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Diversity among timunsuri accession and their cucumis relative in Indonesia

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Timunsuri is a plants that has been widely cultivated in Java. Timunsuri has a fairly high mineral content. The content 100 g fruit consists 1008 mg of potassium, 768 mg of calcium, and 422 mg of phosphorus. Timunsuri also contains other nutrients such as vitamin C 24.86%, fiber 0.8%, fat 0.04%, protein 1.3%, and carbohydrates 2.08%. In addition to the content that has been mentioned, Timunsuri has taste a sweet, fresh taste, smooth flesh, and distinctive aroma. Based on the content and characteristics of a typical fruit, timunsuri plants can be a superior commodity if managed properly. The source of high diversity can produce one or several potential genotypes to be developed. Diversity was studied based on analysis of genetic diversity by PCA and Analysis Cluster. The results of diversity evaluation based on principal component analysis (PCA) on 34 qualitative and quantitative characters have 4 components that have eigenvalue values > 1 with a cumulative diversity value 93%. The results from cluster analysis dendogram on the combined qualitative and quantitative characters divided 16 genotypes into 3 groups at a distance of inequality of 7.73. The first group comprised of 8 genotypes of timunsuri which were clustered at a distance of 3.61. The second group comprised of 4 melon genotypes which were clustered at genetic distance 4.73. The third group grouped at genetic distance 7.73 comprised of 4 cucumber genotypes. Furthermore, timunsuri group was grouped with melons at a distance of 8.14 and then grouped with cucumbers at a distance of 10.58.

Keywords: Morphological Diversity, *Cucumis*, Timunsuri, Melon, Cucumber, Clustering, PCA

INTRODUCTION

Identification, characterization and classification of timunsuri plants have not yet been completed. Timunsuri is included in the *C. melo* group because of the similarity in leaf shape, female flowers protected by leaves, and fruit spines, but have differences in leaf alignment and fruit skin texture (Rahayu and Hartana, 2002). (Firmansyah et al., 2010) explains that timunsuri from South Kalimantan is included in the species *C. sativus* with characteristics of smooth fruit skin, not grainy, yellowish green fruit colour and white stripes.

Among the many species of the *Cucurbitaceae* family there are 4 species of high economic value, 2 of which come from the genus *Cucumis L*. namely, cucumber (*C. sativus*) and melon (*C. melo*) (Jeffrey, 2005). Overall, the genus *Cucumis* has more than 30 species (Burger et al., 2010). There are differences between species *C. sativus* and *C. melo* in terms of morphological characters and chromosome numbers. (Kristkova et al., 2003) stated that the number of chromosome sets in *C. sativus* species was n = 7. Whereas for *C. melo* = 12. Research by (Daryono et al., 2011) who tested the number of Gorontalo local melon chromosomes and showed 2n = 24 chromosome numbers, the

researcher explained that this melon has a relationship with timunsuri which also has n= 24 chromosome numbers. Between *C. sativus* and *C. melo*, it will cause incompatibility in the crossing of the *Cucumis* species (Kristkova et al., 2003).

(Rad et al., 2018) assessed that genetic variation in various species important for managing and protecting plant genetic resources also shows the course of practical applications such as extending the genet ic basis of species and heterosis exploitation for breeders. Information about the magnitude of genetic diversity will help breeders to choose their favorite parent in the production of suitable hybrid cultivars and also maintain population diversity. Characterization is the first step in the selection process in genetic variation, by comparing the characters of the various genotypes obtained. According to Sobir et al., (2005) plants that have not been identified or characterized will not be maximally utilized, even though they have high genetic potential. Morphological characterizations are widely used to evaluate differences between plant accessions, especially for fruit morphological characters which are also a reference to the economic value of a commodity (Rawahi, 2011). Fruit morphology has the most varied characteristics such as shape (tip and base), fruit skin (colour and pattern/ line), and flesh texture (Esteras et al., 2008). Morphological properties associated with the vegetative, generative and morphological stages of mature fruit include quality parameters, such as taste, aroma, and sugar content (Stepansky et al., 1999).

Observation of morphological characterization is very necessary to be able to know the diversity of accessions of timunsuri. In addition, this study will be able to clarify the kinship of this plant in the genus *Cucumis* L. A detailed description is needed to find out the taxonomy of timunsuri at the species level.

MATERIALS AND METHODS

Experimental design

The location of the study was conducted in Sidoarjo-East Java Indonesia. Geographically, Sidoarjo is located $112^{0}5$' and $112^{0}9$' Longitude and 703' and 705' Latitude, located in the lowlands with an altitude between 0-25 Masl. The study was conducted one season on 2018. This research was carried out using several tools and supporting materials, while the supporting tools used were agricultural mechanical equipment, rulers, calipers, analytical scales, stationery, and cameras. Planting material is obtained from exploration in several sub-districts in Sidoarjo Regency. Based on differences in fruit morphology, 8 genotypes of timunsuri were found. In addition, 8 commercial varieties (*Cucumismelo* and *Cucumissativus*) are used as a comparison. Research design use Randomized Block Design Model and repeated three times.

Observation

Observations were made based on two criteria for morphological, qualitative and quantitative, were measured according to the procedure of The International Plant Genetic Resources Institute (IPGRI, 2003). Qualitative morphological plant features studied include the stem colour, leaf shape, leaf lobes, leaf base shape, leaf top shape, leaf colour, leaf petiol attitude, flower bud shape, flower colour, ovary type, fruit surface, young fruit colour, ripe fruit colour, fruit shape, blossom end shape, stem end shape, skin colour pattern, fruit ribbing, fruit sutures, fruit dots, colour of flesh, flesh texture, aroma, seed shape, seed colour. Quantitative morphological plant features were studied and measured including the leaf lenght (cm), leaf width (cm), internode length (cm), days to 50% flowering (d), ovary length (cm), days to ripening (d), number of fruit per plant, fruit lenght (cm), fruit width (cm), fruit weight (kg), main vine lenght (cm), brix (0), 100-seed weight (g).

Statistic analysis

Analysis of genetic diversity was carried out using PCA analysis (Principal Component Analysis) and Cluster Analysis. The main component analysis (PCA) was carried out with the help of XLStat software. PCA analysis is used to find out which characters have a high contribution value to the variation of each genotype observed by using observational data. In accordance with Rad et al, (2018) the selection of suitable characters must be properly considered. PC is determined based on Eigenvalue, Eigenvalue value under one (<1) is not used in calculating the number of main components formed.

Cluster analysis was conducted to determine the similarity and phenotypic differences between the timunsuri genotypes identified by morphological characters. The results of the data obtained were analyzed by clustering data (Cluster Analysis) and making dendograms using the Un-weighted Pair-Group Method Arithmetic (UPGMA) method.

RESULTS

Morphology

Observations of timunsuri plants have several morphological characters similar to melon and cucumber plants (Table 1), some characters are similar to stem colour, flower colour, and fruit ribs. According to Wilde and Duyfjes (2007), describing plants belonging to the genus *Cucumis* L. have yellow flower colours. In line with (Pandey et al., 2013) the assessment of genetic diversity based on the phenotype has limitations, because most morphological characters are needed by environmental factors and plant development. Variations in flower and fruit characteristics provide significant but relatively low results.

In other characters, timunsuri has different characteristics from melon and cucumber plants. Timunsuri plants have the character of Pentalobate leaves and tend to be the same as melon plants. However, this character difference was observed in cucumber plants, where the characters displayed were overall. This is in line with Rahayu and Hartanta (2012) which states that the timunsuri with melon has the same leaf shape. Even though it has the same leaf shape as melon, the characteristic end of the cucumber leaves has a pointed tip that tends to resemble the tip of a cucumber leaf. The character of the timunsuri leaf colour has green leaves with dark intensity. Timunsuri plants have horizontal stalk positions. The morphology of timunsuri longitudinal flowers in a shape similar to the comparable genotype, cucumber, with a slightly larger diameter size.

Analisis PCA

The results of diversity evaluation based on main component analysis (PCA) (Figure 1 and Table 2) on 34 qualitative and quantitative characters from 16 tested genotypes have 4 components that have eigenvalue> 1 with a cumulative diversity value of 93%, according to the guideline "Guttmans principle lower bound "(Kaiser, 1958). (Pal et al., 2017) on the characterization of cucumbers also found four PCs with a cumulative diversity value of 95.61%. The first main component (PC1) has eigenvalues 16.95 contributing to the maximum diversity of 49.84%. The second main component (PC2) has an eigenvalue of 10.03 contributing to the maximum diversity of 29.49%. The third main component (PC3) has an eigenvalue of 2.42 contributing to the maximum diversity of 7.10%. The fourth main component (PC4) has eigenvalue of 1.38 contributing to the maximum diversity of 4.07%. (Rad et al., 2018) stated that qualitative and quantitative characters in PCA showed that 67% of total variability in the first two components could be used as a reference for melon characterization.

Characters that contribute to PC1 are leaf shape, leaf edge, leaf base, leaf tip, leaf stem position, fruit shape, fruit colour pattern, fruit flesh colour, fruit aroma, seed shape, seed colour, leaf length, leaf width, flowering age male, harvest age, number of fruits, fruit diameter, fruit weight, flesh thickness, brix content, and seed weight. The characters that contribute to PC1 can be used as a basic reference for selecting parents (Gour et al., 2017). PC1 has a positive contribution character except the leaf character, leaf stalks, fruit shape, fruit line, fruit aroma, leaf length, leaf width, and number of fruits which show negative contributions. In the study of Parvathaneni et al., (2011), Szamosi et al., (2010) stated that characters such as leaf width, fruit length and fruit diameter had a positive contribution to diversity. Pal et al., (2017) suggest that the characteristics of results that contribute positively as guidelines for improving plant quality.

Characters that contribute to PC2 are leaf tips, leaf colour intensity, flower bud shape, ovary type, fruit surface, young fruit colour, ripe fruit colour, fruit base shape, fruit colour pattern, fruit line, seed shape, leaf length, flowering age male, ovary length, fruit length, fruit weight, and seed weight. The characters that contribute to PC3 are the shape of the fruit tip, the shape of the base of the fruit, and the lump on the fruit. The characters that contribute to PC4 are leaf width and leaf length.

Cluster analysis

Based on the combined dendogram of qualitative and quantitative characters, it can be seen that the genotype of the timunsuri has a closer relationship with the melon compared to the cucumber. It can be seen that the timunsuri genotype grouped with melons at a genetic distance of 8.14 then grouped with cucumber genotypes at a genetic distance of 10.58 (Figure 2). Timunsuri groups with melons based on the similarity of the characteristics of the leaves, base of leaves, and fruit aroma.

Table 1. Morphology character of timunsuri, melon and cucumber

Characters	Timunsuri	Melon	Cucumber
Stem colour	Green	Green	Green
Leaf shape	Pentalobate	Pentalobate	Entire
Leaf lobes	Intermediate	Strong	Very weak
Leaf base shape	Cordate	Cordate	Acute
Leaf top shape	Right-angled	Rounded	Acute
Leaf colour	Intermediate	Dark	Intermediate
Leaf petiol attitude	Horizontal	Semi-erect	Horizontal
Flower bud shape	Long	Globular	Long
Flower colour	Yellow	Yellow	Yellow
Ovary type	Long	Round	Long
Fruit surface	Bergelombang , Suture	Berjaring, Bergelombang,	Benjolan, Berkelut halus
Young fruit colour	Green	Whitish green, Yellowish green, Greyish green	Green, Whitish green, White
Ripe fruit color	Light yellow	Green, Light yellow, Dark green	Light yellow, Grey, White
Fruit shape	Elliptical, Oblate	Globular, Elliptical	Elongate
Blossom end shape	Rounded	Rounded	Truncate , Rounded
Stem end shape	Rounded, Obtuse	Rounded	Acute , Rounded
Skin colour pattern	Striped	No secondary skin colour, Striped	No secondary skin colour
Fruit ribbing	Very weak	Very weak	Very weak
Fruit sutures	Absent	Present, Absent	Absent
Fruit dots	Absent	Absent	Present, Absent
Color of flesh	Pale orange	Pale orange, Cream, Green, Orange	White
Flesh texture	Fibrous-dry , mealy, Fibrous-gelatinus	Fibrous-dry	Fibrous-gelatinous
Aroma	Present	Present	Absent
Seed shape	Roundish	Pine-nut shape	Not pine -nut shape
Seed color	Light brown	Brown	Yellow -white
100-seed weight (g)	2.07 - 2.82	2,89 - 2,91	1,90 - 2,36
Fruit length (cm)	29.03 - 32.03	16,05 - 20,43	18,90 - 30,22
Fruit width (cm)	36.97 - 41.07	36,20 – 44,83	18,77 - 22,50
Fruit weight (kg)	1.77 - 2.09	1,01 - 1,62	0,57 - 0,66
Main vine length (cm)	3.22 - 3.93	2,83 - 3,88	1,62 - 1,73
Brix (^{0})	5.52 - 8.68	5,78 - 8,50	2,41 - 3,28
Leaf length (cm)	11.83 - 14.11	9,47 - 11,34	12,23 - 14,99
Leaf width (cm)	15.72 - 19.59	14,49 - 15,96	17,29 - 20,15
Internode length	6.90 - 8.28	7.03 - 7.43	7.66 - 9.29
Ovary leght (cm)	2.42 - 2.50	1,63 - 1,81	2,02 – 2,37
Days to ripening (d)	60.18 - 61.87	60,00 - 68,63	50,00 - 58,00
Days to 50% flowering (d)	21.16 - 21.82	18,70 - 20,77	17,65 - 19,38
Number of fruit per plant	1.00 - 1.12	1,00 - 1,37	5,98 - 7,53

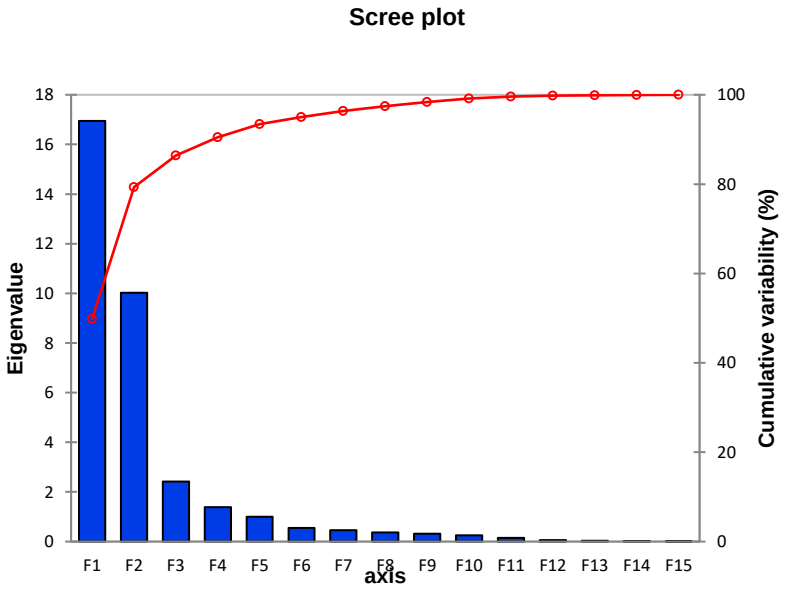

Figure 1.Scree ploot PCA

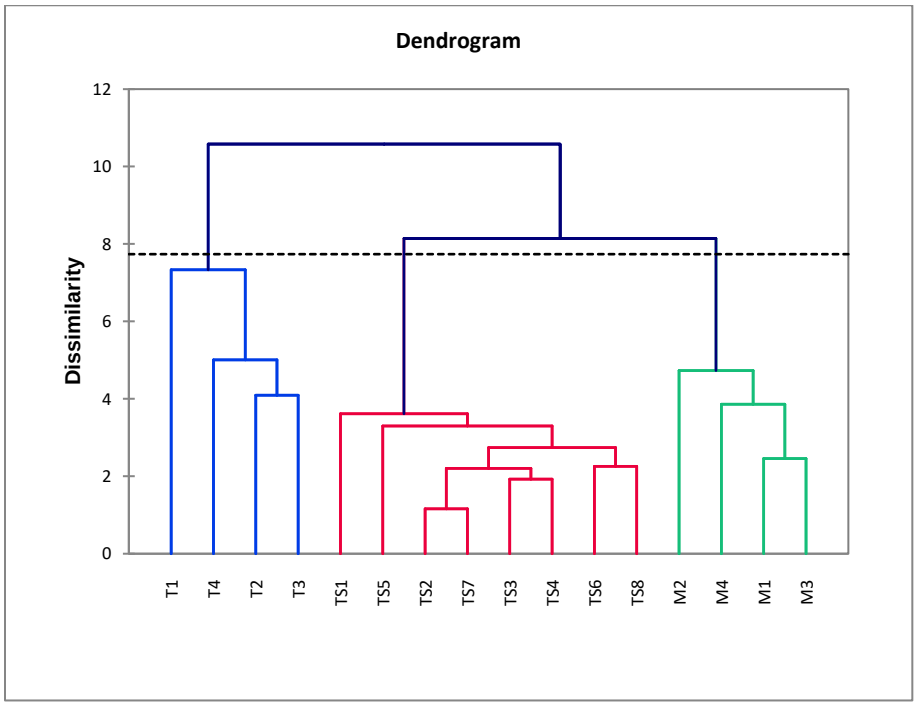

Figure 2.Dendogram of 16 genotypes tested based on 34 agronomic characters

Table 2. Loading factor, eigenvalue, diversity, and cumulative diversity of 16 genotypes were tested based on 34 qualitative and quantitative characters.

characters and components	F1	F2	F3	F4
Leaf shape	**0,98***	0,16	0,01	0,04
Leaf lobes	**0,96***	-0,22	0,06	0,06
Leaf base shape	**-0,98***	-0,16	-0,01	-0,04
Leaf top shape	**0,77***	**-0,62***	0,10	0,07
Leaf colour	0,48	**-0,86***	0,11	0,07
Leaf petiol attitude	**-0,88***	0,30	-0,08	-0,03
Flower bud shape	-0,48	**0,86***	-0,11	-0,07
Ovary type	-0,48	**0,86***	-0,11	-0,07
Fruit surface	0,42	**0,59***	-0,46	-0,05
Young fruit colour	0,17	**0,86***	0,33	-0,12
Ripe fruit colour	-0,40	**-0,56***	-0,44	-0,03
Fruit shape	**-0,94***	0,22	-0,04	-0,14
Blossom end shape	-0,43	-0,14	**0,60***	0,45
Stem end shape	0,16	**-0,50***	**-0,68***	-0,04
Skin colour pattern	**0,57***	**0,74***	-0,08	0,09
Fruit sutures	**-0,57***	**-0,74***	0,08	-0,09
Fruit ribbing	-0,49	0,03	**0,82***	0,21
Colour of flesh	**0,92***	0,29	-0,02	0,13
Aroma	**-0,84***	-0,35	0,02	-0,12
Seed shape	**0,66***	**0,74***	-0,06	-0,01
Seed colour	**0,98***	-0,11	0,05	0,05
Leaf lenght (cm)	**-0,67***	**0,56***	-0,13	0,40
Leaf width (cm)	**-0,54***	0,46	-0,26	**0,53***
Internode length	-0,47	0,07	-0,39	**0,68***
Days to 50% flowering (d)	**0,62***	**0,72***	0,15	-0,08
Ovary leght (cm)	-0,26	**0,93***	0,00	-0,20
Days to ripening (d)	**0,87***	-0,21	0,15	0,07
Number of fruit per plant	**-0,98***	-0,18	-0,01	0,04
Fruit lenght (cm)	-0,09	**0,93***	0,19	-0,09
Fruit width (cm)	**0,98***	0,01	-0,08	0,11
Fruit weight (kg)	**0,79***	**0,58***	-0,06	0,08
Main vine leght (cm)	**0,94***	0,16	-0,01	0,18
Brix (^{0})	**0,89***	0,02	-0,04	0,01
100-seed weight (g)	**0,60***	**-0,64***	-0,07	0,05
Eigenvalue	16,95	0,16	0,01	0,04
Variability (%)	49,84	-0,22	0,06	0,06
Cumulative %	49,84	-0,16	-0,01	-0,04

* contribute significantly to total diversity

The character also separates the cucumber genotype with Timunsuri and melon. In the study of Rahayu and Hartanta (2012) using 25 qualitative characters it can be concluded that the timunsuri plant is in the melon group at a distance of 7 and is separate from the cucumber group at a distance of 7.5. So it can be concluded that the genotype of the Timunsuri has a kinship closer to the melon.

CONCLUSION

Based on the results of the study, Timunsuri plants have a high diversity of fruit morphological characteristics. Multivariate analysis showed that cucumber plants were included in *Cucumismelo* L. The results of the study were also very useful in selecting superior genotypes based on the characters that contributed positively to PC1 such as harvest age, fruit diameter, fruit weight, flesh thickness and brix levels.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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