Phenotypic Characters Stability of Melon (*Cucumis melo* L. 'Kinaya')

Amir Muhammadi[1] Budi Setiadi Daryono[2,*]

[1,2]*Laboratory of Genetics and Breeding, Faculty of Biology, Universitas Gadjah Mada*
[*]*Corresponding author. Email: bs_daryono@mail.ugm.ac.id*

ABSTRACT
Melon is an important commodity in Indonesia and still dominated by imported melons such as Action 434 andSun Lady. The 'Kinaya' cultivar is a crossbreed between 'Kinanti' and 'Sonya' cultivars. The development of 'Kinaya' cultivar as indonesian superior local melon is needed to improve the quality of local melons in order to compete with imported melons. This study examines the stability and uniformity of the phenotypic characters of 'Kinaya' F_3 and F_4 compared to 'Kinanti' and 'Sonya' to support the development of 'Kinaya'' as a superior local melon cultivar. The planting was carried out from August 2019 to October 2020 at Mutihan and Kebondalem Greenhouses, Madurejo Village, Sleman Regency, Special Region of Yogyakarta. The phenotypic data were collected at the Genetics and Breeding Laboratory, Faculty of Biology, Gadjah Mada University. The methods ofqualitative and quantitative phenotypic data collection refer to IPGRI. From this research it can be concluded that 'Kinaya' F_3 melon has different phenotypic characters from 'Kinanti', 'Sonya' and 'Kinaya' F_4 melon on stem color, leaf color, flowering age, fruit type, fruit shape, fruit skin color, fruit skin texture and flesh color. 'Kinaya' F_3 and 'Kinaya' F_4 cultivars have low phenotypic variation and high character stability (83,72%).

Keywords: *Cucumis melo L. 'Kinaya', Characters, Phenotypic*

1. INTRODUCTION

One of the important agricultural commoditiesin Indonesia is melon (*Cucumis melo* L.). Melon known as an exotic fruit and had an expensive price because of its sweet taste, fragrant aroma, rich infiber, minerals, beta carotene and vitamin C [1]. Melon farmers prefer to cultivating imported melons like 'Action 434', 'Sun Lady' and 'Glamour', or bought the seeds from countries such as Thailand, Australia and Malaysia. Itmakes Indonesian melon farmers depends on the availaibility of imported melons from Japan, Korea, and Taiwan even though it's quite fluctuating and expensive.

Kinaya' is a new crossbreed cultivar between 'Kinanti' and Sonya' cultivars. Kinaya has orange color flesh, sweet, oval shape and netted skin [2]. The breeding obstacle are, there are phenotypic variations, that makes intergenerational reproduction results are unstable. This cause differences in phenotypic characteristic between generations so the superior melon characters may no longer appear in the next generation of planting. The occurrence of phenotypic variation wasobserved through morphological characters.

This study aims to find out the phenotypic characters stability of 'Kinaya F_3' compared to'Kinaya F_4', 'Kinanti' and 'Sonya'. This research is expected to provide additional information regarding the stability of the phenotypic characters of the 'Kinaya' cultivar to support the development of the 'Kinaya' melon cultivar as a new superior local melonin Indonesia.

Research on melon breeding that has been carried out previously includes research on genetic variation and uniformity of Hikapel and Meloni melons through the ISSR [3], and research on the stability of the phenotypic and molecular characters of Melonia melon through the ISSR [4]. From the two studies, the value of character stability between varieties was found in the range of 80%-96%. Plant breeding methods can be carried out by means of selection from a population of natural products,

crosses, chromosomal polyploidization, mutation and genetic engineering [5]. The stages in plant breeding begin with; (1) germplasm collection, (2) characterization, (3)selection, (4) expansion of genetic diversity by hybridization, mutation, protoplast fusion, and genetic engineering, (5) selection after expansion of genetic diversity, (6) evaluation and testing, and (7) release of varieties and propagation [6].

2. MATERIALS AND METHODS

2.1. Research Time and Location

This research was conducted from August 2019 to October 2020. 'Kinaya F_3' was planted in Mutihan Greenhouse, Madurejo Village, Sleman Regency, Special Region of Yogyakarta in August 2019. 'Sonya', 'Kinanti' and 'Kinaya F_4' were planted in the Kebondalem Greenhouse, Madurejo Village, SlemanRegency, Special Region of Yogyakarta in February 2020. 'Kinaya F_4' as additional data were planted in the Kebondalem Greenhouse in July 2020. The population size used is 100 plants in each variety. Phenotypic data withdrawal was collected at Genetics and Breeding Laboratory, Faculty of Biology, UGM.

2.2. Tools and Material

The Planting materials are as follows: commercial seeds of cultivar F1 hybrid 'Kinanti' (PT.Tunas Agro Persada). Seeds of F1 hybrid cultivar 'Sonya' (PT. Bisi International Tbk). 'Kinaya' F_3 and F_4 seeds (Genetics and Breeding Laboratory, Faculty of Biology UGM). Insecticides (Dencis, Proclin and Methindo), Fungicides (Daconyl, Detaint, Saromil, and Mentz), Organic fertilizers, NPK fertilizer (Mutiara), Za, and water for irrigation. The tools used in this study are: medline, plastic ruler, digital camera, RHS color chart, 5kg scale, refrctometer, oven, analytic scale.

2.3. Methods

The seeds sprouted for 2-4 days until it's radicle appears, then it's transferred to small polybags mix with fertilizer soils for 7 -10 days, then transferred to Greenhouse [7]. Plants watered every 2 days for the first 2 weeks of planting with 500mL of water. Fertilization is carried out afterthe age of 1 week old DAP (Day After Planting) using NPK fertilizer around 6.67 kg/ha [8]. Cutting lateral branches on trunk segments 1-7is done every 3 days. Melon leaf samples were taken at 3-4 weeks DAP, taken from the 3rd to 5th stem segments of each plant. Harvesting is done after 70-80 DAP or more. Phenotypic character data were taken at 45 DAP and4 days after the fruit was harvested.

Phenotypic character data retrieval was included qulitative and quantitative data according to IPGRI and Permentan 01/ Pert/SR.120/2/2006 Article 14 [9]. The Qualitative data such as: stem base's color, crosssection shape, leaves color, leaves shape, corolla's color, stamen's color, stigma head's color, flower petal's color, flower's shape, fruit skin color, fruit skin texture, fruit texture, fruits type, fruit's flavour, pulp's texture, pulp's color, sheed's shape andsheed's color. The quantitative data such as: diameter of the base of the stem, leaf blade leng, leaf width, number of fruits, fruit weight, fruit length, fruit's top diameter, fruit's bottom diameter, fruit's horizontal circumference, fruit's vertical circumference, fruit'shorizontal diameter, fruit's vertical diameter, thick fruit skin, pulp thickness.

3. RESULTS AND DISCUSSION

Kinaya is a new local melon developed by the Faculty of Biology UGM through Gama Melon research team. Kinaya were born from a cross between Kinanti melons produced by PT. Tunas AgroPersada with Sonya melons assembled by PT. Benihinti Suburintani. The development method of Kinaya is artificial cross (artificial hybridization). Kinaya has been developed since 2019 and now is at the 4th generation (Fig. 1).

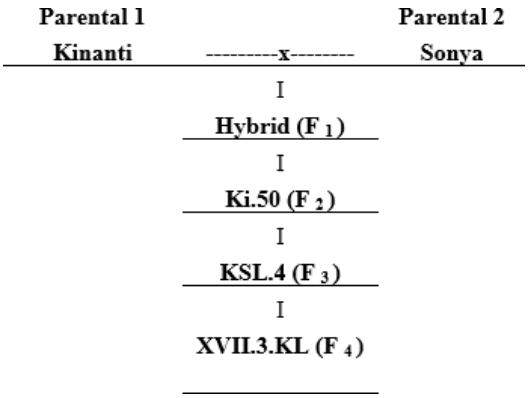

Figure 1. Development scheme of new Kinaya varieties from Kinanti and Sonya.

Both greenhouses have similar characteristics due to their close proximity. The height differences only 1 meter, according to Google Maps data. Kinayageneration F_3 was planted from August until October 2019 in relatively hot weather. The average Greenhouse temperature is 25.45^0C with relative humidity about 77%. Rainfall level is very low in average 0.4mm for 3 months of planting. The plants get a lot of sunlight with light average of 8 hours per day [10]. Greenhouse conditions at thetime are presented in Table 1.

According to data from the Meteorology, Climatography and Geophysics Agency (BMKG), the dry season for the southern part of Boyolali, southeastern Magelang, northern Klaten, central and southern Sukoharjo, and northern Sleman begins in the first-third week of May 2019 and reaches its peak in August 2019.

In the same area, therainy season in 2019-2020 begins in the third week of October to the second week of November and reaches the peak of the rainy season in January 2020 [11].

Table 1. Melon's planting Greenhouse condition.

Location	Kab. Sleman, DI. Yogyakarta	Kab. Sleman, DI. Yogyakarta
Time	August - October 2019	February - April 2020
Altitude	115 Mdpl	114 Mdpl
Latitude	7.80S, 110.51 E	7.78S, 110.46 E
Temperature	25.45 ^{0}C	26.67 ^{0}C
Humidity	77 %	85.4 %
Rainfall	0.4 mm	16 mm
Light	8 hours	5 hours

3.1. Phenotype Character Analysis Results

Characters such as leaf color, stem color, and flower color have many changes and difference intergenerations, although it's just a little. These changes can be caused by random mutations or environmental influences because phenotypiccharacters are the result of the genetic material expression that interacts with environmental factors [12].

Based on the observations (Table 2), it is known that the stem cross-sectional characters (cylindrical), leaf shape (Triangularis), additional characters (trichomes), sex expression (Andromonocious), flower shape (rotate), male flower crown color (RHS 9A), male flower petal color (RHS 143C), female flower petal color (RHS 144A), pistil and stamen color (RHS 7B) in Kinanti, Sonya, Kinaya F_3 and Kinaya F_4 melons, there were no significant differences between those varieties.

Melon Kinaya F_3 and Kinaya F_4's stem color characters derived from Sonya melon (RHS 139D). The leaf color character of Kinaya F_3 (RHS 137B) can be caused by the color distortion of the leaf color character inherited from Kinanti melon that is RHS 139B. Color changes in adjacent ranges can occur due to environmental influences such as light intensity or lack of certain nutrients [13].

Differences in flowering age of each variety canbe caused by differences in genetic variation in each variety and the performance of flowering hormones which are influenced by several factors such as temperature and light intensity obtained by a plant. Plant pruning known

Table 2. The habitus phenotypic characters comparation.

No	Phenotypic Character		Cultivars			
			Kinanti*	Sonya*	Kinaya F 3 *	Kinaya F 4 *
1	Stem color		RHS 143B	RHS 139D	RHS 139D	RHS 139D
2	Rod cross section		*Astigmatism*	*Astigmatism*	*astigmatism*	*Astigmatism*
3	Leaf shape		*Triangular*	*Triangular*	*Triangular*	*Triangular*
4	Leaf color		RHS 139B	RHS 143A	RHS 137B	RHS 139B
5	Additional characters		Trichome	Trichome	trichome	Trichome
6	Gender expression		*Andromonocious*	*Andromonocious*	*Andromonocious*	*Andromonocious*
7	Flower shape		*Rotate*	*Rotate*	*Rotate*	*Rotate*
8	Male crown color		RHS 9A	RHS 9A	RHS 9A	RHS 9A
9	Female crown color		RHS 9A	RHS 7A	RHS 9A	RHS 9A
10	Male petal color		RHS 143C	RHS 143C	RHS 143C	RHS 143C
11	Female petal color		RHS 144A	RHS 144A	RHS 144A	RHS 144A
12	Stamen color		RHS 7B	RHS 7B	RHS 7B	RHS 7B
13	Pistil head color		RHS 7B	RHS 7B	RHS 7B	RHS 7B
14	Flowering age	Hst	35 hst	37 hst	37 hst	35 hst
15	Harvest age	Hst	70 hst	68 hst	80 hst	80 hst
16	Rod length	Cm	343.4 ± 60.04 ^{a}	374.2 ± 61.07 ^{a}	388.4 ± 59.79 ^{a}	346.8 ± 33.65 ^{a}
17	Rod diameter	Cm	1.04 ± 0.05 ^{b}	1.04 ± 0.05 ^{b}	0.94 ± 0.05 ^{a}	1.02 ± 0.04 ^{b}
18	Circumference of the stem	Cm	3.28 ± 0.22 ^{b}	3.18 ± 0.13 ^{b}	2.86 ± 0.15 ^{a}	3.10 ± 0.12 ^{b}
19	Number of laterals branches		26.2 ± 2.77 ^{a}	25.6 ± 2.70 ^{a}	26.6 ± 1.67 ^{a}	24.2 ± 0.83 ^{a}
20	Leaf length	Cm	15.00 ± 0.15 ^{b}	15.10 ± 0.20 ^{b}	13.94 ± 0.13 ^{a}	15.04 ± 0.13 ^{b}
21	Leaf width	Cm	18.72 ± 0.90 ^{a}	20.50 ± 0.50 ^{b}	18.46 ± 0.75 ^{a}	19.80 ± 0.83 ^{b}

can stimulate flower formation by inhibiting the formation of secondary branches, so the photosynthesis results are widely used for flower forming. Flowering is also strongly influenced by flowering hormones fluctuations [14].

Kinaya melon is an andromonocious plant, so it has male and hermaphrodite flowers. Most melons are andromonocious plants [6]. Andromonocious plants are more efficient in pollination and one of the evolutionary forms of modern flowers. The pollination process in this study was assisted by humans because the pollination process with human assistance could improve the fruit quality, in soursop fruit it is known that plants pollinated with human assistance produce better fruit with an oval shape and not grooved [15].

The quantitative data was calculated with One Way ANOVA. The correlation coefficient (cc) used at 5% level: data results interpretation be at 95% confidence level with 5% error standart [16]. Based on the data results obtained: The stem length character values in Kinanti, Sonya, Kinaya F_3 and Kinaya F_4 melons were not significantly different. The characters of the stem diameter, stem circumference and leaf length were divided into two groups where Kinanti, Sonya, and Kinaya F_4 melons were being in the same group and significantly different from Kinaya F_3. Based on the results, we can conclude that on the related character, Kinaya F_3 melon has the most different characters value compared to the other melon, this is caused by diferentation in the location and time of planting.Kinaya F_3 melon was planted at Greenhouse 2 mutihan in August-October (dry season), while the others are planted in the Madurejo Greenhouse inFebruary-April (rainy season).

The number of lateral branches in all types of melon did not differ significantly, this is because the character of the number of lateral branches is a stable character so there is not many differences in each type of melon. The leaf width characters of Kinanti and Kinaya F_3 are in the same group, while Sonyaand Kinaya F_4 melons are in

Table 3. Fruits and seeds phenotypic character comparation.

No	Phenotypic Character		Cultivars			
			Kinanti	Sonya	Kinaya F 3	Kinaya F 4
1	Fruit type		*Non-aromatic Inodorus*	*Non-aromatic Reticulatus*	*Non-aromatic Reticulatus*	*Non-aromatic Reticulatus*
2	Fruit shape		*Ovate*	*Globular*	*Ovate*	*Ovate*
3	Fruit skin color		RHS 15A	RHS 136A	RHS 12A	RHS 12A
4	Skin texture		Plain	With *net*	With *nett*	With *net*
5	Fruit flesh texture		Crunchy	Crunchy	Crunchy	Crunchy
6	Flash color		RHS 22D	RHS 24B	RHS 24D	RHS 24D
7	Seed shape		*Ellipse*	*Ellipse*	*Ellipse*	*Ellipse*
8	Seed color		RHS 164C	RHS 164C	RHS 164C	RHS 164C
9	Shelf life	Day	22 hsp	20 hsp	22 hsp	22 hsp
10	Penducle attachment diameter	Cm	1.34 ± 0.11 ^{ab}	1.58 ± 0.21 ^{b}	1.08 ± 0.13 ^{a}	1.34 ± 0.26 ^{ab}
11	Diameter of the rest of the pistil	Cm	0.48 ± 0.10 ^{a}	1.20 ± 0.15 ^{b}	0.66 ± 0.05 ^{a}	1.40 ± 0.20 ^{c}
12	Fruit weight	Gram	834.0 ± 100.89 ^{a}	888.0 ± 98.33 ^{a}	814.00 ± 82.64 ^{a}	900.00 ± 140.53 ^{a}
13	Fruit length	Cm	18.26 ± 1.23 ^{a}	18.66 ± 2.30 ^{a}	17.56 ± 1.12 ^{a}	19.14 ± 2.56 ^{a}
14	Fruit horizontal diameter	Cm	10.76 ± 1.06 ^{a}	11.48 ± 1.38 ^{a}	10.80 ± 0.75 ^{a}	11.98 ± 1.55 ^{a}
15	Fruit vertical diameter	Cm	12.10 ± 0.74 ^{a}	12.28 ± 1.17 ^{a}	11.60 ± 0.65 ^{a}	12.60 ± 1.94 ^{a}
16	Horizontal circumference of fruit	Cm	33.82 ± 3.34 ^{a}	36.08 ± 4.36 ^{a}	33.92 ± 2.38 ^{a}	37.64 ± 4.90 ^{a}
17	Vertical circumference of fruit	Cm	36.14 ± 2.98 ^{a}	37.32 ± 4.17 ^{a}	35.18 ± 2.10 ^{a}	38.58 ± 5.33 ^{a}
18	Fruit skin thickness	Cm	0.30 ± 0.01 ^{a}	0.34 ± 0.05 ^{ab}	0.44 ± 0.05 ^{b}	0.40 ± 0.14 ^{ab}
19	Thick flesh	Cm	2.34 ± 0.05 ^{a}	2.58 ± 0.13 ^{b}	2.98 ± 0.29 ^{c}	3.04 ± 0.08 ^{c}
20	Fruit sweetness level	^{0} Brix	9.2 ± 0.83 ^{a}	8.4 ± 1.67 ^{a}	8.60 ± 0.89 ^{a}	8.80 ± 0.83 ^{a}
21	Number of seeds		245.80 ± 58.69 ^{a}	307.60 ± 71.17 ^{a}	254.20 ± 67.84 ^{a}	315.40 ± 111.32 ^{a}
22	Weight per 100 dry seeds	Gram	8.74 ± 2.07 ^{a}	10.96 ± 2.51 ^{a}	9.06 ± 2.40 ^{a}	11.22 ± 3.97 ^{a}

another group, it's because Kinaya F_3 leaf width character is closer to Kinanti melon's character, while Kinaya F_4 closer to Sonya. The significant differences that occur between the Kinaya F_3 and Kinaya F_4 phenotypic characters can indicate that the Kinaya traits have not been passed down perfectly stable because they are still changing between generations. More crossbreedingand population selection activities are needed in order to obtain stable and unchanging superior characters melon. It takes at least 7 crossings (up to F_7) beforea character start to become stable and no longer segregate.

Based on Table 3, known that Kinaya is a melon with non-aromatic fruit character. Kinaya has no strong aromas like aromatics melon for example Hikapel or GMP. Non-aromatic properties are inherited from both parents (Kinanti and Sonya). Kinaya melon's fruit is reticulatus or has a nett, which is derived from the character of Sonya. Kinaya (F_3 and F_4) fruit shape is ovate, inherited from Kinanti fruit shape, even though previously Kinaya has a globular shape because of segregation, but the one used for development in this research is the one with ovate shape.

The skin color of the Kinaya melon is RHS 12A close to the color of the Kinanti melon RHS 15A, the color is the result of the interaction between the colors of the Kinanti fruit and Sonya so that a greenish yellow color is produced. The flesh color of Kinaya melon is RHS 24D more similar to Kinanti melon (RHS 22D) than the Sonya melon (24B), although the color is slightly darker. The texture ofthe flesh (crisp), the shape of the seeds (ellipse), andthe color of the seeds are generally the same, but the shelf life of the fruit is different. Sonya melons havea relatively shorter shelf life (20 days) than Kinanti and Kinaya melons. Differences in shelf life can be influenced by various factors such as storage temperature, humidity, sun exposure, and air circulation [3].

Based on the ANOVA analysis, we know that the penducle attachment characteristics of Kinanti and Kinaya F_4 melons were not significantly different from Sonya and Kinaya F_3 melons. There were no significant differences in the character offruit weight, fruit length, horizontal diameter of fruit, character of vertical diameter of fruit, character of horizontal and vertical circumference of fruit, level ofsweetness of fruit, number of seeds, and weight of 100 dry seeds in the four types of melon. The skin thickness character of Kinanti melon was significantly different from Kinaya F_4, but not significantly different from Sonya and Kinaya F_3. Kinanti melons and Sonya melons differed significantly in flesh thickness, but Kinaya F_3 and Kinaya F_4 melons did not differ significantly in these characters, this could be because Kinaya F_3 and Kinaya F_4 were relate closer more than their parental relationships.

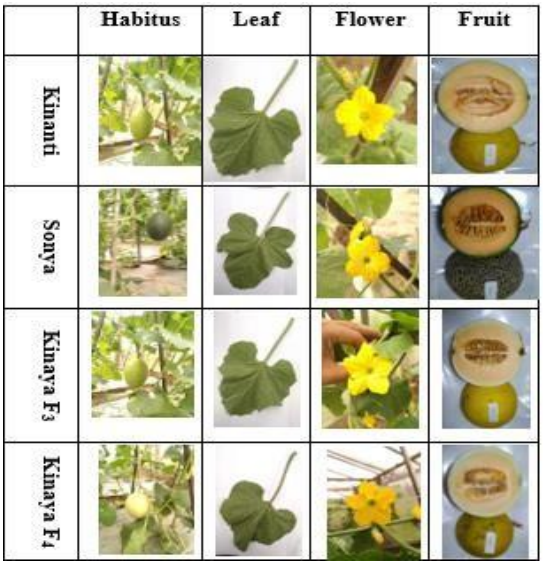

Figure 2. Habitus characters comparation. (Personal documentation, 2019).

Table 4. Similarity comparison based on phenotypic character traits.

Between	Number of similar traits			Number of different traits			Similarity (%)
	Quantitative	Qualitative	Total	Quantitative	Qualitative	Total	
Kinaya F3 x Kinya F4	14	22	36	5	2	7	83,72
Kinaya F4 x Kinanti	16	18	34	3	6	9	79,07
Kinaya F4 x Sonya	17	16	33	2	8	10	76,74
Kinaya F3 x Kinanti	15	16	31	4	8	12	72,10
Kinaya F3 x Sonya	13	17	30	6	7	13	69,76
Kinanti x Sonya	16	13	29	3	11	14	67.44

Based on Table 4, Melon 'Kinaya' F_3 and 'Kinaya' F_4 are known to have the greatest similarity of phenotypic characters, namely 83.72%, it isbecause 'Kinaya' F_3 and 'Kinaya' F_4 are one variety butonly different generations so the differences is not too much. There are several differences between 'Kinaya' F_3 and 'Kinaya' F_4 indicating that the phenotypic characteristics of 'Kinaya' melon as a variety have not been inherited stably and still experiencing some segregation (Fig. 2).

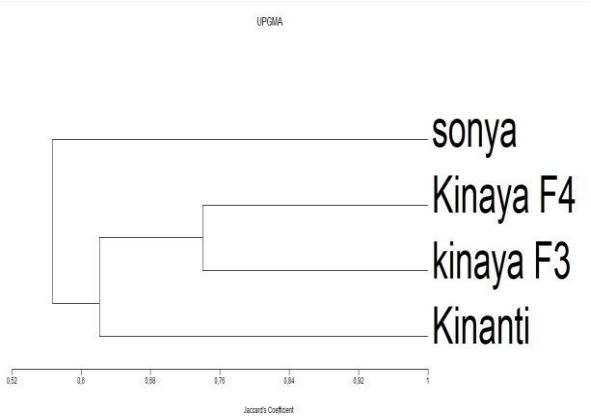

Figure 3. Construction of the Kinanti, Sonya, Kinaya F_3 and Kinaya F_4 melon dendograms using the Multi Variate Statistical Package (MVSP).

The second largest similarity index (79.07%)was held between the 'Kinaya' melon F_4 and the 'Kinanti' melon, its indicates that phenotypically, the 'Kinaya' F_4 melon is lean similar to the 'Kinanti' melonthan the 'Sonya' melon. The similarity index between 'Kinaya' melon F_3 and 'Kinanti' melon (72.10%) was also greater than the similarity to 'Sonya' melon (69.76%), its indicates that phenotypically 'Kinaya' melon F_3 is more similar with melon 'Kinanti' compared to melon 'Sonya'. Phenotypic characters arethe result of the expression of genotypic characters and their interactions with the environment. The magnitude of the similarity index of phenotypic characters between 'Kinaya' F_3 and 'Kinaya' F_4 melonsand 'Kinanti' melons in general can indicate that the phenotypic characters of 'Kinaya' melons (which can be observed) were obtained from 'Kinanti' melons compared to melons. 'Sonya' (Fig. 3)zf.

Based on the results of this study, Kinaya F3and Kinaya F4 have fairly stable characters with a similarity level of 84.72%. The high similarity of characters between generations of Kinaya indicates that the phenotypic traits of Kinaya melon have been passed down between generations quite stable.

However, for the development of Kinaya melon into a cultivar suitable for mass production, it must be selected again until the seventh generation so that its characteristics do not change when replanted. For this reason, it is necessary to conduct further researchrelated to the stability of the character of the next generation of Kinaya melon.

Based on the results, several conclusions can be drawn as follows:

a. 'Kinaya' F3 melon has different phenotypic characters from 'Kinanti', 'Sonya', and 'Kinaya' F4 melon on stem color (RHS 139D & RHS 143B), leaf color (RHS 137B & RHS 139B,RHS 143A), flowering age (37 DAP & 35 DAP), harvest age (80 DAP & 68-70 DAP),fruit type (reticualtus & inodorus), fruit shape (ovate & globular), fruit skin color (RHS 12A &RHS 15A, RHS 136A), fruit skin texture (nett and plain), and flesh color (RHS 24D & RHS 22D, RHS 24B).

b. Kinaya F3 and Kinaya F4 cultivars have lowfenotipic variation and high character stability (83,72%)

AUTHORS' CONTRIBUTION

AM conducted the research, data analysist and wrote the manuscript, BSD supervised the research

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