Net Journal of Agricultural Science
Vol. 7(3), pp. 95-98, August 2019
ISSN: 2315-9766
Full Length Research Paper

Productivity of leafy green vegetable kale in soilless cultivation conditions

M. Kh. Daryadar*, S. Kh. Mairapetyan, A. H. Tovmasyan, J. S. Aleksanyan, A. H. Tadevosyan, L. M. Kalachyan, B. T. Stepanyan, H. M. Galstyan and A. Z. Asatryan

G.S. Davtyan Institute of Hydroponics Problems, NAS RA.

Accepted 12 July, 2019

ABSTRACT

Valuable leafy green vegetable kale (*Brassica oleracea* var. Sabellica L.), also known as a curly cabbage, was first was introduced in Armenia, and its high productivity and productivity were studied and established in water stream hydroponics experimental modules (gully, cylindrical and continuous), classical hydroponics, as well as in soil culture. In kale revived from hydroponical different systems the raw material and the output of pharmaceutical indices (vitamin C, extractive substances, flavonoids and tannins) are higher 1.5 to 1.8 times and 1.2 to 2.3 times, respectively, compared with soil culture. Water stream hydroponics is a safer radio-ecological and biotechnological method for the production of raw material than classical hydroponics and soil culture.

Keywords: Water stream hydroponics, kale, ^{90}Sr, ^{137}Cs, bio-pharmacochemical analyses.

*Corresponding author. E-mail: m.daryadar@ymail.com.

INTRODUCTION

Vegetables take a big place in human's food being an inseparable part of meals. They have important roles in the regulation of the human's nervous system, digestive, and other organs activity, as well they increase the organism's resistance. Especially such said Salads vegetables that are used in raw condition without cooking have great value. During recent years non-traditional cultivated plants that already have a large demand in the consumer market have conquered their specific place in the range of vegetable cultivated plants. The range of such cultivated plants includes the Brussels sprout, pak choi, broccoli, kale and etc. from the cabbage family, which are considered as delicacy cultivated plants, differing from the other kinds of cabbage with their nutritional properties (Pudalov et al., nd; https://nevegetable.org/crops/cabbage-broccoli-cauliflower-and-other-brassica-crops; https://www.hutton.ac.uk/webfm_send/742).

Kale is a biennial vegetable that belongs to the Brassicaceae family. It has green or violet curly leaves that do not form cabbage head. Kale is nearer to the wild cabbage with its properties and chemical content. In food, there are used mainly leaves. The plant blooms and gives seed in the next year (Pudalov et al., nd; http://aggie-horticulture.tamu.edu/archives/parsons/publications/vegetabletravelers/kale.html).

Kale contains a huge amount of proteins equal to meat products (4.3%), all 9 essential amino acids (Val, His, Leu, Lys, Trp and etc.) and 11 non-essential amino acids. In fresh kale leaves the amino acids glutamic acid, proline, and aspartic acid are dominant in total amino acid content (12, 12 and 10%, respectively). The amount of Leu, Lys, Val, Arg, and Ala is between 6 and 8% of total amino acid content and the amount of Tyr, Phe, Thr, His, Ser, and Gly is between 3 to 5% of it. The sulfur-containing amino acids cysteine (1.6%) and Met (2%) have the lowest proportion (Lisiewska et al., 2008). It is rich also with fatty acid omega 3 (Abbey et al., 2018), vitamins (A, C, K, PP, B and etc.), easily digestible Ca (120 to 150 mg), Mg (34 to 47 mg) and other mineral substances (K, P, Na, Fe, Zn, Se, Mn, Cu and etc.). Due to the content of lutein that existed in the plant, it protects the human eye from the sun's ultraviolet rays. Frequent

use of this plant in the diet protects the human organism from a number of diseases, particularly from cardiovascular, gastrointestinal, eye (glaucoma) diseases, diabetes, malignant tumors and etc. (Giacoppo et al., 2013). Kale contains 45 different kinds of flavonoids (sulforaphane, indole-3-carbinol and etc.) that provide the antioxidant and anti-inflammatory properties of this plant, too (Kuntz and Kunz, 2014; Olsen et al., 2009; Sikora and Bodziarczyk, 2012). They increase the organism's immunity; decrease the cholesterol level in blood. Regulating glucose level it promotes the decrease of weight. The high amount of calcium contained in the plant (2 times more than in milk) influences on the bone cells generation and regeneration, by that preventing rickets, osteoporosis, teeth fragility. At present kale is widely spread in the USA, Western Europe, Japan and in several other countries (Kim et al., 2008).

Taking into account the above mentioned, valuable prospective leafy green vegetable kale was firstly introduced into Armenia by our research group by us and it was purposed to study the growing possibility and productivity of this cultivated plant in soilless culture conditions (hydroponics), as well as to detect optimal conditions to receive quality, ecologically more safe plant raw material in the Institute of Hydroponics Problems (IHP).

MATERIALS AND METHODS

Experiments were done in experimental modules of water stream hydroponics (cylindrical, gully, continuous) of IHP[1], as well as in conditions of classical hydroponics (CH) and soil culture.

As a substrate is used volcanic red slag with the 3 to 15 mm diameter and in conditions of soil culture with 8 plant/m^2 density. Plants' nutrition was done with the Davtyan 0.75 N nutrition solution (Davtyan, 1969). In water stream hydroponics the nutrition solution was pumped periodically, irreversibly like a jet during a day about 6 to 20 times (dependent on climate conditions) with a 10 to 15 second duration to the root-bearing stratum of each plant. The amount of one-time giving solution was 20 to 50 ml. Plants were nourished 1 to 3 times during a day in CH and once during 3 to 4 days in soil culture, maintaining all adopted agrotechnical rules (soil aeration, weeds removal, periodic watering, fertilization and etc.) (Mairapetyan, 1989). Leaves harvest was done during July to October.

During vegetation biometric measurements, also bio-pharmacochemical analyses were done. In plant raw material the content of extractive substances, tannins and humidity were determined according to SPh XI (State Pharmacopaea of USSR, 1990), flavonoids were identified according to Borisov et al. (1975), vitamin C was estimated according to Yermakov et al. (1952). Technogenic RN (radionuclides) in samples were determined through radiochemical methods with a small UMF-1500 background radiometer (Pavlotskaya, 1966). The concentration limit values (ACL) have been given according to state standards of Russian Federation (Ministry of Health of RF, 2002; RA Government, 2006) that have been officially accepted also in the Republic of Armenia. Received results were statistically analyzed according to Dospechov (1985).

[1] In the IHP NAS RA it was developed and licensed new, modern system «water stream hydroponics» for the soilless production of different plant species using polymeric film that joins the rank of already existed in the world known hydroponic systems with its low cost, more automated system and beforehand instructed program (Lisiewska et al., 2008).

RESULTS AND DISCUSSION

From the analysis of the data presented in Table 1, it was revealed that during vegetation in all variants, except continuous hydroponics, the maximal output of fresh plant raw material was ensured in July during the first harvest. Besides, kale raw material received using different hydroponic systems 1.5 to 1.8 times exceeded soil culture, at the same time gully and classical hydroponic systems 1.1 to 1.3 times surpassed the experimented other hydroponic variants on with the yield, plant height and stem thickness (Figure 1).

It is necessary to emphasize that growth conditions had had a significant influence on the pharmacochemical indices of plant raw material (Table 2). The increase of extractive substances content (1.2 to 1.5 times) was stated in all water stream hydroponic modules and relatively high content of flavonoids was established in the gully system (by 10 to 35%). In hydroponics, the content of tannins fluctuated between 2.0 to 2.2% that conceded insignificantly with the same index of soil (2.4%). It was revealed also the influence of cultivation conditions on the biosynthesis of vitamin C: cylindric and continuous hydroponic systems exceeded 1.3 to 1.5 times the conditions of the gully, classical hydroponics, and soil by the content of vitamin C (Table 2). Due to the high crop capacity of hydroponic plants the difference between plants of hydroponic systems and soil is significant from the point of mentioned indices: in the case of extractive substances the difference is 1.7 to 2.3 times, for flavonoids it is 1.2 to 2.0 times, in the case of tannins it is 1.2 to 1.6 times and for vitamin C it is 1.8 to 2.2 times.

Plant cultivation conditions influenced specifically on the RN accumulation in plant raw material (Table 3). Thus, plants in water stream hydroponics conceded by the content of ^{90}Sr and ^{137}Cs plants grown as in classical hydroponics (1.2 to 1.3 and 1.1 to 1.2 times), as in soil (1.8 to 2.0 and 1.4 to 1.5 times) conditions.

In different hydroponic systems the content of ^{90}Sr in kale's plant raw material exceeded the content of ^{137}Cs in all 1.1 to 1.2 times and in soil culture it exceeded 1.5 times.

Probably, RN has entered into kale as through the roots from the nutrient solution or irrigation water and soil, as through overground organs by the out of root way from the air basin (atmospheric precipitations, hydro and aerosols, dust).

The calculation showed that the values of observed ratios (OR) of ^{90}Sr-^{137}Cs pair for kale in systems of nutrient solution – plant and soil-plant were 0.07 to 0.08 in hydroponics and 2.1 in soil. That is OR<1, which means that from the nutrient solution the cultivated plants

Table 1. Fresh mass of kale during vegetation in hydroponics and soil, g/plant.

Variant	July	August	September	October	∑
Cylindric	263	132	95	100	590
Gully	293	184	142	100	719
Continuous	108	198	161	114	581
CH	289	141	133	143	706
Soil (control)	224	80	65	31	400
LED_{05}[2]	-	-	-	-	28,7

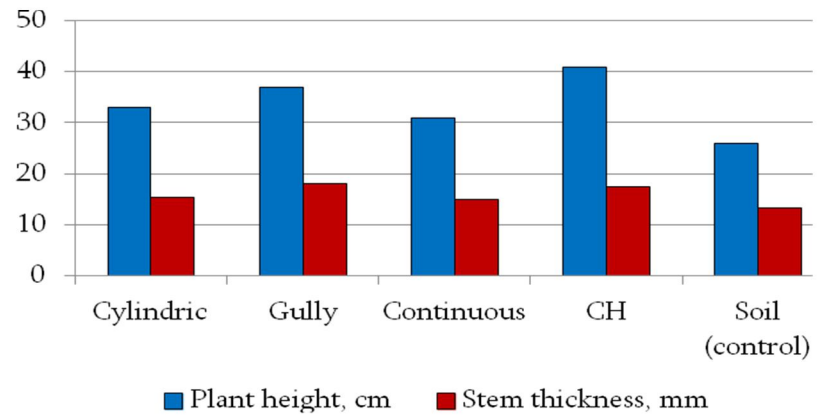

Figure 1. Biometric data of kale in hydroponics and in soil.

Table 2. The pharmacochemical indices of kale in hydroponics and in soil.

Variant	Extractive substances		Total flavonoids, according luteolin		Tannins		Vitamin C		β-carotene	
	%	output, g/plant	%	output, g/plant	%	output, g/plant	mg %	output, mg/plant	mg %	Output, mg/plant
Cylindric	34.7 ± 0.9	205	2.8 ± 0.10	16.5	2.0 ± 0.10	11.8	195 ± 2.5	1151	11.2±0.20	66.1
Gully	36.2 ± 0.9	260	3.8 ± 0.15	27.3	2.2 ± 0.10	15.8	134 ± 2.1	964	12.8±0.42	92.0
Continuous	38.0 ± 1.0	221	3.4 ± 0.15	19.8	2.2 ± 0.12	12.8	189 ± 2.1	1098	11.0±0.21	63.9
CH	26.2 ± 1.2	185	3.4 ± 0.10	24.0	2.2 ± 0.11	15.5	150 ± 2.5	1059	13.1±0.26	92.5
Soil (control)	28.1 ± 1.4	112	3.4 ± 0.11	13.6	2.4 ± 0.12	9.6	132 ± 2.0	528	13.7±0.42	54.8

[2] LED – the least essent

Table 3. The content of ^{90}Sr, ^{137}Cs in kale's plant raw material and RN relative indices in hydroponics and in soil.

Variant	^{90}Sr	^{137}Cs	OR, $^{90}Sr/^{137}Cs$	^{90}Sr	^{137}Cs
	Bq/kg			AC	
Cylindric	9.9 ± 0.32	8.7 ± 0.25	0.08	22.5	290
Gully	8.8 ± 0.25	8.3 ± 0.20	0.07	20.0	277
Continuous	9.5 ± 0.42	8.0 ± 0.15	0.08	21.6	267
CH	11.8 ± 0.20	9.8 ± 0.26	0.08	26.8	327
Soil (control)	17.6 ± 0.20	11.9 ± 0.21	2.1	2.4	1.2
ACL	50	130	-	-	-

absorbed more intensively ^{137}Cs in hydroponics and ^{90}Sr in soil (Table 3). It was confirmed through the values of RN accumulation coefficients (OC) of cultivated plants. For the kale in hydroponics ^{137}Cs AC>^{90}Sr AC 12.2 to 13.8 times, and in soil ^{90}Sr AC>^{137}Cs AC 2.0 times.

CONCLUSION

- Kale, cultivated in different hydroponic systems exceeded with fresh plant raw material and with a number of biochemical indices (vitamin C, extractive substances, flavonoids, and tannins) and conceded with radiochemical indicators to the same indicators of soil culture.
- Modern water stream hydroponic way is a radioecologically safer biotechnological way for plant raw material production than classical hydroponics and soil culture.
- Despite the cultivation conditions the content of controlled technogenic RN (90Sr, 137Cs) in kale's plant raw material did not exceed ACL.
- Kale production with modeling of the innovative technology of modern water stream hydroponics on hectares may satisfy the demand of our Republic.

REFERENCES

Abbey L, Pham TH, Annan N, Leke-Aladekoba A, Thomas RH, **2018**. Chemical composition of kale as influenced by dry vermicast, potassium humate and volcanic minerals. Food Res Int, 107: 726-737.

Borisov MI, Belikov VV, Isakov TI, **1975**. Quantitative content of flavonoids in such plants as *Asperula* L. and *Galium* L. Vegetat Resourc, 11(3): 351-358.

Cabbage, Broccoli, Cauliflower, and Other Brassica Crops. **https://nevegetable.org/crops/cabbage-broccoli-cauliflower-and-other-brassica-crops**.

Davtyan GS, **1969**. Hydroponics as a industrial achievement of agrochemical science. XVIII scientific reading dedicated to the memory of academician D.N. Pryanishnikov. Publishing house SA of Armenian SSR, 85 p.

Dospechov BA, **1985**. Field experiment method, Moscow, Russia, (351pp.), p. 223-228. (In Russian).

Giacoppo S, Galuppo M, Iori R, De Nicola GR, Cassata G, Bramanti P, Mazzon E, **2013**. Protective role of (RS)-glucoraphanin bioactivated with myrosinase in an experimental model of multiple sclerosis. CNS Neurosci Ther, 19(8): 577-584.

Greeks and Romans Grew Kale and Collards. **http://aggie-horticulture.tamu.edu/archives/parsons/publications/vegetabletravelers/kale.html**.

Kim SY, Yoon S, Kwon SM, Park KS, Lee-Kim YC, **2008**. Kale juice improves coronary artery disease risk factors in hypercholesterolemic men. Biomed Environ Sci, 21(2): 91-97.

Kuntz S, **Kunz** C, **2014**. Extracts from *Brassica oleracea* L. convar. acephala var. sabellica inhibit TNF-α stimulated neutrophil adhesion *in vitro* under flow conditions. Food Funct, 5(6): 1082-1090.

Lisiewska Z, Kmiecik W, Korus A, **2008**. The amino acid composition of kale (*Brassica oleracea* L. var. acephala), fresh and after culinary and technological processing. Food Chem, 108(2): 642-648.

Mairapetyan SK, **1989**. Culture of essential oil plants in open-air hydroponics. // Publishing house AS of Arm. SSR, Yerevan, 313 p.

Mairapetyan SKGS, **2007**. Davtyan Institute of Hydroponics Problems of NAS RA in 60 years // Communications of IHP NAS RA, Yerevan, N 31, p. 3-16. (in Armenian).

Ministry of Health of RF, **2002**. Hygienic requests to the safety and food value of food products. Sanitary-epidemiological rules and norms (2.3.2.1078-01). Moscow., 164 p., (in Russian).

Olsen H, Aaby K, Borge GI, **2009**. Characterization and quantification of flavonoids and hydroxycinnamic acids in curly kale (*Brassica oleracea* L. Convar. acephala Var. sabellica) by HPLC-DAD-ESI-MSn. J Agric Food Chem, 57(7): 2816-2822.

Pavlotskaya F, **1966**. Methods of identification of Sr-90 and other long-lived isotopes in soil. In collection "Physical-chemical methods of soil study," Moscow, p. 12. (In Russian).

RA Government, **2006**. Supplement of technical regulations of fresh fruit vegetable – 1913-N decision on December 21. (In Armenian).

Sikora E, **Bodziarczyk** I, **2012**. Composition and antioxidant activity of kale (*Brassica oleracea* L. var. acephala) raw and cooked. Acta Sci Pol Technol Aliment, 11(3): 239-248.

State Pharmacopaea of USSR, **1990**. XI volume, edition 2, Moscow: Medicine. (In Russian)

The Brassicas-The James Hutton Institute. **https://www.hutton.ac.uk/webfm_send/742**.

Yermakov A, Arasimovich A, Smirnov-Ikonnokova M, Murri I, **1952**. Methods of plants biochemical study. Moscow, p. 89. (In Russian).

Citation: Daryadar MKh, Mairapetyan SKh, Tovmasyan AH, Aleksanyan JS, Tadevosyan AH, Kalachyan LM, Stepanyan BT, Galstyan HM, Asatryan AZ, 2019. Productivity of leafy green vegetable kale in soilless cultivation conditions. Net J Agric Sci, 7(3): 95-98.