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Morphology and production character of local eggplant based on principal component analysis

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Abstract. Environmental changes, including loss of biodiversity, threaten agricultural production and quality. The present research investigated morphology and production character in ten accessions of local eggplant. The research was carried out by planting ten plants from each accession in a row, the distance among plants and among beds were 50 cm respectively. The experiment was conducted from March to August 2018 at Agrotechnopark Jatikerto, Malang, East Java. Principal component analysis (PCA) indicated that four components (PC1 to PC4) accounted for about 90% of the total variation among traits in eggplant accession. Out of total principal components PC1, PC2, PC3 with values of 41.6%, 24.4%, and 13.5% respectively contributed greatly to the total variation. The first principal component had the highest positive loading for five characters out of 10 viz. leaf width¹, leaf length², the length of petiole³, stem diameter⁴ and plant height⁵ which contributed greatly to the diversity. Limao Eggplant and Blitar local eggplant which has high yield potential. The result of this study could be exploited in the planning and execution of future breeding programme in local eggplant.

1. Introduction

Eggplant (*Solanum melongena* L.) also known as *terung gelatik* is an important non-tuberous species of the nightshade family Solanaceae. Eggplant has been planted for centuries in Asia, Africa, Europe and the Near East [1]. Now, around 50 million tons of eggplant is produced in more than 1.800.000 ha worldwide. Eggplant production is concentrated in several countries. China (29.5 million tons) is the primary producer, followed by India (13.5 million tons), Egypt (1.2 million tons), Iran (0.85 million tons) and Turkey (0.82 million tons) [2].

Eggplant is a high-yielding crop that can agronomically adapt and has high economic value [3]. Interest in this plant is overgrowing because it is a good source of antioxidants (anthocyanins and phenolic acids), which are beneficial to human health [4]. Eggplant fruit is known for having low calories and a beneficial mineral composition for human health. It also contains a rich source of potassium, magnesium, calcium, and iron [5]. Furthermore, seventy-seven medicinal properties are recorded for eggplant which shows the importance of this plant in local medicine and its promise as a functional food and the natural product industry [6].

Biodiversity is the result of variations in the morphology of plants, animals, microorganisms, genes in them, and their ecosystems [7]. Environmental changes such as land degradation, climate change, water scarcity and loss of biodiversity threaten the quantity and quality of agricultural products [8]. Eggplant fruit has a variety of fruit shapes, fruit colors, and productivity. Indonesia has a diverse range of eggplant varieties with superior varieties developed by seed producers, and local varieties managed by the farmers. These traditional and local cultivars are the most widely used varieties. Improved



varieties have better agronomic performance than local cultivars. Despite its superior agronomic performance, improved eggplant variety has unique requirements and quality of technology and organoleptic that still meet user needs. This situation continues because of the extra work and costs incurred, and their ability to stand with biotic and abiotic pressures [9]. However, farmers' seeds are generally considered low productivity by agronomic experts, this happen because of traditional agricultural technology. Therefore, the main obstacle in increasing eggplant production in Indonesia is the low yield. Increasing superior varieties with high yield potential that is suitable to the needs of the cultivators is needed. In order to solve the increasing food demand, modern agriculture is further developed and focused not only to select performing varieties but also to diversify cultivars in the seed system [10]. The introduction of high-yielding varieties depends mostly on access to local genetic resources. This local resource indeed is an essential component of food security, which is a raw material used by breeders to improve the quality and productivity of eggplant.

Principal Component Analysis (PCA) can be used to express general differences between genotypes in numerical values, which indicate characters that can be used to differentiate between genotypes [11]. Principal Component Analysis or commonly abbreviated as PCA is a multivariate statistical technique that can be used to simplify and analyze relationships between large numbers of variables in a relatively fast period without removing important information from the original dataset [12]. Information about the morphological character and production of local eggplants in previous studies is still limited. The knowledge of the variety of morphological and output characters is expected to contribute to the development of superior accessions of the local eggplant.

2. Method and Materials

This study aimed to determine the diversity of morphological characters and the production of local eggplant. The materials of the present research consisted of 10 collections of *Solanum melongena* L. The collection of planting materials was presented in Table 1.

Table 1. Several species of local eggplant used in the present research

No.	Local/Trade Name	Origin	Status	Note
1.	Surabaya Local Eggplant 1	Surabaya	Accession	Online Seller Fighter Surabaya
2.	Blitar Local Eggplant	Blitar	Accession	Online Seller Trapi Patria
3.	Surabaya Local Eggplant 2	Surabaya	Accession	Online Seller Fighter Surabaya
4.	Kenari	Jember	Variety	Seed Producers Citra Asia
5.	Fullness	Magelang	Variety	Seed Producers Known You Seed, Indonesia
6.	Jeno F1	Purwakarta	Variety	Seed Producers East West Seed, Indonesia
7.	Lima	Jember	Variety	Seed Producers Enno and Company Seed, Indonesia
8.	IPB Tro1U	Bogor	Variety	IPB Campus, Leuwikopo, Dramaga, Bogor, Indonesia
9.	SRITI	Jember	Variety	Seed Producers Citra Asia, Indonesia
10.	Surabaya Local Eggplant 3	Surabaya	Accession	Online Seller Fighter Surabaya

The present research was conducted from March to August 2018, at Universitas Brawijaya Experimental Garden in Jatikerto Village, Kromengan District, Malang Regency, East Java, Indonesia. The seeds were sown. After they have grown, they were transferred to the field. After the seeds had 3-4 whole leaves, the seeds were ready to be planted into the field. Each accession number was planted

ten plants per row and was planted in two rows. The distance among plants was 50 cm, and the distance among accession numbers was 50 cm. The soil was formed in beds with 20 cm in height. 152 kg (with dose of 20 tons/ha) manures were given. The first fertilization was given when the plant was two weeks old. Follow-up fertilization was carried out at intervals of 2 weeks. The fertilizer used was NPK fertilizer at a dose of 500 kg/ha and ZA 150 kg/ha. Fertilizers were given at a distance of 10 cm from the plant. Weeds growing around plants were weeded, and controlling pests and diseases were carried out mechanically.

Observations were made on all individual plants in each population. The characters observed were morphological characters and crop production. Observations were based on descriptors from IBPGR [13] and UPOV [14]. The characters found from each section are as follows:

2.1. The Character of Plant Morphology

Plant morphology was observed into 3 types i.e. visual, fully open and optimal leaf, harvest time. A visual observation included the type of stature, number of primary branches, stem diameter, leaf length (cm), leaf width (cm), upper leaf surface color, leaf curvature, leaf tip angle, leaf stem length (cm). Observation on leaves that fully open and grow optimally was followed by measuring leaf stalks from the base of the stem to the bottom of the leaf blade, leaf stalk color, leaf spines, leaf hair, petal color, number of fruits per plant, fruit length (cm), fruit diameter (cm), fruit body shape, fruit curvature, fruit base shape, ripe age for consumption (day after planting). Observation in the first harvest time included ripe fruit color for consumption, ripe fruit motif for consumption, weight of petals (%), fruit position, physiological ripe age (day after planting), physiological ripe fruit color, number of seeds per fruit, seed color, seed size (mm), weight of 100 grains (g). The time of observation was adjusted to the development of plants.

2.2. The Character of Plant Production

Plant production characters observed were plant height, flowering time (the day after planting), fruit weight of each plant (g). The first harvest of local eggplant can be done when the plants were 45-60 day after planting. Harvesting were done manually by picking eggplants or with pruning shears. Plants that were ready for harvest had a reasonably old age, maximum crop size or leaf formation, and had physical characteristics i.e. ripe color based on the accession/variety, and a proper shape and size for harvest.

2.3. Data Analysis

The qualitative and quantitative characters were analyzed using Principal Component Analysis. This analysis was conducted to determine the essential characteristics that affect plant diversity. Data analysis was performed using xlstat software which would produce eigenvalue values and diagrams that described plant groupings. For the character of production, it was compared directly the total harvest per line among accessions/varieties.

3. Results and Discussion

The results of the principal component analysis (PCA) in this study have reduced the characters observed into four main components that have an eigenvalue > 1 and can explain the diversity of the experiment material by 90%, as presented in Table 2.

Table 2 shows the main factors 1 (F1) represents about 41.62% of the diversity, and the highest contributed characters are the length of the leaves and the width of the leaves. The main factor 2 (F2) represents around 24.37% of the diversity, and the highest contributed characters are the leaf tip angle. The main factor 3 (F3) represents about 13.49% of the difference, and the highest contributed character are plant height. The main factor 4 (F4) represents around 10.69% of diversity, and the highest contributed characters are leaf hair. Grouping of Local eggplant accession/varieties is presented in Figure 1.

Table 2. Analysis of the Principal Components of Local Eggplant Accession / Varieties

Observation Character	F1	F2	F3	F4
The length of the leaves	0.911	0.017	-0.297	-0.097
Plant height	0.618	-0.197	0.745	-0.051
The width of the leaves	0.936	-0.155	-0.168	-0.053
The length of the stem	0.891	0.040	-0.178	0.185
Number of leaves eight weeks after planting	-0.667	-0.119	0.501	0.307
Stem diameter	0.661	0.184	0.585	-0.383
Leaf hair	0.391	0.303	0.105	0.835
Leaf tip angle	0.151	0.917	0.179	0.039
The shape of leaf curves	-0.110	-0.911	0.095	-0.008
Seed size	0.457	-0.749	0.034	0.284
Eigenvalue	4.162	2.437	1.349	1.069
Proposal (%)	41.615	24.368	13.486	10.694
Cumulative (%)	41.615	65.983	79.469	90.163

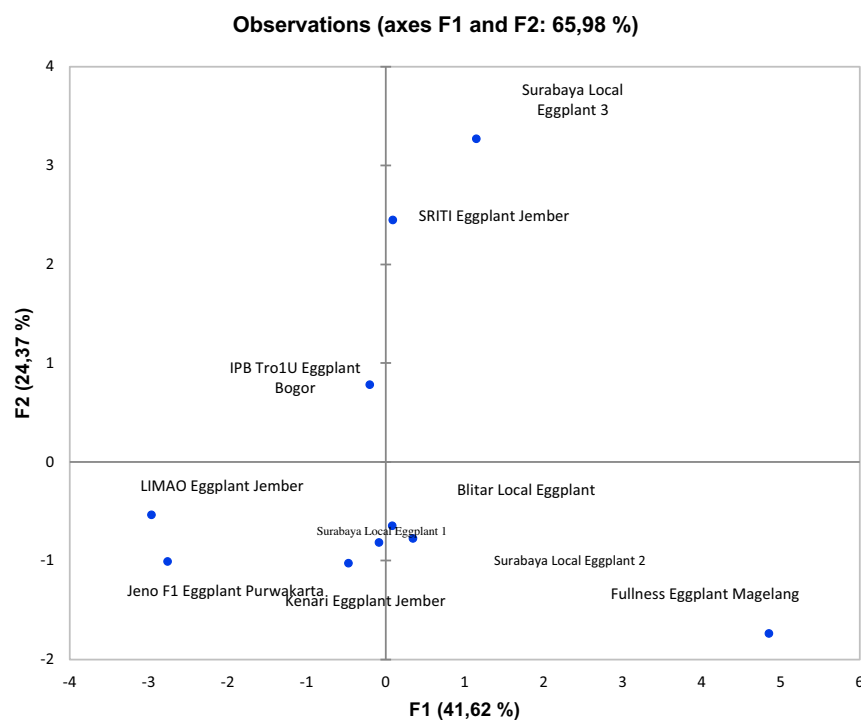


Figure 1. Grouping of Local Eggplant Accession/Varieties

Based on Figure 1, the accession of the local eggplant is divided into four clusters. Cluster 1 consists of Surabaya Local Eggplant 3 and Sriti Eggplant Jember. Cluster 2 consists of Surabaya Local Eggplant 2, Fullness Eggplant Magelang, and Blitar Local Eggplant. Cluster 3 consists of Limao Eggplant Jember, Kenari Eggplant Jember, Jeno F1 Eggplant Purwakarta, Surabaya Local Eggplant 1. Cluster 4 consists

of IPB Tro1U Eggplant Bogor. The local eggplant variety/accession morphology is presented in Table 3.

From Table 3, the character of cotyledon color, fruit length, fruit body shape, fruit curvature, fruit base shape, fruit petal weight percentage, fruit position, and seed size have similar properties; while the other characters are varied. A research conducted by Lestari et al. found that the diversity of quantitative characters is more influenced by environmental factors during plant growth [15]. In addition, the variety of morphological characters can be used to produce new recombinants that have superior properties [16].

Production characters are essential to know. By knowing this character, we can also understand the potential results of the plant. Knowledge of possible outcomes is useful for determining how viable plants are to be developed or cultivated widely. The higher the potential yield of a food crop, the higher the value for cultivation is.

Based on Table 4, Limao Eggplant plants produce the highest total yield (2763.74 grams) compared to the other nine accessions / other varieties. Limao Eggplant has high productivity due to this variety already has better adaptability than other varieties/accessions. It is followed by Blitar Local Eggplant accession as the second highest total yield (2307.22 grams). The origin area of this accession has high temperature, therefore it can grow and produce higher than other varieties/accessions. A research conducted by Scheelbeek et al. found that the quality and quantity of plant production are influenced by the adaptability of plants to the environment [8].

Table 3. Local Eggplant Accession/Varieties Morphology

No	Character	Surabaya Local Eggplant 1	Bitar Local Eggplant	Surabaya Local Eggplant 2	Kenari	Fullness	Jeno F1	Limao	IPB Trolu	Sriti	Surabaya Local Eggplant 3
1.	Cotyledon color	green									
2.	Plant height	medium	short	medium	medium	short	medium	short	short	short	short
3.	Type of plant	upright	medium	upright	medium	upright	medium	medium	medium	upright	medium
4.	Stem diameter (mm)	9.5-13.2	11.4-13.3	10.6-14.4	10.7-11.6	14.7-16.8	10.4-13.3	8.9-11.7	9.9-12.8	9.2-11.1	10.6-10.8
5.	The length of the leaves	medium	medium	medium	medium	long	width	medium	medium	medium	medium
6.	The width of the leaves	width	width	width	width	width	medium	medium	width	medium	width
7.	The surface color of the leaves	dark green	green	dark green	green	dark green	green	green	green	dark green	dark green
8.	The curve of the leaf	medium	medium	medium	medium	within	medium	medium	medium	medium	within
9.	Leaf tip angle	medium	medium	medium	medium	medium	medium	medium	medium	medium	blunt
10.	The length of the stem (cm)	8-9	9.5-11	8.4-9.5	7.9-9	10.6-12.5	8.3-11	7.5-9	8.1-9.5	8.5-10	8-9.5
11.	Color of petiole	purple	green	purple	green	purple	green	green	green	purple	purple
12.	Leaf spines	a few	measly	measly	measly	measly	measly	measly	measly	measly	measly
13.	Leaf hair	measly	a few	a few	a few	a few	a few	a few	a few	a few	a few
14.	Flowering time (day after planting)	22-24	22-24	22-24	22-24	22-24	22-24	22-24	32-34	32-34	43-53
15.	Petal Color	pale purple	white	pale purple	white	pale purple	white	white	pale purple	pale purple	pale purple
16.	Number of fruits per plant	11 fruit	13 fruit	15 fruit	13 fruit	3 fruit	12 fruit	17 fruit	13 fruit	16 fruit	6 fruit
17.	Fruit weight per plant	medium	medium	medium	medium	very light	medium	medium	medium	medium	very light
18.	Fruit length	medium									
19.	Fruit diameter	medium	medium	thick	medium	thick	thick	medium	thick	medium	medium
20.	Fruit body shape	the same width									
21.	Fruit curvature	there is no curve									

No.	Character	Surabaya Local Eggplant 1	Bitar Local Eggplant	Surabaya Local Eggplant 2	Kenari	Fullness	Jeno F1	Limao	IPB Tro1u	Sriti	Surabaya Local Eggplant 3
22.	The basic shape of the fruit	rounded									
23.	Ripe age for consumption (the day after planting)	40-42	32-34	40-42	32-34	40-42	32-34	32-34	50-52	73-85	60-67
24.	Color of ripe fruit for Consumption	green	green	green	green	dark purple	green	green	purple	yellow	purple
25.	Motif of ripe fruit for consumption	striped	striped	striped	striped	uniform	striped	striped	uniform	uniform	uniform
26.	Physiological harvest age (the day after planting)	73-85	73-85	73-85	73-85	73-85	73-85	73-85	73-85	50-52	88-92
27.	Physiological color of ripe fruit	yellow	yellow	yellow	yellow	dark red	yellow	yellow	yellow	shiny purple	yellow
28.	Percentage of fruit petal weight	very small									
29.	Fruit position	hang									
30.	Seed size	medium									

Table 4. The Productivity of Local Eggplant Accession/Varieties per Row

No.	Accession/Varieties	Harvest Period			Total harvest (g)
		Period I (g)	Period II (g)	Period III (g)	
1.	Surabaya Local Eggplant 1	177.22	212.8	849.4	1239.42
2.	Blitar Local Eggplant	250.96	699.36	742	2307.22
3.	Surabaya Local Eggplant 2	347.58	222.1	966.4	1536.08
4.	Kenari	78.26	49.48	816.38	2238.02
5.	Fullness	121.84	137.4	0	259.24
6.	Jeno F1	86.4	188.22	1099.44	2485.46
7.	Lima	37.7	162.4	836.84	2763.74
8.	IPB Tro1U	168.92	584.6	819.8	1573.32
9.	Sriti	46.86	254.7	1041.7	1343.26
10.	Surabaya Local Eggplant 3	87.6	0	0	87.6

4. Conclusion

Analysis of the main components in the accession of the local eggplant produces four main clusters with 90% diversity proportion. The character of the leaf blade width is the character that contributes greatly to the diversity of total local eggplant accession. The potential high yield eggplant accession/varieties are Lima Eggplant, and followed by Blitar Local Eggplant as the second highest.

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