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Table of Content

Volume 3, No. 1, June 2018

Agronomic Characters of Wheat (<i>Triticum aestivum</i> L.) Grown Using Two Cropping Systems in Medium Land of Palopo City <i>Mayasari Yamin, Sartia Hama, Taufiq Hidayat</i>	1-7
Utilization of Vegetable Hydrocolloid Compounds as Edible Coating Material to Extend the Shelf Life of Bananas Muli (<i>Musa acuminata</i> Linn.) <i>Desi Nurjannah, Muh. Akhsan Akib, Nur Ilmi</i>	8-13
Growth and Production of Synthetic Maize Mutants (M3) at Different Water Availability Levels <i>Ifayanti Ridwan, Muh. Farid Bdr</i>	14-20
Growth and Production of Various Wheat Genotypes at Various PEG Concentration in Hydroponic <i>Muh. Farid Bdr</i>	21-26
Genetic Characterization of Galoba Durian (<i>Amomum</i> spp.) in Ambon Island Based on Random Amplified Polymorphic DNA (RAPD) <i>Fuadiska Salamena, Adriana Hiariej, Cecilia A. Seumahu</i>	27-33
Determination of Selection Criteria for Tomato (<i>Solanum lycopersicum</i> L.) Yield Component in the Lowland Based on Path Analysis <i>Marlina Mustafa, Muhamad Syukur, Surjono Hadi Sutjahjo, Sobir</i>	34-41



Agronomic Characters of Wheat (*Triticum aestivum* L.) Grown Using Two Cropping Systems in Medium Land of Palopo City

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Abstract

Wheat (*Triticum aestivum* L.) is a staple food for most of world population and has a good prospect considering the great potential of land to be planted with this plant species which contains carbohydrate of 70% and protein of 3%. The development of this commodity was started from agricultural extensification and production increase through the implementation of cropping system. This study was aimed to provide information on suitable cropping system for wheat cultivation and to examine the effect of cropping system on the increase in wheat production in medium land of Palopo City. This study was conducted in farmer land in Kambo Village, Mungkajang Subdistrict of Palopo City, South Sulawesi at elevation of \pm 600 m asl from June until September 2017. This research uses two factor factorial in randomized block design. The first factor consisted of two cropping systems, namely line up system (S_1) and Hazton system (S_2). While, the second factor included two varieties, namely Guri 4 variety (V_1) and Guri 6 variety (V_2). Study result for vegetative phase showed that the best plant height was obtained using line up cropping system in Guri 4 variety (S_1V_1) with average of 73.91 cm. Implementation of Hazton cropping system in Guri 4 variety (S_2V_1) resulted in the best flag leaf area with average of 40.23 cm². Hazton cropping system implementation in Guri 6 variety (V_2S_2) indicated the best green color with average value of 11.00 unit. Furthermore, application of line up cropping system (S_1) produced the best total tiller number with average of 18.22 tillers. Therefore, it is concluded that the use of Hazton cropping system was able to increase the wheat production and Guri 4 Variety is expected to adapt to grow in the medium land of Palopo City

Keywords: cropping system, extensification, medium land, production, wheat

A. Introduction

Wheat (*Triticum aestivum* L.) is a cerealia plant from the family of Poaceae (Gramineae) originated from subtropical area with optimal temperature of 20°C. This commodity contains great benefits and nutrients, the high component of functional food and storage quality makes wheat becomes a staple food for more than one-third of world population (Porter, 2005). Therefore, consumption and demand of wheat flour in Indonesia experienced increase from 2011 to 2012 with a value of 6% and the supply was mostly depended on wheat import. This situation has encouraged the government in the development and cultivation of tropical wheat which is adapted to the agro-ecosystem of Indonesia.

The development of wheat in Indonesia can be done in highland, medium land, and lowland. However, this commodity will compete with other horticultural commodities that have higher economic value if it is grown in highland. The development of wheat in lowland faces obstacle of high temperature stress. Althuhaish, A.A.K., Miftahudin, Trikoesoemaningtyas & Sudirman, Y. (2014), reported that climate in highland is extremely different from climate in the lowland or medium land at the same latitude. Declining elevation along with the increasing temperature inhibit the growth and development of wheat plant. Yamin (2014) reported that decrease in median value of F4 generation for all agronomic characters in Cisarua (600 masl) was caused by the effect of temperature and water availability. Moreover, wheat farming at high temperature was able to hamper plant growth, number of tiller, and leaf area, as well as declined the yield and yield component (Althuhaish *et al.*, 2014). Unfortunately, wheat development in medium area also faces obstacle due to the limited number of planting location thus agricultural extensification is required.

Extensification is the expansion of agricultural land by utilizing areas that have not been used before. Extensification effort is conducted by opening new land for agriculture such as the utilization of forest area. To increase the production and productivity of wheat in Indonesia, particularly in forest area, wheat varieties with the ability to be cultivated in tropical area can be grown by adopting the conventional system, namely jajar legowo and Hazton, thus the production target can be achieved along with the effort to increase sustainable production of wheat.

One of breakthroughs in productivity increase can be done through the implementation of cultivation using jajar legowo cropping system (Ikhwan, G.R.P., Eman, P., & Mukramin, A.K. (2013). The type of jajar legowo cropping system consists of (1) JAJAR LEGOWO 2 : 1, where every two rows of width twice the distance within rows; (2) jajar legowo 4 : 1, where every four rows of plants is interspersed with one empty row at width of twice the distance within rows (Wahyu, 2012). Cropping system of legowo 4 : 1 type 1 is legowo cropping system in which all rows obtain the inserted plant and is possible to be applied in less fertile land (Abdulrachman, S., Made, J. M., Nurwalen, A., Indra, G., Priyatna, S., & Agus, G. 2013). The advantages of jajar legowo cropping system implementatin (Sembiring, 2001) include: increasing number of plant at the both outsides of each set of legowo and creating oppurtunity in the development of production system for other commodity. Hazron method is a technology that has been developed in several provinces to increase rice productivity. The number of rice seed used in the method is approximately 20 – 30 seed/planting hole, while it is commonly 2 – 3 seed/planting hole (Dirjen Tanaman Pangan, 2016).

Triny, S., Kadir, E., Suhartatik & Sutisna. (2004), stated that cropping system of legowo 2 : 1 was able to increase rice productivity to 18.1%. Natawijaya (2012) reported that Oasis strain has high tolerance to high temperature stress, while HP1744 strain is sensitive to high temperature. Srihartanto, E., Sri, & Suwarti, W.B. (2013), mentioned that implementation of jajar legowo cropping system in hybrid corn grown in inceptisol soil was able to increase the productivity of Bima hybrid corn of 46.8% (10.55 t/ha). Yamin (2014) reported that F3 generation (Oasis x HP1744) in highland (± 1100 mdpl) obtained the best performance, namely O/HP-21, O/HP 93, O/HP 82, O/HP 6, O/HP 104, O/HP 22, O/HP 37, O/HP 115, and O/HP 30 and were used for selection on F4 generation in medium land. Strains of F4 generation in medium land that obtained better performance than founder of Oasis and Selayar (National Variety) according to the selection index were strains of O/HP12-23, O/HP 78-2, O/HP82-15, and O/HP 93-3.

This study was aimed to provide information on suitable cropping system to wheat cultivation and to examine the effect of cropping system on wheat production increase in medium land of Palopo City.

B. Methodology

The research was conducted at farmer land in Kambo Village, Mungkajang Subdistrict of Palopo City, South Sulawesi at elevation of \pm 600 m asl from June until September 2017. This study used experimental design of factorial with two factors in randomized block design. The first factor consisted of two varieties, namely Guri 4 variety and Guri 6 variety. While the second factor consisted of two cropping systems, namely Hazton method (S₁) and Conventional method (S₂). Each factor was repeated three times. Land processing was done manually using hoe. Land processing was aimed to improve the condition of soil to be used. Planting through Hazton method was done using *tugal* system at a planting distance of 25 cm x 25 cm. Each planting hole was planted with 30 wheat seeds. while, planting with conventional method was done using *line up*, in which no distance was created within rows, yet the distance between rows was 25 cm.

Fertilizing was conducted 2 (two) times, the first one was at a dose of 150 kg/ha Urea, 200 kg/ha SP36, and 100 kg/ha KCl which was done at the age of \pm 10 HST (Days After Planting). The second fertilizing at a dose of 150 kg/ha Urea was performed at the age of 30 HST. Number of wheat plant sample observed and measured was 50% of plant population. Agronomic characters measured and observed included plant height (cm), flag leaf area (m²), flag leaf greenness using BWD (Leaf Color Chart), and total tiller number.

C. Discussion

1. Recapitulation of Variance of Several Agronomic Characters of Wheat

The difference between population variance value of Guri 4 and Guri 6 on several agronomic characters in medium land of Palopo is presented in Table 1. Result of variance analysis in Table 1 shows that the character of flag leaf area and flag leaf greenness was not significantly different at α level of 5% and 1%. Moreover, a highly significant effect was found in the character of plant height for variety factor as well as significant effect on the character of total tiller number for cropping system factor.

Table 1. Recapitulation of variance of several agronomic characters of wheat in medium land

Vegetative Character	Character of Variety (V)	Cropping System (S)	V*S	CV (%)
Plant Height	**	tn	*	9.21
Flag Leaf Area	tn	tn	tn	7.10
Flag Leaf Greenness	tn	tn	tn	7.59
Total Tiller Number	tn	*	tn	26.89

Description: * = Significantly different at α level = 5%; ** = highly significant α = 1%; tn = not significant

The difference of variance and coefficient of variance (%) for each character shows the phenotype variation of wheat population used. This finding was caused by the effect of environment and gene expression from the genetic material used and its expressivity. Natawijaya (2012), mentioned that the difference of several phenotypes for each variety on each agronomic character was caused by gene expression.

2. Plant Height (cm)

Observation result in Table 2 shows that treatment of V₂S₁ resulted in the best average of plant height which was not significantly different from other treatments. Guri 6 combined with Hazton cropping system produced an average of 102.09 cm which was classified into the tall group.

Table 2. Plant height average of wheat (*Triticum aestivum* L.) planted in medium land which consists of factors of variety (V) and cropping system (S)

Variety (V)	Cropping System (S)	
	S1	S2
V ₁	40.53 ^d	55.66 ^c
V ₂	102.09 ^a	98.02 ^b

Description: values followed by similar letter is not significantly different in DMRT test at α level of 0.05 (4.99)

According to Budiarti (2005), wheat plant height is classified into: short group (53.5-65.2 cm), medium group (65.2-76.9 cm) and tall group (>76.9 cm). Subagyo (2001), reported that population phenotype appearance for the height character of plant cultivated in highland reached 102 cm.

3. Flag Leaf Area

Observation result for the character of flag leaf area is presented in Figure 1 below. Interaction between varieties of Guri 4 that used conventional cropping system resulted in the best leaf area with average of 40.23 cm. Increase in leaf area was caused by high reception of solar radiation intensity. Gardner, F. P., R. B. Pearce & R. L. Mitchell (1991), reported that there was efficiency in the reception of sunlight.

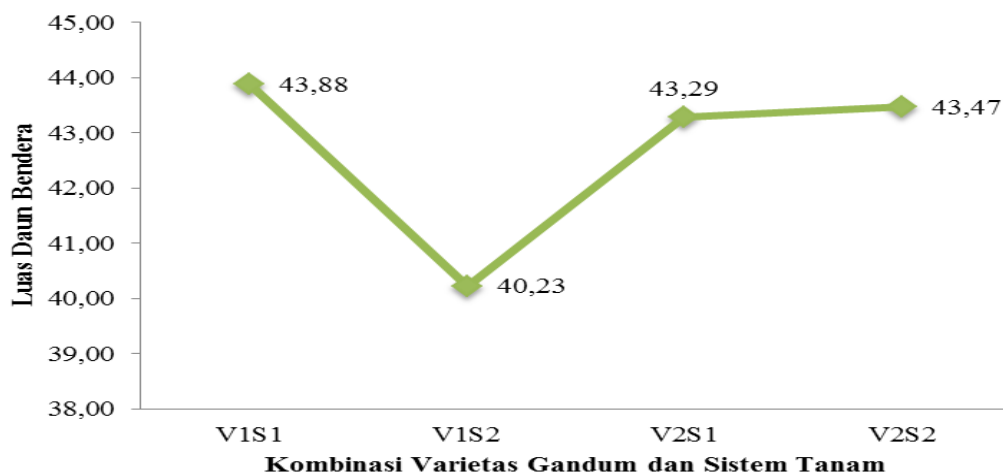


Figure 1 Character of flag leaf area in several combinations of wheat variety and cropping system

Leaf area index is directly proportional to transpiration rate in plants. Wider leaf area will cause plant to loose water. Priyono & Teguh (2016), reported that higher leaf area index of plant means higher transpiration rate of plant. Suyitno (2012), stated that leaf area of plant affect transpiration rate since wider leaf contains more stomata which results in high transpiration rate.

4. Flag Leaf Greenness

Graph of flag leaf greenness presented in Figure 2 shows that treatment of combination between Guri 6 variety and conventional cropping system resulted in the best flag leaf greenness with average of 11.00.

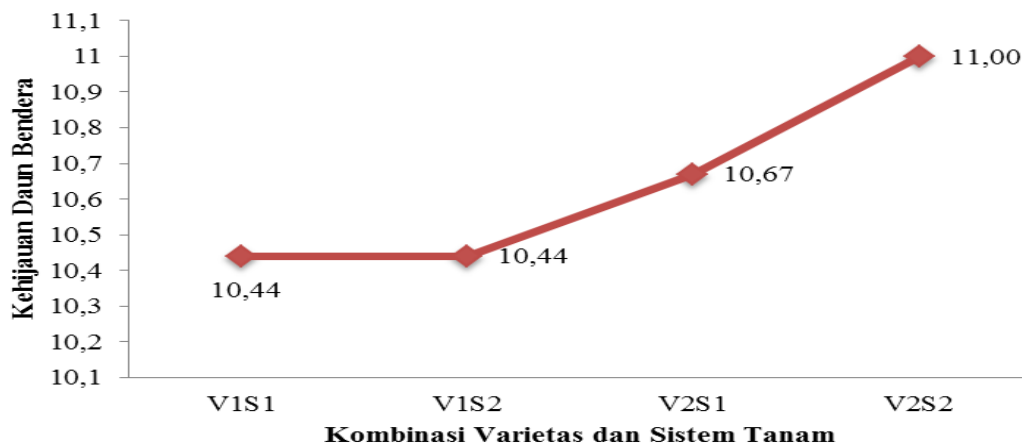


Figure 2 Character of flag leaf greenness in several combinations of wheat variety and cropping system

The green color of leaf is caused by color pigment known as chlorophyll located inside the chloroplast. Nelson & Larson (1988), said that the number of chloroplast tends to follow the increasing leaf area; thus the number of chlorophyll also increases since there will be more leaf area exposed to the sunlight which further contributes to the development of green leaf.

According to Rostini, N., Baihaki, A., Setiamihardja, R., & Suryatmana, G. (2003), leaf with high amount of chlorophyll and are able to maintain the presence of chlorophyll in longer period is like a factory inside plant which has production machine in large number and can work for a long time, thus producing photosynthate in large quantity (Mutiah, 2013).

5. Total Tiller Number

Table 3 shows that the best total tiller number was found in cropping system of S2 at average of 89.50. However, it is still uncertain that the total tiller number will become productive tiller in overall since the energy obtained will be distributed to all tillers thus the chance to distribute energy to seed production activity will be reduced. Therefore, higher number of seed per planting hole will also result in more productive tillers as in Hazton method.

Table 3 The average of total tiller number of wheat (*Triticum aestivum* L.) grown in medium land which consists of factor of variety (V) and cropping system (S)

Variety (V)	Cropping System (S)		Mean
	S1	S2	
V1	59.11	77.33	77.33
V2	50.22	101.67	101.67
Mean	54.67 ^b	89.50 ^a	

Description: Values followed by similar letter is not significantly different in DMRT test at α level of 0.05 (7.71)

Kartaatmadja & Fagi (2000), mentioned that the number of seed per planting hole will affect the existing population, which further will influence the growth of productive tiller and the yield of rice production. Masdar (2006), added that the increasing number of seed per planting hole tends to increase plant competition, both between plants in one planting hole and between planting holes which will create impact on the decreasing total tiller number.

6. Morphological Performance of Wheat in Medium Land

Genotype performance in medium land is depicted in Figure 3 which shows that the performance for vegetative character (\pm 3 months). The difference of performance between Guri 4 and Guri 6 variety which used conventional and Hazton cropping system was caused by environmental condition which particularly included the effect of intensity and duration of radiation, effect of temperature, and water availability in the environment where plants grow (Glover, 2007).



Figure 3. Morphological Performance of Wheat in Medium Land

Effect of temperature may extend the duration of seed filling and reduce kernel growth which further will cause loss in seed density and seed weight up to 7%. In wheat plant, both seed weight and number of seed of each panicle are highly sensitive to high temperature as shown by the decreasing number of seed per panicle along with the increasing temperature (Wahid, A., Gelani, S., Ashraf, M., & Foolad, M.R. (2007).

D. Conclusion

1. The development of wheat in Palopo City using the variety of Guri 4 and Guri 6 as well as cropping system of conventional and Hazton was able to generate performance for several characters.
2. Vegetative phase showed that the best plant height was obtained using line cropping system in Guri 4 (S₁V₁) variate at average of 73.91 cm. Implementation of Hazton cropping system in Guri 4 variety (S₂V₁) indicated that the best flag leaf area was obtained at average of 40.23 cm². Hazton cropping system application in Guri 6 variety (V₂S₂) showed that the best green color was at the average of 11.00 unit.

3. While, the use of larikan cropping system (S_1) resulted in the best total tiller number at average of 18.22 tillers. Therefore, it is conclude that implementation of Hazton cropping system was able to increase the production of wheat plant and Guri 4 variety was able to adapt to the condition of medium land of Palopo City.

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Utilization of Vegetable Hydrocolloid Compounds as Edible Coating Material to Extend the Shelf Life of Bananas Muli (*Musa acuminata* Linn.)

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Abstract

The preserve quality, freshness and extending shelf life of fruit could be done by storing the fruits in the refrigerated room, pressurized room or by modifying the atmosphere of the room. However, this type of storage cost is quite expensive, therefore needed another solution that is fruit coating using edible coating solution made from vegetable hydrocolloids. The aims of this study were to determine the best materials type among the three types of vegetable hydrocolloid materials, namely extract *Aloe vera* leaves, extract *Ceiba pentandra* leaves and extract *Abelmoschus manihot* leaves that are able to preserve the shelf life of *M.acuminata* fruit. This research use was a complete randomized design with four treatments, namely; without edible coating, edible coating of extract *Aloe vera* leaves, edible coating of extract *Ceiba pentandra* leaves, and edible coating of extract *Abelmoschus manihot* leaves, with three replications. The result showed that the lowest shrinkage percentage was found in edible coating of extract *Aloe vera* leaves with an average value of 3.43% and the highest was found in treatment without edible coating of 4.37%. At the end of observation the highest sugar content was obtained in edible coating of extract *Aloe vera* leaves of 20 °Brix while the lowest was in treatment without edible coating that was 16°Brix. In organoleptic test, panelists preferred edible coating of extract *Aloe vera* leaves with an value range of 4 or 5 equivalented with neutral or likes, and did not like of edible coating of wxtract *Abelmoschus manihot* leaves with an value range of 3 or 4 equivalented with slightly dislike or neutral. Based on the conducted observational, the edible coating of extract *Aloe vera* leaves was able to preserve the shelf life of *M.acuminata* fruit up to five days after harvesting

Keywords : edible coating, hydrocolloid, shelf life, shrinkage, sugar content

A. Introduction

Fruits are the source of vitamins and minerals for the human body. In addition to containing vitamins and minerals, fruits also contain carbohydrates, fats, proteins, and water. Muli banana fruit (*Musa acuminata* Linn.) contains 26.6 g of carbohydrates, 0.2 g of fat, 1.3 g of protein, 99 kcal of calories and 4 mg of vitamin C (Judarwanto, 2016).

Musa acuminata (*M. acuminata*) is a horticultural product, belongs to climacteric fruits that are susceptible to physical, chemical and biological changes during storage. *M. acuminata* fruit that has been picked still continuing the process of respiration and transpiration. The rate of respiration can be affected by the ethylene hormone. If respiration and transpiration rates are not inhibited then it may result in shorter shelf life of *M. acuminata* (Fransiska, A., Hartanto, R., Lanya, B., & Tamrin., 2013). *M. acuminata* fruit can last for 7 - 10 days of shelf life after harvesting.

Shelf life of *M. acuminata* fruit can be extended by utilizing post-edible coating technology. Components of edible coatings can be divided into three types: hydrocolloids, lipids, and composites (Wahyu, 2009). Hydrocolloid compounds can be obtained from vegetable materials such as *Aloe vera*, cotton leaves and sunset muskmallow leaves.

Result of the research conducted by Marpaung, D.A., Susilo, B., & Argo, B. D. (2015), proved that the coating of star fruit with edible coating of *Aloe vera* leaves succeeded in extending the shelf life of fruit to 21 days by dipping fruit for 5 minutes and using concentration of 1% CMC (*Carboxymethyl Cellulose*). Research of Mahfudin, Prabawa, S., & Sugianti, C. (2016), indicated that the treatment of edible coating of cotton leaves with the addition of 5% glycerol dan dipping temperature of 60 °C was able to preserve the physical and chemical characteristics of tomatoes in good condition during storage.

The aims of this study were to determine the best materials type among the three types of vegetable hydrocolloid materials, namely extract *Aloe vera* leaves, extract *Ceiba pentandra* leaves and extract *Abelmoschus manihot* leaves that are able to preserve the shelf life of *M. acuminata* fruit.

B. Methodology

The research was conducted at Agricultural Laboratory of Faculty of Agriculture, Animal Husbandry and Fisheries of Muhammadiyah Parepare University, from July to August 2017. This study employed Completely Randomized Design (CRD) with 4 treatments which were without edible coating; edible coating of extract *Aloe vera* leaves; edible coating of extract *Ceiba pentandra* leaves; and edible coating of extract *Abelmoschus manihot* leaves, each treatment repeated 3 times. Each replication consists of 10 experimental units.

C. Result and Discussion

1. Weight Shrinkage of *M. acuminata* Fruit

The result of variance analysis indicated that edible coating had no significant effect on the weight shrinkage of *M. acuminata* Linn fruit. However, the average percentage of fruit weight shrinkage of *M. acuminata* in Table 1 shows that edible coating of extract *Aloe vera* leaves had the lowest weight shrinkage compared to edible coating with cotton leaves, sunset muskmallow leaves and without edible coating.

Table 1. Average percentage of weight shrinkage of *M. acuminata* fruit weight

Treatment	Initial weight 5 DAH (g)	Weight shrinkage (DAH)				Final weight 14 DAH (g)
		7	9	11	13	
Without EC	37,17	1,90	3,10	4,84	7,64	34,36
EC of extract <i>Aloe vera</i> leaves	35,09	1,46	2,57	3,72	5,96	32,99
EC of extract <i>Ceiba pentandra</i> leaves	39,34	1,49	2,97	4,42	7,37	36,45
EC of extract <i>Abelmoschus manihot</i> leaves	40,63	1,61	2,85	4,39	7,13	37,77

Note : EC = Edible coating; DAH = Days after harvesting

Table 1 shows that *M. acuminata* fruit with edible coating of extract *Aloe vera* leaves can slow down the percentage increase of fruit weight shrinkage by 16,40% - 21,98%. This is due to the edible coating of extract *Aloe vera* leaves capable of forming good layer to suppress the respiration rate and transpiration. According to Rudito (2012) and Novita, D.D., Sugianti, U.C., & Asropi. (2015), that the small weight shrinkage is due to a slower rate of respiration. This finding

indicated that *M.acuminata* fruit with edible coating of extract *Aloe vera* leaves can extend the shelf life of fruit to 5 days after harvesting.

Edible coating of extract *Aloe vera* leaves contains oxidase enzyme as an antioxidant serves as a preservative to suppress the rate of respiration when there is an increase in oxygen concentration, exposed by sunlight and metals in pesticides solution hence prevent the occurrence of decay and the appearance of black spots on the food products (Athmaselvi, K.A., Sumitha, P., & Revathy, B., 2012; Chrysargyris, A., Nikou, A., & Tzortzakis, N., 2016; Kumar & Bhatnagar, 2014; Misir, J., Fatema, H.B., & Hoque, M.M., 2014; and Zafika, Y., Mukarlina & Linda, R., 2015). While edible coating of cotton leaves and sunset muskmallows leaves contain tannin compounds which have no effect on coating formation on *M.acuminata* skin (Irwani & Candra, 2016; Maulina, 2016; Ninulia, 2016).

Rapid increase of weight shrinkage in the treatment without edible coating might be due to increased respiration and transpiration rates because of the absence of edible coating which might inhibit the increase of oxygen concentration in the fruit and evaporation of water through the surface of *M.acuminata* (Novita *et al.*, 2015).

Respiration and transpiration activities in fruits continue to occur during storage resulting in shrinkage of fruit weight as a result of water loss and organic material overhaul (carbohydrates, proteins and fats). This is in accordance with the statement of Muchtadi, T.R., Sugiyono, F., & Ayustanigwarno. (2015), that the loss of water during storage can increase the weight shrinkage and cause damage to the fruit thus lowering fruit quality. The loss of water in large quantities will cause the fruit to wither and wrinkle.

The edible coating of extract *Aloe vera* leaves capable of suppressing the respiration and transpiration processes in the fruit thus the water loss affecting the weight shrinkage can be suppressed, hence the average value of weight shrinkage in edible coating of extract *Aloe vera* leaves shows the lowest value of average weight shrinkage. This is in accordance with the statement of Misir *et al.* (2014) that edible coating of extract *Aloe vera* leaves acts as a barrier to the fruit skin thus limiting water loss due to transpiration and carbon reserves loss due to respiration.

The results of this study are in line with research conducted by Hasanah (2009), on paprika fruit coated with *Aloe vera* leaves edible coating with mixture of 1% Carboxy Methyl Cellulose (CMC), it suggested that paprika fruit with coating material showed the lowest weight shrinkage compared to the control treatment. Furthermore, research conducted by Athmaselvi, *et al.* (2012) proved that edible coating of *Aloe vera* leaves can preserve tomatoes shelf life until 39 days while that is only 19 days in the control treatment.

2. Sugar Content of *M.acuminata* Fruit

The sugar content measurement result showed that *M.acuminata* fruit with edible coating of extract *Aloe vera* leaves increased until the end of observation, while in edible coating treatments of extract cotton leaves, sunset muskmallow leaves and without edible coating decreased sugar content before the end of observation as shown in table 2.

Table 2. Average sugar content of *M.acuminata* fruit (°Brix)

Treatment	Initial Sugar content 5 DAH (g)	Sugar content on (DAH)				Final Sugar content 14 DAH (g)
		7	9	11	13	
Without EC	16,0	17,0	20,5	20,1	17,6	16,0
EC of extract <i>Aloe vera</i> leaves	16,0	16,5	17,0	17,5	19,0	20,0
EC of extract <i>Ceiba pentandra</i> leaves	15,0	16,5	18,5	19,5	19,0	18,0
EC of extract <i>Abelmoschus manihot</i> leaves	15,0	16,5	18,5	19,5	18,15	17,0

Note : EC = Edible coating; DAH = Days After Harvesting

Table 2 shows *M.acuminata* fruit with edible coating of extract *Aloe vera* leaves had slower rate of sugar content increasement, thus sugar content reduction did not occur. Edible coating of extract *Aloe vera* leaves could preserve *M.acuminata* sugar content around 10-20%. This is allegedly due to edible coating of extract *Aloe vera* leaves capable of inhibiting oxygen entry into the fruit. It also indicates that the slower climacteric peak was achieved in *M.acuminata* thus the storage time of the fruit might be extended to 5 days after harvesting. According to Chrysargyris *et al.* (2016), Pradhana, A.Y., Hasbullah, R., & Purwanto, A. Y. (2013) and Singh, S., Sharma, V., &

Soni, M.L. (2011), glucose retardation reactions are inhibited and respiration rate decreases due to the inhibition of oxygen into the fruit which inhibits amylase and phosphorylase activities.

Edible coating of extract *Ceiba pentandra* leaves, sunset muskmallow leaves and without edible coating had decreased the sugar content faster. It is suspected that enzyme activities of amylase and phosphorylase are more active due to the increase of oxygen content in the fruit. According to Winarno (2002) and Yassin, T., Hartanto, R., Haryanto, A., & Tamrin. (2013), the breakdown of starch into the constituent sugars led to the rise of fruit sugar content, while the decrease in fruit sugar content occurs because it is used in the respiration process or sugar is converted to other compounds.

Sugar content of *M.acuminata* with edible coating treatment on 9th day after harvesting decreased by 4.5 °Brix until 14th day after harvesting with average decrease per day of 0.9 °Brix. While the *M.acuminata* fruit with edible coating of extract *Aloe vera* leaves increased by 3 °Brix with average increase per day of 0.6 °Brix. Thus it can be seen that the *M.acuminata* fruit in the treatment without edible coating began to decrease in quality on the 9th day after harvesting while the edible coating of extract *Aloe vera* leaves preserved the good quality. This means that the edible coating of extract *Aloe vera* leaves can preserve *M.acuminata* fruit shelf life to 5 days after harvesting, of which starting from the 9th day after harvesting; while the *M.acuminata* fruit without edible coating treatment starts to deteriorate.

3. Organoleptic Test of *M.acuminata* Fruit

The results of organoleptic test showed that *M.acuminata* fruit with edible coating treatment of extract *Aloe vera* leaves had better color, texture, aroma and taste compare to edible coating of cotton leaves, sunset muskmallow leaves and without edible coating. Observational data is shown in table 3.

Table 3. Organic test of *M.acuminata* fruit

Treatment	Type of Test				Average
	Color	Texture	Flavor	Taste	
Without EC	4,8	4,3	5,0	2,5	4,2
EC of extract <i>Aloe vera</i> leaves	5,1	5,2	3,8	4,4	4,6
EC of extract <i>Ceiba pentandra</i> leaves	4,5	4,6	3,2	3,6	4,0
EC of extract <i>Abelmoschus manihot</i> leaves	4,0	3,2	2,3	3,7	3,3

Note: The numbers in the table above are symbols or representatives of qualitative data

Table 3 shows the scale of skin color assessment of *M.acuminata* fruit with edible coating of extract *Aloe vera* leaves on a scale of 5 - 6 (moderately like – like scale). This result might be due to the skin color of the *M.acuminata* fruit was bright yellow because of the clear white material, additionally according to Misir *et al.* (2014), discoloration caused by chlorophyll degradation, anthocyanins accumulation and the carotenoids synthesis. While on edible coating treatments of cotton leaves, sunset muskmallow leaves and without edible coating it could be seen that skin color of *M.acuminata* had darker color and browning occurred, furthermore it might be due to brownish black colored of edible coating cotton leaves influence and brown yellowish colored edible coating of sunset muskmallow.

Assessment scale of *M.acuminata* fruit texture with edible coating of extract *Aloe vera* leaves was on a scale of 5 - 6 (moderately like – like scale). This is due to the texture of the *M.acuminata* fruit with edible coating of extract *Aloe vera* leaves was harder than the edible coating of extract *Ceiba pentandra* leaves, sunset muskmallow leaves and without edible coating, these if because of the occurrence of cell wall stretching. Fruit texture changing of *M.acuminata* on edible coating treatments of cotton leaves, sunset muskmallow leaves and without edible coating are suspected due to the occurrence of cell wall stretching. According to Winarno (2008), the cohesion of the cell wall that binds one cell to another cell weakens hence the hardness decreases and the fruit becomes soft due to changes of insoluble protopectin into water-soluble pectate compound. It can not be separated from oxygen concentration increasement in the fruit which affects the starch break down into constituent sugars led to *M.acuminata* hardness reduction.

M.acuminata fruit flavor with edible coating treatment of *Aloe vera* leaves was on the scale of 4 - 5 (neutral - moderately like scale), it might be due to there has been no change in the typical taste of *M.acuminata* fruit. While in the edible coating treatments of cotton leaves, sunset muskmallow leaves and without edible coating had caused bitter taste, it is suspected that there

has been a process of fermentation that produces alcohol (Marsigit, 2005 and Hasanah, H., Jannah, A., & Fasya, A. G., 2012).

M.acuminata flavor with edible coating treatment was on a scale of 5 (moderately like scale), it might be due to the absence of flavor from the EC material. While the *M.acuminata* fruit with edible coating treatment was on a scale of 2 - 4 (slightly dislike - neutral scale) caused by unattractive flavor of edible coating and removed the distinctive flavor of *M.acuminata* fruit.

Respiration occurring in fruits is a biological process in which oxygen is absorbed to burn organic ingredients in fruits to produce energy, followed by the release of residual combustion of carbon dioxide and water. The rate of respiration is an indicator of tissue metabolism, high respiration rates are usually accompanied by short shelf life (Siagian, 2009).

M.acuminata fruit with edible coating of extract *Aloe vera* leaves enters stage V (the whole surface of yellow fruit peel is still green), while in the treatment without edible coating has entered stage VII (yellow with little brown spots) on the nine days after harvesting observation. On the fourteen days after harvesting, observation of *M.acuminata* fruit with edible coating of extract *Aloe vera* leaves enters stage VII while in treatment without edible coating has entered stage VIII (yellow with brown spots).

D. Conclusion

Extract *Aloe vera* leaves are the best edible coating material that can extend the shelf life of fruit banana Muli (*Musa acuminata* Linn.) to five days after the harvesting.

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Growth and Production of Synthetic Maize Mutants (M3) at Different Water Availability Levels

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Abstract

Drought causes hampered nutrient absorption and water uptake in plants hence abnormal growth and lower yield. One of alternative solutions is the development of maize varieties tolerant to drought stress through plant breeding. This study aims to find superior M3 mutant genotypes of maize that can adapt to dry land with high productivity. The study was conducted in green house of the Faculty of Agriculture, Universitas Hasanuddin using Split Plot Design. Water availability level was set as main plot consisted of 60%, 80% and 100% and maize mutant was set as subplot consisted of four M3 mutants, namely Bisma 100 gy, Bisma 200 gy, Lamuru 100 gy, and Lamuru 200 gy. In addition two varieties were used as controls ie. Bisma, and Lamuru resulted in total of 6 genotypes tested in the study. Mutant genotype of Bisma 200 gy showed tolerance to all water availability levels and significantly differed to other mutants including its parents indicated with higher yield. 100% water availability condition resulted in higher production than the other two water availability conditions with the average yield produced was 44.1 g per plant

Key Words: drought, mutant, synthetic maize, tolerance, water availability

A. Introduction

Maize is one of the important food crops in Indonesia. In the last five years, corn production in Indonesia has increased from about 19.4 million tons in 2012 to 23.6 million tons in 2016 or 21.6%. Similarly there was a 10.6% increase in the productivity since 2012 (4.80 t / ha) until 2016 (5.31 t / ha). The increase in production and productivity from 2012 to 2016 has a positive implication in the decrease of national corn import volume in the last three years from about 3.3 million tons in 2015 to only about 508 thousand tons by 2017. This shows a significant decrease in corn imports in 2017 since 2015 amounted to 84.43%. Expansion of harvested area cultivated with maize for the last 5 years became one of reasons for the production increase. Data recorded shows the area of land cultivating corn in 2012 was 3.9 million ha and increased to 4.4 million ha by 2016 (Pusat Data dan Sistem Informasi Pertanian, 2017).

Despite this success, the productivity increase of 5.3 t / ha is still lower than the genetic potential of the superior varieties in Indonesia that can obtain 7 - 8 ton per hectare (Aqil M., Rapar, C., & Zubachtirodin, 2012). Efforts in aggregating maize production through expansion of plantation areas are constrained on several issues, including the fact that about 70% of maize crops developed on low productivity land due to environmental stress. According to Efendi R., Sunarti, S., Musa, Y., Farid, M., Rahim, M.D., & Azrai, M. (2015), different agro-ecological conditions such as climate, fertility and pathogenesis present in the particular cultivation environment affect productivity of maize.

The expansion of planting areas to new areas that are generally aimed at the less productive lands due to environmental stresses become the factor inhibiting plant growth. Among the various types of environmental stress, drought stress is the most common stress, both in Indonesia and around the world. This causes corn crops are at greater risk of drought stress.

The drought stress is one of the largest stresses affecting growth and production in agriculture lands around 26% (Kalefetoglu & Ekmekci, 2005) with decreasing yield of maize in the tropics around 17-60% (Monneveux, P., Sanchez, C., Beck, D., & Edmeades, G. O., 2005). Drought stress due to limited and uncertain availability of water on agricultural land due to climate anomalies (global warming), limited water supply to agricultural land as it competes with the water demand in industrial and residential sectors. In Indonesia, the cultivation of maize is mostly done in dry land and rainfed rice fields of about 79% and 10% respectively (Kasryno, 2002). Common obstacles encountered on these lands are limited water availability and less fertile land (Monneveux *et al.*, 2008). At certain moments the corn crops are even experiencing drought stress that causes the greater decrease in yield. The results of the study Banzinger M., Edmeades, G.O., Beck, D., & Bellon, M. (2008), stated that drought stress resulted in 80 - 100% yield decline.

Drought stress causes hindered nutrient absorption and water uptake causing abnormal growth and decreasing yield. Corn is very sensitive to drought stress especially in the period of 1 week before up to 2 weeks after flowering. Drought during this period will cause the plant to experience an increase in ASI (Anthesis Silking Interval) so that pollination is not synchronized (Edmeades, G.O., Bolanos, J., & Lafitte, H.R., 1992 ; Banziger *et al.*, 2008), hence the formation of seeds that are not optimal even none of the seeds are formed due to the presence reduction in photosynthesis results (Zinselmeier C., Westgate, M. E., & Jones, R.J., 1995; Schussler & Westgate, 1995).

One alternative solution to the problem is to develop corn varieties that are tolerant of drought stress through plant breeding to support the utilization of lands that have limited water availability. Development of varieties that are tolerant to environmental stress can be done through mutation techniques using gamma-ray radiation. This method used to select several mutant genotypes that are expected to arise as a candidate for new superior varieties that is tolerant to drought and able to produce high yield. At the further stage, selection stages should be carried out by testing the mutants at some levels of drought conditions.

B. Methodology

The study was carried out in Greenhouse of Faculty of Agriculture, Universitas Hasanuddin. The experiment was set in pot trial based on Split Plot Design with water availability level set as main plot and maize mutants as sub plots. Three water levels represent the water availability conditions in the field were used and maintained during the study from planting to harvest namely 60% (A1), 80% (A2) and 100% (A3) of water supply. Maize mutants used in the study was obtained from previous trial. Four mutant genotypes selected were Bisma 100 gy (M1), Bisma 200 gy (M2), Lamuru 100 gy (M3), and Lamuru 200 gy (M4). In addition two varieties of each parental mutant genotypes, Bisma (M5), and Lamuru (M6), were used as controls resulted

in total of six genotypes used. Each treatment was repeated three times with 3 plant units. Thus there were 3 levels of water availability and 6 maize mutants that replicated 3 times resulted in total of 162 units of experiments.

The experiment used 10 kg of soil media per bucket to be filled with water until a predetermined concentration. Seeds from each mutant who passed the selection during the previous planting season was germinated. Determination of the extent of water availability was conducted using a weighing method based on field capacity.

$$WC_{ad} = \frac{a-b}{b} \times 100\%$$

$$WC_{fc} = \frac{c-d}{d} \times 100\%$$

$$SW_{fc} = w \times \frac{(100 + WC_{fc})}{(100 + WC_{ad})}$$

$$Vol = SW_{fc} - w$$

Notes:

WC_{ad} = air dried water content (%)

WC_{fc} = field capacity water content (%)

SW_{fc} = soil weight at field capacity (g)

Vol = water volume added to reach field capacity (ml)

a = initial air dried soil sample weight (g)

b = air dried soil sample oven weight (g)

c = initial field capacity soil sample weight (g)

d = field capacity soil sample oven weight (g)

w = used air dried soil weight (g)

The observed character data included plant height, number of leaves, number of dried leaves, Anthesis Silking Interval (ASI) and production, were analyzed using the Analysis of Variance (ANOVA) for Split Plot design. The significant effect of treatments was analyzed further using the Least Significance Difference (LSD) test to determine the difference between the tested mutants.

C. Results

1. Plant Height

Analysis of variance results indicate that water availability levels and mutants treatments significantly affect plant height, respectively. Table 1 shows that at 100% water supply (A3) resulted in the best plant height with an average height of 190.09 cm. The mutant genotype that showed the best response was Lamuru 200 gy (M4) with an average value of 185.97 cm although not significantly differed with other genotypes except for genotype Bisma (M5).

Table 1. Mean of maize mutant plant height (cm) on difference levels of water availability.

Genotypes	Water availability levels			Mean	LSD _{M 0.05}
	A1 (60%)	A2 (80%)	A3 (100%)		
M1 (Bisma 100 gy)	149.17	176.00	175.67	166.94 ^{ab}	28.60
M2 (Bisma 200 gy)	140.83	164.17	172.17	159.06 ^{ab}	
M3 (Lamuru 100 gy)	143.07	166.70	180.33	163.37 ^{ab}	
M4 (Lamuru 200 gy)	158.41	177.33	222.17	185.97^a	
M5 (Bisma)	105.25	163.33	184.67	151.08 ^b	
M6 (Lamuru)	139.50	161.17	195.17	165.28 ^{ab}	
Mean	137.41 ^y	166.54 ^{xy}	190.90^x		
LSD _{A0.05}	29.98				

Values followed by same letter in the same column (a, b) and the same row (x, y) are not significantly different (p=0.05).

2. Number of Leaves

Analysis of variance results indicates no significant effects of all treatments on the number of leaves of the maize genotypes. Figure 1 shows that the highest leaf numbers showed by the genotypes of Bisma 200 gy (M2) mutant and Lamuru (M6) at 60% of water availability with an average value of 15.67 and 15.33 leaves, respectively. While the lowest number of leaves is shown

by Bisma 100 gy mutant (M1) on water availability of 80% and 100% with an average value of 13.67 leaves.

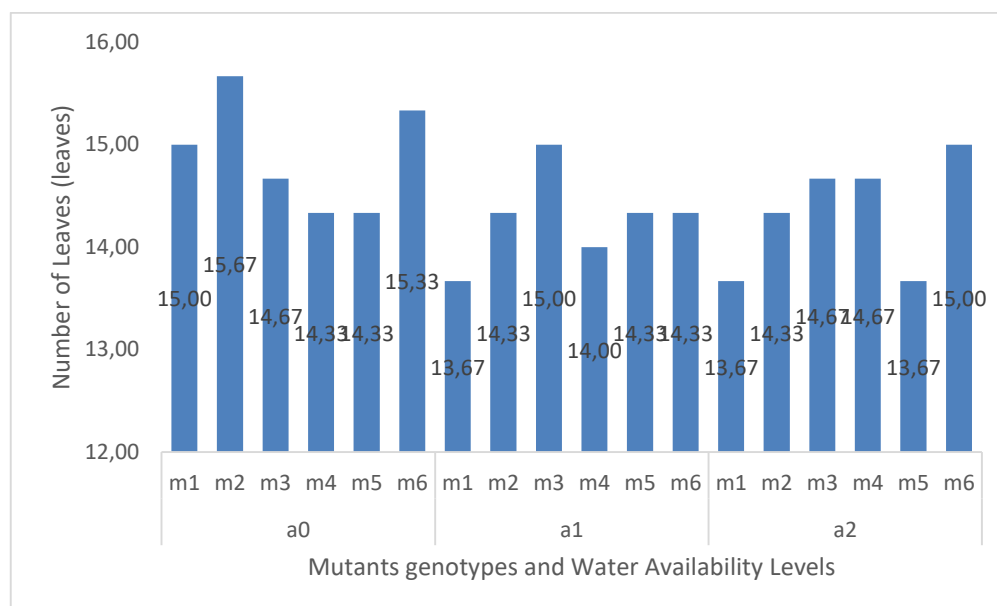


Figure 1. Number of leaves of Maize mutant genotypes at difference levels of water availability (M1: Bisma 100 gy mutant; M2: Bisma 200 gy mutant; M3: Lamuru 100 gy mutant; M4: Lamuru 200 gy mutant; M5: Bisma and M6: Lamuru; A0: 60%, A1: 80% and A3: 100% water availability)

3. Number of dry leaves

Water availability and mutant treatments had a very significant effect on the number of dry leaves of maize plants, whereas no significant interaction between mutant and water availability level treatments. Table 2 shows that at 60% water supply (A1) resulted in the lowest number of dry leaves with an average dry leaf number of 5.67 leaves which is not significantly different with dry leaves number at 80% water availability condition (5.87 leaves). The mutant treatment that showed the best response was M2 with an average value of 4.78 leaves and significantly different with the other mutant treatment.

Table 2. Mean of number of dry leaves (leaves) of the maize mutant on difference levels of water availability.

Genotypes	Water availability levels			Mean	LSD _{M 0.05}
	A1 (60%)	A2 (80%)	A3 (100%)		
M1 (Bisma 100 gy)	6.33	6.00	6.00	6.11 ^b	1.03
M2 (Bisma 200 gy)	4.33	4.67	5.33	4.78^a	
M3 (Lamuru 100 gy)	6.67	7.33	7.00	7.00 ^b	
M4 (Lamuru 200 gy)	5.33	5.67	8.33	6.44 ^b	
M5 (Bisma)	6.67	6.00	7.00	6.56 ^b	
M6 (Lamuru)	5.33	5.67	7.67	6.22 ^b	
Mean	5.67^x	5.87^x	7.07 ^y		
LSD _{A 0.05}	0.454				

Values followed by same letter in the same column (a, b) and the same row (x, y) are not significantly different ($p=0.05$).

4. ASI (Anthesis Silking Interval)

Analysis of variance results indicate that treatment of water availability levels and mutants had a significant effect on the ASI of the maize mutants. Table 3 shows that earlier ASI was obtained at 100% water supply (A3) with an average of 4.56 days and was significantly different from other genotypes. The mutant treatment that showed the best response on ASI parameter was Bisma 200 gy (M2) with an average value of 4.11 days and was not significantly different with Lamuru 100 gy (M3) and Lamuru 200 gy (M4) mutants.

Table 3. Mean of ASI (*Anthesis Silking Interval*) (days) of maize mutant on difference levels of water availability.

Genotypes	Water Availability Levels			Mean	LSD _{M 0.05}
	A ₁ (60%)	A ₂ (80%)	A ₃ (100%)		
M1 (Bisma 100 gy)	6.00	6.00	5.00	5.67 ^b	1.46
M2 (Bisma 200 gy)	3.33	5.00	4.00	4.11^a	
M3 (Lamuru 100 gy)	7.00	5.67	4.00	5.56 ^{ab}	
M4 (Lamuru 200 gy)	6.33	6.33	2.67	5.11 ^{ab}	
M5 (Bisma)	7.00	7.00	5.67	6.56 ^b	
M6 (Lamuru)	6.67	6.67	6.00	6.44 ^b	
Mean	6.06 ^y	6.11 ^y	4.56^x		
LSD _{A 0.05}	1.05				

Values followed by same letter in the same column (a, b) and the same row (x, y) are not significantly different (p=0.05).

5. Production

Water availability level and mutants interacted significantly on affecting the production of maize genotypes tested in the recent trial. Table 4 shows that at 100% water availability condition, the genotype of Lamuru (M6) gave the best crop production with an average of 50.96 g per plant and is not significantly different from the production of Bisma 200 gy and Lamuru 200 gy mutants at the same water availability level. At lower water availability level, highest production was shown by Lamuru 100 gy (M3) and Bisma 200 gy (M2) mutants obtained when water condition was at 80% and 60% water supply, respectively. At 80% water availability level, production of Lamuru 100 gy mutants (M3) was not significantly differed with the production of Bisma 200 gy (M2), while at 60% of water availability, Bisma 200 gy mutant (M2) produced higher grain compared to other mutants even when compared to its parent (M5).

Table 4. Mean of plant production (g.plant⁻¹) of maize mutants on difference levels of water availability.

Genotypes	Water Availability Levels			LSD _{M 0.05}
	A ₁ (60%)	A ₂ (80%)	A ₃ (100%)	
M1 (Bisma 100 gy)	23.17 ^y _b	6.50 ^z _d	36.69 ^x _b	7.23
M2 (Bisma 200 gy)	32.65^z _a	41.00 ^y _a	55.93^x _a	
M3 (Lamuru 100 gy)	10.80 ^y _c	42.63^x _a	37.88 ^x _b	
M4 (Lamuru 200 gy)	6.52 ^y _c	4.02 ^y _d	27.63 ^x _c	
M5 (Bisma)	23.22 ^y _b	14.33 ^z _c	51.36^x _a	
M6 (Lamuru)	21.10 ^y _b	23.17 ^y _b	56.97^x _a	
LSD _{A 0.05}	7.26			

Values followed by same letter in the same column (a, b) and the same row (x, y) are not significantly different (p=0.05).

D. Discussion

Maize mutants differed significantly on plant height, number of dry leaves, ASI (*Anthesis Silking interval*) and average production while character number of leaves shown no difference. The best results in plant production showed by irradiated maize mutant Bisma 200 gy, is supported by growth characteristic components such as leaf number, ASI (*Anthesis Silking Interval*) and number of dried leaves.

Differences in mutant responses to the given treatments primarily on the same cultivar origin but different radiation doses indicated that changes has occurred after mutation. Radiation with gamma rays can cause mutations. The mutations in plants causes a change in gene arrangement, hence causing differences in appearance of each character in plants. According to Wiryosimin (1995), gamma ray irradiation as a mutagen will break the DNA strands. Termination of DNA due to radiation results in changes in the formed amino acids and proteins, which will eventually lead to mutations. The above opinion in accordance with the opinion Sitompul & Guritno (1995), states that the genetic factors of plants is one cause of differences between plants with each other.

The observations on characters correlated significantly with the plant production showed that Bisma 200 gy (M2) genotype tended to show the best results. The mutant treatment showed high characteristic of leaf number, even when water supply decreased to 60% of water available, compared to other mutants and its parent. Therefore, the amount of stomata contained in the Bisma 200 gy mutant leaves were also higher resulting in higher H₂O and CO₂ exchange activities. High transpiration causes a high water loss that affects plant physiological activity resulting in a decrease in production. According to Harjadi & Yahya (1988) and Qing, Z.M., Jing, L.G., & Kai, C. R. (2001), the amount of water used by plants is related to photosynthetic activity and dry weight of production. Drought stress affects plant physiology activities including radiation capture, leaf temperature, stomatal conduction, transpiration, transport electron, photosynthesis and respiration that can decrease production (Qing *et al.*, 2001).

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Growth components such as number of leaves show that Bisma 200 gy (M2) that tended to give the best results on water availability of 60% indicate that Bisma 200 gy is more tolerant to drought stress than other genotypes. This is in line with the limits on drought resistance based on breeding aspect and objectives proposed by Murdiyato & Sugiyarto (1992), that crop resistance to drought as the ability of a plant genotype to become more productive to produce more yield than other genotypes.

Corn plant is very sensitive to water availability especially in the period of 1 week before up to 2 weeks after flowering. The best ASI (Anthesis silking interval) value at the 60%, 80% and 100% water supply were Bisma 200 gy (M2). The ASI characteristic shown by the mutant was strongly correlated with the successful of grain formation, hence produce high yield. Genotypes experiencing drought in this period will experience an increase in ASI causing unsynchronized pollination (Edmeades *et al.*, 1992; Banziger *et al.*, 2008) leading to unoptimal even to no grain formation by the reduction of photosynthesis (Zinselmeier *et al.*, 1995; Schussler & Westgate, 1995).

Production is a character that determines the plant tolerance to low water availability. The Bisma 200 gy mutant (M2) produced high yield at 60%, 80% and 100% water supply treatments. High production is strongly influenced by the character of leaf number and ASI (Anthesis Silking Interval), two characters that related to grain formation and filling process mainly use assimilate synthesized in photosynthesis. The ability of the Bisma 200 gy mutant against a wide range of water availability helps the plant in reducing high air circulation in the leaves. According to Earl & Davis (2003), reported that drought stress reduces maize yields caused by three factors, namely (1) decreased canopy absorption in the event of active photosynthetic radiation (PAR), (2) decreased radiation efficiency, while leaves are heavily weightened resulting in prematurely senescence and reduction resulting in the entire canopy obtaining an exchange of CO₂ by absorbing PAR, (3) decreasing the yield index. Short periods of stress that coincide with the critical period will affect the rate of development of plant tissue. Water stress can prevent fertilization due to a decrease in the seed water potential so that the seed growth stops prematurely. Similarly, on soil conditions with high salt content.

E. Conclusion

1. Bisma 200 gy mutant shows tolerance to water availability of 60%, 80% and 100% and were different significantly from other mutants including its parent, which are shown in the production.
2. 100% water availability provides more production than water availability of 60% and 80% with an average of 44.1 g per plant.

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Growth and Production of Various Wheat Genotypes at Various PEG Concentration in Hydroponic

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Abstract

Wheat is a sub-tropical cereal that can be planted in the tropics, on the highland with altitude >1000 m asl. The development of wheat in the highlands compete with horticultural crops, so the creation of tropical wheat that is adaptive to lowland and drought tolerance is an alternative problem-solving. The aims of this study is to test the generation and to screen three type of mutant that is adaptive in lowland with high temperature. The study was conducted at Tamalanrea Jaya, Tamalanrea regency, Makassar province from May to August 2017. The research was conducted on hydroponic media in the plastic house (green house) at altitude <800 m asl with an average temperature of 28°C (morning) and an average temperature of 33°C (afternoon). The study was used split-plot design with the main plot of polyethylene glycol (PEG), ie 0%, 5%, 10%, and 15%; the plot was 15 wheat genotypes. The results showed that the addition of PEG concentrations at 5%, 10% and 15% decreased the crop yield by 35.91%, 55.63%, and 71.83%. Adaptive and potential genotypes developed in lowland with dry climatic conditions are genotype N.200 2.4.B.6 and genotype N.300 4.3.6

Keywords: hydroponic, lowland, polyethylene glycol, selection, wheat

A. Introduction

Wheat is an important cereal crop in the world due to has a strategic role in supporting food security and fullfilment food needs. According to Wittenberg (2004), wheat consumed about two billion people or 36% of the total world population. The need for wheat in Indonesia is met by importing from wheat-producing countries.

According to APTINDO (2016), Indonesia import for wheat in 2010 reached 5.2 million tons, 6.46 million tons in 2011 and 7.15 million tons in 2012. In 2013/2014, Indonesia's wheat imports reached 7.39 million tons (third world rank after Egypt 10.17 million tons and Algeria 7.49 million tons), while 2014/2015, Indonesia's wheat imports reached 7.49 million tons or ranked second after Egypt's of 11.06 million tons. Indonesia's wheat imports in 2015/2016 reached 8.10 million tons or ranked second after Egypt 11.50 million tons. The projection of Indonesian wheat imports for 2015/2016 was revised, previously imports in that period were estimated at only 7.8 million tons but because there was a purchase of wheat for animal feed consumption from Ukraine that reached to 300 thousand tons then the project rose to 8.10 million tons. Increased imports of wheat in Indonesia may be due to increased demand for Indonesian wheat consumption from 2012/2013, reached to 6.95 million tons; in 2013/2014 increased to 7.16 million tons; in 2014/2015 increased to 7.36 million tons (FAO, 2015).

Increased imports of wheat that reduce the country's foreign exchange must be overcome by creating a national food diversification program through the development of wheat crops in Indonesia. The challenges in the development of wheat in Indonesia from upstream to downstream subsystems are not yet fully controlled by farmers and field officers. Moreover, wheat planted in lowland with a minimum height of 800m above sea level will compete with vegetable commodities and highland fruits. This is caused wheat not to become a priority commodity in the highlands. Therefore, it is needed to undertake various forms of domestic wheat development activities through the application of cultivation technology in accordance with agroclimate conditions in Indonesia and to seek an alternative strategy in the lowlands (Sovan, 2002)

The development of lowland wheat planted on dry land faced the inability to compete with rice and maize commodities. Indonesia has widely dry land, with an estimated 60.7 million hectares or 88.6% of the land area, while the paddy field area is only 7.8 million hectares or 11.4%. Data of 2012, Indonesia has dry land about 148 million ha (78%) and wetlands of 40.20 million ha (22%) of the total 188.20 million ha agriculture land area (National Coordination Agency for Spatial Planning, 2012). Location of dry land is prospectly for the cultivation of wheat for the future.

The development of lowland wheat consequently lead to the high temperature- stressed condition which then affects the decreased pollen viability and crop yield. Barnabas, Jager, & Feher, (2008) explained that the decline in fertility of pollen and the emptiness of panicles caused by disruption of the process of spore and gamete formation in plants. Some of the proteins that play a role in the process are denatured by the influence of high temperature. Enviroment temperature is one of difficult factor to control (Mustafa, Syukur, Sutjahtjo, & Sobir, 2017). Modified cultivation techniques may reduce losses caused by high temperature; However, it is only temporary and less effective because it must be done every growing season and is costly, so the use of tolerant varieties is a more effective solution (Liebisch, Max, Heine, & Horst, 2009). The first stage are screening and identification of tolerant genotypes (Mustafa *et al.*, 2017). The identification of resistant genotypes is largely determined by selection and methods. The increase in temperature occurs due to the effects of drought, yet, the most appropriate selection agent is polyethylen glycol (PEG). This study aimed to select the genotype of mutant derived from mutated wheat using gamma rays that are tolerant to lowland with high temperatures.

B. Methodology

The study was conducted in Tamalanrea Jaya, Tamalanrea Regency, Makassar Province from Mei to August 2017. The study was done by using Hydoponic media in the gase house at 800 m asl with average temperature 30-37 C. The study used split-plot design with the main plot of polyethylene glycol (PEG) are 0%, 5%, 10%, and 15%; plot used are 15 wheat genotypes such as :g1 =N.350 3.6.2 , g2 =N.300 3.6.1, g3 = N.350 3.1.3, g4 = N.350 3.2.2, g5 = N.250 4.5.2, g6 = N.350 3.1.4, g7= Munal 200 1.7.1, g8= N.250 4.6.2, g9= N.350 3.8.9, g10 = N.200 2.4.B.6, g11 = N.200 2.5.2,g12 = N.200 2.3.3, g13= N.300 4.3.6, g14 = NIAS (comparation variety), dan g15 = MUNAL (comparation variety).

Seedling with a height of 10 cm were transferred to charcoal + chocofit media on net pots with flannel axis at hydroponic installation. Hydroponics Media was added with AB Mix with the concentration of 1000 ppm. PEG treatment was applied 2 weeks after planting with the concentration of 0%, 5%, 10%, and 15%. The pH of the solution was adjusted at 6.5; PH measurements were performed using pH meters. Volume of water for one treatment installation was 250 liters. Subsequent maintenance was done by adding nutrient solution daily according to the amount of water volume decrease from 150 liters; to maintain PEG concentration in the media during treatment.

The parameters observed in this study were plant height, the percentage of empty floret, number of spikelet per panicles, the period of seed filling (Seed Replenishment), yield per clump, and stress tolerant index (ITC). The ITC is calculated based on seed production using the formula proposed by Fischer & Maurer (1978):

$$ITC = (Y_{pi} \times Y_{si}) / Y_p^2$$

Where:

Y_{si}: The average of a genotype suffered drought stress

Y_{pi}: The average of a genotype without drought stress

Y_p: The average of the total of genotype that not suffered drought stress

The criterion for to determine the tolerance level for drought stress is; the value of $ITC \leq 0.5$ = sensitive, $0.5 < ITC \leq 1.0$ = medium, and $ITC > 1.0$ = tolerant.

C. Result and Discussion

1. Number of spikelet and the period of seed filling (Seed Replenishment)

Statistical analysis showed that the genotype had a very significant effect on the number of spikelets, plant height, and seed filling duration. The results of LSD Test in Table 1 show that the genotype g10 (N.200 2.4.B.6), g13 (N.300 4.3.6) and g7 (M.200 1.7.1) suggest the highest crop yield and significantly different from the comparison varieties/ variety Nias (a) and Munal (b), whereas for the duration of filling the seeds only g13 (N.300 4.3.6) gives the oldest filling time and is significantly different from the comparison varieties of Nias (a) and variety Munal (b). Treatment g1 (N.350 3.6.2), g2 (N.300 3.6.2), g3 (n.350 3.1.3), g4 (N.350 3.2.2), g7 (M.200 1.7.1) and g10 (N.200 2.4.B.6) show the highest number of spikelet and significantly different from the comparison varieties of Nias (a) and munal (b).

Table 1. The average number of spikelet and the duration of seed filling of several wheat genotypes at different PEG concentrations.

Genotype	Plant height	Period of seed filling	Number of spikelet
g1 (N.350 3.6.2)	23.64	35.88	9.34 ab
g2 (N.300 3.6.1)	28.65	35.43	9.61 ab
g3 (N.350 3.1.3)	31.37 a	33.96	9.68 ab
g4 (N.350 3.2.2)	28.18	36.55	9.49 ab
g5 (N.250 4.5.2)	25.63	35.02	8.58
g6 (N.350 3.1.4)	30.25	37.74 b	8.92 b
g7 (M. 200 1.7.1)	31.85 ab	36.56	9.48 ab
g8 (N.250 4.6.2)	28.30	36.81	8.49
g9 (N.350 3.8.9)	22.43	33.48	8.97 b
g10(N.200 2.4.B.6)	32.62 ab	35.95	9.26 ab
g11 (N.200 2.5.2)	28.47	34.77	8.91 b
g12 (N.200 2.3.3)	23.89	34.40	8.09
g13 (N.300 4.3.6)	31.74 ab	39.11 ab	8.95 b
g14 (Nias) (a)	28.19	35.45	8.50
g15 (Munal) (b)	28.98	34.25	8.08
LSD	2.51	2.57	0.74

Note: The numbers followed by the same letters in the sub plot column (a, b) indicates significantly different from the comparison varieties of variety Nias (a) and Munal (b) on the LSD test at $\alpha = 0.05$.

The treatment with different PEG concentrations to the wheat mutants may show different plant responses even though they are placed on the same plant medium. Treatment of PEG

concentrations in wheat crops may have water deficiency, cell damage, turgor loss, closed stomata, early reaping on plant leaves, disturbed gas exchange and lead to not optimum growth and production of wheat mutants. This is because the ability of PEG to hold water components so that enough water are enable for plants for metabolism activities, thus impact on growth and development of the plants. The parameter affected by the plant experiencing drought stress is plant height, the number of spikelet, the duration of seed filling and the percentage of empty florets; these significantly correlated to the production. Based on the results obtained from the observations with treatment without drought stress; treatment of PEG concentration at 5%, 10%, and 15%; the wheat mutant showing the best response with the highest yield was the wheat mutant g10 (N.200 2.4.B.6)

The high performance of wheat stems is very important in determining the high production genotype as it affects the vulnerability of the plant to fall. The height of the wheat crop has decreased with increasing level of PEG concentration. The decrease of plant height is caused by the lack of water uptake by plant so that the metabolic process of the plant does not occur maximally, this may lead to a lack of energy generated for cell division, premature leaf aging and stunted growth of plant height; PEG in the hydroponic solution media results in the inhibition of root formation of plants since PEG is able to attach to the roots of wheat and thereby inhibiting the water uptake by the plants hence affects the formation of roots is not maximal. Salisbury & Ross (1992) revealed that high concentrations of PEG inhibit the division and development of the cell.

2. Number of Productive Tillers

Statistical analysis shows that the interaction between genotypes with PEG concentrations had a very significant effect on the percentage of empty florets. LSD test in table 2 shows that g8 (N.250 4.6.2) gives the highest number of productive tillers at treatment with PEG concentrations of 0% and 5% and is significantly different from the comparison varieties of Nias (a) and Munal (b), whereas g6 (N. 3503.1.4) shows the lowest percentage of empty florets at 10% PEG and 15% PEG concentrations and significantly different on the comparison varieties of variety Nias (a) and Munal (b).

Table 2. Percentage of empty florets of various wheat genotypes on different PEG concentrations.

Genotype	PEG Concentration				Average
	P ₀ (0%)	P ₁ (5%)	P ₂ (10%)	P ₃ (15%)	
g1 (N.350 3.6.2)	59.13	71.16	84.76	88.46	75.88
g2 (N.300 3.6.1)	61.59	72.30	74.97	75.31	71.04
g3 (N.350 3.1.3)	66.46	73.92	79.70	81.66	75.43
g4 (N.350 3.2.2)	62.52	77.00	81.00	83.64	76.04
g5 (N.250 4.5.2)	70.63	72.15	75.49	78.01	74.07
g6 (N.350 3.1.4)	54.92 ab	60.52	62.03 ab	62.84 ab	60.08
g7 (M. 200 1.7.1)	35.22 ab	65.62	71.31	72.14	61.07
g8 (N.250 4.6.2)	49.22 ab	54.32 ab	63.97	69.58	59.27
g9 (N.350 3.8.9)	66.43	68.69	70.19	74.46	69.94
g10(N.200 2.4.B.6)	54.99 a	64.38	62.06 a	65.18 ab	61.65
g11 (N.200 2.5.2)	61.03	72.21	77.16	81.60	73.00
g12 (N.200 2.3.3)	63.81	70.74	73.08	78.12	71.44
g13 (N.300 4.3.6)	45.66 ab	59.45 b	59.93 ab	60.21 ab	56.31
g14 (Nias) (a)	68.88	69.46	72.46	79.47	72.57
g15 (Munal) (b)	65.85	70.31	72.08	76.95	71.30
Average	59.09	68.15	72.01	75.18	
LSD	7.79				

Note: The numbers followed by the same letters in the sub plot column (a, b) indicates significantly different from the comparison varieties of variety Nias (a) and Munal (b) on the LSD test at $\alpha = 0.05$.

The number of spikelet is a vegetative parameter in wheat plants that can be easily observed and is related to the production of wheat crops. The correlation regression test showed that the number of spikelet has no effect on the production yield with the value of 0.01. It is caused by the slight amount of food and the assimilates which will fill the spikelet so that the number of filled

spikelet is less than the number of empty spikelet. This is supported by the opinion of Wahid, Gelani, Ashraf & Foolad, (2007) which states that wheat suffered drought stress (deficit water) impact on assimilating forming process; that will be inhibited as the filling of floret in spikelet is not optimal.

3. Yield

Statistical analysis shows that the interaction of genotype treatment with PEG concentration had a very significant effect on the crop yield. The LSD test in Table 3 shows that genotype 10 (N.200 2.4.B.6) has the highest production and is significantly different from the comparison varieties of variety Nias (a) and Munal (B) and is tolerant to all PEG concentrations.

Table 3. Production of various wheat genotypes on different PEG concentrations.

Genotype	PEG Concentration								Average	
	P ₀ (0%)		P ₁ (5%)		P ₂ (10%)		P ₃ (15%)			
g1 (N.350 3.6.2)	1.26	ab	0.57	S	0.24	S	0.20	S	0.57	S
g2 (N.300 3.6.1)	0.95		0.63	S	0.53	S	0.33	S	0.61	S
g3 (N.350 3.1.3)	0.88		0.59	S	0.35	S	0.19	S	0.50	S
g4 (N.350 3.2.2)	1.23	ab	0.58	S	0.39	S	0.28	S	0.62	S
g5 (N.250 4.5.2)	0.84		0.62	S	0.43	S	0.27	S	0.54	S
g6 (N.350 3.1.4)	2.12	ab	1.36	ab T	1.18	ab T	0.58	M	1.31	ab T
g7 (M. 200 1.7.1)	1.88	ab	0.93	a M	0.50	S	0.40	S	0.93	ab M
g8 (N.250 4.6.2)	2.72	ab	1.90	ab T	1.00	ab T	0.60	M	1.60	ab T
g9 (N.350 3.8.9)	0.71		0.64	S	0.51	S	0.40	S	0.57	S
g10(N.200 2.4.B.6)	2.58	ab	1.70	ab T	1.36	ab T	0.88	ab T	1.63	ab T
g11 (N.200 2.5.2)	1.16		0.83	S	0.47	S	0.34	S	0.70	S
g12 (N.200 2.3.3)	1.03		0.81	S	0.59	S	0.34	S	0.69	S
g13 (N.300 4.3.6)	2.19	ab	1.37	ab T	0.91	ab M	0.70	ab M	1.29	ab T
g14 (Nias) (a)	0.81		0.46	S	0.45	S	0.31	S	0.51	S
g15 (Munal) (b)	0.82		0.65	S	0.45	S	0.24	S	0.54	S
Average	1.42		0.91		0.63		0.40			
LSD	0.37									

Note: The numbers followed by the same letters in the sub plot column (a, b) indicates significantly different from the comparison varieties of variety Nias (a) and Munal (b) on the LSD test at $\alpha = 0.05$; S: Sensitive, M: Medium, T: Tolerance

The condition of drought stress in wheat crop can lead to the faster flowering and harvest ages, of which the early cross flowering and harvest time resulted in the duration of the seed filling which become not optimal and the decrease of seed production per panicle. This is the mechanism of plants in response to the drought stress so that flowering and harvesting age become faster. According to Stapper & Fischer (1985), during the seed filling process the higher temperature affects the faster development of wheat; although the plants are optimally managed, it can decrease to 4% for temperature rise of 1°C at high temperatures due to the seed filling period become very short.

One response to wheat crops suffered drought stress is the increase in the percentage of empty florets. The percentage of empty florets is the number of empty space found in panicles as the accumulation of assimilates that will fill the panicle is not sufficient, this is due to the not optimal process of photosynthesis so that the assimilate is formed slightly, and in the end the percentage of empty floret is greater than the number of seeds per panicle. The percentage of empty florets

in wheat plants is an indicator that wheat crops are tolerant or not to the stress condition. Simmons; Anderson; in Akbar (2016) stated that too low or too high temperature resulting in the number of sterile florets that cannot be fertilized.

The treatment of PEG in the hydroponic solution will hold water component, impacts water uptake by plants and thereby causing drought. According to Levitt, (1980) drought stress is due to a lack of water supply from the root zone and excessive water demand by leaves; where the period of evapotranspiration exceeds the length of water uptake by plant roots. This will impact on the decline in photosynthetic activity, so the amount of assimilates produced decreases and causes the formation of panicles and the filling of seeds will decrease. Oertli (1985) states that the polyEthylene Glycol Compound is able to stimulate the drought stress condition by decreasing the potential of water present in the root environment and resulting in the decrease of hydrostatic pressure in the cell. This is in line with the opinion by Taiz & Zeiger (2002), that drought stress affects plant morphology and decreases crop yield.

D. Conclusion

The genotype of wheat mutant that potentially adaptive with high yield in hydroponic media at the treatment of without PEG, 5%, 10% and 15% PEG concentration, are N.250 4.6.2 and N.200 2.4.B.6. The characters of seed filling and the percentage of empty floret have a positive correlation to the crop yield.

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Genetic Characterization of Galoba Durian (*Amonum* spp.) in Ambon Island Based on Random Amplified Polymorphic DNA (RAPD)

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Abstract

Galoba durian is one of the endemic floras from Maluku. Galoba durian is a species belonging to the *Amomum* genera *Zingiberaceae* family. It is also used as a medicinal plant for waist and kidney diseases. Based on the color of the fruit, galoba durian is divided into two namely red galoba durian and green galoba durian. Distribution of this plant in Ambon can found in a few places such as highland and coastal area. Different locations influence phenotypic of plants, but may not show different genetic characteristic. Genetic diversity can detected by molecular markers. Genetic characterization from galoba durian using RAPD markers has not been done before. This study aimed to analyze genetic diversity from galoba durian using molecular markers RAPD. Samples of plants are used red galoba durian from Hatu and green galoba durian from Hatalae. The result of the first study, characterization of the morphology of the galoba durian, showed that both galoba have almost similar characteristics. Further DNA was tested by qualitative and quantitative. Result shows good qualitative and quantitative of DNA genomic. The second study was amplification by PCR-RAPD. DNA amplifications were performed using 3 primers out of 9 screened random primers. The primers selection was based on high polymorphism. DNA amplification has 36 bands which were 100% polymorphic. The size of each bands from visualization of agarose was determined by linear regression. Number of band amplified was range from 120 to 1612 bp. Polymorphic band of RAPD showed the highest genetic diversity. It can be concluded that the two plants of galoba durian are different species

Keywords: galoba durian, polymorphic, RAPD

A. Introduction

Zingiberaceae is a family of annual herbs classified as germplasm which beneficial as natural herbs, medicinal plants and essential oils (Syamsuardi, Mansyurdin, Nurainas, & Susanti, 2010). *Zingiberaceae* family has several genera, the largest and often exploited genera were *Curcuma*, *Kaempferia*, *Hedychium*, *Amomum*, *Zingiber*, *Alpinia*, *Elettaria* and *Costus* (Sari, Utami, Wiryani, & Perwati, 2012). Among the dispersed family members, some of them are not widely known and are often regarded as wild plants, as in some species in the *Amomum* genus (Syamsuardi *et al.* 2010).

Amomum is one of the largest genera of *Zingiberaceae* family with species ranging from 150-180 species often used as herbs, vegetables and natural herbs (Kaewsri, Paisooksantivarana, Veasommai, Eiadthong, & Vajrodaya, 2007). Some species in this genera have not been widely known like galoba durian (*Amomum* spp.). According to Rumphius (1972), galoba durian is an endemic flora in Maluku. Based on the color of galoba durian fruit divided into red galoba and green galoba. One of the characteristics of the galoba durian is the shape of fruit similar to durian fruit with small size.

Generally, the genetic characterization of an organism occurred as a result of mutations, recombination and migration of genes which cause changes in nucleotide arrangement in DNA, thus affecting the phenotypic properties of the organism (Sembiring, Putri, & Setiada, 2015). Analyzing of genetic characterization of plant varieties is often conducted of morphological characters observation, but it has limitations since it is easily influenced by the environment as well as uneven genetic characterization depending on the ecosystem in its region. The presence of molecular markers has facilitated accurate genome analysis (Yulita, 2013).

RAPD is an amplification method that can produce millions of copies of DNA segments using a single primer selected at random (Anggraeni, 2008). RAPD markers are often used because they have several advantages over other genomic analysis methods, which are faster and easier to perform and analyze, resulting in large amounts of polymorphisms and the itrequired relatively cheaper in cost compared to other methods (Varesa, syamsuardi, Mansyurdin, Maideliza, & Pratiwi, 2011). Nowadays, RAPD method is widely used in the analysis of the characterization of various plants (Prana & Hartati, 2003) and also to identify plant genotypes (Varesa *et al.*, 2011).

Until now there has been no research on genetic characterization of galoba durian (*Amomum* spp.) and it is expected that this genetic characterization information can be used in conservation efforts. The aims of this research was to discover morphological characteristics and genetic characterization of galoba durian (*Amomum* spp.) in Ambon island based on RAPD molecular marker.

B. Methodology

Samples of galoba durian plants were taken from two different locations in Hatalae and Hatu villages. Samples of plants are used red galoba durian from Hatu and green galoba durian from Hatalae.

1. Morphological Characterization

In both locations, descriptions and measurements of vegetative organs were conducted. The observed characters were the length and width of the leaves, the length of the petiole, the diameter of the stem and the height of the plant. The leaf color, leaf stem and the number of leaves were the other characters observed on one individual plant. Plants used as a reference were the highest and lowest plants and some vegetative characters, because the generative character did not exist yet.

2. DNA Isolation

DNA isolation was performed using the Orozco-Castillo method. Samples of galoba leaf were washed and dried with tissue. After that the dried sample were sliced and the bone leaves were removed to facilitate grinding process. Samples of galoba leaves were crushed to the smallest size with mortar and added with liquid nitrogen. Then put 0.1 gram of poly (1-ethenylpyrrolidin-2-one) (PVPP) into the mortar. Followed by adding the liquid nitrogen slowly as the samples were crushed until powdered and continuously done during the grinding process. The crushed samples were weighted approximately 0.1 grams. The eppendorf tube containing the sample was fed into liquid nitrogen. Added 5 mL of extraction buffer and 500 μ L of 1% β -merkptoetanol that had been heated. Then vortexed and incubated for 30 minutes at 65°C. Every 5 minutes the tubes were shaken thus reaction reacted faster. The sample was allowed to cool in an acid cabinet, then

added 5 ml of chloroform solution : isoamethanal alcohol (24 : 1). The sample was centrifuged at 11,000 rpm for 10 min at 25°C. The supernatant was removed, then added 5 mL of chloroform solution : isoamethanol (24 : 1), vortexed and centrifuged at 11,000 rpm for 10 min at 25°C. The supernatant was removed and 1x volume of cold isopropanol was added. The samples were homogenized by moving the tubes back and forth and then stored in refrigerator (4°C) for 30 minutes. After that centrifuged at 11,000 rpm for 10 minutes at 25°C. The supernatant was removed while the obtained pellets were dried. After drying, the pellet was dissolved in 1 mL TE buffer and then stirred. Around 1/10 volume of 3 M Na-Acetate pH 5.2 and 2.5 mL of absolute ethanol were added and stirred until a batch of white DNA fibers appeared. Samples were stored in freezer -20°C for 30 minutes or overnight. The sample was centrifuged at 12,000 rpm for 10 min at 4°C. The obtained supernatant was removed and the pellet was dried. The pellet was washed using 100 µL of 70% ethanol. The mixture was centrifuged at 8,000 rpm for 5 min at 25°C. The supernatant was removed and the pellet was dried in a laminar air flow cabinet. About 30 µL of TE buffer solution were added to dry pellets and homogenized. Approximately 1/10 of the DNA volume RNase was added to DNA. A total of 3 µL of RNase was added and incubated at 37 ° C for 30 minutes. DNA Quantity Test using Nanodrop Spectrophotometer. Absorbance (A) was measured at wavelengths of 230, 260 nm and 280 nm. A260: A280 and A260: A230 ratios were used for DNA purity measurements.

3. DNA Amplification

Total DNA genomes were amplified using random primers. Screening was performed using 9 random primers to obtain primer with high repetition rates and consistent results. The DNA amplification process was pre-denatured for 4 min at 94 ° C, denatured for 30 s at 94 ° C, annealing for 30 s at 36 ° C-65 ° C, 1 minute elongation at 72 ° C and final elongation.

4. Data analysis

DNA ribbon gel photos were analyzed using linear regression to help predict the size of bases, reflecting the genetic characterization between the two species.

C. Result and Discussion

1. Morphological Characterization

Characterization was performed on vegetative characteristics and not performed on generative features (Figure 1). Generative characteristics were not examined because the time of the study had not been in fruit season. Vegetative characteristics were seen in parts of plants which above the soil surface of the leaves and stems.

The morphological observation of the galoba durian plant from both sites showed some differences in the shape and size of plants (Table 1). Galoba durian in the village of Hatalae has a tapering shape leaf tip, total number of leaves is many, plants growing direction tend to curve down and thick leaf sheets texture. Galoba durian in the village of Hatu has taller plant height than galoba durian from Hatalae, tapered shape leaf tip, the number of leaves is few, the leaf size is longer, the width of the narrow leaf, thicker and slightly stiff leaf texture and the plants growing direction tend to up. Both of these plants had almost the same morphological characteristic. One of the factors causing different characteristics of these two plants might be due to environmental conditions. Environmental conditions in Hatalae village are more humid and shaded, located at an altitude of 230 m above sea level, 25 ° C and has humus soil type. While the environmental conditions in the village Hatu are humid, galoba durian growing unshaded, at an altitude of 54 m above sea level, temperature 27 ° C and has laterite soil type which is red soil. Differences topography and environmental conditions at both locations affect the phenotypic of galoba durian. According to Sudomo & Wuri (2013), environmental factors affecting the phenotypic and plant growth conditions such as cardamom can grow well at 630-703 m altitude, 24-28°C temperatures, acid pH 4.87-5.9 with clay soil texture. Furthermore, it also affects the genetic characterization of the galoba durian. Environmental influences on plant growth and phenotypes cause morphologically inefficient identification to examine genetic characterization (Oktavia, Lasminingsih, & Kuswanhadi, 2009).



Figure 1. Galoba Durian

Table 1. Morphological characteristics of Galoba Durian in Hatalae and Hatu villages.

Character	Locations	
	Hatalae	Hatu
Color of leaf sheet	Dark green	Dark green
Tip of leaf sheet	Tapering	Tapered
Base of leaf sheet	Blunt	Blunt
Texture of leaf sheet	Thick	Thick
Length of leaf sheet (cm)	17.9-52.5	3-58.7
Width of leaf sheet (cm)	2.6-10.5	1.7-17.1
Number of leaves	18-49	77-21
Stem color	Light yellow	Light yellow
Length of stem (cm)	0.5-0.7	0.4-0.5
Diameter of stem (cm)	1-2.2	1.3-3
Plants height (cm)	151.5-384	55-340
Plants growing direction	Curve down	Up

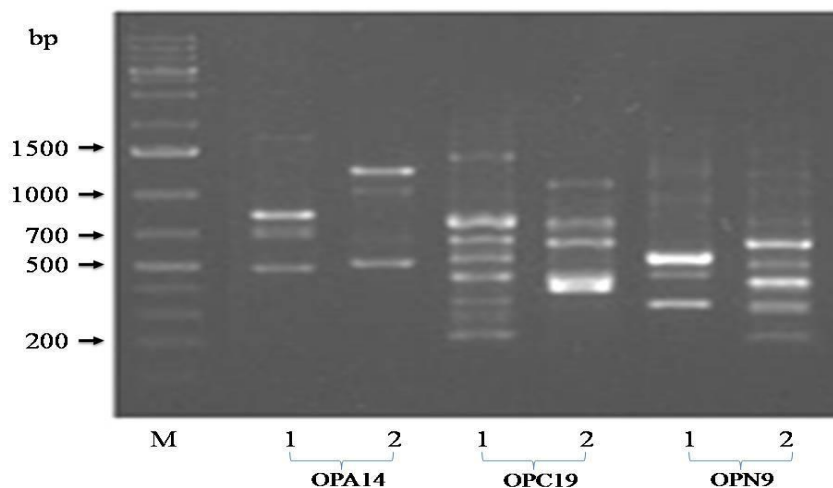


Figure 2. Electroferogram result of DNA amplification using 3 types of primer (M) DNA Lambda Marker sample of green galoba durian in Hatalae (1) and sample of red galoba durian in Hatu (2) which electrophorized using 1% Agarose Gel.

From nine primary RAPDs used were selected three primers which had high band polymorphism result. PCR results were electrophorized using 1.5% agarose gel. The visualization results can be seen in Figure 2. The galoba durian DNA bands that appear on the gel were varied on each primer. The band variation occurs due to many sites attach between primary and DNA genome. The primer selection for the analysis affects the level of polymorphic band result. The

more random primers used the more varied the pattern and size of the fragments obtained (Palupi, 2010). The highest number of bands were generated by OPC19. This means that the OPC19 primer has a complementary base pair with genome DNA thus it has more attachment sites.

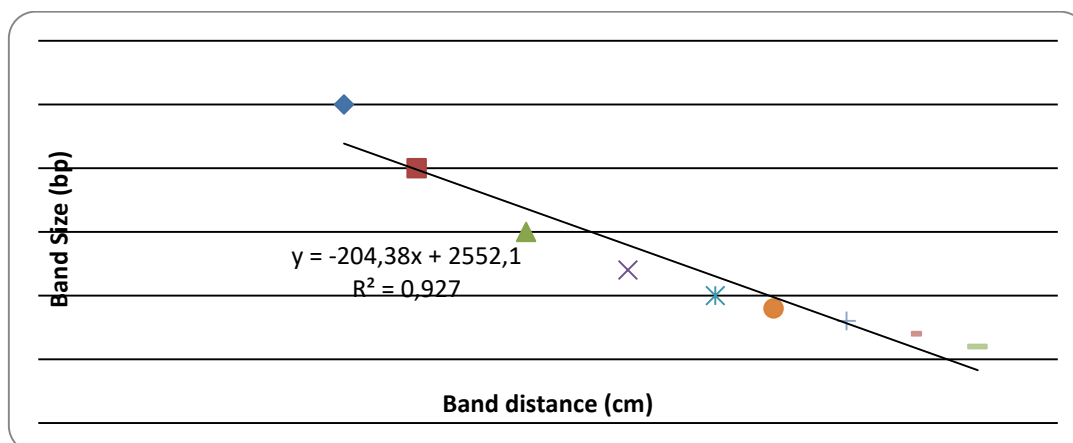


Figure 3. Linear Regression Equation

Table 2. Polymorphic DNA bands of green and red galoba durian samples on each primer

Primer type	Sequence 5-3'	Band size (bp)	Number of bands		Number of resulting bands
			Monomorphic	Polymorphic	
OPA14	TCTGTGCTGG	651-1612	0	8	8
OPC 19	GTTGCCAGCC	161-1469	0	13	13
OPN 9	TGCCGGCTTG	120-1489	0	15	15
Total number of bands					36

To help analyze the resulting band pattern, linear regression analysis was used. Linear regression is one of the methods used to estimate the relationship between independent and dependent variables. The linear regression model parameters consist of simple and multiple properties forming curves with straight lines (Yusnandar, 2004). Using linear regression (Figure 3) yielded 36 polymorphic bands, with band sizes ranging from 120 to 1612 bp (Table 2). The number of bands generated from OPN9 primers is higher than that of OPA14 primers and OPC19 primers. OPN9 produces 15 bands ranging from 120-1489 bp, while OPA14 produces 8 bands and OPC19 produces 13 bands.

The amplification results of both types of galoba durian indicated that all bands were produced 100% polymorphic, there was no monomorphic bands of the three primers were presented. The high percentage of polymorphic obtained suggested high levels of genetic characterization. Genetic characterization may occur since there are genetic variations of genetic arrangement and genotype interaction with the environment (Anggraeni *et al.*, 2008). Geographical conditions affect the phenotype of plants. Samples of galoba durian leaves were taken from two different locations, namely in the highland (Hatalae village) and coastal area (Hatu village). Several studies had succeeded in showing the relationship of six curcuma species using two RAPD primers which resulted in 86% polymorphic presentation on OPC4 primers and 48% on OPC7 (Donipati & Sreeramulu, 2015). Ikhwan (2014) also said that the number of primers that can amplify the DNA of maniram and local cardamom is 15 of 20. The fifteenth primers had succeeded in amplifying DNA and both plants indicating the presence of polymorphism. The number of DNA bands was produced 182 with the number of polymorphic loci was 164 and the number of monomorphic locus was 18.

The result of DNA bands profile analysis of green and red galoba durian leaves from two locations indicated different species thus it could be concluded that there was a high genetic diversity among the galoba durian plants.

2. Morphological Characterization and Amplification Results

The results of morphological characterization and amplification analysis indicated different results. Both galobadurian plants had similar phenotypical appearance and showed few different traits. DNA amplification produced polymorphic bands. The polymorphic level has showed the

high genetic characteristic between green and red galoba durian. The results show that the phenotypic appearance of both galoba durian plants were not different but genetically they were different hence there was high genetic characterization. Genetic characterization among species is an important aspect for the conservation and utilization of germplasm (Matondang, 2000). High genetic characterization can also be used as breeding materials (Kristamtini, Taryono, Basunanda, & Murti, 2014). This study indicates that both species of galoba durian are important for conservation and can be used as prospective selected resources in the plant crosses breeding process.

D. Conclusion

The morphological characterization of both galoba durian plants had similar appearance. The amplification of galoba durian DNA using three RAPD primers produced 36 polymorphic bands. This indicates that both galoba durian plants were genetically different. Similar morphological but has differed genetically, so both of galoba durian is a difference species.

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Determination of Selection Criteria for Tomato (*Solanum lycopersicum* L.) Yield Component in the Lowland Based on Path Analysis

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Abstract

The shifting of tomatoes cultivation from upland to lowland led to a significant decrease of tomatoes production, particularly on tomatoes varieties which are not able to adapt to lowland. Genotypes selection based on appropriate selection criteria is the most effective method to obtain tomatoes genotypes with high production in the lowland. The aim of this study was to determine appropriate selection criteria in the lowland based on high heritability value, high phenotype and genotype correlation to production component, and character relationship closeness with production component through path analysis. This study used a randomized block design with three replications. Selection criteria was chosen based on high heritability value, significant correlations in phenotype and genotype and its high direct impact on fruit weight per plant which were the number of fruits per plant and weight per fruit characters

Keywords: heritability, lowland, path analysis, selection criteria, tomatoes

A. Introduction

The average tomatoes production in Indonesia is still low arounds 6.3 ton/ha compared to Taiwan and India which are 21 ton/ha and 9.5 ton/ha, respectively. One of the reasons behind low tomato production in Indonesia is unsuitable varieties for specific environmental conditions. Most varieties of tomatoes are suitable only to be cultivated in the upland, thus yield and quality of the fruits produced become very low if cultivated in unsuitable environment such as lowland (Wijayani & Widodo, 2005).

Tomatoes cultivation in Indonesia is grown in upland with percentage of 60% while the remaining 40% in lowland. The average yield of tomato crops in lowland is about 6.0 ton/ha while in upland may reach 26.6 ton/ha (Purwati, 2007). Purwati (2009) reported that yield of tomato hybrid adaptive to lowland and upland grown on medium land (550 m asl) was only 1.95 kg plant⁻¹, while the yield potential could reach 3 kg plant⁻¹ or 35% decrease in yield. Well adapted varieties in both medium land to upland grown in the medium land showed decrease in yield from 4-5 kg plant⁻¹ to 1.95 kg plant⁻¹ or 50-60%. Whereas, if these varieties are cultivated in the upland (800 m asl), it can achieve yield around 5.32 kg plant⁻¹ (Soedomo, 2012).

The shifting of tomatoes cultivation area to lowland led to the risk of decreasing quality and fruit production. Lowland high temperatures impact fruit ripening and fruit growth rate of tomatoes (Adams, Cockshull & Cave, 2001). Increased temperatures of 2-4°C from optimum temperatures affect gametes development and inhibit fruit formation thereby decreasing tomatoes production (Peet, Willits, & Gardner, 1997; Sato, Peet, & Gardner, 2001; Firon, Shaked, Peet, Pharr, Zamski, Rosenfeld, Althan, & Pressman, 2006).

The yield performance (production) is a complex character which is greatly influenced by yield component characteristics. Yield and the components characters are controlled by many genes whose expression is strongly influenced by the environment (Wirnas, Widodo, Sobir, Trikoesoemaningtyas, & Sopandie, 2006). The development of high-yielding varieties can be made through direct selection of the yield performance or indirect selection through several other characters related to yield performance (Falconer & Mackay, 1996). Indirect selection or simultaneous selection to improve yield based on index selection will be more efficient compare to selection by one character or two characters combinations (Moeljopawiro, 2002)

In order to perform simultaneous selection, the used character for selection criteria must be chosen based on heritability value and closeness relationship to the desired character (Yunianti, Sastrosumarjo, Sujiprihati, Surahman, & Hidayat, 2010; Mustafa, Syukur, Sutjahjo, & Sobir, 2017). Using the selected characters, it can be compiled to create effective selection index. In this study the relationship between yield character with other characters is known through correlation analysis and path analysis. The study aimed to select yield component characters based on the correlation, cross-coefficient, and heritability thus it can be used to develop selection index for the yield performance of 30 tomato populations in the lowland.

B. Methodology

The research was conducted in March-August 2012. Seedling was carried out in Plant Breeding Laboratory, Faculty of Agriculture, Bogor Agricultural University. Field planting was done at Leuwikopo Experimental Field of Bogor Agricultural University.

The material used was 30 tomato genotypes collection of Tomato Breeding Team, Plant Genetics and Breeding Section, Department of Agronomy and Horticulture, Bogor Agricultural University (Table 1). Those genotypes originated from several locations in Indonesia and Bogor Agricultural University collections. The experiment was carried out using Completely Randomized Design (CRD) with single factor of tomato genotype consisting of 30 genotypes with three replications.

Activity implementation began with seeding. Watering was done every day in the morning. Fertilization was conducted once a week after seeds were two weeks old since seedling using NPK fertilizer (16:16:16) with water concentration of 10 g l⁻¹ applied by leaching at seedlings base. Cultivation activity against plant-disturbing organisms attack were carried out when the attack symptoms on seedbed were seen by spraying pesticides.

Planting was conducted after tomatoes seeds were 30 days old since seedling. Garden plot was made with size of 5 m × 1 m for each experimental unit with spacing of 50 cm each. Furthermore, each plot was given 20 kg of manure and 0.5 kg of calcium. After calcium and manure addition for two weeks, the plot was covered with silver black plastic mulch then hole was made with distance of 50 cm x 50 cm. Planting was done in the afternoon with one plant per planting hole. Seeds embroidery was conveyed a week after planting. Crop maintenance conducted include watering,

fertilizing, giving pesticides, and weeding. Weeding was carried every once a week after the plants (WAP) were a week old since planting (1 WAP) using NPK fertilizer (16:16:16) with concentration of 10 g l⁻¹ around 250 ml plant⁻¹. Pesticide spraying was conducted every two weeks using active Mancozeb 80% or Propinep 70% with concentration of 2 g l⁻¹, insecticide made of active Profenofos 500 g l⁻¹ with concentration of 2 ml l⁻¹ and miticide containing active ingredient Dikofol with concentration of 2 ml l⁻¹. Weed control was done manually. Harvesting activities conducted when fruit criteria was yellow reddish. Harvesting was done every two times in a week for five weeks.

Table 2. List of genotypes used in this study

No	Genotype	Name/Originated	Fruit Characteristics
1	IPBT1	Intan/Balitsa Lembang	Round big fruit
2	IPBT3	G1-K/IPB	Round small
3	IPBT4	Pointed PSPT/IPB	Medium fruit (pointed)
4	IPBT6	SSH 3/IPB	Round medium
5	IPBT8	4974/IPB	Round medium fruit
6	IPBT13	Karina/PT. BCA	Round medium fruit
7	IPBT21	Mawar/PT.BCA	Rose type fruit
8	IPBT23	Rampai/PT.BCA	Round small
9	IPBT26	Kaliurang	Round big fruit
10	IPBT30	SSH 9/IPB	Round small
11	IPBT33	SSH 10/IPB	Round small
12	IPBT34	M4-HH/IPB	Round medium
13	IPBT43	Bogor1/IPB	Round small
14	IPBT53	Bogor2/IPB	Round small
15	IPBT56	Medan3	Medium, slightly oval, pointed
16	IPBT57	Medan4	Small fruit
17	IPBT58	Bukit Tinggi1	Round medium
18	IPBT59	Bukit Tinggi2	Round small
19	IPBT60	Kediri	Round medium
20	IPBT63	Brastagi3	Tomato fruit, big slightly oval
21	IPBT64	Papua2	Round medium
22	IPBT73	Maros 1	Rose type fruit
23	IPBT74	Maros 2	Medium, oval
24	IPBT78	Maros 6	Tomato fruit, big slightly oval
25	IPBT80	Mantero/PT.BCA	Round medium
26	IPBT82	Fatma/CV.One Tani	Round medium, pointed
27	IPBT83	Ratna/Panah Merah	Tomato fruit, medium, slightly oval
28	IPBT84	Dellana/Cv.Laksmi	Medium, slightly oval
29	IPBT85	Palupi/CV.Enno CoSeed	Medium fruit, sightly oval
30	IPBT86	Roma/Denmark	Rose type fruit

The characters observed in this study were plant height (cm), stem diameter (mm), leaf length (cm), leaf width (cm), day to Flowering (dap), day to harvesting (dap), fruit length (cm), diameter (cm), fruit size (mm), fruit flesh thickness (mm), number of locules (locule), fruit hardness (kg cm⁻¹), water content of fruit (%), total soluble solids (°brix), number of fruits per plant (fruit), weight per fruit (g), fruit weight per plant (g).

C. Result and Discussion

1. Heritability

Characters showing high broad-sense heritability value are leaf length, leaf width, fruit length, fruit diameter, fruit size, fruit flesh thickness, number of locules, fruit hardness, number of fruits per plant, weight per fruit, weight per plant and fruit cracking index. While characters with

moderate heritability value are flowering age, harvest age, total soluble solid and water content of fruit (Table 2).

Tabel 2. Nilai Heritabilitas beberapa karakter tomat

Karakter	h ² _{bs}	Kriteria	Karakter	h ² _{bs}	Kriteria
Plant height	0.76	high	Fruit flesh thickness	0.82	high
Leaf length	0.75	high	Number of locules	0.97	high
Leaf width	0.75	high	Total soluble solids	0.35	Moderate
Day to flowering	0.39	Moderate	Fruit hardness	0.70	high
Day to harvesting	0.41	Moderate	Water content of fruit	0.38	Moderate
Fruit length	0.92	high	Number of fruit per plant	0.85	high
Fruit diameter	0.91	high	Weight per fruit	0.93	high
Fruit size	0.89	high	Weight per plant	0.62	high

h²_{bs}: Broad sense heritability

Traits of characters used as selection criteria are high heritability estimate value and correlate significantly with fruit rupture index. Heritability estimate value can be employed to select the characters for selection criteria (Tenaya, Setiamihardja, Baihaki, & Natasasmita, 2003; Lestari, Dewi, Qosim, Rahardja, Rostini, & Setiamihardja, 2006). Heritability estimate value with high criteria can be directly used as selection character in the early generations (Hadiati, Murdaningsih, Baihaki, & Rostini, 2003; Sudarmadji, Mardjono, & Sudarmo, 2007). Several studies on tomatoes indicated high heritability value for the character of number of flowers per cluster (El-Gabry, Solieman, & Abido, 2014), the number of locules (Li, Li, & Wang, 2007), and the number of fruits per cluster (Hanson, Chen, & Kuo, 2002). High broad-sense heritability indicate that the observed characters are strongly controlled by genetic factors than environmental factors, the genetic variation expressed in plant phenotypic appearance.

2. Phenotype-Genotype Correlation

The phenotype-genotype correlation shows the closeness relationship between characters as presented in Table 3. The result of phenotypic correlation analysis indicated that fruit diameter, number of locules, number of fruits per plant and weight per fruit were positively and significantly correlated to fruit weight per plant. Total soluble solids and fruit hardness were negatively and significantly correlated to fruit weight per plant. Genotype correlations tended to show similar result except for fruit hardness and harvest age. Fruit hardness was significantly correlated to phenotypic weight per plant yet genetically not correlated, while harvest age was phenotypically not correlated with weight per fruit yet significantly genetically correlated. Characters of fruit diameter, number of locules, total soluble solids, number of fruits per plant and weight per fruit showed similar result which was significantly correlated to to weight per fruit in phenotype and genotype.

Positively correlated characters indicate that the addition of these characters will increase fruit weight per plant and vice versa, the addition of negatively correlated characters will decrease fruit weight per plant. It shows that genotypes with heavier weight per plant can be seen from genotypes with large fruit diameter, large number of locules, low total soluble solids, low fruit hardness, higher fruit per plant and heavier weight per fruit. Improvement of these characters will increase tomatoes weight per plant. This finding is supported by Wahyuni (2014) and Saputra (2014) studies that fruit diameter, number of locules, total soluble solids, number of fruits per plant and weight per fruit were significantly correlated to fruit weight per tomato plant. According to Hussien (2014), the character heavily correlated to fruit weight per plant (yield) is weight per fruit. According to Islam, Ivy, Rasul, & Zakaria, (2010), characters positively correlated to tomato yield per plant are number of fruits per plant, fruit length, fruit diameter, and fruit weight per plant.

3. Path Analysis

High correlation only shows the closeness of relationship between characters yet can not show cause-and-effect relationship (Yunianti *et al.*, 2010). Path analysis can be used to identify cause-and-effect relationship and sort them into direct and indirect effects (Roy, 2000). Based on path analysis results (Table 4), characters with great direct effect on weight per plant were number of fruits per plant and weight per fruit with direct effect of 0.532 and 0.456, respectively. Fruit size,

total soluble solids, and fruit hardness have negative direct effect which indicates that indirect effect is the cause of the correlation (Singh & Chaudhary, 1979).

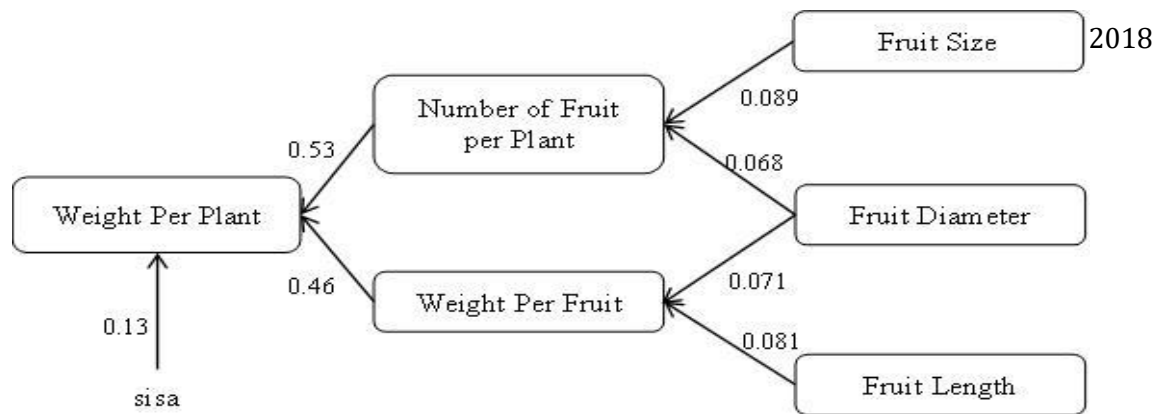


Figure 1. Path diagram of several characters on tomatoes weight per plant

Efforts in determining the characters which can be used as effective selection criteria may be seen from the magnitude of direct effect of fruit weight per plant, correlation between characters with fruit weight per plant and deviation of correlation between independent characters with its direct effect on fruit weight per small plant. If those three characters are fulfilled then the characters will be very effective as selection criteria (Yunianti *et al.*, 2010). Based on this determination, the characters contributed to greatest direct effect and total of small indirect effect were the number of fruits per plants and weight per fruit. The relationship path scheme with fruit weight per plant is presented in Figure 1. Based on heritability value, correlation coefficient and cross coefficient, the characters can be used as selection criteria for resistance to fruit weight per plant were the number of fruits per plant and weight per fruit. Characters affecting weight per plant through the number of fruits per plant were fruit size and fruit diameter, while through weight per fruit was fruit diameter and fruit length. Hussien (2014) and Islam *et al.* (2010) reported similar finding that the characters of number of fruits and weight per fruit in tomato plants have great direct effect on tomato production.

D. Conclusion

Selection criteria based on high heritability value, significant phenotypic-genotype correlation and having high direct effect on fruit weight per plant were the number of fruits per plant and weight per fruit.

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Table 3. Phenotype and genotype correlation among character with weight per plant

Character	PH	LL	LD	DF	DH	FL	FD	FZ	FT	NL	TSS	FH	WC	NFP	WF	WP
PH	1	-0.11 ^{ns}	-0.25*	0.16 ^{ns}	-0.17 ^{ns}	-0.11 ^{ns}	0.39**	0.13 ^{ns}	0.00 ^{ns}	0.48**	0.05 ^{ns}	0.13 ^{ns}	0.06 ^{ns}	-0.20 ^{ns}	0.24*	0.20 ^{ns}
LL	0.08 ^{ns}	1	0.85**	0.15 ^{ns}	0.35**	0.56**	0.06 ^{ns}	0.41**	0.50**	-0.41**	0.25*	0.20 ^{ns}	-0.21*	-0.36**	0.28*	-0.18 ^{ns}
LD	-0.02 ^{ns}	0.97**	1	0.09 ^{ns}	0.27*	0.47**	-0.07 ^{ns}	0.29*	0.50**	-0.43**	0.16 ^{ns}	0.21 ^{ns}	-0.20 ^{ns}	-0.20 ^{ns}	0.15 ^{ns}	-0.11 ^{ns}
DF	0.43*	0.76**	0.67**	1	0.41**	0.47**	0.20 ^{ns}	0.43**	0.39**	-0.14 ^{ns}	0.19 ^{ns}	0.30**	-0.21 ^{ns}	-0.33**	0.37**	-0.01 ^{ns}
DH	0.29 ^{ns}	0.81**	0.67**	0.98**	1	0.55**	0.27*	0.52**	0.37**	-0.21 ^{ns}	0.25*	0.27*	-0.27*	-0.45**	0.44**	-0.16 ^{ns}
FL	0.08 ^{ns}	0.78**	0.69**	0.76**	0.76**	1	0.32**	0.86**	0.80**	-0.39**	0.33**	0.39**	-0.43**	-0.69**	0.54**	-0.12 ^{ns}
FD	0.65**	0.38*	0.22 ^{ns}	0.22 ^{ns}	0.63**	0.48**	1	0.76**	0.43**	0.65**	-0.06 ^{ns}	0.00 ^{ns}	-0.02 ^{ns}	-0.59**	0.71**	0.38**
FZ	0.38*	0.69**	0.55**	0.80**	0.80**	0.92**	0.84**	1	0.78**	0.08 ^{ns}	0.19 ^{ns}	0.27*	-0.31**	-0.79**	0.76**	0.12 ^{ns}
FT	0.19 ^{ns}	0.76**	0.71**	0.75**	0.70**	0.92**	0.61**	0.91**	1	-0.22**	0.16 ^{ns}	0.28*	-0.41**	-0.62**	0.46**	-0.02 ^{ns}
NL	0.63**	-0.27 ^{ns}	-0.33 ^{ns}	0.06 ^{ns}	0.04 ^{ns}	-0.30 ^{ns}	0.68**	0.15 ^{ns}	-0.13 ^{ns}	1	-0.25*	-0.28*	0.34**	-0.04 ^{ns}	0.25*	0.49**
TSS	0.39*	0.77**	0.66**	0.99**	0.95**	0.74**	0.49**	0.71**	0.65**	-0.04 ^{ns}	1	0.40**	-0.22*	-0.33**	0.16 ^{ns}	-0.38**
FH	0.25 ^{ns}	0.48**	0.55**	0.71**	0.70**	0.66**	0.32 ^{ns}	0.59**	0.61**	-0.20 ^{ns}	0.72	1	-0.37**	-0.31**	0.23*	-0.28*
WC	0.36*	0.57**	0.51**	0.87**	0.91**	0.41*	0.52**	0.50**	0.42*	0.25 ^{ns}	0.90**	0.44*	1	0.29 ^{ns}	-0.25*	0.07 ^{ns}
NFP	-0.22 ^{ns}	-0.49**	-0.29 ^{ns}	-0.57**	-0.80**	-0.78**	-0.66**	-0.91**	-0.72**	-0.04 ^{ns}	-0.67**	-0.46*	0.47**	1	-0.72**	0.37**
WF	0.26 ^{ns}	0.34 ^{ns}	0.15 ^{ns}	0.58**	0.67**	0.58**	0.76**	0.82**	0.51**	0.24 ^{ns}	-0.36*	0.33 ^{ns}	-0.41*	-0.81**	1	0.34**
WP	0.26 ^{ns}	-0.35 ^{ns}	-0.31 ^{ns}	-0.17 ^{ns}	-0.43*	-0.18 ^{ns}	0.47**	0.13 ^{ns}	-0.06 ^{ns}	0.62**	-0.64**	-0.33 ^{ns}	0.15 ^{ns}	0.47*	0.41*	1

*: significant, **: highly significant, ^{ns}:Not Significant, PH: Plant Height, LL: Leaf Length, LD: Leaf width, DF: day to flowering, DH: day to harvesting, FL: fruit length, FD: fruit diameter, FZ: fruit size, FT: fruit flesh thickness, NL: Number of locules, TSS: total soluble solids, FH: fruit hardness, WC: water content of fruit, NFP: number of fruit per plant, WF:weight per fruit, WP:weight per plant. Phenotype correlation value: upper right diagonal, genotype correlation value : lower left diagonal.

Table 4. Direct and indirect influence of each character on weight per plant

Character	Direct Effect	FL	FD	FZ	FT	NL	TSS	FH	NFP	WF	Total
FL	0.327		0.023	-0.059	0.000	-0.026	-0.020	-0.019	-0.121	0.081	0.186
FD	0.218	0.023		-0.035	0.000	0.029	0.003	0.000	-0.068	0.071	0.240
FZ	-0.211	-0.059	-0.035		0.000	-0.003	0.007	0.008	0.089	-0.073	-0.305
FT	-0.002	0.000	0.000	0.000		0.000	0.000	0.000	0.001	0.000	-0.001
NL	0.201	-0.026	0.029	-0.003	0.000		0.009	0.008	-0.004	0.023	0.236
TSS	-0.183	-0.020	0.003	0.007	0.000	0.009		0.011	0.033	-0.014	-0.153
FH	-0.148	-0.019	0.000	0.008	0.000	0.008	0.011		0.024	-0.016	-0.131
NFP	0.532	-0.121	0.068	0.089	0.000	-0.004	0.032	0.024		-0.175	0.446
WF	0.456	0.081	0.071	-0.073	0.000	0.023	-0.014	-0.016	-0.175		0.353

FL: fruit length, FD: fruit diameter, FZ: fruit size, FT: fruit flesh thickness, NL: Number of locules, TSS: total soluble solids, FH: fruit hardness, NFP: number of fruit per plant, WF: weight per fruit.