

# Ecological diversity of Hungarian medicinal and aromatic plant flora and its regional consequences

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INTERNATIONAL  
JOURNAL OF  
HORTICULTURAL  
SCIENCE



AGROINFORM  
Publishing House, Hungary

**Key words:** medicinal plants, aromatic plants, collected species, cultivated species, production regions, ecological requirements, geographical distribution, effect of temperature, nutrition, water, soil reaction

**Summary:** During the last century the medicinal and aromatic plant sector has become a successful part of the Hungarian Agriculture. Some of the national products have been accepted as a special Hungarian ones ("Hungaricum"), evaluated on the world market, respectfully. By the estimates the cultivation area of medicinal and aromatic plants increased up to 37,000–42,000 hectares and considerable amount – about 10, 000–15, 000 tonnes of dry biomass – are produced by utilisation of Hungarian indigenous flora, year by year.

In the present work ecological requirements of 97 collected and 55 cultivated medicinal and aromatic plants are characterised. Based on the analysis of  $\Sigma T$  (temperature regime values) about 63 per cent of cultivated species came from Submediterranean and Mediterranean type of habitat, originally, while the majority of collected plants (61.8 per cent of them) prefer the deciduous forest conditions. The differences between collected and cultivated species are appreciable too, if the distributions of their characteristic water regime ( $\Sigma W$  values) are compared. The majority of cultivated species require dry (moderate dry) and fresh (moderate fresh) habitats, while the amplitude of water requirement of collected species is much more wide-ranging.

The regional specialisation of Hungary according to production of medicinal and aromatic plants is known from the beginnings of the 20<sup>th</sup> century. As a result of spontaneous process seven well-defined production areas were developed. The relationship between regions, their climatic conditions and spectrum of species produced there are analysed.

## Introduction

Medicinal and aromatic plants, especially for self-consumption are produced in the territory of Hungary many centuries back. The first written reports about the small scale cultivation were present in the books written by monks settled here in the middle ages arriving from the Mediterranean regions (Italy, France). Further more many medicinal and aromatic plants, especially many of the members of Lamiaceae family had been introduced into the Carpathian basin at that early time period. However, till the end of 19th century the cultivation of medicinal and aromatic plants was carried out on the "garden" scale, only.

The shortage of medicines, teas and spices at the time of the 1<sup>st</sup> World War and in the following time period draw much more attention to the large scale production and utilisation of medicinal and aromatic plants. Till the late 30es Hungary has become one of the "leading" medicinal plant production countries of Europe (Bernáth, 1998a, Bernáth & Németh, 1998). In that time period Hungarian expert János Kabay invented a new method for morphine production using dry poppy straw (Bernáth, 1998b). The

peppermint (*Mentha piperita*), the English and French lavender (*Lavandula intermedia* and *L. angustifolia*) were introduced into the large-scale cultivation. The Hungarian camomile flower (*Matricaria recutita*) collected from the Hungarian Great Plain became worldwide known in that time, too. As a result of quick development of Hungarian Pharmaceutical Industry – beyond the poppy straw production – the parasitic cultivation of ergot (*Claviceps purpurea*) and large-scale production of foxglove (*Digitalis lanata*) was developed.

After the 2<sup>nd</sup> World War the former structure of the medicinal and aromatic plant section - which could have been characterised by increasing effectiveness changed in a great deal. In spite of the administrative, political and economical contradictions existing in the former "socialist" system medicinal and aromatic plant sector became a successful part of the Hungarian Agriculture. Some of the national products (Lange, 1996, Lange, 1998) had been accepted as a special Hungarian product ("Hungaricum") and esteemed on the world market (*Chamomillae flos*, *Basilici herba* and *folium*). By the estimates the cultivation

area of medicinal and aromatic plants increased up to 37 000–42 000 ha and considerable amount – about 10 000–15 000 t of dry biomass – is produced by Hungarian indigenous flora, year by year (Bernáth, 1994).

The regional specialisation of Hungary in utilisation of both indigenous flora and cultivation of medicinal and aromatic plants is known from the beginning of the 20<sup>th</sup> century (Bernáth, 1998a). The regions have developed spontaneously, affected by different biological, economical and social factors. The idea of present paper is to prove the importance of biological and ecological factors in this quasi-spontaneous process.

- One of our ideas was to give more detailed description and characterisation of ecological requirements of Hungarian medicinal and aromatic plants,
- We wanted to clear up what kind of differences exist between the ecological requirements of species belonging to collected and cultivated plant groups,
- Based on the analysis we wanted to clear up whether the traditional regions and the ecological requirements of species are in coincidence,
- Finally our expectation was whether our results can contribute either to develop new regions of production or optimize the traditional ones.

### Method of ecological analysis

According to the actual data 180–200 medicinal and aromatic plants are produced in Hungary, more or less regularly (Bernáth, 2000). From these plant spectrum 97 wild growing and 55 cultivated species of main importance were drawn into the analysis. The list of the species is given in Table 1. and Table 2. The species are characterised from different point of view, describing the name of their utilised plant part, their geographical distribution, original habitat of their occurrence, as well as their known ecological requirements.

The description of utilised plant part of the species is identical with items of Hungarian Pharmacopoeia (VII. edition) and the Hungarian Commercial Regulations (Bernáth, 2000). The abbreviations for the drugs are: Aeth: *Aetheroleum*, c: *caput*, co: *cortex*, f: *folium*, fl: *flos*, fr: *fruit*, gem: *gemma*, h: *herba*, Oil: *oleum*, pseudofr: *pseudofructus*, r: *radix*, rh: *rhizoma*, s: *semen*, sum: *summitas*, stip: *stipes*, str: *strobulus*, t: *tuber*, tereb: *terebinthina*.

The definition of life form was applied according to Raunkier system published by Simon (1992). The abbreviations of life forms are as follows: MM: tree, M: shrub, N: semi-shrub, Ch: Chamaephyta, H: Hemokryptophyta, G: Kryptophyta, TH: Hemitherophyta, Th: Therophyta, E: Epiphyta.

The geographical distribution of the species was completed using data of different authors (Simon et al., 1984, Simon, 1992, Bernáth 2000). The terms of abbreviations were used in conform to work of Simon (1992): ad: adventive, Afr: African, Am: American, amph-

Atl: Amphyatlantic, As: Asian, Atl: Atlantic, Circ: Circumpolar, cosm: cosmopolitan, Cont: Continental, E: East, Eu: European, Eua: Eurasian, Eusib. Eurosiberian, Ind: Indian, Med: Mediterranean, midl: middle, N: North, Pont: Pontius, S: South, Sib: Siberian, Subatl: Subatlantic, SubMed: Submediterranean, Trop: Tropical, W: West.

The ecological amplitudes of the species were identified by using data of Duke & Hurst (1975), which were completed by many additional information published afterwards. The abbreviations are identical to the terms, which were used in original publication of Duke & Hurst, fixing the name of the actual life zone of geographical occurrence (after Holdridge, 1966), which were characterised by mean year temperature values of the zone and amount of precipitation :

Tx:	Tropical Desert Scrub	(>24 °C, 125 – 250 mm)
Tt:	Tropical Thorn Woodland	(>24 °C, 250–500 mm)
Tv:	Tropical Very Dry Forest	(>24 °C, 500–1000 mm)
Td:	Tropical Dry Forest	(>24 °C, 1000–2000 mm)
Tm:	Tropical Moist Forest	(>24 °C, 2000–4000 mm)
Tw:	Tropical Wet Forest	(>24 °C, 4000–8000 mm)
St:	Subtropical Thorn Woodland	(18–24 °C, 250–500 mm)
Sd:	Subtropical Dry Forest	(18–24 °C, 500–1000 mm)
Sm:	Subtropical Moist Forest	(18–24 °C, 1000–2000 mm)
Sw:	Subtropical Wet Forest	(18–24 °C, 2000–4000 mm)
Wt:	Warm Temperate Thorn Steppe	(12–18 °C, 250–500 mm)
Wd:	Warm Temperate Dry Forest	(12–18 °C, 500–1000 mm)
Wm:	Warm Temperate Moist Forest	(12–18 °C, 1000–2000 mm)
Cs:	Cool Temperate Steppe	(6–12 °C, 250–500 mm)
Cm:	Cool Temperate Moist Forest	(6–12 °C, 500–1000 mm)
Cw:	Cool Temperate Wet Forest	(6–12 °C, 1000–2000 mm)

In the tables the ecological requirement of the species are characterised by giving `T` (temperature regime), `W` (water regime) and `R` (soil reaction) data of actual habitat of growth. The categories used in evaluation and some of the data were taken from work of Ellenberg (1950), Walter (1979) and completed by the result of up to date botanical researches (Simon, 1992) and our observations (Bernáth, 2000).

In the case of cultivated plants (Table 2) the ecological requirements of species are attached, additionally, based on the experiences of countrywide cultivation (Bernáth, 2000). In this respect the data regarding to the temperature, water and nutrition requirement of species seems to have high practical values.

Table 1 Characterization of medicinal and aromatic plants growing wild in Hungary

Species	Utilized plant part (drug)	Life form	Geographical distribution	'T' temperature regime	'W' water regime	'R <sub>p</sub> ' soil reaction
<i>Achillea collina</i>	h., Aeth.	H	E-midl-Eu	deciduous forest	dry	not specific
<i>Acorus calamus</i>	rh.	HH	S-SE-As	Mediterranean, Atlantic-evergreen forests	rather watery	slightly limy
<i>Adonis vernalis</i>	h.	H	Eua-Cont	Sub-Mediterranean	moderate dry	limy, basic
<i>Aesculus hippocastanum</i>	co., f., s.	MM	S-Eu-S-As	deciduous forest	moderate fresh	not specific
<i>Agrimonia eupatoria</i>	rh.	H	Eu-(Med)	deciduous forest	moderate dry	close to neutral
<i>Agropyron repens</i>	rh.	G	Circ	deciduous forest	extreme dry	not specific
<i>Althaea officinalis</i>	f., f.	H	SubMed	Mediterranean, Atlantic-evergreen forests	moderate dry	limy, basic
<i>Arctium lappa</i>	f., f.	H	Eua-(Med)	deciduous forest	moderate wet	limy, basic
<i>Artemisia absinthium</i>	f., h., Aeth.	TH	Eua-(Med)	deciduous forest	moderate wet	slightly limy
<i>Artemisia vulgaris</i>	h., f., Aeth.	H	Eua-(Med)	Sub-Mediterranean	moderate dry	slightly limy
<i>Atropa bella-donna</i>	f., f., (s.)	H	circ-(Med)	deciduous forest	moderate fresh	not specific
<i>Betula pendula</i>	f.	MM	Atl-Med-(midl-Eu)	deciduous forest	fresh	close to neutral
<i>Calluna vulgaris</i>	h.	Ch	Eusib	taiga	moderate fresh	not specific
<i>Capsella bursa-pastoris</i>	h.	Th	Eu	deciduous forest	moderate fresh	acidic
<i>Castanea sativa</i>	f.	MM	Cosm	Sub-Mediterranean	fresh	not specific
<i>Centaurium erythraea</i>	h., f.	Th, TH	SubMed	deciduous forest	moderate fresh	slightly acidic
<i>Chelidonium majus</i>	h., f.	H	Eua-(Med)	deciduous forest	fresh	close to neutral
<i>Cichorium intybus</i>	f., h.	H	Eua-(Med)	deciduous forest	moderate fresh	limy, basic
<i>Colebiticum autumnale</i>	t., s.	G	Eua-(Med)	Mediterranean, Atlantic-evergreen forests	moderate wet	slightly limy
<i>Consolida orientali.</i>	fl., h.	Th	midl-Eu-(SubMed)	deciduous forest	moderate dry	slightly limy
<i>Consolida regalis</i>	fl.	Th	SE-Eu-S-Med	Mediterranean, Atlantic-evergreen forests	moderate dry	slightly limy
<i>Convallaria majalis</i>	f., (h., fl., rh.)	H	Eua	deciduous forest	moderate fresh	close to neutral
<i>Corylus avellana</i>	f., (co.)	M	Eu	deciduous forest	fresh	close to neutral
<i>Cotinus coggygria</i>	f.	M	S-Eua	deciduous forest	dry	limy, basic
<i>Crataegus monogyna</i>	sum. fl., f., fr.	M	Eua-(Med)	deciduous forest	moderate fresh	close to neutral
<i>Crataegus laevigata</i>	sum. fl., f., fr.	M	midl-Eu	deciduous forest	fresh	close to neutral
<i>Cynodon dactylon</i>	rh.	G	cosm	deciduous forest	moderate dry	not specific
<i>Datura stramonium</i>	f., s.	Th	cosm	deciduous forest	moderate fresh	not specific
<i>Dryopteris filix-mas</i>	rh.	H	cosm	deciduous forest	fresh	not specific
<i>Echium vulgare</i>	h.	TH	Eua	Sub-Mediterranean	moderate dry	not specific
<i>Epiobium parviflorum</i>	h.	H	S-Eua	deciduous forest	watery	not specific
<i>Equisetum arvense</i>	h.	G	Circ	deciduous forest	moderate watery	not specific
<i>Euphrasia rostkoviana</i>	h.	Th	Subatl-midl-Eu	deciduous forest	fresh	close to neutral
<i>Filipendula ulmaria</i>	h., fl., (r.)	H	Eusib	taiga	moderate watery	not specific
<i>Frangula alnus</i>	co.	M	Eua-(Med)	deciduous forest	wet	close to neutral
<i>Fumaria officinalis</i>	h.	Th	Eua-(Med)	deciduous forest	moderate dry	close to neutral
<i>Galega officinalis</i>	h.	H	SE-Eua-Pont-Med	deciduous forest	moderate watery	slightly limy
<i>Galium odoratum</i>	h.	H	Eua	deciduous forest	moderate watery	slightly limy
<i>Galium verum</i>	rh., r.	H	Eua-(Med)	deciduous forest	fresh	close to neutral
<i>Geum urbanum</i>	h.	H	Eua-(Med)	deciduous forest	moderate dry	slightly limy
<i>Glechoma hederacea</i>	rh., r.	H-Ch	Eua-(Med)	deciduous forest	moderate fresh	slightly limy
<i>Glycyrrhiza glabra</i>	h.	H	Eua	deciduous forest	wet	not specific
<i>Glycyrrhiza paniculata</i>	rh., r.	H	Pont-Med	deciduous forest	fresh	slightly limy
<i>Hedera helix</i>	f.	H	Eua	Mediterranean, Atlantic-evergreen forests	dry	limy, basic
<i>Helichrysum arnarianum</i>	fl.	E-M	Atl-Med	deciduous forest	fresh	close to neutral
<i>Hepatica nobilis</i>	h., f.	H	midl-Eua	deciduous forest	rather dry	not specific
<i>Herniaria glabra</i>	h.	H	Eu	deciduous forest	fresh	slightly limy
<i>Hyoscyamus niger</i>	f., s., r.	Th-TH	Eua-(Med)	Sub-Mediterranean	dry	slightly acidic
<i>Hypericum perforatum</i>	h.	TH-TH	Eua-(Med)	deciduous forest	moderate dry	not specific
<i>Inula helenium</i>	rh., r.	H	adv	deciduous forest	moderate dry	not specific
				Mediterranean, Atlantic-evergreen forests	fresh	slightly limy

Species	Utilized plant part (drug)	Life form	Geographical distribution	Characterisation of original habitat by TWR values		
				"T" temperature regime	"W" water regime	"R" soil reaction
<i>Juniperus ommunis</i>	pseudofr., Aeth.	M	Circ	mixed coniferous-deciduous	moderate dry	slightly limy
<i>Lamium album</i>	fl., h.	H	Eua-(Med)	deciduous forest	moderate fresh	not specific
<i>Leonurus cardiaca</i>	h.	H	Eua-(Med)	deciduous forest	moderate dry	slightly limy
<i>Malva sylvestris</i>	fl., f.	Th-TH	Eua-SubMed	deciduous forest	moderate wet	slightly limy
<i>Marrubium vulgare</i>	h.	H-Ch	Eua	Mediterranean, Atlantic-evergreen forests	moderate fresh	close to neutral
<i>Matricaria recutita</i>	fl., Aeth.	TH-TH	Eua	Sub-Mediterranean	moderate fresh	limy, basic
<i>Mellilotus officinalis</i>	h., fl.	Th-TH	Eua-(Med)	deciduous forest	moderate dry	not specific
<i>Nepeta cataria</i>	h., Aeth.	Ch-H	Eua-(Med)	deciduous forest	moderate dry	slightly limy
<i>Ononis spinosa</i>	r.	H	Eua-(Med)	deciduous forest	moderate dry	not specific
<i>Origanum vulgare</i>	h., Aeth.	Th	Eua-(Med)	deciduous forest	moderate dry	slightly limy
<i>Papaver rhoeas</i>	fl.	MM	Eua	Mediterranean, Atlantic-evergreen forests	moderate dry	slightly limy
<i>Pinus sylvestris</i>	tereb., Aeth.	MM	Eua	taiga	moderate dry	limy, basic
<i>Plantago lanceolata</i>	f.	H	Eua	deciduous forest	moderate fresh	not specific
<i>Polygonatum odoratum</i>	rh., r.	G	Eua-(Med)	deciduous forest	moderate dry	slightly limy
<i>Polygonatum aviculare</i>	h.	Th	cosm	not specific	moderate dry	close to neutral
<i>Populus nigra</i>	gem.	MM	Eua-(S-Eu)	deciduous forest	wet	slightly limy
<i>Potentilla anserina</i>	h.	H	cosm	deciduous forest	wet	close to neutral
<i>Potentilla erecta</i>	rh. (r.)	H	Eua-(Med)	deciduous forest	wet	not specific
<i>Primula veris</i>	r, rh.(f., fl.)	H	Eua	deciduous forest	moderate dry	limy, basic
<i>Pulmonaria officinalis</i>	f., (h.)	H	midl-(Eu)	deciduous forest	moderate wet	close to neutral
<i>Rosa spp.</i>	fr.	M	Eua-(Med)	deciduous forest	moderate dry	close to neutral
<i>Rubia tinctorum</i>	r.	H	adv	Sub-Mediterranean	dry	not specific
<i>Rumex spp.</i>	fr.(r.)	Th, H	Eua-(Med)	deciduous forest	dry	slightly acidic
<i>Sambucus nigra</i>	fl., (f., fr.)	M-MM	Eua-(Med)	deciduous forest	fresh	close to neutral
<i>Saponaria officinalis</i>	h., r.	H	Eua-(Med)	deciduous forest	moderate fresh	not specific
<i>Solidago canadensis</i>	h.	H	adv	not specific	moderate watery	slightly limy
<i>S. gigantea</i>	h., r.	H	adv	not specific	moderate watery	slightly limy
<i>S. virga-aurea</i>	h., r.	H	Eua-(Med)	mixed coniferous-deciduous	moderate fresh	close to neutral
<i>Stellaria media</i>	h.	Th-TH	cosm	not specific	fresh	not specific
<i>Symphytum officinale</i>	rh. et r.	H	Eu	deciduous forest	moderate watery	not specific
<i>Tanacetum vulgare</i>	h., fl., Aeth.	H	Eua-(Med)	deciduous forest	wet	not specific
<i>Taraxacum officinale</i>	r., f., h.	H	Eua-(Med)	not specific	fresh	not specific
<i>Thymus serpyllum</i>	h., Aeth.	Ch	midl-S-Eu	deciduous forest	rather dry	close to neutral
<i>Tilia spp.</i>	fl.	MM	midl-SE-Eu	deciduous forest	fresh	close to neutral
<i>Tussilago farfara</i>	f., fl.	G (H)	Eua-(Med)	deciduous forest	fresh	slightly limy
<i>Urtica dioica</i>	f., (h., r., fr.)	H	cosm	deciduous forest	fresh	slightly limy
<i>Vaccinium myrtillus</i>	f., fr.	Ch-N	Circ	taiga	moderate fresh	acidic
<i>Valeriana officinalis</i>	rh. r., Aeth.	H	Eua-(Med)	deciduous forest	moderate fresh	slightly limy
<i>Veratrum album</i>	rh. r.	G	Eua	deciduous forest	moderate fresh	slightly limy
<i>Verbascum phlomoides</i>	fl., (f.)	TH	Eua-(Med)	deciduous forest	wet	slightly limy
<i>Veronica officinalis</i>	h.	TH-H	cosm	deciduous forest	moderate dry	slightly limy
<i>Vinca minor</i>	h.	Ch	cosm	Sub-Mediterranean	moderate fresh	slightly limy
<i>Viola odorata</i>	f., (rh. r. fl.)	Ch	amph-All	deciduous forest	moderate fresh	slightly acidic
<i>Viola tricolor</i>	h.	Th-H	SubMed-(midl-Eu)	deciduous forest	moderate fresh	close to neutral
<i>Viscu</i>	f., stip.	E	Eu	Sub-Mediterranean	moderate dry	slightly limy
			S-Eua-(Med)	deciduous forest	moderate fresh	not specific

\* All abbreviation in text

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Table 2 Ecological characteristics of medicinal and aromatic plants of main importance cultivated in Hungary

Species	Utilised plant part (drug)	Life form	Geographical distribution	Holdridge-Duke life zone parameters	Characterisation of original habitat by TWR values				Ecological requirement based on cultivation		
					"T" temperature regime	"W" water regime	"R" soil reaction	Temperature experiences	Water	Nutrition requirement	
<i>Achillea collina</i>	h., fl., Aeth.	H	E-mid-Eu	Cm - Sd	deciduous forest	dry	not specific	warm	moderate dry	low	
<i>Althaea officinalis</i>	r.f.	H	Eua-(Med)	Cm - Sd	deciduous forest	moderate wet	limy, basic	warm	moderate wet	moderate high	
<i>Althaea rosea</i> var. <i>nigra</i>	fl.	H-TH	S-Eu-(Med)	Cm - Sd	Sub-Mediterranean	fresh	not specific	warm	fresh	moderate high	
<i>Anethum graveolens</i>	h., fr., Aeth.	H	Med-E-India	Bw - Txt	Mediterranean, Atlantic-evergreen forest	fresh	not specific	moderate warm	moderate fresh	moderate high	
<i>Angelica archangelica</i>	h., r., rh., Aeth.	TH	Eua-N-Eu	Cmw - Wd	mixed coniferous deciduous forest	fresh	not specific	moderate cold	moderate wet	high	
<i>Anthemis nobilis</i>	fl., Aeth.	H	Med	Wdm - Sdm	Mediterranean, Atlantic-evergreen forest	fresh	not specific	warm-Med	fresh	low	
<i>Artemisia absinthium</i>	f., h., Aeth.	Ch-H	Eua-(Med)	Cmw - Sd	Sub-Mediterranean	moderate dry	slightly limy	warm	moderate dry	moderate	
<i>Artemisia annua</i>	h., Aeth.	Th	Eua	Cmw - Wmd	deciduous forest	moderate fresh	slightly limy	warm	dry	moderate	
<i>Artemisia dracunculoides</i>	h., Aeth.	H	N-E-As-(N-Am)	Bm - Wtm	mixed coniferous deciduous forest	moderate wet	close to neutral	warm	fresh	high	
<i>Borago officinalis</i>	s., Oil.	Th	As-S-Eu-Afr	Cmw - Sd	Sub-Mediterranean	fresh	not specific	warm	moderate fresh	moderate	
<i>Brassica</i> spp.	s.	Th	Eua-Med	Cmw - Txt	Sub-Mediterranean	dry	not specific	moderate warm	moderate dry	low	
<i>Calendula officinalis</i>	fl.	Th	Med	Cmw - Twv	Mediterranean, Atlantic-evergreen forest	dry	not specific	warm-Med	moderate fresh	moderate	
<i>Carthamus tinctorius</i>	fl.	Th	As-Ind-Med	Cmw - Tv	Mediterranean, Atlantic-evergreen forest	moderate dry	not specific	warm	moderate dry	moderate	
<i>Carum carvi</i> f. <i>annuus</i>	fr., Aeth.	Th	Eua-(Med)	Bm - Wdm	Sub-Mediterranean	moderate wet	close to neutral	moderate warm	fresh	moderate	
<i>Carum carvi</i> f. <i>biennis</i>	fr., Aeth.	TH	Eua	Bm - Txt	deciduous forest	wet	close to neutral	moderate cold	fresh	moderate	
<i>Chrysanthemum cinerariaefolium</i>	fl.	H	S-Eu-Med	Cm - Txt	Mediterranean, Atlantic-evergreen forest	rather dry	limy, basic	warm-Med	dry	low	
<i>Cnicus benedictus</i>	h.	Th	Med-As	Cmw - Txt	Sub-Mediterranean	moderate fresh	not specific	warm	dry	low	
<i>Coriandrum sativum</i>	fr., Aeth.	Th	Med	Cmw - Tv	Sub-Mediterranean	fresh	close to neutral	warm	moderate fresh	moderate	
<i>Cucurbita pepo</i> var. <i>styriaca</i>	s.	Th	Am-Trop	Cmw - Tv	Sub-Tropical	fresh	close to neutral	warm-Med	moderate fresh	high	
<i>Digitalis lanata</i>	f., h.	TH	Balk-Pann	Csm - Sd	Sub-Mediterranean	moderate dry	slightly limy	warm	moderate fresh	moderate high	
<i>Dracocephalum moldavica</i>	h., Aeth.	Th	E-mid-As	Cm - Wd	mixed coniferous deciduous forest	fresh	close to neutral	moderate warm	moderate fresh	moderate	
<i>Echinacea</i> spp.	r., h.	H	N-Am	Cm - Wd	mixed coniferous deciduous forest	fresh	close to neutral	warm	fresh	moderate high	
<i>Fagopyrum esculentum</i>	h.	Th.	Mid-As	Cm - Sd	mixed coniferous deciduous forest	fresh	close to neutral	warm	moderate fresh	low	
<i>Foeniculum vulgare</i>	fr., Aeth.	H	S-Eu-(Med)	Cmw - Tv	Sub-Mediterranean	moderate dry	close to neutral	warm	moderate fresh	high	
<i>Hippophae rhamnoides</i>	fr., Oil.	M	Eua-(Med)	Bm - Cm	Sub-Mediterranean	moderate dry	limy, basic	moderate cold	moderate dry	low	
<i>Humulus lupulus</i>	str.	H	Cirk	Cmw	deciduous forest	wet	not specific	moderate cold	moderate fresh	high	
<i>Hyoscyamus niger</i>	f., s.	H-Th	Eua-(Med)	Cmw - Tv	Sub-Mediterranean	moderate dry	not specific	moderate cold	moderate dry	high	
<i>Hypericum perforatum</i>	h., fl.	H	Eua-(Med)	Cmw	deciduous forest	moderate dry	not specific	moderate warm	moderate dry	moderate	

Species	Utilised plant part (drug)	Life form	Geographical distribution	Holdridge-Duke life zone parameters	Characterisation of original habitat by TWR values			Ecological requirement based on cultivation experiences		
					'T' temperature regime	'W' water regime	'R' soil reaction	Temperature	Water	Nutrition requirement
<i>Hyssopus officinalis</i>	h., Aeth.	Ch	Med-(As)	Cmw - Sd	Mediterranean, Atlantic- evergreen forest	dry	limy, basic	warm	dry	low
<i>Lavandula angustifolia</i>	f., h., Aeth.	N	Med-(S-Eu)	Cmw - Wmd	Mediterranean, Atlantic- evergreen forest	dry	limy, basic	warm-Med	dry	moderate
<i>Lavandula x intermedia</i>	f., h., Aeth.	N	Med-(S-Eu)	Cmw - Wmd	Mediterranean, Atlantic- evergreen forest	dry	limy, basic	warm-Med	dry	moderate
<i>Leuzea carthamoides</i>	h.	H	E-Sib-(midl-As)	Bm - Cm	taiga	moderate dry	not specific	moderate cold	moderate dry	high
<i>Levisticum officinale</i>	h., r., f., Aeth.	H	S-W-As	Cw - Wt	deciduous forest	fresh	not specific	moderate warm	fresh	high
<i>Linum usitatissimum</i>	s., Oil.	Th	E-Med	Cmw - Tvd	Sub-Mediterranean	moderate dry	slightly limy	moderate warm	moderate fresh	moderate
<i>Majorana hortensis</i>	h., Aeth.	Th	N-Afr-S-W-As	Cmw - Sdm	Mediterranean, Atlantic- evergreen forest	moderate dry	close to neutral	warm-Med	fresh	moderate high
<i>Malva sylvestris</i> subsp. <i>mauritiana</i>	fl., f.	H	Med-N-Afr	Cm - Sdm	Mediterranean, Atlantic- evergreen forest	moderate dry	close to neutral	warm-Med	fresh	moderate high
<i>Marrubium vulgare</i>	h.	H-Ch	Eua	Cmw - Wtm	Mediterranean, Atlantic- evergreen forest	moderate fresh	close to neutral	warm	moderate dry	low
<i>Matricaria recutita</i>	fl., Aeth.	Th	Eua	Cw - Sd	Sub-Mediterranean	moderate fresh	limy, basic	warm	moderate dry	low
<i>Melissa officinalis</i>	h., f., Aeth.	H	S-(Midl)-Eua	Cmw - Sd	deciduous forest	moderate dry	limy, basic	warm	moderate fresh	moderate high
<i>Mentha piperita</i>	h., f., Ae <sup>h</sup> .	H	E-As-(Eu)	Cmw - Sdw	deciduous forest	moderate wet	not specific	warm	et	high
<i>Ocimum basilicum</i>	h., Aeth.	Th	Ind-(S-As)	Cmw - Tmw	Mediterranean, Atlantic- evergreen forest	fresh	slightly limy	warm-Med	fresh	moderate high
<i>Oenothera erythrosepala</i>	s., Oil	Th	Eu-(N-Am)	Csm - Wdm	deciduous forest	moderate dry	not specific	warm	moderate dry	low
<i>Papaver somniferum</i>	cap., s.	Th	As-(W-Med)	Csw - Tvd	Sub-Mediterranean	moderate fresh	close to neutral	moderate warm	moderate fresh	moderate
<i>Pimpinella anisum</i>	fr., Aeth.	Th	Med-(N-Afr)	Cw - Sm	Sub-Mediterranean	moderate fresh	close to neutral	warm	moderate dry	moderate high
<i>Plantago</i> spp.	f.	H	Eua	Cm - Sd	deciduous forest	moderate fresh	not specific	moderate warm	dry	moderate
<i>Ruta graveolens</i>	h.	N	Med	Cmw - Tm	Mediterranean, Atlantic- evergreen forest	moderate dry	limy, basic	warm-Med	fresh	high
<i>Salvia officinalis</i>	f., Aeth.	H-N	Med	Cmw - Td	Mediterranean, Atlantic- evergreen forest	dry	limy, basic	warm-Med	moderate dry	moderate high
<i>Salvia sclarea</i>	Aeth.	Th-H	Med-As-N-Afr	Csm - Wdm	Mediterranean, Atlantic- evergreen forest	moderate dry	slightly limy	warm-Med	dry	moderate high
<i>Satureja hortensis</i>	h., Aeth.	Th	Med-W-As	Cw - Sd	Mediterranean, Atlantic- evergreen forest	dry	slightly limy	warm-Med	moderate dry	moderate
<i>Silybum marianum</i>	s.	Th	Med	Cm - Std	Mediterranean, Atlantic- evergreen forest	dry	close to neutral	warm-Med	moderate dry	low
<i>Sinapis</i> spp.	s.	Th	Med-W-As	Bw - Sd	Mediterranean, Atlantic- evergreen forest	moderate dry	not specific	moderate warm	moderate dry	low
<i>Thymus vulgaris</i>	h., Aeth.	Ch	Med	Cmw - Tdm	Mediterranean, Atlantic- evergreen forest	dry	limy, basic	warm-Med	dry	moderate
<i>Trigonella foenum-graecum</i>	s.	Th	Med-N-Afr	Cw - Tv	Mediterranean, Atlantic- evergreen forest	dry	limy, basic	warm-Med	moderate fresh	low
<i>Valeriana officinalis</i>	r., sh., Aeth.	H	Eua-(Med)	Cw - Tv	deciduous forest	moderate fresh	slightly limy	moderate warm	fresh	moderate high
<i>Verbascum phlomoides</i>	fl., f.	Th	Midl-Eu-(Med)	Cw - Sd	deciduous forest	dry	not specific	moderate cold	dry	low

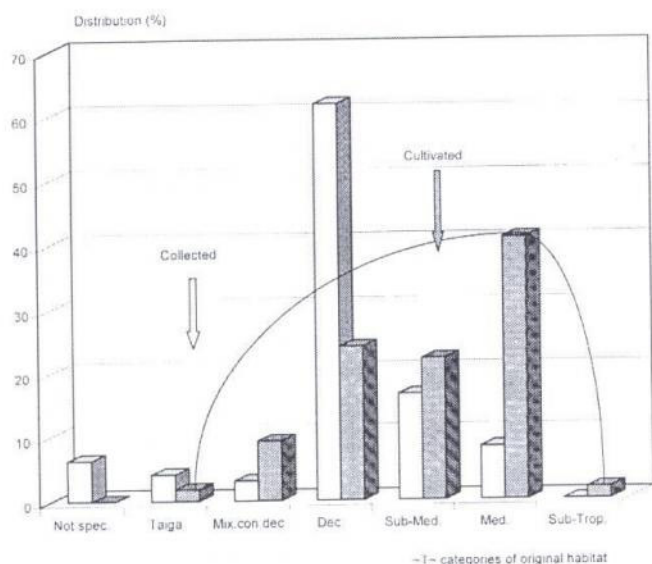
\* All abbreviation in text

## Results and discussion

### Differences in ecological requirements of wild growing and cultivated species

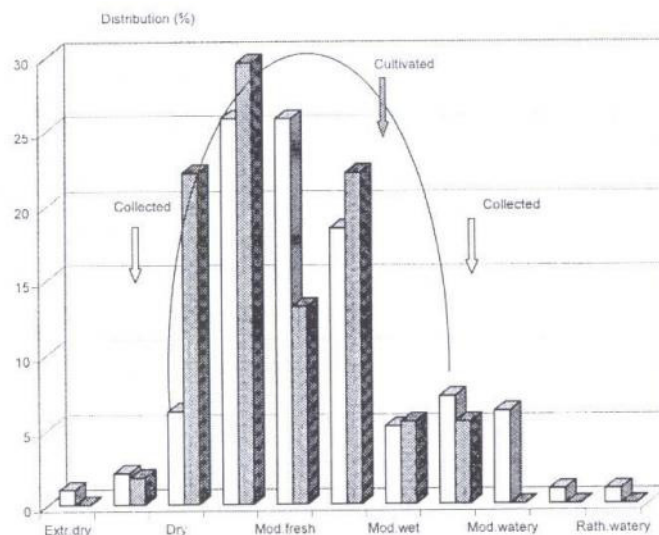
The main ecological characteristics of plant species registered and produced as medicinal and aromatic plants in Hungary are given in *Table 1.* and *Table 2.* It is obvious from the data that the ecological requirement of the two plant groups, collected and cultivated ones, are quite different. They can be distinguished easily, if the distribution of their temperature regime ('T') values are calculated and compared. Based on the data of *Figure 1.* the species used for cultivation require Submediterranean (Sub-Med.) and Mediterranean (Med.) type of climate, mainly. About 63 per cent of cultivated species belong to these two ecological groups. Furthermore the original habitat of one cultivated species (*Cucurbita pepo*) is assumed to be a Subtropical one. In contrary the majority of collected plants (61.8 per cent of them) are grouped into the category, which can be characterised by deciduous forest habitat.

The differences between collected and cultivated species are appreciable too, if the distribution of their characteristic water regime values ('W') are compared. By the data of *Figure 2.* the water requirement of cultivated species is less extreme as that of the collected ones. The majority of cultivated species require dry (moderate dry) and fresh (moderate fresh) habitats, and none of them occurs under extreme dry or watery habitats. In the case of collected species the amplitude of water requirement is much more wide-ranging. Species occur either in rather dry (*Thymus*



**Figure 1** Collected and cultivated groups of Hungarian medicinal and aromatic plants characterised by 'T' (temperature regime) values of their original habitats

**Not spec:** not specific, **Taiga:** taiga, **Mix.con.dec:** mixed coniferous deciduous forest, **Dec:** deciduous forest, **Sub-Med:** Submediterranean, **Med:** Mediterranean, **Sub-Trop:** Subtropical



**Figure 2** Collected and cultivated groups of Hungarian medicinal and aromatic plants characterised by 'W' (water regime) values of their original habitats

**Extr.dry:** extreme dry **Rath.dry:** rather dry, **Dry:** dry **Mod.dry:** moderate dry, **Mod.Fresh:** moderate fresh, **Fresh:** fresh, **Mod.wet:** moderate wet, **Wet:** wet **Mod.watery:** moderate watery, **Watery:** watery, **Rath.watery:** rather watery

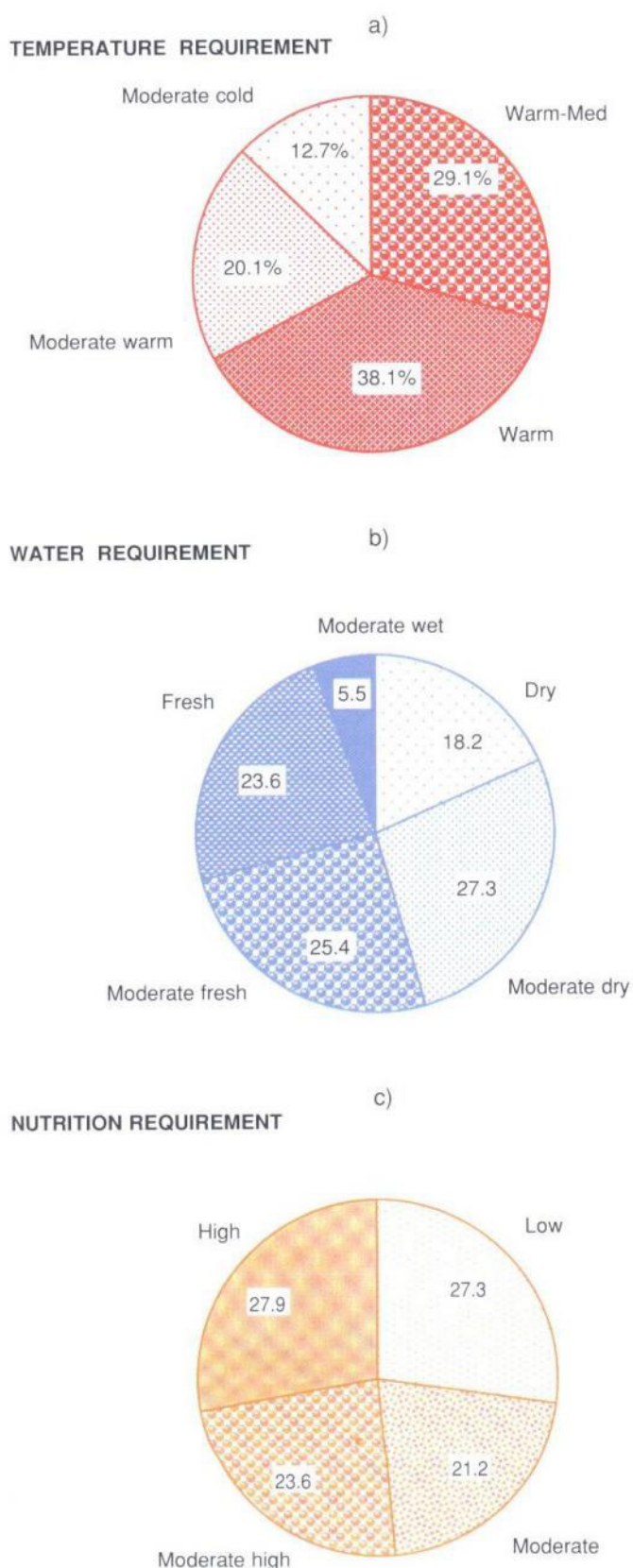
*serpyllum*, *Helichrysum arenarium*), extreme dry (*Alkanna tinctoria*), or in moderate watery (*Equisetum arvense*, *Filipendula ulmaria*, *Galega officinalis*, *Solidago gigantea*, *S. canadensis*, *Symphytum officinale*), watery (*Epilobium parviflorum*) and rather watery (*Acorus calamus*) habitats.

### Ecological requirements of species based on cultivation experiences

The ecological requirements of species belonging to the cultivated group of Hungarian medicinal and aromatic plants can be characterised by the results of experiences have been accumulated in the course of practical production. The ecological characteristics of the species, which were taken from the up to date survey of that subject (Bernáth, 1992, Bernáth, 1993, Bernáth, 2000) are specified in *Table 2.*

In harmony with our earlier statements – concerning the characterisation of original habitats of the species - the majority of medicinal and aromatic plants, which are cultivated on a large scale in Hungary require warm or warm Mediterranean conditions (*Figure 3.a*). It does mean that about 70 per cent of species prefer cultivation sites situated in a South part of Hungary or in the special regions having warm slopes, or soil types warming up easily. The ratio of species requires moderate cold conditions are relatively small. Characteristic species belonging to that later group are *Angelica archangelica*, *Carum carvi f. biennis*, *Hippophaë rhamnoides*, *Humulus lupulus*, *Hyoscyamus niger* and *Verbascum phlomoides*.

The optimum of water supply is an important phenomenon from both theoretical and practical point of view. Based on the practical experiences fresh or wet soil



**Figure 3** The ecological requirements of species belonging to the cultivated group of Hungarian medicinal and aromatic plant characterised by temperature (a), water (b) and nutrition (c) requirements

conditions are required by about the half of cultivated species (Figure 3.b). Especially the high water consumption of *Angelica archangelica*, *Echinacea* spp., *Humulus lupulus*, *Levisticum officinale*, *Mentha piperita*, *Valeriana officinalis* has to be emphasized. However, there are some species, which are less sensitive to the water condition of soil, but need regular, or occasional irrigation under Hungarian conditions. Species belonging to that group are *Calendula officinalis*, *Cucurbita pepo* var. *styriaca*, *Digitalis lanata*, *Majorana hortensis*, *Ocimum basilicum*.

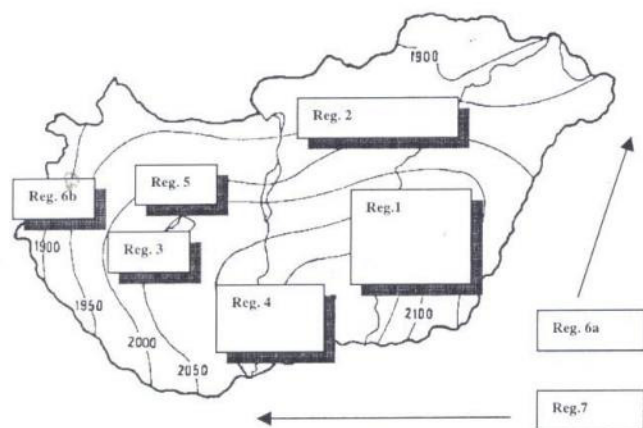
According to the nutrition requirement medicinal and aromatic plants cultivated on a large scale in Hungary can be divided into four groups (Figure 3.c). Especially groups of high and low nutrition requirements have to come into consideration. 27.9 percent of cultivated species need high level of fertilisation. According to the practical observations *Angelica archangelica*, *Cucurbita pepo* var. *styriaca*, *Hyoscyamus niger*, *Leuzea carthamoides*, *Levisticum officinale*, *Mentha piperita*, *Ruta graveolens* are the most important members of that group. Contrary, about the same number of species (15) need low level of nutrition supply. These species usually originated from the xerophilous habitat of Mediterranean region or from local ruderal flora. Some of these species can be utilised for exploitation of fields of unfavourable character.

#### Regional specialisation of medicinal and aromatic plant production

The regional specialisation in Hungary for utilisation of indigenous flora is known from the beginnings of the 20<sup>th</sup> century. This type of specialisation was the result of the increasing demand for plant raw due to the enlarging home and export demand. This specialisation took place spontaneously and the utilisation of indigenous flora was completed by cultivation, afterwards. As a result of spontaneous specialisation well-defined production areas have appeared, which have had a great influence on the effectiveness of medicinal plant sector in the past and may effect its future development as well. The actual regions of production and one of the important factors of our climate (duration of sunshine) are indicated in map of Hungary, parallel (Figure 4)

*Region 1.:* The Great Plain of Hungary is a dry countryside (500–550 mm precipitation per year) characterised by 2000–2100 hour of duration of sunshine and 21–22 °C mean temperature in July being the most important region of camomile (*Matricaria recutita*) production. This specialisation had been started at the beginning of the century and was effected by both biological and social-economical factors. The *Chamomillae flos* became a well-known Hungarian product and sold on the world market with high success. By the data of trade companies in the harvesting time of camomile flowers as much as 15,000–20,000 people are involved into the collection even nowadays. Because of the short time-period of camomile harvest and processing (one or two month





**Figure 4** Main regions specialised for production of medicinal and aromatic plants in Hungary and their climatic background indicated by total duration of sunshine (Bernáth, 1998a, Tókei, 1997)

under optimum condition) the regional activity had to be completed by utilisation of other medicinal and aromatic plants being indigenous and adapted well to the ecological conditions of the region (*Juniperus communis*, *Achillea collina*, *Gypsophila paniculata*, *Crataegus* spp. *Rosa* spp. etc.). Based on this expanded activity the processing centres were settled all around the border of the region (Balmaúzváros, Füzesabony, Békéscsaba, Meggyesegyháza, etc.).

**Region 2.:** The development of special region for utilisation of indigenous plant flora was obvious in mountain areas of Hungary from the beginning of our century. The climate of this region can be characterised by 600–800 mm of precipitation, 1900 hours of sunshine and about 19 °C mean temperature in July. In that production area many species, which were characterised by deciduous habitat in Table 1. could be collected (*Achillea collina*, *Crataegus* spp., *Hypericum perforatum*, *Rosa* spp., *Sambucus nigra* etc.), based on buying up systems and centralised processing facilities installed there. As examples Balassagyarmat, Pásztó, Örbottyán and other towns are the centres of medicinal and aromatic plant production at the Northern part of Hungary.

**Region 3.:** That special region had been created for lavender cultivation (*Lavandula angustifolia* and *L. intermedia*) based on ecological considerations, mainly. The plantation was made on the south slopes of Tihany Peninsula and in the neighbouring territories (Balatonakali, Daránypuszta etc.) which have some kind of Mediterranean meso-climatic character. However, the macroclimate of neighbouring territories is much similar to that of the region 5. (2000–2050 hour of sunshine, 600–800 mm of precipitation, 20–21 °C mean temperature in July). The importance of lavender plantation and the region at all decreased in the past decades.

**Region 4.:** Both ecological and economical considerations lead to the formation of region specialised for thyme (*Thymus vulgaris*), marjoram (*Origanum*

*majoranna*) and basil (*Ocimum basilicum*) in the south part of Hungary being relatively warm and supplied by appropriate sunshine (2100–2150 hour of sunshine, 550–700 mm of precipitation, 20–21 °C mean temperature in July), which climate meets the ecological requirement of species being of Mediterranean and Subtropical origin. From economical point of view this area is known as a main cultivation area for red pepper too. The drying and post harvest processing of red pepper and medicinal and aromatic plant species show lot of similarity. It does mean that the available technology and the processing facilities settled in the region can be utilised by both group of plants.

**Region 5.:** The formation of cultivation area of ergot (*Claviceps purpurea*) was motivated by both ecological and economical considerations. From the wide-ranging cultivation areas of host plant (*Secale cereale*) such a special area had to be chosen in which the ecological conditions were suitable for the development of fungi (2000–2050 hour of sunshine, 600–800 mm of precipitation, 20–21 °C mean temperature in July). As a result of compromise the southwest slopes of Bakony mountain were selected for the purpose. The cultivation area had been equipped afterwards with valuable cultivation and post harvest technological tools.

**Region 6.:** The cultivation of poppy (*Papaver somniferum*) has a great tradition in Hungary (Sárkány et al., 2000). It is due to its wide-ranging utilisation being an important food plant and source of oil and industrial raw at the same time. The cultivation region can be divided into two sub-regions. The cultivation of spring sown type varieties (Region 6a) is concentrated into the Great Plain of Hungary and some parts of the north-west regions of the country (2000–2150 hours of sunshine, 650–700 mm of precipitation, 20–22 °C in July). The cultivation of the autumn sown type varieties, because of their over-wintering risk is situated at the western part of Hungary (Region 6b) where the winter is usually much milder and the snow covers the field more frequently (characterised by 1900–950 hours of sunshine, 700–800 mm of precipitation, 19–20 °C or less mean temperature in July).

**Region 7.:** There are several medicinal and aromatic plants, which can be cultivated in Hungary without much territorial restriction. (characterised by wide range of climatic parameters: 1900–2150 hours of sunshine, 600–800 mm of precipitation, 19–22 °C, or warmer mean temperature in July) The majority of species belonging to the Apiaceae family (*Foeniculum vulgare*, *Carum carvi*, *Anethum graveolens*, *Coriandrum sativum*, *Pimpinella anisum* etc.), mustard (*Sinapis* and *Brassica* spp.) *Silybum marianum*, *Cucurbita* spp. etc. can be cultivated under various conditions with exception of mountainous and extreme areas.

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