Collection and identification of different Purslane (*Portulaca oleracea* L.) accessions available in Western Peninsular Malaysia

Md. Amirul Alam[1*], Abdul Shukor Juraimi[1], M. Y. Rafii[1, 2], Azizah Abdul Hamid[3] and Farzad Aslani[1]

[1]Dept. of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia, UPM Serdang, Selangor, DE 43400, Malaysia
[2]Institute of Tropical Agriculture, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia
[3]Faculty of Food Science and Technology, Universiti Putra Malaysia, UPM Serdang, Selangor, DE 43400, Malaysia
amirul81@gmail.com

Abstract: Purslane (*Portulaca oleracea* L.) is widely distributed around the globe and is popular as a beneficial herb in many areas of Europe, Asia, and the Mediterranean region. It is already very well known for its nutritional as well as medicinal values for both human and animal feeds. It is a rich source of potassium, magnesium, calcium and possesses the potential to be used as vegetable source of omega-3 and 6 fatty acids. It is very good source of alpha-linolenic acid and gamma-linolenic acid of any green leafy vegetable. It also contains high amount of α-tocopherol and ascorbic acid. The antioxidant content and nutritional value of purslane are important for human consumption. It revealed tremendous nutritional potential and has indicated the potential use of this herb for the future. Purslane is a very fast growing plant and can reproduce vegetatively from stem cuttings by forming adventitious roots from the cut end of the stem. Recently many plant species are threatened with extinction through human activity and the force of globalization. Plant collections are a valuable tool both in research and as a valid means of providing students at many educational levels with knowledge of and appreciation for the wonder, diversity, and beauty of plant life. Collection of diverse accessions, identification, preservation and proper management of such beneficial plants is very important for their diversity analysis which is essential for present and future human well-being. The identification of representative and manageable subset of accessions would facilitate access to the diversity available in large collections. Giving importance on the above matters a total of 45 different purslane samples were collected from different locations of Western Peninsular Malaysia, properly identified and subjected for future detailed analysis of morpho-physiological and nutritional variations among the collections.
[Alam MA, Shukor AS, Rafii MY, Hamid AA, Aslani F. **Collection and identification of different Purslane (*Portulaca oleracea* L.) accessions available in Western Peninsular Malaysia.** *Life Sci J* 2014;11(6):431-437]. (ISSN:1097-8135). http://www.lifesciencesite.com. 61

Keywords: Purslane (*Portulaca oleracea* L.); sample collection; identification; morphological variation.

1. Introduction

The Purslane (*Portulaca oleracea* L.) is listed in the World Health Organization (WHO) as one of the most used medicinal plants under the family Portulacaceae and it has been given the term 'Global Panacea' (Dweck, 2001; Samy *et al.,*2004).The genus *Portulaca* comprising about 70 species is characterized by conspicuously fleshy sessile leaves (Vengris *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 Asia (Liu *et al.,* 2000; Rashed *et al.,* 2003). There are about 7 types of purslane available in Malaysia and mostly these are morphologically different (Alam *et. al.,* 2014). Purslane has been ranked the eight most common plants in the world and is widespread as a weed, fast growing, self-compatible and has amazing ability to produce seeds even on death's doorstep (Liu *et al.,* 2000). It is well established that significant morpho-physiological as well as biochemical variation can be found among the same species of plant due to geographical and/or regional variation. So, the differences among those species can be determined through a research of individually collected samples. Even common species are sometimes misidentified in the field; less common species can be easily misidentified (lack of distinguishing features, lack of magnification, lack of time, large or difficult groups) or overlooked. The best way to be certain of identification is to collect specimens and identify them in a lab with all the tools and resources at hand (ANPC, 2006). It has long been recognized that sampling procedure play an important role in population and community studies in ecology (Greig-Smith, 1983). The collection, proper identification and detailed description of targeted plant samples are the first and foremost key materials for conducting any fruitful research. Plant collections are a valuable tool both in research and as a valid means of providing students at many educational levels with knowledge of and appreciation for the wonder, diversity, and beauty of plant life (ANPC, 2006). Storrie (2009) stated that, the key to accurate

identification of plants is to supply the agronomist or botanist with good quality specimens and sufficient information about the plant, including details of the area from which it was collected and, if possible, supplementary photographs of the plant growing in its habitat. Sampling plays a critical role in plant analysis. Separate samples should be taken from areas that appear different from the rest of the field. Many plant species does not produce viable seeds but can be propagated using vegetative materials like, stems, roots, or other parts of donor plants and directly planted on the project site or sent to a nursery to produce rooted cuttings. The potential to produce roots from vegetative cuttings varies by species (BRIT, 2010). The ornamental purslane does not produce seeds so; using cuttings are the only viable alternative to planting seedlings to reestablish native vegetation. Purpose of plant sample collection is to obtain records and specimens of plants, either for a personal collection, conducting research or to be stored in a herbarium. Properly run herbaria where specimens are suitably stored and catalogued have great scientific value. Small collections of common plants can have great value as reference for identification (Wondafrash, 2008). Obtaining the appropriate species and stock type for a revegetation project takes good planning and lead time. To obtain genetically adapted materials often requires the collection of plant materials near or in the general geographic area of the project site (NRIBAS, 2011). The use of plant collections for research and their value in teaching and in documenting biodiversity is under-appreciated (ANPC, 2006). It is a good idea to use the following rule of thumb: never collect a plant when you can see fewer than 6 individuals in the area. Select vigorous, typical specimens. Avoid insect-damaged plants. Make sure the plant has flowers and/or fruits. It may be a good idea to collect extra flowers and fruit for identification purposes (BRIT, 2010). While collecting any plant sample collect details information which may include date of collection, a photo, location using a geographical positioning system (GPS), or written description of the location including the county, elevation, landmarks, reference points, travel directions, and a description of habitat and associated vegetation (Mealor and Mealor, 2010).

Due to vast depletion of medicinal species over exploitation and destruction of forests, it has now become necessary to cultivate them on mass scale and hence their propagation, multiplication and agro techniques need to be standardized (NRIBAS, 2011). Experimental studies related to germplasm evaluation and preservation through seed germination, vegetative propagation as well as molecular based diversity analysis is very important for such medicinal species to expand their cultivation and uses. With this objective in view a survey was conducted in selected areas in Western Peninsular Malaysia, especially in Selangor, Negeri Sembilan, Melaka, Kedah, Perak, Perlis and Penang to identify and morphological characterization of collected different purslane accessions.

2. Material and Methods

Site of sample collection

A survey was conducted from October-November, 2012 to collect and identify different types of purslane accessions in various coastal areas of Western Peninsular Malaysia. In tropical countries like Malaysia plant species composition is consistent throughout the year due to the fact that monthly temperatures and day length do not fluctuate greatly from month-to-month. Average temperatures during the survey period ranged from 24^0C to 32^0C, total annual rainfall measured 1800 to 2000 mm, and relative humidity averaged 80%. A total of 7 states (Selangor, Negeri Sembilan, Melaka, Kedah, Perak, Perlis and Penang) of Western Peninsular Malaysia were surveyed for sample collection. GPS (Geographical Positioning System) machine (model: Garmin GPSMAP 76CS, USA) was used to locate and identify the exact longitude and latitude position of the collected sample. The collected samples with details have been shown in Table 1.

Sampling techniques

Purslane samples were collected from different locations of Western Peninsular Malaysia following the Simple Random Sampling (SRS) methods described by Greig-Smith, 1983. This method is the most common sampling design in vegetation science, which can be used with large sample populations avoiding biasness. Simple random sampling is a type of probability sampling where each sampling location is equally likely to be selected, and the selection of one location does not influence which is selected next. In statistical terms, the sampling locations are independent and identically distributed. The sampling methods have been shown in Figure 1.

The figure (Fig. 1) shows how the SRS method works. First we pointed four samples at random and collected randomly not going to the first sample (marked as 1) first, made measurements, then traipse to the second sample. Rather, pick an efficient path, as from sample 3 to sample 1 to sample 4 to sample 2. Purslane samples in each sampling location were properly identified, tagged well and recorded for further analysis.

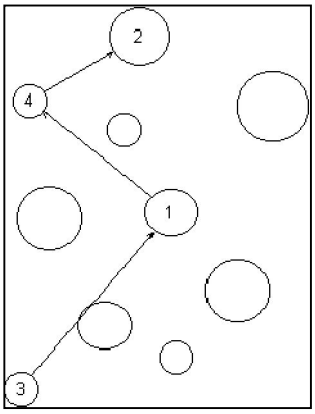

Figure 1. Simple Random Sampling Methods (adapted from Greig-Smith, 1983)

Data collection

Table 2. Morphological variations among collected purslane accessions

Plant characters	Variations
Leaf type	Wedge shape
	Paddle shape
Leaf color	Deep green
	Green
	Green with red margin
Stem color	Green
	Red/pinkish
Flower type	Minute/small
	Normal
Flower color	Yellow
	Pink
	Purple
	Orange yellow
	White pink

Different types of purslane were collected, identified and tagging of each accession was done based on morphological variations. Mainly there were two types of purslane common or wild purslane and ornamental purslane. Collected purslane accessions were differentiated considering leaf type, leaf color, stem color, flower type and flower color. Details of purslane morphological characteristics are presented in Table 2.

3. Results

A total of 45 purslane samples were collected from 7 states of West Peninsular Malaysia, including 11 samples from 5 locations in Selangor, 5 samples from 4 locations in Melaka, 5 samples from 4 locations in Nigeri Sembilan, 9 samples from 4 locations in Kedah, 5 samples from 5 locations in Perak, 5 samples from 3 locations in Penang and 5 samples from 5 locations in Perlis. Collected plant samples were properly identified, divided into 7 groups (Table 3, Figure 2) and transplanted in plastic pots in glass house, Field-2, Faculty of Agriculture for further research. A brief morphological description and collection details of all collected 45 purslane samples have been described in Table 1.

Table 3. Total 45 collected purslane accessions grouped into 7 types

Common/wild purslane (2 types)	**Ornamental purslane (5 types)**
1. Wild, yellow flower, green-red leaf, green-red stem (30 samples)	1. Yellow flower (5 samples)
2. Wild, yellow flower, green leaf, green stem (1 sample)	2. Purple flower (2 samples)
	3. Pink flower (5 samples)
	4. Orange yellow flower (1 sample)
	5. White-pink flower (1 sample) (*leaf and stem color was near about same*)

Table 1. Brief morphological descriptions and collection details of purslane samples

Sl. No.	Sample Code	State	Locations	Latitude (^{0}N)	Longitude (^{0}E)	Brief morphology of the collected purslane plants
1	Slg-1	Selangor	Sungai Buloh	03^{0}19′	101^{0}59′	Pink flower, wedge shaped margin red green leaf, red stem
2	Slg-2	-	Sungai Buloh	03^{0}19′	101^{0}59′	White-pink colored flower, wedge shaped green leaf, red stem
3	Slg-3	-	Sungai Buloh	03^{0}19′	101^{0}59′	Yellow flower, paddle shaped green leaf, red stem
4	Slg-4	-	AgroBio. UPM	02^{0}98′	101^{0}73′	Yellow flower, red margin wedge shaped green leaf, red stem
5	Slg-5	-	UPM	03^{0}01′	101^{0}706′	Wild, yellow flower, wedge shaped green leaf, green-red stem
6	Slg-6	-	Seri Kembangan	03^{0}00′	101^{0}713′	Wild, yellow flower, small paddle shaped red-green leaf, red stem
7	Slg-7	-	Tanjung Karang	03^{0}41′	101^{0}19′	Yellow flower, paddle shaped green leaf, red stem.
8	Slg-8	-	Tanjung Karang	03^{0}41′	101^{0}19′	Pink flower, paddle shaped green leaf, red stem.
9	Slg-9	-	Nursery, Klang	03^{0}02′	101^{0}26′	Purple flower, wedge shaped red green leaf, pink stem

10	Slg-10	-	Nursery, Klang	03^{0}02′	101^{0}26′	Pink flower, wedge shaped green leaf, green red stem
11	Slg-11	-	Port Klang	03^{0}00′	101^{0}36′	Wild, yellow flower, wedge shaped green red leaf, red stem
12	Mlk-1	Melaka	Kg. Pulau Gadong	02^{0}24′	102^{0}21′	Wild, yellow flower, wedge shaped green leaf, red-green stem
13	Mlk-2	-	Kg. Pulau Gadong	02^{0}21′	102^{0}19′	Wild, yellow flower, wedge shaped green leaf, green stem
14	Mlk-3	-	Kg. Bukit Gadong	2° 93'	102° 29'	Wild, yellow flower, small green leaf, red stem
15	Mlk-4	-	Taman Pertam Jaya	2°19'	102°27′	Wild, yellow flower, wedge shaped green leaf, red stem
16	Mlk-5	-	Alor Gajah	2°38'	102°22′	Wild, yellow flower, wedge shaped green leaf, red stem
17	PD-1	Nigeri Sembilan	Kg. Ayer Meleleh	02^{0}54′	101^{0}80′	Wild, yellow flower, paddle shaped green leaf, red green stem
18	PD-2	-	Kg. Ayer Meleleh	02^{0}54′	101^{0}81′	Wild, yellow flower, wedge shaped green-red leaf, red stem
19	PD-3	-	Jln Persiaran, Seremban	02^{0}43′	101^{0}56′	Wild, yellow flower, wedge shaped green leaf, red stem
20	PD-4	-	Jelebu	03^{0}07′	102^{0}17′	Wild, yellow flower, paddle shaped green leaf, red stem
21	PD-5	-	Kuala Pilah,	02^{0}75′	102^{0}25′	Wild, yellow flower, wedge shaped green leaf, green red stem
22	Kdh-1	Kedah	Nursery, Kedah	06^{0}11′	100^{0}37′	Orange-yellow flower, wedge shaped green leaf, red stem
23	Kdh-2	-	Nursery, Kedah	06^{0}11′	100^{0}37′	Pink flower, wedge shaped green leaf, Red stem
24	Kdh-3	-	Nursery, Kedah	06^{0}11′	100^{0}37′	Purple flower, paddle shaped green leaf, red stem
25	Kdh-4	-	Kuala Kedah	06^{0}11′	100^{0}29′	Wild, yellow flower, green wedge shaped leaf, green stem
26	Kdh-5	-	Kota Setar	06^{0}16′	100^{0}54′	Wild, yellow flower, green wedge shaped leaf, green-red stem
27	Kdh-6	-	Jitra-1	06^{0}24′	100^{0}43′	Wild, yellow flower, green wedge shaped leaf, green-red stem
28	Kdh-7	-	Jitra-2	06^{0}23′	100^{0}42′	Wild, yellow flower, wedge shaped green-red leaf, red stem
29	Kdh-8	-	Jitra-3	06^{0}33′	100^{0}42′	Wild, yellow flower, wedge shaped green-red leaf, red stem
30	Kdh-9	-	Jitra-4	06^{0}27′	100^{0}41′	Wild, yellow flower, green wedge shaped leaf, green-red stem
31	Prk-1	Perak	Kuala Kangsar	04^{0}77′	100^{0}94′	Wild, yellow flower, wedge shaped green-red leaf, red stem
32	Prk-2	-	Ipoh	04^{0}77′	100^{0}95′	Wild, yellow flower, wedge shaped green-red leaf, red stem
33	Prk-3	-	Perak Tengah	04^{0}36′	100^{0}98′	Wild, yellow flower, wedge shaped green leaf, green- red stem
34	Prk-4	-	Bota Perak	04.34′	100^{0}88′	Wild, yellow flower, wedge shaped green leaf, red stem
35	Prk-5	-	Teluk Intan	04^{0}02′	101^{0}02′	Wild, yellow flower, wedge shaped green red leaf, red stem
36	Png-1	Penang	Seberang Perai,	05^{0}54′	100^{0}47′	Yellow flower, paddle shaped, margin green red leaf, Red stem leaf
37	Png-2	-	Seberang Perai,	05^{0}54′	100^{0}47′	Pink flower, wedge shaped green red leaf, red stem
38	Png-3	-	Seberang Perai,	05^{0}54′	100^{0}47′	Wild, yellow flower, wedge shaped green red leaf, red stem
39	Png-4	-	Bumbung Lima	05^{0}55′	100^{0}44′	Wild, yellow flower, wedge shaped green-red leaf, red stem
40	Png-5	-	Lorong Malinja,	05^{0}51′	100^{0}42′	Yellow flower, wedge shaped green red leaf, red stem
41	Pls-1	Perlis	Balai Baru Beseri	06^{0}51′	100^{0}23′	Wild, yellow flower, wedge shaped green leaf, red stem
42	Pls-2	-	Jalan Kalei Bukit	06^{0}52′	100^{0}24′	Wild, yellow flower, wedge shaped red-green leaf, red stem
43	Pls-3	-	Kg. Simpang Empat	06^{0}34′	100^{0}19′	Wild, yellow flower, wedge shaped green-red leaf, red stem
44	Pls-4	-	Kuala Perlis	06° 23'	100° 82'	Wild, yellow flower, wedge shaped green leaf, red stem
45	Pls-5	-	Kg. Telok Jambu	06° 45'	100° 17'	Wild, yellow flower, wedge shaped green leaf, red stem

1. Common purslane: Yellow flower, single-layered petals, paddle -shaped leaves, green-red stem

2. Common purslane: Yellow flower, Single-layered petals, paddle –shaped green leaves, green stem

3. Pink flower, single layered petals, wedge-shaped green leaves, red stem

4. Purple flower, single layered petals, wedge-shaped green leaves, green-red stem

Figure 2. Different types of purslane (*Portulaca oleracea* L.) available in Malaysia

4. Discussions

Humans have always needed to classify objects in the world around them. It is the only means we have of acquiring and passing on knowledge. Recognizing and describing plants has always been especially important because of their use for foods and medicines (Bowles, 1986). Accurate plant identification, particularly in relation to biodiversity protection, alien invaders, and commercial collecting of wild plants, is of immense importance (AAFC, 2006). There are two main reasons for collecting plants. The first is to obtain records and specimens of plants, either for a personal collection or to be stored in a herbarium for long term conservation especially for identification and teaching purposes. Secondly different plant samples are collected for research purpose to determine and to evaluate different bioactive compounds for nutritional as well as medicinal aspects. The collection also provides information for developing new crops and for ecological studies (AAFC, 2006). It is noted that collections "make innumerable contributions to science and society in areas as divergent as homeland security, public health and safety, monitoring of environmental change and traditional taxonomy and systematic (Suarez and Tsutsui, 2004). Prather *et al.*, (2004) opined that collecting and collections are very important because they provide the essential tools to document the incompletely known and changing flora which includes: unknown taxa, unknown distributions, newly established aliens and changes in status and occurrence. They also reported that collections are the foundation for ecological and biogeographic research and are a prerequisite for making informed land-management and conservation decisions.

One of the most important uses of the collection is the preservation of specimens used in scientific research. These are referred to as vouchers, and they are available for checking to help verify and ensure the validity of research results at any time. The collection includes vouchers for genetic studies, chromosome number determinations, breeding material, and general classification research including the assignment of plant names (AAFC, 2006).

The entire 45 collected purslane accessions were divided into 7 different groups considering their morphological similarity or relatedness. Significant differences were observed among the groups purslane accessions. The first group includes a total of 30 common/wild purslane accessions with wedge shaped green-red leaf and green-red or pinkish stems. Among those 30 common or wild purslane samples 3 were collected from Selangor state, 5 samples from Melaka state, 5 samples from Nigeri Sembilan state, 5 samples from Kedah state, 5 samples from Perak state, 2 samples from Penang state and 5 samples collected from Perlis state. Whereas the second group formed by the only common purslane accession with green wedge shaped leaf and green stem collected from Kuala Kedah, Kedah state. The third group was formed by 5 samples of ornamental purslane with yellow coloured flower, paddle and or wedge shaped green leaf and red/pinkish stem. Among those 5 samples 3 were collected from Selangor state and another 2 were collected from Penang state. The fourth group was formed by two ornamental purslane accessions with purple flower, wedge and/or paddle shaped red green leaf and pinkish stem, one was collected from Selangor state and another one was collected from Kedah state. Pink coloured flowers with wedge and/or paddle shaped green leaf and red/pinkish stems of 5 ornamental purslane samples were under the group five. Among those 5 samples 3 were collected from Selangor state, one from Kedah and the last one was collected from Penang state. The sixth group was formed by the only one ornamental purslane accession with orange-yellow flower, wedge shaped green leaf and red/pinkish stem collected from Kedah state of Western Peninsular Malaysia. The seventh and the last group was formed by the only one ornamental purslane accession collected from Selangor state with white-pink flower, wedge shaped green leaf and red/pinkish stem.

5. Conclusions:

Variability among individuals is the source material for creating desired variation for greater purposes. And it can only be achieved by collecting different types of plant samples with their appropriate management. The collection also provides information for developing new crops and for ecological studies. It has long been recognized that sampling procedure play an important role in population and community studies in natural sciences. The collection, proper identification and

detailed description of targeted plant samples are the first and foremost key materials for conducting any fruitful research. So, collection of different purslane samples and their multidisciplinary research plays an important role in fulfilling required demand for essential plant nutrients and pharmaceuticals.

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 PhD Fellowship.

Corresponding Author:
Md. Amirul Alam
Department of Crop Science
Faculty of Agriculture
Universiti Putra Malaysia
UPM Serdang, 43400, Selangor, Malaysia
E-mail: amirul81@gmail.com

References

1. Agriculture and Agri-Food Canada (AAFC). 2006. The Agriculture and Agri-Food Canada collection of vascular plants. Canadian Botanical Association Bulletin, 39(1): 13-19.
2. Alam, M.A., Juraimi, A.S., Rafii, M.Y., Hamid, A.A., Aslani, F., Hasan, M.M., Zainudin, M.A.M. Uddin, M.K., 2014. Evaluation of antioxidant compounds, antioxidant activities and mineral composition of 13 collected purslane (*Portulaca oleracea* L.) accessions. *BioMed Res. Int.* 2014, 1-10.
3. Alberta Native Plant Council (ANPC). 2006. Plant Collection Guidelines for Researchers, Students and Consultants. Published by the Alberta Native Plant Council on line at http://www.anpc.ab.ca/), pp. 1-9.
4. Botanical Research Institute of Texas (BRIT). 2010. Plant Collection & Preservation, 1700 University Drive Fort Worth, Texas 76107, pp 1-5.
5. Bowles J.M. 1986. The collecting scroll: a practical alternative to the field press. *The Plant Press,* 4: 74-75.
6. Dweck, A.C. 2001. Purslane – Portulaca oleracea: The global panacea. *Personal Care Magazine* 2, 4. pp 7-15.
7. Greig-Smith, P. 1983. Quantitative Plant Ecology. University of California Press, Berkeley, California, pp. 359.
8. Liu, L., Howe, P., Ye-Fang Zhou, Zhi-Qiang Xu, Hocart, C. and Zhang, R. 2000. Fatty acids and b-carotene in Australian Purslane (*Portulaca oleracea*) varieties. *Journal of Chromatography A*., 893: 207–213.
9. Liu, L., Peter Howe, Ye-Fang Zhou, Zhi-Qiang Xu, Charles Hocart and Ren Zhang, 2000. Fatty acids and b-carotene in Australian Purslane (*Portulaca oleracea*) varieties. *Journal of Chromatography A*., 893: 207–213.
10. Mealor, R. and Mealor, B. 2010. Picking plants: How to collect plants for identification. *SUMMER*, pp 23-25.
11. National Research Institute of Basic Ayurvedic Sciences (NRIBAS). 2011. Central Council for Research in Ayurvedic Sciences, an autonomous organization under the Department of AYUSH, Ministry of Health and Family Welfare, Govt. of India. Source: http://www.rria.nic.in/garden.html
12. Prather, L.A., Alvarez-Fuentes, O., Mayfield, M.H. and Ferguson, C.J. 2004. Implications of the decline in the plant collecting for systematic and floristic research. *Systematic Botany,* 29(1): 216-220.
13. Rashed, A.N., Afifi, F.U. and Disi, A.M. 2003. Simple evaluation of the wound healing activity of a crude extract of *Portulaca oleracea* L. (growing in Jordan) in *Mus musculus* JVI- 1, *Journal of Ethnopharmacology.*, 88(2-3): 131-136.
14. Samy, J., Sugumaran, M. and Lee, K.L.W. 2004. Herbs of Malaysia: An Introduction to the medicinal, culinary, aromatic and cosmetic use of herbs. Kuala Lumpur: Times Edition.
15. Storrie, A. 2009. Collecting and preparing plant specimens for identification. Primefacts 919, Replaces Agnote DPI-492, State of New South Wales (NSW), Department of Industry and Investment, Australia, pp 1-5.
16. Suarez, A.V. and Tsutsui, N.D. 2004. The value of museum collections for research and society. *BioScience,* 54(1): 66-74.
17. Vengris, J., Dunn, S. and Satcewicz, M. 1972. Life History as Related to Weed Control in the Northwest: 7 species of Purslane. Research Bulletin 598, Northwest Regional Publication, The University of Massachusetts, Amherst, USA.
18. Wondafrash, M. 2008. A Preliminary Guide to Plant Collection, Identification and Herbarium Techniques. The National Herbarium, AAU. Faculty of Science, Biology Department, Po Box 3434, Addis Ababa. pp 1-7.

5/10/2014