Evaluation of morpho-agronomic characterization *Apple cucumber*: a new variety of melon from Indonesia

N W Saputro*, T Hidayat, F M Bayfurqon and M B R Khamid

1 Department of Agrotechnology, Singaperbangsa University Karawang
2 Department of Biology, Indonesia University of Education

*Corresponding author: nurcahyo.widyodaru@staff.unsika.ac.id

Abstract. The Cucurbitaceae has been known to many farmers as a plant that has beneficial for agriculture industries. For decades plants that belong to Cucurbitaceae such as cucumber (*Cucumis sativus*), watermelon (*Citrullus lanatus*), and melon (*Cucumis melo*) has been cultivated to meet consumer needs. In Indonesia, a new variety of melon has been discovered namely apple cucumber. This new variety has blurred the difference between melon and cucumber due to the vegetative resemblance. This research was conducted to clarify the different characters and to study the morpho-agronomic characteristic in qualitative and quantitative-based on IPGRI descriptors. Important and significant diagnostic characters were observed to developed good cultivar in quality and quantity. 16 qualitative and 15 quantitative characters from 120 characters of apple cucumber were observed to determine the specific characters for good cultivar. Principal Analysis Component (PCA) using Python was used to showed discriminative character and also to distinguished apple cucumber to melon and cucumber based on 120 characters of apple cucumber. Morphological differences existing among melon, cucumber, watermelon, and apple cucumber, in particular, are presented.

**Keywords:** Apple cucumber, morpho-agronomic, IPGRI, Principal Analysis Component (PCA), qualitative and quantitative character

1. Introduction

Cucurbitaceae family-inclusive to the order Cucurbitales, class Magnoliopsida (subclass Rosidae) and one of the most important in the Angiosperm taxa [1]. Previously studied a number of genera and species of Cucurbitaceae is still unclear, [2] declare that the Cucurbitaceae family consist of 9 genera and 15 species of fruits and vegetables while [3] informed 100 genera and 800 species and [4] claimed that Cucurbitaceae consists of 117 genera and 825 species. [5] suggested 100 genera and more than 750 species along with [6] indicated that 122 genera and 940 species of Cucurbitaceae family are distributed in an equatorial and warm temperate section of the world. Recently studied confirmed Cucurbitaceae family comprises of 96 genera and distribute to 1000 species [7]. Phylogenetic research in cucurbitaceous has been carried out from 1964 [8] and currently in 2018 [9] studied the Phylogeny of Zehneria (Cucurbitaceae) with special focus on Asia. Cucurbitaceae is known for its practicality as nutritive and medicinal use [10]. Due to medicinal properties and associated with Cucurbitaceae domestication, the genetic mechanisms and the substances involved in their production have been studied thoroughly and clarified recently [11, 12]. Among all Cucurbitaceae species, melon (*Cucumis melo*) and cucumber (*Cucumis sativus*) has been used on a daily basis as a mixture in a salad or as a...
healthy drink (Smoothies). A recent study in melon and cucumber showed that they have numerous wild descendants in Australia and Asia, and the closest species of melon is from Australia [13].

In Aceh Indonesia, people who live there have been astonished by the appearance of unique tropical fruit, namely “Apple cucumber“ for many years. The appearance of “Apple cucumber” resembles apple fruit shape but has a fruit flesh and flavor similar to a melon, this particular variety distributed from Jember, Karawang, to other regions. Currently, there is no information about the evaluation of morpho-agronomic in “Apple cucumber because of lack of morphological data to justified the difference between melon and cucumber due to the vegetative resemblance.

2. Materials and methods

Morphological studies samples used are mentioned in table 1. The fieldwork was conducted at Singaperbangsa University Karawang, Agrotechnology Department, Indonesia. All recommended plant cultivation ordinance and protection were measured accordingly to maintain the availability of sample plant growth. Morphological characters were recorded based on the International Plant Genetic Resources Institute [14] and divided into two main observations (Qualitative & Quantitative).

Qualitative morphological plant features studied include leaf petiole length, fruit shape, fruit size, predominant fruit skin color, secondary skin color pattern, secondary color of immature fruit, secondary fruit skin color, fruit surface, fruit skin hairiness, fruit corking/netting pattern, fruit corking/netting intensity, fruit corking/netting distribution, diameter of peduncle, flesh flavor, main color of flesh, and placenta color.

Quantitative morphological plant features were examined and checked in the middle of flowering and harvesting period (20-40 days after planting) including hypocotyl diameter, cotyledon ratio, stem thickness, stem hairs, plant branches, days to 50% flowering, days to first flowering, leaf ratio, peduncle length, mean length of standard petal, mean width of standard petal, maturation period, fruit length/width ratio, days to first mature fruit, and total fruit weight per plant. Measurements were taken using ten of each of the plant sample parts. For example, hypocotyl diameter was taken from 10 hypocotyls and the average diameter was documented, and so on. The impression of morphological features from each species used for the study was documented with a digital camera.

Table 1. Source of plant material studied.

| No. | Plant (local name)         | Species           | Code | Location |
|-----|----------------------------|-------------------|------|----------|
| 1   | Apple Cucumber             |                   | A    | Karawang |
| 2   | Apple Cucumber             |                   | B    | Karawang |
| 3   | Apple Cucumber             |                   | C    | Karawang |
| 4   | Apple Cucumber             |                   | D    | Jember   |
| 5   | Apple Cucumber             |                   | E    | Jember   |
| 6   | Apple Cucumber             |                   | F    | Jember   |
| 7   | Apple Cucumber             |                   | G    | Aceh     |
| 7   | Melon                      | Cucumis melo      |      |          |
| 8   | Cucumber                   | Cucumis sativus   |      |          |
| 9   | Watermelon                 | Citrullus lanatus |      |          |

3. Result

3.1. Morphology

The habitat of all Apple cucumber samples collected from Aceh, Karawang, and Jember is closed to the shoreline. trailing herbaceous plant with a woody rootstock, often angled stem with bristly hairs, short (figure 1). Tendrils are simple and spiral. The leaves of apple cucumber are simple, cordate with no shallow lobes and variously serrated margins, alternate on long petioles, acute, a little hairy on the abaxial surface, deep green, and about 7 – 10 cm in diameter. Male flowers founded in clusters and
appear before the female flowers. Both have yellow petals, five in number, and sepals, also five in number and greenish in color. Male and female flowers develop on the same plant. Occasional hermaphrodite flowers are produced usually after female flowers appeared. The fruits are round and flattened with no grooves, about 14 – 20cm in diameter. The seeds are small, light brown and smooth, between 0.4 and 1.1cm long and 0.2 – 0.3cm wide. The skin is white to green. The flesh is white to greenish, intermediate, delicately flavored, juicy. Apple cucumber then compared to cucumber, watermelon, and melon to distinguish the qualitative and quantitative characters.

Figure 1. Apple cucumber, A) petiole, B) transverse cut of fruit, C) apple cucumber fruit in the habitat, D) and E) apple cucumber flower.

3.2. Qualitative characteristic
Weights of the fruits (apple cucumber, cucumber, watermelon, and melon) were differed from very small to small and small to intermediate among the sample. The only cucumber has the lowest weight among apple cucumber, watermelon, and melon (table 2). Watermelon has the highest weight among apple cucumber, cucumber, and melon, due to the water content possessed by watermelon is very high. Watermelon has been investigated for its water content and results have shown that it has 91.45 % percentage of water content on their fleshy fruit part [15].

A variation on fruit shape was observed, the flattened shape was the character of apple cucumber, while cucumber had elongated and watermelon and melon had globular fruit. The flattened shape of the apple cucumber makes it unique because it resembles the shape of apple fruit. Even though there was a relatively low alteration for the fruit shape in apple cucumber, the most observed sample has a flattened shape. This shape is very different from cucumber, watermelon, and melon. The color of fruit skin was quite diverse ranging from white to pale green and green among the sample. White fruit skin can be found in other cucurbits such as muskmelon, honeydew melon and Chinese white cucumber.
[16]. The fruit groove was absent in all samples. Stripes were one of the fundamental characters to determine watermelon from apple cucumber, cucumber, and melon. Netting was present in melon but absence in apple cucumber, cucumber, and watermelon. Fruit skin hairiness was a presence in apple cucumber while absence in watermelon, cucumber, and melon. The diameter of the peduncle was small in apple cucumber and cucumber but intermediate in watermelon and melon. The density of the outer layer of the pericarp (rind thickness) was typically medium in watermelon and very small in apple cucumber, cucumber, and melon. Fruit fleshes of watermelons are commonly red [17], compared to white to greenish flesh in apple cucumber and cucumber to pale green in melon.

### Table 2. Qualitative characters between apple cucumber, cucumber, watermelon and melon.

| No | Character                          | Apple cucumber Karawang | Apple cucumber Jember | Apple cucumber Aceh | Cucumber | Watermelon | Melon |
|----|-----------------------------------|-------------------------|----------------------|---------------------|----------|------------|-------|
| 1  | Leaf petiole length               | Short (approx. 3 cm)    |                      |                     |          | Medium (approx. 10 cm) |       |
| 2  | Fruit shape                       | Flattened               | Elongate             |                     |          | Globular (round)       |       |
| 3  | Fruit size                        | Small (approx. 450 g)   | Very small to small (approx. 200 g) |          | Small to intermediate (approx. 800 g) |       |
| 4  | Predominant fruit skin color      | White                   |                      |                     | Pale green | Green |       |
| 5  | Secondary fruit skin color        | Green                   |                      |                     | Dark green | Brown |       |
| 6  | Secondary color of immature fruit | Absence                |                      |                     | Striped | Speckled |       |
| 7  | Secondary skin color pattern      | Absence                 |                      | Smooth              | Partially wrinkled |      |       |
| 8  | Fruit surface                     | Smooth                  |                      |                     |          |           |       |
| 9  | Fruit corking/netting distribution | Absence                |                      |                     | Pronounced |      |       |
| 10 | Fruit corking/netting intensity   | Absence                 |                      |                     |          |           |       |
| 11 | Fruit corking/netting pattern     | Absence                 |                      |                     |          | Netted |       |
| 12 | Fruit skin hairiness              | Presence (very short)   |                      |                     |          | Absence |       |
| 13 | Diameter of peduncle              | Small                   |                      |                     |          | Intermediate |       |
| 14 | The main color of flesh           | White                   | Red                  | Pale green          |          |           |       |
| 15 | Flesh flavor                      | Intermediate            | Insipid              | Sweet               |          |           |       |
| 16 | Placenta color                    | White                   | Green                | Red                 | Green |           |       |

### 3.3. Quantitative characteristic

Watermelon has the largest hypocotyl diameter and cotyledon ratio, compare to apple cucumber, cucumber, and melon (table 3). This because watermelon has a bigger seed compare to apple cucumber, cucumber, and melon. Recent studies on hypocotyl diameter and cotyledon ratio in watermelon tissue culture showed a decrease in micropropagation time and can optimized shoot formation [18], watermelon has the thickest stem thickness because size in stem diameter is response
to plant water status and soil water content (SWC) [19] and also size-dependent adjust in the physiological characters of individual organs, changes also directly related to plant size stem and has an important part in Adean giant rosette plants [20]. Stem hairs absence in watermelon while presence in apple cucumber, cucumber, and melon. Watermelon has the highest plant branch and leaf ratio.

Table 3. Quantitative characters between apple cucumber, cucumber, watermelon, and melon.

| No | Characters                                | Apple cucumber Karawang | Apple cucumber Jember | Apple cucumber Aceh | Cucumber | Watermelon | Melon |
|----|------------------------------------------|-------------------------|-----------------------|---------------------|----------|------------|-------|
| 1  | Hypocotyl diameter (mm)                   | 2                       | 2                     | 2                   | 2        | 2          | 1.08  |
| 2  | Cotyledon ratio (mm)                       | 3                       | 4                     | 2                   | 3        | 2          | 7.8   |
| 3  | Stem thickness (mm)                        | 8                       | 6                     | 7                   | 6        | 8          | 9.7   |
| 4  | Stem hairs (mm)                            | 2                       | 2                     | 1                   | 2        | 1.5        | 0     |
| 5  | Plant branches                            | 5                       | 3                     | 5                   | 5        | 4          | 6     |
| 6  | Leaf ratio                                | 2                       | 2                     | 1                   | 2        | 1.5        | 1     |
| 7  | Days to first flowering                    | 20                      | 22                    | 23                  | 20       | 21         | 35    |
| 8  | Days to 50% flowering                      | 23                      | 24                    | 25                  | 22       | 23         | 31    |
| 9  | Peduncle length (cm)                       | 5                       | 5                     | 5                   | 5        | 5          | 3     |
| 10 | Mean length of standard petal (cm)         | 2                       | 3                     | 3                   | 2        | 2          | 2.5   |
| 11 | Mean width of standard petal (cm)          | 3                       | 3                     | 4                   | 3        | 3          | 3.1   |
| 12 | Fruit length/width ratio                  | 5                       | 4                     | 5                   | 6        | 5          | 4     |
| 13 | Days to first mature fruit                 | 55                      | 53                    | 56                  | 55       | 57         | 70    |
| 14 | Maturation period                          | 20                      | 23                    | 24                  | 22       | 23         | 21    |
| 15 | Total fruit weight per plant (Kg)          | 5                       | 6                     | 5                   | 5        | 4.2        | 20    |

The relationship between leaf ratio and plant branch was found to be linear, showed capability in increased photosynthesis capacity [21] this will lead to increased photosynthetic production that will fill sink cells in fruit leads to an increase in fruit weight per plant. Watermelon has the highest weight among all samples. Apple cucumber, melon and cucumber has a similarity in days to first flowering, ranging from 20-23 days but watermelon took an average 31 days to first flowering.

3.4. PCA analysis

PCA analysis was conducted to see the relationship between apple cucumber, cucumber, watermelon, and melon using 120 morphological data characters (figure 2). From the analysis, we can clearly see
the clustered region of apple cucumber from Karawang, Jember, and Aceh was nested in the same region. Melon, watermelon, and melon were scattered away from the Clustered region of apple cucumber. The nearest species to the clustered region of apple cucumber is cucumber, this shows the closeness of apple cucumber and cucumber based on morphological characteristics although apple cucumber and cucumber have differences in fruit shape, flesh flavor, and placenta color. Watermelon was the furthers from the clustered apple cucumber region, this shows the distance relationship between apple cucumber and watermelon. Although melon has some distance to apple cucumber, the melon region is next to the clustered apple cucumber region. This shows that apple cucumber and melon are closely related even though there are some morphological differences among them.

4. Discussion
Morphological traits between qualitative and quantitative had been analyzed and showed some standout character. Current research on morphological traits of melon in the Northeast region Brazil showed high variation in the productivity and fruit quality characteristic [22], a similar result also found in this research. High variation in morphological traits can be influenced by the genotype-environment relationship on the genetic diversity expression caused accessions because this is partially addressed in genetic diversity studies due to the expense of evaluating accessions that are placed in more than one experimental location [23]. Morphological quantification and characterization of genetic variability are essential to finding out the diversity and also to selected plant groups so that improvement in morphological traits can be tracked and accounted for in order to maintain the purity of the original traits. From this research quantitative character showed a variation in fruit shape, all apple cucumber samples showed flattened shape making it differed from watermelon and melon that suspected relationship. Watermelon has a globular shape with stripe and cucumber has an elongated shape as the main feature of their species [24]. Although apple cucumber and cucumber possess an identical name, namely cucumber but the fruit shape differs. Variation among genotypes can make accessions within germplasm collections [25]. Principal Component Analysis (PCA) has been used to identify the most relevant characters and to distinguished the relationship among species. PCA has been used to clarify the existing three classical morphotypes of melon namely aestivalis, europeus and hiemalis, under the convar Europeus [26]. The PCA result used in this research is to differentiate apple cucumber from melon, cucumber, and watermelon based on morphological characters.
5. Conclusion

All the sample species present characteristics typically to the family Cucurbitaceae, although from the qualitative characters showed apple cucumbers are different from another sample, but due to sharing some common traits among samples. Based on the results, further research especially related to molecular phylogenetic analysis is still needed to address the phylogenetic and taxonomic identity of apple cucumber.

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