Research article

Genetic Parameters of Inodorus Melon Lines (Cucumis Melo L.) Based on a Smart Farming Hidroponic System

Bambang Supriyanta[1]*, Indah Widowati[1], Frans Richard Kodong[2], and Ananda Safitri[1]

[1]Faculty of Agriculture, Universitas Pembangunan Nasional “Veteran” Yogyakarta, Indonesia
[2]Faculty of Industrial Technology, Universitas Pembangunan Nasional “Veteran” Yogyakarta, Indonesia

ORCID
Bambang Supriyanta https://orcid.org/0000-0001-9962-7222

Abstract.
The focus of this research was to determine the growth and yield of several melon lines in generation S3, as well as to estimate the genetic variants, morphologies, and yield heritability. A randomized design was used, which consisted of a single factor with four replications. Six melon lines from generation S3 were used, namely DS-1-1-4, DS-1-1-10, DS-1-1-11, DS-1-2-10, DS-1-2-17, and DS-1-3-3, for a total of 24 experimental units. There were ten plants in each experimental unit. The smart farming hydroponic system was used. Plant height, stem diameter, male and female flowering, horizontal and vertical fruit girth, pulp thickness, fruit weight, and total soluble solids were the parameters measured. The data were analyzed using analysis of variance and the genetic parameter was estimated by analyzing the genetic coefficient of variation and broad sense heritability. Except for plant height, the results showed that all of the characteristics had a low genetic coefficient of variation. Plant height two weeks after planting showed high broad sense heritability (84.56%), as did pulp thickness (77.89%), female flowering (75.83%), male flowering (74.65%), plant height three weeks after planting (66.25%), and plant weight (50.81%). Plant height, male and female flowering, vertical fruit girth, and fruit weight were best represented by the DS-1-2-10 lines.

Keywords: Melon lines, genetic parameters, smart farming, heritability.

Corresponding Author: Bambang Supriyanta; email: bambangsg2@gmail.com

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1. Introduction

Melon (*Cucumis melo* L.) is a horticultural commodity that has high economic value. Melon is much in demand by the public because of the sweet taste of its flesh. Melon contains many nutrients, for instance, vitamins A, K, C, B-6, E, and niacin, as well as the minerals calcium, potassium, ferum, magnesium, phosphorus, sodium, and zinc. Melon contains low sodium and potassium as essential nutrients and does not contain fat [1]. Melon also contains adenosine which is useful for preventing blood clots and carotenoids which function as antioxidants [2].

Melon plants have any variation of fruit characters. The varietion of fruit characters consists of size, shape, skin and flesh color, the texture of fruit flesh, sweetness level, and aroma. One of melon fruit types is inodorus which has a smooth fruit skin without a mesh and it colors white or yellow [3]. Inodorus melon fruit shapes round to oval. The flesh of inodorus melon type has a crunchy texture and it colors green or orange.

Hybrid melons have the dominance which they have the same shape and the quality and high growth capability. One of the attempts to obtain hybrid variety is through the formation of plant lines. It aims to attain plant populations with homogenous peculiarities. Plant traits can be known through the estimation of the genetic parameters, so it is adequate for determining the direction, method, and target to be achieved through plant breeding activities. It becomes effective with the estimated value of genetic parameters [4].

Heritability in a broad sense is the proportion of genotype variance compared to phenotypic variance. The high heritability value in a broad sense (h^2_{bs}) indicates that the genotype variance is relatively larger in controlling a character compared to the phenotypic variance. If the heritability value in the broad sense is low, the character appearance is more influenced by environmental variety, so that the improvement of the character through plant breeding has not been effective [4].

Hydroponics is a method of cultivating plants without using soil media and plant nutrient needs are met by nutrient solutions [2]. Smart farming is a future agricultural concept, the application of the *Internet of Things* in agriculture can ease the monitoring and remote control of the conditions of planting media and plant growth automatically and it is on a scheduled basis through web pages [5]. The utilization of hydroponics based on a smart farming system in melon cultivation is expected to increase plant growth and yield. Research needs to be done which can support the effectiveness of estimating the genetic parameters of melon plants which are related to the application of a hydroponic culture system based on smart farming.

2. Methodology

The tools used were hoe, shovel, nursery tray, stationery, raffia rope, ladder, sprayer, knife, scissors, bucket, roll meter, caliper, refractometer, digital scale, bricks, sticky trap, TDS (Total Dissolved Solids) meter, pH meter, PVC pipe, PE hose, water tower (*toren*) with 300 and 2000liter capacity, water pump, fertigation hose, misting hose, nozzle misting, iron stem, microclimate sensor, *Habibi Dose* and *Habibi Grow* equipment.

Meanwhile, the materials utilized in this research were the seeds of 6 lines S3 generation melon, namely DS-1-1-4, DS-1-1-10, DS-1-1-11, DS-1-2-10, DS-1-2 -17, and DS-1-3-3. Other stuffs were planter bag, cocopeat, husk charcoal, compost, AB mix fertilizer, trichoderma, neem leaf vegetable pesticide, carbofuran, propineb, and small rope.

This research was a field experiment conducted in the CV greenhouse. *Agroniaga* or Market of Agriculture Products used a single factor Completely Randomized Design (CRD) with four replications. The levels employed were 6 lines of S3 generation melon fruits, consisting of DS-1-1-4 (A), DS-1-1-10 (B), DS-1-1-11 (C), DS-1-2 -10 (D), DS-1-2-17 (E), and DS-1-3-3 (F). Each experimental unit consisted of 10 plants.

Parameters observed included plant height and stem diameter which were observed and measured when the plants were 2 and 3 WAP (Weeks After Planting), the flowering age of stamen (male flower), the flowering age of pistil (female flower), horizontal circumference, vertical circumference, flesh thickness, fruit weight, and sweetness level.

3. Result and Discussion

Table 1: Mean Plant Height (PH) at The Age of 2 and 3 WAP (cm).

Lines	Mean	
	PH 2 WAP	PH 3 WAP
DS-1-1-4	39,74 c	113,41 b
DS-1-1-10	51,66 b	120,99 b
DS-1-1-11	27,25 c	95,00 b
DS-1-2-10	95,24 a	190,41 a
DS-1-2-17	54,00 b	128,42 b
DS-1-3-3	44,58 b	118,58 b

Note: The numbers in each column followed by the same letter indicate that there is no significant difference according to the Scott-Knott test at 5% level.

Table 1 shows that the result of plant height analysis in all lines increases at the observation of plants aged of 3 WAP (Weeks After Planting). The plant height of the DS-1-2-10 Lines is significantly higher than the other lines, namely 95.24 cm at the age of 2 WAP and 190.41 cm at the age of 3 WAP. Height growth in plants is related to elongation and cell division events. Height growth occurs within the intercalary meristems of the internodes. The segment lengthens as a result of the increasing number and enlargement of the cells [2].

Note: The numbers in each column followed by the same letter indicate that there is no significant difference according to the Scott-Knott test at 5% level.

TABLE 2: Mean of Stem Diameter (SD) at Ages 2 and 3 WAP (cm).

Lines	Mean	
	SD 2 WAP	SD 3 WAP
DS-1-1-4	0,94 a	1,25 a
DS-1-1-10	0,92 a	1,27 a
DS-1-1-11	0,82 a	1,18 a
DS-1-2-10	0,81 a	1,25 a
DS-1-2-17	0,83 a	1,21 a
DS-1-3-3	1,00 a	1,36 a

Table 2 indicates that there is no significant difference between the lines in the stem diameter parameters at the age of 2 and 3 WAP. Therefore, this case reveals that all the lines have strong stems so that they have the opportunity to produce heavier fruit weights. The larger the diameter of the stem, the greater the xylem as a carrier of nutrients and water from the soil proceeds in more nutrients and water from the soil. As a result, the quantity of photosynthesis is getting higher which causes an increase in the formation of flowers and fruit [6].

TABLE 3: Mean Age of Flowering of Male (AFM) and Female (AFF) Flowers (days).

Lines	Mean	
	AFM	AFF
DS-1-1-4	23,75 a	30,00 a
DS-1-1-10	20,25 b	27,75 b
DS-1-1-11	25,50 a	30,50 a
DS-1-2-10	16,50 c	24,25 c
DS-1-2-17	23,50 a	28,25 b
DS-1-3-3	21,50 a	27,75 b

Note: The numbers in each column followed by the same letter indicate that there is no significant difference according to the Scott-Knott test at 5% level.

Table 3 points out that there are significant differences between the lines on the age of the flowering of stamen (male flower) and pistil (female flower). The DS-1-2-10 Lines has a male flowerage of 16.5 days after planting (DAP) and a female flowerage of 24.25 DAP which was significantly more mature than the other lines. The sooner the flowers appear, the faster the melon harvest will be. Each Lines has a different generative growth time which can be influenced by the genetic composition of each Lines so that the flowering time is also different. The differences in genetic composition are one of the factors causing the diversity of plant appearances. The genetic differences of each line will be expressed in various plant traits that include the form and function of the plant so as to produce a diversity of plant growth [7].

TABLE 4: Mean Horizontal Circumference (HC) and Vertical Circumference (VC) (cm).

Lines	Mean	
	HC	VC
DS-1-1-4	42,81 a	45,17 a
DS-1-1-10	44,40 a	45,83 a
DS-1-1-11	42,03 a	43,15 b
DS-1-2-10	43,91 a	48,03 a
DS-1-2-17	38,96 b	42,05 b
DS-1-3-3	40,91 b	41,35 b

Note: The numbers in each column followed by the same letter indicate that there is no significant difference according to the Scott-Knott test at 5% level.

Table 4 presents that the DS-1-1-10 Lines with a horizontal circumference of 44.4 cm is significantly larger than the other lines, but not significantly different from the DS-1-2-10, DS-1-1-4, and DS-1-1-11 stains. Meanwhile, the vertical circumference of the DS-1-2-10 Lines, which measures 48.03 cm, is significantly larger than the other lines but not significantly different from the DS-1-1-10 and DS-1-1-4 lines. Melon fruit circumference can be determined by the number of fruits per plant and the interaction between genetic and environmental factors [8].

TABLE 5: Average Thickness of Fruit Flesh (cm).

Lines	Mean
DS-1-1-4	3,52 c
DS-1-1-10	4,28 a
DS-1-1-11	3,71 b
DS-1-2-10	3,94 b
DS-1-2-17	3,09 d
DS-1-3-3	3,84 b

Note: The numbers in each column followed by the same letter indicate that there is no significant difference according to the Scott-Knott test at 5% level.

The mean flesh thickness data shown in Table 5 indicates that the DS-1-1-10 lines with 4.28 cm flesh thickness is undoubtedly thicker than the other lines. The thickness of the flesh is one of the characteristics of the quality of the melon. The thickness of the fruit flesh can be caused by the number of fruit maintenances per plant, the maintenance of one fruit per plant produces fruit with a greater flesh thickness than the maintenance of two fruits per plant. The maximum accumulation of photosynthate in the fruit can boost the thickness of the flesh, which means the thicker the flesh, the greater the weight of the fruit will be [9].

Table 6: Average Fruit Weight (g).

Lines	Mean
DS-1-1-4	1319,65 a
DS-1-1-10	1429,82 a
DS-1-1-11	1189,78 b
DS-1-2-10	1436,85 a
DS-1-2-17	981,21 b
DS-1-3-3	1134,41 b

Note: The numbers in each column followed by the same letter indicate that there is no significant difference according to the Scott-Knott test at 5% level.

The result of the analysis in the Table 6 explains that the DS-1-2-10 lines with a fruit weight of 1436.85 g is significantly larger than the other lines, but not significantly different from the DS-1-1-10 and DS-1-1-4 lines. The DS-1-2-10 Lines is expected to produce more photosynthate than the other lines. Fruit weight is the net result of the photosynthesis process so that it can affect the quality and quantity of a plant [10]. The decrease of assimilation due to respiration and translocation can affect the production of a plant. The greater the fruit weight of a plant indicates that the productivity of the plant is also greater [11].

Table 7: Average Sweetness Level (brix).

Lines	Mean
DS-1-1-4	12,79 a
DS-1-1-10	12,66 a
DS-1-1-11	12,58 a
DS-1-2-10	11,33 a
DS-1-2-17	13,00 a
DS-1-3-3	13,00 a

Note: The numbers in each column followed by the same letter indicate that there is no significant difference according to the Scott-Knott test at 5% level.

Table 7. The Average of Sweetness Level. The level of sweetness is one of the quality determinants of melon. Table 7 implies that there is no important difference between the lines on the character of the sweetness level. This case occurs because the accumulation of sucrose depends on the expression of the genotype and environmental factors. The genotype expresses the sweet flesh taste as a result of the high sucrose accumulator of metabolic processes. Meanwhile, the environment plays a role in influencing genotype expression during the period of sucrose accumulation. If the period of sucrose accumulation raises, there will be an increased sugar in the fruit [10].

Table 8: Estimated Values of Genetic Parameters.

Variable	$\sigma^2 g$	$\sigma^2 p$	%CGV	%AGP	$\%h^2_{bs}$
PH 2 WAP (cm)	514,93	608,91	43,56 s	46,43 t	84,56 t
PH 3 WAP (cm)	946,5	1428,5	24,07 s	22,71 t	66,25 t
SD 2 WAP (cm)	0,0028	0,015	6,01 r	2,96 r	18,17 r
SD 3 WAP (cm)	0,00013	0,014	0,91 r	0,11 r	0,91 r
AFM (days)	9,39	12,58	14,03 r	14,05 t	74,65 t
AFF (days)	4,53	5,97	7,57 r	7,64 ct	75,83 t
HC (cm)	3,16	6,73	4,22 r	3,35 ar	47,02 s
VC (cm)	4,39	12,49	4,73 r	3,25 r	35,19 s
TF (cm)	0,15	0,19	10,51 r	10,74 t	77,89 t
FW (gr)	25,976	51,131	12,91 r	10,66 t	50,81 t
LS (brix)	0,2003	0,97	3,56 r	1,87 r	20,61 s

Note : PH = Plant Height, SD = Stem Diameter, AFM = Flowering Age of Male Flowers, AFF = Flowering Age of Female Flowers, HC = Horizontal Circumference, VC = Vertical Circumference, TDB = Thickness of Flesh, BB = Fruit Weight, TK = Level Sweetness, $\sigma^2 g$ = Genetic Variance, $\sigma^2 p$ = Phenotypic Variance, CGV= Coefficient of Genetic Varian, h^2_{bs} = Heritability in the broadest sense, EGP= Expected Genetic Progress, r = low, ar = moderately low, s = moderate, ct = moderately high, t = high

Table 8 displays the estimated value of the genetic parameters of all the characters in the used lines. The calculation of the coefficient of divergence is utilized to estimate the level of divergence between populations in certain characters. The criteria for the coefficient of genetic divergence are 0-25% (low), 25-50% (medium), 50-75% (high), and >75% (very high) [12]. The results of the analysis of the coefficient of genetic divergence for all characters in each Lines obtain a value that is classified as low, except for the character of plant height at 2 and 3 WAP (Weeks After Planting), which is allocated as moderate. A low coefficient of genetic divergence means that the divergence of characters is narrow. The narrowness of the coefficient of genetic divergence indicates that the genetic background of the characters in the tested lines has a close relationship with the observed characters [13].

The analysis of the expected genetic progress on the observed characters with a selection intensity of 30% shows varied results. The intensity of the selection is determined based on the number of samples taken in each experimental unit. The criteria for the Coefficient of Genetic Expectancy (CGE) are 0 < CGE 3.3% (low), 3.3% < CGE 6.6% (somewhat low), 6.6% < CGE 10% (enough high), and CGE >10% (high) [14]. Plant characters that have high CGE values are plant height at 2 WAP (46.43%) and 3 WAP (22.71%), the flowering age of male flower (14.05%), flesh thickness (10.74%), and fruit weight (10.66%). The estimated value of the expected genetic progress reflects how much a character will increase if one selection cycle is applied to the population. A high predictive value of CGE indicates that the selection to be carried out on the population will be effective and efficient, whereas if the predictive value of genetic progress is low, it indicates that if the selection is carried out on the population, the selection activity has not been effective and efficient [4].

Analysis of heritability in the broad sense of each character in the observed lines earns varied values. The heritability value in a high-broad sense is in the character of plant height at 2 WAP (84.56%), fruit flesh thickness (77.89%), female flower age (75.83%) and male flower (74.65%), plant height at 3 WAP (66.25%), and fruit weight (50.81%). Research on heterosis and heritability on the character and yield of melons attains heritability values in a broad sense which are determined as high, namely on the characters of plant height, flowering age, flesh thickness, and fruit weight [15]. The heritability value in a broad sense is used to estimate the size of the genetic and environmental, which can influence the visible plant characters. If the genetic influence affects a character, the greater the heritability value will be higher. However, if the environmental influence is greater, then the heritability value will be lower [4].

The characters of horizontal and vertical circumference, also the fruit sweetness level have heritability values in a broad sense, which are classified as moderate. This case can be provoked by an increased environmental temperature during the fruit enlargement process. High temperatures lead to greater evapotranspiration so that the plants become deprived of water and nutrients [2]. The addition of potassium at fertilization can increase the sweetness of the fruit [16], while excess nitrogen can reduce the quality of melons, namely reducing the level of sweetness, increasing the fruit cavity, and reducing the thickness of the flesh [17].

Based on the analysis results of variance, the DS-1-2-10 Lines has the characteristics of plant height, flowering age of male flower (staminate), flowering age of female flower (pistillate), vertical circumference, and fruit weight that are superior to other lines. On the other hand, some of these characters have heritability values in terms of high broad sense, except for the vertical circumference character. A character that has high heritability estimation is more effective in selecting due to the genetic factors have a greater influence on the appearance of a character. A trait that is more controlled by genetic factors will be very likely to be passed on to their offspring, but for traits that are controlled by environmental factors, it cannot be passed on to their offspring. S3 generation plants are plants which seeds all come from S2 generation plants - which is a very essential generation. Segregation can occur in the S3 generation if the selected S2 plant turns out to be heterozygous [18].

4. Conclusion

The coefficient of genetic divergence of plant height characters aged 2 and 3 WAP is moderate, while other characters are low in the S3 generation melon lines observed. The heritability value in a broad sense is high, which is the character of plant height at 2 WAP (84.56%), fruit flesh thickness (77.89%), female flower age (75.83%) and male (74.65%), plant height at 3 WAP (66.25%), and fruit weight (50.81%). The DS-1-2-10 Lines has the greatest yield on the characters of plant height, early-ripening period of male and female flowers, vertical circumference, and fruit weight.

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