

**Pest Risk Assessment for *Diabrotica virgifera* prepared by  
the French Plant Protection Service\***

Translation

**1 Name***Diabrotica virgifera* LeConte Coleoptera Chrysomelidae (galerucinae)

English name: Western corn rootworm

Colorado corn rootworm

French name: chrysomèle des racines du maïs

The taxonomy of the species was confused until recently because of the existence of several closely related species and of several sub-species. This situation was mainly due to the strong variability in colour of insects in this group. Recent studies (Mendoza and Peters, 1964; George and Hintz, 1966; Krysan et al. 1980, 1983) have been carried out which allow to discriminate correctly between species (at both adult and larval stages).

Sub-species: *Diabrotica virgifera virgifera* LeConte: nominal sub-species*Diabrotica virgifera zea* Krysan et Smith: Mexican corn rootwormClosely related species *Diabrotica longicornis* (Say)*Diabrotica barberi* Smith et Lawrence**2(a) Is the pest present in the EU or does it enter through natural migration ?**

No

**2(b) Are there any reasons to suspect that the pest is already established in the EU ?**

No. No information on possible interceptions in EU countries.

**3 EEC Status**

Not listed.

**4 EPPO status**

Quarantine pest, A2 list.

**5 Which are its host plants ?**

*D. virgifera* is oligophagous. Its main host is maize *Zea mays*, but it can also survive for at least 10 days on 18 other species of Poaceae and can even achieve its complete development cycle on 13 species of those (in bold below). It is recognized that these plants do not allow a large multiplication of the pest but that they nevertheless favour the maintenance of the species where crop rotation is applied.

The genera and species of Gramineae present in France are underlined.

For example, the genus *Elymus* is present in France, but not the species *E. canadensis*. Moreover, *D. virgifera* cannot complete its life cycle on this species.

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\* Note that this PRA refers to import of maize seeds as a dangerous pathway. The Working Party on Phytosanitary Regulations has already declared that it is not.

<u><i>Agropyron cristatum</i></u>	<u><i>Hordeum vulgare</i></u>
<u><i>Agropyron elongatum</i></u>	<u><i>Oryza sativa</i></u>
<u><i>Agropyron intermedium</i></u>	<u><i>Panicum miliaceum</i></u>
<u><i>Agropyron smithii</i></u>	<u><i>Secale cereale</i></u>
<u><i>Agropyron trachycaulum</i></u>	<u><i>Setaria italica</i></u>
<u><i>Agropyron trichophorum</i></u>	<u><i>Setaria lutescens</i></u>
<u><i>Elymus canadiensis</i></u>	<u><i>Setaria viridis</i></u>
<u><i>Eragrostis curvula</i></u>	<u><i>Triticum aestivum</i></u>
<u><i>Eragrostis trichodes</i></u>	<u><i>Triticum spelta</i></u>

References: Branson & Ortman, 1967; Branson & Ortman, 1970, Bonnier, 1934.

This list shows that, apart from the main host plant of *D. virgifera*, at least 7 host grasses are present in France. In particular, *Setaria* spp. are very common weeds in maize crops. Moreover, some widely distributed French weeds have not been studied (e.g. *Echinochloa crus-galli*).

## 6 Current geographical distribution

**America**  
 USA (economical impact after 1945)  
 Canada (?)  
 Mexico (probable area of origin)

**Europe**  
 Yugoslavia (1992)  
 Croatia (1995)  
 Hungary (1995)  
 Bosnia-Herzegovina (1996)  
 Romania (1996)

The situation in Europe is evolving with a rapid spread towards the north-west.

**COLLER LES DEUX CARTES**

### Source:

Europe: Baca *et al.*, 1995, modified by EPPO; USA & Mexico: Krysan *et al.*, 1980, modified.

## 7 Could the pest establish in the EU ?

The following two stages, which are needed for the final establishment of *D. virgifera* in France should be studied:

- Introduction (import pathways)
- Maintenance (depending on the ecological adaptation of the pest to agro-meteorological conditions in maize cultivation in France).

### 7.1 Which pathways present a risk ?

France produces enough maize to satisfy its own needs. A large quantity of maize is in fact exported. Two types of maize are nevertheless imported:

- Maize for consumption

Some cultivars of maize are imported by specialized pathways for industrial processing. Quantities vary, depending on years, from 150 000 tonnes to 350 000 tonnes (1 or 2 % of French exports). For example, 164 000 tonnes were imported during the 96/97 season (partial figures).

Figure 3 shows the main origins. This particular pathway does not seem to present a risk as plant protection treatments, industrial processing and distance from the production areas are most probably unfavourable to pest establishment.

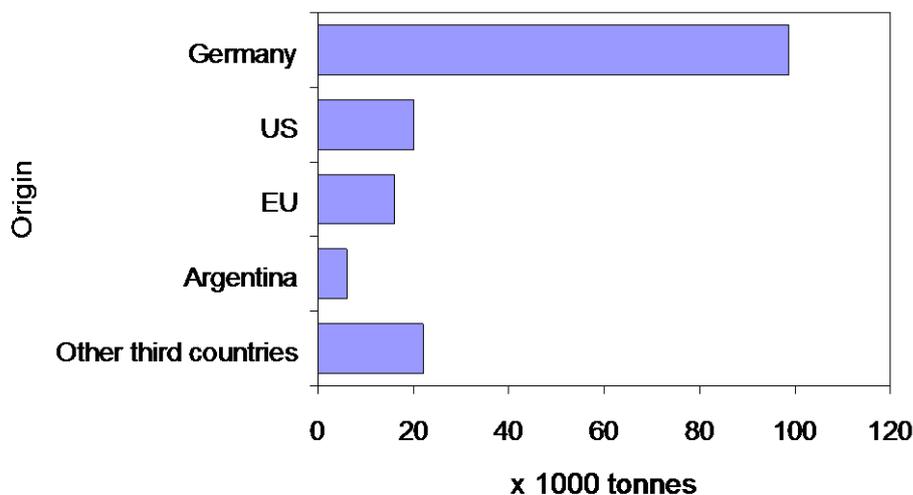


Fig 3: Import pathways of maize for consumption in 96/97

- Maize for seed

Information on this pathway is available as an import declaration is needed for customs clearance. GNIS (Groupement interprofessionnel des semences, graines et plants) provided most of the figures mentioned below. Very small quantities are imported (table 1) but they present a non-negligible risk for several reasons. Seeds (imported as grain or ear) are directed towards production places. They originate from a large number of countries (map 1 and table 2) and *D. virgifera* is present in some of them.

Table 1 Imports of maize seeds

year	Quantity (tonnes)
94/95	28 800 (source AGPM)
95/96	21 221 (source GNIS)
96/97	28 000 (forecast AGPM)

Map 1: Origin of maize seeds imports (1995-1996)

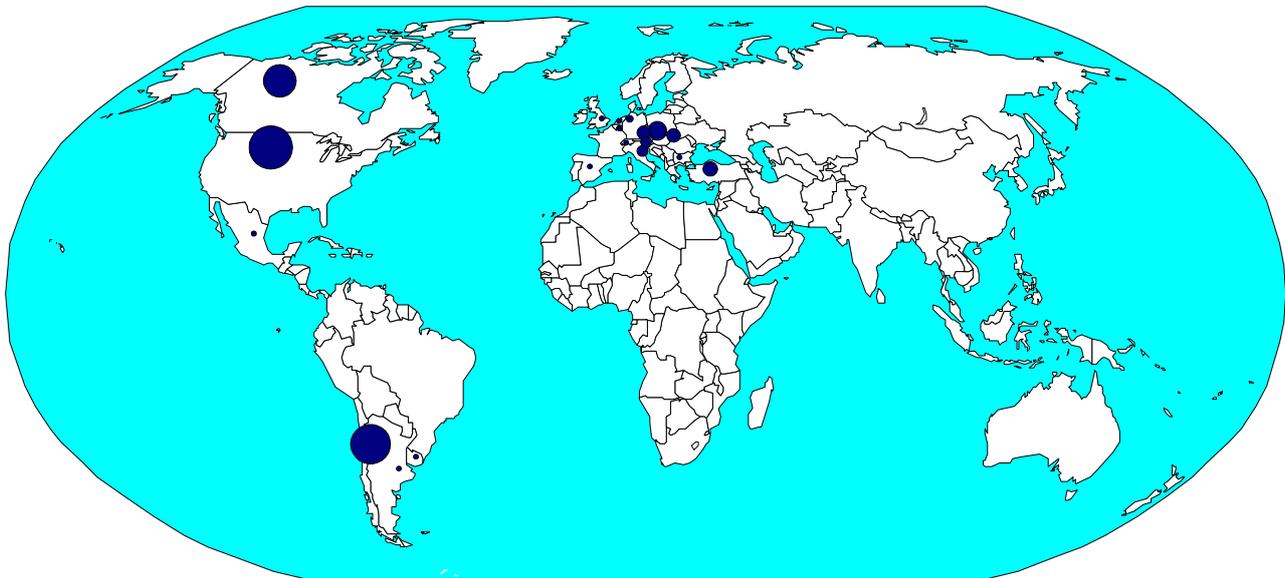


Table 2: Imports of maize seeds in France (95/96)

Country	Weight (tonnes)	Is <i>D. virgifera</i> present in the country ?
USA	6540.4	YES
Chile	4996.8	
Canada	4230.5	YES
Hungary	1791.5	YES
Austria	811.6	
Turkey	674.0	
Romania	637.6	YES
Croatia	421.2	YES
Germany	391.9	
Italy	369.5	
Netherlands	87.3	
Spain	85.3	
Belgium	81.7	
Argentina	41.5	
Bulgaria	23.0	
Portugal	20.7	
New Zealand	5.5	
Switzerland	4.9	
Uruguay	2.5	
Mexico	1.8	YES
United-Kingdom	0.6	
Japan	0.3	
Costa Rica	0.1	

In conclusion, there is a significant flux of maize seed from several countries where *D. virgifera* occurs. Some seed are controlled at entry on the French territory, but *D. virgifera* is not an EU quarantine pest and is therefore not specifically inspected for. However, controls are systematically carried out during the growing season on the plots of seed-producing stations. If present, this pest would be quickly detected. Moreover, traps with attractants can be placed at those high risk sites.

7.2 Can *D. virgifera* maintain in France ?

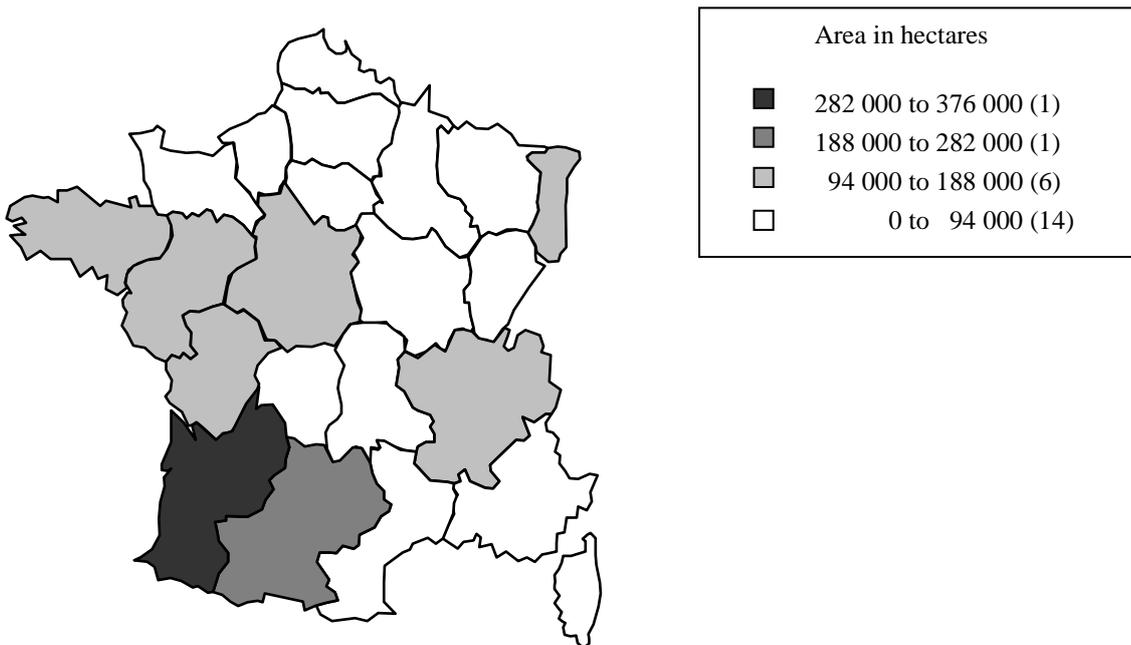
The final establishment of *D. virgifera* depends on two main conditions: presence of its host plant and suitable agro-meteorological conditions to ensure a complete cycle.

Maize, its main host plant, is widely cultivated in France (maps 2, 3, 4).

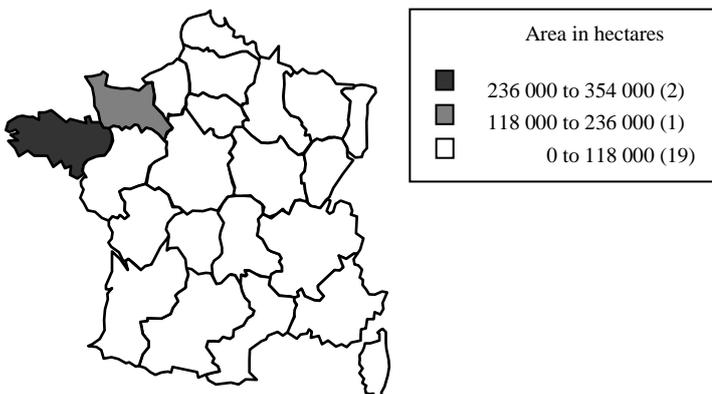
In 1996, 1 682 579 hectares of maize were grown for consumption, 1 577 531 ha for fodder and 42 218 ha for seed.

Large quantities of maize, both for consumption and for seed are produced in the south-west (Aquitaine and Midi-Pyrénées), which accounts for more than 1/3 of French production. The western central region (Pays de Loire and Poitou-Charentes), where irrigation is widely used, provides slightly less than 20 % of national production. The eastern region (Rhônes Alpes and Alsace) which has obtained good yields in recent years, produces about 20 % of French maize (Source AGPM).

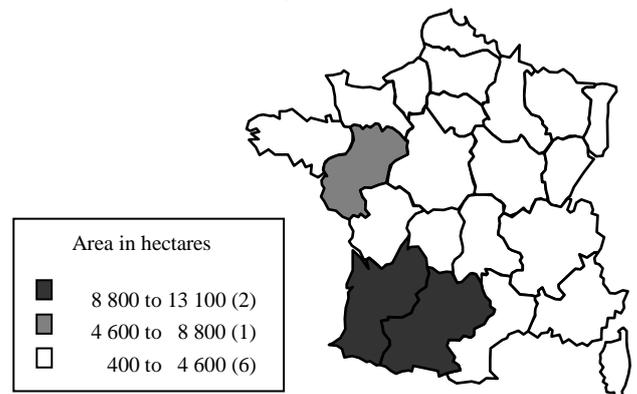
Map 2 Area cultivated in maize in each region



Map 3 Area in fodder maize



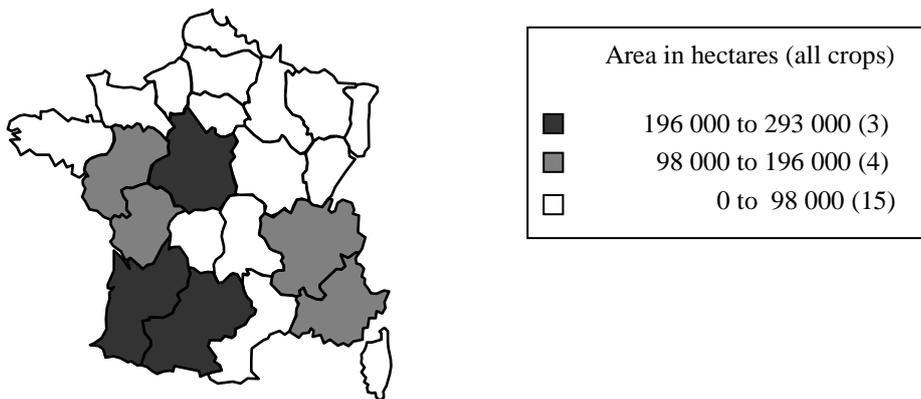
Map 4 Area in seed maize



It is difficult to estimate the area which is cropped as a monoculture (most exposed to *D. virgifera*) because statistical surveys rarely take this parameter into account. However, it is known that maize is the first irrigated crop (703 000 hectares in 1995, according to the publication Agreste, 1996) in France and irrigation, mainly fixed irrigation, very often corresponds to monoculture.

Map 5 shows that the irrigated area, and thus most probably monoculture, is mainly located in the south-west of France, which would make the introduction of *D. virgifera* very worrying.

Map 5: area irrigated in 1995 (all crops)



#### Are agro-meteorological conditions suitable in France ?

Yes, there are very probably suitable. To illustrate this, we compared agro-meteorological conditions in three regions: Springfield (lat. 39.8N, long. 89.7O – Illinois) chosen as one of the favourite areas of *D. virgifera* in the US; Belgrade (lat. 44.8N, long. 20.5E – Yugoslavia); Lyon (lat. 45.7N long. 5.0O – Rhône Alpes – France) chosen amongst French maize-growing regions for its intermediate climate (It is colder than the south-west, but warmer than the north-east). The conditions needed for the development of *D. virgifera* have mainly been studied in the US, on egg, larvae and adults. Eggs normally need overwintering, with an optimal temperature in the laboratory of 4 to 5 °C (Chiang et al., 1972 in Chiang, 1973). The same study shows that one week at – 10 °C in the soil induces 50 % mortality, while this percentage reaches 100 % at – 15 °C. The estimated development threshold is 11 °C (Wilde, 1971 in Gustin, 1981), and humid soils are favourable to egg laying.

Appendix I shows that isotherms of January (mean temperatures) are similar at the three sites. Belgrade is the coldest area, but *D. virgifera* is nevertheless able to develop there.

Temperatures suitable for egg maturation can be found France. Low temperatures which lead to high mortality are nearly never observed.

Larvae develop at temperatures above 11 °C, with an optimal temperature of 29 °C (Kuhlman et al., 1970 in Chiang, 1973). Early sowing and maize monoculture are very favourable to the larvae.

Lime soils are more favourable to the development of larvae than sandy soils. Turpin & Peters (1971) think that this due to susceptibility to desiccation. Soils from the south-west of France are mainly of a podzol type, i.e. relatively unfavourable to the pest. However, soils from the west-central region and from the east are generally favourable (brown soils with a good capacity for water retention); this may vary depending on local soil characteristics.

Soils around Belgrade are very fertile (brown soils and tchernozioms) with a good water retention ability. Illinois soils are brown soils.

The amount of precipitation is similar at the three sites (see Appendix 3). It varies between 600 and 1000 mm per year. The amount per month (Appendix 3) is comparable at the three sites.

Precipitation in France are between those in Belgrade and Springfield. There is no reason to think that they would be limiting factors for the development of *D. virgifera* in France.

Considering the usual sowing dates of maize crops in France, maize would be available at the probable hatching date of the eggs (from the 15 May onwards, in the US and in central Europe).

Agro-meteorological conditions necessary to the development of the larvae are present in France (Appendix 1 to 4) and the pest cycle is compatible with the development of maize. Soils vary greatly and can be locally unfavourable. However, the common practice of irrigation partly compensates for this disadvantage.

Adults do not lay eggs below 10 °C and their optimal temperature lays between 16 and 18 °C. Survival is possible at 10 °C. Migratory flights can bring adults at several kilometres. Accidental introduction of *D. virgifera* would probably be followed by its rapid spread with prevailing winds.

### 8. Which is the probable potential of this pest in the EU as (i) a pest or (ii) a virus vector ?

Maize cropping in France relies on high yields (35 to more than 50 tonnes per ha). This productivity is obtained using good cultivars and intensive crop protection measures.

Soil disinfection is often already widely practised as a preventive measure. It targets, amongst others, wireworms (*Agriotes* spp., *Athous* spp. etc..) and more rarely *Oscinella* spp. and *Geomyza* spp. About 10 active ingredients are registered for this use. Several are mentioned as being effective against larvae of *D. virgifera*, for example carbofuran, chlorpyrifos, fonofos, phorate or terbufos (sources: Internet, University of Pennsylvania, <http://www.inform.umd.edu/EdRes/Topic/AgrEnv/ndd/agronomy/>).

If *D. virgifera* established in France, its economical impact could probably be lowered by cultural practices, such as crop rotation which is more frequent than monoculture, existing cultural practices (such as grinding against *Sesamia* spp.) and soil treatments.

Measures taken during the growing season against *Ostrinia nubilalis* would probably indirectly induce the decrease of adult populations during the growing season (at least at the beginning of the flight).

*D. virgifera* is known in the US to transmit a comovirus (CPMV, cowpea mosaic comovirus; Jansen & Staples). This virus does not occur in Europe (pers. comm. Alex, LNPV Avignon).

However, the introduction of *D. virgifera* should not be allowed as this is a dangerous pest, which is responsible for the use of a large amount of pesticides in the US, where 50 to 60 % of the area grown in maize is treated (Metcalf, 1986 in Levine, 1991).

### 9. What is the probability of introduction of the pest in France ?

The prospects for maintaining the country free from this pest are good since *D. virgifera* has never been intercepted in our country despite the large quantities of maize which have been imported from North America for years. Moreover it has never been observed on production sites.

The establishment of *D. virgifera* in eastern Europe should trigger us to a great attention. The pest can probably not reach our territory on its own (the continuity of maize crops between Eastern Europe and France is probably not sufficient). However, meteorological conditions are favourable to its development in the field and we should carefully control pathways at risk.

### 10 Eradication prospects ?

Eradication projects are good provided that the outbreak is identified quickly and is treated during the same year. They are worse if the outbreak is not discovered during the first year. This was the case in Eastern Europe. The pests spreads relatively rapidly and the success of preventive measures applied on a large scale is uncertain since maize is not the only host plant in France. Common weeds could allow the maintenance of residual populations which could not be eradicated.

## 11 How could eradication be carried out (elements) ?

Classical control mainly relies on the control of larvae in the soil using a soil-applied insecticide. In North America, many studies have been carried out on the efficacy of active ingredients. In order to obtain satisfactory results, the plant protection products must be applied at the right place (depth and area) and at the right time. The product should persist, in order to be effective, for at least one month after application at a level toxic for the insect (Felsot, 1985).

Treatments have failed in some cases since the beginning of the 60's. Large-scale treatments were applied against this insect with aldrin as early as 1952. Already in 1962, 100 fold concentrations were needed to obtain the same mortality for some individuals (Ball & Weekman, 1962). Numerous cases of resistance appeared afterwards.

The control of adults is rarely recommended in North America. Adults can only be pests during the susceptible stage of the maize crop (male flowering). The peak of flight and the right stage of maize must therefore coincide. Damage thresholds expressed as a number of adults per plant have been developed.

At least two years would be needed to eliminate an outbreak in the field.

As soon as the source of infestation is discovered, an eradication programme against adults should be carried out on the plot and on all adjacent plots (including nearby sites liable to shelter the pest). Trapping should be implemented as soon as possible in order to evaluate the extent of the infested area.

In the following year, a programme of soil treatment should be carried out on a sufficient area, in parallel with the trapping programme. Moreover, any cultural practices which could possibly lower the density of the pest should be promoted by growers (crop rotation, grinding, late sowing, etc...).

The use of biological (*D. virgifera* has few natural enemies) or genetical (resistant plants) means does not seem possible as a routine for the moment. Research programmes on this subject have been developed in North America.

## 12. Conclusion

Several related species of the genus *Diabrotica* occur in North America. One of them (*Diabrotica virgifera* LeConte) established in 1992 in Eastern Europe, near Belgrade. This species seems to be a potential maize pest of maize in France. Agro-meteorological conditions are favourable to this pest and would not hamper its development. All French maize-producing regions are potentially concerned. The south-east of France, where monoculture and intensive irrigation are practised, seem more favourable.

Some pathways present a risk (maize from infested countries), in particular maize seeds. However, despite long-lasting and regular imports, *D. virgifera* has never been intercepted in France. Regular visual inspections in seed producing stations have been carried out by the agents of the Plant Protection Service.

## 13. Further studies

A complementary trapping programme can be envisaged at clearance points and at place of production of seed.

A further study of climate could be performed using CLIMEX in order to determine the potential distribution of *D. virgifera* in France.

The awareness of the persons responsible for the seed-producing stations could be increased by the agents of the Plant Protection Service.

It would be possible to determine a theoretical economic damage threshold based on the economical and technical features of maize production in France.

**References**

**Appendix 4***Meteorological summary*

	France (Lyon)	Yugoslavia (Belgrade)	USA (Illinois)
General type of climate	Type III Temperate - continental	Type III Temperate - continental	Type III Cool – continental
tendency	Oceanic	Intermediate	Continental
temperature	Cool type	Hot summers Relatively cold winters	Hot summers Cold winters
Precipitation	Spring and autumn	Spring and autumn	Maximum in spring
Minimum air temperature	Rarely below $-10^{\circ}\text{C}$	-	Down to $-25^{\circ}\text{C}$