

RESEARCH ARTICLE

Characterization of 13 Accessions of Purslane (*Portulaca* sp.) from Bogor, West Java, Indonesia

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Abstract

Characterization is part of crop the breeding process aims to protect biodiversity and preserve local germplasm. Indonesia has two known species of *Portulaca*, *Portulaca oleracea* and *P. grandiflora*. Thirteen *Portulaca* accessions have been collected from Bogor area, comprising five accessions of *Portulaca oleracea* and eight accessions of *Portulaca grandiflora*. This study was aimed at the characterization of the 13 accessions and was undertaken at Indoflower BLST, Bogor, between October 2015 to February 2016. The results showed a significant difference in the color of flowers between the two species of *Portulaca*. The most significant difference is the overall appearance of *P. oleracea* species. Character color and shape of the flowers between the *P. grandiflora* white (GW) and *P. oleracea* are similar. Significant differences between the species exist in relation to the root systems, but the root systems of accessions within each species are generally similar. The branching characteristics between the two species and among accessions are generally similar, with branches emerging through the base of leaves or nodes. However, there are differences in the leaf characteristics between the two species. This study has provided information on flower characteristics of *P. grandiflora* and *P. oleracea* which will be valuable for future breeding efforts in *Portulaca*.

Keywords: ornamental, bedding plants, morphology, moss rose, purslane

Introduction

Floriculture in Indonesia has experienced a very rapid development. This is supported by the increasing housing development in urban areas and the use

of ornamental plants for different types of events. Minimalist housing in urban areas requires plants with aesthetic value which can give the impression of cool and natural conditions, so the house occupants can feel comfortable when inside the house. Ornamental plant businesses have an important economic value in the Indonesian economy (Nisa, 2008). Indonesian Ministry of Agriculture (Kementan) cites an 8.3% annual increase in the demand for cut flowers, with the demand for other ornamental plant products also increasing significantly (Kementan, 2015). Part of this demand is coming from industrial properties and services that requires garden decor, room decor, and landscaping.

Portulaca is also known as purslane and is a flowering plant from within the *Portulacaceae* family. *Portulaca* can be used as bedding plants, a plant in hanging baskets, mini flowering potted plants, as well as in small urban gardens areas. It has been estimated there are a about 100 different species of *Portulaca* worldwide, of which only 70 species have been studied (Jonas et al., 1972). In some areas *Portulaca* is regarded as a weed due to its rapid growth and adaptation. Although considered a weed, *Portulaca* has flowers that are beautiful and attractive in form, so it has the potential to be used as an ornamental plant and therefore has potential economic value. *Portulaca* is an edible plant that contains a five times greater content of omega-3 fatty acids than spinach. *Portulaca* is also rich in vitamin A, vitamin C, calcium, phosphorus, iron and antioxidants (Uddin et al., 2014).

Portulaca morphological characterization is very important in relation for the identification of local germplasm resources. Analysis of genetic diversity provides the basis of the pattern of population grouping of genotypes and for the identification of the characters that form the basis of each genotype

group. Analysis of diversity and phylogenetic relationships can provide information on the close biological relationships between genotypes, which can then be used as the basis for breeding programs. Analysis of genetic parameters is used to obtain information on gene actions, genetic variability, heritability, and other genetic information. The genetic information is of great importance to allow more efficient and effective plant selection (Syukur et al., 2012). Plant characterization before a plant species is to be introduced as landscape plants in urban areas are important, to ensure that the plants are suited to the new environmental condition (Aisyah et al., 2014). This study aimed to investigate the characteristics of 13 accessions of *Portulaca* collected in the city of Bogor, and to study the genetic relationships among the accessions.

Materials and Methods

Experimental Site

The experiment was conducted in an experimental field at Indoflower BLST, Bogor, West Java, Indonesia (Latitude: -6.5878°, Longitude: 106.8017°, altitude 250 meters above sea level). The study was undertaken between October 2015 and February 2016. The experimental location was open land that allowed full natural and even illumination of the area.

Plant Materials

This study used 13 accessions of *Portulaca* collected in Bogor City, Indonesia, comprising two species, *P. oleracea* and *P. grandiflora* (Table 1).

Experimental Design

The experimental plants were planted into polybags measuring 20x20cm, with each polybag containing one plant. The planting medium used was a mixture of soil, rice husks, vermi compost, cow and goat manure (5: 5: 1: 2: 2 by volume). The plants were propagated from cuttings from mature plants with a length of 5cm each. Cuttings were treated with rooting hormone Rootone-F (a.i. 1-Naphthaleneacetamide) with the recommended dose of use, and then planted in the media. Irrigation and fertilizer being applied as needed. A completely randomized design was used for the experiment, with six replications (plants) of each accession.

Data Collection

Thirty-four morphological characteristics of each *Portulaca* accession were recorded according to scoring methods developed by The International Union for the Protection of New Varieties of Plants (UPOV, Table 2). Location of root initiation was recorded using the UPOV scoring system, i.e. tip: 3, nodes: 5, and tip and nodes: 7. Stem and leaf

Table 1. *Portulaca* accessions from Bogor City, West Java Indonesia

Accession Code	Flowers Characteristics		Code according to RHCC*
	Petal	Petal Color	
<i>P. grandiflora</i>			
GU	Single layer	Purple	RHS N74A
GW	Single layer	White	RHS N99D
GP	Single layer	Pink	RHS N57D
GV	Single layer	White & Pink	RHS N99D & N57D
GMT	Multi layer	Red	RHS 45A
GPT	Multi layer	Pink	RHS N57D
GUT	Multi layer	Purple	RHS N74A
GVT	Multi layer	White & Pink	RHS N99D & N57D
<i>P. oleracea</i>			
OU	Single layer	Purple	RHS N74A
OW	Single layer	White	RHS N99D
OP	Single layer	Peach	RHS 41B
OK	Single layer	Yellow	RHS 4A
OV	Multi layer	Yellow and red	RHS 4A & 44A

* RHCC: The Royal Horticultural Society Colour Chart

color scoring was determined based on color codes according to the Royal Horticultural Society Colour Chart (RHSCC). Plant height, i.e. the maximum height of each plant from the potting media surface, and the longest stem per plant was scored when the plants were ten-week-old.

Data Analysis

Data on plant height, length of the longest stem of each plant, and number of branches per plant were subjected to analysis of variance (ANOVA) using the STAR software version 2.0.1. Means were separated using the Duncan Multiple Range Test (DMRT) at 5% level of significance.

Table 2. *Portulaca* plant morphological characteristics and scoring system based on The International Union for the Protection of New Varieties of Plants (UPOV, 2008)

Plant characteristics
Plant: growth habit (1) semi-upright, (2) creeping
Only semi-upright varieties: Plant height - (3) short, (5) medium, (7) tall
Plant width: (3) narrow, (5) medium, (7) broad
Number of shoots: (3) a few, (5) medium (7) many
Shoots: coloring of anthocyanins - (1) absent or very weak, (3) weak, (5) medium, (7) strong
Leaf characteristics
Leaf: petioles - (1) absent, (9) present
Leaf blade: length - (3) short, (5) medium, (7) long
Leaf blade: width - (3) narrow, (5) medium, (7) broad
Leaf blade: shape - (1) elliptic, (2) spatulate, (3) linear
Leaf blade: intensity of green color - (3) light, (5) medium, (7) dark
Leaf blade: variegation - (1) absent, (9) present
Leaf blade: color of variegation - (1) light green-yellow, (2) greyish-green, (3) pink-white
Leaf blade: anthocyanin coloring of the leaf margin - (1) absent, (9) present
Flower characteristics
Flower: petaloid staminodes - (1) absent, (2) present
Only varieties with petaloid staminodes absent: Flower: shape in lateral view - (1) flat, (2) moderately concave, (3) strongly concave
Flowers: diameter - (3) small, (5) medium, (7) large
Calyx: anthocyanin coloration - (1) absent, (9) present
Petal: macule - (1) absent, (9) present
Petal: color of macule by RHSCC
Petal: number of colors (macule excluded)
Petal: main color (macule excluded) by RHSCC
Only varieties with more than one color: Petal: secondary color (macule excluded) by RHSCC
Only varieties with more than one color: Petal: distribution of secondary color (macule excluded) - (1) in stripes, (2) gradient. (3) on margin
Only varieties with more than two color: Petal: distribution of secondary color (macule excluded) - (1) in stripes, (2) gradient, (3) on margin
Petal: length - (3) short, (5) medium, (7) long
Petal: width - (3) narrow, (5) medium, (7) long
Petal: margination - (1) absent or shallow, (2) medium, (3) deep

Results and Discussion

There are significant morphological differences between *P. grandiflora* and *P. oleracea* (Figure 1) in relation to branching mechanisms, root, leaf, and stem characteristics. However, there are also similarities in the shape and color of the flowers in some accessions.



Figure 1. Differences in the overall phenotypic characteristics of *P. grandiflora* (A) and *P. oleracea* (B).

The roots of both *Portulaca* species are succulent and tender, and can be easily broken (Figures 2 A and B).



Figure 2. Root initiation of (A) *Portulaca oleracea* and (B) *Portulaca grandiflora* from Bogor, West Java, Indonesia.

Root Initiation

P. oleracea cuttings (Figure 2 A) took three days to root, and root initiation occurs only on the bases of the cuttings. Roots of *P. grandiflora* cuttings (Figure 2 B) were formed on the nodal sections of the cuttings one day after planting. Therefore both species are easy-to-root, but *P. oleracea* cuttings take a longer time to root than *P. grandiflora*. The root system of *P. grandiflora* (Figure 2) is likely to allow for better absorption of water and nutrients. Root growth in general is influenced by genetic and environmental factors and, according to Suardi (2002) the rooting properties can

be used to predict whether plants have resistance to environmental stresses such as drought and nutrient deficiencies. *P. oleracea* species seems to adapt to a dry environment, while *P. grandiflora* species are more adapted to higher moisture environments. Rao et al. (2016) also stated that rooting characters, such as root length, the number of root hairs, root and branch root anatomy, can be used to assess the potential of plant resistance and/or adaptation to problems such low levels of soil nitrogen, phosphorus deficiency and excessive aluminum.

Stem Morphology and Branching Characteristics

The stems of *P. oleracea* are generally tall and long, with a tendency of the stems to stoop and semi-upright to avoid the collapse and breakage of stems. Among the accessions of *P. grandiflora*, GU and GP exhibited hairs on the stem surface, while accessions GW and GV did not exhibit this character.

P. grandiflora single generally had more branches than multi-layer petal *P. grandiflora*, whereas *P. oleracea* generally had fewer branches than *P. grandiflora*. The largest number of branches was in the GMT accession which had 14, and the least in accession OK which had 8. The higher number of branches in accession GMT is believed to reflect its good adaptability and its associated ability to absorb water and nutrients.



Figure 3. Stems and branches of (A) *P. oleracea* and (B) *P. grandiflora*

P. oleracea accessions generally have purple-brown stems, except for OW that had light green to whitish green. However, there were differences in color between the top and basal section of the stems, and the color changes with maturity. The young stems tended to be brownish to white in color which, turning to brown with increasing maturity. The petal color usually correlates with the stem color, e.g. plants with light green stem color usually have white petals. However, the final petal color was determined by other different parameters and was difficult to predict in advance of actual flowering.

Tabel 3. Morphological characterization of 13 Bogor Portulaca accessions ¹⁾

Morphological characteristics	Accessions													
	GU	GW	GP	GV	GMT	GPT	GUT	GVT	OU	OW	OP	OK	OV	
Plant: growth habit	1	1	1	1	2	2	2	2	1	1	1	1	1	
Only semi-upright varieties	5	5	5	5	0	0	0	0	7	7	7	7	7	
Plant: width	5	5	5	5	7	7	7	7	5	5	5	5	5	
Plant: number of shoots	5	5	5	5	7	7	7	7	5	5	5	3	5	
Shoots: anthocyanin coloration	3	1	3	3	3	3	3	3	3	1	3	3	3	
Leaf: petiole	1	1	1	1	1	1	1	1	1	1	1	1	1	
Leaf blade: length	7	7	7	7	5	5	5	5	7	7	7	7	7	
Leaf blade: width	3	3	3	3	3	3	3	3	5	5	5	5	5	
Leaf blade: shape	3	3	3	3	3	3	3	3	2	2	1	2	1	
Leaf blade: intensity of green color	5	3	5	3	5	5	5	5	5	3	5	5	5	
Leaf blade: variegation	1	1	1	1	1	1	1	1	1	1	1	1	1	
Leaf blade: color of variegation	0	0	0	0	0	0	0	0	0	0	0	0	0	
Leaf blade: anthocyanin coloration of the margin	1	1	1	1	1	1	1	1	9	9	9	9	9	
Flower: petaloid staminodes	1	1	1	1	2	2	2	2	1	1	1	1	2	
Only varieties with petaloid staminodes absent flower: shape in lateral view	0	0	0	0	2	2	2	2	0	0	0	0	1	
Flower: diameter	7	7	7	7	5	5	5	5	5	5	5	5	5	
Calyx: anthocyanin coloration	1	1	1	1	1	1	1	1	1	1	1	1	1	
Petal	9	9	9	1	1	1	9	1	9	1	9	1	9	
Macule color of the petal ²⁾	71	8	70	61	0	0	57	0	4	0	4	0	44	
Petal: number of colors (macule excluded)	1	1	2	1	1	1	2	1	1	1	1	1	1	
Petal: main color (macule excluded) ²⁾	74	99	99	57	45	74	57	57	41	99	74	4	4	
For varieties with more than one petal color: secondary color	0	0	57	0	0	0	99	0	0	0	0	0	0	
Only varieties with more than one petal color: distribution of secondary color	0	0	1	0	0	0	1	0	0	0	0	0	0	
Only varieties with more than two petal color: distribution of secondary color	0	0	0	0	0	0	0	0	0	0	0	0	0	
Petal: length	7	7	7	7	5	5	5	5	5	5	5	5	5	
Petal: width	7	7	7	7	3	3	3	3	5	5	5	5	3	
Petal: margination	3	1	2	2	1	1	1	1	2	1	2	1	1	
Color of petaloid staminodes ²⁾	0	0	0	0	45	74	57	57	0	0	0	0	44	
Style: anthocyanin coloration	7	1	3	5	5	7	3	5	3	1	7	3	3	
Time to the first flower	3	3	3	5	7	7	7	7	3	3	7	5	3	

¹⁾ Plant morphological characteristics and scoring system based on The International Union for the Protection of New Varieties of Plants (UPOV, 2008)

²⁾ Color was scored according to The Royal Horticultural Society Colour Chart (RHSCC)

Plant height was between 82 cm and 28 mm, with the tallest accession being GPT and the shortest accession being OK (Table 4). Alam et al. (2014) reported a range in *Portulaca* plant height from 30 to 66 cm for 60 day-old plants in saline and drought treatments. *P. oleracea* did not seem to grow well in polybags, indicated by the inhibited plant growth of the longest accession, GPT, was only 135 mm, and the shortest accession, OK, was 22 mm. GMT had the highest number of branches, averaging 6.18 per plant, while OK had the lowest number, averaging just 1 per plant (Table 4). The plant growth based on the speed and vigor of vegetative growth was best in GPT and GMT.



Figure 4. Leaf morphology of (A) *P. oleracea* and (B) *P. grandiflora*

Leaf Morphology

Portulaca is a semi-succulent that stores moisture in its fleshy leaves and stems. *P. grandiflora* leaves are oblong to cylindrical with pointed tips. *P. oleracea* leaf character resembles the leaf character of *P. grandiflora*, and just has a different leaf shape, with the leaf shape *P. oleracea* being oval or spatulate according to UPOV description method. The leaf of *P. oleracea* is wider and oval shape (Figure 4). The leaves of *P. oleracea* have venation at the center of the leaves which divides the leaves into two symmetric halves; the leaf surface is smooth and thick. *P. oleracea* leaf length was in the range of one to five cm. The leaves of *P. grandiflora* have no venation, and are narrower when compared to *P. oleracea*, with leaf length in the range of 2-4 cm. *Portulaca* leaves exposed to high salt stress had darker color (Alam et al., 2014).

Flower Characteristics

Flower initiation begins with the appearance of floral buds on the end of the stem. The floral buds of *P. grandiflora* are generally larger than *P. oleracea*.

Table 4. Growth characteristics of 13 Bogor purslane (*Portulaca*) accessions

	GU	GW	GP	GV	GMT	GPT	GUT	GVT	OU	OW	OP	OK	OV
Plant height (mm) ¹⁾	77abcde	88abcd	97abc	58bcde	119 ab	73abcde	128a	96 abc	48 cde	28 de	29 de	15 e	65 abcde
Length of the longest stem (mm) ¹⁾	144ab	116abc	122ab	76bcd	122ab	168a	132ab	106abc	68bcd	24d	45cd	15d	68bcd
Number of stem per plant ¹⁾	5.0ab	3.7bcd	3.1cde	2.3ef	6.1a	3.1cde	5.0ab	4.0bcd	4.3bc	1.2f	2.2ef	1.0f	2.9de
Location of root initiation	5	5	5	5	5	5	5	5	3	3	3	3	3
The number of flowers per stem	5	5	5	5	5	5	5	5	7	7	7	7	7
Stem color ²⁾	145B	145B	150B	150B	152B	152B	152B	152B	181A	145B	181A	181A	181A
Leaf color ²⁾	141D	141D	141D	141D	137C	137C	137C	137C	137C	137C	137C	137C	137C

Note:

¹⁾ Data at seven weeks after planting. Means in the same line followed by the same letter are not significantly different according to DMRT at 5%

²⁾ Color was scored according to The Royal Horticultural Society Colour Chart (RHSCC)

The size of *P. grandiflora* floral buds at seven days after the first visible bud is 4 to 7 mm in diameter and 5 to 12 mm in length, whereas in *P. oleraceae* it was 3 to 4 mm diameter and 4 to 7 mm in length. There are differences in the size and color of the floral buds among the different accessions. Single layer *P. grandiflora* has the largest floral buds, followed by *P. oleraceae* and multi-layer *P. grandiflora*.



Figure 5. The growth of floral bud of single layer petal *P. grandiflora* at 1 (A), 3 (B) and 7 days (C) after initiation.



Figure 6. The growth of floral bud of multi-layer petal *P. grandiflora* at 1 (A), 3 (B) and 7 days (C) after initiation.

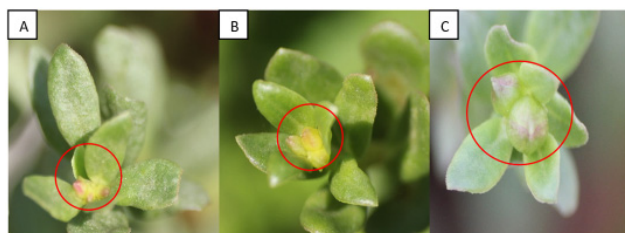


Figure 7. The growth of floral bud of multi-layer petal *P. oleraceae* at 1 (A), 3 (B) and 7 days (C) after initiation.

Portulaca flowers reached anthesis within eight days from the beginning of the visible floral bud initiation. Number of days from the visible floral bud to anthesis is an important character for breeding purpose because Portulaca flowers only last 8 to 12 hours after anthesis. The effectiveness of cross breeding among the different accessions of Portulaca is likely to correlate with the structure of the flowers. Single layer Portulaca has larger and taller stamens and stigma (Figure 8) compared to the multi layers (Figure 9). In addition the stamens and stigma of the multilayer Portulaca are sometimes shaded by their

petals. Due to their flowering characteristics, single layer Portulaca would likely to have better chance of success in pollination and the breeding efforts than the multi layers.

The color and shape of the flower affects the success of pollination in the natural environment, whereas natural selection and genetic variants affect the flower color (Fenster et al., 2014). Flower color has a pattern associated with the process of evolution of a plant (Fenster et al., 2014).



Figure 8. Single-layer petal *P. grandiflora* accessions: GW (A), GV (B), GP (C), and GU (D)



Figure 9. Multi-layer petal *P. grandiflora* accessions: GMT (A), GVT (B), GPT (C), and GU (D)



Figure 10. Petal colors of *P. oleraceae* accessions OW (A), OK (B), OP (C), OU (D), and OV (E)

Purple-color petal usually correlates with orange-color pollen (Figure 8), which is clearly visible in single layer petal *P. grandiflora*. The correlation is less clear in *P. oleraceae* (Figures 9 and 10). Petal color reflects the level of anthocyanins levels in a flower (Kim et al. 2007). The level of anthocyanin pigment is the basis of the appearance of orange, red, purple, and blue colors (Kim et al. 2007). Among the 13 accessions of Portulaca covered in this study, the highest levels of anthocyanins are believed to be in accessions GU, GUT and OU.

Conclusions

This study has demonstrated morphological variations among the 13 accessions of Portulaca collected from

Bogor city, West Java, Indonesia. Plant roots, stems, leaves and flowers are among the plant characteristics of particular interest in defining and identifying the basis of the *Portulaca* germplasm. This study has provided information on flower characteristics of *P. grandiflora* and *P. oleracea* which will be valuable for breeding efforts in *Portulaca*.

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