26*	0.22TN	0.2TN	0.01TN	-0.2TN	-0.26*	0.31*	0.09TN	0.27*	0.24TN	0.26*	0.08TN	0.38**	0.3*	1							
18	0.11TN	0.09TN	0.11TN	-0.07TN	-0.13TN	-0.21TN	-0.04TN	-0.02TN	0.22TN	0.38**	0.28*	0.38**	-0.02TN	-0.07TN	0.45**	0.29*	0.32*	1						
19	0.13TN	0.04TN	0.19TN	0.16TN	0.07TN	-0.03TN	-0.1TN	-0.27*	0.27*	0.18TN	0.29*	0.24TN	0.14TN	-0.06TN	0.43**	0.28*	0.82**	0.64**	1					
20	0.19TN	0.17TN	0.53**	0.29*	0.2TN	0.28*	0.03TN	0.01TN	0.29*	-0.24TN	0.07TN	-0.43**	0.07TN	0.16TN	-0.13TN	0.22TN	0.19TN	-0.13TN	0.04TN	1				
21	0.09TN	0.17TN	0.49**	0.22TN	0.26*	0.16TN	-0.13TN	0.05TN	0.35**	-0.14TN	0.08TN	-0.36**	0.16TN	0.16TN	-0.03TN	0.26*	0.11TN	-0.16TN	-0.05TN	0.77**	1			
22	0.25TN	0.21TN	0.64**	0.37**	0.09TN	0.13TN	0.02TN	0.2TN	0.39**	-0.22TN	0.08TN	-0.29*	0.07TN	0.24TN	-0.11TN	0.25TN	0.13TN	-0.06TN	0.03TN	0.67**	0.68**	1		
23	0.19TN	0.18TN	0.39**	0.1TN	0.16TN	0.19TN	-0.01TN	0.04TN	0.43**	0.09TN	0.26*	-0.13TN	-0.01TN	-0.05TN	0.06TN	0.38**	0.24TN	0.14TN	0.3*	0.34**	0.32*	0.39**	1	
24	0.37**	0.47**	0.47**	-0.06TN	0.11TN	-0.13TN	-0.22TN	0.2TN	0.83**	0.38**	0.59**	0.32*	0.28*	0.35**	0.43**	0.98**	0.3*	0.26*	0.26*	0.27*	0.28*	0.28*	0.37**	1

Note: the number followed by the sign means (**) = very real, (*) = real, tn = not real,

1. Plant Height
2. Number of leaves
3. Stem Diameter
4. Harvest Age
5. Flowering Age of Females
6. Male Flowering Age
7. Anthesis Silking Interval (ASI)
8. Cob Height
9. Weight of Peeled Cobs
10. cob diameter
11. cob length
12. Length of Seeded Cobs
13. Number of Seed Lines Per Cob
14. Seed Yield
15. 1000 Seed Weight
16. Lint Cover 24. Productivity
17. Chlorophyll a Index
18. chlorophyll index b
19. total chlorophyll index
20. Light Absorbance
21. Light Reflection
22. Light Transmission
23. Normalized difference vegetation index (NDVI)

Correlation expresses the magnitude of the relationship that occurs between the observed parameters. The results of the correlation coefficient analysis in Table 4 show the results of the correlation analysis of all observation characters where the productivity parameter is the main parameter, so the correlation of productivity parameters is prioritized. The study showed that the parameters of plant height (r =0.37), number of leaves (r =0.47), stem diameter (r =0.47), cob weight (r =0.8), cob diameter (r =0.38), cob length (r =0.59), cob length (r =0.320), number of seed rows (r =0.28), 1000 seed weight (r =0.43), seed yield (r =0. 35), kelobot opening (r = 0.98), chlorophyll A (r = 0.3), chlorophyll B (r = 0.26), total chlorophyll (r = 0.26), light absorption (r = 0.27), light reflection (r = 0.28), light transmission (r = 0.28), and NDVI (r = 0.37) provide a positive correlation that has a significant effect and a very significant effect on productivity. It was not correlated with male flowering age (r = -0.06), female flowering age (r = -0.13), and anthesis silking interval (r = -0.22).

2. Discussion

Fertilizer is among the most critical production factors besides land, labour and capital. Balanced fertilization plays a vital role in efforts to increase corn yields. Fertilization recommendations should be made more rational and balanced based on the ability of the soil to provide nutrients and the needs of plants for nutrients, thus increasing the effectiveness and efficiency of fertilizer use and production without damaging the environment due to excessive fertilization (Tuherkih and Sipahutar, 2008). Organic fertilizer can improve soil structure, increase soil absorption of water, improve living conditions, and act as a plant food source. Meanwhile, inorganic fertilizers can stimulate overall growth, especially branches, stems, and leaves, and play an essential role in forming green leaves (Lingga, 2008).

Productivity is a consistent parameter influenced by the interaction of treatments and varieties. The genetic traits of the type strongly influence corn productivity, and these traits can only develop in an optimized environment. The more cultivation technology used, the more varied the production will be. Fahrurrozi F., Muktamar Z., Setyowati N., Sudjatmiko S., dan Chozin M (2019) said that productivity is significantly influenced by environmental relationships, along with plant density. Therefore, various N:P:K fertilizers and varieties can be applied to increase corn production.

The treatment combination that produced the lowest productivity was the N:P:K fertilizer dosage of 160:120:80, with the Jakarin variety (P1V2) showing a value of 3.81 t.ha-1. Flooding at the research site affects the growth and yield of corn plants, especially in the critical phase of flooding. Waterlogging stress causes anaerobic respiration in the root zone, affecting corn plants' metabolism. Plant responses to water stress can be seen in leaves and roots so that morphological characteristics and internal anatomical structures adapt to adverse environments. The main symptoms of leaves against waterlogging stress are curling, yellowing, wilting, falling, and rotting, which causes decreased production.

The productivity of the N:P:K fertilizer dose of 240:180:120 (P3) showed the highest average of 6.66 t.ha-1 compared to other fertilizer doses. As described by Lingga & Marsono (2013), the provision of urea, TSP and KCl fertilizers as a source of N, P and K is an effort to increase crop production. Nitrogen (N) is one of the macronutrients for plant growth, which is generally needed for plants' vegetative growth, such as roots, stems and leaves. Phosphorus is one of the essential macro-nutrients for plant growth and yield. It plays a vital role in spurring the formation of flowers and spikelets in panicles, strengthening straw so it does not lodge and improving grain quality. The central part of potassium for plants is an activator of various enzymes that play a role in metabolic processes (Husnain A., Kasno, S., dan Rochayati, 2016). The environment also affects the increase of corn crop production. An environment with optimal water availability can help corn plants in the vegetative and generative phases. Sirappa and Nasruddin Razak (2010) reported that if maize plants experience drought stress in the flowering or seed-filling phase, the yield is only about 30-60% of the work under normal conditions, while if drought stress occurs in the flowering stage until harvest, the product is approximately 15-30% of the creation of plants that do not experience drought stress. Waterlogged maize plants in the vegetative phase cause plants to become stunted, leaves curl, rot, and are susceptible to disease attacks. Corn plants that grow with sufficient water will produce optimal productivity.

The highest average productivity was obtained from the ADV variety (V6) with a value of 9.28 t.ha-1. Increased productivity cannot be separated from selecting suitable types that have physical and biological advantages. Bahtiar, B., Azrai, M., Biba, M.A., and Syakir, M (2018) explained that the benefits of ADV varieties have the main characteristics of very high yield potential, reaching 13.5 tons of dry peeled/hectare, high yield, and drought tolerance, so it is perfect to be planted in the dry season and in areas with minimal rainfall potential, and patience to downy mildew which is the primary disease of corn plants. ADV varieties are reliable in areas with high disease stress.

The lowest average productivity value was obtained from the Sinhas 1 (v3) variety, which was 4.53 t.ha-1 lower than other varieties. Genetic differences between varieties, such as adaptability and disease resistance, play a role in determining crop productivity. Variety is also another factor that plays a vital role in determining crop productivity. Apart from that, the cropping conditions during the study were also waterlogged, which caused water stress. Waterlogging stress causes anaerobic respiration in the root region, affecting corn plants' metabolism. The plant's response to water stress can be seen in leaves and roots so that morphological characteristics and internal anatomical structures adapt to adverse environments.

The Normalized Difference Vegetation Index (NDVI) variance results showed that the ADV Joss variety showed the best vegetation index value with a value of 0.82. The validation test results show the potential of imagery with this model to estimate the greenness of vegetation, especially by using the value of the vegetation index, which has a strong relationship with field measurements. Wahono, D. Indradewa, B.H Sunarminto, E Haryono, and D. Prajitno (2019) supports this in that using Unmanned aerial vehicles (UAV) with ArcGIS software provides complete and accurate data information. Digital image data from the range of light obtained from uncrewed aircraft can be used to quickly assess and record leaf chlorophyll and N content in corn plant leaves. Using UAVs and multispectral cameras, data capture can produce high-resolution Normalized Difference Vegetation Index (NDVI) readings. NDVI is highly proposed because light absorption and reflectance in leaves have been measured with a technological approach from satellites. NDVI data provides a strong approximation in measuring leaf chlorophyll and nitrogen concentrations during the growing season.

The correlation coefficient shows the close relationship between the two variables. The correlation coefficient ranges from -1 to +1. If a correlation value of zero is obtained, it can be concluded that there is no correlation between the two traits. The relationship shown is very close if the coefficient value is brought closer to +1. If the correlation value is more comparable to +1, an increase in one trait will be followed by a rise in the other trait and closer to - 1 means that an increase in one feature will reduce the additional quality. The criteria for the degree of closeness based on the correlation coefficient are 0: no correlation between two variables, 0 - 0.25: very low correlation, 0.25 - 0.5: moderate correlation, 0.5 - 0.75 = high correlation, 0.75 - 0.99 = very high correlation, while 1 = perfect correlation.

Based on the results of the correlation analysis, the characters of plant height (r=0.37), cob diameter (r=0.47), number of rows of seeds per cob (r=0.28), 1000 seed weight (r=0.43), peeled cob weight (r=0.83) and NDVI value (r=-0.37) have a significant influence on productivity, so that these characters can be used as a standard or as a consideration in determining fertilizer packages, varieties, and interaction of fertilizer packages with types in this study. According to Priyanto, S.B., A. Muhammad, and T.M Andi (2018) hybrid corn research (2017), one of the characteristics that correlate very significantly with yield is the weight of the cob. This proves that the importance of the hulled cob influences gain, where the seed yield increases considerably according to the increase in the weight of the hulled cob. An increase in the weight of the cob with cob and cob without cob in corn plants will be in line with the quantity of yield obtained. This is in line with Pratikta, Sri and Ketut (2013) research, which states that cob weight affects corn production because the more significant the cob weight, the greater the corn production. Therefore, producing quality seeds and high seed productivity can be done by selecting plant height, cob height, cob diameter, number of rows of kernels per cob, weight of 1,000 seeds, length of seeded cob and weight of husked cob.

Production characters such as cob weight (r =0.83), cob diameter (r =0.38), cob length (r =0.59), seed cob length (r =0.32), number of seed rows (r =0.28), 1000 seed weight (r =0.43). It also showed a positive correlation with productivity parameters. The values obtained for cob diameter, cob length, cob length, number of seed rows, and 1000 seed weight directly affect maize productivity. The weight of 1000 seeds is a measure to determine the average weight and the accumulation of carbon dioxide net results throughout growth. This is in line with the opinion that carbon dioxide assimilation is the result of the absorption of solar energy due to solar radiation that is evenly distributed to the entire surface of the leaf that is absorbed and the efficiency of utilizing this energy for carbon dioxide fixation. The nutrients absorbed will be accumulated in the leaves into proteins that can form seeds; with the fulfilment of plant nutrients, the metabolism runs optimally, and the formation of seeds increases and has a maximum size and weight.

The correlation matrix table between observation parameters where the NDVI (Normalized Difference Vegetation Index) value character (r = 0.37) accurately correlates to productivity. The more active the photosynthesis process, the higher the NDVI value and vice versa; the lower the greenness of the plant will give a lower NDVI value. The relationship between NDVI and the growth phase of corn is related to the variation of NDVI values for each stage of corn growth. In their research, Farid and Wahono (2021) explained that vegetation age is classified as medium and the density of plant stands. The thickness of the plant canopy generally provides a high ratio value on the vegetation index value. In this study, it is analogous that the stand density also affects the canopy density, so the analysis results show a solid relationship. The denser the vegetation stands, the greater the canopy density and will affect the vegetation index value. The taller the corn plant and the older the plant, the denser the leaf canopy. The growth and change of a relatively thicker and denser vegetation canopy cover significantly affects the pixel value of aerial imagery so that the chlorophyll and nitrogen vegetation index values are higher.

C. Conclusion

From the results of the study it can be concluded that the morphophysiological parameters of several varieties of corn showed a significant effect, including the fertilizer dose that provides the highest productivity compared to the other three fertilizer packages, namely the fertilizer dose of N:P:K 240:180:120 (P3) showing the highest average of 6.66 t.ha-1, the variety that produces the highest productivity compared to five types is the ADV variety (V6) with an average value of 9.28 t.ha-1. The combination of N:P:K 160:120:80 fertilizer dose treatment with ADV Joss variety (P1V6) showed the highest productivity compared to other treatment combinations with a value of 9.38 t.ha-1.

D. References

Alfiqriyansyah., Fachri H. P. (2019) Smart Farming 4.0 Akan Menjadi Masa Depan. Institut Teknologi Sumatera. Pengenalan Komputer dan Software.

Asbur, Y., Rahmawati dan M. Adlin. (2019). Respon Pertumbuhan dan Produksi Tanaman Jagung (Zea mays L.) Terhadap Sistem Tanam dan Pemberian Pupuk Kandang Sapi. *Jurnal Agriland* Vol. 7 No. hal 9-16.

Bahtiar, B., Azrai, M., Biba, M. A., & Syakir, M. (2018). Daya Saing Calon Varietas Hibrida Nasa 29 di Jawa Timur. *Jurnal Penelitian Pertanian Tanaman Pangan 2* (1): 35-42.

Balai Pengkajian Teknologi Pertanian (BPTP) Bali. (2020). Jajar Legowo Pada Jagung. http://www.litbang.pertanian.go.id/inf o-teknologi/2510/

Davies, B., Coulter, J.A., Pagliari, P.H. (2020). Timing and rate of nitrogen fertilization influence maize yield and nitrogen use efficiency. PLoS ONE 15(5): 1-19. Doi.org/10.1371/journal. pone.0233674.

Direktur Jenderal Tanaman Pangan. (2020). Pedoman Pelaksanaan Kegiatan Jagung Tahun 2017. Jakarta.

Fahrurrozi, F., Muktamar, Z., Setyowati, N., Sudjatmiko, S., & Chozin, M. (2019). Comparative effects of soil and foliar applications of tithonia-enriched liquid organic fertilizer on yields of sweet corn in closed agriculture production system. *AGRIVITA*, *Journal of Agricultural Science*, 41(2), 238-245.

Farid. H., dan Wahono (2021). Perbandingan Akurasi Pengukuran Klorofil dan Kadar Nitrogen Antara Spad Dengan NDVI Pada Tanaman Jagung (*Zea mays* L.) *Jurnal Agro Indragiri* Vol 8. No 2.

Husnain, A. Kasno, S. Rochayati. (2016). Pengelolaan Hara dan Teknologi Pemupukan Mendukung Swasembada Pangan di Indonesia . *Jurnal Sumberdaya Lahan* Vol. 10 No. 1 :25-36.

Kulcheski, F.R., Correa, R., Gomes, I.A., Lima, J.C.D., Margis, R. (2015). NPK Macronutrients and Micro RNA Homeostatis. Frontiers In Plant Science 6:451. Doi: 10.3389/FPLS.2015.00451.

Liferdi, L., Poerwanto, R., Susila, A. D., Idris, K., & Mangku, I. W. (2008). Korelasi kadar hara fosfor daun dengan produksi tanaman manggis. *Jurnal Hortikultura*, 18(3).

Lingga, P. Dan Marsono. (2013). Petunjuk Penggunaan Pupuk. Edisi Revisi. Jakarta: Penebar Swadaya.

Munawar, Ali. (2011). Kesuburan Tanah dan Nutrisi Pemupukan. IPB PRESS

Paeru, R.H. dan T.Q. Dewi, (2017). Panduan Praktis Budidaya Jagung. Penebar Swadaya, Jakarta

Prasetyo R., H. H Handayani , W Agus (2013). Analisa Kesehatan Tanaman Padi Berdasarkan Nilai Normalized Difference Vegetation Index (NDVI) Menggunakan Citra Aster. (Studi Kasus : Kabupaten Indramayu - Jawa Barat). GEOID Vol. 08. No. 02: 107-117.

Priyanto, S.B., A. Muhammad, dan T.M. Andi, (2018). Parameter Genetik dan Korelasi Karakter Komponen Hasil Jagung Hibrida. Buletin Penelitian Tanaman Serealia, 1 (2).

Pusparini, P., G.A. Yunus dan D. Harjoko. (2018). Dosis Pupuk NPK Terhadap Pertumbuhan dan Hasil Jagung Hibrida. Agrosains 20(2): 28-33.

Salamah U,. W.B> Sawarno, Aswidinnoor, Hajrial, dan A. Nindita. (2017). Keragaman Agronomi dan Pontensi Hasil Genotipe Jagung (*Zea mays* L) Generasi S1 dan S2 di Dua Lokasi. *J. Agron. Indonesia*, 45 (2) : 138 – 145.

Shrestha, J., Chaudhary, A., Pokhrel, D. (2018). Application of nitrogen fertilizer in maize in Southern Asia: a review Aplicación de fertilizantes nitrogenados al maíz en Asia meridional: una revision. *Peruvian Journal of Agronomy* 2 (2): 22 – 26. DOI.org/10.21704/pja.v2i2.1201.

Sirappa, M. P., dan Razak, N. (2010). Peningkatan Produktivitas Jagung Melalui Pemberian Pupuk N, P, K dan Pupuk Kandang Pada Lahan Kering di Maluku. Prosiding pekan serealia nasional, 277-286.

Soehandi, R. dan Syahri. (2013). Potensi Pengembangan Jagung di Sumatera Selatan. *Jurnal Lahan Suboptimal*, 2 (1): 81-92.

Subekti, A., Nuning, Syafruddin, E. Roy dan S. Sri. (2007). Morfologi Tanaman dan Fase Pertumbuhan Jagung. Maros: Balai Penelitian Tanaman Serealia Maros.

Tuherkih, E. Sipahutar, I.A. (2008). Pengaruh Pupuk NPK Majemuk (16:16:15) Terhadap Pertumbuhan dan Hasil Jagung (Zea Mays L) Di Tanah Inceptisols. Balai PenelitianTanah. 77–88.

United States Departement of Agriculture (USDA), (2020). Zea mays L. Classification. https://plants.usda.gov/core/profile. Diakses pada 30 Mei 2021.

United States Departement of Agriculture National Database For Standar Reference (2016). Nutrient Values of Corn Grain, Yellow. https://ndb.nal.usda.gov./ndb/. Diakses pada 28 Juni 2021.

Wahono, D. Indradewa, B. H. Sunarminto, E. Haryono, and D. Prajitno, (2019). "CIE L*a*b* Color Space Based Vegetation Indices Derived from Unmanned Aerial Vehicle Captured Images for Chlorophyll and Nitrogen Content Estimation of Tea (*Camellia sinensis* L. Kuntze) Leaves," Ilmu Pertan. (Agricultural Sci., vol. 4, no. 1, pp. 46–51.

Wahyudin, A.Y., Yuwariah, F.Y. Wicaksono dan R.A.G. Bajri. (2017). Respons Jagung (*Zea mays* L.) Akibat Jarak Tanam Pada Sistem Tanam Legowo (2:1) Dan Berbagai Dosis Pupuk Nitrogen Pada Tanah Inceptisol Jatinangor. *Jurnal Kultivasi* Vol. 16 (3).

Wang, X., Miao, Y., Dong, R., Chen, Z., Kusnierek, K., Mi, G., Mulla, D.J. (2020). Economic Optimal Nitrogen Rate Variability of Maize in Response to Soil and Weather Conditions: Implications for Site-Specific Nitrogen Management. Agronomy 10: 1-18. Doi:10.3390/agronomy10091237.

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Effects of Variations in the Application of Cocoa Pod Shell Compost and Mexican Lilac Liquid Organic Fertilizer on the Growth and Production of Yellow Bell Pepper Plants in Lowland

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Abstract

A research study aimed at evaluating the efficacy and determining the optimal dosage of cocoa pod shell compost fertilizer for enhancing the growth and production of yellow pepper plants in the lowland was conducted. This research was carried out at Experimental Field II, Faculty of Agriculture, Cokraminoto University, Palopo, located on Jalan Lamaranginang, Batu Pasi Village, North Wara District, Palopo City, from July to October 2023. The experimental design employed was Randomized Block Design, encompassing six treatments with four replications. The level treatments used were designed as follows: P0 (no treatment), P1 (135 gr cocoa husk compost and 100 ml/L of liquid organic fertilizer of mexican lilac), P2 (185 gr cocoa husk compost and 150 ml/L of liquid organic fertilizer of mexican lilac), P3 (235 gr cocoa husk compost and 150 ml/L of liquid organic fertilizer of mexican lilac + 200 ml/L of liquid organic fertilizer (gamal), P4 (cocoa pod husk compost 285 gr and liquid organic fertilizer of mexican lilac 250 ml/L, P5 (cocoa pod husk compost 335 gr and liquid organic fertilizer of mexican lilac 300 ml/L). The parameters observed included plant height, flowering age, number of flowers, number of fruit, fruit weight and fruit diameter. Upon conducting research and data analysis, it was revealed that the P3 treatment exerted a highly significant effect on the parameters of fruit weight (449.78 grams). Conversely, P3 demonstrated no significant impact on the parameters of the number of fruits (4.00), fruit diameter (135.20 cm), plant height (39.38 cm), number of flowers (7.88 florets) and flowering age (34.63 HST). In light of these findings, it is recommended to consider an increase in the dosage of cocoa pod husk compost and liquid organic fertilizer (Mexican lilac) to optimize the growth and production of yellow bell pepper plants in subsequent research endeavors

Keywords: yellow pepper, organic fertilizer, cocoa pod shell, mexican lilac

A. Introduction

The bell pepper plant (*Capsicum annuum* var. Grossum) belongs to the eggplant tribe and thrives at altitudes ranging from 700 to 1500 meters above sea level. Originating from Latin American countries such as Mexico, Peru, and Bolivia, the bell pepper plant holds significant market potential in Indonesia's horticultural sector. Currently, West Java stands as the primary supplier of bell peppers in Indonesia, as reported by the Central Bureau of Statistics (BPS, 2019). Beyond its sweet taste, bell peppers are nutritionally rich, containing proteins, carbohydrates, fats, various essential vitamins, and valuable plant secondary metabolite compounds. Noteworthy research has been conducted on paprika plants, as evidenced by studies conducted by Aviantara and Sarjana (2018) and Supriatna and Azzahra (2021). However, it is pertinent to note that the cultivation of yellow bell pepper plants in lowland areas has not been extensively explored.

Cocoa (*Theobroma cacao*) is one of the leading commodities in Luwu Raya. The annual cocoa bean yield in South Sulawesi Province is reported to range from 700 to 800 kg per year (Kabar News, December 2018). The aftermath of cocoa bean harvesting results in cocoa pods, which, if left unattended, can lead to waste accumulation and the potential for disease, emitting unpleasant odors in the cocoa plantation vicinity. Addressing this challenge has become a focal point for researchers aiming to mitigate and manage cocoa pod shell waste. Several studies have explored the valorization of cocoa shell agricultural waste in various domains, including its utilization as animal feed (Min, Bockki, Jongbin Lim, Sanghoon Ko, Kwang-Geun Lee, Sung Ho Lee and Suyoung Lee, 2011; Redgwell, R., V. Trovato, S. Merinat, D. Curti, S. Hediger, A. Manez, 2003; Ayinde, O. E., Adeyina, A.A., Adesoye, O., 2010; Magistrelli, D. Zanchi, R., Malagutti, L., Galazssi, F., Canzi, E., Rosi, F., 2016; Okiyama D. C. G., Sandra L. B. N., & Christianne E. C. R., 2017) and as a heavy metal adsorbent (Saucier C., Adebayo, M. A., Lima E. C., Cataluna R., Thue, P. S., Prola, L. D., Puchana-Rosero, M. J., Machado, F. M., Pavan, F. A., & Dotto, G. L., 2015). The composition of cocoa pod material comprises environmentally friendly components, such as protein, fat, dietary fiber, soluble saccharides, polyphenols, and other valuable constituents (Okiyama et al., 2017).

Efforts have been undertaken to diminish cocoa pod shell waste through its conversion into compost. According to Kasim, A., Yatim, H., and Maharia, D. (2021), cocoa pod husk compost exerts a noteworthy influence on the vegetative phase of peanut plants. This compost is characterized by nutrient content including 1.81% nitrogen (N), 26.61% organic carbon (C), 0.31% phosphorus pentoxide (P2O5), 6.08% potassium oxide (K2O), 1% calcium oxide (CaO), and 1.37% magnesium oxide (MgO). Furthermore, it is asserted that this compost has the potential to enhance the physical, biological, and chemical attributes of soil (Bahari, 2019).

Gamal leaves (*Gliricidia sepium*), belonging to the Leguminoseae family, are recognized for their substantial nitrogen content (Oviyanti, 2016). The transformation of gamal leaves into liquid organic fertilizer has been shown to have a beneficial impact on the growth and yield of flower cabbage and sweet corn plants (Novriani, 2016 and Jeanne. M. P, Jemmy. N, Paula. C. H. S, Dianne. S.T, 2020).

This research focuses on the cultivation of organic-based yellow bell pepper plants in lowland areas. It involves the utilization of cocoa pod compost and liquid organic fertilizer derived from gamal leaves.

B. Methodology

This research was carried out at the Experimental Garden of Campus II, Cokroaminoto University Palopo, located on Lamaranginang Street in Batupasi Village, North Wara District, Palopo City. The study was conducted from July to October 2023.

Various materials were employed in this research, comprising F1 Yellow Star variety yellow bell pepper plants, cocoa fruit peel compost, gamal leaf POC (liquid organic fertilizer derived from gamal leaves), and water. The tools utilized during the study included hoes, shovels, machetes, stakes, meters, ropes, labels, cameras, buckets, hoses, scales, vectors, treatment labels, research boards, and stationery.

The methodology employed in this study adhered to a group randomized design, encompassing six distinct treatments, each replicated four times. The treatments included cocoa pod husk compost (KBK) and gamal leaf POC (DG). The specific variations applied to each treatment are elucidated as follows:

P0 = No treatment (control)
P1 = KBK 135 g + DG 100 ml/L
P2 = KBK 185 g + DG 150 ml/L
P3 = KBK 235 gr + DG 200 ml/L
P4 = KBK 285 gr + DG 250 ml/L
P5 = KBK 335 gr + DG 300 ml/L

The parameters subject to observation were categorized into vegetative phase parameters, specifically plant height (cm), and generative phase parameters, which encompassed flowering age (hst), the count of flowers (florets), the count of fruits (fruit), and the weight of fruits (grams). After the collection of observational data, an analysis of variance (ANOVA) was employed for statistical analysis. In instances where a significant effect was detected, post hoc analysis was conducted using the Bonferroni-Dunn procedure (BNJ) at the 5% significance level.

C. Result and Discussion

Based on the results of observations and data analysis, it is discerned that yellow bell pepper plants exhibit the capability to thrive and yield produce in lowland regions situated at an altitude of 5 meters above sea level. In the context of this study, emphasis was directed towards the parameters of the generative phase, as opposed to the vegetative phase. This deliberate focus was driven by the primary objective of addressing the pivotal challenge in this investigation, which revolves around achieving successful yellow bell pepper plant production through the utilization of organic fertilizers in lowland environments. The sole vegetative phase parameter subjected to observation was plant height, and the corresponding results are elucidated in Figure 1.

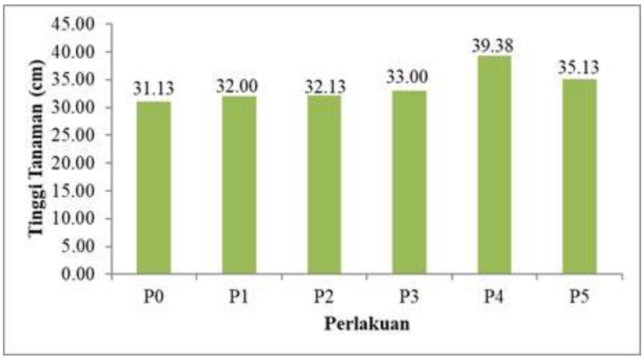

Figure 1. Average Height of Yellow Bell Pepper Plants (cm) for Each Treatment Variation

According to the findings depicted in Figure 1, the P4 treatment yields the most favorable outcomes for the height of bell pepper plants. However, upon scrutiny of the analytical results, it is evident that the administered treatments did not exert a statistically significant influence on the height of yellow bell pepper plants. Despite this, the processed data presented in Figure 1 prompts researchers to hypothesize that the P4 treatment represents an optimal dosage for yellow bell pepper plants cultivated in lowland conditions. This speculation is further substantiated by the observed height fluctuations in P1-P3 and a subsequent decline at P5. Moreover, there is a suspicion that the absorption of nitrogen (N) by yellow bell pepper plants at the P4 treatment level is optimal. It is noteworthy that, despite the favorable outcomes, the height of yellow bell pepper plants in this study remains inferior to that reported in the study conducted by Tulung & Demmassabu (2011).

Observations pertaining to the flowering age (hst) further revealed that plants subjected to the P4 treatment exhibited the most expeditious flowering, surpassing the flowering duration of plants subjected to treatments other than P4. Figure 2 illustrates a comparative analysis of the flowering ages across different treatments administered to each plant.

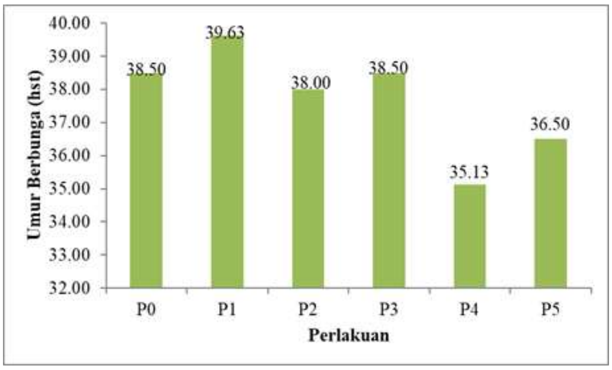

Figure 2. Average Flowering Age (hst) of Bell Pepper Plants for Each Treatment Variation

The data presented in Figure 2 highlights that plants subjected to the P4 treatment exhibit the most rapid flowering. However, akin to the observations in the plant height parameter, the variations in treatment do not yield a statistically significant impact on flowering age. Researchers posit that the treatment combinations may not have achieved an optimal effect on plants, particularly in terms of the flowering age parameter. Consequently, it is conjectured that meticulous adjustment of fertilizer nutrient levels is paramount for optimizing plant performance.

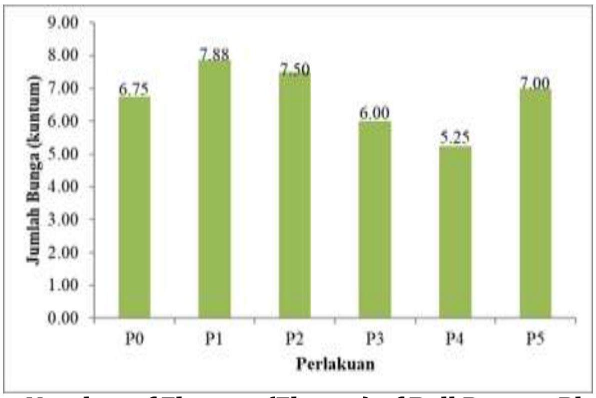

Figure 3. Average Number of Flowers (Florets) of Bell Pepper Plants in Each Treatment

Another generative parameter under scrutiny was the count of flowers (florets), serving as a metric to gauge the plant's ability to absorb nutrients and generate flowers. Figure 3 delineates the data pertaining to the number of flowers corresponding to each treatment. The data concerning the number of flowers underwent variance analysis, leading to the determination that the administered treatment did not impart a substantive effect. This outcome is attributed to adverse weather conditions, wherein rainfall is identified as a contributing factor causing premature shedding of budding flowers. This assertion finds support in the work of Nautiyal Pankaj & Supyal, Varun & Rathore, Arun Singh & Singh, Esha & Chaudhary, Ashutosh & Rayeen, Shifa & Pal, Sagar & Tiwari, Ayushi & Khaniya, Saugat & Deo, Nandani (2022), which affirms that climate-related factors, including fluctuations in wind speed and rainfall, constitute significant contributors to premature flower fall before the onset of fruiting.

The trend of the graph concerning the parameter of the number of flowers diverges from that of the graph representing the number of fruits. As illustrated in Figure 4, it becomes apparent that not all blooming flowers successfully progress to maturation and fruition.

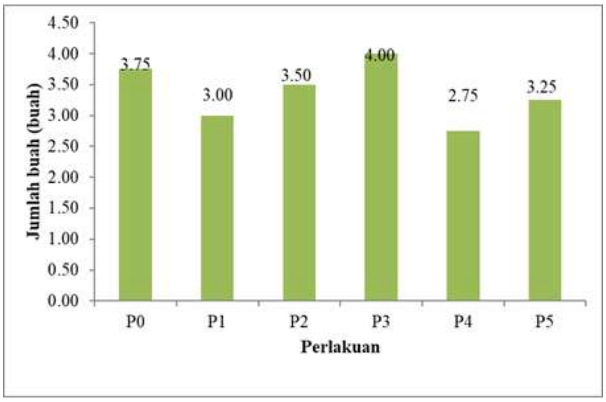

Figure 4. Average Number of Fruits (Fruit) of Yellow Bell Pepper Plants for Each Treatment

The flowers that successfully progressed to maturation and fruition, as depicted in Figure 4, constituted less than half of the total number of flowers that initially bloomed (Figure 3). The primary contributing factor to this discrepancy is identified as fruit fly infestation. According to the outcomes of the variance analysis, the administered treatment does not yield a statistically significant effect on the number of fruits produced by yellow bell pepper plants. It is noteworthy that, despite the challenges posed by fruit fly infestation, the quantity of yellow bell peppers generated in this study surpassed the yield reported in a parallel study conducted by Tulung & Demmassabu in 2011.

The weight of fruits obtained in this study exhibited an average that was double the magnitude reported in a corresponding study by Tulung & Demmassabu in 2011. The outcomes of the variance analysis for fruit weight data underscored that the administered treatments exerted a statistically significant influence on the fruit weight of yellow bell peppers. The trend in the fruit weight of bell pepper plants, corresponding to various treatment variations, is visually represented in Figure 5.

After establishing the substantive effect for fruit weight data, a Bonferroni-Dunn procedure (BNJ) at the 5% significance level was applied for further analysis. The outcomes of this analysis indicate that the provision of treatments imparts a discernible effect on yellow bell pepper plants in comparison to the absence of treatment. However, it is noteworthy that only the P5 treatment exhibited a fruit weight that was significantly distinct from the other four treatment variations. Of particular interest is the observation that the average fruit weight of yellow bell pepper plants subjected to P3 was the highest among all treatments applied. This elevation in fruit weight in P3 is attributed to the absence of fruit fly infestation. It is pertinent to note, however, that despite the favorable conditions contributing to increased fruit weight, the yellow bell pepper fruits produced are categorized as very large (Suwarno, 2006).

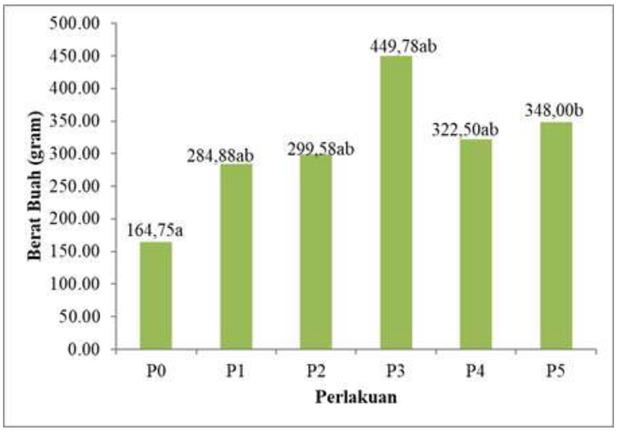

Figure 5. Average fruit weight (g) of bell pepper plants for each treatment

The accumulation of adverse weather conditions, suboptimal plant height, inadequate pest control, and varying treatment doses, both appropriate and suboptimal, are identified as contributing factors to the lack of a significant effect on the observed plant parameters for yellow bell pepper plants. Despite these challenges, the overall objectives of this research, particularly the experimental cultivation of yellow bell pepper plants in lowland conditions, have been realized. Subsequent research endeavors are anticipated to explore the enhancement of the P4 treatment dosage, as applied in this study, to further refine and optimize the cultivation practices for yellow bell pepper plants in lowland environments.

C. Conclusion

Derived from the outcomes of meticulous observations and comprehensive data analysis, it is deduced that the application of cocoa pod compost and liquid organic fertilizer did not impart a statistically significant effect on various parameters, including plant height, flowering age, number of flowers, number of fruits, and fruit diameter of yellow bell pepper plants. Notably, the treatment exhibited a substantial influence exclusively on the parameter of fruit weight, where a significant difference was observed at P5 for this parameter. It is conclusively ascertained that the cultivation of yellow bell pepper plants in lowland conditions is viable.

D. Acknowledgments

On this occasion, the researchers extend their sincere appreciation to all parties who contributed to the successful implementation of this research. Special thanks are also conveyed to Cokroaminoto University Palopo for providing the necessary research infrastructure and support.

E. References

Aviantara, I. G. N. A., Sarjana, P. (2018). Kajian Sistem Jaminan Mutu pada Budidaya Paprika di Greenhouse di Desa Candikuning Kecamatan Baturiti, Kabupaten Tabanan, Bali. Jurnal Ilmiah Teknologi Pertanian: Agrotechno. 3(2): 338-341.

Ayinde, O. E., Adeyina, A.A., Adesoye, O. (2010). Economics of Using Cocoa Bean Shell as Feed Supplement for Rabbit, Pak. J. Nutr., 9, 195–197.

Bahari, M. F. (2019). Pembuatan Kompos Blok Limbah Kulit Buah Kakao Dan Aplikasinya Pada Pertumbuhan Tanaman Tomat dan Sawi Hijau (Doctoral dissertation, Fakultas Teknologi Pertanian).

Jeanne. M. P, Jemmy. N, Paula. C. H. S, Dianne. S.T, (2020), Aplikasi POC (Pupuk Organik Cair) Daun Gamal untuk Meningkatkan Pertumbuhan dan Produksi Jagung Manis Berbasis Organik. Jurnal Pengembangan Penyuluhan Pertanian 17(31): 38-45.

Kasim, A., Yatim, H., & Maharia, D. (2021). Pengaruh Pemberian Kompos Kulit Kakao Terhadap Pertumbuhan Dan Produksi Tanaman Kacang Tanah (Arachis hypogaea L). Jurnal Ilmiah Mahasiswa Fakultas Pertanian, 1(2). https://doi.org/10.52045/jimfp.v1i2.179.

Magistrelli, D. Zanchi, R., Malagutti, L., Galazssi, F., Canzi, E., Rosi, F. (2016). Effect of Cocoa Husk Feeding on Composition of Swine Intestinal Microbiota, J. Agric. Food. Chem., 64, 2046–2052.

Min, Bockki, Jongbin Lim, Sanghoon Ko, Kwang-Geun Lee, Sung Ho Lee & Suyoung Lee. (2011). Enviromentally Friendly Preparation of Pectins from Agricultural Byproducts and Their Structural/Rheological Characterization, Bioresources Technology, 102, 3855–3860.

Nautiyal, Pankaj & Supyal, Varun & Rathore, Arun Singh & Singh, Esha & Chaudhary, Ashutosh & Rayeen, Shifa & Pal, Sagar & Tiwari, Ayushi & Khaniya, Saugat & Deo, Nandani. (2022). Causes and control of flower drop in fruit crops: A review. The Pharma Innovation Journal. 11(2). 1165-1168.

Novriani. (2016). Pemanfaatan Daun Gamal sebagai Pupuk Organik Cair (POC) untuk Meningkatkan Pertumbuhan dan Produksi Tanaman Kubis Bunga (Brassica oleracea L.) pada Tanah Podsolik. Klorofil XI - 1 : 15 – 19, Juni 2016.

Okiyama, D. C. G., Sandra L. B. N., & Christianne E. C. R. (2017). Cocoa Shell and Its Compounds: Applications in the Food Industry, Trends in Food Science & Technology., 63, 103–112.

Oviyanti, F., Syarifah, S., & Hidayah, N. (2016). Pengaruh pemberian pupuk organik cair daun gamal (Gliricidia sepium (Jacq.) Kunth ex Walp.) terhadap pertumbuhan tanaman sawi (Brassica juncea L.). *Jurnal biota*, *2*(1), 61-67.

Redgwell, R., V. Trovato, S. Merinat, D. Curti, S. Hediger, A. Manez. (2003). Dietary Fibre in Cocoa Shell: Characterization of Component Polysaccharides, Food Chem., 81, 103–112.

Saucier, C., Adebayo, M. A., Lima E. C., Cataluna R., Thue, P. S., Prola, L. D., Puchana-Rosero, M. J., Machado, F. M., Pavan, F. A., & Dotto, G. L. (2015). Microwave-assissted Activated Carbon from Cocoa Shell as Adsorbent for Removal of Sodium Diclofenac and Nimesulide from Aqueous Effluents, J. Hazard. Mater., 289, 18–27.

Supriatna, J., dan Azzahra, I. D. (2021). Budidaya Tanaman Paprika (*Capsicum annuum* var. Grossum) secara Hidroponik dengan Sistem Irigasi Tetes di PS4 Tottal Cantigi Farm. Community Empowerment. 6(8): 1545-1556.

Suwarno, E. H. (2006). Standar Operasional Prosedur Paprika di Greenhouse. Departemen Pertanian Dirjen Hortikultura.

Tulung, S. M. T., dan Demmassabu, S. (2011). Pertumbuhan dan Hasil Paprika (*Capsicum annuum* var. Grossum) pada Beberapa Jenis Naungan. Eugenia. 17(2): 157-162.

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Fertility Status of the Soil in the Area Where Rubber (*Hevea brasiliensis*) Plants are Being Replanted (*Elaeis guineensis* Jacq)

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Abstract

Rubber plants (*Hevea brasiliensis*) will experience a decrease in production as plant age and the nutrient content in the soil decreases. This study aims to find out the chemical properties of soil on plantations of rubber crops that are converted into palm and coconut crops. The research was conducted from October 2023 to January 2024 at the palm coconut plantation of PTPN III Aek Nabara North Garden in Labuhanbatu district and analyzed in the Land Laboratory of the Faculty of Agriculture of the University of Northern Sumatra. The methods used are observation methods, field sampling, and analysis in the laboratory to obtain quantitative data. Observation parameters include soil pH, C-organic, Total Nitrogen, Available P, Cation Interchange Capacity, and Base Fulness. The results of the survey showed that the level of soil fertility at the site of the research was included in the low category. The main limiting factor that causes the low fertility of the soil is the low content of organic material in the soil. In order to improve the fertility status of the ground at the research site for further planting, it is necessary to make efforts such as irrigation and fertilization, as well as the addition of organic materials, to make the availability of nutrients for plants more affordable

Keywords: replanting area, rubber plants, conversion, soil fertility, quantitative data

A. Introduction

Replanting rubber plants into oil palm plants is an alternative effort to maintain the continuity of plantations, especially oil palm, however, the use of replating land for planting oil palm and new seeds has several disadvantages, including the level of land productivity and changes in soil structure due to previous rubber planting. According to (Merhan, Kesumawati and Sufardi, 2016) alluvial soil is clay-textured soil and has a neutral reaction with a pH of around 6.5, low organic C content, very low total N content, very high available K content and high P content.

The results of Faizal's research (2021) show that during the replanting period of oil palm soil in Rokan Hulu (age 26 years) the results were not good, data was obtained that the pH was classified as acidic, C-organic was classified as low, the N content was classified as low category, content in the very low category, K content in the low category and CEC in the low category. The research results of (Kiki, Aspan and Hayati, 2022), also show that the soil fertility status of the oil palm replanting land studied in Sanggau Regency, West Kalimantan is included in the low criteria. Soil reaction (pH) is very acidic, C-Organic is low, N-total is medium criteria, P-total is very low, K-total is low criteria, CEC is low criteria and base saturation is low.

Planting oil palm plants can be done in three ways, namely opening new land (new planting), planting on converted land (land used by other crops) and replanting on land used by oil palm plants (replanting). Of these three methods, the recommended planting method for existing plantations is to replant on open land (replanting).

This land use can be an effective solution for the continuity of oil palm plants because it can reduce illegal logging, forest burning and can avoid conflicts with local communities (Lubis and Siregar, 2009). Implementing replanting of oil palm plants requires land evaluation to determine the condition of the land. as well as the level of soil fertility.This is due to the possibility of changes in soil physical elements and soil chemical elements which affect soil fertility on land due to the absorption of oil palm plants during the previous planting period (Harahap, Sitompul, Rauf, Harahap, and Walida, 2019)

The main obstacle in using land for agriculture and especially plantations is the low level of soil fertility caused by a number of chemical obstacles that limit plant growth, such as acidity problems, nutrient availability and low soil organic matter content. According to Rinojati et al., (2017) this condition is further exacerbated by the limited use of organic fertilizers and the inappropriate use of inorganic fertilizers at the time, dose, type and application. So good soil management efforts are needed based on soil chemical fertility parameters, meaning that they are in accordance with the needs of the type of plant being cultivated.

For this reason, strategies are needed to be able to carry out rejuvenation well, one of which is by paying attention to the chemical properties of the soil on oil palm plantations, so what are the chemical properties of the soil on rubber plantations that are around 20 years old, Why is it necessary to test the chemical properties of the soil and how to increase the nutrient content of the land? So before replanting on the replanting land

B. Methodology

The research was carried out on replanted rubber plantation land which will be planted with oil palm owned by PTPN III Kebun Aek Nabara Utara, Labuhanbatu Regency at a height of 32 meters above sea level in Figure 1. This research was carried out from October 2023 to January 2024 on oil palm plantations and analyzed at the Soil Laboratory, Faculty of Agriculture, University of North Sumatra.

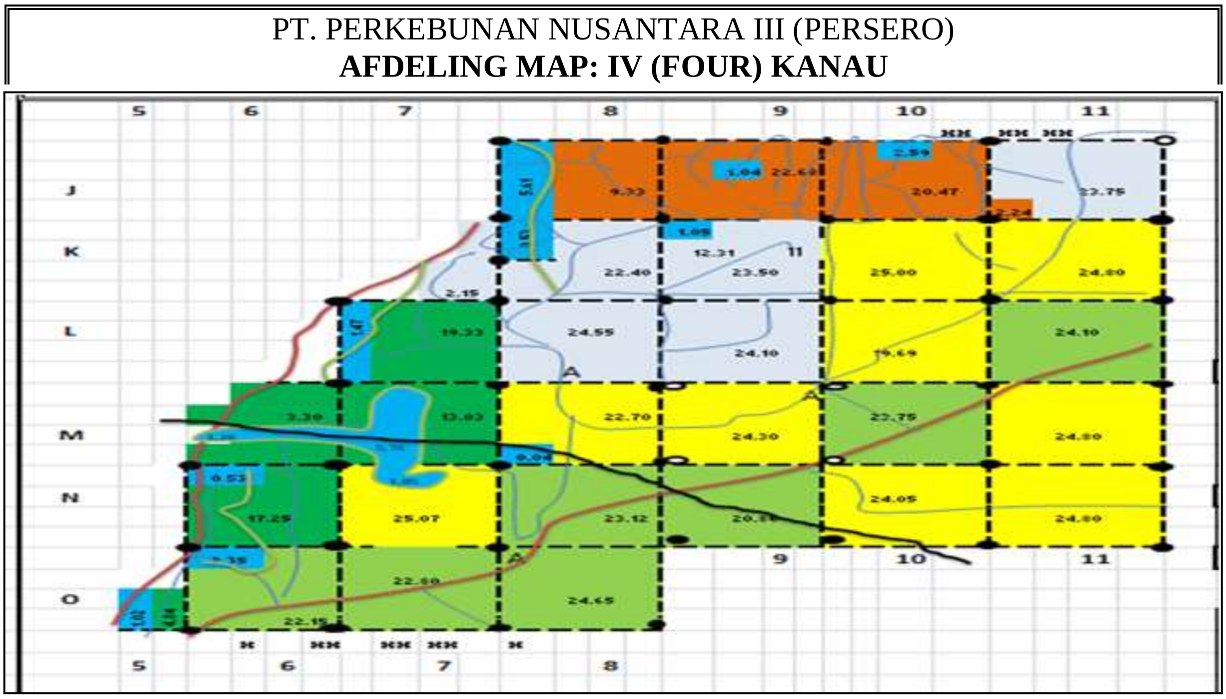

Figure 1. Map of research locations

The research began with pre-research by taking soil samples and the method used is the observation method, taking samples in the field and analyzing them in the laboratory to obtain quantitative data. The method used in this research is a free grid measurement method at a semi-detailed survey level (observation frequency of 1 sample per 500 meters). Take soil samples from up to 5 sampling points with a distance of 100 meters in the field using a random method, spread over a predetermined area based on the base map as shown in Figure 3 (Rauf and Harahap, 2019).

Sampling was carried out using a random sampling method at predetermined points in each block, sampling was carried out from two depths, namely from 5 samples each at the same two depths for checking chemical content. explore the properties of the soil with certain predetermined criteria. To determine the chemical properties of soil using certain criteria that have been determined based on the Technical Guidelines for Soil Fertility Evaluation (PPT, 1995) which are presented in Table 1.

Soil Parameters	Very low	Low	Currently	Tall	Very high
C-organic (%)	< 1.00	1.00-2.00	2.01-3.00	3.01-5.00	> 5.00
Base Saturation (%)	< 20	20-35	36-50	51-70	> 70
P2O5 HCl 25%	< 10	10-20	21-40	41-60	> 60
K2O HCL 25%	< 10	10-20	21-40	41-60	> 60
CEC (me/100 g)	< 5	5-15	17-24	25-40	> 40

Source: (PPT Bogor, 1995)

Soil samples are analyzed to determine the nutrient content, namelysoil pH,Nitrogen (N)Kjeldah method unit %, Pospor (P) MethodHCl 25% unit mg/100, C-Organic MethodsWalkey and Black units %,Cation exchange capacity and Base Saturation

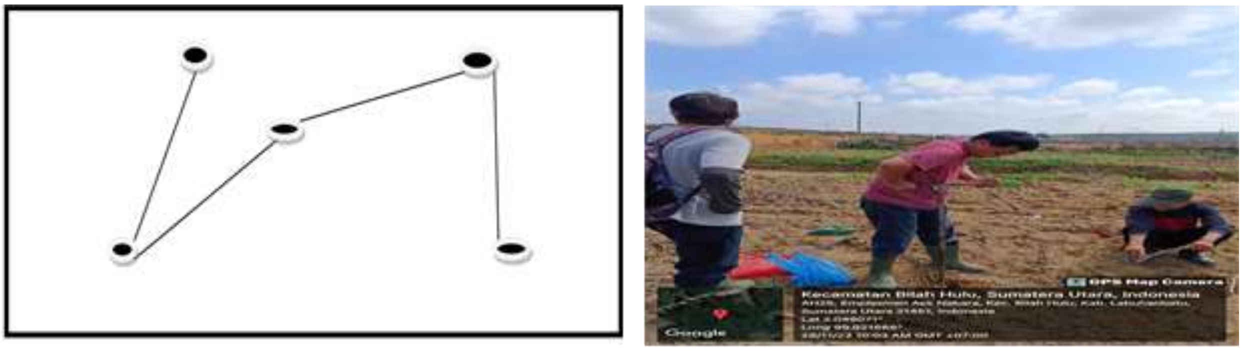

Figure 2. Taking soil sample points in the field

C. Results and Discussion

Primary data (analysis data) obtained from the results of soil analysis in the laboratory were valued according to the PPT Bogor soil fertility assessment (1995). So it is known that the value of soil chemical fertility parameters including low, medium and high status can be seen in Table 1. The results of measuring soil fertility parameters and soil fertility status of land replating rubber plantations converted to oil palm are presented in Table 2.

Parameter	Unit	Sample				
		I	II	III	IV	V
Soil pH		4.91	5.67	5.65	5.27	5.33
N-Total	%	0.13	0.19	0.12	0.18	0.81
P2O5	ppm	46.50	32.86	42.88	26.33	23.43
C-Organic	%	1.72	1.15	1.34	1.62	1.55
CEC	me/100 gr	10.72	9.85	9.48	10.28	10.18
KB	%	17.91	10.80	7.54	20.12	18.17

The results of Table 1 show that the soil pH at the research location is included in the slightly acidic category, namely around 4.91-5.67. Soil pH is a soil reaction that indicates the acidity or alkalinity of the soil. Soil pH plays an important role in determining whether or not nutrients are easily absorbed by plants. Nutrients can generally be absorbed well by plants at a neutral pH. Soil microorganisms and fungi can grow well at a pH above 5.5, if it is less then their activity will be hampered. Low soil pH will cause plants to be unable to utilize the N, P, K and other nutrients they need. Low pH also causes the availability of toxic elements such as aluminum which always poisons plants and also binds phosphorus so that it cannot be absorbed by plants (Hardjowigeno 2007).

Base Saturation (KB) of Soil Base saturation is the ratio between the number of base cations exchanged with the CEC of the soil expressed in percent. The soil at the research location has a low base saturation value with a value of 7.54 to 20.12%. According to Bohn et al. (2009), the CEC value of soil is usually directly proportional to the CEC of the soil, because base saturation is a reflection of the high number of cations in the soil colloid complex. Addition of fertilizer at the time of planting is one of the causes of the increase in CEC at the research location. Apart from CEC, base saturation also determines soil fertility. Base saturation is a comparison between the number of base cations exchanged and the cation exchange capacity (CEC) of the soil expressed in percent. Base saturation at the research location is included in the medium and very high categories. The CEC value of soil is usually directly proportional to the base saturation (KB) of the soil, because base saturation is a reflection of the high number of cations in the soil colloid complex (Bohnet 2009).

Soil C-organic levels The results of determining organic C levels at the research location with low criteria were between 1.34-1.72%. This is thought to be due to the fact that in oil palm cultivation at the research location organic fertilizer is rarely added, only inorganic fertilizer is given. Low organic C content indirectly results in low oil palm production, because soil organic matter is one of the parameters that determines soil and plant productivity. The results of measuring the total phosphorus content of soil from each field in the planting year were very moderate in value23.43 – 46.50 ppmThis is also in line with the low organic material content at the research location. The P elements in the soil come from organic materials (manure and plant residues) in addition to phosphate minerals in the soil (apatite) (Sukisno et al., 2011). The land at the research location rarely had organic material added to it, which ultimately further impoverished the soil fertility. Phosphorus is an essential macro element second to nitrogen which is really needed by plants which functions in cell division, albumin formation, formation of flowers, fruit and seeds, accelerates ripening and strengthens stems so they don't collapse easily. The phosphorus element in soil comes from organic materials, soil minerals and artificial fertilizers (Anggreany, Muljono, and Sadono, 2016).

Cation exchange capacity (CEC) is an indicator of soil fertility. Soil at the research location has a CEC value between 9.48-10.72me/100 with low status. Based on this fact (Sufardi, Zaitun, and TF, 2017). stated that one thing that influences the CEC value of soil is the soil humus content and the type of clay minerals. Soils dominated by Al and Fe oxide-hydrate fractions usually have a low negative charge on the colloid surface (Sposito, 2010), so the CEC value of the soil is usually low. This is in line with the generally low organic material content in research locations. Naturally, the organic matter content of soil in tropical areas rapidly decreases and the decline reaches 30-60% within 10 years (Sufardi et al., 2017).

Evaluation of Soil Fertility Status

Evaluation of Soil Fertility Status According to in Husni (2016) Soil fertility is the ability of a soil to provide nutrients, in certain doses and balances to support the growth of a type of plant in an environment with other growth factors in favorable conditions. Sutedjo (2002) added that fertile soil has sufficient nutrient availability for plants and there are no limiting factors in the soil for plant growth. Soil fertility status is the condition of soil fertility at a certain place and time which is assessed based on standard criteria for soil fertility parameters according to technical instructions for evaluating soil fertility.

Soil Research Center, PPT Bogor 1995 (Susila, 2013). Based on the determination of soil fertility status based on technical instructions for evaluating soil fertility, the Soil Research Center, Bogor (PPT, 1995) shows that the assessment of the overall fertility status of oil palm plantation land is low fertility status. The low fertility status at the research location is caused by limiting factors, namely low soil organic C content and soil base saturation. The C-organic content (organic matter) of the soil greatly influences the soil's ability to maintain soil fertility and productivity through the activity of soil organisms. Many soil properties, both physical, chemical and biological, are directly and indirectly influenced by organic matter.

Organic matter also plays a role in the formation of soil aggregates. Organic additions absolutely must be given because soil organic matter plays a very important role in creating soil fertility (Tolaka, Wardah, and Rahmawati, 2013). Furthermore, soil base saturation is always associated as an indication of the fertility of a soil. The ease of releasing absorbed ions for plants depends on the degree of base saturation. S oil is very fertile if the base saturation is > 80%, if the base saturation is between 50-80% the soil fertility is moderate and the soil is not fertile if the base saturation is < 50%.

D. Conclusion

The level of soil fertility at the research location is included in the low category. The main limiting factor that causes low soil fertility is low soil organic matter content. To improve the soil fertility status at the research location for further planting, efforts are needed in the form of liming and fertilizing as well as adding organic material so that the availability of nutrient elements for plants is more adequate.

E. References

Anggreany, S., Muljono, P., & Sadono, D. (2016). Partisipasi petani dalam replanting kelapa sawit di Provinsi Jambi. *Jurnal Penyuluhan*, *12*(1).

Faizal, M. (2021). Chemical Properties of Soil at Different Ages of Palm Oil Planting in Kabun District, Rokan Hulu Regency. Thesis. Sultan Syarif Kasim Riau State Islamic University. Pekanbaru.

Ferry, M., Saad, A., & Farni, Y. (2024). Evaluation of Soil Fertility Status During the Replanting Period of Oil Palm Plantations on Mineral Soils in Jambi Province. Journal of Soil and Land Resources, 11(1), 17-27.

Harahap, F. S., Sitompul, R., Rauf, A., Harahap, D. E., & Walida, H. (2019). Land suitability evaluation for oil palm plantations (Elaeisguenensis jacq) on Sitellu Tali Urang Julu, Pakpak Bharat District. In *IOP Conference Series: Earth and Environmental Science* (Vol. 260, No. 1, p. 012116). IOP Publishing.

Harahap, F.S., Purba, J., & Rauf, A. (2021). The relationship between rainfall and groundwater availability patterns on oil palm (Elaeis guineensis Jacq) production in the highlands. Agriculture, 32(1), 37-42.

Hardjowigeno, S. (2007). Soil Science. Jakarta(ID): Pusaka Utama.

Husni, M.R., Sufhardi, S., dan Khalil, M. (2016). Evaluasi Status Kesuburan Tanah Pada Beberapa Jenis Tanah di Lahan Kekeringan Kabupaten Pidie Provinsi Aceh. JIM FP, Vol. 1, No 1: 147-154.

Kiki, L., A. Aspan & R. Hayati. (2022). Soil Fertility Status during the Replanting Period of Oil Palm Plantations in Kelompu Village, Kembayan District, Sanggau Regency. Equator Agricultural Science Journal. 11(1): 1-15.

Lubis, R.M., & Siregar, D. (2019). Evaluation of the soil fertility status of FP-UISU's oil palm plantations in Mancang village, Finish subdistrict, Langkat district. Agriland: Journal of Agricultural Sciences, 7(1), 22-26.

Merhan., E. Kesumawati and Sufardi. (2016). Growth and Yield of Several Varieties of Shallots (*Allium ascalonicum* L.). Floratec Journal, 11(2): 117-133.

Nugroho, P.A. (2012). Land Preparation Without Burning (Zero Burning) in Rejuvenating Rubber Plants in Commercial Plantations. Tropical Plantations and Land, 2(2), 39-50.

Nugroho, P.A (2019). Soil processing in preparing land for rubber plants. Perspectives, 17(2), 129-138.

PPT. (1995). Technical Instructions for Soil Fertility Evaluation. Technical Report No.14. Version 1.0.1. REP II Project, CSAR, Bogor.

Qishty, M.Y., Harahap, F.S., Sepriani, Y., & Adam, D.H. (2023). Study of Several Nutrient Elements in Replanting Land for Oil Palm Plants (*Elaeis Guineensis* Jacq.) in Bakaran Batu Village, Rantau Selatan District. Agro Estate Journal, 7(1), 54-60.

Rauf, A. and Harahap, F.S., (2019). Optimalisasi Lahan Pertanian Menggunakan Agen Biomassa. USU Press

Rinojati, N.D., Putra, R.C., Afifah, E., & Muliawansyah, I. (2016). Analysis of banana farming efficiency among rubber plants: case study at Cibungur Gardens, PTPN VIII West Java. Perkaretan News, 35(1), 37-48.

Rochmah, H.F., Suwarto, S., & Muliasari, A.A. (2020). Optimizing oil palm replanting land using an intercropping system for corn (*Zea mays* L) and peanuts (*Arachis hypogaea* L). Symmetric Journal, 10(1), 256-262

Sihaloho, N.F. (2019). Relationship between Soil Type and Production Level of Oil Palm (Elaeis guineensis Jacq.) at PT. Perkebunan Nusantara IV Laras Business Unit, Simalungun Regency, North Sumatra Province (Doctoral dissertation, Brawijaya University).

Stevanus, C.T., Saputra, J., & Wijaya, T. (2015). The role of microelements for rubber plants. Perkaretan News, 34(1), 11-18.

Sufardi, Darusman, Zaitun, S., Zakaria, Karmil, T.F. (2017). Chemical characteristics and status of soil fertility on some dryland areas of Aceh Besar District (Indonesia). Proceedings of the International Conference on Sustainable Agriculture. Yogyakarta 17-18, 2017.

Sufardi, Lukman, M., Muyassir. (2017). Cation Exchange in Several Types of Soil in Dry Land, Aceh Besar Regency, Aceh Province (Indonesia). Proceedings of the 2017 Unsyiah Postgraduate National Seminar (SNP), April 13, 2017, Banda Aceh, Indonesia.

Sukisno, K.S., Hindarto, Hasanuddin, Wicaksono, A.H. (2011). Mapping the Potential and Status of Soil Damage to Support Biomass Productivity in Lebong Regency. Soil Science Study Program, UNIB Faculty of Agriculture..

Surianto, S., Rauf, A., Sabrina, T., & Sutarta, E.S. (2015). Soil Characteristics and Comparison of Oil Palm (Elaeis Guineensis Jacq.) Production Using the Large Hole Planting Method and 2:1 Drainage Trenches on Spodosol Land in East Barito Regency, Central Kalimantan Province, Indonesia. Tropical Agriculture, 2(2), 157007.

Susila, Dharma K. (2013). Study of plant nutrients and evaluation of soil fertility on orange farming land in Cgila village, South Kuta sub-district. Agrotrope 3(2): 13-20. Sposito, G. 2010. The chemistry of soils. Oxford Univ. Press., London.

Sutedjo, Mulyani, M., (2002). Pupuk dan Cara Pemupukan. PT. Rineka Cipta. Jakarta.

Tolaka, W., Wardah, W., & Rahmawati, R. (2013). Sifat Fisik Tanah Pada Hutan Primer, Agroforestri dan Kebun Kakao di SUBDAS Wera Saluopa Desa Leboni Kecamatan Pamona Puselemba Kabupaten Poso. *Jurnal Warta Rimba*, *1*(1).

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The Critical Period of Hybrid Maize Varieties Against Weeds

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Abstract

The corn crop cannot be separated from the presence of weeds as crop disturbers. The presence of weeds often causes a decrease in yield and seed quality in corn crops. The yield reduction depends on the type of weed, density, duration of competition, and allelopathic compounds released by weeds. This study aimed to determine the age of the critical period of competition of hybrid varieties of corn plants against weeds, as well as corn grain production due to competition with weeds. The research was conducted in a group randomized design consisting of seven weed control treatments based on corn planting age and repeated three times. Observation parameters consisted of plant height, number of leaves, cob length, cob weight, and cob circumference. The observation results were analyzed followed by Least Significant Different (LSD) at 0.05 percent level. The test results showed that the critical period of competition of corn plants against weeds occurred at the age of 20-45 days after planting. The highest average corn cob weight occurred in the weed control treatment in the third week after planting which was 126.67 gr. There was a compatibility between corn plants and weeds in the form of competition for nutrients and growing space, which affects production

Keywords: critical period, hybrid corn NK 212, seed production, weed competition

A. Introduction

Maize (*Zea mays* L.) is one of the world's staple food sources of carbohydrates. In addition, maize is one of the most economical agricultural commodities and has the opportunity to be developed. Apart from being an important component of animal feed, maize is also a raw material for the food industry, chemical industry, and pharmaceutical industry. Maize production has been increasing every year. However, a decrease in maize crop production can occur with the presence of plant disruptors such as pests and plant diseases and the presence of weeds in the crop.

The presence of weeds in maize crops causes competition for nutrients. The ability of plants to compete with weeds is determined by weed species, weed density, time and duration of competition, cultivation methods and crop varieties and soil fertility levels (Pranasari, Nurhidayati, and Purwani, 2012; Saitama, Widaryanto, and Wicaksono, 2016). Weeds are able to compete strongly with cultivated plants to fulfil their needs for nutrients, water, sunlight, air and growing space. In addition to competition, weeds also act as pathogen hosts for maize plants

(Sudarma, Suada, Yuliadh, and Puspawati, 2012; Maqbool, Tanveer, Ata, and Ahmad, 2006; Hussain, Ismail, Sadikun, and Ibrahim, 2009), and produce allelopathies (Oyerinde, Otusanya, and Akpor, 2009; Zarwazi, Chozin, and Guntoro. 2016).

Weed competition in maize depends on four factors: the stage of plant growth, the number of weeds present, the degree of water and nutrient stress, and the weed species. Weed interference with maize crops is mainly a matter of competition for light, water and nutrients (Sudarma *et al*,. 2012). Maize is particularly sensitive to competition during the critical period between stages V_3 and V8 (3^{rd} and 8^{th} leaf stage of maize growth). Before the V_3 stage, weeds usually play an important role because weeds are larger than maize or the plant is under water stress. Maize needs a stadia period between V_3 and V_8 when weeds are less present. After V_8 stadia until ripening the maize plant usually has the ability to reduce sunlight reaching the weeds so that it is sufficient to suppress weeds (Lafitte, 1994).

According to Barus (2003) the presence of cultivation competition with weeds, it will result in several loss factors, among others; plant growth is inhibited so that the time to start production is longer, a decrease in the quantity and quality of production, and weeds will become a hotbed of pests and diseases and weed control requires expensive costs.

The losses caused by weeds to cultivated crops require studies related to competition between weeds and cultivated plants. Therefore, after gaining knowledge about the competition, efforts can be made to reduce the production losses of cultivated plants caused by weeds. Based on this, research will be conducted on the critical period of competition of hybrid maize varieties against weeds.

B. Methodology

1. Place and Time of Research

This research was conducted in Motolohu Village, Randangan District, Pohuwato Regency. The research lasted for 3 months from September to December 2021. The selection of this location was carried out by purposive sampling, with the consideration that the area is a place where most of the corn farming sector.

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, EM_4, 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 study used a group randomised design (RAK) consisting of 7 (seven) treatments, including: (M_0) : No weed control, (M_1) : Weed control carried out at the age of 7 days after planting (DAP), (M_2) : Weed control is carried out at plant age 21 DAP, (M_3) : Weed control is carried out at plant age 35 DAP, (M_4) : Weed control is carried out at the age of the plant 49 DAP, (M_5) : Weed control is carried out at plant age 63 DAP, and (M_6) : Weed control is carried out at the age of 77 DAP. Each treatment was repeated 3 (three) times so that there were 21 observation units.

4. Procedure

This research was carried out with the following steps:

a. Land Processing

Before planting, land clearing and tillage were carried out. This process aims to turn and loosen the soil so that plant growth becomes better. Furthermore, the land is plowed until the land (planting media) becomes loose. Then, beds measuring 2 m x 1 m were made, with a distance of ± 50 cm between beds. Each treatment was repeated 3 times so there were 21 plots.

b. Planting

Planting is the process of inserting seeds into the planting media holes. The planting distance to be used is 30 cm x 60 cm. The uniformity of the planting hole will determine the uniformity of the appearance of corn seedlings on the ground. Then the seeds are inserted into the hole as many as 2 seeds per hole.

c. Maintenance

Maintenance activities include watering, fertilizing and pest and disease control. Watering is done in the morning using a watering can. Fertilizers to be used are urea and ponska, fertilization will be done twice, the first fertilization will be done at the age of 10 DAP, and the second fertilization will be done at the age of 20 DAP. The dose to be used is 2 Kg ponska x 1 Kg urea then mixed until evenly distributed. Fertilizer is given by ditugal ± 5 - 10 cm, then covered with soil and the use of insecticides and fungicides. Pest management is carried out by mechanical means, namely collecting and killing them directly while disease control is carried out by applying Amistar Top fungicide when symptoms of disease attack such as spotting and blight appear.

d. Weed Control

Weed control will be done physically mechanically. The aim is to physically damage the body parts of the weeds so that their growth is inhibited or even killed.

e. Harvesting

Harvesting of NK212 hybrid corn varieties is done at the age of 101 DAP. Corn harvesting is done when it meets the criteria: the clobber is brown, the hair is black and dry and shiny.

5. Technique of Data Collection

Variables that will be observed in this study; 1). Plant height (cm), measured from the base of the stem to the growing point of the plant, which will be measured every week from 7 HST until the release of male flowers, 2). Number of leaves, counted every week since 7 DAP, 3). Length of cob (cm), measured from the base of the cob to the tip of the cob, 4). Cob weight (gr), weighed after the skin is peeled, and 5). Cob circumference (cm), measured in a circle right in the middle of the cob.

6. Data Analysis

The data obtained were analyzed by variance analysis using the linear model equation according to Mattjik, Sumertajaya, Wibawa, and Hadi. (2011) as follows:

$\boldsymbol{Y_{ij} = \mu + \tau_i + \rho_j + \varepsilon_{ij}}$; Description I = treatment and j = group

Description:

Y_{ij} = Observation value in treatment I group j

μ = Generalized mean

τ_i = Effect of variety

ρ_j = Effect of grouping or blocking

ε_{ij} = Effect of error that spreads normally $(0,\sigma^2)$.

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 Least Significant Different (LSD) at a level of 5% (Sastrosupadi, 2000).

C. Findings and Discussion

Observations include plant height (cm), number of leaflets (strands), cob length (cm), fruit diameter (cm), and fruit weight (gr). Observations of plant height and number of leaf blades were carried out weekly until the age of the plant was 7 weeks after planting (49 days), while cob length, fruit diameter, and fruit weight were carried out at the time of fruit harvesting.

A. Plant Height (cm)

Observations of plant height were made every week, namely when the plants were 1-7 weeks after planting. The average plant height increased every week as shown in Figure 1.

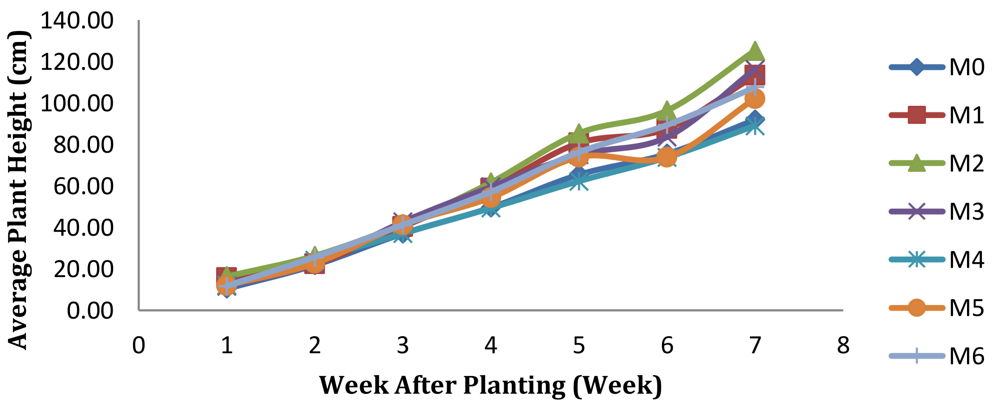

Figure 1. Graph of The Average Increase in Corn Plant Height (cm)

Figure 1 shows that there was an increase in plant height during observation in each treatment. Corn plants at the age of 1 week after planting showed that bed M_2 gave the highest average plant height (16.35 cm) compared to other beds. However, the results of the analysis of variance of the average plant height in the first week did not show significant differences. The M_5

treatment in the 6th week after planting decreased by about 0.16 cm, the decrease in plant height occurred due to pest attacks and weed competition with the main crop.

The average height of corn plants in this study was shorter than other corn plants. This occurred because during growth, plants were attacked by pests in the vegetative stage and there was competition between weeds and corn plants. In addition to pest attack and sugarbeet competition, this growing season the Gorontalo region experienced a long dry season. The critical period of corn plants competing with weeds occurs on days 20 and 45, then also the critical period of corn plants occurs on days 80 to 150 after planting (Sembodo 2010). When there is competition between weeds and cultivated plants, the weeds will release allelopathic substances. Allelopathic substances are chemicals released by weeds against the main crop that cause the morphology of the leaves to be filled with brown and white spots, stunted plant height, and abnormal root length.

B. Number of Leaves

Observations of the number of leaves were made at the age of 1-7 weeks after planting. The graph of the increase in the number of leaves in each treatment can be seen in Figure 2.

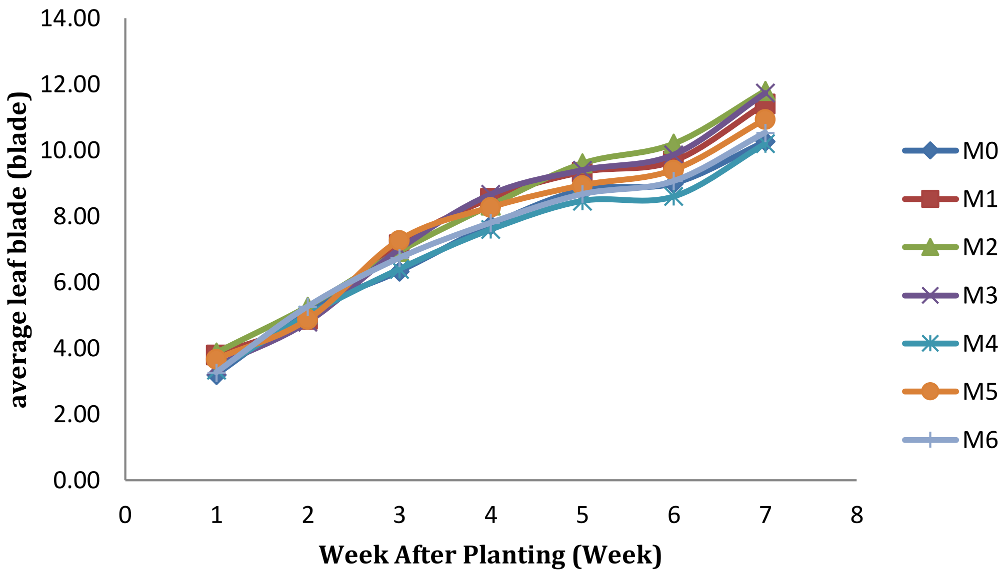

Figure 2: Graph of The Average Number of Leaves (Leaf Blade)

Figure 2 shows that the average number of leaves at 1 MST observation was highest in the M_2 treatment (3.87 leaves) and showed significant differences in each treatment. The average number of leaves in each treatment showed an increase every week, but the observation of 3-7 weeks after planting did not show a significant difference. This may occur due to competition between corn plants and weeds. The dominant weed in corn plants is *Cyperus rotundus*. This type of weed is intraspecies which affects the growth of corn plants (Padang, Purba, and Bayu. 2017). In addition to weed competition with corn plants, salinity also affects the rate of leaf growth by reducing the rate of cell enlargement in leaves so that growth and changes in plant structure are smaller (Pranasari et al., 2012).

The results of the analysis of variance showed that the treatment at 1-2 weeks after planting had a significant effect on the leaf blade of corn plants, but the results of the BNT (Least Significant Difference) test did not show significant differences. The results of the analysis of variance showed that the treatment of weed control at 1-2 weeks after planting was not significantly different on the number of leaves of corn plants.

C. Cob Weight (gr)

Cob weight was observed at the time of harvesting. The average weight of corn cobs in each treatment can be seen in Figure 3.

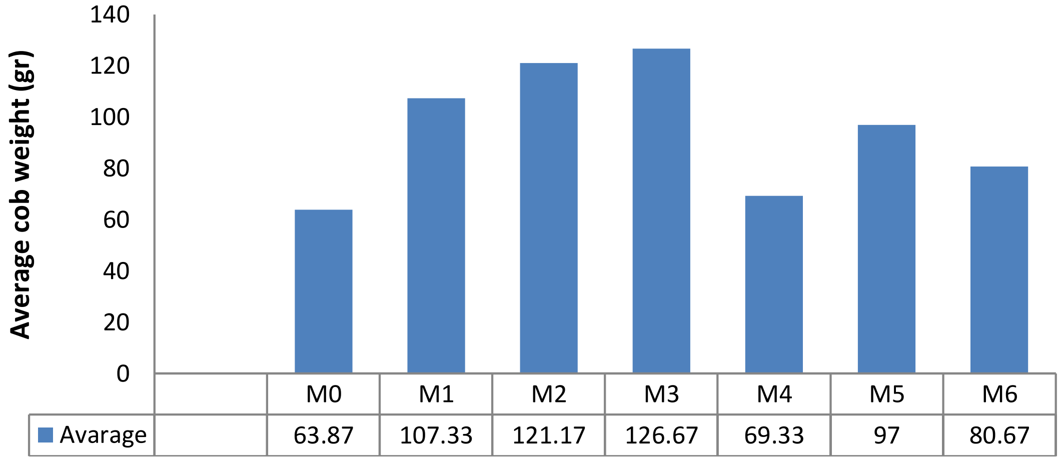

Figure 3. The Average Weight of Corn Cobs

Figure 3 shows the average cob weight of 95.15 g. M_3 treatment showed the highest average cob weight (126.67 g), while the lowest average weight occurred in M_0 (63.87 g). This is due to competition between weeds and the main crop. This is in line with the research of Pranasari *et al*. (2012) who reported that the decrease in photosynthesis influenced by drought conditions caused by salinity with decreased turgor pressure causes closed stomata resulting in the supply of CO_2 for photosynthesis is reduced, so that the rate of photosynthesis decreases and photosynthate decreases. Photosynthate distributed throughout the body also decreases, eventually affecting the dry weight of the plant.

D. Cob Length (cm)

The observation of cob length showed different averages based on weed control treatment. The diagram of the average cob length of each treatment can be seen in Figure 4.

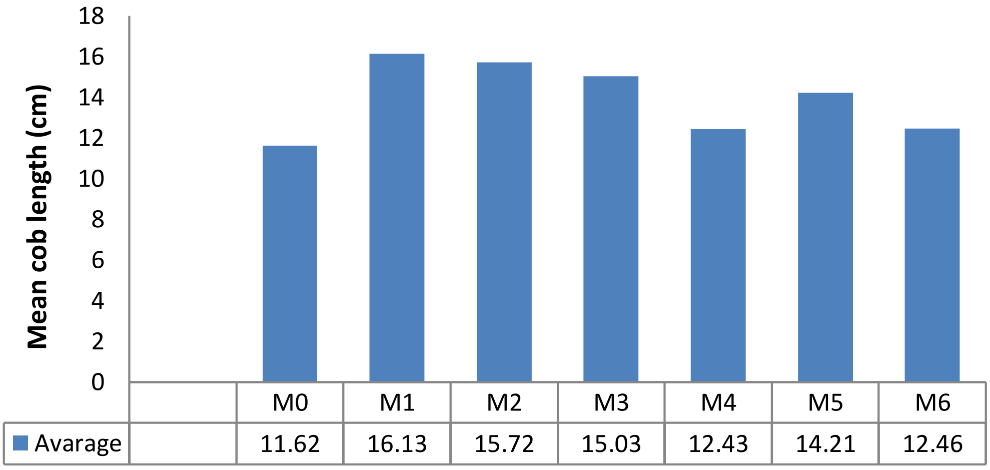

Figure 4. Diagram of Cob Length (cm) of Corn Hybrid Variety NK 212

Figure 4 shows that the highest average cob length occurred in the M_1 treatment (16.13 cm) while the lowest occurred in the M_0 treatment (11.62 cm). This is thought to be because the first week of control provides an opportunity for plants to develop well and get the right light for photosynthesis compared to other treatments. So that the photosynthate produced is greater which supports leaf growth and translocation of photosynthate results in more seeds. This is in accordance with the opinion of Bilman (2001), that the rate of net assimilation depends on the level of sunlight to the plant. The distribution of solar radiation on the canopy determines the rate of dry matter production per unit leaf area during vegetative growth. The presence of mutual shading between corn plants and weeds will reduce the net assimilation rate.

E. Cob Circumference (cm)

Cob circumference observations were made at harvest time by separating the corn cobs from the cob. The diagram of cob circumference for each treatment is presented in Figure 5.

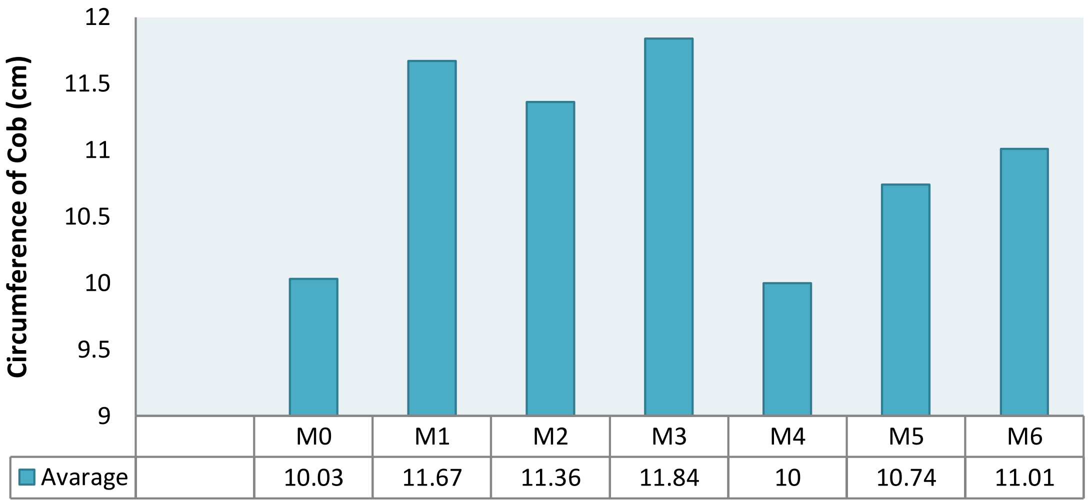

Figure 5. Diagram of Cob Circumference (cm) of Maize Hybrid Variety NK 212

Figure 5 shows that the highest average cob circumference occurred in M_3 at 11.84 cm, and the lowest in M_4 at 10.00 cm. The highest cob circumference in M_3 is possible because the competition between corn plants and weeds occurs at the age of 6 weeks after planting, this is in line with the research of Suryaningsih, Joni, and Darmadi. (2015) which states that when there is competition between weeds and cultivated plants, the weeds will release allelopathic substances, seen in the observation of corn at the age of 6 weeks after planting, due to the addition of weeds so that allelopathic substances are also increasing. Allelopathic substances cause stunted corn marked by incomplete corn growth, including loss of leaf green substance (chlorosis) marked by yellowish leaves and tissue death (necrosis) marked by brown leaves. This affects the decrease in photosynthesis so that photosynthate is reduced and distribution throughout the body also decreases. Finally, it will affect the dry weight of the plant and the circumference of the cob (Sudarma *et al*., 2012).

F. Weed Identification

Based on observations on the experimental field, the identification of several

The types of weeds found in corn crops are *Cyperus rotundus* weeds which are classified as weeds while *Amaranthus spinosus*, *Phylanthus urinaria*, Linn., *Physalis peruviana*, Linn., *Acalypha indica* L, and *Portulaca oleracea* are classified as broadleaf. Meanwhile, other weeds such as spinach thorns, meniran, ciplukan, cat-whiskers, sikejut leaves, purslane, and purslane are the most common broadleaf weeds found in corn fields. The following are the types of weeds that have been identified in maize fields (Figure 6).

Figure 6. Species Characteristics of Various Weeds that Compete with Maize Crops; a). Thorn spinach (*A. spinosus*), b). Teki (*C. rotundus*), c). Meniran (*P. urinaria*, Linn.), d). Ceplukan plant (*P. angulata* L.), e). Kucing-kucingan (*A. indica* L.), f). Purslane (*P. oleracea*).

a. *Amaranthus spinosus* (Amaranthaceae)

Thorn spinach is included in the Kingdom Plantae, Division Magnoliophyta, Class Magnoliopsida, Order Caryophyllales, Family Amaranthaceae, Genus Amaranthus, Species *Amaranthus spinosus* L. (Barus, 2003). Spinach thorns include plants that have soft or wet stems, the height can reach 1 metre. A distinctive sign of spinach duri plant is on the stem, precisely at the base of the petiole there are thorns, so people know as spinach duri. Spinach thorns include wild plants among bushes, roadsides or empty land that is not maintained. This plant is easy to grow in lowlands up to an altitude of 1,400 m above sea level. Thorn spinach is easy to grow with its small seeds (Barus. 2003; Pujiwati. 2017).

b. *Cyperus rotundus* (Cyperacea)

Teki is included in the Divisiono Spertophyta, Class Monokotiledoneae, Order Cyperales, Family Cyperacea, Genus Cyperus, Species *Cyperus rotundus* (Moenandir, 1988). Weeds of the teki group have stems that are generally triangular, sometimes also round and usually not hollow. Leaves arranged in three rows, do not have leaf tongues (ligula). Mother stalk wreaths are not bookish. Flowers are often in spikelets (spica), usually protected by a single protective leaf. The fruit does not open. This weed is quite fierce and widely spread (Moenandir, 1988).

This weed is almost always around cultivated plants, because it has a high ability to adapt to various soil types. This weed is a perennial weed with in-ground parts consisting of roots and tubers. Tubers first form at three weeks after initial growth. The bulbs form slender roots and bulbs again, and so on (1 m2 10 cm deep = 1,600). Tubers are not resistant to drying out, and after 14 days in the sun, they lose their growth capacity. The stem is triangular. Leaves at the base of the stem consist of 4-10 leaflets, the midrib is covered with soil. The leaflets are striped and green and shiny. Flowers have three stamens, bright yellow anthers, and a brown three-pronged stalk. Teki can grow widely especially in dry tropical areas, ranging in altitude from 1-1000 m above sea level, and rainfall between 1500-4000 mm per year (Moenandir, 1988).

c. *Phylanthus urinaria*, Linn. (Phyllantthaceae)

Meniran is included in the Kingdom Plantae, Division Magnoliophyta, Class Magnoliopsida, Order Euphorbiales, Family Phyllantthaceae, Genus Phyllanthus, Species *Phylanthus urinaria*, Linn. Meniran is a common weed that grows wild in humid and rocky places such as roadsides, ditches and abandoned lands. The plant grows upright as high as 30-50 cm. Meniran is a seasonal plant that grows a lot at the beginning of the rainy season (Sukma and Yakub, 2002).

This type of weed is herbaceous, upright, annual, 0.5-1 m, stem: One-level branching, green, glabrous, Leaves: Single, stalked, ovate, elongated round, obtuse rounded base, pointed obtuse rounded tip, bright green top, 0.5-2 cm x 0.25- 0.5 cm, Male flowers: Located in leaf axils of base branches 1-4,2-3 flowers, peduncle 0.5-1 mm, jewellery lobes inverted ovate, bright red, Female flowers: Located in leaf axils of terminal branches, pedicels 0.75-1 mm, jewellery lobes rounded-tiered, green, 125-1.5 mm, Stamens: Anthers opening horizontally, Pistil: Single, 3-9 chambers, Fruit: Smooth, diameter 2-2.5 mm, stalk 1.5-2 mm, thickened at the end (Sukma and Yakub, 2002).

d. *Physalis angulata* L. (Tubiflorae)

Ceplukan weed has a complete classification as follows Divisiono Spermatophyta, Class Dicotyledoneae, Family Tubiflorae (Solanales, Personatae), Order Solanaceae, Genus Physalis, Species *Physalis angulata* L. (Sembodo, 2010).

Ceplukan is an annual weed, erect, often strongly branched, 0.1 to 1.00 m tall. In Java this plant commonly grows from lowlands to approximately 1550 masl (especially below 1200 m) in fields that are not watered, lightly shaded or irradiated as weeds in fields and gardens, in bushes, on roadsides. Stem sharply ribbed, hollow. Leaf blade elongated ovate lanceolate, with pointed tip, flat-edged or not, flower stalk erect, petals 5-slit, corolla broad bell-shaped light yellow with green base. The fruit is elongated round, when ripe yellow, edible (Sembodo, 2010).

e. *Acalypha indica* L. (Euphorbiaceae)

Cat-weed is included in the Kingdom Plantae, Division Spermatophytes, Class Dicotyledoneae, Order Euphorbiales, Family Euphorbiaceae, Genus Acalypha, Species *Acalypha indica* Linn. (Setiawan, Utari, and Oktarini. 2005).

Cats are annual, erect, branched weeds with rough longitudinal lines, and fine hair. In addition, this plant has single leaves, long-stemmed, and scattered. The leaf blade is ovate to lanceolate, thin, with a pointed tip and base, serrated edges and green in colour. The plant also has compound, unisexual flowers that emerge from the leaf axils, are small, and in a spikelet-shaped arrangement. The fruit is square, round and black. Seeds are long round, brown in colour. The root is taproot, dirty white in colour (Setiawan *et al*., 2005).

f. *Portulaca oleracea* (Portulaceae)

Purslane is included in the Division of Spermatophyta, Class Monocotyledoneae, Order Portulacales, Family Portulaceae, Genus Portulaca, Species *Portulaca oleracea*. Purslane is a seasonal weed with propagation in the form of seeds, and is associated with 45 types of crops (Moenandir, 1993). This type of weed is a succulent, fleshy stem stretched and reddish in colour, and round in shape. Length ± 10-50 cm, where old internodes are hairless. Leaves are partial, scattered, opposite, short-stemmed, leaf tips bend inward, rounded or blunt, box-shaped fruit and many seeds, oval seeds shiny black colour, the surface is covered with slightly wrinkled skin (Moenandir, 1993; Holm, Plucknett, Pancho, and Herberger. 1977; Andalusia 2018).

This weed at the beginning of its growth is slow and becomes fast after 15 days and at the end of the 4th week 10 leaves are formed. Flowers are formed throughout the season in the tropics (life cycle 3-5 months) under shaded conditions will grow stretched and upright, and form flowers. The optimum temperature required is 15-35o C where flowers and seeds are produced very well. Conversely, under high light intensity purslane can wilt (Moenandir, 1993).

D. Conclusion

The critical period of competition of maize plants against weeds at the age of 20 - 45 days after planting (DAP) and had no significant effect on all observed variables, namely plant height, number of leaves, cob length, cob circumference and cob weight. Maize plant growth is stunted by the presence of weeds, there is a struggle for nutrients, light, water, sunlight, growing space between weeds and the main crop so that yield and production decrease.

E. References

Abrar, H., Athar, N., Imran, A., & Masood, A. (2009). Effect of weed competition periods on the growth and yield of black seed (Nigella sativa L.). Pakistan Journal of Weed Science Research, 15(1), 71-81.

Andalusia, S. N. (2018). Inventarisasi Gulma Pada Tanaman Jagung (*Zea Mays* L.) Di Dataran Rendah Dan Dataran Tinggi (*Doctoral dissertation*, Universitas Brawijaya).

Barus, E. (2003). Pengendalian gulma di perkebunan, efektivitas dan efisiensi aplikasi herbisida. Kanisius.

Bilman, W. S. (2001). Analisis pertumbuhan tanaman jagung manis (*Zea mays* saccharata), pergeseran komposisi gulma pada beberapa jarak tanam. *Jurnal Ilmu-Ilmu Pertanian Indonesia*, 3(1), 25-30..

Holm, L. G., Plucknett, D. L., Pancho, J. V., & Herberger, J. P. (1977). *The world's worst weeds. Distribution and biology*. University Press of Hawaii.

Hussain, K., Ismail, Z., Sadikun, A., & Ibrahim, P. (2009). Evaluation of metabolic changes in fruit of Piper Sarmentosum in various seasons by metabolomics using Fourier Transform Infrared (FTIR) spectroscopy. Int J Pharm Clin Res, 1(2), 68-71.

Lafitte, H. R. (1994). *Identifying production problems in tropical maize: a field guide*. Cimmyt.

Maqbool, M. M., Tanveer, A., Ata, Z., & Ahmad, R. (2006). Growth and yield of maize (*Zea mays* L.) as affected by row spacing and weed competition durations. *Pakistan Journal of Botany*, 38(4), 1227.

Moenandir, J. (1993). *Pengantar ilmu dan pengendalian gulma*. Rajawali Pers, Jakarta.

Oyerinde, R. O., Otusanya, O. O., & Akpor, O. B. (2009). Allelopathic effect of Tithonia diversifolia on the germination, growth and chlorophyll contents of maize (*Zea mays* L.). *Scientific Research and Essay*, 4(12), 1553-1558.

Padang, W. J., Purba, E., & Bayu, E. S. (2017). Periode Kritis Pengendalian Gulma Pada Tanaman jagung (*Zea mays* L.): Critical periode of weed control in *Zea mays* L. *JURNAL ONLINE AGROTEKNOLOGI*, 5(2), 409-414.

Pranasari, R. A., Nurhidayati, T., & Purwani, K. I. (2012). Persaingan tanaman jagung (*Zea mays*) dan rumput teki (*Cyperus rotundus*) pada pengaruh cekaman garam (NaCl). *Jurnal Sains dan Seni ITS*, 1(1), E54-E57.

Pujiwati, I. (2017). *Pengantar Ilmu Gulma*.

Saitama, A., Widaryanto, E., & Wicaksono, K. P. (2016). Komposisi vegetasi gulma pada tanaman tebu keprasan lahan kering di dataran rendah dan tinggi the composition of weeds vegetation in ratoon crops dryland at low and high area. *Jurnal Produksi Tanaman*, 4(5), 406-415.

Sembodo, D.R.J. (2010). *Gulma dan Pengolahannya*. Penerbit Graha Ilmu. Edisi Pertama. Yogyakarta.

Setiawan, A. N., Utari, L., & Oktarini, M. (2005). Pengaruh Macam dan Ketebalan Mulsa Organik Terhadap Populasi Gulma dan Hasil Melon (Cucumis melo L.). Planta Tropika, 1(1), 11-15.

Sudarma, I. M., Suada, I. K., Yuliadh, K. A., & Puspawati, N. M. (2012). Hubungan Antara Keragaman Gulma Dengan Penyakit Bulai Pada Jagung (*Zea mays* L.) Stadium Pertumbuhan Vegetatif. *Agrotrop*, 2(1), 91-99.

Sukma dan Yakub, (2002). *Gulma dan Teknik Pengendaliannya*. Raja Grafindo Persada. Jakarta.

Suryaningsih, Joni M, dan Darmadi AAK. (2015). Inventarisasi Gulma Pada Tanaman Jagung (*Zea Mays* L.) Di Lahan Sawah Kelurahan Padang Galak, Denpasar Timur, Kodya Denpasar, Provinsi Bali. *Jurnal Simbiosis*. No. 1(1): 1-8. ISSN: 2337-7224.

Zarwazi LM, Chozin MA, dan Guntoro D. (2016). Potential of Weed Problem on Three Paddy Cultivation Systems. *J. Agron. Indonesia* 44 (2) : 147 - 153 (2016).

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Estimation Genetic Parameter and Selection of Yield Components in Two Population F2 Bird Pepper (*Capsicum frutescens* L)

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Abstract

Bird pepper *(Capsicum frutescens* L.) is one of the main commodities of horticulture in Indonesia. The process of assembling bird pepper was done by selected from the segregation population. This study aimed to obtain selected plant candidates in the F2 population by index selection on the character of the yield components on bird pepper. The results of this study showed that in population F2-285290 the correlation value showed a very significant significance for all characters on the yield component character while in the population F2-321290 only fruit thickness and fruit stalk length were not significantly correlated. The broad mean heritability value in the high category of the two populations were in fruit weight, fruit length, fruit diameter and fruit stalk length. The results of index selection in the population F2-285290 with a selection intensity 10 percent obtained by selected plants as many as 20 best plants, namely plants no 16, 30, 31, 36, 43, 50, 65, 80, 82, 102, 123, 134, 153, 190, 216, 244, 245, 263, 273 and 290 while in populations F2-321290 selected plants are no. 18, 21, 23, 30, 32, 37, 42, 154, 155, 162, 165, 167, 180, 185, 199, 220, 221, 230, 228 and 229

Keywords: bird pepper, character, correlation, heritability, index selection

A. Introduction

Bird pepper (*Capsicum frutescens* L.) is one of the main horticultural commodities in Indonesia and is one of the types of vegetables that has the potential to be developed. Productivity of bird pepper in Indonesia in 2018 around 6.69 tons ha1 (BPS and Director General of Horti 2018), even though the potential can reach 12-20 tons ha-1 (Sujinto and Dianawati, 2015). The productivity of bird pepper in Indonesia was still low due to many factors, one of which were that farmers have not used many high yielding superior varieties.

The success of the breeding program is determined by the accuracy in applying selection method by utilizing genetic information and heritability. Jalata, Z.A., Ayana, H., Zeleke (2011) said that characters whih not influenced by the environment usually have high heritability. Selection is one of the important stages in plant breeding activities. Selection can be interpreted as the process of selecting individuals or groups of plants from mixed populations. Selection according to Barmawi (2007) is one of the activities in plant breeding programs to obtain superior varieties.

Selection is best done in population F2 because this population was the peak with maximum segregation. Selection can be done on qualitative and quantitative characters. Many quantitative characters are related to economic value, one of which is yield component. Yunandra (2016) stated that the selection on the character of yield will be more effective if it was followed by selection on the character of the other yield components. This is due to the productivity of chili was strongly influenced by the character of the yield components such as fruit weight, fruit diameter, fruit length, fruit thickness and number of fruit so that it needs to be selected on several characters at once.

Selection methods on several characters at once can be done by several methods. One method that can be done is the selection index method. According to Syukur, M., Sujiprihati, S., Yunianti, R. (2015) selection can be done on one character or several characters. Selection of several characters was divided into three types, namely sequential selection, simultaneous selection, and index selection. In this study the selection method used was index selection. According to Poespodarsono (1988) index selection was done through several characters that are considered important based on economic value, correlation genotypes and phenotypes between characters and heritability. The characters chosen are given a weighting index whose size depends on the more important nature. The highest indexed individual or population chosen to be passed on to the next generation of selection. Index selection was considered more efficient than sequential and simultaneous selection.

This study aim to obtain selected plants in the F2 population by utilizing weighted index selection on the character of the yield component.

B. Methodology

1. Research Methods

The trial was conducted from September 2016 to April 2017. The seeding was carried out at the Laboratory of Genetic and Plant Breeding, Department of Agronomy and Horticulture, IPB. Planting in the field was carried out at the Alam Sinarsari Experimental Station with an altitude of 202 m above sea level.

The genetic material used in this experiment are two populations F2-285290 and F2-321290. Each F2 population was planted with 300 plants. Population P1 (IPB C285), P1 (IPB C321), P2 (IPBC290), F1 (IPB C285 x IPB C290) and F1 (IPB C321 x IPB C290) each planted 40 plants.

The experimental activity begins with seedling of seeds P1, P2 and F2 at the Laboratory of Genetic and Plant Breeding, Department of Agronomy and Horticulture, IPB. Seeds were sown as much as one seed per hole in a tray containing seedling media. Maintenance includes watering, fertilizing every week and controlling plant pest organisms. The planting activity was carried out at the Alam Sinarsari Experimental Station. Planting is carried out in the field with a spacing 50 cm x 50 cm, with a system of planting two rows of plants. The beds are covered with black silver plastic mulch (MPHP). Plants were planted if they are ± 5-6 weeks old, with strong seedling growth characteristics, leafy 4-5 strands, green leaf color and not affected by pests. The maintenance carried out is watering, fertilizing with NPK solution (16:16:16) with a concentration of 10 g L-1 and leaf fertilizer 5 g L-1 carried out once a week. The dosage of each plant is given about 250 ml of fertilizer solution. Pest and disease control uses insecticides, fungicides and akaricide which are applied if needed. Water shoots are carried out so that plants can grow optimally and weed control was carried out manually.

The characters observed were: flowered time (DAP), harvested time (DAP), fruit weight (g), fruit diameter (mm), flesh thickness (mm), fruit length (cm), fruit stalk length (cm), number of fruits (fruit) and yield (g tan-1).

2. Data Analysis

Data analysis used in the study included:

1. Correlation between characters was analyzed using the Minitab 14 program, calculation of the correlation coefficient was carried out on quantitative data to calculate the closeness of the relationship between character variables with the Pearson method.
2. The estimated value of heritability was calculated using the calculation of derivative varians (Syukur *et al*., 2015) as follows:

〖h^2〗 _bs=(V_F2-[(V_F1+V_P1+V_P2)/3])/V_F2

Description: h2bs: broad sense heritabillity, VF1: population varians F1, VF2: varians population F2, VP1: population varians P1, VP2: population varians P2. Value of broad sense heritability category high if 〖h^2〗 _bs ≥ 50%, medium 20% ≤ 〖h^2〗 _bs≤ 50%, loe 〖h^2〗 _(bs)< 20%

3. Selection index. Selection was done based on weighted selection index by looking at the correlation between the character yield component to yield with the formula referring to Falconer (1978):

$$I = Z1 + Z2 + 2Z3 + 3Z4, \text{ where } Zn = (x - \bar{x}) / (\sqrt{\sigma 2})$$

Information:
I = Selection Index Value
Z1 = the standardized phenotype fruit weight
Z2 = the standardized phenotype value of fruit length
Z3 = the standardized phenotype value number of fruit
Z4 = the standardized phenotype yield
x = variable mean of a genotype
$\bar{x}$ = average variable of a total of all genotypes
$\sigma 2$ = varians

The weightings used are: weight per fruit (+1), fruit length (+1), number of fruits (+2), and fruit weight per plant (+3). The selection results are based on the highest selection index and taken 10% (20 selected plants) from each population

C. Result

Table 1 shows the correlation value analysis of other characters for yield in two bird pepper populations. Poespodarsono (1988) stated that correlation analysis was used to see the closeness of the relationship between the character of one anothers. Desita (2014) stated that there are two correlation coefficient values, namely negative and positive. Negative correlation coefficient means that the higher the value of a character, the other character values will be lower and vice versa. Positive correlation coefficient value means that the higher the value of a character, the higher the value of other characters. The characters that have positive and very significant correlations for all population characters in population F2-285290 while in populations F2-321290 all the characters that have a positive correlation and are very significant except for fruit thickness and fruit stalk length have no significant effect. The results of the research by Yunandra (2016) and Sidiq, A.R.F., Syukur, M., dan Marwiyah, S (2017) showed that the character number of fruits, fruit weight and fruit length there was positive and significant correlation with the yield character.

Table 1 Pearson Correlation of character yield components to yield in two bird pepper populations

Character	Correlation Coefficient			
	F2-285290		F2-321290	
fruit weight (g)	0.264	**	0.325	**
fruit length (cm)	0.234	**	0.357	**
fruit diameter (mm)	0.203	**	0.266	**
flesh thickness (mm)	0.212	**	0.172	ns
fruit length (cm)	0.222	**	0.087	ns
flowered time (DAP)	-0.337	**	-0.476	**
harvested time (DAP)	-0.371	**	-0.479	**
number of fruit	0.789	**	0.870	**

Selection in order to increase yield can be done based on several characters. Selection based on several characters can be more effective than just based on yield. According to Sutjahjo, S.H., Rustikawati, A.W., Sandhi, S.G (2007) said that selection becomes effective if character selection into index selection was based on the value of heritability and correlation of the character to fruit weight per plant.Character fruit weight, fruit length and number of fruits were chosen as the basic characters in determining the genotype which will be continued to the next generation. The selection of these three characters as the basis for index selection was due to having a better correlation coefficient compared to other characters. Based on heritability and correlation values, we selected characters fruit weight, fruit length, number of fruits and yield which were the characteristics of index selection. The same thing was done in Yunandra (2016) studied for these characters which were used as the basis for selection index .

Weighting was done differently between the selected characters. The weighting value used was the same as the weighting value in the study conducted by Yunandra, Syukur, M., Maharijaya, A. (2017), the yield has the highest weighting, given a score 3. number of fruits was given a score 2 because this character has the highest correlation compared to characters others. Fruit length and fruit weight are each given a score 1.

Table 2 Index selection values of fruit weight, fruit length, number of fruits and yield population of bird pepper population F2321290

Genotype	fruit weight	fruit length	number of fruits	yield	Index selection
F2321290-42	-0.28	-0.59	8.89	12.61	20.64
F2321290-220	-0.66	-0.16	8.41	11.92	19.51
F2321290-199	-0.36	-0.89	7.05	9.96	15.76
F2321290-23	1.77	1.87	4.67	6.54	14.85
F2321290-228	-0.28	0.07	4.78	6.70	11.27
F2321290-37	1.09	2.36	3.16	4.38	10.99
F2321290-162	1.23	1.38	2.97	4.09	9.67
F2321290-229	2.19	1.28	2.57	3.52	9.56
F2321290-155	-1.17	-0.69	4.61	6.46	9.21
F2321290-21	-0.06	0.16	3.70	5.15	8.96
F2321290-18	-0.10	0.03	3.70	5.15	8.79
F2321290-154	1.09	1.05	2.77	3.81	8.72
F2321290-185	0.31	-0.79	3.82	5.32	8.66
F2321290-30	1.35	2.59	1.95	2.63	8.52
F2321290-221	1.60	1.15	2.34	3.20	8.28
F2321290-165	1.31	0.62	2.57	3.52	8.02
F2321290-32	-0.45	0.16	3.36	4.66	7.74
F2321290-230	0.64	1.25	2.46	3.36	7.70
F2321290-180	0.14	0.56	2.94	4.05	7.69
F2321290-167	1.21	1.15	2.14	2.91	7.42

The selection intensity used in this study was 10%, its mean that from 200 F2 plants, 20 F2 individuals will be selected to be followed to F3 generation. The results of the selection based on selection index were 20 genotypes in the population F2-321290 can be seen in Table 2. Genotypes F2321290-42 was genotypes that have the highest index value, which is equal to 20.64. Genotypes F3321290-220, F2321290-119, F2321290-23, F2321290-228 and F2321290-37 are genotypes that have a fairly high index value with an index value of more than 10 (Table 2).

The results of the selection based on the selection index were 20 genotypes in the population F2-285290 can be seen in Table 3. Genotypes F2285290-82 was genotypes that have the highest index value, which is equal to 22.11. Genotypes F2285290-50, F2285290-31, F2285290-16, F2285290-245, F2285290-190, F2285290-273, F2285290-273, F2285290-216, F2285290-153, F2285290-153, F2285290-65 and F2285290-30 are genotypes that have the selection index value was high with an index value of more than 10 (Table 3)

Table 3 Index selection values of fruit weight, fruit length, number of fruits and yield population of bird pepper population F2285290

Genotype	fruit weight	fruit length	number of fruits	yield	Index selection
F2285290-82	1.62	2.24	6.15	12.10	22.11
F2285290-50	0.87	1.49	7.23	10.39	19.97
F2285290-31	-0.68	-1.00	8.56	7.51	14.39
F2285290-80	0.33	0.82	4.39	7.20	12.74
F2285290-16	0.07	0.11	3.87	7.84	11.89
F2285290-245	0.63	1.00	5.47	4.78	11.87
F2285290-190	-0.01	0.24	4.02	7.54	11.80
F2285290-273	0.08	0.69	3.53	7.25	11.54

F2285290-216	0.22	0.42	3.39	7.01	11.05
F2285290-153	0.23	0.78	2.95	6.99	10.94
F2285290-65	2.20	-0.73	2.27	7.10	10.84
F2285290-30	0.21	-0.96	3.95	6.86	10.05
F2285290-290	3.33	3.49	-0.20	2.31	8.93
F2285290-244	-0.96	-1.27	5.05	5.97	8.79
F2285290-134	0.06	-0.20	3.39	5.49	8.75
F2285290-123	2.47	0.96	1.82	3.24	8.48
F2285290-263	1.09	2.73	0.88	3.70	8.39
F2285290-102	0.75	0.11	2.84	4.65	8.35
F2285290-36	0.42	-1.22	2.76	5.91	7.87
F2285290-43	-0.82	-0.02	3.47	5.14	7.77

The component values of variability and heritability of populations F2-285290 was presented in Table 4. The value of heritability of broad sense for quantitative characters ranges from 14.21% - 71.25. Characters that have broad heritability values included in the high category were fruit weight (FW), fruit length (FL), fruit diameter (FD) and fruit stalk length (FSL). Characteri of flesh thickness (FT), number of fruits (NF), yield (Y) and harvested time (HT) were included in the medium category. Flowered time (FLT) characters wa in the low category.

High heritability indicate that these characters was more influenced by genetic factors than environmental factors so that characters who have high heritability illustrate that these characters are easily inherited (Widyawati, W., Izmi, Y., Respatijarti, 2014). A.D., Dewi, W., Qosim, W.A., Rahardja, M., Rostini, N., Setiamihardja, R (2006) and Zen (1995) said that characters with high heritability predictions can be selected in the early generations because these characters was easily inherited to their offspring, whereas if the estimated heritability was low then the selection is carried out in the next generation.

Some studies on chilli showed that the predicted high mean broad heritability was found in flowered time characters (Lestari *et al.*, 2006), yield, number of fruits per plant, fruit length (Syukur, M., Sujiprihati, S., Yunianti, R., Undang 2010); fruit weight, fruit length, fruit diameter, fruit thickness, number of fruitt, yield, flowered time, harvested time, (Widyawati, 2014); flowered time (Hastuti, N.M.D., Yulianah, I., dan Saptadi, D., 2016); harvested time (Arif, B.A., Sujiprihati, S., Syukur, M. 2012); fruit length (Dewi, A.A., Ainurrasjid, Saptadi, D., 2016); fruit weight, fruit diameter, yield, harvested time, number of fruits (Qosim, W.A., Rachmadi, M., Hamdani, J.S., Nuri, I, 2013); number of fruits, fruit length, yield (Meena, M.L., Kumar, N., Meena, J.K., Rai, T., 2016); number of fruits, yield, fruit length and fruit weight (Farhad, M., Hasanuzzaman, M., Biswa, S.B.J., Azad, A.K., Arifuzzaman, M., 2008, Chakrabarty and Islam 2017) fruit weight, fruit length and fruit thickness (Hakim, A., Syukur, M., Wahyu, Y., 2019). Heritability values for fruit diameter characters (FD) are included in the medium category.

Table 4 Components of variability and heritability in the character of yield components the bird pepper population of IPB 285x IPB C290

population	fruit weight	fruit length	fruit diameter	fruit thickness	fruit stalk length	number of fruit	yield	flowered time	harvested time
varians P1	0.08	0.09	1.19	0.04	0.12	4938.58	3353.38	15.90	25.92
varians P2	0.14	0.09	0.92	0.02	0.11	1565.00	4585.89	15.42	29.22
varians F1	0.05	0.08	0.25	0.01	0.13	2801.47	6901.60	12.09	28.00
varians F2	0.30	0.21	2.16	0.04	0.24	5808.98	8913.74	16.86	42.30
varians E	0.09	0.09	0.79	0.02	0.12	3101.68	4946.96	14.47	27.71
varians G	0.22	0.12	1.37	0.02	0.12	2707.30	3966.78	2.40	14.58
h^2bs	71.25	58.64	63.48	45.58	51.04	46.61	44.50	14.21	34.48

varians E : varians of environmental; varians G : varians of genetic; h^2bs : heritability broad sense

Table 5 Components of variability and heritability in the character of yield components of the bird pepper population of IPB 321x IPB C290

population	fruit weight	fruit length	fruit diameter	fruit thickness	fruit stalk length	number of fruit	yield	flowered time	harvested time
varians P1	0.01	0.03	0.18	0.01	0.03	4350.40	3723.12	18.61	35.95

varians P2	0.14	0.09	0.92	0.02	0.11	1565.00	4585.89	15.42	29.22
varians F1	0.04	0.05	0.88	0.01	0.08	3641.17	4949.30	21.49	18.63
varians F2	0.19	0.37	2.11	0.03	0.44	4974.76	5416.41	20.28	61.02
varians E	0.06	0.06	0.66	0.01	0.07	3185.52	4419.44	18.51	27.93
varians G	0.12	0.32	1.45	0.02	0.36	1789.24	996.97	1.77	33.09
h^2bs	66.20	84.84	68.69	54.20	83.15	35.97	18.41	8.74	54.23

The component values of the variety and heritability of the population F2-321290 are presented in Table 5. The broad mean heritability values ranged from 8.74 - 84.84%. Characters that have broad mean heritability values included in the high category are weight per fruit (BB), fruit length (PB), fruit diameter (DB), flesh thickness (TDB) and harvest (UP) age. The character of the number of fruits per plant belongs to the medium category. The character of fruit weight per plant and flowering age are in the low category. Ruchjaningsih, A., Imran, M., Thamrin, dan Kanro, M.Z. (2000) state that selection of a character is effective if the character's heritability is high

D. Conclusion

The population of F2-285290 correlation values showed a very significant significance for all characters on the character of fruit weight per plant while in the population F2-321290 only the character of fruit flesh thickness and the length of the fruit stalks were not significantly correlated. The broad mean heritability value in the high category of the two populations is in the weight character per fruit, fruit length, fruit diameter and fruit stalk length. The results of index selection in the population F2-285290 with a selection intensity of 10 percent obtained by selected plants as many as 20 best plants, namely plants no 16, 30, 31, 36, 43, 50, 65, 80, 82, 102, 123, 134, 153, 190, 216, 244, 245, 263, 273 and 290 while in populations F2-321290 selected plants are no. 18, 21, 23, 30, 32, 37, 42, 154, 155, 162, 165, 167, 180, 185, 199, 220, 221, 230, 228 and 229.

E. References

Arif, B.A., Sujiprihati, S., Syukur, M. (2012). Estimation of Several Genetic Parameter on Quantitative Charactersof Hybridization Between Big and Curly Chilli (*Capsicum annuum* L.). *J. Agron. Indonesia. 40 (2): 119 – 124.*

Barmawi, M. (2007). Segregation and Heritability Patterns of Soybean Resistance to Cowpea Mild Mottle Virus Population Wilis X MLG2521. *J. HPT Tropika 7:48-52.*

[BPS; DJH] Statistics Indonesia and Directorate General of Horticulture. (2018). Vegetable Productivity in Indonesia, 2015-2016. Jakarta (ID): Statistics Indonesia and Directorate General of Horticulture.

Chakrabarty, S., Islam, A.K.M.A. (2017). Selection Criteria for Improving Yield in Chili (*Capsicum annuum*). *Advances in Agriculture : 1-9.*

Dewi, A.A., Ainurrasjid, Saptadi, D. (2016). Identification of Seven Cayenne Pepper Genotypes (*Capsicum frutescens* L.) Resistance to *Phytophthora capsici* (causes steem rot disease) *J. Produksi Tanaman. 4(3): 174 – 179.*

Desita, A.Y. (2014). Horticultural Character Evaluation of IPB Ornamental Chili Lines in The Leuwikopo Experimental Garden. [Undergraduate Thesis]. Bogor (ID): Institut Pertanian Bogor.

Falconer, D.S. (1981). Introduction to Quantitative Genetics. London (UK). Longman.

Farhad, M., Hasanuzzaman, M., Biswa, S.B.J., Azad, A.K., Arifuzzaman, M. (2008). Reliability of Yield YUContributing Characters for Improving Yield Potential in Chilli (*Capsicum annuum*). *Int. J. Sustain. Crop prod. 3(3):30-38.*

Hakim, A., Syukur, M., Wahyu, Y. (2019). The Estimation of Varian Components and Heritability Two Population of Bird Pepper (*Capsicum frutescens* L.). *J. Hort. Indonesia. 10(1): 36-45*

Hastuti, N.M.D., Yulianah, I., dan Saptadi, D. (2016). Heritability and Genetic Gains 7 Families of F3 Population Chilli (*Capsicum annuum* L.) Derived from a Cross TW 2 X PBC 473. *J. Produksi Tanaman. 4(1) :63 – 72.*

Jalata, Z.A., Ayana, H., Zeleke. (2011). Variability, Heritability and Genetic Advance for Some Yield and Yield Related Traits in Ethiopian Barley (*Hordeum vulgare* L.) Landraces and Crosses. *J Plant Breed Genet. 5: 44-52.*

Lestari, A.D., Dewi, W., Qosim, W.A., Rahardja, M., Rostini, N., Setiamihardja, R. (2006). Genetic Variability and Heritability of The Characteristics of Yield Components and Fifteen Genotypes of Red Chili. *Zuriat. 17 (1):97-98.*

Meena, M.L., Kumar, N., Meena, J.K., Rai, T. (2016). Genetic Variability, Heritability and Genetic Advances in Chili, *Capsicum annuum* Biosci. *Biotech. Res. Comm. 9(2): 258-262.*

Poespodarsono, S. (1988). Basics of Plant Breeding Sciences. Inter-University Center. Bogor Agricultural Institute. Bogor (ID). 169 p.

Qosim, W.A., Rachmadi, M., Hamdani, J.S., Nuri, I.(2013). Phenotypic Performance, Variability, and Heritability of 32 High Yielding Red Pepper Genotypes*. J. Agron. Indonesia. 41 (2): 140 – 146.*

Ruchjaniningsih, A., Imran, M., Thamrin, dan Kanro, M.Z. (2000). Phenotypic Appearance and Some Genetic Parameters of Eight Peanut Cultivars in Rice Fields. *Zuriat 11(1):8-14*.

Sidiq, A.R.F., Syukur, M., dan Marwiyah, S. (2017). Estimation of Genetic Parameters and Selection on Quantitative Characters of Bird Pepper (*Capsicum annuum* L.) F3 Population Populasi F3. *Bul. Agrohorti. 5 (2): 213-225.*

Sutjahjo, S.H., Rustikawati, A.W., Sandhi, S.G. (2007). Genetic Study and Selection of S5 Green Bean Genotype (*Vigna radiata*) Towards High Yield and Simultaneously Harvested Cultivars. *Jurnal Penelitian dan Informasi Pertanian. 11(1):10-18.*

Syukur, M., Sujiprihati, S., Yunianti, R., Undang. (2010). Diallel Analysis Using Hayman Method to Study Genetik Parameters of Yield Components in Pepper (*Capsicum annuum* L.). *Hayati J Biosci. 17:183-188.*

Syukur, M., Sujiprihati, S., Yunianti, R. (2015). Plant Breeding Techniques. Bogor (ID): Penebar Swadaya.

Sujinto, E., Dianawati, M. (2015). Harvest Production of Many New Varieties of *Capsicum frutescens* in Dry Land on Garut District, West Java. *Pros Sem Nas Masy Biodiv Indon. 1: 874-877.*

Widyawati, W., Izmi, Y., Respatijarti. (2014). Heritability and Genetic Gains of F2 Population in Chilli (*Capsicum annuum* L.). *J. Produksi Tanaman. 2(3): 247-252*.

Yunandra. (2016). Character Inheritance of Yield Components and Utilization of Transgressive Segregant of Large and Curly Chili in Order to Improve Yield. [Thesis] Bogor (ID): Institut Pertanian Bogor.

Yunandra, Syukur, M., Maharijaya, A. (2017). Selection and Selection Advance of Yield Component Character in Curly and Large Chilli Pepper Crossing. *J. Agron. Indonesia. 45(2):170-175.*

Zen, S. (1995). Heritability, Genotypic and Phenotypic Correlations of Upland Rice Characters. *Zuriat*. 6 (1): 25-32.