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Flora and vegetation of the Slovak vineyards

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Die Weinrebe wird auf einer Fläche von 29 707 ha im südlichen Teil der Slowakei bis in eine Höhe von 320 m ü.NN auf den weniger fruchtbaren Böden, und zwar vorwiegend auf den Abhängen des Vorgebirges der Westkarpaten und auf den Abhängen des Vorgebirges der Westkarpaten und auf den Sandböden der slowakischen Tiefebene angebaut.

Die slowakischen Weinberge wurden an Stelle der ursprünglichen thermophilen laubabwerfenden Wälder im Areal der pannonischen und Westkarpatenflora gegründet. In der Unkrautflora der bewirtschafteten Weinberge kommen diese Florenelemente nur noch wenig zur Geltung. Einjährige Arten überwiegen, während Baumarten selten vorkommen. Typische Segetalunkräuter sind die häufigen Arten der Weinberge, während nicht segetale Pflanzen weniger oft vorhanden sind. Das Zahlenverhältnis dieser beiden Gruppen ist bei den einjährigen Pflanzen 1 : 1, bei den ausdauernden jedoch etwa 1 : 3. Die Unkrautflora auf den Sandböden besitzt einen spezifischen Charakter: Hier überwiegen thermophile Arten südlicher Herkunft.

Die Unkräuter kommen mit einer typischen Saisondynamik vor. Es wurden saisonale Etappen und saisonale Aspekte unterschieden. Die Dauer der Aspekte wird durch agrotechnische Maßnahmen eingeschränkt.

In den slowakischen Weinbergen kommen zur Zeit keine speziellen Weinberg-Unkrautgesellschaften vor. Die Assoziationen lassen sich in drei Gruppen einteilen:

I. Verband *Eu-Polygono-Chenopodion polyspermi* auf den Tonböden in den nördlichen Regionen,

II. Verband *Panico-Setarion* auf den Tonsandböden in den Niederungen,

III. Ordnung *Eragrostietalia* auf den Sandböden und Sanddünen.

Die Vegetation der aufgegebenen Weinberge, einschließlich der Problematik ihres Schutzes wird kurz beschrieben. Außerdem wird der Einfluß einer langfristigen Anwendung von Herbiziden auf die Unkrautflora und -vegetation der slowakischen Weinberge angesprochen.

Abandoned vineyards, chemical weed-control, plant succession, seasonal dynamics, vineyard-regions, weed aspects, weed communities, weed flora.

1. Introduction

Flora and vegetation of the vineyard areas in Slovakia have not been systematically studied. More attention evoked only herbicide use for weed killing in vineyards. Only following botanical problems were analysed: weed communities in cultivated vineyards (JURKO 1964; ELIÁŠ 1974b, 1981), seasonal dynamics of weed occurrence in vineyards (ELIÁŠ 1971, 1978), and vegetation succession in abandoned vineyards (OSVAČILOVÁ 1956; ELIÁŠ 1980b). A short survey of the recent state of the weed research in the Czechoslovak vineyards was published by ELIÁŠ (1980a)

The thorough scientific knowledge of the weed flora of vine-growing areas is of a great importance both from the point of view of agrobotany and that of agricultural praxis (UBRIZSY 1967). Agrobotanical and agrophytocoenological researches in vineyard areas reveal species structure of weed flora, distribution and quantitative occurrence of individual species in several vineyard regions. They help to distinguish common species, most important species as well as rare or scarce species in vineyard areas. They also contribute to the knowledge of the most frequent weed-species combinations, of weed communities, of ecological behaviour of weeds and of conditions under which they associate into communities etc. They render possible to obtain data inevitable needed for effective mechanical, chemical or biological weed-control in vineyards. The long-term research of weeds in a territory made possible the prediction of weed-species occurrence and degree of weed occurrence in next years, considering also weather conditions as well as man's agrotechnical measures.

The informations detailed concerning the weed flora and communities enable an elaboration of new principles of weed control based on certain degree of weed occurrence, weed aspects and weed communities. They enable the elaboration of proper agrotechnical measures, assortment and rotation of herbicides etc. indispensible in the effective and economical control of weed in vineyards (UBRIZSY 1967). Vineyards as a perennial row-crop are also important and interesting objects for phytocoenological studies of the weeds. They contribute to the solution of syntaxonomical classification problems of weed communities in arable fields.

This contribution deals with the weed flora and communities of cultivated vineyards, seasonal dynamics of weed occurrence in vineyard areas, with vegetation succession in vineyards fallowed as well as with chemical weed-control effects on weed flora and communities of the Slovak vineyards. It is based on the author's data obtained by him during the last ten years (1969 to 1980). It also contains informations on ecology of vineyard-regions of Slovakia.

2. Vineyard areas in Slovakia

The cultivation of grapes (viniculture) in the territory of the present-day Slovakia has a long history (about 1500 years). Its origin reaches to 3th century and it is connected with the presence of the Roma-empire legions in the Danube-river valley (e.g. Devín near Bratislava in SW-Slovakia). Vineyard areas in Slovakia changed following periods of viniculture declines and expansions. In 1720, vineyard area in the present-day Slovakia only was about 57 000 ha (KIŠON, HANÁK 1962). During the second half of 19th century it was a gradual decline of viniculture caused by hard frosts and mainly new grape pests imported from North America. Restoration of the vineyard areas started in the beginning of 20th century and it continues up to now.

A new stage in the Slovak viniculture started in 1948. In the period of 1949-1960, the Research Institute for Viniculture and Winery in Bratislava realized field research resulted in regionalization of vineyard areas in Czechoslovakia (KIŠON, HANÁK 1962) and it gave a scientific basis for further development of the viniculture in Czechoslovakia. At present, the Slovak viniculture has a large-scale character (cooperative farms and governmental farms), but important part of vineyards has as yet a private small-scale character.

The Czechoslovak vineyard areas occur in the north boundary limited the economic profitable cultivation of the grape-vine in Central Europe. The Czechoslovak viniculture, therefore, reaches not high grape-yields per hectare, but produces the wines with high quality, with features specific for cultivars planted and typical for the Czechoslovak cultivation conditions. At present time, vineyards in Slovakia occur on the area of 29 707 ha (this is more than 1% of total agricultural land area) and grape yields are about 6.06 tons per hectare (see Table 1).

In Slovakia, the following vineyard regions were distinguished (KIŠON, HANAK 1962; see Fig. 1):

1) The Skalica-Záhorie region
2) the Malé Karpaty region
3) the Hlohovec-Trnava region
4) the Nitra region
5) the Danube-valley region
6) the Modrý Kameň region
7) the East Slovakia region
8) the Tokaj region.

Short ecological characteristics of the vineyard regions are given in Table 2. The largest area of vineyards occur in the Malé Karpaty region (i.e. 3 227.94 ha in 1960). This is the most intensive and the most important vineyard region of the Czechoslovakia with the highest concentration of the vineyard areas and with a typical vineyard landscape.

On the other hand, the vineyard areas are far spatially dispersed in the Nitra, Modrý Kameň and East Slovakia regions with 158, 155 and 101 settlements with vineyard areas, respectively. More than 50% of the vineyard area of the Czechoslovakia occur in western part of Slovakia. The vineyards produce more than 60% of the grape and wines.

Table 1: Some statistical data on the Czechoslovak viniculture

	number of vineyard regions	number of settlements with v.a. (1960)	vineyard areas (v.a.) (ha) 1960	1980	grape yield (means) (t/ha) 1967 - 1980
Bohemia	1	42	192.97	14548	7.24
Moravia	3	304	6095.39		6
Slovakia	8	632	13351.40	29707	6.06
Czechoslovakia	12	978	19639.76	44255	6.43

Table 2: Some ecological data on the Slovak vineyard regions

vineyard-regions	vineyard area 1960 (ha)	number of vineyard settlements	number of vineyard districts	geographical regions	climatical region *	terrain (elevation and slope)	phytogeographical regions	natural vegetation
Skalica-Záhorie	536.41	38	3	Záhorská nížina Myjavská pahorkatina Malé Karpaty Biele Karpaty	T_4, T_2	200-240 m 5-12°	Eupannonicum Praecarpaticum	acidophilous *Pinus sylvestris* forests on sandy dunes, thermophilous oak forests, oak-hornbeam forests
Malé Karpaty	3227.94	23	2	Malé Karpaty Podunajská nížina	T_2, MT_9, MT_{10}	160-280 m 5-30°	Praecarpaticum (Eupannonicum)	oak-hornbeam forests, oak and *Quercus cerris* forests
Hlohovec-Trnava	1852.14	105	7	Podunajská nížina Považský Inovec (Malé Karpaty)	T_4, T_2	160-240 m	Eupannonicum Praecarpaticum	oak-hornbeam forests, oak and *Q. cerris* forests, xerophilous oak forests
Nitra	3116.54	155	10	Tríbeč Podunajská nížina Pohronský Inovec Burda	T_4, T_2, T_5, T_3, MT_{11}	160-240 m (-340 m) 3-6-18°	Praecarpaticum Eupannonicum Matricum	oak-hornbeam forests, oak and *Q. cerris* forests, xerophilous oak forests
Danube-valley	1862.56	45	3	Podunajská nížina	T_5	110-210 m 0-5-10°	Eupannonicum	oak and *Q. cerris* forests, xerophilous oak forests, pontic-pannonian oak forests
Modrý Kameň	1157.02	158	11	Krupinská planina Cerová vrchovina Juhoslovenská nížina Slovenské Rudohorie	T_4, T_5, T_1 T_3	120-300 m 6-24°	Matricum (Praecarpaticum)	oak-hornbeam forests, xerophilous oak and *Q. cerris* forests
East Slovakia	1177.83	101	12	Vihorlat Východoslovenská nížina Slánske vrchy Slovenský kras	T_3, T_1	105-280 m 4-25°	Praecarpaticum Eupannonicum Matricum	oak-hornbeam forests, oak and *Q. cerris* forests, xerophilous oak forests
Tokaj	420.96	7	1	Zemplínske vrchy Východoslovenská nížina	T_3	139-250 m 5-25°	Eupannonicum	oak-hornbeam forests, oak and *Q. cerris* forests

* according QUITT (1971)

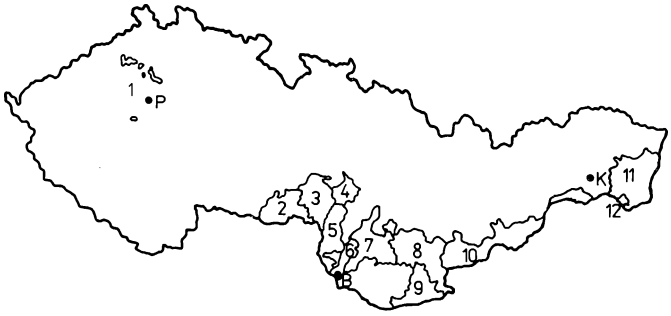

Fig. 1: The geographical distribution of the vineyard areas in Czechoslovakia.
P - Prague, B - Bratislava, K - Košice.
Bohemia: 1 - the Czech vineyard region (v.r.)
Moravia: 2 - the Znojmo-Mikulov v.r.
3 - the Hustopeč-Hodonín v.r.
4 - the Bzenec-Strážnice v.r.
Slovakia: 5 - the Skalica-Záhorie v.r.
6 - the Little Carpathians v.r.
7 - the Hlohovec-Trnava v.r.
8 - the Nitra v.r.
9 - the Danube-river valley v.r.
10 - the Modrý Kameň v.r.
11 - the East Slovakia v.r.
12 - the Tokaj v.r.

Vineyard areas occur in the territory of southern part of Slovakia (Fig. 1): in large Lowlands (Záhorská, Podunajská, Juhoslovenská, and Východoslovenská) and in slopes at the foot of the lower mountains of the West Carpathians (Malé Karpaty, Tríbeč, Vihorlat, Zemplínske Vrchy, Slánske Vrchy, Slovenský Kras etc.). The altitudes of the areas range from 105 to 340 meters, but in large-scale cultivations the altitude maximum is 320 m above the sea level.

In Slovakia, the grape-vine is cultivated in the agricultural ground which is less suitable or unsuitable for other field crops. There are mainly slope grounds at south foots of the mountains, furthermore sandy soils in plains of the lowlands in southern Slovakia. Nearly 75% of vineyards were planted in slopes, the rest in plains, mainly in the Podunajská Záhorská lowlands.

The Slovak vineyard areas occur in different macroclimatical conditions (see Fig. 2), however, most of them occur in the warmest climatic regions of the Czechoslovakia, designated by QUITT 1971 als T_1, T_2, T_3 and T_4 units of warm climatic regions. Some vineyards occupying high slopes of foots of the Malé Karpaty, Tríbeč, and Považský Inovec Mountains lay in only moderately warm climatic regions (MT_9, MT_{10} and MT_{11} sensu QUITT 1971). In the last case, the microclimatical conditions differ from climatic characteristics of the macroclimatical regions. Sunny southern, southwestern and southeastern slopes offer good properties for better ecological, mainly temperature conditions.

Within the Slovak vineyard areas, mean annual temperatures vary between (7)-8-10 °C, annual sums of precipitation range from 550 to 800 mm (in vine growing period from 300 to 450 mm) and annual sums of sunshine are higher than 2000 h. Mean January temperature is usually higher than -5 °C and number of days with frost per year range from 90 to 130. Number of days with mean temperature 10 °C and more varies between 140 and 180 (and more) and is usually higher than 160. Mean Juli temperature is usually 17 to 20 °C and number of summer days ranges from 40 to 70.

Maternal substrates for soils of the Slovak vineyards are rocks of different geological age. In Lowlands there are Tertiary substrates (Neogene), but in piedmonts of the mountains there are lower eruptive rocks (Granite etc.), upper Paleozoic (Carboniferous, Permian), lower Mesozoic (Triassic) and upper eruptive rocks (Andesite, Basalt etc.). In the vineyard areas various soil associations occur: degraded Chernozem or black soils, brown soils with gleyic layer, but in the piedmonts brown forest soils prevail. Sandy soils, i.e. soils with more than 70% of sand particles (0.02 to 2 mm in diameter), occur in three different geographical regions of Slovakia: a) in Southern Slovakia, namely in Podunajská nížina, in plains with 3500 ha suitable for the grape-vine cultivation; the soils contain 5 to 10% of $CaCO_3$. b) in the Záhorie region, namely in Záhorská nížina, with approx. 1000 ha suitable for European cultivars of the grape-vine; the soils contain more than 90% of silicate sand without $CaCO_3$. c) in the East Slovakia, namely in Východoslovenská nížina, with total area from 600 to 700 ha.

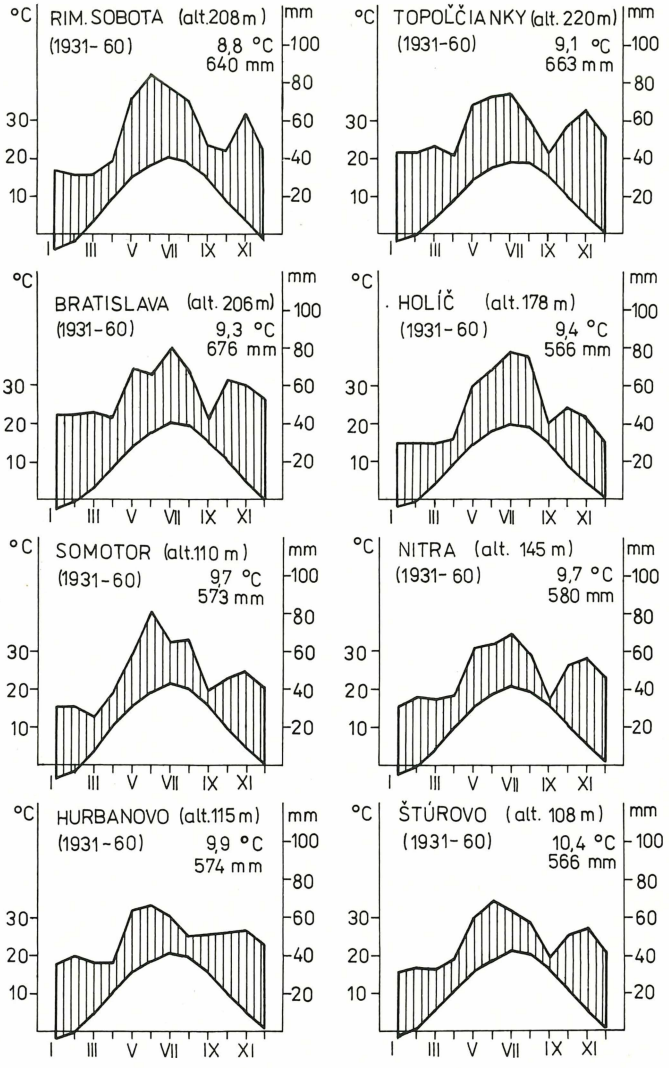

Fig. 2: Climadiagrams for some selected vineyard localities in Slovakia illustrating macroclimatical conditions of the Slovak vineyard areas.

3. Grape-vine crop and its management in Slovakia

Vineyards are peculiar perennial row-crops with typical stand structure. In these plantations, grape-vine plants are planted in parallel rows. The inter-rows distance varies from 1.3 m in traditional private small-scale cultivations to 1.8 - 2.2 m and 3.0 - 3.2 m in modern large scale vineyards. Grape plants in rows are distant 1.2 m in former case and 1.2 - 1.3 m in the latter one. In 1980, the vineyards with wide inter-row and inter-plant distances occurred in 50% of total vineyard area of Czechoslovakia (43.6% in Slovakia), and vineyards with middle wide distances in 32.3% (33.8%). The rest formed vineyards with narrow distances between rows and between plants within rows. The rows are usually oriented perpendicular to slopes or parallel with slopes but in slopes with high inclinations they are planted on terraces. In old vineyards, the grape plants were formed as "root-crown" and were supported by woody stakes. At present, in modern vineyards heavy wires stretched between cement or iron posts are usually used to support the grape plants.

Traditional agrotechnique of grape-vine cultivations was characterized by traditional soil cultivation as the hand-hoeing and hand-spadeing. The furrows had been plowed to a depth of 20-30 cm at least once a year and the mounds had been hoed periodically. Weed control was based on mechanical weed killing such as hand-weeding, and repeated soil cultivations (3-5 hoeings yearly). The vineyard soils were manured by stable dung produced by domestical animals. In new vineyards constructed during the past 20-25 years, large-scale production methods are used. The grape-vine plant treatments are mechanized using peculiar machineries. Mechanical soil cultivation of the inter-row areas is combined with herbicide treatments. In vine rows the hand-hoeings and/or herbicide treatments are used. The vineyards are fertilized by fertilizers. For other informations on the grape-vine management in Slovakia see e.g. JAŠA (1969) and VEREŠ et al. (1980).

Possibilities and manners of herbicide applications for weed killing in the Slovak vineyards have been verified since 1960 in experimental plots (cf. RÁGALA 1963, 1971; ELIÁŠ 1980a), but in viniculture praxis first herbicides were introduced three years later. During the past 20 years the vineyard areas treated by herbicides as well as the amount sold of herbicides for weed killing rapidly increased in vineyards of Czechoslovakia (cf. Fig. 3). The vineyard areas treated by herbicides were in 1971 and 1975 4 180 ha and 12 790 ha, respectively. This is 2.18% of total Czechoslovak vineyard area in former case, and 2.81% in latter one. The herbicides used for weed killing in vineyards were Simazin (1963), Hungazin DT (1964-1967) and after 1967 several other selective herbicides, e.g. Herbex, Gesatop 50, Semparol, Gramoxone, Prefix, Casaron, Caragard etc.

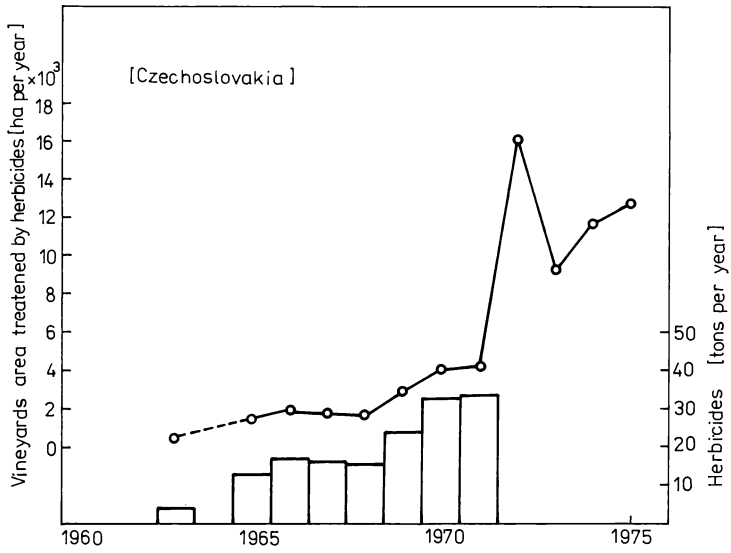

Fig. 3: Vineyard areas treated by herbicides and sold amounts of selective herbicides for weed killing in vineyards of Czechoslovakia (1963-1975).

4. Weed flora of the Slovak vineyards

Slovak vineyards lay mainly in the region of Central-European and East-European thermophilous pannonian flora (Pannonicum) and partly, the northern vineyard districts, also in the region of the West-Carpathians flora (Carpaticum occidentale; cf. Table 2). The survey of the phytogeographical units occurring in vineyard areas of Slovakia is given in Table 3. In the vicinity of cultivated vineyards and in fallow vineyards many thermophilous and xerophilous species (xerothermophytes) occur; some of them are recognized as rare or scarce species of the Slovak native flora. But in cultivated vineyards they occur rarely and usually accidentally, in few individuals only.

Table 3: Survey of the phytogeographical units occurring in vineyard-areas of Slovakia.

The Pannonical Province (Pannonicum)	
Eupannonicum	Devínska Kobyla
	Záhorská nížina
	Podunajská nížina
	Košická kotlina
	Východoslovenská nížina
Matricum	Burda
	Ipeľsko-rimavská brázda
	Slovenský kras
The Carpathian Subregion (Carpaticum)	
Praecarpaticum	Biele Karpaty
	Malé Karpaty
	Považský Inovec
	Tríbeč
	Slovenské Stredohorie
	Slovenské Rudohorie
	Slánske vrchy
	Vihorlat

Slovak vineyards were established in the areas early occupied by broad-leaved forests, usually thermophilous and xerophilous oak forests (alliances *Quercion pubescenti-petraeae* Br.-Bl. 1931, *Querco-Potentillion* sensu Knapp 1944, *Aceri-tatarici-Quercion* Zolyomi 1957) and by warm variants of oak-hornbeam forests (*Carpinion betuli* Mayer 1937, Oberdorfer 1953), locally also on rocky grasslands and sandy dunes. In present vineyard weed-flora the species of original vegetation usually are absent or some of them are few frequent and their importance is slight. Only vineyards in sandy dunes form an exception. Present weed flora of the Slovak vineyards is formed predominantly by the species with large ecological amplitude; many of them are 'ubiquitous' and typical colonizing species spread over the whole world. Thy are adapted to man-made habitats and interfering there with human activities, and often exhibit phenotypic plasticity and heterogeneity within the species.

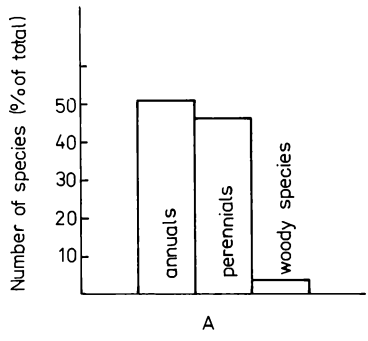

Fig. 4: Weed flora structure of the Malé Karpaty vineyard region according growth forms.

Table 4: Flora of the cultivated vineyards in the Malé Karpaty vineyard region

growth forms	common species	frequent species	less frequent species	rare species
Annual grasses	*Setaria viridis*	*Digitaria sanguinalis* *Echinochloa crus-galli* *Poa annua*	*Bromus arvensis* *Bromus sterilis*	*Bromus arvensis* *Hordeum murinum* *Setaria glauca*
Annual (and biennial) forbs	*Amaranthus retroflexus* *Anthemis arvensis* *Capsella bursa-pastoris* *Chenopodium album* *Conyza canadensis* *Fumaria officinalis* *Galinsoga parviflora* *Lamium amplexicaule* *Lamium purpureum* *Mercurialis annua* *Senecio vulgaris* *Stellaria media* *Solanum nigrum* *Sonchus asper* *Veronica persica* *Veronica polita* *Viola tricolor* *Tripleurospermum maritimum*	*Amaranthus lividus* *Anagallis arvensis* *Anthirrhinum orontium* *Cerastium brachypetalum* *Chenopodium hybridum* *Chenopodium polyspermum* *Daucus carota* *Erodium cicutarium* *Euphorbia helioscopia* *Fallopia convolvulus* *Filago arvensis* *Galium aparine* *Galium tricorne* *Geranium pusillum* *Malva neglecta* *Medicago lupulina* *Oxalis stricta* *Papaver rhoeas* *Polygonum aviculare* *Polygonum persicaria* *Sonchus oleraceus* *Thlaspi arvense* *Veronica arvensis* *Veronica hederifolia* *Vicia lathyroides*	*Atriplex patula* *Cerastium vulgare* *Chaenorrhinum minus* *Erysimum cheiranthoides* *Lactuca serriola* *Lycopsis arvensis* *Matricaria chamomilla* *Polygonum tomentosum* *Portulaca oleracea* *Raphanus raphanistrum* *Scleranthus arvensis* *Sinapis arvensis* *Stachys annua* *Urtica urens*	*Amaranthus chlorostachys* *Atriplex acuminata* *Atriplex oblongifolia* *Chelidonium majus* *Chenopodium glaucum* *Chenopodium urbicum* *Conringia orientalis* *Datura stramonium* *Galium parisiense* *Galium spurium* *Holosteum umbellatum* *Lappula myosotis* *Lapsana communis* *Myosotis arvensis* *Myosotis micrantha* *Neslia paniculata* *Persicaria hydropiper* *Polygonum mite* *Ranunculus arensis* *Reseda lutea* *Senecio vernalis* *Sherardia arvensis* *Sinapis sativa* *Spergula arvensis* *Spergularia rubra* *Veronica triphyllos* *Vicia tetrasperma*
Perennial grasses	*Agropyron repens*	*Arrhenatherum elatius*	*Lolium perenne* *Poa trivialis*	*Agrostis alba* *Poa pratensis*
Perennial forbs	*Achillea millefolium* *Cirsium arvense* *Convolvulus arvensis* *Linaria vulgaris* *Sonchus arvensis* *Taraxacum officinale*	*Aristolochia clematitis* *Artemisia vulgaris* *Cardaria draba* *Coronilla varia* *Glechoma hederacea* *Lathyrus tuberosus* *Plantago lanceolata* *Plantago major* *Potentilla reptans* *Rumex acetosella* *Rumex crispus* *Tragopogon dubius* *Vicia hirsuta*	*Armoracia rusticana* *Centaurea scabiosa* *Falcaria vulgaris* *Lactuca viminea* *Linaria genistifolia* *Pimpinella saxifraga* *Potentilla argentea* *Potentilla recta* *Rorippa silvestris* *Stellaria graminea* *Symphytum officinale* *Trifolium pratense* *Trifolium repens* *Tussilago farfara* *Veronica chamaedrys*	*Anthemis tinctoria* *Anthriscus silvestris* *Asperula cynanchica* *Ballota nigra* *Barbarea vulgaris* *Berteroa incana* *Bryonia dioica* *Campanula* spec. *Centaurea stoebe* *Chondrilla juncea* *Cichorium intybus* *Cirsium vulgare* *Diplotaxis muralis* *Echium vulgare* *Epilobium parviflorum* *Epilobium roseum* *Equisetum arvense* *Eryngium campestre* *Euphorbia cyparissias* *Euphorbia esula* *Fragaria* spec. *Galeopsis pubescens* *Galium mollugo* *Galium pumilum* *Hieracium pilosselloides* *Hypericum perforatum* *Inula britannica* *Lactuca quercina* *Lathyrus silvestris* *Medicago sativa* *Melilotus officinalis* *Odontites rubra* *Rumex obtusifolius* *Silene alba* *Solanum lycopersicum* *Tanacetum vulgare* *Trifolium campestre* *Trifolium dubium* *Verbascum phlomoides* *Vicia cracca* *Vicia sativa* *Vicia villosa*
Woody perennials				*Clematis vitalba* *Juglans regia* *Prunus spinosa* *Robinia pseudacacia* *Rubus fruticosus* *Rubus idaeus* *Sambucus racemosa*

For an analysis of the weed flora of the Slovak vineyards we used the flora of the Malé Karpaty region (Table 4). This is a typical flora for vineyards on loamy and sandy-loamy soils with soil reactions nearly neutral. Species richness of the flora is more than 180 species. In comparison of all species found in the vineyards, annuals little prevail (50.5% of all species), perennial herbs are frequent (46.1%) and woody perennials are rare (cf. Fig. 4). Common and frequent species are typical segetals (agrestals) occurring in arable fields (total 68 species). Most of less frequent and rare species are typical non-segetal species which originally belong to natural or seminatural vegetation (e.g. several perennial herbs: *Lactuca viminea, L. quercina, Potentilla recta, Linaria genistifolia, Anthemis tinctoria, Odontites rubra, Asperula cynanchica, Lathyrus silvestris)* and many ruderals (cf. Table 4). Some of less frequent and rare annual species are weeds with specific requirements (e.g. *Portulaca oleracea*, some are cereal weeds).

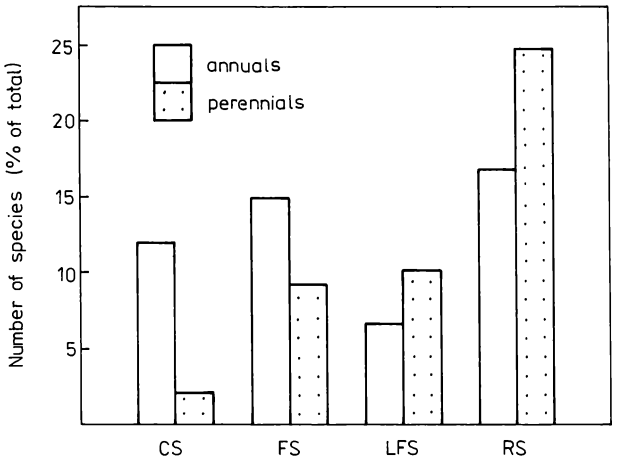

Fig. 5: Analysis of the weed flora of the Malé Karpaty vineyard region according presence or absence in vineyard-settlement localities.
CS - common species, FS - frequent species, LFS - less frequent species, RS - rare species.

Further analysis of annuals and perennials show large differences in occurrence (frequency) between common, frequent, less frequent and rare species (see Fig. 5). The relation of the common and frequent species to the less frequent and rare species is 49.9% : 50.0% in annuals but only 26.1% : 73.8% in perennials. The common and frequent annuals form 25.2% of all species found in the vineyards. It is evident that annuals are the most important component of the weed flora of the Slovak vineyards. Typical grain-crop weeds are scarce or less frequent and root-crop (row-crop) weeds unambiguously dominate.

Weed flora of vineyards in other vineyard regions of Slovakia occurring in related macroclimatical and pedological conditions is similar (cf. JURKO 1964; ELIÁŠ 1982). In the East Slovakia region, e.g. the occurrence of the following rare or scarce species is of interest: *Gagea arvensis, G. minima, G. pratensis, Muscari comosa, Ornithogalum* sp., *Pulsatilla pratensis* (cf. JURKO 1964).

Weed flora of the vineyards in sandy soils differs evidently from the weed flora in loamy soils. Thermophilous species of southern origin requiring high summer temperatures, mainly species of the alliances *Eragrostion* and *Panico-Setarion*, occur frequently in the vineyards in sandy soils in the Skalica-Záhorie region, the Danube-valley region and in southern part of the East Slovakia region (cf. Table 5). Species requiring high soil moisture content are absent or occur rarely in the vineyards.

The herbicide weed-control effects on weed flora of the Slovak vineyards, as general unit, have small range, at present time, because of both a relatively short period of herbicide applications in the vineyards and a small area of vineyards treated by herbicides. Only some bulbuous geophytes diminished. But there are some 'relict' localities with old vineyard cultivations in some regions of Slovakia where various rare species may occur.

Table 5: Weeds occurring frequently in the Slovak vineyards on sandy soils.

Amaranthus albus	*Eragrostis minor*
Amaranthus blitoides	*Heliotropium europaeum* *
Amaranthus lividus	*Hibiscus trionum* *
Chenopodium hybridum	*Hyoscyamus niger*
Chondrilla juncea	*Medicago minima*
Conyza canadensis	*Portulaca oleracea*
Cynodon dactylon	*Salsola cali* subsp. *ruthenica*
Digitaria sanguinalis	*Setaria verticillata*
Echinochloa crus-galli	*Tragus racemosus* *
Equisetum ramosissimum	*Tribulus terrestris* subsp. *orientalis* *

* Species occurred only in southern part of the Podunajská Nížina lowlands.

However, the effects of chemical weed control on the weed flora have large range in single vineyard cultivations treated periodically by herbicides. In the cultivations, richness and diversity of the weed flora as well as frequency and population density of individual species are clearly lower than in untreated vineyards. On the other hand, certain species, called usually as 'herbicide-resistant' species, occur with high population density and dominate. In the Slovak vineyards such species are e.g. *Convolvulus arvensis* and *Cirsium arvense* from perennials (cf. ELIÁŠ 1978) and *Conyza canadensis, Chenopodium album* and *Amaranthus retroflexus* from annuals. *Cynodon dactylon* and *Digitaria sanguinalis* react similarly in vineyards on sandy soils.

5. Seasonal dynamics of the weed occurrence in the vineyards

Weed communities are characterized by the adaptation to both seasonal dynamics of an agro-ecosystem and weed control made by man. The species structure of the communities is formed by weed species adapted to the life cycle of a crop throughout their own life cycle or by weed species adapted to human measures in a crop through rapid phenological development, high seed production and high regeneration ability. This double-dealing adaptation of the weed communites enable them to exist in crops. It is manifested also in variations of the floristic composition of weed communities and of densities of weed populations from season to season of one year, forming distinct spring, summer, autumn and winter aspects.

Table 6: Seasonal periods and weed aspects in the Slovak vineyards.

period	months	aspects	peculiar and important species
1. Winter	XI-II	1. *Lamium purpureum* - *Stellaria media*	winter species
2. Early Spring	II-III	1. *Lamium purpureum* - *Stellaria media*	wintered annuals
3. Spring	III-V	1. *Veronica hederifolia* - *Stellaria media*	spring ephemerophytes and ephemeroides
4. Early summer	V-VI	1. *Bromus sterilis* - *Convolvulus arvensis*	late spring species
		2. *Bromus tectorum* - *Convolvulus arvensis*	
5. Fully summer	VII-IX	1. *Setaria glauca* - *Galinsoga parviflora*	summer annuals
		2. *Setaria viridis* - *Mercurialis annua*	
		3. *Oxalis fontana* - *Chenopodium polyspermum*	
		4. *Portulaca oleracea* - *Eragrostis minor*	
		etc.	
6. Autumn	IX-XI	1. *Stellaria media* - *Galinsoga parviflora*	summer species wintered species

Seasonal dynamics of the weed occurrence in vineyards were observed in Western Slovakia during 1969-1971 in two different regions: in the Nitra region in private small-scale cultivations and in the Malé Karpaty region in 'modern' large-scale cultivations (cf. ELIÁŠ 1971, 1978). They were characterised by six phenological periods, each having its own aspect (Table 6). The periods differ (cf. Fig. 6) by quality and quantity of weed occurrence (weed species, population density, plant cover etc.), by relations between weeds and grape plants and between several weed species, and by climatic conditions (weather), viz by the whole ecology of a vineyard. Qualitative occurrence of geophytes, hemicryptophytes and wintered species from therophytes is relatively stable during a year (Fig. 7). But qualitative occurrence of other therophytes, which are character species for the individual periods, changes from period to period; e.g. spring ephemerophytes and ephemeroides occur only in spring aspect, while late spring therophytes are typical for midsummer period.

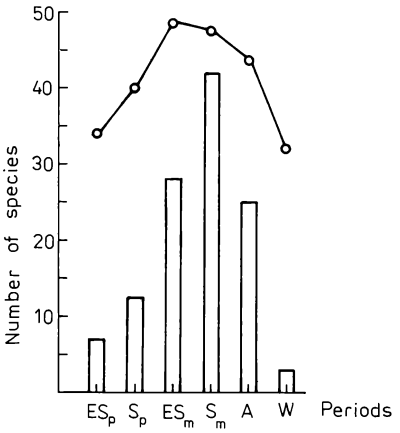

Fig. 6: Number of flowering species (columns) and number of total species (line with circles) presented in individual seasonal periods.
An example from the Nitra vineyard region (by ELIÁŠ 1971, modified).
Periods: ESp - early spring, Sp - spring, ESm - early summer, Sm - summer, A - autumn, W - winter.

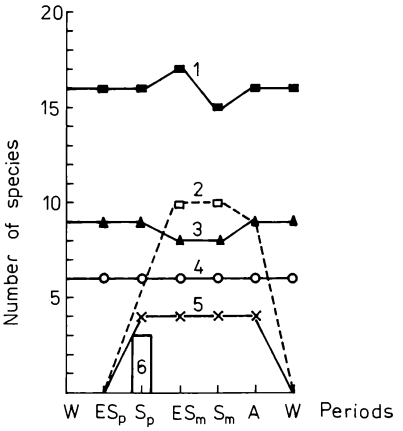

Fig. 7: Dynamics of the weed species presence according life forms in individual seasonal periods.
An example from vineyards of the Nitra region (from ELIÁŠ 1971).
Periods: see Fig. 6.
Life forms: 1 - perennials, 2 - summer species germinated in late spring, 3 - winter annuals germinated in autumn, 4 - wintered species frequently flowering during winter period, 5 - spring species germinated in early spring, 6 - spring ephemers and ephemeroides.

During the years large variations were observed in quantitative occurrence (plant cover, populations density) of all weed species presented (Fig. 8) as well as in phenophase occurrence of the same species in individual periods of a year. In the spring period with high soil moisture content, weed aspect is formed by short-lived winter annuals that germinated mainly in autumn, ripen their seeds in late spring and very soon perish. In the summer period with lower soil moisture content, weed aspects are formed by summer annuals requiring a high soil temperature for germination and germinated, therefore, usually in late spring.

Seasonal dynamics of the weed communities in vineyards is characterized by aspects succeeded with relatively independent development from germination to seed ripening or killing by hoeing. Duration of weed aspects is limited by hoeing, ploughing or other weed control measures (chemical treatments etc.). The aspects are, therefore, separated by short periods (some weeks only) without weed vegetation (only bare furrows). These are important differences from seasonal dynamics of natural plant communities (ELIÁŠ 1971).

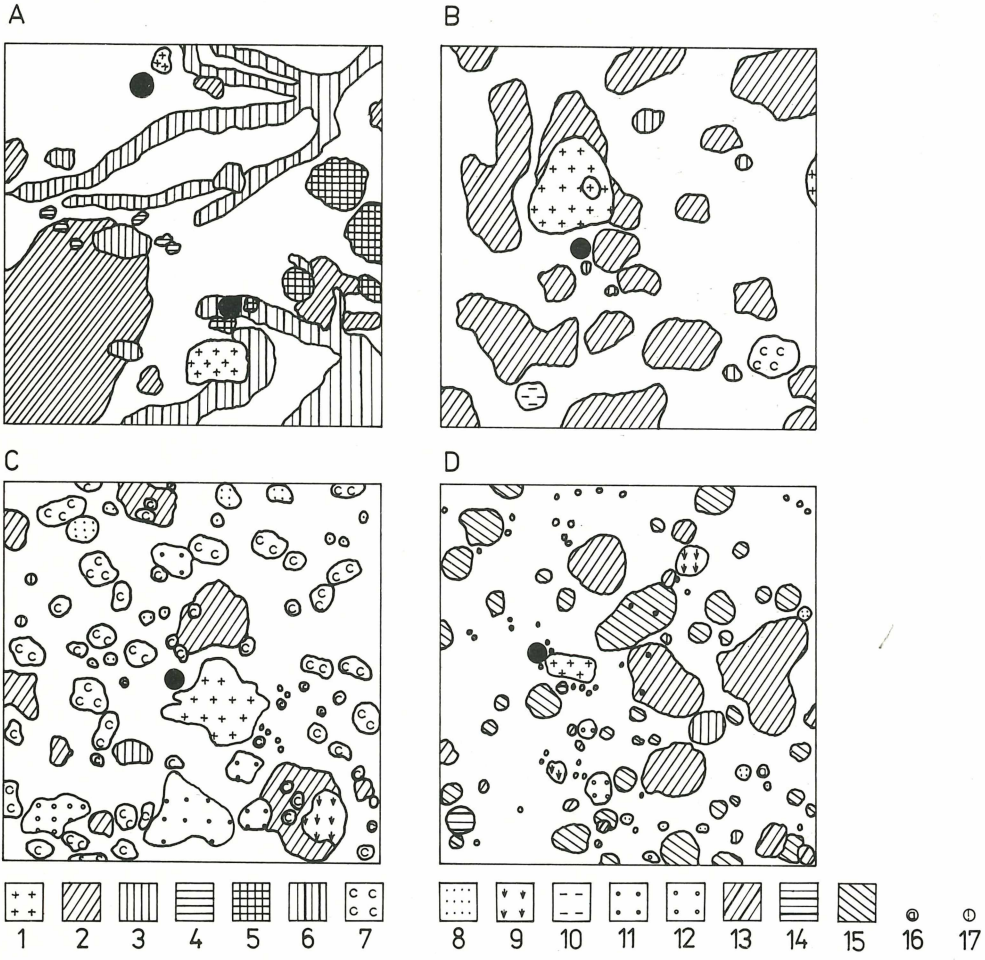

Fig. 8: Horizontal distributions of weed-species populations on observation areas (1 m²) in various vineyards in western Slovakia (Velčice near Zlaté Moravce, the Nitra region).
Some examples from spring aspect (April 12, 1969).
Weed species: 1 - 'rootcrown' of grape plants, 2 - *Stellaria media*, 3 - *Capsella bursa-pastoris*, 4 - *Lamium purpureum*, 5 - *Bromus sterilis*, 6 - *Glechoma hederacea*, 7 - *Cardaria draba*, 8 - *Linaria vulgaris*, 9 - *Agropyron repens*, 10 - *Sonchus arvensis*, 11 - *Erodium cicutarium*, 12 - *Medicago lupulina*, 13 - *Vicia lathyroides*, 14 - *Silene alba*, 15 - *Matricaria chamomilla*, 16 - *Plantago major*, 17 - *Erophila verna*.

In large-scale cultivations, different weed-control measures applicated to the spaces between rows and within rows of grape-vine plants, cause differences in weed occurrence and seasonal dynamics of weeds in the spaces. Weeds growing in the space between rows are damaged and killed more frequently than those within the rows. This microhabitat is disturbed much more by cultural techniques than the space between grape plants. There are, therefore, large differences in plant cover, populations densities and phenophases between the groups of weeds (cf. ELIÁŠ 1978).

6. Weed communities in the Slovak vineyards

In the phytocenological system, weed communities of the Slovak vineyards may be united, together with other row-crop weed communities, in the class *Chenopodietea* Br.-Bl. 1951 em. Lohmeyer, J. et R. Tüxen 1961. The weed associations found in vineyards occur also in other row-crops; at the present time, peculiar vineyard weed-communities are not known in Slovak vineyards. JURKO (1964) reported the association *Geranio rotundifolii-Allietum vineali* (von Rochow 1948) Tüxen 1951 from the East Slovakia region as partly poored geographical variant ('subcarpaticum'). The short communication was based on phytocenological analysis of spring aspect only. Environmental conditions in modern vineyards with new agrotechnique and chemical weed-control are not suitable for growing of phytocenoses of the association in Slovakia.

Table 7: The syntaxonomical survey of the weed communities occurring frequently in the Slovak vineyards.

Class *Chenopodietea* Braun-Blanquet 1951 em. Lohmeyer, J. et R. Tüxen 1961

A. Order *Polygono-Chenopodietalia* (Oberdorfer 1960) J. Tüxen 1961

1. Alliance *Eu-Polygono-Chenopodion polyspermi* Koch 1926 em. Sissingh in Westhoff et al. 1946

Associations:

1. *Panico-Chenopodietum polyspermi* Br.-Bl. 1921
2. *Panico-Mercurialetum* (Allorge 1922) R. Tüxen 1950
3. *Setario-Veronicetum politae* Oberdorfer 1957
4. *Veronico-Fumarietum* J. Tüxen 1955
5. *Amarantho-Fumarietum* J. Tüxen 1955
6. *Geranio rotundifolii-Allietum* (von Rochow 1948) R. Tüxen 1950

2. Alliance *Panico-Setarion* Sissingh in Westhoff et al. 1946

Associations:

1. *Setario-Galinsogetum* (Tx. et Becker 1942) R. Tx. 1950
2. *Setario glaucae-Echinochloetum* Felföldy 1942
3. *Setario-Digitarietum* Felföldy 1942

B. Order *Eragrostietalia* J. Tüxen 1961 em. Soó 1968

1. Alliance *Tribulo-Eragrostion* Soó et Tîmár in Tîmár 1957

Associations:

1. *Digitario-Portulacetum* (Felföldy 1942) Bodrogközy 1955
2. *Hibisco-Eragrostietum poaeoidis* Soó et Tîmár in Tîmár 1957
3. *Tribulo-Tragetum* Soó et Tîmár in Tîmár 1957

2. Alliance *Consolido-Eragrostion* Soó et Tîmár in Tîmár 1957

A survey of the weed communites occurring typically in Slovak vineyards is given in Table 7. Three groups of associations may be distinguished:

I. Weed communities of heavy loamy soils or clay-loamy soils with high soil moisture content (fresh to humid soils) and with good mineral balance. These communities are united in the alliance *Eu-Polygono-Chenopodion polyspermi* Koch 1926 em. Sissingh in Westhoff et al. 1946. They occur in northern vineyard districts, in vineyards localized in southern slopes of the piedmonts

of the West Carpathians and also in hill lands within the lowlands Podunajská, Juhoslovenská and Východoslovenská Nížina. The following species belong to the group of important diagnostic species: *Chenopodium polyspermum, Lamium purpureum, Fumaria officinalis, Sonchus arvensis, S. asper, Polygonum persicaria, P. lapathifolium, Veronica persica* etc.

II. Weed communities of the light silt loamy and sandy-loamy soils, usually poor in $CaCO_3$, which represent a transition between group I and group III. The thermophilous communities occur in lower altitudes, in plaines of the Slovak lowlands, are classified within the alliance *Panico-Setarion* Sissingh in Westhoff et al. 1946. The important species are *Setaria viridis, S. glauca, Echinochloa crus-galli, Digitaria ischaemum* and *D. sanguinalis.*

III. Weed communities of the sandy soils are united within the order *Eragrostietalia* J. Tüxen 1961 em. Soó 1968. The communities of the light, warm and dry soils and sandy dunes, which occurred only in Záhorská, Podunajská and partly Východoslovenská Nížina, have specific floristic structure. Thermophilous species of southern origin (cf. Table 5) are typical for the weed stands.

The structure of the weed communities of vineyards is strongly affected by continuous application of herbicides over several years. At present, typical weed communities occur only in old, private small-scale cultivations (30 to 40 species in one stand). Repeated application of herbicides led to a reduction in the weed population density, to a decrease in species diversity and dominance structure of the communities. Therefore, in modern large-scale cultivations, weed stands are poor in species (low species diversity), their stand cover is low and population density of the species presented is also low (cf. ELIÁŠ 1978). Phytocenological classification of the weed stands is very complicated and frequently impossible because of absence of diagnostic important species.

7. Vegetation of the abandoned vineyards in Slovakia

Abandoned vineyards of various ages occur in each vineyard region of Slovakia. They are late private small-scale cultivations which lay fallow different long periods (from some years to much years). They represent an excellent series for the study of vegetation development (succession) in originally arable land. The surface area of Slovakia occupied by abandoned vineyards is not known. Large areas with recently abandoned vineyards occur locally only in sandy soils in the Záhorie region. Vineyards which became fallow during 13th - 19th centuries are covered by forests (e.g. in Bratislava) or they are used as arable fields. In most cases, the fallow vineyards are former individual cultivations among active private vineyards. They fell fallow since 1950 or 1960 and this process continues up to date.

In Czechoslovakia, vegetation in abandoned vineyards was studied only in western Slovakia (cf. OSVAČILOVÁ 1956; ELIÁŠ 1980b). This vegetation differs from vegetation of cultivated vineyards. Perennial forbs predominate in undisturbed vineyards lying fallow more than 5 years. Deciduous forests occur in areas fallow since more than 50 years.

The course of successions on anthropogenic habitats (ecotopes) is often different depending on the substrate type, character and intensity of the factors of anthropogenic influences, types of contact communities as well as on the duration of the successional stages (cf. ELIÁŠ 1979). In abandoned vineyards, the following succession stages may be distinguished:

I. First successional stage is formed by plant communities of annual, wintered and biennial species (weeds and ruderals) of *Sisymbrietea* and *Chenopodietea*. It occurs in vineyards fallow since 1 to 3 years. In the Slovak vineyards, the associations *Erigero-Lactucetum* or *Erigero-Brometum tectoris* occur most frequently.

II. Second successional stage is formed by anthropogenic, ruderal and semi-ruderal communities of biennial and perennial species *(Artemisietea vulgaris, Onopordetea* or *Meliloto-Artemisietea absinthii,* and *Agropyretea repentis).* It occurs in undisturbed vineyards 3 to 6 (10) years after abandonment. In the Slovak vineyards, the associations *Tanaceto-Artemisietum vulgaris, Echio-Melilotetum* and *Agropyretum repentis* occur often.

III. Third successional stage is formed by semi-natural and natural perennial grass communities of *Agropyretea repentis, Molinio-Arrhenatheretea elatioris* and *Festuco-Brometea*. It occurs in vineyards fallow since more than 10 years. The associations *Arrhenatheretum elatioris* (loamy soils) and *Calamagrostietum epigejos* (sandy soils) were frequently observed in the Slovak vineyards. The natural grass communities of the class *Festuco-Brometea* were found in abandoned vineyards of southwestern Slovakia (see OSVAČILOVÁ 1956). They are the last herbaceous communities in the succession series in fallow vineyards.

IV. Fourth successional stage is formed by natural communities of perennial woody plants (scrubs and forests of *Quercetea pubescentis-petraeae* and *Querco-Fagetea)*. Deciduous forests, usually thermophilous associations, were observed as climax communities in the Slovak vineyard regions (cf. e.g. OSVAČILOVÁ 1956; KALESNÝ 1970). On sandy soils, *Pinus sylvestris* and *Robinia pseudacacia* stands may be expected as climax communities in fallow vineyards. This succession stage is considered as final stage and is the result of the long-term succession.

Some exemples of plant succession in the Slovak vineyards are given in Table 8.

The preservation of representative fallow vineyards to permit continued studies of developmental trends in the vegetation and assure availability of sites for terrestrial field studies was recommended (cf. McCORMICK 1968). The conservation value of these areas is based on diversity, rarity, educational value, refuge for rare species, and function of recreation. They were proposed as an open-air museum displaying old grape varieties, spice and aroma-plants, tinctorial plants, and root-crop weeds (KONOLD 1980). Problems of conservation of old, typical vineyard-cultivations in Slovakia were discussed by JANOTA (1968, 1974) and ELIÁŠ (1974a).

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