OPEN ACCESS
AMERICAN JOURNAL OF SOCIAL ISSUES AND HUMANITIES

PRODUCTIVE POTENTIAL OF FENUGREEK (FABACEAE: *TRIGONELLA FOENUM-GRAECUM* L.) IN VENEZUELA

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Abstract
A bibliographical review about fenugreek (*Trigonella foenum-graecum* L.) botanical description, growth, and production was carried out, as well as its chemical composition, forage and medicinal quality with the goal to evaluate adaptation possibilities of this species to some ecoregions of Venezuela. Descriptions related to climate, vegetation, slope types and soils in Venezuela have been made, which are compared to fenugreek adaptation in other regions of the world. According to morphological characteristics and suitable conditions of altitude to introduce this species as a crop, it is necessary to identify seed sources more reliable and carry out quality site studies that identify appropriate areas to establish this species under crop production.

Keywords: Fenugreek, *Trigonella foenum-graecum* L., medicinal, forage, Venezuela

Abbreviations: ADF: Acid detergent fiber; **DM:** dry matter; **CP**: crude protein; **IVDMD**: *in vitro* digestibility of dry matter; **NDF**: neutral detergent fiber; **SEM:** standard error of the mean.

INTRODUCTION

Plants are worldwide recognized as a vital component of biological diversity and world sustainability. Thousands of wild plants have a great economic and cultural importance, providing food, medicine, fuel, clothing and shelter for human beings. They also play a role in maintaining environmental equilibrium of the Earth and ecosystem stability, providing with habitat for animals and wild life in the planet [1]. Genetic diversity provides with species the capability to adapt to different environments, including new pests and diseases [2], as well as to new climatic conditions and stress factors [3, 4]. Phytogenetic resources provide raw material to cultivate new crop varieties [5, 4]. These, at the same time, provide with a basis for production system more capable and resistant which faces pests and diseases, as well as drought conditions and overpasture, among others [6, 7]. Fenugreek (*Trigonella foenum-graecum* L.) is an annual leguminous plant whose seed is traditionally used for condiments, artificial flavoring and hormone production [8-15]. The crop is currently developed in India and places of West Asia, North of Africa, Mediterranean Europe, Australia, Argentina, United States of America and Canada [11]. Additionally, fenugreek presents a set of characteristics suitable for rapid adaptation to different soil and climatic conditions, growth, potential resistance to drought and local diseases, which become an interesting species from an utilization point of view as a "forage crop". The objective of this review has been to investigate botanical, agronomic, biochemical and medicinal aspects of fenugreek crop with the goals to evaluate possibilities of introduction of the crop in suitable ecoregions of Venezuela as a potential forage crop.

TAXONOMY

The genus *Trigonella* L. (Fabaceae) is composed of annual or perennial herbs, with pinnate leaves, trifoliate, fragrant, and legumes that are characteristic of the family. *Trigonella* species are widely distributed in the dry regions around Mediterranean, West of Asia, Europe, North and South Africa, North America, and South Australia [16]. There has been much controversy regarding the number of species, which includes the genus, Fazli [17] considered 97 species, Vasil'chencko [18] recognized 128 species, Hector [19] and Hutchinson [20] recorded about 70 species. In recent studies, Martin et al. [21] included approximately 100 species and Govaerts et al. [22] recognized about 93 species. However, the exact number depends on accepted synonymies. Several authors have proposed artificial classifications within the genus to recognize groups of species, in this sense Tutin and Heywood [23] considered the genus into three subgenera: *Trigonella*, *Trifoliastrum*, and *Foenumgraecum*. These subgenera are recognized with based on characters of the shape and outline of calyx and pod. On the other hand, Furry [24] divided cultivated species according to corolla color and calyx characteristics. Ingham [25] created three groups within *Trigonella*, based on its capability results to release cumarine in macerated tissues. However, these classifications do not permit understanding of the genus natural history, for that reason is necessary phylogenetic systematic studies for knowledge of species and their relationships. Several authors have studied the taxonomy of the genus for regions or countries [18, 26, 27] as well as aspects of morphology, cytology, and pollen [16, 27-34]. The genus *Trigonella* has a wide diversity of species, including among these to *T. foenum-graecum* which is the most popular species in the genus by its countless uses and properties. The taxonomic position of this species is described below based on Snehlata and Payal [35]:

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Fabales
Family: Fabaceae
Genus: *Trigonella*
Species: *foenum-graecum* Linn.

This species was described by Linnaeus in 1753 in his book "*Species plantarum*"; however, after the original description were published other homonyms for this species:
1. *Trigonella foenum-graecum* Suter Fl. Helv. ed. Hegetschw. 2: 149. 1822;
2. *Trigonella foenum-graecum* Sibth. & Sm. Flora Graeca 8: 48, pl. 766. 1833;
3. *Trigonella foenum-graecum* [Habl.] Desc. Taur. 138. Without specific year [36].

ETYMOLOGY

The origin of the name *Trigonella* comes from Latin that means "small triangle" in reference to triangular form of flowers. The specific epithet *foenum-graecum* means "Greek hay". Romans obtained this plant from Greece, where it was a crop very common in ancient times, hence its name. It also was named "bull horn" or "goat horn" because of projection of pods, which hold seeds [37]. Some common names in different languages for this species are: Abish, Alforva, Alholva, Boidana, Fenegriek, Fenigrec, Fenogreco, Fenogrego, Fenugrec, Fenugreek, Fieno Greco, Grezsezki, Hhelbah, Hhelbeh, Hulabah, Hulba, K'u-Tou, Khul'ba, Koroba, Methi, Moschositaro, Pazhitnik, Pazsitnyik, Schemlit, Senegre, Shambala, Shambalilae, Szeno, Tili, Tintelis, Tipilina,Trigonelle, Trigoniskos,Tsimeni,Ul'ba [35, 37-39]. Its great popularity ought to that it is a species of medicinal plants more ancient, particularly in India, where it is used in Ayurveda medicine and Unami Systems [39], moreover, it is currently known by its properties for condiments, dyeing and especially as a forage plant.

MORPHOLOGY

The description of *T. foenum-graecum* is based on Sinskaya [40], Hutchinson [20]; Tutin and Heydwood [23], Fazli and Hardman [41], and Petropulus [38]. Stems 20-230 cm long, straight, rarely ascending, branching, rarely simple, sparsely pubescent, usually hollow, anthocyanin tinged at base or all the way up, rarely completely green. First leaf simple, sometimes weak trifoliate, oval or orbicular with entire margin and long petiole. Stipules fairly large, covered with soft hair. Leaf petiole thickened at the top, attenuate beyond point of attachment of lateral leaflets. The petioles are very small, cartilaginous. The leaves are rich source of calcium, iron, ß-carotene and others vitamins [42]. The petioles and the blade of the leaflets are anthocyanin-tinged to a varying degree of green. Flowers in leaf axils, more rarely solitary. Calyx 6-8 mm, soft hairy with teeth as long as the tube, half as long as the corolla. Corolla 13-19 mm long pale yellow (white at the end of flowering period). Sometimes is lilac coloured at the base. Standard tend backwards oblong emarginated at apex with bluish spots (these spots are absent from some genotypes), wings half as long as the standard: keel obtuse, split at base. Pods are 10-18 cm long and 3.5 x 5.0 cm broad, curved, rarely straight, with transient hairs. Before ripening the pod is green or reddish coloured, when ripe turn into light straw or brown containing 10-20 seeds. Seeds vary from rectangular to rounded in outline with a deep groove between the radical and cotyledons, the length is 3.5-6.0 mm and the width 2.5-4.0 mm, light grayish, brown, olive green or cinnamon coloured, with a pronounced radical that is half the length of the cotyledons. The seed coat characters have provided an approach to the systematic relationships among the species of the *Trigonella* [43-46]. The seeds are very big importance because contain lysine and L-Tryptophan rich proteins, mucilaginous fiber and other rare chemical constituents such as saponins, coumarin, fenugreekine, nicotinic acid, sapogenins, phytic acid, scopoletin and trigonelline, which are thought to account for many of its presumed therapeutic effects [47].

GROWTH

Fenugreek can grow in the wild although it is also cultivated as a forage crop, mainly in Central and Southern Europe. It is an annual plant with fast growth that reproduces by seeds. These can be obtained in an easy and economic way from ripe pods. Germination occurs within 4-10 days from sowing. Stalks are erect, hollow according to fenugreek variety; soil fertility and plant density enhance stems development without secondary ramifications, with stems originating from basal nodes. In some cases, main stem does not significantly differ from lateral shoots; this type of plant produces a greater amount of pods/plant. Fenugreek flowering, according to variety, climate and sowing time, starts approximately 35-40 days from sowing, flowers are axillary, generally two per axile, occasionally one. Two types of flower shoots are presented, the most common with indeterminate growth with tip constantly differentiating in vegetative and floral organs. And the so called “blind” shoots where floral shoots end in a flower. Considering floral morphology, these are pentamerous; they have calyx, corolla, ten stamens and one pistil; calyx tube is formed by undivided sepals; ending in five teeth almost as large as the tube. Corolla is composed of petals named banner, two lateral petals and two united petals that form a structure called keel. The flowers can be of two types: more common cleistogamous (with closed flowers) and less frequently occurring aneictogamous (with open flowers). This last type generally presents anomalous flowers in its morphology, they usually develop in the “blind” shoots and offer a great possibility to cross-pollination when keeping open [48]. Fenugreek plants can be divided into two types according to number of pods per node. Those that grow near the stem apex are called solitary pods (only one pod per node), and when there are two pods per node, growing in an opposite direction from one another, they are called twin/double pods. Pods become ripe after 60-90 days [49].

PRODUCTION

Fenugreek presents a set of characteristics, as its easy adaptation to diversity of soil and climatic conditions, straight growth, potential resistance to drought, among others; that become an interesting species from an utilisation point of view as a forage crop. On the other hand, it is a 4-7 month life plant therefore its harvest is annually made, depending on its varieties, seasonal variations and seed and pod maturation [40]. During annual production the whole plant is harvested and it is dried before being threshed to obtain seeds, Apart from leaves, seed is the main product of interest and of main use as a traditional-medicinal plant. Average yields reported by farmers in Canada during the dry season is approximately 1500 kg/ha (1300 lb/ac). Nevertheless, reliable data about demands, imports and exports, world commercialization and prices for fenugreek seed are not easily available [50]. Perhaps, this lack of data has been the main obstacles that have hampered acceptance of alternatives medicines in developing countries; mainly due to lack of documentation and strict quality control. There is also a need for documentation of the research work conducted on traditional medicines and applications [51].

CHEMICAL COMPOSITION AND FORAGE QUALITY

Legumes as an important dietary protein source have a great opportunity to increase relevance in agricultural systems of the 21st century particularly in case of economically backward developing countries of Africa and Latin America. Legumes include many genera of economically important crops that are used by humans food products, medicinal herbs, oils and as forage for animals. Fenugreek is an annual leguminous originally cultivated at the tropics and mid-east. Interest for this species cultivation in temperate climates, like the Western of Canada has increased (52) since the seed contains a high great protein and diosgenin percentage [53]. Although, few research has been made on fenugreek forage studies; Upadhyay et al [54] and Dua et al [55] reported that fenugreek forage harvested at its ripeness contains 14.4 and 13.9 % of crude protein (CP) and 58.3 and 51.2 % of IVDMD, respectively. Moreover, Mir et al [56] found that fenugreek is cultivated in the northeast part of Saskatchewan (Canada) and harvested at 50 % level fill stage seed with 14 % CP and 73.1 % of *in vitro* digestibility of dry matter (IVDMD) in comparison to those of alfalfa (*Medicago sativa* L.).

Mir et al. [57], studied nutritive values of fenugreek forage which was evaluated and compared to that of alfalfa considering its chemical composition (IVDMD) and *in vitro* gas production. Forage samples were cultivated in greenhouse conditions and/or under irrigated plots and fenugreek forage was harvested after, 9, 15 and 19 weeks and was compared to alfalfa nutritive quality harvested at early maturity. Experiment results are detailed as follows: Experiment 1 (Table 1), CP content of fenugreek cultivated in greenhouse after 9 weeks was greater (P < 0.05) than alfalfa cultivated in the field and harvested when flowering initiation, additionally, ashe content and IVDMD in fenugreek was greater. Also, fenugreek collected in greenhouse after 15 and 19 weeks contained less CP than alfalfa, while fenugreek neutral detergent fiber (NDF) content after 19 weeks was greater. Moreover, IVDMD of fenugreek after 15 and 19 weeks were greater [57]. Experiment 2, fenugreek cultivated after 15 and 19 weeks contained less CP (P < 0.05) than alfalfa cultivated in the field. NDF after 19 weeks was greater (P < 0.05) for fenugreek. Acid detergent fiber (ADF) contents after 15 and 19 weeks were similar to those of alfalfa. Also, IVDMD after 15 and 19 weeks (52.8 and 53.9 %) were greater (P < 0.05) than those of alfalfa (47.8) (Table 1). Although, fenugreek content present similar values of CP, ADF and NDF to those reported by Mier et al [57], IVDMD values (52.8 %) were considerably inferior, about 73.1 % to those obtained in the study mentioned above. IVDMD low values in the present study were probably caused by high lignin and ash levels that are found in fenugreek cultivated under greenhouse conditions.

Table 1. Nutrient composition (% DM) and IVDMD (%) of 9, 15 and 19-wk-old of fenugreek and alfalfa forages experiments 1 and 2.

	Experiment [1]			**Experiment [2]**			
	Fenugreek (Weeks)	**Alfalfa^{z}**		**Fenugreek (Weeks)**		**Alfalfa^{z}**	
	9	**Early bloom**	**SEM**	**15**	**19**	**Early bloom**	**SEM^{y}**
CP	21.7^{a}	17.8^{b}	0.66	13.5^{m}	12.9^{m}	18.7^{n}	0.28
ADF	29.4	28.8	0.25	34.8	36.7	35.9	1.16
NDF	32.6^{b}	40.4^{a}	1.04	42.0^{m}	47.3^{n}	43.9^{m}	0.53
Lignin	6.4	8.7	0.27	11.0	10.4	8.0	0.82
Ash	12.9^{a}	8.6^{b}	0.05	10.3	8.7	8.7	0.26
IVDMD	59.5^{a}	47.7^{b}	1.50	52.8^{n}	53.9^{n}	47.8^{m}	1.24

^{y}SEM: standard error of the mean; ^{z}Alfalfa forages in experiments 1 and 2 were different.
$^{a–b}$ Means in the same row with different letters for experiment 1 are different (P < 0.05).

[m-n] Means in the same row with different letters for experiment 2 are different (P < 0.05); **Source**: [57]

Table 2. Nutrient composition (% DM) and IVDMD (%) of 9-, 15- and 19-wk old field grown fenugreek and early bloom alfalfa forages, experiment 3.

	Age of fenugreek plants (wk)			Alfalfa	
	9	15	19	Early bloom	SEM[x]
CP	24.8^{a}	19.8^{ab}	15.7^{b}	18.2^{b}	0.93
ADF	29.1^{c}	37.1^{b}	38.7^{b}	43.9^{a}	2.29
NDF	25.2^{c}	30.6^{b}	33.7^{ab}	35.9^{a}	1.58
Lignin	5.4^{b}	5.6^{b}	5.5^{b}	8.0^{a}	0.47
Ash	12.6^{a}	9.9^{b}	8.8^{b}	8.7^{b}	0.40
IVDMD	64.1^{a}	66.5^{a}	66.2^{a}	59.2^{b}	1.00

[a–c] Means in the same row with different letters are different (P < 0.05).
[x]SEM: standard error of the mean; **Source**: [57]

Experiment 3, CP values for fenugreek after 9 weeks were greater than those for alfalfa forage and for fenugreek after 19 weeks (Table 2).These CP values of fenugreek cultivated in plots are greater by 12.7 %, than those values reported by Stapleton [58] after 20-22 growth weeks and 13.9 and 14.4 % on a dry matter (DM) basis at the dry stage than those indicated by some researchers [53-55]. These authors inform that these differences may have occurred due to variations in plant maturity and growing conditions including the fertility status of the soil. NDF content was lower (P < 0.05) for all fenugreek samples than early-bloom alfalfa. In addition, lignin content was 8.0 % of DM for alfalfa, while for fenugreek was 5.6 % of DM. ADF content after 9 and 15 weeks was lower than those for alfalfa. While FDN content of 32.34 % for fenugreek after 19 weeks was similar to those values reported by Dua et al, [55] and values obtained for lignin and NDF 5.97 % and 48.4 % respectively were higher. Ash content was higher (P < 0.05) in fenugreek 9 weeks compared to fenugreek (15 and 19 weeks) and to alfalfa (Table 2). The CP, NDF and ADF values of early-bloom alfalfa in the present study were comparable to those by National Research Council [59]. The IVDMD of fenugreek forage was greater than that of alfalfa and confirmed earlier findings by Mir et al. [56] .These IVDMD values (Tables 1 and 2) were greater than those reported by Dua et al. [55] and Upadhyay et al. [54]. The high digestibility of DM from fenugreek forage compared to alfalfa cut at early-bloom may result in greater efficiency of feed utilization in the ruminants, thereby decreasing the need for excessive supplementation [57].

Table 3. Chemical composition (% DM) of fenugreek at different maturity stages.

Year and maturity stage	CP	NDF	ADF	Cellulose	Hemicellulose	Lignin	Ash	Digestibility
1980-81								
A	19.1	32.9	28.9	20.2	4.0	7.9	12.6	67.4
B	7.4	35.8	31.2	21.7	4.6	9.0	11.5	65.3
C	16.0	40.8	35.0	24.2	5.8	9.7	10.6	63.1
D	14.8	47.2	38.4	26.7	8.8	10.6	9.2	59.7
1981-82								
A	20.8	25.8	21,6	14.7	4,2	6.2	10.9	70.7
B	18.8	27.2	22.7	15.4	4.5	6.8	9.8	69.6
C	18.1	26.8	21.3	14.5	5.5	6.5	9.0	69.6
D	17.3	34.8	27.3	18.6	7.5	7.8	8.4	65.8
1982-83								
A	21,4	24.3	20.1	13.6	4,.2	5.7	10.3	71.6
B	19.6	26.1	21.8	14.7	4.3	6.2	10.0	71.0
C	19.0	26.8	22.1	15.2	4.7	6.3	8.7	70.2
D	17.6	32.6	25.4	17.7	7.2	7.2	8.1	67.1

A: Flowering, 20-30 % of flowering plants, B: Initiation of formation of legumes; C: Legumes formed D: Ripe legumes. **Source:** [60]

Trevino et al [60] studied during three consecutive years the yield and nutritive quality of the fenugreek as fodder plant in the dryland region of Spain; analyzing the effects of the stage of maturity, cultivation year, sow density and oats association. Authors mentioned above, reported that the chemical composition and digestibility of the fenugreek varied with maturity stage when the plant was harvested (Table 3). Differences were significantly to the 1 % level for all constituents analyzed. Also, CP and ash proportions decreased during bloom and formation period and during the development and ripening of the legumes. Decrease was practically continuous but the intensity was not the same during the three years evaluation period. The CP decreased by 18.9 % and ash by 23.9 % between bloom stage and ripening legumes. On the other hand, fiber proportion and that of its main constituents followed an inverse evolution with respect to that of protein and ash, increasing with plant maturity. Thus, the mean NDF showed an increase of 37.9 %, ADF 22.9 %, cellulose 29.9 % and about 89 % hemicellulose and 22.3 % lignin between the stages of maturity mentioned before. They concluded that forage nutritional quality based on the protein content and digestibility was good and similar to those of forage legumes commonly used.

MEDICINAL PROPERTIES

Fenugreek leaves and seeds have been used extensively for medicinal purposes. It is known that fenugreek seeds demonstrate anti-diabetic, anti-cancer and anti-nociceptive properties and can also impact hypocholesterolaemic conditions, and thyroxine-induced hyperglycaemia [11, 12]. Acharya et al [11, 12] identified the chemical constituent of fenugreek responsible for the health effects in human and to develop a strategy for improving these constituents in fenugreek plants. The researchers observed that the chemical components of the seed, for instance, saponins, fiber, protein, amino acids and fatty acids content also differ and they argue that this variability is often taken for granted or under estimated in clinical essays; and suggest that genetic variability and genotype x environment interaction play an important role when the crop is used by the nutraceutical industry (nutrition and pharmaceutical) in Canada, where the high quality seeds production is currently difficult. Researchers mentioned above led an investigation to identify the chemical components, which are responsible for the effects on human health, and to develop a strategy for this components improvement in fenugreek. For this, fenugreek accessions were obtained from Plant Gene Resources of Canada, Saskatoon and from condiment markets in India, choosing four cultivars: Amber, F-70, F-86, L-3314, which were obtained from the Lethbridge Research Centre, Agriculture and Agri-Food Canada.

The main results are presented in Table 4, where it was observed that the CP content of seeds from cultivars produced in the south of Alberta (Lethbridge) was significantly greater than that of India. Protein content of the four cultivars in Lethbridge was not significantly different. This was expected since these cultivars were chosen by their capacity to produce a high forage yield so they have growth habits and morphological characteristics very similar and was cultivated under uniform conditions. Sapogenin content were significantly greater ($P < 0.05$) in amber cultivar (0.4) and the India seeds (0.5), compared to other three cultivars essays. Cultivars F-70, F-86, and L-3314 had approximately 0.3 % sapogenin. In diosgenin, steroidal sapogenins were found predominant in all cultivars, but were not significantly different ($P > 0.05$) in the five cultivars essays. Diosgenin observed values in these samples were within the values range formerly observed by Taylor et al. [61], in a detailed study.

Table 4. Composition of fenugreek seeds (%, w/w, dry basis)[- 1]

Components	Fenugreek varieties				
	Amber	**F-70**	**F-86**	**L-3314**	**India**
Crude protein	$31.6±0.8^{a}$	$28.7±0.3^{b}$	$30.1±0.5^{ab}$	$31.6±0.2^{a}$	$26.0±0.3^{c}$
Soluble fiber	$18.8±0.2^{b}$	$21.7±0.3^{a}$	$16.1±0.3^{c}$	$18.2±0.3^{b}$	$17.5±0.8^{bc}$
Insoluble fiber	$25.8±0.3^{d}$	$25.8±0.4^{cd}$	$32.3±0.5^{a}$	$27.4±0.6^{bc}$	$28.1±0.1^{b}$
Sapogenins	$0.4±0.0^{a}$	$0.3±0.0^{b}$	$0.3±0.0^{b}$	$0.3±0.0^{b}$	$0.5±0.0^{a}$
Diosgenin	$47.8±1.6^{a}$	$41.0±5.1^{a}$	$43.9±2.9^{a}$	$44.6±2.1^{a}$	$43.8±3.2^{a}$

[1]Means sharing the same superscript in a row is not significantly different ($P > 0.05$) from one another. **Source**: [11]

Medicinal parts are the dried ripen seeds. Fenugreek seeds contain 45-60 % of carbohydrates, mainly mucilaginous fiber (galactomannans), 20-30 % of protein with high content of lysine and tryptophan, fixed oils 5-10 % (lipids), alkaloids type pyridine, mainly trigonelline (0, 2-0, 36 %), choline (0.5 %), gentianine, and carpaine; flavonoids of apigenin, luteolin, orientin, quercetin, vitexin, and isovitexin; free amino acids, such as 4-hydroxyisoleucine (0.0 9%); arginine, histidine, and lysine; calcium and iron; saponins (0.6-1.7 %); glycosides that produced steroidal sapogenin in hydrolyses(diosgenin, yamogenin, tigogenin, neotigogenin); cholesterol and sitosterol; vitamins A, B_1, C, and nicotinic acid; and 0.015 % volatile oils (n-alkanes and sesquiterpenes). Seeds also contain the saponin fenugrin B, coumarin compounds, alkaloids (trigonelline, gentianine, carpaine). A large portion of the trigonelline is degraded into nicotinic acid and pyridines, which is responsible for the flavor of the seed. Seed is also responsible for 8 % of fixed, foul-smelling oil [61].

ADAPTIVE POTENTIAL OF THE SPECIES IN VENEZUELA

Venezuela is located in the Northern extreme of South America between 0º 45' and 15º 40' N and 59º 45' and 73º 25' W. It has a 916445 kilometers territory from which 882050 are continental. It limits with the Caribbean Sea and the Atlantic Ocean to the North, with Colombia to the West and with Brazil and Guyana to the South. Venezuela is a federal state with 23 states and a federal district. Its population is of 24600000 inhabitants [63] and its demographic growth rate is 1.9 % per year. Urban population is 87 % from the total. Valleys and "*pie de monte*" of the Coast Mountain and Andean Mountain contain 60 % of the population. While, population are more scattered at the great basins of Orinoco and Apure rivers. Abundant lands for cultivation and temperate climate provide ideal conditions for agriculture. Although, today approximately one fifth of the land is used for agriculture remains as an important employment source (about 14 % of labor). More than the half of agrarian income comes from livestock production while milk products, fruits, grains, chicken production and vegetables provide approximately 40 % of the income; the rest comes from the forest and fish sectors. Venezuela has two big and important basins, that of Atlantic Ocean and the Caribbean Sea. Atlantic Ocean watershed receives Orinoco and various important rivers and cover 82 % of the territory, with 70 % drained by the Orinoco river, which splits Venezuela into two parts. The Caribbean watershed receives water from various small basins including Maracaibo Lake and those drain the Northern portion of mountains. Although, it only covers 17.5 % of the territory, it is extremely important since it is heavily populated. Venezuela geography is relatively complex and detailed analyses recognize 27 climatic zones, 12 vegetation types, 23 slope types and 38 geological units [64]. In a broaden analysis, the following ecozones: Central Andes, Eastern Andes, Coro System, Maracaibo Lake, Plains (Llanos), Orinoco Delta, South of Orinoco and Islands, are generally recognized[65]. In Venezuela, there are ecoregions in which fenugreek might be easily introduced. The wide distribution of crop in the world is an indication of its adaptation to altitude and variable climatic conditions. According to Duke [8] the crop have survived in agro-ecosystems that go from temperate cold humid steppe in the very dry tropical forest zone with annual rainfall between 380-1530 mm and an average annual temperature of 7.8-27.5 ºC. Considering soils, Rosengarten [37] sugested that fenugreek is better cultivated in loam well drained soils, with optimum pH 8-8.5. Duke [8] indicated that it grows very well in gravel and sandy soils and does not adapt to clay soils and it is quite tolerant to salinity. In this case, the country has different types of soils mosaic with representation of 10 orders within Soil Taxonomy. Zones with mainly acid and low fertility levels such as Central and Andean Mountains comprise about 50 % of the country. Plain zones (the other 50 % of the country) can be divided into two great sectors: the smaller semi-arid sector concentrated on the North of the country, possesses neutral soils or alkaline ones, some saline, medium textures and medium to high fertility and the larger sector is represented in the forms of valleys and semi-humid and humid plains. These may further be divided into two areas: those with acid soils, low fertility and with medium and sandy textures predominant, mainly in the Central, Eastern and Southern regions. It is considered that fenugreek with its potential as forage and medicinal plant can adapt to various ecoregions as described above by carrying out studies for site quality and yield parameters. Our general review indicates good potential for introducing this crop in Venezuela.

CONCLUSION AND FUTURE PERSPECTIVES

Fenugreek is a short cycle plant that allows quality productions even under low rainfall areas and aridity conditions, which makes an alternative and attractive crop due to its food, forage and medicinal qualities. In Venezuela, there are favorable regions to introduce fenugreek germplasms. However, it is necessary to consider legal framework of each country and to identify reliable and certified seeds, as well as, to carry out site quality studies that can identify more suitable areas for optimal crop introduction.

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