Elsevier Editorial System(tm) for Industrial Crops and Products

Manuscript Draft

Manuscript Number: INDCRO-D-19-00886R2

Title: Herbal yield, nutritive composition, phenolic contents and antioxidant activity of purslane (Portulaca oleracea L.) grown in different soilless media in a closed system

Article Type: Research Paper

Section/Category: Bio-based Materials from Crops

Keywords: Purslane; soilless cultivation substrates; yield; proximate composition; phenolic compounds; antioxidant activity.

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Abstract:
Purslane (Portulaca oleracea L.) is a valuable plant and crop with potential industrial uses, yet little is known on how its cultivation could benefit from soilless substrates. This study aimed to assess the effects of different soilless growth media on herbal yields (fresh and dry), proximate chemical composition, total phenolic, flavonoid and anthocyanin content, and antioxidant activity of purslane cultivated in a closed system. The greatest yields over five harvest cycles were obtained with tuff-peatmoss (2:1 mixture) compared with other soilless substrates, although the edible leaves were not as rich in proteins, lipids, minerals, and phenolic compounds. The highest content of proteins (31.4% and 30.4%), lipids (0.68% and 0.75%), total phenolics (646.9 and 684.9 mg/100 g), flavonoids (597.8 and 563.8 mg/100 g), and moisture (92.5% and 93.5%) in the leaves were found in purslane grown in tuff-peatmoss-perlite (2:1:1) and in zeolitic tuff, respectively. Antioxidant activity of leaf extracts was also the highest in purslane grown in both substrates and was similar to the antioxidant activity of leaf extracts from soil-grown purslane obtained commercially and from the wild. The protein and lipid content obtained with tuff-peatmoss-perlite (2:1:1) and zeolitic tuff were superior to those of soil-grown purslane. The results show that the nutritive and antioxidant qualities of purslane can be enhanced through soilless cultivation and selection of suitable culture media.

July 2019

Opender Koul, PhD
Editor-in-Chief, *Industrial Crops and Products*

Dear Dr. Koul,

Revised manuscript INDCRO-D-19-00886R2

Original Article – "Herbal yield, nutritive composition, phenolic contents and antioxidant activity of purslane (*Portulaca oleracea* L.) grown in different soilless media in a closed system"

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Please receive the revised version of the aforementioned manuscript in which we addressed all the comments and suggestions received. A point-by-point response to reviewers' and editors' comments is also provided in a separate file.

Our paper is the first to report on the yield, proximate composition, total phenolic, flavonoid and anthocyanin contents, and antioxidant activity of purslane (*Portulaca oleracea* L.) grown in different soilless media. The findings have applications for the agricultural production of purslane and should thus be of interest to the readership of *Industrial Crops and Products*.

We thank you for your consideration. We appreciate the opportunity to improve our manuscript and hope that it will be acceptable for publication in your journal.

Please let me know if you have any queries. We look forward to hearing from you.

Best regards,

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Files submitted:
Cover letter; Revised manuscript INDCRO-D-19-00886R2; Revised tables and figure; Revised highlights; Authors response to the comments from Reviewers 1 and 2 and Editors.

Manuscript INDCRO-D-19-00886R2 (July 2019)

Revised title: "Herbal yield, nutritive composition, phenolic contents and antioxidant activity of purslane (*Portulaca oleracea* L.) grown in different soilless media in a closed system"

Initial title: "Herbal yield, nutritive composition, phenolic content and antioxidant activity of purslane (*Portulaca oleracea* L.) are influenced by soilless growth medium in a closed system"

Response to the comments from Reviewer 1

Dear Reviewer,

Thank you kindly for your thorough assessment of our work. Your constructive comments are appreciated.

Best regards

	Reviewer's Comment/Authors' response
Comment	*The paper entitled: "Herbal yield, nutritive composition, phenolic content and antioxidant activity of purslane (Portulaca oleracea L.) are influenced by soilless growth medium in a closed system" does not present major errors or inconsistencies in its current state.*
Response	Thank you for your appreciation of the manuscript.

Revised title: "Herbal yield, nutritive composition, phenolic contents and antioxidant activity of purslane (*Portulaca oleracea* L.) grown in different soilless media in a closed system"

Initial title: "Herbal yield, nutritive composition, phenolic content and antioxidant activity of purslane (*Portulaca oleracea* L.) are influenced by soilless growth medium in a closed system"

Response to the comments from Reviewer 2

Dear Reviewer,

Thank you kindly for your thorough assessment of our work. Your constructive comments are appreciated. They have all been taken into account to improve the manuscript as indicated below. Red font is used to highlight the revisions in the manuscript.

Best regards

	Reviewer's Comment/Authors' response
Comment	*Herbal yield, nutritive composition, phenolic content and antioxidant activity of purslane (Portulaca oleracea L.) are influenced by soilless growth medium in a closed system: In general the article is interesting, well written, with future application.*
Response	Thank you for your appreciation of the manuscript.
Comment	*1. Introduction: Several old references. Update as possible.*
Response	The references have been updated whenever possible, with the addition of recent ones, including **Rouphael and Kyriacou (2018)**, **Kopsell et al. (2016)**, **Alam et al. (2014)**, and **Uddin et al. (2012)**. As noted in the introduction, there is a dearth of information on the impact of soilless culture and substrate on the yield and composition of purslane. Recent reports are even scarcer, which limits the number of recent papers that could be included.
Comment	*2. Materials and Methods:* *2.2. Line 106 and 107 - "Cultivation started at the end of February; harvesting began in April and continued until July": Please, insert more details of the harvest, how was it made? Remove the leaves? Close to the root?*
Response	Details about the harvesting have been added as suggested (section 2.2.1). The above-ground biomass, which consisted of stems and leaves, was harvested manually by cutting the stems at 5 cm above the level of the soilless substrates.
Comment	*2.6. Determination of antioxidant activity using the DPPH assay - Line 186: Why only one method was used? Using other methods, the antioxidant is better evaluated.*
Response	The DPPH scavenging assay was used as it is a well-established, simple and reliable method for determining the antioxidant activity of extracts or compounds from plant materials. Our objective in this study was not to compare different methods for assessing antioxidant activity. While we agree that the use of multiple methods would be valuable, this was outside the scope of the study. Suggestions for further research on the antioxidant capacity of purslane products were added to the discussion (section 3.5) to address your comment.
Comment	*3. Results and Discussion:* *Paragraph 252: This paragraph is confuse. Please rewrite the sentence.*
Response	This sentence was rephrased as suggested: "This creates suitable conditions for root growth that may support effective growth of purslane. Higher content and availability of nutrients in tuff-peatmoss substrate could explain the enhanced yields as well as height of purslane" (section 3.1).

Comment	*Line 331: "Ash content was the highest (29.0%) with tuff-peatmoss-perlite (2:1:1)." However, in the table 4 it can be the highest value for "soil" sample (35.2[a]), please rewrite the sentence.*
Response	This sentence was rephrased to clarify: "Among the soilless media, ash content was highest with tuff-peatmoss-perlite" (section 3.4).
Comment	*Conclusion: It should be reduced emphasizing the main findings and applications. Sounds like a abstract.*
Response	The conclusion has been reduced, emphasizing the main findings and possible applications.

Revised title: "Herbal yield, nutritive composition, phenolic contents and antioxidant activity of purslane (*Portulaca oleracea* L.) grown in different soilless media in a closed system"

Initial title: "Herbal yield, nutritive composition, phenolic content and antioxidant activity of purslane (*Portulaca oleracea* L.) are influenced by soilless growth medium in a closed system"

Response to Editors' Comments

Dear Editors,

Thank you kindly for your thorough assessment of our work. Your constructive comments are appreciated. They have all been taken into account to improve the manuscript as indicated below. All the comments and suggestions from the reviewers have also been addressed. Red font is used to highlight the revisions in the manuscript.

Best regards

	Editors' Comment/Authors' response
Comment	*Discussion requires to show novelty of the study with conclusive comparisons*.
Response	As noted in the introduction, there is a dearth of information on the impact of soilless culture and soilless substrates on the yield, composition and phenolic content of purslane. The present study was conducted to address this gap. The novelty of this study was also emphasized in the revised discussion (section 3.1): "To our knowledge, it is the first study to report on the yield, height as well as proximate composition, total phenolic, flavonoid and anthocyanin contents, and antioxidant activity of purslane grown in different soilless media". Conclusive comparisons are presented in sections 3.1 to 3.5, based on the conclusive comparisons shown in tables and figure.
Comment	*In addition to the comments of the reviewers, follow the check list below and modify your manuscript accordingly. If an item on the checklist doesn't apply to your manuscript, just skip it. Write in red all changes made to your manuscript in next revision, do not use Word Track changes.*
Response	The manuscript has been carefully revised considering all the items in the checklist. Red font was used to indicate the changes made in the manuscript.
1)	*Title: Avoid low impact words such as 'effects of', 'influence of', 'characterization of', etc., any part of the title. Title must be declarative, descriptive or a question*
	OK, the revised title is descriptive and does not contain low impact words.
2)	*Do not use abbreviations in highlights*
	OK, the highlights do not contain any abbreviations.
3)	*All acronyms must be spelled out in the abstract*
	OK, the abstract does not contain acronyms.
4)	*Write in third person, avoid personal pronouns, such as we, they, you, I, or our, their, yours*
	OK, third person is used throughout the manuscript.
5)	*Abstract must have rationale, objective, materials and methods and conclusions. First sentence must be a rationale*
	OK, the revised abstract starts with a rationale (lines 26-28), followed by the other elements.
6)	*Common names of plants, animals, fungi, etc. must be followed by the Latin name the first time the common name is used. Latin name must include Authority example: maize (Zea mays* L.*)*
	OK, in title, abstract and introduction.

7)	*Equations must have the form y=a + bx, correct text , figures and tables*
	OK, Equations follow this format.
8)	*All statistical parameters y, x, n, r^2, P, p... etc must be in Italics in text figures and tables. Use small case r^2 for linear equations , R^2 is used only for non-linear regressions*
	OK, this format has been used in the text, tables and figure.
9)	*Use significant digits only in values and use . period for decimal separation check all tables and Figures*
	OK, all the tables and figure have been checked and corrected when needed.
10)	*For currency use only US dollars and Euros*
	Not applicable
11)	*Justify first column of tables to the left*
	OK, first column of tables is justified to the left.
12)	*Tables, make sure the independent variables are in the first column. You might need to transpose columns and rows, dependent variables in columns #2 to #n with the unit below.*
	OK, the independent variables are in the first column of tables.
13)	*Do not start sentences with abbreviations or numbers*
	OK, there are no sentences starting with an abbreviation or number.
14)	*Abbreviation for number is no*
	OK
15)	*No space between the unit and Celsius symbol, correct all*
	OK, there is no space between the unit and Celsius symbol (e.g., 20ºC).
16)	*replace 'compared to' with 'compared with', correct all*
	OK, “compared with” was used throughout the manuscript.
17)	*Add one sentence of rationale to the beginning of your abstract*
	The revised abstract starts with a rationale (lines 26-28).
18)	*No bold text or values in tables*
	OK, there is no bold text or bold values in the tables.
19)	*Replace ppm for mg/kg or mg/L*
	Not applicable
20)	*Tables: Units go below header lines. Delete units from captions. Correct all tables*
	OK, all the tables have been checked and corrected when needed.
21)	*Add in your manuscript your reply to comments where the question was raised. A future reader of your publication might have a similar question*
	OK, our responses to the questions raised were added to the revised manuscript (red font) as suggested.
22)	*Format your tables to journal style. No vertical lines and only 3 horizontal lines, top, bottom and line below header*
	OK, all the tables have been formatted according to the journal style, with no vertical lines and only 3 horizontal lines in each table.
23)	*Only one table per page after references. Move Figures to the end of the text after tables, one*

	figure per page with the caption below the Figure
	OK, one table per page after the references, followed by the figure, with the caption below the figure. The illustrations have been submitted in a separate Word document.
24)	*Check references format (Johnson, 1993), (Johnson and Smith, 1993), (Johnson et al., 2003). Use Elsevier reference formatting*
	Reference format has been checked, ensuring that Elsevier format for this journal is used in the text and reference section.
25)	*Tables must stand alone, indicate the meaning of all abbreviations used on the table in a footnote. Footnotes indicators must have small case letter in italics and superscript (a, b, c or x, y z) do not use * for footnotes. One line per footnote below the table*
	OK, all the tables have been formatted as suggested. * is no longer used for footnotes.
26)	*Use 12 August 2016 to indicate dates, not August 12th, 2016*
	OK, this format was used.
27)	*All units and values are separated by space except % and Celsius degree symbol ^{o}C examples: 15 mL, 20 mi, 600 nm, 1000 kg/ha, 46%, 20^{o}C, 8.60 g*
	OK, this format was used throughout the manuscript.
28)	*Use a comma before the final item in a list of three or more items. For example: "Cores were inside plastic liners, capped, and stored on ice…"*
	OK, this format was used in lists containing three or more items.

***Highlights (for review)**

- Highest herbal yields in soilless purslane grown on a combination of tuff-peatmoss.
- Highest protein and lipid contents in purslane grown on tuff-peatmoss-perlite.
- Highest total phenolics and flavonoids in purslane grown on tuff-peatmoss-perlite.
- Highest antioxidant activity in tuff-peatmoss-perlite and zeolitic tuff.
- Soilless purslane is a good source of proteins, lipids, and antioxidant phenolics.

Herbal yield, nutritive composition, phenolic contents and antioxidant activity of purslane (*Portulaca oleracea* L.) grown in different soilless media in a closed system

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ABSTRACT

Purslane (*Portulaca oleracea* L.) is a valuable plant and crop with potential industrial uses, yet little is known on how its cultivation could benefit from soilless substrates. This study aimed to assess the effects of different soilless growth media on herbal yields (fresh and dry), proximate chemical composition, total phenolic, flavonoid and anthocyanin content, and antioxidant activity of purslane cultivated in a closed system. The greatest yields over five harvest cycles were obtained with tuff-peatmoss (2:1 mixture) compared with other soilless substrates, although the edible leaves were not as rich in proteins, lipids, minerals, and phenolic compounds. The highest content of proteins (31.4% and 30.4%), lipids (0.68% and 0.75%), total phenolics (646.9 and 684.9 mg/100 g), flavonoids (597.8 and 563.8 mg/100 g), and moisture (92.5% and 93.5%) in the leaves were found in purslane grown in tuff-peatmoss-perlite (2:1:1) and in zeolitic tuff, respectively. Antioxidant activity of leaf extracts was also the highest in purslane grown in both substrates and was similar to the antioxidant activity of leaf extracts from soil-grown purslane obtained commercially and from the wild. The protein and lipid content obtained with tuff-peatmoss-perlite (2:1:1) and zeolitic tuff were superior to those of soil-grown purslane. The results show that the nutritive and antioxidant qualities of purslane can be enhanced through soilless cultivation and selection of suitable culture media.

Keywords: Purslane, Soilless cultivation substrates, Yield, Proximate composition, Phenolics and flavonoids, Antioxidant activity.

1. Introduction

Common purslane (*Portulaca oleraceae* L.) is an edible herbaceous plant commonly distributed in much of Europe, the Mediterranean region, the Middle East, Asia, Mexico, the Caribbean and North America. It belongs to the *Portulacaceae* family, which consists of more than 120 species of succulent herbs and shrubs, and grows well in poor soils and hot dry conditions (Cudney et al., 2007). In many parts of the world, including Asia and Mediterranean countries, purslane is grown as a specialty crop valued for its nutritional and medicinal properties. Its leaves and stems have a slightly sour and salty taste similar to spinach and are consumed as a leafy vegetable (Chan et al., 2000). Its yellow flower buds are also consumed. Purslane is a rich source of essential nutrients, mainly minerals (Bianco et al., 1998; Uddin et al., 2012), vitamin C, vitamin E and ω-3 fatty acids, particularly α-linolenic acid (Liu et al., 2000; Petropoulos et al., 2015; Simopoulos, 2004), as well as bioactive phytochemicals such as carotenoid and phenolic antioxidants with proposed health benefits (Alam et al., 2014; Erkan, 2012; Kopsell et al., 2016; Uddin et al., 2012). The aerial parts of the plant are used for their antiseptic, anthelmintic, anti-inflammatory, and antispasmodic properties, and to help manage arthritis, osteoporosis as well as psoriasis (Uddin et al., 2014; Xiang et al., 2005).

Agronomic practices have attracted much attention recently to optimize the factors involved in crop management through a better control of plant growth and nutrient requirements to improve plant health, yields, and product quality under greenhouse conditions (Aaby et al., 2010; Atanassova et al., 2007). Soilless culture is considered as one of the main components of sustainable protected horticulture and is gaining particular interest in countries with scarce water resources, limited agricultural land, and soil salinity problems (Putra and Yuliando, 2015). Closed soilless techniques offer new opportunities to minimize water losses and maximize the efficiency of fertilizer use, in addition to

reducing environmental pollution caused by fertilizer runoff (Rouphael and Kyriacou, 2018; Rouphael et al., 2004; Van Os, 1999). Other advantages of closed soilless culture, which contribute to its importance on commercial scale, include high yields, cleaner and year-long cultivation, and products with minimum herbicide and pesticide residues, which is expected for crops intended for human consumption as foods or health products (e.g., nutraceuticals and nutritional supplements) (Hassanpouraghdam et al., 2010; Martínez et al., 2013). Soilless closed systems are also favored to control the growth of pests and insects, reduce contamination and improve the recirculation of plant nutrients. For pest control, these systems offer a safer alternative technique to the use of methyl bromide, a now-banned or phased out pesticide used to disinfect soils before planting (Alcon et al., 2010).

The chemical composition and nutritional quality of some crops have been shown to differ in soil and soilless systems. Strawberries, for instance, were found to have lower values of sugars, total solids, and sugars-to-acid ratio when cultivated in soilless closed systems compared with soil in an open system, except when coconut fiber was used as a soilless substrate in an open system (Recamales et al., 2007). Very few studies are available on the impact of soilless cultivation on plant phenolic content and antioxidant capacity. Some differences in total phenolic and anthocyanin content have been noted in strawberries grown in closed vs. open soilless systems (Hernanz et al., 2007). Except for one report indicating that purslane adapts well to a peat-based floating cultivation system, producing a high yield and lipid content (Cros et al., 2007), there is a dearth of information on the impact of soilless culture and substrates on the yield, nutritional quality, and phenolic content of purslane.

The aim of the present study was to assess the effects of soilless substrates (tuff, peatmoss, perlite, and their combination) on the yield, height, proximate composition, total phenolic,

flavonoid and anthocyanin contents, and antioxidant activity of common purslane grown in a closed system. A comparison with soil-grown purslane was also conducted in terms of chemical composition and antioxidant activity.

2. Materials and methods

2.1. Plant materials and chemicals

Purslane seeds were obtained from a local store in Irbid, Jordan. For purslane cultivated in soil (open systems), fresh samples were obtained from three local sources in Irbid, namely the Jordan University of Science and Technology (JUST) campus where purslane was cultivated in an open garden (same seeds as for soilless-grown purslane), a local market, and one location in the city where wild (non-cultivated) purslane was found. These samples were designated as "soil", "market", and "wild", respectively, and characterized for chemical composition, phenolic contents and antioxidant activity. All chemical reagents were of analytical grade.

2.2. Soilless cultivation under closed conditions

2.2.1. Soilless cultivation substrates and experimental design

Soilless cultivation was conducted in a greenhouse at the JUST campus (Irbid, Jordan) during one growing season. Cultivation started at the end of February; harvesting began in April and continued until July. Germination and subsequent growth after transplantation were under natural light conditions. Ventilation was provided automatically by a cooling system when the air temperature exceeded 28°C. Purslane seedlings were transplanted at the four-leaf stage into multicellular iron trays (20 cm x 300 cm x 25 cm, W x L x D) filled with seven soilless horticultural substrates, namely (1) tuff, (2) peatmoss, (3) peatmoss and perlite (2:1), (4) tuff and peatmoss (2:1), (5) tuff, peatmoss and perlite (2:1:1), (6) zeolitic tuff, and (7) tuff and peatmoss (1:1). Tuff, perlite and zeolitic tuff are inorganic components, while peatmoss is organic. Different combinations of these

materials were tested in this study. The bases of the beds were elevated at a slope of 1.5% with a hole in the tray wall to which a channel was attached to drain excess water which was collected into tanks for reuse. Harvesting of the above-ground biomass, which consisted of stems and leaves, was performed manually by cutting the stems at 5 cm above the level of the soilless substrate. This biomass was used to determine the yields, while the other determinations were carried out using the leaves. Treatments were randomly assigned to experimental units (i.e., trays) using a randomized complete block design with substrate as factor and three replications per treatment.

2.2.2. Nutrient solution and irrigation system

Water and nutrients were provided with complete nutrient solutions prepared from commercial fertilizers with some modifications. The procedures for nutrient replenishment and water discharge were applied at the same time to all replicates using a drip irrigation system. The nutrient solutions were prepared freshly once every three weeks. Clark's nutrient solution (Clark, 2008) was pumped from independent tanks. Electrical conductivity and pH values of the nutrient solution were maintained at 2.0-2.5 and 5.5-6.5 dS/m, respectively.

2.3. Plant height and yield measurements

Biomass measurements of soilless-grown purslane were taken at five harvesting points during the growing season. Plant height (cm) was measured, then the plants were harvested at 5 cm above the ground. Fresh and dry weights (g) were measured and converted to fresh and dry yields (g/m^2), respectively. For dry yield, the samples were dried at room temperature for 10 days. Plant material obtained from the first cycle of harvest was used for chemical analyses.

2.4. Proximate analysis

147 Proximate chemical composition of the leaves of soilless- and soil-grown purslane was
148 determined according to the AOAC method (1990) with triplicate determinations.
149 Moisture content was determined by drying the samples at 100°C until constant weight.
150 Total nitrogen content of the dried samples was determined using the micro-Kjeldahl
151 method and a conversion factor of 6.25 to calculate crude protein content. Total lipids
152 were determined by Soxhlet extraction. For crude fiber, the dried samples were digested
153 with 1.25% sulfuric acid and 1.25% potassium hydroxide. Ash content was determined by
154 burning 1 g of dried sample in a muffle furnace at 550°C for 24 h.

155 *2.5. Determination of phenolic compounds*

156 *2.5.1. Total phenolic content*

157 Half a gram of dried leaves from soilless- and soil-grown purslane was mixed with 50 ml
158 of methanol at 30°C for 12 h, with stirring, to extract the total phenolic constituents. The
159 samples were then filtered into a 50 ml volumetric flask through a filter paper (Whatman
160 no. 42) and the volume was completed to mark. The extracts were kept in the refrigerator
161 at 4°C until further analyses. The content of total phenolics in the extracts was determined
162 according to the Folin-Ciocalteu method described by Singleton et al. (1999). Two
163 milliliters of extracts were transferred into a test tube and mixed with 2.5 ml of 10% Folin-
164 Ciocalteu reagent. After 3 min, 2 ml of 10% sodium carbonate solution (Na_2CO_3) was
165 added. The tubes were allowed to stand for 1 h at room temperature, then absorbance was
166 measured in triplicate at 760 nm using a UV-VIS spectrophotometer (SpectroScan 50,
167 Biotech Engineering Management Co., UK) against a blank which consisted of methanol
168 instead of test sample. Gallic acid was used as calibration standard, with different
169 concentrations to prepare a standard curve, and the concentration of total phenolics was
170 expressed as gallic acid equivalent (mg of GAE/100 g of sample on a dry weight basis).

171 *2.5.2. Total flavonoid content*

172 Total flavonoid content of the leaves was determined according to the aluminum chloride
173 colorimetric method described by Zhishen et al. (1999). Half a milliliter of methanolic
174 extract was mixed with 150 µl of a 15% sodium nitrite solution ($NaNO_2$). After 6 min,
175 150 µl of a 10% $AlCl_3$ was added with stirring, then after another 6 min, 2 ml of NaOH
176 solution (4%) and 2 ml of distilled water were added to bring the final volume to 5 ml. The
177 mixture was mixed and allowed to stand for 1 h at room temperature, then absorbance was
178 measured in triplicate at 510 nm (UV-VIS spectrophotometer, SpectroScan 50, Biotech
179 Engineering Management Co., UK) against a blank which consisted of methanol. Catechin
180 was used as calibration standard and the concentration of total flavonoids was expressed as
181 catechin equivalent (CE) (mg of CE/100 g on a dry weight basis).

182 *2.5.3. Total anthocyanin content*

183 Anthocyanins were extracted using the method described by Rabino and Mancinelli
184 (1986). Two grams of dried leaves were mixed with acidified methanol (50 ml, 1% HCl)
185 by stirring at 60°C for 60 min. The resulting extract was filtered by using filter paper
186 (Whatman no. 3) and then kept in the dark in the refrigerator until further analyses.
187 Absorbance was measured in triplicate at 530 nm and 657 nm. Anthocyanin content was
188 expressed as cyanidin 3-glucoside equivalent (CGE) (mg of CGE/100 g on a dry weight
189 basis) and calculated using the following equation:

190 $$Anthocyanins\ (mg/g) = \left(\frac{AS530-(0.25*AS657)}{29.60}\right) \text{ x Mw x Df x } \left(\frac{V}{Sw}\right) \quad (1)$$

191 where AS_{530} and AS_{657} are the absorbance at 530 nm and 657 nm, respectively, Mw is the
192 molecular weight of cyanidin 3-glucoside (449.1 g/mol), 29.60 is the extinction
193 coefficient, Df is the dilution factor, V is the total volume (ml), and Sw is the sample
194 weight (g).

195 *2.6. Determination of antioxidant activity using the DPPH assay*

196 The antioxidant activity of purslane leaves was measured using the 2,2-diphenyl-1-
197 picrylhydrazyl (DPPH) assay described by Brand-Williams et al. (1995). Sample solutions
198 with different concentrations were prepared from the methanolic extracts of total
199 phenolics. For each concentration, an aliquot of freshly prepared DPPH solution in
200 methanol (0.5 mg/ml). The mixture was mixed thoroughly and incubated for 60 min in a
201 dark environment at room temperature. Its absorbance was then measured in triplicate at
202 517 nm with a spectrophotometer (UV-VIS SpectroScan 50, Biotech Engineering
203 Management Co., UK). The percentage of DPPH free radical scavenging was calculated
204 using Eq. (2):

205 $$\%\, Scavenging = \left(\frac{Ab-As}{Ab}\right) \text{x } 100\% \text{.....} \quad (2)$$

206 where Ab is the absorbance of the blank (DPPH solution alone) and As is the absorbance
207 of the test sample. The values of IC_{50}, which represent the extract concentration required
208 to inhibit (scavenge) 50% of the DPPH radicals, were calculated from the plot of
209 percentage scavenging against extract concentration. The values of IC_{50} are inversely
210 proportional to the sample antioxidant activity.

211 *2.7. Statistical analyses*

212 The data were analyzed by analysis of variance (ANOVA) performed with MSTAT-C
213 (version 4.0, 1985, Michigan State University, East Lansing, MI, USA) using a least
214 significant difference (LSD) of $p \leq 0.05$ for mean separation.

215

216 **3. Results and discussion**

217 *3.1. Effect of soilless substrates on purslane fresh yield*

218 Fresh and dry plant yields are important indicators required by purslane growers to assess
219 the economic value of this crop. Moreover, appropriate growth substrates are critical for
220 achieving high crop production, especially when water is a limiting factor. In this study,

221 the effect of soilless substrate on purslane yield and height was evaluated over five harvest
222 cycles. To our knowledge, it is the first study to report on the yield, height as well as
223 proximate composition, total phenolic, flavonoid and anthocyanin contents, and
224 antioxidant activity of purslane grown in different soilless media.
225 As shown in Table 1, fresh yield at all the harvest cycles varied significantly depending on
226 soilless substrate. Tuff-peatmoss (2:1) resulted in the highest fresh yields across all the
227 harvest cycles, ranging from 3889 to 6238 g/m^2 at the 1st and 4th cycles, respectively. The
228 effect of other substrates tended to vary depending on harvest cycle. The second or third
229 highest values of fresh yield after those obtained with tuff-peatmoss (2:1) were achieved
230 with tuff, peatmoss, tuff-peatmoss (1:1), peatmoss-perlite (2:1) or tuff-peatmoss-perlite
231 (2:1:1), depending on harvest cycle.
232 In contrast, zeolitic tuff resulted in the lowest fresh yields, ranging from 121.1 to 3035
233 g/m^2 at the 1st and 3rd harvest cycles, respectively. Peatmoss-perlite (2:1) and peatmoss
234 also resulted in relatively low fresh yields (265.6 and 3246 g/m^2) but only at the 1st and 3rd
235 cycles, respectively. Regardless of the soilless substrate, fresh yield initially increased with
236 harvest cycle, followed by a slight reduction after a certain number of harvest, usually
237 after the 4th or 3rd cycle depending on the substrate. This influence of harvest cycle could
238 be due to the adaptation of the plants to the substrates and their rapid vegetative growth
239 (including increasing dimensions of leafs and stems) in the initial stages, followed by dry
240 matter accumulation and moisture reduction in later stages as the plants mature. Higher
241 yields may reflect relatively large stem diameters, which would be expected to enhance the
242 mechanical strength of the stems and thus their ability to resist breaking and bending under
243 growing conditions. Purslane with greater stem diameter may thus be obtained more
244 successfully with tuff-peatmoss (2:1) and after a few harvest cycles.

These novel findings indicate the superiority of soilless substrates that contain peatmoss for supporting the rapid growth of purslane in a closed system. This is consistent with the high purslane yield obtained in a peat-based floating system as compared with coir and perlite (Cros et al., 2007). In our work, tuff-peatmoss (2:1) was particularly effective at all the harvest cycles. This suggests that the nutrient content, availability and specific physicochemical characteristics of peatmoss-containing substrates best meet the physiological needs of purslane for rapid growth and development under the closed growing conditions used. This is probably related to the high water holding capacity (WHC), high cation exchange capacity (CEC) and high organic matter content of tuff-peatmoss substrates (Manoloc et al., 2005). Their high CEC helps retain the minerals (which reduces nutrient leaching) and enables a gradual release of nutrients over time, while high WHC improves water retention and management. Tuff and peatmoss in combination also improve the structure of the growth substrate, which contributes to proper aeration and drainage. This creates suitable conditions for root growth that may support effective growth of purslane. Higher content and availability of nutrients in tuff-peatmoss substrate could explain the enhanced yields as well as height of purslane.

High quality peatmoss imparts beneficial physical properties to horticultural growth media in addition to a high CEC (Treadwell et al., 2007). Peat is also considered an important sink for atmospheric carbon dioxide, although the time needed to regenerate a peat bog after harvest tends to be quite long (several decades), which can limit the availability of peat from some locations (Raviv et al., 1998; Treadwell et al., 2007). Caution is required when using peat for some plants as it may contribute to the propagation of Pythium damping-off, a plant disease caused by *Pythium ultimum* (Hoitink and Boehm, 1999). Thus, the sterilization of peat-based media has been recommended to eliminate pathogens before basil seeding (Reuveni et al., 2002; Treadwell et al., 2007).

Combining peatmoss with perlite (2:1) or tuff, peatmoss and perlite (2:1:1) resulted in moderate yields of purslane in our work. In crisp-head lettuce, Gül et al. (2005) found that plant growth was significantly lower with perlite compared with zeolite. The higher growth obtained with zeolite was attributed to an increase in the uptake of nutrients since zeolites have a high CEC, which enables them to act as a reservoirs, holding elements in their structure for slow release to the rhizosphere (Gül et al., 2005). In contrast, Maloupa and Gerasopoulos (1999) reported that the use of perlite for gerbera cultivation led to a higher yield than zeolite. The relatively low yields of purslane obtained with zeolitic tuff in our work suggest that this substrate lacked important characteristics required to support the rapid growth of purslane. Zeolites have a high CEC and a high content of macro and micro-minerals, but their organic content is very low (Gül et al., 2005). These characteristics may have limited the provision of essential nutrients by zeolitic tuff or their uptake by purslane, which resulted in lower plant yields compared with the other soilless substrates. Cros et al. (2007) and Biernbaum (2007) noted that the highest yields were obtained in plants grown for short time in either peat or vermiculite-based closed cultivation system as compared with coir or perlite.

3.2. Effect of soilless substrates on purslane dry yield

The impact of soilless growth medium on purslane dry yield was significant at all the harvest cycles (Table 2) and was similar to the effect on fresh yield. Consistent with the latter, tuff-peatmoss (2:1) resulted in the highest dry yields across all harvest cycles, ranging from 365.1 to 558.6 g/m^2 at the 1st and 4th cycles, respectively. The effect of other soilless substrates tended to vary depending on the harvest cycle. The second or third highest values of dry yield after those obtained with tuff-peatmoss (2:1) were achieved with tuff, peatmoss, tuff-peatmoss (1:1), peatmoss-perlite (2:1) or tuff-peatmoss-perlite (2:1:1), depending on harvest cycle. These results indicate the superiority of soilless

295 substrates that contain peatmoss for supporting the rapid growth of purslane in a closed
296 system.
297 In contrast, zeolitic tuff resulted in the lowest dry yields, ranging from 8.0 to 266.4 g/m^2 at
298 the 1st and 4th harvest cycles, respectively. Peatmoss-perlite (2:1) resulted in similarly low
299 values at the 1st and 2nd cycles. However, the yields obtained with both substrates
300 increased substantially after a few cycles. At the 3rd, 4th 5th harvest cycles with zeolitic
301 tuff, they were about 2-fold lower than the highest dry yields obtained with tuff-peatmoss
302 (2:1), while they were about 40-fold and 4-fold lower at the 1st and 2nd cycle, respectively.
303 This suggests a relatively rapid adaptation of purslane to zeolitic tuff. Regardless of
304 substrate, dry yield continuously increased across all harvest cycles, but seemed to level
305 off after the 4th cycle, which is consistent with plant adaptation and rapid vegetative
306 growth in the early stages, followed by maturation in later stages.
307 *3.3. Effect of soilless substrates on purslane height*
308 The effect of soilless growth medium on purslane height was significant at all the harvest
309 cycles (Table 3) and was consistent with the effect on fresh and dry yields. Tuff-peatmoss
310 (2:1) resulted in the highest plant heights across all the harvest cycles, ranging from 45.87
311 to 67.40 cm at the 1st and 4th cycles, respectively. Tuff-peatmoss (1:1) and peatmoss also
312 produced a high height at the first harvest cycle, which did not differ significantly from the
313 value obtained with tuff-peatmoss (2:1). After the first cycle, the second or third values of
314 plant height after those obtained with tuff-peatmoss (2:1) were achieved with tuff,
315 peatmoss, tuff-peatmoss (1:1), peatmoss-perlite (2:1) or tuff-peatmoss-perlite (2:1:1),
316 depending on the harvest cycle. The lowest plant heights across all the cycles were
317 obtained with zeolitic tuff (18.23 to 46.60 cm) and peatmoss-perlite (2:1) (22.80 to 53.80
318 cm). Regardless of the substrate, plant height initially increased with harvest cycle,

319 followed by a slight decline after the 4th cycle, in agreement with the results obtained in
320 terms of fresh yield.
321 These findings show the superiority of soilless substrates that contain peatmoss for
322 supporting rapid purslane growth in a closed system. Similarly, Cros et al. (2007) reported
323 higher plant height in purslane grown in a peat-based floating system as compared with
324 coir and perlite. In barley, a significant increase in straw yield and plant height has been
325 reported upon the enrichment of loamy sand soil with a peatmoss-shrimp waste compost
326 (Hountin et al., 1995). These researchers evidenced a significant relationship between soil
327 organic carbon and straw yield and plant height, while grain yield was correlated with soil
328 total nitrogen.
329 *3.4. Proximate composition of purslane leaves from soilless- and soil-grown plants*
330 The proximate chemical composition of purslane leaves from soilless-grown and soil-
331 grown plants is shown in Table 4. The effect of soilless substrate was significant on all the
332 compositional characteristics considered. Moisture content was the highest (92.5%-93.5%)
333 in purslane leaves grown in peatmoss-perlite (2:1), tuff-peatmoss-perlite (2:1:1), zeolitic
334 tuff, and tuff-peatmoss (1:1). The highest protein contents (29.9%-31.4% of dry weight)
335 were obtained with tuff, peatmoss, peatmoss-perlite (2:1), tuff-peatmoss-perlite (2:1:1),
336 zeolitic tuff, and tuff-peatmoss (1:1), while the highest lipid contents (0.68%-0.75%) were
337 obtained with tuff-peatmoss-perlite (2:1:1) and zeolitic tuff. Fiber content (about 12%)
338 was relatively constant across soilless substrates. Among the soilless media, ash content
339 was the highest (29.0%) with tuff-peatmoss-perlite (2:1:1), which was comparable to the
340 level found in commercial (market) and wild purslane, but lower than the level (35.2%)
341 found in purslane grown in soil at the research facilities.
342 Overall, the leaves of purslane grown in tuff-peatmoss-perlite (2:1:1) and zeolitic tuff
343 stood out as displaying among the highest levels of proteins and lipids. These

compositional characteristics are highly valuable from the nutritional standpoint, but they have not been reported before in soilless grown purslane. Purslane lipids are mainly unsaturated and rich in ω-3 fatty acids (Petropoulos et al., 2015). The fact that the highest yields of purslane were recorded with another soilless substrate (tuff-peatmoss 2:1) is not entirely surprising. In other food crops, it has been reported that the nutritional quality of the crop tends to decline as crop yields increase (Benbrook, 2009; Halweil, 2007). Too much readily available nitrogen (N) in the soil or other growing media generally reduce nutrient density as well as flavor of the food (Halweil, 2007). In our study, it is plausible that tuff-peatmoss-perlite (2:1:1) and zeolitic tuff supplied less N to the plant compared with tuff-peatmoss (2:1), which may explain the greater content of some nutrients in purslane leaves grown in the former substrates.

Significant differences in proximate composition were also found between soilless-grown and soil-grown purslane. Protein and lipid contents were significantly greater in purslane leaves grown in tuff-peatmoss-perlite (2:1:1) and zeolitic tuff compared with soil-grown purslane (market, wild and soil). Moisture content was also higher in general in soilless-grown leaves compared with soil-grown leaves. For fiber and ash, in contrast, one type of soil-grown purslane (soil) yielded the greatest levels (16.0% and 35.2%, respectively). For soil-grown purslane, our findings are in agreement with those presented by Ezekwe et al. (1999) for proteins (22.8 to 25.4%), total carbohydrates (49.0 to 56.1%), ash (15.9 to 21.5%) and moisture (79.4 to 90.6%) in the leaves of different purslane accessions. However, the total lipid contents in their study (3.8 to 6.5%) were higher than in our work. For total lipids, our findings are consistent with those reported by Uddin et al. (2012) (0.51%) in the leaves of soil-grown purslane.

The differences in proximate composition evidenced in the present study may be explained by differences in the balance and bioavailability of nutrients in the substrates that were

tested. The influence of growth substrate on the chemical composition of vegetables and fruits has been reported in some crops, although not in purslane. In tomatoes, several studies reported higher contents of dry matter, sugar, vitamins, and carotenoids in soilless systems compared with soil (Gruda, 2009). A few studies, however, found that these contents were higher in soil-grown tomatoes than in soilless-grown fruits (Gruda, 2009). In a review of the effects of organic and inorganic culture media on vegetable quality and productivity under greenhouse conditions, Olle et al. (2012) concluded that it is difficult to draw general conclusions on the impact of growth media on vegetable composition as results vary with crop, physicochemical composition of the substrate, and nutrient bioavailability to the plant.

3.5. Phenolic contents and antioxidant activity of purslane leaves from soilless- and soil-grown plants

The total phenolic, flavonoid and anthocyanin contents of methanolic extracts from purslane leaves varied significantly depending on growth substrate, as illustrated in Table 5 for plants cultivated under soilless and soil conditions. Variations amongst soilless substrates are discussed first. In soilless-grown purslane, the highest concentrations of total phenolics were obtained with zeolitic tuff, tuff-peatmoss-perlite (2:1:1), and tuff-peatmoss (2:1) (684.9, 646.9, and 633.4 mg/100 g, respectively). These values did not differ significantly. In contrast, tuff-peatmoss (1:1), tuff, and peatmoss resulted in the lowest levels of total phenolics (456.8, 481.4, and 501.5 mg/100 g, respectively), which did not differ significantly. Flavonoid content was the highest with tuff-peatmoss-perlite (2:1:1) (597.8 mg/100 g), followed by zeolitic tuff (563.8 mg/100 g). Both values differed significantly. Tuff-peamoss (1:1) and tuff in resulted in the lowest flavonoid contents (429.1 and 448.6 mg/100 g, respectively), which did not differ significantly. Anthocyanin content was the highest with peatmoss (311.7 mg/100 g), which was significantly greater

than the second highest values obtained with tuff and zeolitic tuff (294.7 and 289.5 mg/100 g, respectively). Tuff-peatmoss (2:1) yielded the lowest concentration of anthocyanins (196.7 mg/100 g).

These findings show that the leaves of purslane grown in zeolitic tuff, tuff-peatmoss-perlite (2:1:1), or tuff-peatmoss (2:1) are particularly rich in total phenolics. Tuff-peatmoss-perlite (2:1:1) and zeolitic tuff also resulted in high levels of flavonoids, while peatmoss resulted in high anthocyanin content. Amongst the soilless substrates tested in this study, tuff-peatmoss-perlite and zeolitic tuff appear especially promising as they also resulted in the highest levels of proteins, lipids and total solids in the leaves, in addition to high total phenolic and flavonoid contents and intermediate contents of anthocyanins. Tuff-peatmoss (2:1), which resulted in the highest plant yields, resulted in high contents of total phenolics and intermediate contents of flavonoids.

When all the soilless-grown and soil-grown treatments were compared, the leaves from wild purslane showed significantly higher contents of total phenolics, flavonoids, and anthocyanins (1019, 644.9, and 412.9 mg/100 g, respectively) (Table 5). For total phenolics, the second highest levels were found in plants grown in zeolitic tuff, tuff-peatmoss-perlite (2:1:1), tuff-peatmoss (2:1) as well as in purslane from the market and from soil cultivation at our facilities, with no significant difference amongst these values. For flavonoids, the highest contents were found in wild purslane and in market samples. Both were significantly higher than the contents obtained with tuff-peatmoss-perlite (2:1:1) and zeolitic tuff. For anthocyanins, the highest levels after wild purslane were found in purslane cultivated in soil at the research facilities, followed by purslane grown in peatmoss, with significant differences between these values. Commercial (market) purslane displayed the lowest anthocyanin content compared with the other treatments.

These findings show that purslane grown in tuff-peatmoss-perlite and zeolitic tuff

compared favorably with soil-grown purslane in terms of their richness in total phenolics and flavonoids. For anthocyanin content, peatmoss-grown plants compared favorably with wild purslane and with purslane cultivated in soil at the research facilities. Anthocyanin content obtained with peatmoss, zeolitic tuff and tuff-peatmoss-perlite (2:1:1) was superior to those of market purslane. Overall, tuff-peatmoss-perlite and zeolitic tuff stand out as soilless substrates of choice as they resulted in high phenolic and nutrient concentrations. Based on these novel findings, the leaves of soilless purslane grown in tuff-peatmoss-perlite (2:1:1) or zeolitic tuff could be recommended as rich sources of phenolics and flavonoids for use in various industries including the food industry.

Consistent with the high total phenolic contents of the leaves, the phenolic extracts from purslane leaves grown in tuff-peatmoss-perlite (2:1:1) and zeolitic tuff showed the highest antioxidant activity (lowest IC_{50} values of 0.596 and 0.584 mg/ml, respectively, which did not differ significantly) compared with other soilless substrates, followed by tuff-peatmoss (2:1), as illustrated in Figure 1. The high antioxidant activity found with tuff-peatmoss-perlite and zeolitic tuff did not differ significantly from the high antioxidant activity detected in extracts from wild purslane and market purslane (Figure 1). Their antioxidant activity, however, was significantly lower for the extracts from purslane grown in soil at the research facilities. The lowest antioxidant activities (highest IC_{50}) were found with peatmoss (1.247 mg/ml), followed by tuff and tuff-peatmoss (1:1) (1.097 and 1.029 mg/ml, respectively).

Thus, purslane leaves from cultivation in tuff-peatmoss-perlite (2:1:1) and zeolitic tuff possessed a high antioxidant activity, similar to that of wild and commercial purslane, in addition to high contents of total phenolics and flavonoids. The antioxidant activity obtained with tuff-peatmoss (2:1) was relatively high despite being lower than with tuff-peatmoss-perlite and zeolitic tuff. This is noteworthy because tuff-peatmoss (2:1) is the

444 soilless substrate that resulted in the highest plant yields and height. These findings
445 suggest that the leaves of soilless purslane grown in the above substrates could be used as
446 a source of natural preservatives with antioxidant properties. Further research could be
447 conducted to confirm the antioxidant activity of extracts from soilless purslane using
448 complementary methods in addition to the DPPH assay which was used in the present
449 study.
450 There are no published reports of purslane phenolic composition and antioxidant activity
451 when this plant is cultivated in soilless substrates. For wild purslane leaves, the relatively
452 high antioxidant activity in our work (IC_{50} of 0.56 mg/ml) is consistent with the IC_{50} value
453 of 0.511 mg/ml reported by Erkan (2012) in methanolic extracts. Uddin et al. (2012)
454 reported the phenolic content of soil-grown purslane at different stages of growth. In
455 ethanolic extracts, these researchers found that the total phenolic contents of the leaves
456 ranged from 174.5 to 348.5 mg/100 of fresh weight at 15 and 60 days, respectively. They
457 reported slightly lower total phenolic and flavonoid contents in ethanol extracts (276.8 and
458 41.3 mg/100 g, respectively) than in methanol extracts (360.3 and 49.2 mg/100 g) at day
459 30. These values seem lower than the levels found in the present work, especially for
460 flavonoids. However, it should be kept in mind that their values were expressed on a fresh
461 weight basis, while ours are based on dry weight, which could explain some of the
462 discrepancy. Uddin et al. (2012) reported lower antioxidant activity of the leaf extracts,
463 i.e., greater IC_{50} values (1.71 to 1.30 mg/ml at day 15 and 60, respectively) than in our
464 work (0.2 to 1.2 mg/ml).
465 Values of IC_{50} of 0.456 and 0.391 mg/ml were reported by Montoya-García et al. (2018) at
466 two different harvest times of soil-grown purslane. These values increased to 0.508 mg/ml
467 upon the application of 300 kg of N/ha to the fertilizer. The values of IC_{50} in their work
468 are comparable to the values found in the present study with soil-grown purslane and with

purslane grown in zeolitic tuff and tuff-peatmoss-perlite. Montoya-García et al. (2018) further showed that the decrease in antioxidant activity resulting from nitrogen application was accompanied by a decrease in total flavonoid content and a slight increase in total phenolics. Cultivation methods such as organic, conventional, soil and soilless methods in open or closed systems have been showed to influence the phenolic contents of other crops (Benbrook, 2009; Hernanz et al., 2007), although no clear trends have been established because of conflicting results. In strawberry fruits, for instance, Asami et al. (2003) reported higher levels of total phenolics from organic and sustainable cultivation compared with conventional practices, while Hakkinen and Torronen (2000) found no consistent effect of organic cultivation on the total phenolic content compared with conventional cultivation. Wild strawberries have been found to exhibit greater levels of phenolic compounds compared with cultivated fruits (Muthukumaran et al., 2017; Yildiz et al., 2014), as found in the present work with purslane leaves.

4. Conclusions

The findings from this study indicate that purslane soilless cultivation in select culture media has promising potential for producing high quality purslane with value-added characteristics, specifically high protein, oil, total phenolics, flavonoids, and antioxidant activity, which are highly valuable and sought after for applications in the food, nutraceutical, and pharmaceutical industries, among others. Tuff-peatmoss-perlite (2:1:1) and zeolitic tuff showed particularly high potential with respect to the high contents of proteins, lipids, total phenolics and flavonoids in the leaves. For some applications, tuff-peatmoss-perlite may be preferred over zeolitic tuff as the latter produced relatively low purslane yields. The highest herbal yields were obtained with tuff-peatmoss (2:1). Other soilless substrates could also prove useful depending on the responses or characteristics

494 desired in purslane. This warrants further investigation with consideration of the various
495 nutrients and biologically active phytochemicals present in this plant.
496
497 **Acknowledgments**
498 The authors gratefully acknowledge the financial support of the Jordan University of
499 Science and Technology for this research.
500
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Table 1

Effect of different soilless substrates on the fresh yield of purslane over five harvest cycles during the growing season under closed conditions.

	Fresh yield (g/m^2)					
Soilless substrates	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest	Total
Tuff	841.1^{d}	2773^{cd}	4026^{c}	4306^{c}	4253^{b}	16199^{c}
Peatmoss	2291^{b}	2718^{d}	3246^{e}	3473^{d}	3308^{d}	15036^{d}
Peatmoss:Perlite (2:1)	265.6^{ef}	2217^{e}	4078^{c}	4241^{c}	3708^{c}	14509^{d}
Tuff:Peatmoss (2:1)	3889^{a}	4890^{a}	5868^{a}	6238^{a}	6038^{a}	26923^{a}
Tuff:Peatmoss:Perlite (2:1:1)	410.0^{e}	3390^{b}	3651^{d}	3704^{d}	3446^{d}	14601^{d}
Zeolitic tuff	121.1^{f}	1278^{f}	3035^{e}	2758^{e}	2547^{e}	9739^{e}
Tuff:Peatmoss (1:1)	1265^{c}	2948^{c}	4487^{b}	4712^{b}	4332^{b}	17744^{b}

Mean (n=3) separation within columns was by least square difference (LSD) at the 5% level. Means in the same column followed by different letters are significantly different ($p \leq 0.05$).

Table 2

Effect of different soilless substrates on the dry yield of purslane over five harvest cycles during the growing season under closed conditions.

	Dry yield (g/m^2)					
Soilless substrates	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest	Total
Tuff	62.03[d]	199.9[d]	316.1[b]	412.3[b]	408.3[b]	1398[b]
Peatmoss	178.9[b]	194.1[d]	272.4[c]	341.4[c]	325.9[e]	1312[c]
Peatmoss:Perlite (2:1)	18.77[ef]	157.2[e]	333.0[b]	398.7[b]	385.4[c]	1293[c]
Tuff:Peatmoss (2:1)	365.1[a]	404.9[a]	439.8[a]	558.6[a]	553.2[a]	2315[a]
Tuff:Peatmoss:Perlite (2:1:1)	30.8[e]	281.9[b]	308.7[b]	344.4[c]	339.3[c]	1305[c]
Zeolitic tuff	8.00[f]	97.47[f]	232.2[d]	266.4[d]	245.2[f]	849.2[d]
Tuff:Peatmoss (1:1)	94.83[c]	221.5[c]	338.9[b]	394.0[b]	366.4[d]	1415[b]

Mean (n=3) separation within columns was by least square difference (LSD) at the 5% level. Means in the same column followed by different letters are significantly different ($p \leq 0.05$).

Table 3

Effect of different soilless substrates on the height of purslane over five harvest cycles during the growing season under closed conditions.

	Plant height (cm)				
Soilless substrates	1st harvest	2nd harvest	3rd harvest	4th harvest	5th harvest
Tuff	28.27^{bc}	44.07^{c}	48.67^{d}	54.93^{c}	51.00^{b}
Peatmoss	40.80^{a}	44.27^{c}	47.93^{df}	53.67^{c}	49.33^{b}
Peatmoss:Perlite (2:1)	22.80^{cd}	35.40^{d}	45.13^{f}	53.80^{c}	47.80^{bc}
Tuff:Peatmoss (2:1)	45.87^{a}	53.87^{a}	59.47^{a}	67.40^{a}	59.53^{a}
Tuff:Peatmoss:Perlite (2:1:1)	32.00^{b}	49.87^{b}	50.67^{c}	58.60^{b}	48.00^{bc}
Zeolitic tuff	18.23^{d}	35.33^{d}	46.60^{ef}	44.60^{d}	44.27^{c}
Tuff:Peatmoss (1:1)	42.67^{a}	43.00^{c}	53.00^{b}	57.47^{b}	51.67^{b}
LSD	6.026	2.078	1.715	1.405	4.063

Mean (n=3) separation within columns was by least square difference (LSD) at the 5% level. Means in the same column followed by different letters are significantly different ($p \leq 0.05$).

Table 4.

Proximate chemical composition of the leaves of purslane grown in different soilless substrates and in soil.

Treatments	Proteins (%)	Lipids (%)	Crude fiber (%)	Moisture (%)	Ash (%)
Soilless-grown, closed conditions					
Tuff	30.3^{abc}	0.165^{b}	11.9^{bc}	92.0^{b}	24.0^{cd}
Peatmoss	29.9^{abc}	0.046^{b}	11.9^{bc}	92.0^{b}	23.0^{cd}
Peatmoss:Perlite (2:1)	30.4^{ab}	0.046^{b}	11.6^{bc}	93.5^{a}	26.0^{bc}
Tuff:Peatmoss (2:1)	28.0^{bc}	0.083^{b}	11.9^{bc}	90.5^{c}	22.0^{d}
Tuff:Peatmoss:Perlite (2:1:1)	31.4^{a}	0.681^{a}	11.9^{bc}	92.5^{ab}	29.0^{b}
Zeolitic tuff	30.3^{abc}	0.755^{a}	11.0^{cd}	93.5^{a}	24.0^{cd}
Tuff:Peatmoss (1:1)	30.5^{ab}	0.088^{b}	13.3^{b}	92.5^{ab}	22.0^{d}
Soil-grown, open conditions					
Market	21.8^{d}	0.156^{b}	9.31^{d}	85.0^{d}	29.5^{b}
Wild	27.8^{c}	0.141^{b}	10.0^{cd}	81.5^{e}	28.9^{b}
Soil, at the research facilities	19.3^{d}	0.193^{b}	16.0^{a}	91.5^{bc}	35.2^{a}
LSD	2.516	0.372	2.014	1.317	3.6

Results are expressed on a dry weight basis.

Mean (n=3) separation within columns was by least square difference (LSD) at the 5% level. Means in the same column followed by different letters are significantly different ($p \leq 0.05$).

Table 5.

Contents of total phenolics, flavonoids and anthocyanins of the leaves of purslane grown in different soilless substrates and in soil.

Treatments	Total phenolics (mg GAE/100g)	Flavonoids (mg CE/100g)	Anthocyanins (mg CGE/100g)
Soilless-grown, closed conditions			
Tuff	481.4^{d}	448.6^{e}	294.7^{d}
Peatmoss	501.5^{d}	481.0^{d}	311.7^{c}
Peatmoss:Perlite (2:1)	611.1^{c}	508.6^{d}	288.1^{e}
Tuff:Peatmoss (2:1)	633.4^{bc}	500.5^{d}	196.7^{g}
Tuff:Peatmoss:Perlite (2:1:1)	646.9^{bc}	597.8^{b}	238.3^{f}
Zeolitic tuff	684.9^{b}	563.8^{c}	289.5^{de}
Tuff:Peatmoss (1:1)	456.8^{d}	429.1^{e}	238.2^{f}
Soil-grown, open conditions			
Market	646.9^{bc}	631.9^{a}	139.0^{h}
Wild	1019^{a}	644.9^{a}	412.9^{a}
Soil, at the research facilities	636.5^{bc}	395.1^{f}	345.7^{b}
LSD	73.60	28.46	6.397

Results are expressed on a dry weight basis.
Mean (n=3) separation within columns was by least square difference (LSD) at the 5% level. Means in the same column followed by different letters are significantly different ($p \leq 0.05$).
GAE: gallic acid equivalents, CE: catechin equivalents, CGE: cyanidin-3-glucoside equivalents.

Figure

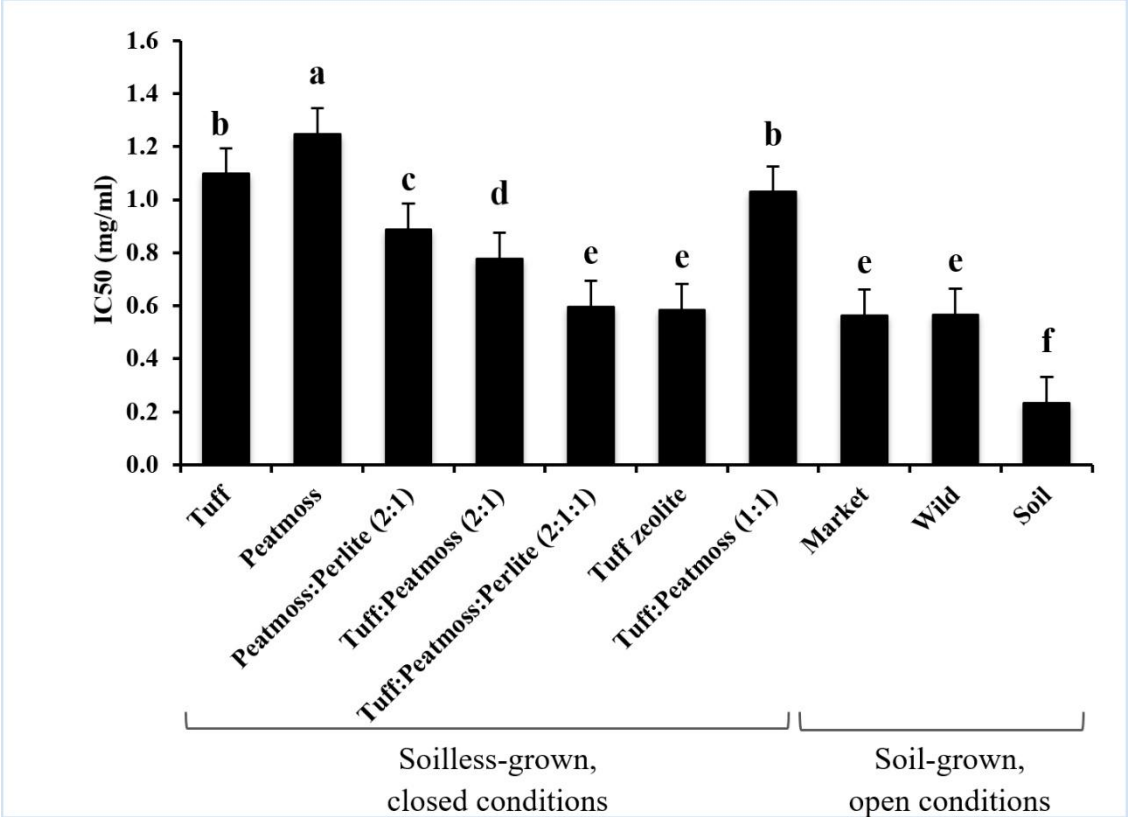

Fig. 1. Antioxidant activity expressed as IC_{50} of extracted phenolics from the leaves of purslane grown in different soilless substrates and in soil. Different letters indicate significant differences in treatment means from three determinations ($p \leq 0.05$).