Variation and Non-formal Classification of Indonesian Eggplant (Solanum melongena L.) Accessions Based on Macro and Micro-morphological Characters

Uni Baroroh Husnudin¹, Suharyanto², Budi Setiadi Daryono³ and Purnomo⁴*)

¹) Faculty of Biology, Universitas Gadjah Mada, Yogyakarta, Indonesia
²) Laboratory of Plant Structure and Development, Faculty of Biology, Universitas Gadjah Mada, Yogyakarta, Indonesia
³) Laboratory of Genetics and Breeding, Faculty of Biology, Universitas Gadjah Mada, Yogyakarta, Indonesia
⁴) Laboratory of Plant Systematics, Faculty of Biology, Universitas Gadjah Mada, Yogyakarta, Indonesia

ABSTRACT

Indonesia has a variety of eggplant germplasms and is considered as one of the largest producing countries in the world. The study was conducted to assess the variation of 21 accessions and 2 commercial cultivars of eggplant from Indonesia based on 30 macromorphological and 8 leaves micromorphological characters. Cluster analysis was conducted by UPGMA (Unweighted Pair Group Methods with Arithmetic averages) to create a dendrogram and construct eggplants grouping. PCA (Principal Component Analysis) was also performed to define the role of each character in the group by using MVSP (Multivariate Statistical Program) v.3.1 software. Results showed that eggplant accessions have macromorphological variation in fruit curvature, fruit shape, fruit apex, and fruit color, as well as leaves micromorphological characters such as the epidermal wall, trichome shape, and stomata type. Dendrogram based on macromorphological characters divided the accessions into 2 groups: curved and non-curved fruit groups. The non-curved fruit group divided into more spiny and less spiny leaves sub groups. Dendrogram based on leaves micromorphological characters divided the accessions into 2 groups based on the epidermal wall, trichome shape, and stomata type. Eggplant grouping doesn’t occur based on the origin of collection areas indicating that its variability isn’t affected by the environment.

INTRODUCTION

Eggplant (Solanum melongena L.) is a member of genus Solanum and becomes the most important vegetable crop in the world after tomato (Knapp, Vorontsova, & Prohens, 2013; Samuels, 2015). The eggplant fruits have become widely used as a food, food supplement, and the vegetative plant parts like peduncles, roots, stalks, and leaves are used for curing diverse ailments such as abscesses, intestinal haemorrhages, and toothache (Daunay & Janick, 2007; Meyer, Bamshad, Fuller, & Litt, 2014; Scorsatoo et al., 2019). This plant has been cultivated from wild forms since a long time ago in various continent like Africa, Europe, America and Asia (Weese & Bohs, 2010), with thousands of localized landraces and many commercial cultivars (Samuels, 2015).

In Asia continent, the greatest genetic diversity of eggplant is found in South and Southeast Asia (Samuels, 2015) and India or Indo-China is considered to be the center of eggplant diversity (Behera et al., 2006). Eggplant is warm season crop mostly cultivated in tropical and subtropical regions of the world. The distribution of S. melongena is cosmopolitan by abiotic factors such as water flow and biotic factors by human as a vegetable crop and cultivation (Daunay & Janick, 2007). The eggplant was domesticated in India, southern China, and the Malay islands, including Indonesia, Malaysia, the Philippines, and other countries in the Malay
Indonesia is one of the largest eggplants producing countries after China, India, Egypt, Turkey, Iran, and Japan (FAO, 2016). Indonesia has a diversity of eggplant germplasm, the database involves more than 200 accessions collected by The Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD) gene bank and 78 eggplant cultivars have been registered in the information system of plant varieties protection of the Indonesian Ministry of Agriculture (Ditbenih, 2017). Eggplant varieties obtained from domestication, mutation, natural intercrossing, human selection and hybridization have brought an extensive genetic diversity to improve eggplant varieties for sustainable production and adaptation to climate change challenges (Sękara, Cebula, & Kunicki, 2007).

Screening of available accessions for desirable traits and morphological description of the accessions are key issues for the breeding processes (Kaushik, Prohens, Vilanova, Gramazio, & Plazas, 2016). Characterization using conventional morphological descriptors has been proven useful for describing and establishing relationships among local eggplant genetic resources (Plazas et al., 2014). Morphological characters have been the major criteria for classification, although the other characters such as anatomical features, phytochemical contents, embryology, cytology, and molecular features have played important role in plant classification (Singh, 2010). The classification based on morphological feature is also a common reference that contributes specifically to plant groupings.

Morphological characters are divided into macromorphological and micromorphological characters (Stace, 1991). Study of macromorphological characters of eggplant conducted by Kumar et al. (2008) show the diversity of India accessions of eggplant. Begum, Islam, Rasul, Mian, & Hossain (2013) study also reported grouping of Bangladesh eggplant accessions based on macromorphological characters for selecting genotypes as parents for crossing. Micromorphological is characters of plant organs, such as very small seed skin, epidermis on leaves, petals trichomes and papillae (Singh, 2010). Micromorphological characters is important for supporting plant classification. This study used a combination of macromorphological and some micromorphological characters of eggplant leaf epidermis, such as distribution and type of trichomes, the anticlinal walls of epidermal cells, also the type and distribution of stomata. Leaf epidermis characters are useful in distinguishing the Solanum species (Nurit-Silva, Costa-Silva, Basílio, & de Fátima Agra, 2012; Sampaio, Araújo, & Agra, 2014).

The classification of cultivated plants is different from the wild ones, it’s usually known as non-formal classification which is set in The International Code of Botanical Nomenclature (ICBN). The categories which are based on the species level are cultivar, group, graft chimera and hybrid (Hetterscheid & Brandenburg, 1995). Systematic groups in cultivated plants are called cullon which consists of categories of cultivars and groups of cultivar (Spooner, Hetterscheid, van den Berg, & Brandenburg, 2003). Regarding the importance of eggplant as a vegetable crop, there are still limited informations on the morphology of the eggplant and moreover there is no study on leaf epidermal of eggplant accessions that has been previously carried out. Therefore, the objective of this research was to determine variations and non-formal intraspecific classification of the Indonesian eggplant accessions based on macro and micro-morphological characters.

**MATERIALS AND METHODS**

The research was conducted from December 2017 to March 2018. A total of 21 accessions and 2 commercial cultivars of eggplant were used in this study. Eggplant accessions collected from different provinces in Indonesia, were obtained from The Indonesian Center for Agricultural Biotechnology and Genetic Resources and Development (ICABIOGRAD), Bogor. The accession number, local name, and origin of samples are listed in Table 1. All of eggplant seeds were soaked in warm water for ± 60 minutes and then planted in the media of soil and compost in a ratio of 1:1 for germination. The newly growing plants were then maintained for 4-5 weeks. The eggplants were transplanted under greenhouse conditions at Pusat Antar Universitas (PAU) Universitas Gadjah Mada for 4-5 months until they produced fruits. Macro and micro-morphological observations were conducted in the Laboratory of Plant Systematics and Laboratory of Plant Structure & Development, Faculty of Biology, Universitas Gadjah Mada.
Data was analyzed descriptively and numerically. The descriptive analysis aimed to illustrate the plant morphology based on each character. The step for analysis was to put a score for each character that had been observed and measured. All plants were observed using 30 morphological characters based on the descriptor list (Table 2) adopted from the International Board for Plant Genetic Resources (Lester & Niakan, 1988). Macromorphological characters were observed starting from seedling stages (4-5 weeks old plants), vegetative characters (leaf and stem) and reproductive characters (flower, fruit, seed). The leaf epidermis (micromorphological) observation procedure was carried out based on Sampaio, Araújo, & Agra (2014), paradermal sections of fifth leaf from the terminal shoot were soaked for 2 minutes by commercial sodium hypochlorite, neutralized with 0.2% acetic acid for 30 seconds and the leaves were rinsed with distilled water. The leaves underwent staining process using 1% safranin by add safranin solution, then absorbed by tissue paper and mounted in 50% glycerinated gelatin. The observations and photomicrographs were performed by light microscope connected to the optilab. The observed leaf epidermis characters included the shape of anticlinal epidermal wall, distribution of stomata, type of stomata, leaf trichome (grandullar and non-grandular) at adaxial and abaxial side (Table 3).

All macromorphological and micromorphological characters were scored as binary data (0 for absent or 1 for present) and multistate data based on character coding eg. 0 (green), 1 (white), 2 (purple), etc. Cluster analysis was conducted by UPGMA (Unweighted Pair Group Methods with Arithmetic averages) using Average Distance method analysis to create a dendrogram with MVSP (Multivariate Statistical Program) v.3.1 software (KCS, 2007). PCA (Principal Component Analysis) was also performed to defined the role of each morphological character in grouping of accessions in a scatter plot diagram.

RESULTS AND DISCUSSION

Morphological Variation

The evaluated eggplant accessions show variation in terms of macromorphological characters (Table 2). The variation appears on the characters of seedling, stem, leaf, flower, and fruits. In seedling stage, there are two variations in anthocyanin coloration at hypocotyl i.e. absent and present. Variation on the stem surface was related with the existence of anthocyanin coloration, which are sometimes present or absent.

Table 1. List of Indonesian eggplant accessions used in the study

| No. | A.N. | Local name          | Code | Origin                      |
|-----|------|---------------------|------|-----------------------------|
| 1   | 9    | Terong gelatik      | K14  | Pandeglang, Banten, West Java |
| 2   | 32   | Terong butuh        | K17  | Serang, Banten, West Java   |
| 3   | 49   | Terong ungu         | K16  | Bogor, West Java            |
| 4   | 68   | Terong gelatik; lalap| K32  | Ciamis, West Java           |
| 5   | 94   | Terong telunjuk     | K20  | Gunungkidul, Yogyakarta     |
| 6   | 95   | Terong              | K62  | Gunungkidul, Yogyakarta     |
| 7   | 156  | Terong gelatik kecil| K13  | Cilacap, Central Java        |
| 8   | 181  | Terong telunjuk     | K88  | Deli Serdang, North Sumatera |
| 9   | 199  | Terong kecap        | K90  | Deli Serdang, North Sumatera |
| 10  | 217  | Terong hijau        | K178 | Tanah Karo, North Sumatera  |
| 11  | 240  | Terong manggis      | K110 | Padang Pariaman, West Sumatera |
| 12  | 257  | Terong talang       | K69  | Ogan Ilir, South Sumatera   |
| 13  | 267  | Terong apel         | K50  | Muara Enim, South Sumatera  |
| 14  | 271  | Terong lalap rebus  | K83  | Ogan Komering Ulu, South Sumatera |
| 15  | 288  | Terong kercil       | K135 | Muara Enim, South Sumatera  |
| 16  | 606  | Terong gading       | K118 | Kubu Raya, West Kalimantan  |
| 17  | 615  | Terong pinang       | K57  | Singkawang, West Kalimantan |
| 18  | 637  | Terong asam         | K51  | Bengkayang, West Kalimantan |
| 19  | 759  | Faimatak            | K82  | Belu, West Nusa Tenggara    |
| 20  | 801  | Poki-poki           | K93  | Minahasa, North Sulawesi    |
| 21  | 150  | Terong jawa         | K18  | Cilacap, Central Java        |
| 22  | -    | Terong ungu         | TU   | Commercial cultivar          |
| 23  | -    | Kania F             | KF1  | Commercial cultivar          |

Remarks: A.N. = accession number
### Table 2. List of macromorphological character of eggplant accessions

| No. | Accession                  | Cotyledon colour | Anthocyanin coloration of hypocotyl | Plant growth habit | Anthocyanin coloration of stem | Leaf stem colour | Leaf colour (adaxial)* | Leaf blade lobing | Leaf tip |
|-----|----------------------------|------------------|------------------------------------|--------------------|-------------------------------|-----------------|------------------------|------------------|---------|
| 1   | Terong gelatik (K14)       | Green            | Present                            | Erect              | Present                       | Purplish green  | NN137A                 | Intermediate     | Acute   |
| 2   | Terong butuh (K17)         | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Acute   |
| 3   | Terong ungu (K116)         | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Acute   |
| 4   | Terong lalap (K32)         | Green            | Absent                             | Erect              | Absent                        | Green           | 137A                   | Intermediate     | Acute   |
| 5   | Terong gelatik (K20)       | Green            | Absent                             | Erect              | Absent                        | Green           | 137B                   | Intermediate     | Acute   |
| 6   | Terong (K62)               | Green            | Absent                             | Erect              | Absent                        | Green           | 137B                   | Intermediate     | Acute   |
| 7   | Terong gelatik kecil (K13) | Green            | Present                            | Erect              | Present                       | Purplish green  | NN137A                 | Intermediate     | Acute   |
| 8   | Terong telunjuk (K88)      | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Acute   |
| 9   | Terong kecap (K90)         | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Acute   |
| 10  | Terong hijau (K178)        | Green            | Present                            | Erect              | Present                       | Purplish green  | NN137A                 | Intermediate     | Acute   |
| 11  | Terong manggis (K110)      | Green            | Present                            | Erect              | Present                       | Purplish green  | 137A                   | Intermediate     | Obtuse  |
| 12  | Terong talang (K69)        | Green            | Present                            | Erect              | Present                       | Purplish green  | 137A                   | Intermediate     | Obtuse  |
| 13  | Terong apel (K50)          | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Acute   |
| 14  | Terong lalap rebus (K83)   | Green            | Absent                             | Erect              | Absent                        | Green           | 137A                   | Intermediate     | Acute   |
| 15  | Terong kerci (K135)        | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Acute   |
| 16  | Terong gading (K118)       | Green            | Absent                             | Erect              | Absent                        | Green           | 137B                   | Intermediate     | Obtuse  |
| 17  | Terong pinang (K57)        | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Acute   |
| 18  | Terong asam (K51)          | Green            | Present                            | Erect              | Present                       | Purplish green  | 137B                   | Intermediate     | Obtuse  |
| 19  | Faimatak (K82)             | Green            | Absent                             | Erect              | Absent                        | Green           | 137B                   | Intermediate     | Obtuse  |
| 20  | Poki-poki (K93)            | Green            | Present                            | Erect              | Present                       | Purplish green  | NN137A                 | Intermediate     | Acute   |
| 21  | Terong jawa (K18)          | Green            | Present                            | Erect              | Present                       | Purplish green  | 137A                   | Intermediate     | Acute   |
| 22  | Terong ungu (TU)           | Green            | Present                            | Erect              | Present                       | Violet          | 137C                   | Intermediate     | Acute   |
| 23  | Kania F1 (KF1)             | Green            | Absent                             | Erect              | Absent                        | Green           | 137A                   | Intermediate     | Acute   |

Remarks: *using 6th Royal Horticulture Society (RHS) colour chart (2015)
Table 2. (continued)

| No. | Accession                  | Leaf prickles | Leaf lobe tip | Leaf base | Number of flowers per inflorescence | Corolla colour | Number of corolla | Number of calyx | Leaf calyx prickles |
|-----|----------------------------|---------------|---------------|-----------|-------------------------------------|----------------|------------------|-----------------|-------------------|
| 1   | Terong gelatik (K14)       | Very few      | Acuminate     | Rounded   | More than three                     | Dark violet    | More than five   | More than five   | Absent            |
| 2   | Terong butuh (K17)         | Few           | Rounded       | Rounded   | More than three                     | Light violet   | More than five   | More than five   | Absent            |
| 3   | Terong ungu (K116)         | Few           | Rounded       | Emarginate| One to three                        | Light violet   | More than five   | More than five   | Present           |
| 4   | Terong lalap (K32)         | Very few      | Obtuse        | Acute     | One to three                        | White          | More than five   | More than five   | Absent            |
| 5   | Terong gelatik (K20)       | None          | Rounded       | Rounded   | More than three                     | White          | More than five   | More than five   | Absent            |
| 6   | Terong (K62)               | None          | Rounded       | Emarginate| More than three                     | Dark violet    | More than five   | Five            | Absent            |
| 7   | Terong gelatik kecil (K13) | Very few      | Obtuse        | Rounded   | One to three                        | Light violet   | More than five   | More than five   | Absent            |
| 8   | Terong telurjuk (K88)      | Very few      | Rounded       | Emarginate| One to three                        | Dark violet    | Five             | Five            | Absent            |
| 9   | Terong kecap (K90)         | Very few      | Rounded       | Emarginate| More than three                     | Dark violet    | More than five   | Five            | Absent            |
| 10  | Terong hijau (K178)        | Very many     | Rounded       | Rounded   | More than three                     | Light violet   | More than five   | More than five   | Present           |
| 11  | Terong manggis (K110)      | Very few      | Rounded       | Emarginate| More than three                     | Light violet   | More than five   | More than five   | Absent            |
| 12  | Terong lalang (K69)        | None          | Rounded       | Emarginate| One to three                        | Dark violet    | More than five   | More than five   | Absent            |
| 13  | Terong apel (K50)          | Few           | Rounded       | Emarginate| More than three                     | Dark violet    | More than five   | More than five   | Absent            |
| 14  | Terong lalap rebus (K83)   | Few           | Obtuse        | Emarginate| One to three                        | Dark violet    | More than five   | More than five   | Absent            |
| 15  | Terong kerci (K135)        | Very few      | Obtuse        | Acute     | One to three                        | Light violet   | More than five   | More than five   | Absent            |
| 16  | Terong gading (K118)       | Few           | Rounded       | Emarginate| More than three                     | Dark violet    | More than five   | More than five   | Absent            |
| 17  | Terong pinang (K57)        | Very few      | Rounded       | Rounded   | More than three                     | Light violet   | More than five   | Five            | Absent            |
| 18  | Terong asam (K51)          | Very few      | Rounded       | Emarginate| More than three                     | Light violet   | Five             | Five            | Absent            |
| 19  | Faimatak (K82)             | Few           | Rounded       | Emarginate| More than three                     | White          | Five             | Five            | Absent            |
| 20  | Poki-poki (K93)            | Few           | Rounded       | Emarginate| More than three                     | Dark violet    | More than five   | Five            | Absent            |
| 21  | Terong jawa (K18)          | Very few      | Rounded       | Emarginate| More than three                     | Light violet   | More than five   | More than five   | Absent            |
| 22  | Terong ungu (TU)           | Very few      | Obtuse        | Acute     | One to three                        | Light violet   | More than five   | More than five   | Absent            |
| 23  | Kania F, (KF1)             | Very few      | Obtuse        | Rounded   | More than three                     | Light violet   | More than five   | More than five   | Absent            |
| No. | Accession          | Fruit shape | Fruit length: breadth ratio | Fruit curvature | Fruit position | Fruit apex | Fruit colour at commercial ripeness | Fruit colour at physiological ripeness | Fruit glossiness |
|-----|--------------------|-------------|-----------------------------|----------------|---------------|-----------|---------------------------------|-----------------------------------|-----------------|
| 1   | Terong gelatik (K14) | Globular    | Broader than long           | None           | Pendant       | Flattened | Green                           | Orange                               | Present         |
| 2   | Terong butuh (K17)  | Obovate     | Slightly longer than broad   | None           | Pendant       | Indented  | Violet                          | Yellowish purple                        | Present         |
| 3   | Terong ungu (K116)  | Ellipsoid   | Three times as long as broad | Slightly curved | Pendant       | Rounded   | Violet                          | Yellow                   | Absent          |
| 4   | Terong lalap (K32)  | Globular    | Broader than long           | None           | Pendant       | Flattened | Green                           | Orange                               | Present         |
| 5   | Terong gelatik (K20) | Globular    | Broader than long           | None           | Pendant       | Flattened | Green                           | Orange                               | Present         |
| 6   | Terong (K62)        | Globular    | As long as broad            | None           | Pendant       | Flattened | White                           | Yellow                  | Present         |
| 7   | Terong gelatik kecil (K13) | Globular | As long as broad            | None           | Pendant       | Flattened | White                           | Orange                               | Absent          |
| 8   | Terong telunjuk (K88) | Cylindrical | Several times as long as broad | Curved         | Pendant       | Pointed   | Green                           | Orange                               | Absent          |
| 9   | Terong kecap (K90)  | Ovoid       | Slightly longer than broad   | None           | Pendant       | Rounded   | Green                           | Orange                               | Absent          |
| 10  | Terong hijau (K178) | Obovate     | Slightly longer than broad   | None           | Pendant       | Indented  | Green                           | Yellow                  | Absent          |
| 11  | Terong manggis (K110) | Globular   | Broader than long           | None           | Pendant       | Flattened | Violet                          | Orange                               | Present         |
| 12  | Terong talang (K69) | Obovate     | Twice as long as broad       | None           | Pendant       | Indented  | Violet                          | Yellowish purple                        | Absent          |
| 13  | Terong apel (K50)   | Globular    | Broader than long           | None           | Pendant       | Rounded   | White                           | Orange                  | Absent          |
| 14  | Terong lalap rebus (K83) | Globular | As long as broad            | None           | Pendant       | Flattened | Green                           | Orange                  | Absent          |
| 15  | Terong kercil (K135) | Globular    | Broader than long           | Several times as long as broad | None           | Pendant       | Flattened | Violet                          | Orange                  | Present         |
| 16  | Terong gading (K118) | Cylindrical | Several times as long as broad | Curved | Pendant       | Pointed   | White                           | Orange                  | Absent          |
| 17  | Terong pinang (K57) | Obovate     | Slightly longer than broad   | None           | Pendant       | Rounded   | Green                           | Orange                  | Absent          |
| 18  | Terong asam (K51)   | Globular    | As long as broad            | None           | Pendant       | Rounded   | White                           | Yellow                  | Absent          |
| 19  | Faimatak (K82)      | Ovoid       | Slightly longer than broad   | None           | Pendant       | Rounded   | Green                           | Orange                  | Absent          |
| 20  | Poki-poki (K93)     | Cylindrical | Three times as long as broad | Curved         | Pendant       | Rounded   | Green                           | Orange                  | Present         |
| 21  | Terong jawa (K18)   | Obovate     | Twice as long as broad       | None           | Pendant       | Indented  | Violet                          | Yellowish purple                        | Absent          |
| 22  | Terong ungu (TU)    | Cylindrical | Several times as long as broad | Several times as long as broad | Curved | Pendant       | Rounded   | Violet                          | Yellowish purple                        | Present         |
| 23  | Karia F₁ (KF1)      | Cylindrical | Several times as long as broad | Curved | Pendant       | Pointed   | White                           | Yellow                  | Absent          |
Table 2. (continued)

| No. | Accession | Macromorphological characters | Seed colour* |
|-----|-----------|--------------------------------|--------------|
|     |           | Fruit stripes | Fruit patches | Fruit flesh density | Fruit colour of flesh | Fruit cross section |   |
| 1   | Terong gelatik (K14) | Absent | Present | Dense | Greenish white | Few grooves | 164C |
| 2   | Terong butuh (K17) | Present | Absent | Dense | Greenish white | Many grooves | 164B |
| 3   | Terong ungu (K116) | Present | Absent | Spongy | White | Circular, no grooves | 164C |
| 4   | Terong lalap (K32) | Absent | Present | Dense | Greenish white | Circular, no grooves | 164B |
| 5   | Terong gelatik (K20) | Absent | Present | Dense | White | Circular, no grooves | 164B |
| 6   | Terong (K62) | Absent | Absent | Dense | Greenish white | Circular, no grooves | 164B |
| 7   | Terong gelatik kecil (K13) | Absent | Present | Dense | Greenish white | Circular, no grooves | 164B |
| 8   | Terong telunjuk (K88) | Present | Present | Spongy | Greenish white | Circular, no grooves | 164B |
| 9   | Terong kecap (K90) | Absent | Present | Dense | Greenish white | Circular, no grooves | 164B |
| 10  | Terong hijau (K178) | Absent | Present | Dense | Greenish white | Circular, no grooves | 164B |
| 11  | Terong manggis (K110) | Absent | Absent | Dense | White | Circular, no grooves | 164B |
| 12  | Terong talang (K69) | Present | Absent | Spongy | Greenish white | Circular, no grooves | 164B |
| 13  | Terong apel (K50) | Absent | Absent | Dense | Greenish white | Circular, no grooves | 164B |
| 14  | Terong lalap rebus (K83) | Absent | Present | Dense | Greenish white | Circular, no grooves | 164B |
| 15  | Terong kerci (K135) | Absent | Absent | Dense | White | Circular, no grooves | 164B |
| 16  | Terong gading (K118) | Absent | Absent | Spongy | White | Circular, no grooves | 164C |
| 17  | Terong pinang (K57) | Absent | Absent | Spongy | White | Circular, no grooves | 164B |
| 18  | Terong asam (K51) | Absent | Absent | Dense | Greenish white | Circular, no grooves | 164B |
| 19  | Faimatak (K82) | Absent | Present | Dense | White | Circular, no grooves | 164C |
| 20  | Poki-poki (K93) | Absent | Present | Dense | White | Circular, no grooves | 164B |
| 21  | Terong jawa (K18) | Present | Absent | Spongy | Greenish white | Circular, no grooves | 161B |
| 22  | Terong ungu (TU) | Absent | Absent | Spongy | White | Circular, no grooves | 164B |
| 23  | Kania F1 (KF1) | Absent | Absent | Spongy | White | Circular, no grooves | 164B |

Remarks: *using 6th Royal Horticulture Society (RHS) colour chart (2015)
Variations among the evaluated eggplant accessions were also observed on leaf petiole color, leaf color, leaf spines, leaf tip shape, leaf base shape, and leaf lobe tip. Leaf petiole color has three variations, i.e. green, purple-green, and purple. Some accessions have leaves with many spines, yet others have fewer. The spines have a function to protect the plants from herbivors that may damage the plant organ (War et al., 2012). The variation of the color was observed on corolla color (white, light purple, dark purple) and number of flowers per inflorescence (1-3 or more than 3 flowers per inflorescence). Based on Kaushik, Prohens, Vilanova, Gramazio, & Plazas (2016) in eggplant breeding, the number of large flowers per inflorescences will be reduced in order to increase the uniformity of the fruit. The most distinguished characters among eggplant accessions are fruit appearance. The fruit variation is resulted from a characteristics of fruit shape, fruit length:breadth ratio, curved on fruit, fruit tip, and fruit skin color (Fig. 1). Fruit skin color of eggplant are divided into commercially ripe fruit with varied color (purple, white, green) mostly accumulate purple anthocyanins and physiologically ripe fruits caused by biosynthesis orange-colored or carotenoid pigments (Liu et al., 2018; Barchi et al., 2019).

The micromorphological data (Table 3) shows variation of leaf surface features (Fig. 2). The shape of the anticlinal walls of epidermal cells in surfaces of adaxial and abaxial were varied from straight to curved. It was clearly observed on Terong Ungu (TU), Terong Apel (K50) and Terong Kecap (K90). The shape of walls on epidermal cells at the adaxial and abaxial surface was straight to curved, curved and sinuous, and they are dominant on the leaf surface. The shape of the curved wall is a common shape found in genus Solanum (Nurit-Silva & de Fátima Agra, 2011).

The characteristic of non-glandular trichome are sessile stellate, stalked stellate, unicellular hair and peltate. Stellate trichome is common found in all eggplant accessions and cultivars. The glandular trichome is not varied among the tested accessions. The amphistomatic patterns of stomata distribution were found in the leaves of all tested accessions. These patterns are resulted as an adaptation to increase the rate of photosynthesis in natural environment (Sampaio, Araújo, & Agra, 2014). The two different types of stomata were recognized on leaf epidermis, that is anisocytic and anomocytic. the anomocytic type was predominant at the abaxial surface whereas the anisocytic type was predominant at the adaxial surface of the leaf (Nurit-Silva, Costa-Silva, Basílio, & de Fátima Agra, 2012).

**Non-formal Classification**

The dendrogram (Fig. 3) shows that S. melongena is divided into 2 main groups based on 30 macromorphological characters. PCA analysis shows that the grouping was based on the combination of several characters such as the shape of the fruit, the ratio of fruit length:breadth, the curve of the fruit and leaf spines (Fig. 4). Group I consists of all accessions with average distance value of 0.557 that have curved fruit, the fruit length:breadth ratio is three times or more than the broad and the shape of fruit are ellipsoid or cylindrical. This group consisted of 6 accessions, i.e. K39, K116, K88, K118, KF1 and TU. Group II is the accession that has non-curved fruit, fruit length:breadth ratio are longer or the same as the broad and the shape of fruit are globular, ovoid or obovate. This second group composes of 17 accessions that divided into 2 sub-groups; II.A and II.B with average distance value of 0.990. Group II.A was composed of the accession Terong Hijau (K178) which has total leaf spines more than 20. While group II.B was composed of 16 accessions i.e. K18, K69, K17, K14, K82, K90, K57, K62, K110, K51, K135, K50, K83, K32, K20, K13 that have lesser leaf spine (total of spine 1-5).

Intraspecific classification in cultivated plant based on morphological characters are considered appropriate for species which has great phenotypic variations. Earlier studies by Begum, Islam, Rasul, Mian, & Hossain (2013) showed that 92 eggplant genotypes from Bangladesh were grouped into ten different groups with the role of days to first harvested-fruit and days to first flowering indicating the important component of genetic divergence, Cakir, Balkaya, Saribas, & Kandemir (2017) was divided 42 Turkish eggplants into 9 group based on fruit characters, i.e. fruit shape, fruit curvature, fruit apex shape, fruit length and fruit diameter. Purnomo, Faizah, & Daryono (2017) and Sari, Purnomo, Daryono, Suryadiantina, & Setiyowati (2016) also used morphological characters to create some group of cultivated plants. Based on macromorphological characters used in the study, S. melongena accessions of Indonesia can be divided into 2 groups.
Table 3. List of micromorphological character of eggplant accessions

| No. | Accession    | Anticlinal cell walls | Distribution of stomata | Grandular trichome | Stellate sessile trichome (non-grandular) |
|-----|--------------|-----------------------|-------------------------|-------------------|-------------------------------------------|
|     |              | Adaxial    | Abaxial    | Adaxial | Abaxial | Adaxial | Abaxial | Adaxial | Abaxial |
| 1   | Terong gelatik (K14) | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 2   | Terong butuh (K17)   | Straight to curved | Sinous      |          |         |         |         | Present | Present | Present |
| 3   | Terong ungu (K116)   | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 4   | Terong lalap (K32)   | Curved      | Curved      |          |         |         |         | Present | Present | Present |
| 5   | Terong gelatik (K20) | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 6   | Terong (K62)         | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 7   | Terong gelatik kecil (K13) | Curved | Sinous      |          |         |         |         | Present | Present | Present |
| 8   | Terong telunjuk (K88) | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 9   | Terong kecap (K90)   | Straight to curved | Sinous      |          |         |         |         | Present | Present | Present |
| 10  | Terong hijau (K178)  | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 11  | Terong manggis (K110) | Curved     | Sinous      |          |         |         |         | Present | Present | Present |
| 12  | Terong talang (K69)  | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 13  | Terong apel (K50)    | Straight to curved | Sinous      |          |         |         |         | Present | Present | Present |
| 14  | Terong lalap rebus (K83) | Curved | Sinous      |          |         |         |         | Present | Present | Present |
| 15  | Terong kercil (K135) | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 16  | Terong gading (K118) | Curved      | Curved      |          |         |         |         | Present | Present | Present |
| 17  | Terong pinang (K57)  | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 18  | Terong asam (K51)    | Sinous      | Sinous      |          |         |         |         | Present | Present | Present |
| 19  | Faimatak (K82)       | Curved      | Curved      |          |         |         |         | Present | Present | Present |
| 20  | Poki-poki (K93)      | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 21  | Terong jawa (K18)    | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| 22  | Terong ungu (TU)     | Straight to curved | Straight to curved |          |         |         |         | Present | Present | Present |
| 23  | Kania F1 (KF1)       | Curved      | Sinous      |          |         |         |         | Present | Present | Present |
| No. | Accession         | Stellate stalked trichome (non-grandular) | Spine trichome (non-grandular) | Peltate trichome (non-grandular) | Type of stomata      |
|-----|-------------------|------------------------------------------|--------------------------------|----------------------------------|----------------------|
|     |                   | Adaxial | Abaxial | Adaxial | Abaxial | Adaxial | Abaxial | Adaxial | Abaxial |                      |
| 1   | Terong gelatik (K14) | Absent | Absent | Present | Present | Absent | Absent | Anisocytic | Anomocytic |
| 2   | Terong butuh (K17)  | Absent | Present | Present | Absent | Absent | Anisocytic | Anomocytic |
| 3   | Terong ungu (K116)  | Absent | Absent | Absent | Absent | Present | Absent | Anisocytic | Anomocytic |
| 4   | Terong lalap (K32)  | Absent | Absent | Present | Present | Absent | Anomocytic, Anisocytic | Anomocytic |
| 5   | Terong gelatik (K20) | Absent | Absent | Present | Absent | Absent | Anisocytic | Anomocytic |
| 6   | Terong (K62)       | Present | Present | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 7   | Terong gelatik kecil (K13) | Absent | Absent | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 8   | Terong telunjuk (K88) | Present | Present | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 9   | Terong kecap (K90)  | Present | Present | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 10  | Terong hijau (K178) | Absent | Absent | Present | Present | Absent | Anomocytic | Anomocytic |
| 11  | Terong manggis (K110) | Absent | Absent | Present | Absent | Present | Absent | Anomocytic | Anomocytic |
| 12  | Terong talang (K69) | Absent | Absent | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 13  | Terong apel (K50)   | Present | Absent | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 14  | Terong lalap rebus (K83) | Absent | Absent | Present | Absent | Absent | Anisocytic | Anomocytic |
| 15  | Terong kercil (K135) | Absent | Absent | Absent | Absent | Absent | Anomocytic | Anomocytic |
| 16  | Terong gading (K119) | Absent | Present | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 17  | Terong pinang (K57) | Present | Absent | Present | Present | Absent | Anisocytic | Anomocytic |
| 18  | Terong asam (K51)  | Absent | Absent | Absent | Absent | Absent | Anomocytic | Anomocytic |
| 19  | Faimatak (K82)     | Present | Present | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 20  | Poki-poki (K93)    | Present | Present | Present | Absent | Absent | Anisocytic | Anomocytic |
| 21  | Terong jawa (K18)  | Absent | Absent | Absent | Absent | Absent | Anisocytic | Anomocytic |
| 22  | Terong ungu (TU)   | Absent | Absent | Present | Absent | Absent | Anomocytic | Anomocytic |
| 23  | Kania F, (KF1)     | Absent | Absent | Present | Absent | Absent | Anisocytic | Anomocytic |
Remarks: A. Terong Ungu (TU); B. Kania F1 (KF1); C. Terong Butuh (K17); D. Terong Jawa (K18); E. Terong Pinang (K57); F. Terong Talang (K69); G. Poki-poki (K93); H. Terong Telunjuk (K88); I. Terong Ungu (K116); J. Terong Gading (K118); K. Faimatak (K82); L. Terong Manggis (K110); M. Terong Gelatik Kecil (K13); N. Terong Gelatik (K14); O. Terong Gelatik (K20); P. Terong Lalap (K32); Q. Terong Apel (K50); R. Terong Asam (K51); S. Terong (K62); T. Terong Lalap Rebus (K83); U. Terong Kecap (K90); V. Terong Kercil (K135); W. Terong Hijau (K178)

Fig. 1. Variation of shape and skin color of Indonesian eggplant fruits
Remarks: A. Anticlinal walls of epidermal cells straight to curved; B. Anticlinal walls of epidermal cells curved; C. Anticlinal walls of epidermal cells sinuous; D. Stellate sessile (sts) and spine (sp) trichome; E. Stellate stalked (stlk) trichome; and F. Peltate (plt) trichome

Fig. 2. Variation of leaf micromorphological of eggplant accessions (at a magnification x100)

Fig. 3. Dendrogram of 23 eggplant accessions based on macromorphological characters using UPGMA analysis. Name of each accession listed in Table 1
The two groups are curved, non-curved with more spiny leaves and non-curved with less spiny leaves. Both groups can be clearly recognized by some of the markable macromorphological characters. The grouping of 23 eggplant accessions based on macromorphological characters were presented in Table 4.

Group formation based on macromorphology is strongly influenced by a combination of several characters, there are fruit shape, ratio and fruit curvature. Group I consists of eggplant accessions with curved fruit and they have two fruit shapes (cylindrical or ellipsoid). Group II composes of accessions with non-curved fruit and three fruit shapes (globular, ovoid or obovate). The data also confirmed that the eggplant grouping does not occur based on the origin of the collection area. These indicated that the used character is a steady character or its variability is not affected by the environmental factors (Sari, Suryadiantina, Daryono, & Purnomo, 2018). This can be due to the dominating character of grouping as a qualitative character that tends to be more stable towards environmental change (Engels, 1983).

Similar findings was also reported by Caguiat & Hautea (2014) that also grouped 32 accession of Philippine eggplant become 4 main groups based on morphological and molecular characters without any correlation of their geographical origin.

Cluster analysis of 23 eggplant accessions based on micromorphological characters resulted in a dendrogram (Fig. 5) that formed 2 groups.
PCA analysis shows that the grouping was based on the combination of several characters such as characters of stomatal type in the adaxial and the abaxial epidermal cell wall (Fig. 6). Group I consists of two accessions with average distance value of 0.818, namely Terong Lalap (K32) and Terong Ungu (TU). Group II is derived into 2 sub-groups. Sub group II.A consists of Faimatak (K82) and separated with average distance value of 0.912 based anisocytic stomatal type on adaxial and abaxial. While, subgroup II.B consists of 20 eggplant cultivar/accessions with variation in adaxial and abaxial stomatal types. Sampaio, Araújo, & Agra (2014) stated that the characters of leaf epidermis and its annexes, mainly themorphology of trichomes, are useful in distinguishing the Solanum species (clade Brevantherum) from Northeastern Brazil. The result of cluster analysis based on macro and micro-morphological characters formed 2 main groups. However, the member of accessions within each group and number of characters to construct dendrogram based on macro and micro morphological (30 macro and 8 micromorphological characters) were different.

**Fig. 5.** Dendrogram of 23 eggplant accessions based on micromorphological characters using UPGMA analysis. Name of each accession listed in Table 1
CONCLUSION

The evaluated eggplant accessions have macromorphological variation especially in fruit characters. The variation of the accessions were also observed on micromorphological characters such as anticlinal walls epidermis, the shape of trichome and the type of stomata. The eggplant accessions are classified into 2 groups, namely “curved fruit group” and “non-curved fruit group” based on macromorphological characters. The phenetic relationship of eggplant accessions based on micromorphological characters was divided into 2 groups based on the epidermal wall, trichome shape, and stomata type characters.

ACKNOWLEDGEMENT

The authors express a gratitude to the head officer of The Indonesian Center for Agricultural Biotechnology Research and Genetic Resource and Development (ICABIOGRAD), Bogor for providing materials of this study and BPPTN Bh Research Faculty of Biology UGM, No. UGM/BI/1689/M/01/05 and Student Thesis Recognition Grant, Universitas Gadjah Mada through Contract No. 2129/UNI/DITLIT/DIT-LIT/LT/2019 for funding this research.

REFERENCES

Barchi, L., Pietrella, M., Venturini, L., Minio, A., Toppino, L., Acquadro, A., ... Rotino, G. L. (2019). A chromosome-anchored eggplant genome sequence reveals key events in Solanaceae evolution. Scientific Reports, 9, 11769. https://doi.org/10.1038/s41598-019-47985-w

Begum, F., Islam, A. K. M. A., Rasul, M. G., Mian, M. A. K., & Hossain, M. M. (2013). Morphological diversity of eggplant (Solanum melongena) in Bangladesh. Emirates Journal of Food and Agriculture, 25(1), 45–51. https://doi.org/10.9755/ejfa.v25i1.4937

Behera, T. K., Sharma, P., Singh, B. K., Kumar, G., Kumar, R., Mohapatra, T., & Singh, N. K. (2006). Assessment of genetic diversity and species relationships in eggplant (Solanum melongena L.) using STMS markers. Scientia Horticulturae, 107(4), 352–357. https://doi.org/10.1016/j.scienta.2005.11.004

Caguiat, X. G. I., & Hautea, D. M. (2014). Genetic diversity analysis of eggplant (Solanum melongena L.) and related wild species in the philippines using morphological and SSR markers. Sabrao Journal of Breeding and Genetics, 46(2), 183–201. Retrieved from https://pdfs.semanticscholar.org/2dde/50e6bb0915ecec88edba5e316f2f8b01b4e.pdf
Cakir, Z., Balkaya, A., Saribas, S., & Kandemir, D. (2017). The morphological diversity and fruit characterization of Turkish eggplant (Solanum melongena L.) populations. Ekin Journal of Crop Breeding and Genetics, 3(2), 34–44. Retrieved from http://www.ekinjournal.com/images/bisab/sixth/EJ6-2.pdf

Daunay, M.-C., & Janick, J. (2007). History and iconography of eggplant. Chronica Horticulture, 47(3), 16–22. Retrieved from https://hort.purdue.edu/newcrop/chronicaeggplant.pdf

Ditbenih. (2017). Database varietas terdaftar hortikultura. Direktorat Perbenihan Hortikultura Kementerian Pertanian Republik Indonesia. Retrieved from http://varitas.net/dbvarietas/

Engels, J. M. M. (1983). A systematic description of cacao clones. I. The discriminative value of quantitative floral characters. Euphytica, 32(2), 377–385. https://doi.org/10.1007/BF00021446

FAO. (2016). FAOSTAT crops data. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/faostat/en/#data/QC

Hetterscheid, W. L., & Brandenburg, W. A. (1995). Culton versus taxon: Conceptual issues in cultivated plant systematics. Taxon, 44(2), 161–175. https://doi.org/10.2307/1222439

Kaushik, P., Prohens, J., Vilanova, S., Gramazio, P., & Plazas, M. (2016). Phenotyping of eggplant wild relatives and interspecific hybrids with conventional and phenomics descriptors provides insight for their potential utilization in breeding. Frontiers in Plant Science, 7, 677. https://doi.org/10.3389/fpls.2016.00677

KCS. (2007). MVSP 3.1 - A multivariate statistical package. Wales, UK: Kovach Computing Services. Retrieved from https://www.kovcomp.co.uk/mvsp/MVSP3ProInfo1.pdf

Knapp, S., Vorontsova, M. S., & Prohens, J. (2013). Wild relatives of the eggplant (Solanum melongena L.: Solanaceae): New understanding of species names in a complex group. PLOS ONE, 8(2), e57039. https://doi.org/10.1371/journal.pone.0057039

Kumar, G., Meena, B. L., Kar, R., Tiwari, S. K., Gangopadhyay, K. K., Bisht, I. S., & Mahajan, R. K. (2008). Morphological diversity in brinjal (Solanum melongena L.) germplasm accessions. Plant Genetic Resources, 6(3), 232–236. https://doi.org/10.1017/S1479262108994211

Lester, R. N., & Niakan, L. (1988). Descriptors for eggplant. International Board for Plant Genetic Resources. Retrieved from https://books.google.co.id/books?id=3mFQgAACAAJ

Liu, Y., Tikunov, Y., Schouten, R.E., Marcelis, L.F.M., Visser, R.G.F., and Bovy, A. 2018. Anthocyanin biosynthesis and degradation mechanisms in Solanaceous vegetables: A Review. (Review). Front. Chem, 6(52), 1-17

Meyer, R. S., Bamshad, M., Fuller, D. Q., & Litt, A. (2014). Comparing medicinal uses of eggplant and related Solanaceae in China, India, and the Philippines suggests the independent development of uses, cultural diffusion, and recent species substitutions. Economic Botany, 68(2), 137–152. https://doi.org/10.1007/s12231-014-9267-6

Meyer, R. S., Karol, K. G., Little, D. P., Nee, M. H., & Litt, A. (2012). Phylogeographic relationships among Asian eggplants and new perspectives on eggplant domestication. Molecular Phylogenetics and Evolution, 63(3), 685–701. https://doi.org/10.1016/j.ympev.2012.02.006

Nurit-Silva, K., & de Fátima Agra, M. (2011). Leaf epidermal characters of Solanum sect. polytrichum (Solanaceae) as taxonomic evidence. Microscopy Research and Technique, 74(12), 1186–1191. https://doi.org/10.1002/jemt.21013

Nurit-Silva, K., Costa-Silva, R., Basílio, I. J. L. D. & de Fátima Agra, M. (2012). Leaf epidermal characters of Brazilian species of Solanum section Torva as taxonomic evidence. Botany, 90(9), 806–814. https://doi.org/10.1139/b2012-046

Plazas, M., Andújar, I., Vilanova, S., Gramazio, P., Javier Herraiz, F., & Prohens, J. (2014). Conventional and phenomics characterization provides insight into the diversity and relationships of hypervariable scarlet (Solanum aethiopicum L.) and gboma (S. macrocarpon L.) eggplant complexes. Frontiers in Plant Science, 5, 318. https://doi.org/10.3389/fpls.2014.00318

Purnomo, Faizah, L. N., & Daryono, B. S. (2017). Variability and intraspecific classification of gembili (Dioscorea esculenta (Lour.) Burk.) based on morphological characters. Sabrao Journal of Breeding and Genetics, 49(1), 1–8. Retrieved from http://sabraojournal.org/wp-content/uploads/2017/12/SABRAO-J-Breed-Genet-49-1-1-8-Purnomo.pdf

Sampaio, V. S., Araújo, N. D., & Agra, M. F. (2014). Characters of leaf epidermis in Solanum (clade Brevantherum) species from Atlantic Forest of
Uni B. Husnudin et al: Variation and Non-formal Classification of Indonesian Eggplant ............................

Northeastern Brazil. South African Journal of Botany, 94, 108–113. https://doi.org/10.1016/j.
sajb.2014.06.004

Samuels, J. (2015). Biodiversity of food species of the Solanaceae family: A preliminary taxonomic
inventory of subfamily Solanoideae. Resources, 4(2), 277–322. https://doi.org/10.3390/
resources4020277

Sari, N., Suryadiantina, Daryono, B. S., & Purnomo. (2018). Variability and intraspecific classification
of Indonesian edible canna (Canna indica L.) based on rapid marker analysis. Sabrao Journal
of Breeding and Genetics, 50(2), 156–167. Retrieved from http://sabraojournal.org/wp-
content/uploads/2018/06/SABRAO-J-Breed-
Genet-50-2-156-167-SARI.pdf

Sari, N., Purnomo, Daryono, B. S., Suryadiantina, & Setyowati, M. (2016). Variation and intraspecies
classification of edible canna (Canna indica L.) based on morphological characters. AIP
Conference Proceedings, 1744, 020041. https://
doi.org/10.1063/1.4953515

Scorsatto, M., Rosa, G., Luiz, R. R., da Rocha Pinheiro
Mulder, A., Teodor, A. J., & de Oliveira, G. M. M. (2019). Effect of eggplant flour (Solanum
meloengena L.) associated with hypoenergetic
diet on antioxidant status in overweight women
- a randomised clinical trial. International Journal
of Food Science & Technology, 54(6), 2182-
2189. https://doi.org/10.1111/ifs.14125

Sękara, A., Ceba, S., & Kunicki, E. (2007). Cultivated
eggplants – origin, breeding objectives and
genetic resources, a review. Folia Horticulturae,
19(1), 97-114. http://ptno.org.ar.krakow.pl/
Wydawn/FoliaHorticulturae/Spisy/FH2007/
Abstract19012007/fh1901abstract09.htm

Singh, G. (2010). Plant systematics: An integrated
approach (3rd ed.). CRC Press.

Spooner, D. M., Hetterscheid, W. L. A., van den Berg,
R. G., & Brandenburg, W. A. (2003). Plant
nomenclature and taxonomy: An horticultural and
agronomic perspective. Horticultural Reviews.
John Wiley & Sons, Inc. Retrieved from https://
pubag.nal.usda.gov/pubag/downloadPDF.
xml?id=3433&content=PDF

Stace, C. A. (1991). Plant taxonomy and biosystematics
(2nd ed.). Cambridge University Press.

War, A. R., Paulraj, M. G., Ahmad, T., Buhroo, A. A.,
Hussain, B., Ignacimuthu, S., & Sharma, H. C.
(2012). Mechanisms of plant defense against
insect herbivores. Plant Signaling and Behavior,
7(10), 1306–1320. https://doi.org/10.4161/
psb.21663

Weese, T. L., & Bohs, L. (2010). Eggplant origins: Out
of Africa, into the Orient. Taxon, 59(1), 49–56.
https://doi.org/10.1002/tax.591006