J. Agr. Sci. Tech. (2014) Vol. 16: 1633-1648

A Comparison of Yield Potential and Cultivar Performance of 20 Collected Purslane (*Portulaca oleracea* L.) Accessions Employing Seeds *vs.* Stem Cuttings

M. A. Alam[1*], A. S. Juraimi[1], M. Y. Rafii[1], A. Abdul Hamid[2], F. Aslani[1], and G. M. Mohsin[3]

ABSTRACT

A glasshouse experiment was conducted in Universiti Putra Malaysia (UPM) to evaluate the regeneration and yield potential in purslane using both seeds and stem cuttings of 20 collected accessions from different locations in Western Peninsular Malaysia. Analysis results revealed significant variations (P< 0.05) for morphological traits viz., plant height, number of main branches, number of nodes, internodal distance, stem diameter, number of leaves, leaf area, number of flowers, root length, fresh and dry weight but no significant difference were observed for physiological traits *viz.,* total chlorophyll, net photosynthesis, stomatal conductance, transpiration, water vapor deficit and for either major micro or macro minerals. Hope our research findings will eliminate the doubt of using cutting methods for purslane propagation and cultivation among producers and consumers and will promote their determination to follow purslane production in this summer at any season and anywhere. To the best of our knowledge, this is the first attempt to evaluate and to detect any significant variations arising in morphological, physiological, and especially mineral nutrition in purslane propagated through cuttings *vs.* through seeds.

Keywords: Mineral nutrition, Morphological and physiological traits, *Portulaca oleracea* L., Purslane, Regeneration.

INTRODUCTION

The genus *Portulaca* comprised of 70 species is characterized by conspicuously fleshy sessile leaves (Jonas *et al*., 1972). Many varieties of purslane under many names grow in a wide range of climates and regions. It can be found in Europe, Africa, North America, Australia and as well in Asia (Liu *et al*., 2000; Rashed *et al*., 2003). It is a widespread weed, ranked among the eighth most common plants in the world. It is fast growing and self-fertile, with the potential to produce seeds even when close to death, the reason for this plant to be so prolific (Liu *et al*., 2000). The common purslane begins flowering 20 to 30 days following emergence and produces a single, five-petalled little yellow flower at the ends of its stems, while the ornamental ones producing flowers of different colors. The blossoms of the common ones remain open only briefly, but the resultant seedpod is filled with tiny seeds. The plants produce 4 to 15 seeds/capsule depending on environmental conditions, with an average of 9.4 seeds per capsule (Galinato *et al*., 1999). Seed production of this weed ranges from 126 to 16,300 seeds/plant with an

[1] Department of Crop Science, Faculty of Agriculture, University of Putra Malaysia, UPM Serdang, Selangor, DE 43400, Malaysia.
[*] Corresponding author; e-mail: amirul81@gmail.com
[2] Faculty of Food Science and Technology, University Putra Malaysia, UPM Serdang, Selangor, DE 43400, Malaysia.
[3] Lal Teer Seed Limited (Bangladesh), Bashon, Gazipur, Bangladesh.

[DOR: 20.1001.1.16807073.2014.16.7.17.3]

average of 6,940 seeds/plant (Galinato *et al.*, 1999). Freshly collected seeds have no dormancy and germinate immediately after maturity (Balyan and Bhan, 1986a). Seeds of purslane are of the potential to remain dormant but fertile in soil for even up to 40 years (Helen, 2004). Its shiny, fleshy leaves bear red margins, and are teardrop or wedge-shaped. Leaves are between 1/4 and 2 inch long, and 1/6-1/2 inch wide. Leaves are attached to stems with no stalks, and at the lower ends of stems, leaves are arranged alternately, but are produced in clusters at stem tips. Stems are smooth, branched and often either pinkish or reddish. Stems radiate up to 20 inches outward from a central root. In Malaysia there are about 70 species of edible herbs, which are called by their local names Ulam (Samy *et al.*, 2004). Some of these herbs are claimed to be of high antioxidant, as well as medicinal properties (Alam *et al.*, 2014; Uddin *et al.*, 2012; Lim and Quah, 2007), are high in potassium and magnesium, as well as vitamins A, B and C and also high in oxalic acid, which binds and prevents the body from absorbing calcium and other minerals. Recent research demonstrates that purslane benefits from a richer nutritional quality than the major cultivated vegetables, with higher β-carotene, ascorbic acid, and α-linolenic acid (an essential fatty acid) content (Liu *et al.*, 2000). Additionally, purslane has been described as a ‘‘power food’’ because of its high nutritive and antioxidant properties (Simopoulos *et al.*, 1995). Simopoulos *et al.* (1992) demonstrated that purslane, largely consumed in the Mediterranean basin, is a richest source of α-Linolenic Acid (ALA) among green leafy vegetables and a rich source of antioxidants. It is listed in the World Health Organization as one of the most used medicinal plants, having been given the term ‘Global Panacea’ (Dweck, 2001; Samy *et al.*, 2004). Different varieties, harvesting times, and environmental conditions can contribute to purslane nutritional composition, to its benefits (Liu *et al.*, 2000), and also possibly to its biological activity.

In Malaysia purslane is still being treated only as a weed, very little being known about its production as a food crop and the effects of cultural conditions on its nutritional value. The ornamental purslane is propagated mainly by stem cuttings due to their inability to produce seeds whereas the common one can produce by both seeds and stem cutting but the performance of stem cutting is significantly lower regarding growth and development and ultimate yield. However, in this experiment the morphological, physiological and nutritional variations have been determined using both seeds and stem cuttings of common purslane and ornamental ones using stem cuttings as the propagation media.

MATERIALS AND METHODS

Experiment Location and Soil

A pot (24×22 cm) experiment was conducted during January 2012 to August 2012 in a glasshouse at the Faculty of Agriculture, University Putra Malaysia (3° 00′ 21.34″ N, 101° 42′ 15.06″ E, 37 m elevation). The plastic pots were filled with soil (39.51% sand, 9.03% silt and 51.35% clay) of pH 4.8 with 2.6% organic carbon, 1.24 g cc^{-1} bulk density and CEC of 7.07 me 100 g^{-1} soil. Soil nutrient status was 0.16% total N, 5.65 ppm available P, 15.3 ppm available K, 3,295 ppm Ca, and 321 ppm Mg. At field capacity, soil water retention was 31.18% (wet basis) and 45.31% (dry basis). The experimental soil belongs to the Serdang series.

Plant Materials and Experimental Design

Ten common purslane samples of 10-15 day young seedlings as well as 10 samples (cuttings) of different types of ornamental purslane were collected from different locations of West Peninsular Malaysia. Considering the location and morphological

[DOR: 20.1001.1.16807073.2014.16.7.17.3]

variations of the plants, they were divided into groups, transplanted into the pots and reared for about 60 days for seed collection from the common purslane, and propagation of the ornamental purslane. The plastic pots were then filled up with the prepared soils, organized in a randomized complete block design of three replications. Brief descriptions of the collected samples and locations have been presented in Table 1. The propagation and cultivation through seeds of common purslane and trough stem cuttings of either of ornamentals or common purslane are presented in Figures 1, 2 and 3.

Plants' Rearing, Data Collection and Analysis

Five 10-day old seedlings of common purslane along with 8-10 cm stem cuttings from 15-day old common purslane plants and as well from ornamentals were transplanted in each pot and surface irrigated thrice a week (every alternate day) throughout the growing period using only tap water. All types of weed or any other plant seedlings were uprooted just soon after their emergence with regular constant observations continued up to harvest. Since purslane blooms everyday, so the total number of flowers were counted daily and recorded. Regarding morphological attributes, plant height (cm), number of nodes, average internode distance (cm), average number of main branches, stem diameter (mm), total number of leaves, average leaf area (cm^2), root length (cm), total fresh (g) and total dry weights (g) of the plants were recorded. Leaf area was assessed through leaf area meter (LI-Cor, Model LI-3100 Area Meter, LI-COR Inc. Lincoln, Nebraska, USA).

Regarding physiological data; the net photosynthesis rate (μmol CO_2 m^{-2} sec^{-1}), Stomatal conductance (cm/sec), Transpiration rate (mol m^{-2} sec^{-1}) and Water vapor deficit (mol H_2O m^{-2} sec^{-1}) were determined applying LI-COR, LI 6400 Portable Photosynthesis System; LI-Cor, Inc., Lincoln, NE, USA. Relative chlorophyll content or greenness of leaves was determined within 60 days after transplanting ($SPAD_{60}$) using either portable chlorophyll meter or SPAD meter (MINOLTA™ SPAD-502, Minolta Camera Co., Osaka, Japan). Five leaf SPAD readings were taken and averaged to have the mean SPAD reading for each replicate. Chlorophyll meter (Minolta) uses light sources and detects the light transmitted by a plant leaf at two wavelengths (red and infrared regions of the spectrum) (Biljana and Aca, 2009).

The purslane plant is very succulent, containing mucilaginous substances with water contents of about 90% or more; so for initial drying just after harvest,the fresh samples were stored in a cool dry place for 3 days, then kept in oven at 40^0 C temperature for 3 days (to make them dry while being prevented from sudden burning injury) and then transferred to 70^0 C medium for another 3 day (72 hours) time period.

Oven-dried samples were ground and stored in plastic vials. For a measurement of macro (N, P, K, Na, Ca and Mg), and micro (Fe, Mn and Zn) mineral contents, the samples were analyzed using digestion method (Ma and Zua, 1984) and applying an Atomic Absorption Spectrophotometer (AAS; Perkin Elmer, 5100, USA). As for the macro minerals, N (Nitrogen) was determined using micro Kjeldahl method (Hawk *et al*., 1948), and P (Phosphorus) determined calorimetrically following the method of Sekine *et al*. (1965).

Statistical Analysis

The data were subjected to analysis of variance using SAS statistical software package version 9.2 (SAS 2013). Significant differences among means were determined using Fisher's protected Least Significant

Table 1. Brief description of the collected 20 purslane samples with their specific locations in West Peninsular Malaysia.

Sl. No.	Sample code	State	Locations	Latitude (ºN)	Longitude (ºE)	Brief morphology of the plants
1	Slg-1	Selangor	Sungai Buloh	03'19"	101'59"	Pink colored flower, wedge shaped margin red green leaf, red stem.
2	Slg-2	"	Sungai Buloh	03'19"	101'59"	White-pink colored flower, wedge shaped green leaf, red stem.
3	Slg-3	"	AgroBio. UPM	02'98"	101'73"	Yellow colored flower, red margin wedge shaped green leaf, red stem.
4	Slg-4		Nursery, Klang	03'02"	101'26"	Pink flower, wedge shaped green leaf, green red stem.
5	Kdh-1	Kedah	Nursery, Kedah	06'11"	100'37"	Yellow flower, wedge shaped green leaf, red stem.
6	Kdh-2	"	Nursery, Kedah	06'11"	100'37"	Pink flower, wedge shaped green leaf, red stem.
7	Kdh-3	"	Nursery, Kedah	06'11"	100'37"	Purple flower, paddle shaped green leaf, red stem.
8	Kdh-4	"	Kuala Kedah	06'11"	100'29"	Orange-yellow flower, green wedge shaped leaf, green stem.
9	Png-1	Penang	Seberang Perai, Pulau Penang	05'54"	100'47"	Yellow flower, paddle shaped margin green red leaf, red stem leaf.
10	Png-2	"	Seberang Perai, Pulau Penang	05'54"	100'47"	Pink flower, wedge shaped green red leaf, red stem.
11	Slg-5	Selangor	Seri Kembangan	03'00"	101'713"	Wild, yellow colored flower, small paddle shaped red-green leaf, red stem.
12	Slg-6	"	Port Klang	03'00"	101'36"	Wild, yellow flower, wedge shaped green red leaf, red stem.
13	Mlk-1	Melaka	Kg. Pulau Gadong-1	02'24"	102'21"	Wild, yellow flower, wedge shaped green leaf, red-green stem.
14	PD-1	N. Sembilan	Kg. Ayer Meleleh-1	02'54"	101'80"	Wild, yellow flower, paddle shaped green leaf, red green stem.
15	Kdh-5	Kedah	Jitra-1	06'24"	100'43"	Wild, yellow flower, green wedge shaped leaf, green-red stem.
16	Kdh-6	"	Kota Setar	06'16"	100'54"	Wild, yellow flower, green wedge shaped leaf, green-red stem.
17	Kdh-7	"	Jitra-3	06'33"	100'42"	Wild, yellow flower, wedge shaped green-red leaf, red stem.
18	Prk-1	Perak	Kuala Kangsar	04'77"	100'94"	Wild, yellow flower, wedge shaped green-red leaf, red stem.
19	Png-3	Penang	Seberang Perai, Pulau Penang	05'54"	100'47"	Wild, yellow flower, wedge shaped green red leaf, red stem.
20	Pls-1	Perlis	Balai Baru Beseri	06'51"	100'23"	Wild, yellow flower, wedge shaped green leaf, red stem.

Seeds

Seedlings

Mature plant

Young plant

Figure 1. Regeneration of new plants from seeds of common purslane.

Stem cuttings

New shoots from cuttings

Mature plant

Young plant

Figure 2. Regeneration of new plants from stem cuttings of common purslane.

Figure 3. Regeneration of new plants from stem cuttings of ornamental purslane.

Difference (LSD) test at 5% level of significance.

RESULTS

Morphological Traits Analysis of Ornamental Purslane Propagated through Cuttings

The analysis of variance for 10 collected ornamental purslane accessions indicated that the morphological traits differed significantly (P< 0.05) while comparing one with another. The average morphological traits *viz*., Plant Height (PH; cm), Number of main Branches (NB), Number of Nodes (NN), Internode Distance (ID; cm), Stem Diameter (SD; mm), total Number of Leaves (NL), Leaf Area (LA; cm^2), Number of Flowers (NF), Root Length (RL; cm), total Fresh Weight (FW; g) and total Dry Weight (DW; g) were determined, recorded, and presented in Table 2. The analysis results revealed the highest plant height (33.3 cm), number of main branches (4.0), number of nodes (16.8), internode distance (3.14 cm), stem diameter (2.98 mm), number of leaves (750.8), leaf area (2.09 cm^2), number of flowers (551.2), root length (10.56 cm) fresh weight (272 g), and dry weight (26.17 g) were observed in V10, V9, V7, V5, V1, V5, V2, V8, V7, V10 and V10 respectively (Table 2), whereas, the lowest plant height (20.6 cm), number of main branches (1.4), number of nodes (10.4), internode distance (2.38 cm), stem diameter (2.52 mm), number of laves (97.0), leaf area (1.04 cm^2), number of flowers (89.4), root length (6.5 cm), fresh weight (50 g) and dry weight (3.25 g) were found for V7, V1, V2, V4, V1, V2, V4, V10, V8, V5 and V3 respectively (Table 2).

Table 2. Descriptive statistics of the evaluated morphological traits recorded for the 10 collected accessions of ornamental purslane.[a]

Acc. no.	PH (cm)	Main branch	No. of nodes	Internode dis. (cm)	No. of leaves	Leaf area (cm^2)	No. of flowers	Stem dia (mm)	Root length (cm)	FW (g)	DW (g)
V1	32.5ab	1.4d	11.2c	3.10a	298.6d	1.91ab	324.4bc	2.98a	9.7a-c	130c	9.57d
V2	28.6a-c	2c	10.4c	2.90ab	190.4e	2.09a	227.6cd	2.52a	8.5d	70d	3.69f
V3	28.6a-c	1.8cd	11.6c	2.80a-c	97f	1.71d	94.8de	2.88a	7.18e	50d	3.25f
V4	23.4cd	1.8cd	10.8c	2.38c	435c	1.04i	441.8a-c	2.89a	9.9ab	75d	7.66e
V5	28.4a-c	2.8b	11.8bc	3.14a	750.8a	1.67a-c	533.8a	2.86a	8.7cd	50d	3.66f
V6	27bc	3.2b	15ab	2.98ab	579.4b	1.23cd	261.3c-e	2.72a	10.5a	80d	3.73f
V7	20.6d	2.8b	16.8a	2.57be	433.8c	1.5b-d	395.8a-c	2.88a	10.56a	200b	12.2c
V8	27.6a-c	1.8cd	11.6c	2.56be	612.4b	1.63a-c	551.2a	2.61a	6.5e	178b	9.81d
V9	30ab	4.1a	11c	2.96ab	370cd	1.66a-c	479.4ab	2.81a	9.3b-d	180b	15.02b
V10	33.2a	3.2b	10.8c	3.10a	192e	1.97ab	89.4e	2.95a	8.6cd	272a	26.17a
LSD	5.86	0.52	3.39	0.48	86.09	0.52	186.29	0.46	1.18	32.03	0.71
CV	12.21	12.14	16.34	9.99	12.67	18.64	31.48	9.58	7.69	14.53	4.34

[a] Mean values followed by the same letter are not significantly different (Fisher's LSD, P< 0.05).

Physiological Traits Analysis of Ornamental Purslane Propagated through Cuttings

The physiological characteristics regarding total chlorophyll content (SPAD value), net photosynthesis rate (μmol CO_2 m^{-2} sec^{-1}), stomatal conductance (cm sec^{-1}), transpiration rate (mol m^{-2} sec^{-1}) and water vapor deficit (mol H_2O m^{-2} sec^{-1}) were evaluated from the 10 collected ornamental purslane accessions. Significant differences (P< 0.05) were observed between the accessions and within all the traits measured (Figure 4). Among the recorded physiological parameters, the highest chlorophyll content (35.94, SPAD value), net photosynthesis rate (28.73 μmol CO_2 m^{-2} sec^{-1}), transpiration rate (2.86 mol m^{-2} sec^{-1}), stomatal conductance (0.17 cm sec^{-1}) and water vapor deficit (2.27 mol H_2O m^{-2} sec^{-1}) were found for V3, V2, V3, V3, and V5 respectively (Figure 4), whereas, the lowest chlorophyll content (26.2, SPAD value), net photosynthesis rate (22.23 μmol CO_2 m^{-2} sec^{-1}), transpiration rate (0.79 mol m^{-2} sec^{-1}), stomatal conductance (0.04 cmsec^{-1}) and water vapor deficit (1.14 mol H_2O m^{-2} sec^{-1}) were

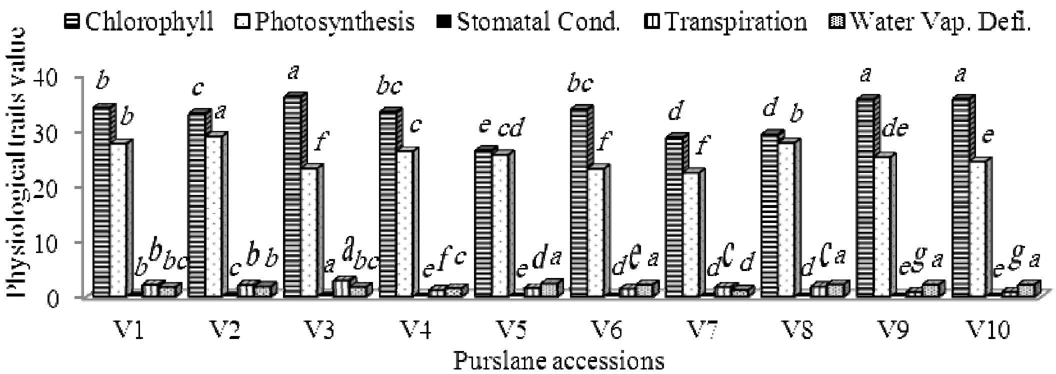

Figure 4. Different physiological trait values of ornamental purslane, propagated through cuttings. Means with different letters are significantly different at *P*< 0.05.

found for V5, V7, both in V9 and V10, V9 and V10, and V7 respectively (Figure 4).

Mineral Nutrition Analysis of the Collected 10 Ornamental Purslane Accessions

Results from statistical analyses of major macro (N, P, K, Na, Ca and Mg) and micro (Zn, Fe and Mn) minerals indicate the presence of significant (P< 0.05) variation between accessions and for all the minerals evaluated. Elemental compositions of the dry samples, reported on dry weight basis, are presented in Table 3. From the analyzed minerals it was observed that, the highest concentration of N (90.56 ppm), P (6.23 ppm), K (255 ppm), Na (12.66), Ca (62.2 ppm), Mg (32.07), Fe (5.9 ppm), Zn (1.26 ppm) and Mn (0.85 ppm) was recorded in V2, V7, V9, V3, V4, V1, V10, V2 and V4 respectively (Table 3), while the lowest concentrations of N (56.5 ppm), P (3.03 ppm), K (171 ppm), Na (1.52 ppm), Ca (23.05 ppm), Mg (8.7 ppm), Fe (1.07 ppm), Zn (0.37 ppm) and Mn (0.09 ppm) were recorded for V10, V6, V7, V2, V7, V2, V4, V10 and V9 respectively (Table 3).

Morphological Traits Analysis of Common Purslane Propagated through Cuttings

The same morphological traits were recorded for the common purslane plants, propagated through cuttings. There were significant variations (P< 0.05) observed among those parameters and accessions. The analyzed results are presented in Table 4; where the highest plant height (34.3 cm), number of main branches (4.26), number of nodes (19.8), internode distance (3.16 cm), stem diameter (3.21 mm), number of leaves (542), leaf area (1.98 cm^2), number of flowers (387.4), root length (9.31 cm) fresh weight (240 g) and dry weight (18.67 g) were observed for V14, V17, V11, V14, V11, V18, V11, V15, V15, V14, and V20 respectively (Table 4). The lowest plant height (21.13 cm), number of main branches (2.23), number of nodes (9.16), internode distance (1.99 cm), stem diameter (2.24 mm), number of laves (143.83), leaf area (1.05 cm^2), number of flowers (125.9), root length (5.64 cm) fresh weight (63.66 g) and dry weight (5.94 g) were on the other hand found for V11, V14, V12, V11, V12, V20, V16, V11, V14, V12 and V12 respectively (Table 4).

Physiological Traits Analysis of Common Purslane Propagated through Cuttings

The analyzed data obtained from 10 common purslane accessions propagated through stem cuttings showed significant (P< 0.05) differences among accessions and

Table 3. Macro and micro mineral compositions (ppm) in ornamental purslane, propagated through cuttings.[a]

Acc. no.	N	P	K	Na	Ca	Mg	Fe	Zn	Mn
V1	87.2*a*	5.28*c*	185*f*	3.99*f*	42.65*c*	32.07*a*	2.53*f*	0.75*d*	0.67*c*
V2	90.56*a*	3.82*g*	228*bc*	1.52*i*	27.30*f*	8.70*e*	3.11*e*	1.26*a*	0.76*b*
V3	80.6*b*	5.84*b*	237*b*	12.66*a*	24.05*f*	27.65*b*	2.17*g*	0.65*d*	0.21*d*
V4	80.9*b*	6.20*a*	177*fg*	7.85*b*	62.20*a*	23.55*c*	1.07*h*	0.92*c*	0.85*a*
V5	72.9*d*	4.38*e*	219*cd*	5.33*e*	34.55*d*	27.60*b*	5.50*b*	0.42*ef*	0.12*e*
V6	78.2*bc*	3.03*h*	213*de*	6.48*d*	25.15*fg*	31.60*a*	2.98*e*	0.50*e*	0.21*d*
V7	79.2*bc*	6.23*a*	171*g*	1.94*h*	23.05*f*	23.05*c*	3.41*d*	1.06*b*	0.80*ab*
V8	75*cd*	3.24*h*	237*b*	6.82*c*	45.40*b*	31.75*a*	2.14*g*	0.46*ef*	0.14*e*
V9	71.2*d*	4.8*d*	255*a*	2.37*g*	30.60*e*	26.55*b*	3.81*c*	0.47*ef*	0.09*e*
V10	56.5*e*	4.06*f*	205*e*	4.11*f*	27.15*f*	18.75*d*	5.90*a*	0.37*f*	0.09*e*
LSD	5.01	0.23	9.36	0.23	2.53	2.7	0.14	0.11	0.05
CV	3.78	2.84	2.56	2.49	4.31	6.26	2.56	8.74	7.77

[a] Means followed by the same letter are not significantly different (Fisher's LSD, P< 0.05).

Table 4. Descriptive statistics of the evaluated morphological traits from the 10 collected common purslane accessions propagated through cuttings.[a]

Acc. no.	PH (cm)	Main branch	No. of nodes	Internode dis. (cm)	No. of leaves	Leaf area (cm^2)	No. of flower	Stem dia (mm)	Root length (cm)	FW (g)	DW (g)
V11	21.13*f*	3.23*b*	19.8*a*	1.99*d*	182.67*de*	1.98*a*	125.9*d*	3.21*a*	6.47*de*	214.7*b*	11.77*c*
V12	25.10*de*	2.33*c*	9.16*d*	2.56 *bc*	242.33*c-e*	1.13*cd*	264.13*bc*	2.24*c*	6.72*de*	63.7*e*	5.94*f*
V13	27.43*bc*	3.96*a*	17.56*ab*	3.13*a*	294.66*cd*	1.47*bc*	174.20*d*	2.79*ab*	8.06*bc*	183.7*c*	10.3*cd*
V14	34.3*a*	3.23*b*	13.73*c*	3.16*a*	270.36*c-e*	1.69*ab*	183.73*cd*	2.86*ab*	5.64*e*	240*a*	16.73*b*
V15	27.16*c*	2.93*fb*	13.46*c*	2.20*cd*	427.33*ab*	1.61*ab*	387.40*a*	2.68*bc*	9.31*a*	107.3*d*	5.97*f*
V16	24.50*de*	3.30*b*	16.90*ab*	3.09*a*	236.13*c-e*	1.05*d*	191.10*cd*	2.89*ab*	6.40*de*	179.3*c*	15.13*b*
V17	23.26*e*	4.26*a*	10.43*d*	2.37*b-d*	339.40*bc*	1.15*cd*	345.56*ab*	2.62*bc*	8.67*a-c*	119*d*	9.72*d*
V18	25.93*cd*	4.13*a*	16.76*b*	2.79*ab*	542*a*	1.21*cd*	379.56*a*	2.69*a-c*	9.11*ab*	102*d*	8.67*de*
V19	25.56*cd*	3.40*b*	9.70*d*	2.61*bc*	350.26*bc*	1.12*cd*	307.76*ab*	2.68*bc*	8.69*a-c*	99*d*	7.66*e*
V20	29.13*b*	3.0*b*	15.56 *bc*	2.60*bc*	143.83*e*	1.82*ab*	266.73*bc*	2.73*a-c*	7.47*cd*	220*ab*	18.67*a*
LSD	1.91	0.51	2.96	0.43	131.67	0.39	88.64	0.52	1.22	24.64	1.61
CV	4.23	8.74	12.02	9.55	25.34	16.29	19.67	11.11	9.29	9.39	8.51

[a] Mean values followed by the same letter are not significantly different (Fisher's LSD, $P< 0.05$).

all the physiological characteristics described in the previous section (Figure 5). Among the evaluated physiological parameters, the highest chlorophyll content (35.6, SPAD value), net photosynthesis rate (28.52 μmol CO_2 m^{-2} sec^{-1}), transpiration rate (1.11 mol m^{-2} sec^{-1}), stomatal conductance (0.17 cm sec^{-1}) and water vapor deficit (2.25 mol H_2O m^{-2} sec^{-1}) were found for V12, V14, V17, V11 and V11 respectively (Figure 5), whereas, the lowest chlorophyll content (28.3, SPAD value), net photosynthesis rate (20.25 μmol CO_2 m^{-2} sec^{-1}), transpiration rate (0.79 mol m^{-2} sec^{-1}), stomatal conductance (0.03 cm sec^{-1}) and water vapor deficit (0.52 mol H_2O m^{-2} sec^{-1}) were detected in V15, V11, V15, V15 and V20 respectively (Figure 5).

Mineral Nutrition Analysis of the Collected 10 Common Purslane Accessions Propagated through Cuttings

Major macro (N, P, K, Na, Ca and Mg) and micro (Zn, Fe and Mn) minerals were determined for all the 10 accessions of common purslane where significant ($P< 0.05$) variations were found among accessions and for all the minerals evaluated. The highest concentrations of N (106.8 ppm), P (7.45 ppm), K (277 ppm), Na (49.39), Ca (39.61 ppm), Mg (30.67), Fe (4.72 ppm), Zn (0.94 ppm) and Mn (0.78 ppm) were recorded for V12, V12, V13, V11, V15, V15, V19, V11 and V12 respectively (Table 5), while the lowest levels of N (55.03 ppm), P (4.09 ppm), K (191.33 ppm), Na (1.03 ppm), Ca (12.16 ppm), Mg (20.34 ppm), Fe (1.11 ppm), Zn (0.41 ppm) and Mn (0.06 ppm) were observed in V17, V17, V11, V17, V14, V14, V14, V19 and V17 respectively (Table 5).

Morphological Traits Analysis of 10 Collected Common Purslane Accessions Propagated through Seeds

The average performances of all the morphological traits analyzed from 10

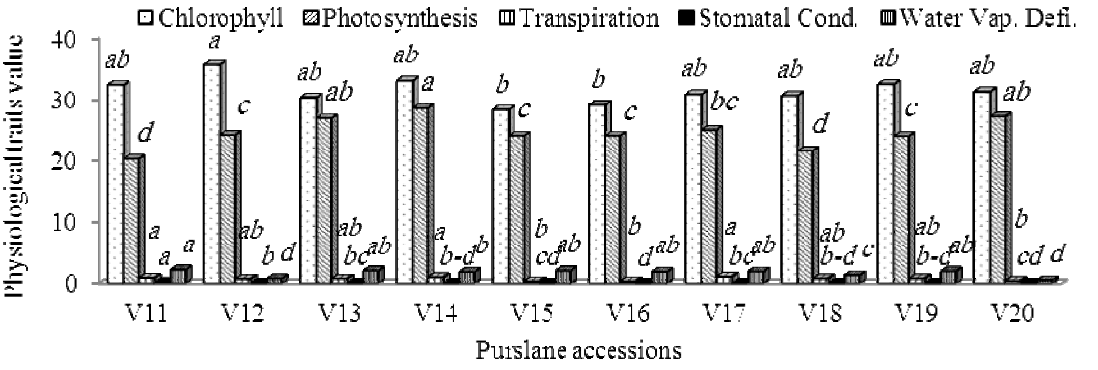

Figure 5. Different physiological trait values of 10 common purslane accessions propagated through cuttings. Means with different letters are significantly different at $P< 0.05$.

Table 5. Macro and micro mineral compositions (ppm) of the 10 collected accessions of common purslane propagated through cuttings.[a]

Acc. no.	N	P	K	Na	Ca	Mg	Fe	Zn	Mn
V1	85.03*b*	4.49*f*	191.33*e*	49.36*a*	22.77*e*	21.67*c*	1.48*f*	0.94*a*	0.53*b*
V2	106.8*a*	7.45*a*	259.67*b*	18.30*d*	31.57*c*	20.80*c*	1.21*gh*	0.79*b*	0.78*a*
V3	71.56*d*	4.85*e*	277.0*a*	35.33*b*	21.84*e*	21.61*c*	1.69*e*	0.53*cd*	0.16*e*
V4	65.36*e*	5.21*d*	230.67*c*	6.47*f*	12.16*f*	20.34*c*	1.11*c*	0.61*c*	0.35*c*
V5	77.33*c*	4.24*gf*	192.0*e*	8.90*e*	39.61*a*	30.67*a*	2.22*c*	0.56*cd*	0.19*e*
V6	84.56*b*	5.88*c*	219.0*d*	5.25*g*	14.37*f*	23.14*bc*	1.66*e*	0.72*b*	0.54*b*
V7	55.03*g*	4.09*g*	240.0*d*	1.03*i*	22.58*e*	24.73*b*	2.65*b*	0.48*de*	0.06*f*
V8	59.73*f*	6.45*b*	210.67*c*	2.98*h*	26.88*d*	28.42*a*	1.33*fg*	0.50*d*	0.08*f*
V9	82.23*b*	5.91*c*	214.67*d*	6.77*f*	35.61*b*	29.41*a*	4.72*a*	0.41*e*	0.07*f*
V10	64.36*e*	4.79*e*	214.66*d*	24.01*c*	13.94*f*	22.83*bc*	2.0*d*	0.75*b*	0.27*d*
LSD	3.48	2.11	11.37	1.18	3.33	3.03	0.16	0.08	0.06
CV	2.7	3.01	2.94	4.35	8.05	7.25	4.75	7.94	12.61

[a] Mean values followed by the same letter are not significantly different (Fisher's LSD, $P< 0.05$).

collected common purslane accessions propagated through seeds also showed significant ($P< 0.05$) differences among accessions as well as analyzed traits (Table 6). The analysis results revealed the highest plant height (37.16 cm), number of main branches (4.4), number of nodes (23.4), internode distance (3.43 cm), stem diameter (3.78 mm), number of laves (608), leaf area (2.12 cm^2), number of flowers (493), root length (9.74 cm) fresh weight (240 g) and dry weight (20.37 g) for V17, V17, V11, V14, V11, V18, V11, V15, V15, V20 and V20 respectively (Table 6), whereas, the lowest plant height (27.14 cm), number of main branches (1.9), number of nodes (10.5), internode distance (2.3 cm), stem diameter (2.38 mm), number of leaves (146.6), leaf area (1.05 cm^2), number of flowers (134.6), root length (5.9 cm) fresh weight (70 g) and dry weight (6.45 g) reported for V13, V12, V12, V11, V12, V11, V19, V11, V14, V12 and V19 respectively (Table 6).

Physiological Traits Analysis of 10 Collected Common Purslane Accessions Propagated through Seeds

Significant variations ($P< 0.05$) were also found among accessions and as well for physiological parameters measured from 10 collected common purslane accessions propagated through seeds (Figure 6). The highest chlorophyll content (37.16, SPAD value), net photosynthesis rate (26.5 μmol CO_2 m^{-2} sec^{-1}), transpiration rate (1.16 mol m^{-2} sec^{-1}), stomatal conductance (0.14 cm sec^{-1}) and water vapor deficit (2.65 mol H_2O m^{-2} sec^{-1}) figures were for V17, V17, V14, V17 and V11 respectively (Figure 6),

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Table 6. Descriptive statistics of the evaluated morphological traits from 10 collected common purslane accessions propagated through seeds.[a]

Acc. no.	PH (cm)	Main branch	No. of nodes	Internode dis. (cm)	No. of leaves	Leaf area (cm^2)	No. of flower	Stem dia (mm)	Root length (cm)	FW (g)	DW (g)
V11	31.32*f*	2.6*f*	23.4*a*	2.30*h*	146.6*d*	2.12*a*	134.6*f*	3.78*a*	7.32*de*	230*a*	13.69*c*
V12	28.56*g*	1.9*gh*	10.5*f*	2.74*c-h*	380.4*b*	1.18*g-i*	278.7*d-e*	2.38*e*	7.1*de*	70*d*	6.52*f*
V13	27.14*h*	3.8*bc*	19.6*a-c*	3.33*ab*	330.20*bc*	1.56*c-h*	185.6*ef*	2.98*b-d*	8.5*bc*	175*b*	9.8*de*
V14	31.60*f*	3.4*cd*	14.6*d-g*	3.43*a*	249*cd*	1.79*a-d*	191.8*ef*	3.10*b*	5.9*f*	220*a*	15.34*b*
V15	32.14*ef*	2.8*ef*	15.4*de*	2.50*f-h*	548.4*a*	1.71*a-e*	493*a*	2.71*b-e*	9.74*a*	118*c*	6.57*f*
V16	31.6*f*	3.2*de*	20.8*ab*	3.21*a-c*	250.4*cd*	1.13*hi*	210.4*ef*	3.04*bc*	6.60*ef*	190*b*	16.05*b*
V17	37.16*a*	4.4*a*	11.6*e-h*	2.53*e-h*	405.2*b*	1.21*f-i*	385.8*bc*	2.92*b-d*	8.92*a-c*	130*c*	10.63*d*
V18	35.82*b*	3.9*a-c*	17.8*b-d*	3.0*a-e*	608*a*	1.25*e-i*	415*ab*	2.85*b-e*	9.4*ab*	110*c*	9.37*e*
V19	27.38*h*	3.4*cd*	12.8*e-h*	2.80*c-g*	412.6*b*	1.05*i*	326.6*b-d*	2.86*b-e*	9*a-c*	110*c*	6.45*f*
V20	35.7*b*	3.4*cd*	17.8*b-d*	2.67*d-h*	155.4*d*	1.88*a-d*	290.6*c-e*	2.89*b-d*	7.9*cd*	240*a*	20.37*a*
LSD	0.84	0.54	3.83	0.47	104.22	0.46	143.73	0.48	1.11	26.67	0.77
CV	1.59	11.35	16.27	10.04	16.93	18.02	27.33	10.24	7.89	11.21	4.5

[a] Mean values followed by the same letter are not significantly different (Fisher's LSD, P< 0.05).

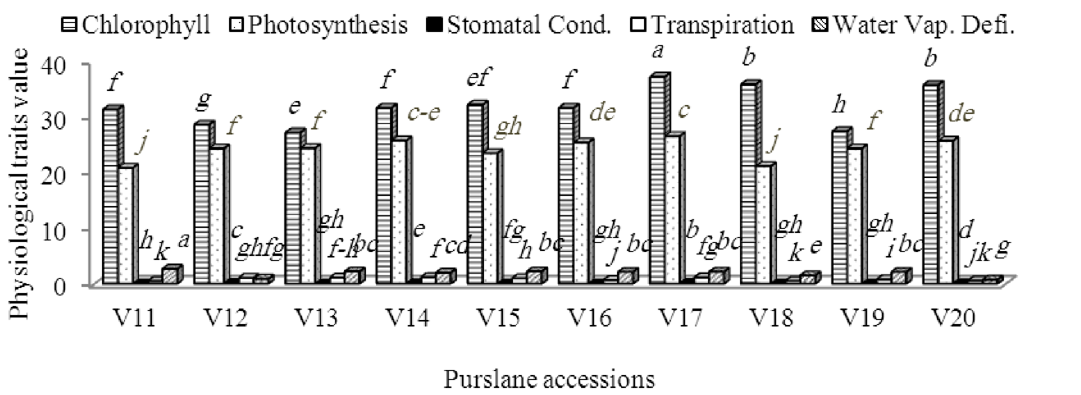

Figure 6. Different physiological trait values of 10 common purslane accessions propagated through seeds. Means with different letters are significantly different at *P*< 0.05

whereas, the lowest figures of chlorophyll content (27.14, SPAD value), net photosynthesis rate (20.8 μmol CO_2 m^{-2} sec^{-1}), transpiration rate (0.46 mol m^{-2} sec^{-1}), stomatal conductance (0.02 cm sec^{-1}) and water vapor deficit (0.7 mol H_2O m^{-2} sec^{-1}) noted in V13, V11, V11, V11 and V20 respectively (Figure 6).

Mineral Nutrition Analysis of the Collected 10 Common Purslane Accessions Propagated through Seeds

Results from statistical analyses of major macro (N, P, K, Na, Ca and Mg) and micro (Zn, Fe and Mn) minerals also showed significant (P< 0.05) variations among accessions and as well for all the minerals evaluated (Table 7). The highest concentrations of N (106.0 ppm), P (7.58 ppm), K (276.0 ppm), Na (52.17), Ca (39.65 ppm), Mg (30.6), Fe (4.69 ppm), Zn (0.96 ppm) and Mn (0.77 ppm) were recorded for V12, V12, V13, V11, V15, V15, V19, V11 and V12 respectively (Table 7), whereas, the lowest concentrations of N (55.5 ppm), P (4.11 ppm), K (192 ppm), Na (1.04 ppm), Ca (12.5 ppm), Mg (20.25 ppm), Fe (1.08 ppm), Zn (0.41 ppm) and Mn (0.06 ppm) found for V17, V17, V11, V17, V14, V14, V14, V19 and V17 respectively (Table 7).

The pairwise genetic distances obtained from morphological, physiological and mineral traits of all the 20 clones based on the Pearson's similarity coefficients were

Table 7. Macro and micro mineral compositions (ppm) of 10 collected accessions of common purslane propagated through seeds.[a]

Acc. no.	N	P	K	Na	Ca	Mg	Fe	Zn	Mn
V1	85.3*cd*	4.58*h*	192*ij*	52.17*a*	23.25*ij*	21.85*gh*	1.51*m*	0.96*c*	0.51*d*
V2	106*a*	7.58*a*	262*b*	20*d*	31.45*f*	20.40*hi*	1.20*o*	0.79*d*	0.77*b*
V3	71.9*ij*	4.81*g*	276*a*	36.15*b*	21.25*j*	22.65*f-h*	1.74*l*	0.56*fg*	0.16*gh*
V4	65.5*k*	5.28*f*	233*cd*	6.53*h*	12.50*k*	20.25*hi*	1.08*op*	0.61*ef*	0.36*e*
V5	77.3*gh*	4.30*i*	196*i*	8.99*f*	39.65*d*	30.60*ab*	2.25*j*	0.56*fg*	0.18*gh*
V6	84.5*c-e*	60.3*d*	217*fg*	5.36*i*	14.60*k*	23.85*fg*	1.71*l*	0.74*d*	0.53*d*
V7	55.5*m*	4.11*j*	221*ef*	1.04*n*	21.40*j*	25*ef*	2.71*h*	0.46*h-j*	0.06*j*
V8	61.6*l*	6.44*b*	240*c*	2.98*k*	27.85*g*	28.75*b-d*	1.34*n*	0.51*gh*	0.07*j*
V9	82.4*d-f*	5.96*de*	211*gh*	6.78*h*	36.50*e*	29.85*a-c*	4.69*c*	0.41*jk*	0.0 *j*
V10	64.7*kl*	4.94*g*	216*fg*	24.25*c*	13.95*k*	22.27*f-h*	1.97*k*	0.75*d*	0.26*f*
LSD	3.68	0.16	8.18	0.43	2.6	2.51	0.12	0.08	0.07
CV	2.92	1.94	2.26	2.37	5.38	6.11	2.75	8.16	11.72

[a] Mean values followed by the same letter are not significantly different (Fisher's LSD, P< 0.05).

employed for clustering the clones with the help of UPGMA method. Based on the tertiary branching at 0.54 coefficient level, the clones were grouped into five clusters (Figure 7). The Pearson's similarity coefficient obtained through morpho-physiological marker ranged between 0.13 and 1.25 (Figure 7) indicating the strong diversity among purslane accessions.

DISCUSSION

Purslane is a nutritious vegetable as well as a medicinal herb of high antioxidant properties and high mineral content (Alam *et al*., 2014; Uddin *et al*., 2013; Yazici *et al*., 2007). There are two types of purslane; common, or wild, *vs*. ornamental which are found profusely and both are safe for human consumption (Yen *et al*., 2001). Common purslane produces large numbers of seeds, while the ornamental type does not produce seeds and therefore is propagated through cuttings. Though the common purslane produces a huge number of seeds, but sometimes it shows dormancy resulting in very low or no germination even for several years. To overcome some of these difficulties, cuttings are promised to be the best alternatives.

The ornamental purslane produces very nice attractive flowers but due to self-incompatibility, which prevents self-

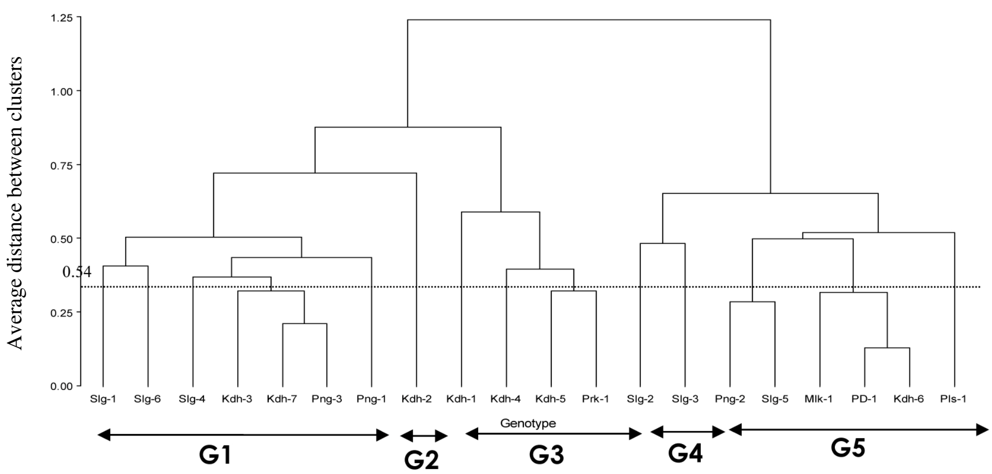

Figure 7. Dendrogram showing phenotypic relationship among the collected 20 accessions of purslane as based upon Pearson's similarity coefficient generated through morpho-physiological markers. Slg: Selangor, PD: Port Dickson (Nigeri Sembilan), Prk: Perak, Png: Penang, Pls: Perlis, Kdh: Kedah, Mlk: Melaka.

fertilization no seeds are produced. Throughout the present study it has been tried to make comparisons among the observed morphological traits from 10 ornamental (V1-V10) *vs.* 10 common (V11-V20) purslane accessions. Within the two methods of plant propagation, the highest significant variance was observed in the case of plant height. The average plant height obtained from the cuttings of 10 ornamental purslane accessions was recorded 28 cm, while the plant heights of 4 accessions (V4, V6, V7 and V8) were recorded lower than the average plant height and rest 6 accessions were a bit higher than the average height (Table 2). On the other hand, the average plant height from common purslane propagated through cuttings was recorded 26.35 cm, lower than the average height for ornamental purslane. Plant height of six accessions (V11, V12, V16, V17, V18 and V19) propagated from cuttings of common purslane showed lower plant height than the average (26.35 cm) and the rest 4 recorded higher than the average. The average plant height in seed propagated common purslane was observed the highest (31.84 cm) compared with others (Tables 2, 4 and 6). Perhaps it was due to cutting and transplanting shock that the plant height was reduced when compared with those accessions produced from stem cuttings (Kathiravan *et al*., 2009). Purslane is in general bushy in nature producing several branches from the base of the plant near soil surface. The highest number of main branches (4.26, V17, Table 4) was produced by common purslane propagated through cuttings followed by ornamental cuttings (4.1, V9, Table 2) and common purslane (4.0, V17, Table 6) propagated through seeds, respectively. That means there was no significant difference among ornamental cuttings and common purslane propagated through seeds for the number of main branches. Number of nodes and internode distance traits are closely related with plant height. Seed propagated common purslane plants produced the highest number of nodes (23.4, V11, Table 6) and internode distances (3.43, V14, Table 6) followed by cuttings of common purslane (19.8, V11; 3.16, V14, Table 4) and by ornamental cuttings (16.8, V7; 3.14, V5, Table 2) respectively. Significant variations were also noted for the number of leaves among ornamental cuttings and common purslane propagated from both cuttings and seeds. The highest average number of leaves (395.94) was recorded for ornamental cuttings followed by cuttings of common purslane (348.62) and seed propagated purslane (302.89; Tables 2, 4 and 6). There were very limited and not significant differences for stem diameter, leaf area and root length, whereas, average number of flowers differed significantly among both the ornamentals and common purslane (Tables 2, 4 and 6). The average highest level of fresh weight (FW) production was achieved by those accessions of common purslane propagated through cuttings with dry matter production rate not differing significantly (Tables 2, 4 and 6).

According to the physiological traits analysis (Figures 4, 5 and 6), results from ornamental cuttings, common purslane cuttings and seeds, the highest level of total chlorophyll (37.16, SPAD value) was produced by the accessions V17 propagated from seeds of common purslane whereas the 2nd highest level of chlorophyll (35.94 SPAD value) was recorded for V3 propagated from ornamental cuttings. The seed propagated purslane V12 produced the 3rd highest (35.6 SPAD value) level of total chlorophyll (Figures 4, 5 and 6). These results proved that there was only significant variation in total amount of chlorophyll which may be due to different morphological variations in growth and development of purslane plants but surprisingly no significant differences were observed among all the other physiological traits, perhaps due to equal environmental conditions in the glasshouse (Zhang and Chen, 2007).

Vegetables are the fresh and edible portions of herbaceous plants containing a substantial amount of vitamins and minerals. They are important food complements and are highly beneficial for the maintenance of health and prevention of diseases. They contain valuable food ingredients which can be successfully utilized to build up and repair the body organs. Minerals are naturally occurring inorganic substances with definite chemical composition and an ordered atomic arrangement (Nudelman and Nudelman, 1976).

From the mineral composition analysis results it is found that Potassium (K) content was the highest among all other minerals followed by Nitrogen (N), Calcium (Ca), Magnesium (Mg), Sodium (Na), Phosphorus (P), Iron (Fe) and Manganese (Mn) respectively (Tables 5, 10 and 15). Hussain *et al*. (2011), Bangash *et al*. (2011), Muhamed and Hussein (1994) also reported their findings for Potassium (K) as the highest, but reported different results regarding other minerals. Farissi *et al*. (2014) reported the variations in mineral compositions also in alfalfa populations. From a comparison of macro and micro mineral contents, it is observed that both of the common purslane plants (cuttings *vs*. seeds) carry significantly higher mineral contents than the ornamentals but there was no significant difference observed between common purslane propagated by cuttings *vs.* by seeds (Tables 3, 5 and 7). That means common purslane contains more minerals than the ornamental one and that the medium of propagation did not affect mineral contents either.

The Pearson's similarity coefficients were employed for clustering all those 20 collected purslane clones with the help of UPGMA method. Based on the tertiary branching, the clones were grouped into five clusters (Figure 7).The first group (G1) included the clones Slg-1, Slg-4, Slg-6, , Kdh-3, Kdh-7, Png-1 and Pls-3; the second group (G2) included only kdh-2; while, the third group (G3) consisted of clones Kdh-1, Kdh-4, Kdh-5 and Prk-1. The fourth cluster (G4) included the clones Slg-2 and Slg-3 and finally the fifth group (G5) included Png-2, Slg-5, Mlk-1, PD-1, Kdh-6 and Pls-1. Pearson's similarity coefficient obtained through morphological marker ranged between 0.13 and 1.25. The highest pairwise phenotypic similarity was observed for the clones PD-1 and Kdh-6 (0.13). Lokhande *et al*. (2009) has described the UPGMA dendrogram for morphological traits of the collected Sea purslane (*Sesuvium portulacastrum* L.) clones.

CONCLUSIONS

Morphological variation in plants is very normal depending on variety, soil and environmental conditions. Plant physiological characteristics are also influenced by their environmental conditions. But nutritional quality is mainly controlled by genetic factors and this may be the reason why we didn't observe any significant variations among mineral nutrient contents of purslane propagated through seeds *vs*. that propagated through cuttings. Though there was significant variations in morphological traits within all the 10 common purslane propagated from cuttings *vs.* seeds but the best accessions always performed the best in both cases for the majority of traits. In this regard, for the number of main branches V17, for number of nodes, stem diameter and leaf area V11, for internode distance V14, for number of leaves V18, for number of flowers and root length V15 and for dry matter production V20 performed the best in either case. Hope the findings would encourage readers to cultivate purslane vegetables propagating them more quickly and directly from cuttings rather than waiting for several weeks as done through seeds propagation.

ACKNOWLEDGEMENTS

The authors sincerely acknowledge UPM Research University Grant (01-02-12-1695RU) for financial support of the project and IGRF (International Graduate Research Fellowship, UPM) for the PhD Fellowship.

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مقایسهٔ پتانسیل میزان عملکرد محصول و کارآیی رقم (Cultivar Performance) در مورد بیست جدایهٔ گیاه خرفه (*Portulaca oleracea* L.) با به کارگیری تکثیر از طریق بذر در مقایسه با تکثیر از طریق قلمه زدن

م . ا. علم، ا.س جورائی می، م. ی. رفیعی، ا. عبدالحمید، ف. اصلانی و م. محسن

چکیده

آزمایشی گلخانه‌ای در دانشگاه پوترا مالزی (Llniversiti Putra Malaysia (LIPM) در جهت بازتولید و پتانسیل برداشت محصول در مورد گیاه خرفه صورت گرفت در حالیکه از هریک از دو روش تکثیر از طریق بذر و یا از طریق قلمه‌زنی استفاده می‌شد. آزمایش در مورد ۲۰ جدایهٔ گیاه، جمع‌آوری شده از نقاط مختلف در شبه جزیره‌ی غرب مالزی به انجام رسید. نتایج آزمایش تفاوتهای معنی‌داری (P <۰/۰۵) را در مورد صفات مورفولوژیکی یعنی ارتفاع گیاه، تعداد شاخه‌های اصلی، تعداد گره‌ها، فاصلهٔ بین گره، قطر ساقه، تعداد برگ، تعداد گل، طول ریشه، وزن بوته (تازه و خشک) نشان داد، اما در مورد صفات فیزیولوژیکی یعنی کلروفیل کل، فتوسنتز خالص (net Photosynthesis) هدایت استوماتائی (Stomatal conduetance)، تعرق، کمبود بخار آب، و همچنین درخصوص کانیهای ماکرو و میکرو تفاوت‌های معنی‌داری مشاهده نشد. امید به اینکه اطلاعات بدست آمده از تحقیق حاصل شک و ترید را از به کارگیری روش قلمه‌زنی در تولید گیاه خرفه از میان برداشته و اینکه تولید کنندگان بتوانند تولید خرفه را (از طریق قلمه‌زدن) در هر زمان و در هر مکان به انجام برسانند. تا آنجا که اطلاعات نشان می‌دهد، این اولین اقدام در زمینهٔ ارزیابی و مقایسهٔ هر گونه تفاوتهای معنی‌دار درخصوص صفات مورفولوژیکی و فیزیولوژیکی (خصوصاً تفاوتها در عناصر غذائی) در گیاه تکثیر شده از طریق قلمه زنی و یا از طریق بذر می‌باشد.