BOTANICAL FILES

A study of the real chances for spontaneous gene flow from cultivated plants to the wild flora of the Netherlands

by

F.T. de Vries[1], R. van der Meijden[1] and W.A. Brandenburg[2]

1) Rijksherbarium/Hortus Botanicus, State University Leiden, P.O. Box 9514, 2300 RA Leiden, The Netherlands

2) Centrum voor Plantenveredelings- en Reproduktieonderzoek, CPRO-DLO, P.O. Box 16, 6700 AA Wageningen, The Netherlands

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Summary

Separate 'Botanical files' have been made for 42 species of cultivated plants. Each file gives information about the cultivated plant itself (use, origin, etc.), its wild relatives in the Netherlands, a report on actual hybridization and/or crossing (indicating gene flow by pollen), and observations on escapes from the field to nature (indicating gene flow by diaspores); the information is summarized to a conclusion and a numerical code, indicating the possible ecological effects of the cultivated plant on the wild flora of the Netherlands. This study was especially undertaken for questions regarding biosafety research on Genetically Modified Organisms (GMO's). The sources are the herbarium collections of the State Herbarium at Leiden, floristic archives and botanical literature, as well as expert judgment on the flora of the Netherlands and crop plants. An important consideration is that the *absence* of certain hybrids in the State Herbarium can be interpreted as a decisive indication that such a hybrid does not occur in the wild in the Netherlands. The botanical files show that in *c. 50%* of the cases no gene flow is expected; in *c. 15%* of the cases small, often local-scale effects are expected; in *c. 25%* of the cases considerable gene flow to the wild is expected; in *c. 10%* of the cases further research should be done before a definite conclusion can be drawn (most of the cases need further taxonomic research).

1. Introduction

The objectives of this study were to describe which (floristic) factors should be taken into account for assessing the risk that certain genes will spread from a certain cultivated plant to the natural flora of the Netherlands. This question is put forward regarding the current public discussion on whether the introduction and use of Genetically Modified Organisms (GMO's) can be tolerated. It is also especially meant for the purpose of the Provisional Committee on Genetic Modification (VCOGEM).

The *nature* of transgenes that might escape 'to nature' is explicitly not included in this study. Thus it is primarily confined to a distribution problem of plants present in the wild: this type of problems belongs to the domain of floristics (including partly plant ecology and vegetation science). The floristic research of the Netherlands is traditionally concentrated in the State Herbarium at Leiden.

This institute, founded in 1830, preserves the floristic archives, the corresponding literature and the sizeable collections of dried specimens of plants found in the wild in the Netherlands. The State Herbarium and the Leiden Hortus Botanicus together constitute a research institute representing an independent branch of the Faculty for Physics and Science of the Leiden State University.

The aim was to integrate in particular the considerable expertise that exists in the Netherlands regarding the influence of man on the wild flora, in order to reduce the number of purely theoretical questions.

1.1. General considerations

A number of different sources of information were used for this study:

1) specialized taxonomic knowledge (published and unpublished) about cultivated plants and their wild relatives in the Netherlands;
2) specialized floristic knowledge (published and unpublished) about the distribution of cultivated plants, their wild relatives and (crosses and) hybrids between them in the Netherlands.

1.1.1. Taxonomic knowledge

Traditionally the fields (and therefore also literature) of the taxonomy of cultivated plants and the botanical taxonomy are rather strongly separated. It implies that research of available literature had to be very critical. Furthermore, the species concept – that plays an important role in the distinction between a 'cross' and a 'hybrid' (see also paragraph 2) – is not always used in an unambiguous way in the practice of taxonomic research (and of the resulting publications).

Consequently, to avoid adding further confusion, there has been regular consultation with botanical taxonomists of the State herbarium in Leiden as well as with taxonomists of cultivated plants in Wageningen (Centre for Plant Breeding en Reproduction Research/Agricultural Research Department CPRO/DLO; Department of Plant taxonomy, Agricultural University).

1.1.2. Floristic knowledge

In this study we have heavily leant on knowledge of (often unpublished) data about the distribution of wild plants and of the escapes and hybrids of cultivated plants in 'nature'. An important starting-point with this respect is that the *absence* of a certain hybrid in the State Herbarium can be interpreted as a decisive indication that such a hybrid does not occur in the wild in the Netherlands. This assumption is founded on the consideration that there is a long-standing floristic tradition in the Netherlands, of which one of the features is that extraordinary specimens (among which hybrids) will be collected. These collections are checked and stored in the State Herbarium. Another consideration was that the Netherlands are, floristically, the best known country in the world.

This starting-point enabled a very narrow definition of the term 'wild relative': this includes only those species that are native to the Netherlands, and with which *spontaneously* formed hybrid plants have been observed in the wild. This attitude implies that experiments for the *possible* hybridization between a cultivated plant and a wild species of the same genus need not be carried out if the hybrid has not been observed previously in the wild in the Netherlands.

1.2. Dispersal of genes from cultivated plants

This study confined itself to possible gene flow from cultivation to populations growing in the wild, and furthermore to plants growing in the Netherlands. Gene flow from one crop to another is not subject of this study, just as is the question of what can happen outside the Netherlands.

1.2.1. General

In this study we presumed that GMO's show essentially the same behaviour as do 'normal' plants. We started from the definitions for 'wild plants' as presented in the national checklist[6], but our definitions for running wild and hybridization are somewhat different (see glossary, paragraph 6).

Contrary to what is presumed about the absence of *hybrid* plants in the herbarium as stated in 1.1.2, the collections of the State Herbarium are not suited to evaluate the extent to which cultivated plants escape into 'nature'. Generally, the available data show that the 'escapability' of plants declines with their longer history of cultivation.

2. Gene dispersal by plants

The dispersal of genes of plants (D_g) can be effected two ways:

1) experimentally, by natural or artificial transfer of genes from one cultivated plant to another (D_e). This paper will not elaborate on that.
2) spontaneously, by natural transfer of genetic material (D_s).

2.1. Spontaneous gene dispersal (D_s)

There are also two ways in which *spontaneous dispersal* (D_s) can take place:

1) by pollen of the cultivated plant to plants growing elsewhere (both cultivated and wild plants), leading to sexual reproduction (D_p);
2) by seeds, or other diaspores, from the cultivated plant to the wild (D_d).

2.1.1. Spontaneous gene dispersal by pollen (D_p)

D_p is related to taxonomic relationship:

1) between organisms belonging to the same biological species, D_p in principle occurs spontaneously (crossing);
2) between organisms belonging to different species, D_p will not occur or will occur in largely reduced frequencies (hybridization). D_p does not occur between organisms belonging to different genera except for some extraordinary cases known from literature, like for instance in the Gramineae (grasses).

2.1.2. Spontaneous gene dispersal by seeds or other diaspores (D_d)

D_d is related to the fitness of populations resulting from diaspores of the cultivated plant, and to the dispersal capacity of diaspores. In this study the dispersal capacity is determined only indirectly (but in some cases it will have to be ascertained in further research on population dynamics).

For the assessment of fitness the following factors should be taken into account:

a) the seed quality (or the quality of other diaspores);
b) the competitiveness of seedlings or juvenile plants;
c) the capacity of adult plants for the production of viable seeds (or other diaspores).

2.2. Frequency of the plants in the wild (D_f)

The two dispersal codes D_p and D_d have a largely qualitative character, and cannot be extrapolated to conclusions on the realization of such dispersals. Therefore, a quantitative code is added, indicating the distribution of the cultivated plant in the wild, as a native to the Netherlands (as included in the national checklist[6]), as a more or less regularly occurring escape or as an establishing cultivated plant. For this code, we used the distribution data as published in the A.N.F.[21 22]

3. Results

The data found in literature, herbarium and floristic archives during this study are assimilated to a so called 'Botanical File' for each examined species. Every botanical file is set up according to a standard format.

3.1. Botanical Files

The caption of the file is the scientific name of the cultivated species, and usually that applies to only one species. Some files apply to more than one species, when several species of the same genus are cultivated, and their expected ecological effects are comparable. In those cases the caption is the genus name, and the species to which the botanical file applies are listed in a block below the caption.

Where appropriate and available standardized vernacular names in Dutch, English, French and German are added, listed directly under the caption. They are extracted from the ISTA Multilingual Glossary of Common Plant-names.[143]

3.1.1. Introduction

Common knowledge of the cultivated plant is outlined here: what kind of plant is it and for which purpose is it cultivated. If appropriate a short description of the plant is given with reference to its habit, use, way of reproduction (vegetatively, sexually), stolons, runners or root-stocks, pollinators, etc.

The other captions under this heading contain information about how it is grown (in greenhouses or in the field, in home gardens, orchards, parks) and where it is grown (restricted to a specific part of the Netherlands, or widely grown). If known information is added about the origin of the cultivated plant: in what parts of the world is it native; what is its original habitat; when was it taken into cultivation and where.

3.1.2. Escape

This paragraph deals with the data from literature and herbarium about the capacities of the cultivated plant for causing gene flow by escaping (D_d).

The other captions of this paragraph contain information about the hardiness of the species outside cultivation, whether it can survive in the Dutch climate (especially during winter); about whether a cultivated plant growing 'in the wild' can really be regarded as running wild; what habitat it occupies when running wild, in what part(s) of the Netherlands; and whether there are records of the escaped species in the wild in the herbarium or in literature.

3.1.3. Wild relatives

This paragraph describes the wild relatives that are part of the flora of the Netherlands. Only the wild relatives as described in the definitions (paragraph 6) are included. Their distributions are extracted from the Heukels' Flora[1], from the A.N.F.[21] [22], and from what is known in the herbarium.

3.1.4. Hybridization

This paragraph on the hybridizing capacity of the examined species is based on spontaneous crosses and hybrid plants as found and collected in the wild and therefore present in the Herbarium. These data are completed with those found in the archives and literature concerning hybrids occurring in the wild. If appropriate the results of experimental hybridizations, or information about incompatibility systems are provided.

3.1.5. Conclusion

Every botanical file concludes with a short comment on the information as presented, with an estimate of the expected ecological effects of the possible introduction of genetically manipulated plants on the flora of the Netherlands.

As stated earlier in this introduction, these conclusions are valid for the floristic consequences only, they cannot be applied to the effect of the transgene itself. If necessary a recommendation is made for further research to fill in gaps found during this project. Some of the conclusions will therefore appear to be incomplete.

3.1.6. Distribution patterns

As far as available and appropriate, distribution maps of wild and/or cultivated species with D_{pdf}-codes of 2.2.2 or higher are presented. The wild distributions are taken from the A.N.F.[21 22], the distribution of the cultivated plants is based on the Agricultural Data, as provided by the Central Office for Statistics (CBS), Main Division Agricultural Statistics.[12] To this should be added, that wild relatives of the species with a D_{pdf}-code of 5.4.3 are so very common that their distribution maps would be (nearly) uniformly black. Such maps do not provide any further information and are therefore excluded.

The maps were made comparable as far as was possible. Although the nature of the data showed considerable differences, it proved to be possible to provide maps roughly indicating where species occur *occasionally, frequently* or *often*. It is possible to assess from a combination of the maps in what areas there is the most likely chance for gene flow to nature. This is not elaborated in the texts, however.

3.2. Dispersal codes

De conclusions of the botanical files are also summarized to the dispersal codes D_{pdf}, as explained earlier. The values of the different codes are defined as follows.

3.2.1. Categories for D_p

0: There are no wild species from the same genus as the cultivated plant that are native to the Netherlands; there are also no native species from other genera, with which any form of hybridization is found.

1: There are wild species from the same genus as the cultivated plant that are native to the Netherlands, but hybrid plants have never been observed in the wild in the Netherlands. Experiments show that hybridization between the two species yields no viable offspring.

2: The possibility of hybridization between the cultivated plant and a wild relative is experimentally proven, but spontaneously formed hybrids have not been found in the wild.

3: The cultivated plant has a wild relative in the Netherlands of a different species, with which spontaneously occurring hybrids have been observed in the wild; such hybrids are usually sterile or have a much reduced fertility.

4: The cultivated plant has a wild relative in the Netherlands that belongs to the same species, and is considered to be part of the flora of the Netherlands. Crossing with this species must be considered to occur spontaneously in the wild but is generally undetectable. N.B.: the extent to which such crosses arise is low in self-fertilizing plants, and considerably higher in cross-fertilizing plants.

5: The cultivated plant has wild relatives in the Netherlands, both of the same species and of another species, both considered to be part of the flora of the Netherlands. Crossing with these species must be considered to occur spontaneously in the wild but is generally undetectable. N.B.: the extent to which such crosses arise is low in self-fertilizing plants, and considerably higher in cross-fertilizing plants.
9: The possibility for hybridization with a wild relative could not be ascertained, because relationships with the wild species are uncertain, or there were no reliable records in the herbarium or in literature.

3.2.2. Categories for D_d

0: The cultivated plant is not recorded outside the places where cultivation takes place on a regular scale.
1: There are records of the cultivated plant outside the places where cultivation takes place; however these plants are unable to reproduce effectively i.e. they cannot produce viable offspring in the wild.
2: There are records of the cultivated plant outside cultivation. The cultivated plant can spread vegetatively, and/or establish for some time in the wild.
3: There are records of the cultivated plant outside cultivation. The cultivated plant is capable of founding new populations in the wild.
4: The 'escapability' of the cultivated plant is unknown. Because the same species is native to the Netherlands, the distinction between the wild and the cultivated form causes problems.
9: The records of this plant outside cultivation were unreliable; a conclusion on this feature could not be made.

3.2.3. Categories for D_f

0: The examined species is not considered to be part of the flora of the Netherlands, and is not found running wild outside cultivation.
1: The examined species or its nearest wild relative is considered to be part of the flora of the Netherlands, and has an Hour-block Frequency Class[6] of 1 to 5: extremely rare to rare; or the species is not considered to be part of the flora of the Netherlands, but is found (to some extent) outside cultivation.
2: The examined species or its nearest wild relative is considered to be part of the flora of the Netherlands, and has an Hour-block Frequency Class[6] of 6 or 7: less rare to rather common.
3: The examined species or its nearest wild relative is considered to be part of the flora of the Netherlands, and has an Hour-block Frequency Class[6] of 8 or 9: very common.
9: The exact distribution in the Netherlands of the examined species or its nearest wild relative is unknown or uncertain.

3.3. Woody plants

Woody plants were excluded from this study, because the available knowledge, especially floristic, was insufficient for our purpose. Both effective hybridization and/or outcrossing to nature and the effects of running wild are inadequately known.

From germination to the production of viable offspring takes a long time (decades); establishing and/or naturalization take an even longer period, which means that these events usually escape floristic observation.

For the same reason no reliable data were available about viable hybrids of woody plants in the wild.

3.4. Ornamental plants

During this study it became clear that the absence of taxonomic background-knowledge about cultivars grown for ornamental purposes constitutes a serious handicap in assessing the chance for gene flow to nature. Within most groups of ornamentals there are so many hybrids between species that are usually cross-incompatible under natural conditions, that the taxonomic classification is confused, which frustrates the comparison between the species.

This was specifically the case in *Chrysanthemum* s.l., which recently was revised taxonomically.[144] The very large group of cultivated *Chrysanthemum* was divided into 12 different smaller genera with a considerable amount of synonyms. Because of the complexity of this group the wild relatives could not sufficiently be ascertained with the result that no botanical files for *Chrysanthemum* are included in this report.

3.5. Unreliability of literature and herbariumlabels

For some species information as obtained from the Herbarium and from literature is not reliable for the purpose of this study. The terminology in most floras on the subject of occurrence in the wild of cultivated plants is too general. For our purpose we wanted to make a distinction between real escapes from the cultivated field to the wild and casual appearances of cultivated plants outside cultivation. It is important for our aim to know whether originally cultivated plants are able to maintain themselves more or less durably in the wild.

The same situation can be found on herbarium-specimens: often a collector will record a cultivated plant as running wild only because that is the general opinion on this particular species, as voiced in botanical literature. Nevertheless examination of herbarium-specimens can show that a certain species is recorded from the same site over a number of years, indicating that the species is establishing, at least temporarily. Or it can show that there has never been a further record from the same site, indicating that the species has accidentally or purposedly been introduced at that site.

The distinction between an accidental escape of a cultivar, and an actually establishing cultivated plant was made using expert judgment.

3.5.1. Agrostis castellana

Agrostis castellana has probably been growing in the Netherlands for some decades, but until recently it was not recognised as a different species, because its habit is very much like other wild species of *Agrostis*. It was introduced with seeds of *A. capillaris* and the species apparently established. Because its spontaneous distribution is insufficiently known and its relationship with *A. capillaris* and *A. stolonifera* could not be ascertained, *A. castellana* is provisionally included as a wild relative. This view was very recently confirmed; see the botanical file of *A. capillaris*.

3.5.2. *Avena sativa*

The cultivated oat is reported to be able to hybridize with its wild relative *A. fatua*. The hybrid would appear sporadically in or around oat-fields, or where oats have been previously grown. It is reported to occur sporadically across Europa, from Sweden to Bulgaria and Turkey, and throughout much of Canada and the U.S.A.[70 156] No evidence for the Netherlands of this hybrid could be found in the Herbarium, but for the D_{pdf}-code the possibility was taken into consideration, as it could not be ruled out.

3.5.3. *Brassica*

There is a lot of confusion in botanical and floristic literature between *Brassica napus* (cole-seed) and *B. rapa* (rape), they are often mistaken for each other. Both species are reported to be found equally often on waysides, waste lands and other more or less unnatural habitats. Part of this confusion is caused by a mistake in the Heukels' flora[1], where the distribution of *B. rapa* was copied to *B. napus*.

B. napus is a crop with a considerable area of cultivation. It is often grown for the seeds, so the plant will be found on the field in the fruiting stage. Furthermore, cole-seeds are used in winter fodder mixtures for wild animals, and are sown in on waysides. Yet the number of records of *B. napus* being found growing outside cultivation is limited, and there are no records of lasting populations. The escapability of the species must therefore be considered to be low.

On the contrary, *B. rapa* is cultivated on a modest scale only. Usually it is grown for the leaves or the tubers, and flowering of the plant is undesirable, as this reduces the yield of the vegetative parts. Rape seeds are not used as a winter fodder for wild animals, they are however sown in on waysides. The far more frequent occurrence of rape in the wild must therefore be considered to be largely due to (sub)spontaneous dispersal rather than to repeated introduction.

To this must be added that the occurrence of rape in the wild was already known in Linnaeus's time. In his Species Plantarum he named a cultivated rape (*B. rapa*) and a weedy rape (*B. campestris*) that could be found on non-cultivated places. These two 'species' are now regarded as one, *B. rapa*.[154] So rape has a history of being found in the wild, while cole-seed has none. This opinion was recently substantiated by Stace[156]; *B. napus* is mentioned as a frequent relic of cultivation, and from seed-importation only, whereas *B. rapa* subsp. *campestris* is referred to as wild turnip. Its frequent and (sub)spontaneous occurrence in fact might justify the inclusion of the species in the national checklist.[6]

This information has resulted in two different D_{pdf}-codes for two seemingly similar species.

The literature on *Brassica oleracea* running wild is ambiguous: although some authors state that *B. oleracea* is found running wild in some places in the Netherlands, the available information by other authors and in the herbarium indicates that these specimens are often recorded from former home-gardens and tips. The plants growing there must be regarded as a relic of previous cultivation, there are no signs of spontaneous distribution starting from these escapes.

This conclusion is specifically confined to the Netherlands, because the wild distribution of *B. oleracea* in Europe is not studied in this report.

3.5.4. *Cichorium & Lactuca*

In botanical literature *Cichorium intybus* (chicory) and *C. endivia* (endive) are treated as two separate species, distinguished on a few characters. However, specimens of chicory and endive found in the wild suggest that these characters are not decisive in all cases. The two species might well be more closely related than on species level. For this report there was insufficient information to decide on this relationship, so they are treated as two different species, and a recommendation is made for further research into their taxonomic relationships.

A similar situation is found in *Lactuca sativa* and *L. serriola*. The latter, the wild lettuce, is recently increasing in suburban areas, especially near places of lettuce cultivation. If *L. serriola* is more closely related than is assumed now, for instance if it is even part of the same species, it could imply that the cultivated lettuce is escaping to the wild increasingly. Then the effect by gene flow to the wild population of lettuce will be substantial. Although these lettuces are inbreeders, there are no breeding barriers between *L. sativa* and *L. serriola*, as is known from plant-breeding experience.

3.5.5. *Festuca pratensis*

Although only some sterile hybrids were mentioned in literature for *Festuca*, we included the parents of these hybrids in the report as wild relatives, because a considerable amount of hybrid specimens are present in the Herbarium, indicating that they occur to such an extent to have some ecological effect.

3.5.6. *Lupinus luteus*

The literature on *Lupinus luteus* suggests that plants of this species run wild and establish in the Netherlands. However, there is no evidence recorded in the herbarium. The specimens of *L. luteus* in the Herbarium were found on waysides and near fields where lupin had been cultivated, but there are no specimens of the same site several years later. And although cultivars of *Lupinus* have been cultivated for green manuring in the Netherlands for many years, none of them seem to have been established.

3.5.7. *Poa pratensis*

In literature many interspecific hybrids of *Poa pratensis* with wild *Poa* species that are native to the Netherlands, are recorded. Of these only one combination is found in the Herbarium. Yet it seems unlikely, considering the apomictic nature of the species, that such hybrids really occur; recently Stace[156] does not mention any such hybrid for Britain. We considered therefore that only crosses with wild *Poa pratensis* will occur in the Netherlands.

3.5.8. *Raphanus sativus*

Hybrids between *Raphanus sativus* and *Raphanus raphanistrum* are recorded in literature[156], but not in the Herbarium. Because they have the same pollinators, the possibility of hybridization cannot be ruled out for these species. The fact that radishes with a more or less intermediate habit to *R. raphanistrum* have been found in the wild, indicates that hybridization might well occur. The absence of hybrids in the Herbarium is not interpreted as proof of impossibility.

3.5.9. Trifolium repens

For some species of *Trifolium* hybrids have been recorded, but these must be considered to be doubtful: in the same article[70] the author mentions very strong breeding barriers between virtually all species of *Trifolium.*

Therefore hybridization of the cultivated *Trifolium repens* with the other wild species of *Trifolium* is not considered to be important. However, gene flow from cultivated to wild *Trifolium repens* will occur by crossing of cultivated and wild specimens.

4. Evaluation of the D_{pdf}-codes

It is not a part of this study to go into specific types of genes, although for the overall assessment of the permissibility of GMO's it will no doubt be of great importance. This study deals with the actual indications about whether *gene flow to nature* occurs spontaneously. For this purpose the dispersal codes D_{pdf} as defined in the previous paragraphs were developed. In the following paragraphs some recommendations are made for the application of these codes. See paragraphs 3.2.1. to 3.2.3. for the definitions of the different categories of D_{pdf}-codes.

4.1. Evaluation of the codes for D_p (dispersal of pollen)

Cat. 0: No chance for D_p to the wild because in the Netherlands there are no wild species of the same genus as the cultivated plant: no expected ecological effects when the cultivated plants come into flower.

Cat. 1: No chance for D_p to the wild because it is experimentally proven that wild species of the same genus in the Netherlands are not compatible with the cultivated plant: further as Cat. 0.

Cat. 2: No chance for D_p to the wild because there is no record of spontaneously formed hybrids of the cultivated plant with wild species of the same genus in the Netherlands: further as Cat. 0.

Cat. 3: D_p to the wild occurs only occasionally and is therefore of little importance; further as Cat. 0.

Cat. 4: Chance for D_p to the wild is real; flowering of the cultivated plant will have ecological effects on the flora of the Netherlands.
The size of the chance depends on:
a) The distribution density of the wild relatives,
b) The fitness of the offspring,
c) The extent to which the cultivated plant is self-fertilizing or cross-fertilizing (and whether it is wind or insect pollinated).
For the evaluation it can also be important to know the place of the wild relatives in the Dutch ecosystem; what is the 'nature value' of the wild relatives in the Netherlands.

Cat. 5: Chance for D_p to the wild very real; further as Cat. 4.

4.2. Evaluation of the codes for D_d (dispersal of diaspores)

Cat. 0: No chance for D_d to the wild: no ecological effects are expected from the fruiting of the cultivated plants.

Cat. 1: D_d to the wild occurs only occasionally and is therefore of little importance; further as Cat 0.

Cat. 2: Chance for D_d (by spontaneous vegetative reproduction) real; fruiting of the cultivated plant is essentially undesirable; further population-dynamic research necessary. For the assessment the position of the plants in the Dutch ecosystem can be of importance.
N.B. although there are no water plants included in the present study, it should be pointed out that nearly all water plants will be assigned to D_d, Cat. 2. Moreover, it is known that there is a very real chance for invasions with this category of plants.

Cat. 3: Chance for D_d to the wild real; ecological effects can be expected from fruiting of the cultivated plant.

Cat. 4: Chance for D_d to the wild very real; further as Cat. 3.

4.3. Evaluation of the codes for D_f (frequency of dispersal)

Cat. 0: No plants of this species or of a wild relative in the wild; no ecological effects are expected from the introduction of the cultivated plant.

Cat. 1: Plants of this species or of wild relatives are very rare in the wild, and occur sporadically, chances for hybridizing or blending with the wild population are negligible; ecological effects from the introduction of the cultivated plant may be expected on a local scale only.

Cat. 2: Plants of this species or of wild relatives are not very common in the wild, chances for hybridizing or blending with the wild population are small; some ecological effects from the introduction of the cultivated plant may be expected.

Cat. 3: Because plants of this species or of wild relatives are (very) common in the wild, chances for hybridizing or blending with the wild population are substantial; gene flow from the cultivated plant to the wild must be expected.

4.4. Short summary of the codes

The D_{pdf}-code implies that there are no, only local, small or considerable ecological effects to be expected from the cultivated plant. When the effects could not be assessed from what is known now, the number for that code is a 9, meaning that further research is necessary (see table 2).

Table 1. Values for the codes D_p, D_d and D_f

Agrostis capillaris L.	5.4.3	*Lilium* spec.	1.2.1
Agrostis stolonifera L.	5.4.3	*Lolium perenne* L.	5.4.3
Allium cepa L.	1.1.0	*Lupinus luteus* L.	0.1.1
Allium porrum L.	1.1.0	*Lycopersicon esculentum* Miller	0.2.1
Alstroemeria spec.	0.0.0	*Medicago sativa* L.	4.4.2
Anthurium andreanum Linden	0.0.0	*Narcissus pseudonarcissus* L.	4.4.1
Asparagus officinalis L.	4.4.2	*Nerine* spec.	0.0.0
Avena sativa L.	3.1.2	*Nicotiana* spec.	0.1.0
Beta vulgaris L.	4.1.1	*Phaseolus vulgaris* L.	0.1.0
Brassica napus L.	1.2.2	*Pisum sativum* L.	0.1.0
Brassica oleracea L.	1.1.1	*Poa pratensis* L.	5.4.3
Brassica rapa L.	4.4.3	*Rheum* × *hybridum* Murray.	0.1.0
Cichorium intybus L.	4.4.2	*Scorzonera hispanica* L.	0.1.0
Cucumis melo L.	0.1.0	*Secale cereale* L.	0.1.0
Cucumis sativus L.	0.1.0	*Solanum tuberosum* L.	1.2.0
Daucus carota L.	4.4.3	*Trifolium repens* L.	4.4.3
Festuca pratensis Hudson	5.4.3	*Tulipa sylvestris* L.	4.4.1
Fragaria × *ananassa* (Weston) L., V., N. & D.	2.2.2	*Tulipa* spec.	2.1.1
Lilium bulbiferum L.	4.4.1	*Vicia faba* L.	2.1.0

Table 2. Preliminary values for the codes D_p, D_d and D_f

Cichorium endivia L.	3.3.9	*Narcissus* spec.	3.4.9
Lactuca sativa L.	3.4.9	*Raphanus sativus* L.	3.4.9

Table 3. Expected ecological effects of the different categories.

No	0.0.0, 0.1.0, 0.1.1, 0.2.1, 1.1.0, 1.1.1, 1.2.0, 1.2.1, 2.1.0, 2.1.1
Minimal or local	1.2.2, 2.2.2, 3.1.2, 3.4.1, 4.1.1
Substantial	4.4.1, 4.4.2, 4.4.3, 5.4.3
Unknown	3.3.9, 3.4.9

5. Conclusions

This report intends to present some of the aspects necessary for risk assessments in connection with the introduction of GMO plants: the ecological effect of gene flow from the cultivated plant to the wild. Other important aspects, such as the character of the built-in gene, are explicitly not included in this study.

The most important starting-point in this study is that for the assessment of the effective chance for gene flow from GMO's to nature one can use the already existing knowledge in the field of floristics in the Netherlands. It means that we suppose that:

- gene flow from GMO's will not be basically different from gene flow from cultivated plants changed by classical breeding methods;
- any hybrids (as defined under 6) of GMO's with wild relatives will not act basically different from 'normal' hybrids;
- escape patterns of GMO's will not basically differ from those of 'normal' cultivated plants.

Regarding these premises we may conclude that for the assessment of possible ecological effects:

- In *c. 50%* from the cases in this study no ecological effects for 'nature' can be expected of the introduction of a transgenic crop.
- In *c. 15%* from the cases in this study small, often local-scale effects can be expected of the introduction of a transgenic crop.
- In *c. 25%* from the cases in this study considerable effects for 'nature' can be expected of the introduction of a transgenic crop.
- In *c. 10%* from the cases in this study further research should be done before a more definite conclusion can be drawn (most of these cases need further taxonomic research).

6. Glossary

Taxon, Taxa:	Systematic unit of organisms, regardless of the rank, like subspecies, species or genus that is assigned to that unit.
Genus, -era:	Taxon, consisting of a group of species with a common ancestor, that are more closely related to each other than to a species outside that genus.
Species:	Group of closely related organisms that can be distinguished from other species by a set of taxonomic characters. Within a species spontaneous genetic exchange generally takes place between individuals of that group.
Subspecies:	Infraspecific taxon, i.e. under the level of species, distinguished on a combination of habit characters and distribution. Crosses between subspecies of the same species are possible.
Infraspecific:	Taxa that are distinguished on a lower level than species level: subspecies, (sub)varietas, forma.
Cross:	Mechanism, or operation causing exchange of genetic material. Also used for exchange of genetic material between individuals of the same species.
Hybrid:	In taxonomic meaning: offspring resulting from crossing a plant with an individual of another species; a hybrid has a usually much reduced fertility.
Fertile:	A fertile plant is capable of a normal fruit set, yielding germinative seeds. This as opposed to sterile plants, that may look perfectly normal, but are not capable of normal generative reproduction.
Running wild:	The escape from garden, home-garden or field of a cultivated plant by germination of diaspores. The plant may establish, but it is not considered to be part of the flora of the Netherlands, because the plants usually produce no or insufficiently viable offspring.
Wild relative:	In this report we consider as wild relatives only those species (or subspecies) that are considered to be part of the flora of the Netherlands, and of which spontaneous crosses or hybrids with the cultivated plant have been recorded.
Cultivated plant:	Plant of which the features desired by man, have been fixed by domestication.
Diaspores:	Organs for reproduction and spreading of the individual plant, both generative (seeds) and vegetative (tubers, bulbs, runners, stolons).
Greenhouse:	In this report we used the term greenhouse for all sorts of indoor cultivation like hot or cold greenhouses, under glass, on windowsills.
Home-Garden:	In this report we used the term home-garden for the small-scale, but wide-spread non-commercial cultivation on private plots, allotments, etc.
Field:	In this report we used the term field for all cultivation in the open, like agriculture, horticulture, market-gardening, green manuring, and waysides.

SPECIAL PART

BOTANICAL FILES

Agrostis capillaris L. — D_{pdf}: 5.4.3

Dutch : Gewoon struisgras
English : Browntop, Common bent
French : Agrostide commune, Agrostide vulgaire, Agrostide ténue
German : Gemeines Straussgras, Rotes Straussgras

1. Introduction

What: Common bent (*Agrostis capillaris* L.; Gramineae) is a grass of dry and not too moist sandy soils, native to the Netherlands.[20] It is generally used in grass seed mixtures for lawns and pastures, especially bowling greens, because it tolerates short mowing well, and because it forms dense sods by means of runners.[7] Like most Gramineae it is pollinated by wind.[81]

Origin: Europe.[20]

Where: Throughout the Netherlands.

How: In the field.[7]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]

Run wild: Known in the wild.[1]

Where: Very common; poor grasslands and waysides, railways, cleared woodland and deciduous woods.[1]

Seen: Yes (Herbarium).

3. Wild relatives

What: *A. capillaris* L., *A. castellana* Boiss. & Reuter, *A. gigantea* Roth, *A. stolonifera* L.[1 6]

Where: All relatives are fairly to very common in the Netherlands: *A. capillaris*: poor grasslands and waysides, railways, cleared woodland, deciduous woods; *A. castellana*: waysides, possibly elsewhere, distribution insufficiently known; *A. gigantea*: mainly open, moist places on rich soil; *A. stolonifera*: various moist, open to grassy, often eutrophic places, also in moist woods, on high salt marshes, floating and sterile in shallow water.[1]

4. Hybridization

Possible: Species of *Agrostis* hybridized with *Polypogon* and *Calamagrostis* are known in Europe[70]; interspecific hybridization also takes place, more or less easily, in the wild. Hybrids are of rather frequent occurrence; they are usually intermediate between the parents and wholly or largely sterile. Probably commonest of these are *A. capillaris* × *A. gigantea* and *A. capillaris* × *A. stolonifera*.[20] As *A. castellana* was recognized only recently to be part of the Dutch flora, facts on possible hybridization with *A. capillaris* are not yet available. Very recently[156] the hybrid *A. capillaris* × *castellana* has been recognized for Britain; it is partially fertile.

Where: In the wild.

Seen: Yes (Herbarium).

5. Conclusion

Common bent is native to the flora of the Netherlands, both growing and grown throughout the Netherlands. Hybridization with wild relatives of the same or other species is possible and occurring. It implies that both dispersion by escape from cultivation (D_d) and by crossing out (D_p) are generally undetectable. See also paragraph 3.5.1. of the general introduction.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Agrostis stolonifera L. — D_{pdf}: 5.4.3

Dutch : Wit struisgras
English: Creeping bent, White bent, Fiorin
French : Agrostide stolonifère
German: Flechtstraussgras

1. Introduction

What: Fiorin (*Agrostis stolonifera* L.; Gramineae) is a very variable species of bent at moist soils.[20] It is generally used in mixtures with other grasses for lawns, also because it tolerates dry circumstances well. It spreads further by means of long runners, forming dense sods.[7] Like most Gramineae it is pollinated by wind.[81]
Origin: Europe.[20]
Where: Throughout the Netherlands.
How: In the field.[7]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]
Run wild: Known in the wild.[1]
Where: Very common, on various moist, open or grassy, eutrophic places, also in moist woods, on high saltmarshes; floating and sterile in shallow water.[1]
Seen: Yes (Herbarium).

3. Wild relatives

What: *A. capillaris* L., *A. gigantea* Roth, *A. stolonifera* L., *A. vinealis*[1 6 156]
Where: All relatives are fairly to very common in the Netherlands: *A. capillaris*: poor grasslands and waysides, railways, cleared woodland, deciduous woods; *A. gigantea*: mainly open, moist places on rich soil; *A. stolonifera*: various moist, open to grassy, often eutrophic places, also in moist woods, on high salt marshes; floating and sterile in shallow water.[1]

4. Hybridization

Possible: Species of *Agrostis* hybridized with *Polypogon* and *Calamagrostis* are known in Europe[70]; interspecific hybridizing also takes place, more or less easily, in the wild. Hybrids are of rather frequent occurrence; they are usually intermediate between the parents and wholly or largely sterile: *A. capillaris* × *A. stolonifera*.[20] *A. stolonifera* × *vinealis* has recently been recognized in Britain.[156]

Where: In the wild.

Seen: Yes (Herbarium).

5. Conclusion

Fiorin is native to the flora of the Netherlands, both growing and grown throughout the Netherlands. Hybridization with wild relatives of the same or other species is possible and occurring. It implies that both dispersion by escape from cultivation (D_d) and by crossing out (D_p) are generally undetectable. See also paragraph 3.5.1. of the general introduction.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Allium cepa L. — D_{pdf}: 1.1.0

Dutch : Ui
English: Onion
French : Oignon
German: Küchenzwiebel, Zwiebel

1. Introduction

What: Onions (*Allium cepa* L.; Liliaceae) are grown in just about every country in the world[81], for their edible bulbs in a wide range of cultivars. They are used raw, cooked or pickled in brine or vinegar, usually for improving the taste of food. Sometimes they are grown for their attractive dense flower heads[13 20], for dyes or for animal fodder.[27] The plants are highly self-compatible[24], but cross-pollination is common.[25] The flowers are attractive to many species of bees and other Hymenoptera, flies and other Diptera, and numerous other orders of insects. Under normal conditions they are pollinated by honey bees, solitary bees and flies, feeding upon both nectar and pollen[81]; wind and gravity play minor roles in pollination.[24]

Origin: Unknown, apparently derived from *A. oschaninii* B. Fedtsch. of central Asia but known from Dead Sea chalcolitic (3500–3000 B.C.)[13 71]; presumably from northern India, where genuinely wild specimens would have been found.[64]

Where: Southwestern and central clay soils and southern sandy soils in Flevoland, North and South Holland and North Brabant mainly.[7 12]

How: In the field and in gardens.[7 8 20]

2. Escape

Hardy: Yes[13], but onions can withstand temperatures down to –5° C only.[27]

Run wild: Yes, occasionally found outside cultivation (Herbarium), and sometimes mentioned as 'run wild'.[32 34] Not known in the wild.[1 13]

Where: Tips; Goeree[32], Deventer, Gorselse Heide[34], Dordrecht, Wartena[85] (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: Hybrids within the genus *Allium* are almost unknown; *A. cepa* × *A. fistulosum* L. is the only well authenticated cross[13], but *A. fistulosum* is not recorded for the Netherlands.[1 6] (Archives, Herbarium).

Where: —

Seen: —

5. Conclusion

Onions are not native to the Netherlands, and cannot cross with any of the wild species of *Allium* that are part of the flora of the Netherlands, as far as is known now (D_p). They are only occasionally recorded as running wild, and cannot establish and disperse independently (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Allium porrum L. — D_{pdf}: 1.1.0

Dutch : Prei
English: Leek
French : Poireau
German: Breitlauch, Porree

1. Introduction

What: Leek (*Allium porrum* L.; Liliaceae) is a perennial, bulbous herb, cultivated for its edible leaves and leaf-sheaths which have a distinctive taste, especially when raw. In the Dutch climate it behaves like a biennial: a set of leaves in the first year, and flowers in the second[108], although some early races tend to flower in late summer. It is used fresh or deep-frozen, and usually cooked before consumption. It is grown mainly for inland use, year round, with special winter and summer races. Grown from seeds on nurseries and planted out on the field.[8] The floral mechanism appears to be similar to that of *A. cepa*, the limited information available indicates that they are pollinated by bees.[24 25]

Origin: Derived from Asiatic *A. ampeloprasum* L. through many centuries of cultivation.[20] Native to Mediterranean region, cultivated since ancient times (Egypt).[23 102 108]

Where: North Brabant and Limburg mainly.[8]

How: In the field[8] and in home gardens.

2. Escape

Hardy: Yes, winter races can withstand frost.

Run wild: Yes, found outside cultivation[62] (Herbarium).

Where: On a former garden complex in Loosduinen, a wayside in the environment of Werkhoven, near a factory in Steenwijk, near a garden, twice without specification (Herbarium); a tip in Castricum.[62]

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 13]

Where: —

4. Hybridization

Possible: Hybrids within the genus *Allium* are almost unknown, and none are recorded for *A. porrum*.[13]

Where: —

Seen: —

5. Conclusion

Leeks are not native to the Netherlands, and cannot cross with any of the wild species of *Allium* that are part of the flora of the Netherlands, as far as is known now. They are only occasionally recorded as running wild, and cannot establish and disperse independently.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Alstroemeria spec. — D_{pdf}: 0.0.0

Dutch : Incalelie
English : Inca lily, Peruvian lily
French : Alstrémère
German : Inkalilie

Including: *Alstroemeria aurea* Graham, *A. brasiliensis* Sprengel, *A. haemantha* Ruiz & Pavon, *A. ligtu* L., *A. paupercula* Philippi, *A. pelegrina* L., *A. psittacina* Lehm., *A. pulchra* Sims, *A. pygmaea* Herbert and cultivars.[35]

1. Introduction

What: Alstroemeria (Amaryllidaceae) is a genus of herbs with leafy stems. Most species of *Alstroemeria* L. have bright coloured flowers, and a wide range of cultivars and hybrids is cultivated for cut-flower production.[26 35] No reliable information could be found on pollinating agents; possibly pollinated by butterflies.

Origin: South America; Chile, Peru, Argentina, Brazil[26]; probable progenitors of the modern hybrids are *A. aurea*, *A. ligtu* and *A. pelegrina*.[36]

Where: Mainly in North and South Holland.[12]

How: In greenhouses mainly, the less tender species can be cultivated outside in the milder areas of Europe.[13]

2. Escape

Hardy: No (Herbarium).

Run wild: No (Herbarium); locally naturalized in Britain.[156]

Where: —

Seen: No (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: Cultivars of *Alstroemeria* are usually highly sterile.[36]

Where: —

Seen: —

5. Conclusion

Alstroemeria is a solely ornamental greenhouse plant, with no wild relatives in the Netherlands (D_p). It is not hardy to the Dutch climate and has never been found outside cultivation (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Anthurium andreanum Linden — D_{pdf}: 0.0.0

Dutch : Flamingobloem
French : Anthure
German : Blütenschweif, Flamingoblume, Schwanzblume

1. Introduction

What: Anthuriums (*Anthurium andreanum* Linden; Araceae) are terrestrial or epiphytic ornamental plants, and they are cultivated widely because of their attractive foliage and inflorescences. Several cultivars and hybrids of *A. andreanum* with other species of *Anthurium* are grown.[14 37] No reliable information could be found on pollinating agents; possibly pollinated by flies.

Origin: Western slopes of the Andes in southern Colombia and northern Ecuador.[38]

Where: Throughout the Netherlands.

How: In greenhouses and indoors as a window-sill plant.[14]

2. Escape

Hardy: No, it needs a heated greenhouse, even in southern Europe.[14]

Run wild: No (Herbarium).

Where: —

Seen: No (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: No intergeneric hybrids known[38], interspecific hybrids are known and cultivated, but there are no wild relatives in the Netherlands (Herbarium).

Where: —

Seen: —

5. Conclusion

Anthurium andreanum is a solely ornamental greenhouse and window-sill plant, with no wild relatives in the Netherlands (D_p). It is not hardy to the Dutch climate, and has never been found outside cultivation (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Asparagus officinalis L. — D_{pdf}: 4.4.2

Dutch : Asperge
English: Asparagus
French : Asperge
German: Spargel

1. Introduction

What: Asparagus (*Asparagus officinalis* L. subsp. *officinalis*; Liliaceae) is a dioecious, perennial herb with much-branched, smooth stems[20 23] usually propagated by root-stocks, sometimes by seedlings. It is grown as a luxury vegetable for the young, etiolated stems (spears or stalks)[5], for direct consumption or tinning[13]; it has been used as a mild diuretic.[27] Bees are responsible for the pollination, although there is also some wind-borne pollen.[27 81]

Origin: Native to Europe, North Africa, South-West Asia.[13] Cultivated since ancient times.[5 23] Presumably domesticated in the eastern part of the Mediterranean, introduced in the Netherlands before the 16th century.[155]

Where: Predominantly in Limburg and North Brabant, scattered elsewhere.[12] (Fig. 1a.)

How: In the field mainly, also in greenhouses for earlier crops.[9]

2. Escape

Hardy: Yes, a subspecies of the species is native to the Netherlands[1 6]; perfectly capable of surviving in the wild.[21] There are records of single specimens of over 20 years old (Herbarium). However, they can withstand temperatures down to –5° C only[27], so they are restricted to the milder coast regions.[21]

Run wild: Yes, found naturalized widely.[1 21] Because of many centuries of cultivation it is hard to establish where asparagus is originally native and where it has established after escape from cultivation.[5]

Where: Through its whole area of cultivation, especially south of the major rivers[21]; naturalized within its native range and further north.[20] (Fig. 1b.)

Seen: Yes (Herbarium).

3. Wild relatives

What: *A. officinalis* subsp. *prostratus* (Dumort.) Corb.[1 6]

Where: In the dune-district[118], and (less common) to the Wadden Islands, establishing throughout the Netherlands, especially south of the major rivers.[1 21]

4. Hybridization

Possible: Many intraspecific crosses are made artificially to improve yield or quality.[39 40]

Where: In laboratories and possibly in the field.

Seen: No, a cross between parents of the same species would not be recognizable (Herbarium).

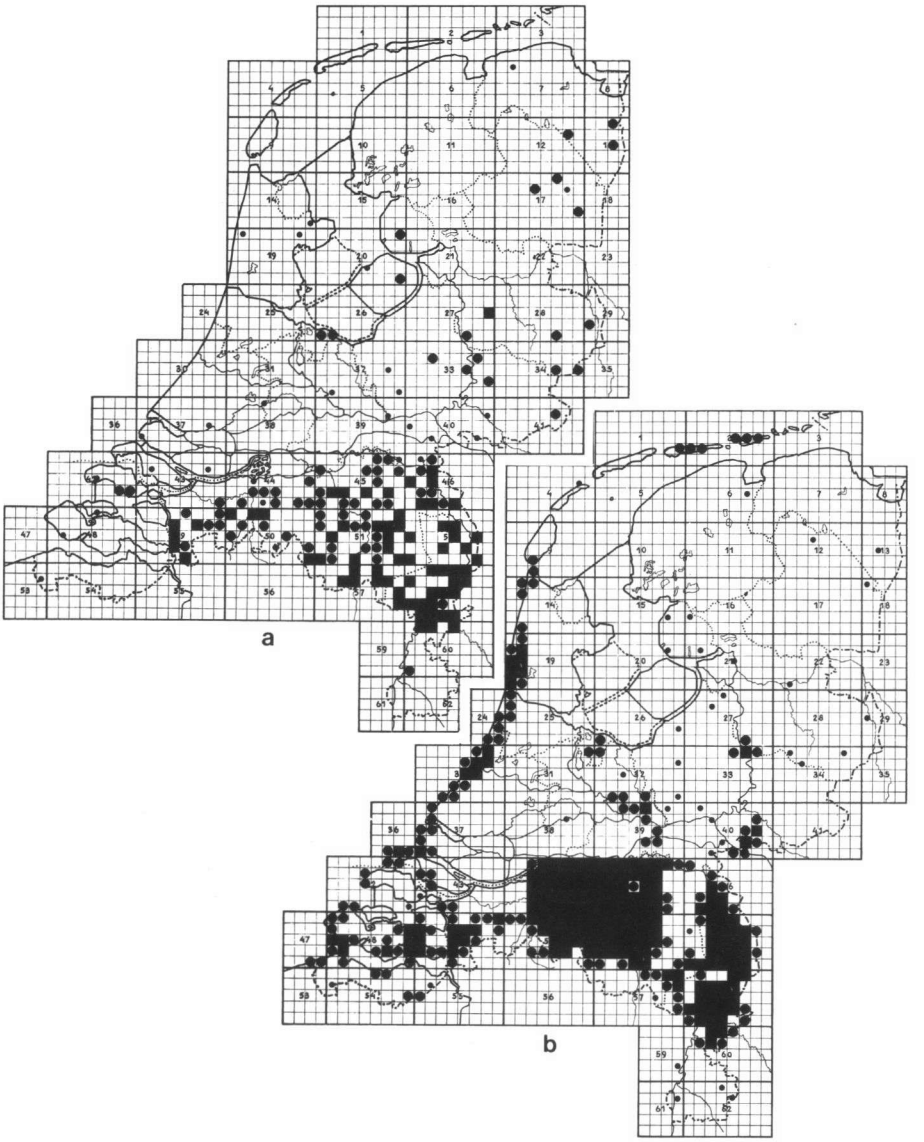

Fig. 1. Distribution of *Asparagus officinalis* L.

a. cultivated. Scale of cultivation:
- • = less than 50 ha;
- ● = between 50 and 500 ha;
- ■ = more than 500 ha.

b. wild:
- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

5. Conclusion

Asparagus officinalis was introduced in the Netherlands as a cultivated plant, but it escaped and established in the dune region presumably before the 16th century. Its wild subsp. *prostratus* is now considered to be part of the flora of the Netherlands. *Asparagus officinalis* subsp. *officinalis*, the cultivated asparagus, is rapidly increasing near places of cultivation as a result of escaping (D_d). It can both escape and establish easily: individual plants of over 20 years old are recorded in the wild.

Apart from spreading by running wild itself, the cultivated asparagus can also spread by outcrossing (D_p). Dioecious plants are always cross-fertilizers, and the main vectors of asparagus-pollen, bees, are present in the Netherlands. So male cultivated asparagus-plants are capable of fertilizing female wild specimens.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

General legend to the figures:

For the occurrences of wild plants the following frequencies are assumed:

- • = record in isolated grid square of the national topographic map, assumed occurrence infrequent;
- ● = record in a particular grid square which directly borders 1 or 2 grid squares in which that species has been recorded as well; assumed occurrence rather frequent;
- ■ = record in a particular grid square which directly borders 3 or 4 grid squares in which that species has been recorded as well; assumed occurrence frequent.

Source: Archives of the State Herbarium. The assumption behind this way of presentation is that the frequency of occurrence within a grid square is related to the number of bordering grid squares in which that species is recorded.

Avena sativa L. — D_{pdf}: 3.1.2

Dutch : Haver
English: Oat
French : Avoine, Avoine cultivée
German: Hafer

1. Introduction

What: Oat (*Avena sativa* L.; Gramineae) is a cereal used for animal fodder and for human consumption. It is sown directly in the arable field.[7] Like most Gramineae it is pollinated by wind.[25 81]

Origin: Originally south-eastern Europe, South-West Asia[1 102]; a form of *A. fatua* L. taken into cultivation by the Germans[84], cultivated since 3000 B.C.[23]

Where: Throughout the Netherlands. Northern sands and reclaimed peat bogs are most important, also northern sea clay, Flevoland and Zeeland.[7]

How: In the field.[7]

2. Escape

Hardy: Yes.

Run wild: Yes, occasionally found outside cultivation (Herbarium); cultivated on a large scale and occasionally running wild.[29 121]

Where: Throughout the Netherlands, near flour mills, canal sides[76 103], ruderals[85], tips, river sides[86], sea dykes[120] (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: *A. fatua* L.[1 6]

Where: Farmland, also open waysides.[1]

4. Hybridization

Possible: *A. fatua* × *A. sativa* is a naturally occurring hybrid, which has a low fertility; back-crossing has been observed.[70 137 156]

Where: Found sporadically in Europe[70], but to be expected wherever both parents are growing together.[137]

Seen: No (Herbarium).

5. Conclusion

Oats are not native to the Netherlands, but they are fairly common cereals, grown throughout the Netherlands. They are occasionally running wild, and then found at unnatural places only. Neither in the Herbarium, nor in literature there seem to be records of oats getting established in the wild (D_d).

Although there is no positive evidence in the Herbarium, there are indications in literature that hybridization of this cultivated species with the wild oat growing in the Netherlands, is possible (D_p). See also paragraph 3.5.2. of the general introduction.

Expectation: The D_{pdf}-code indicates a **small ecological effect** on the flora of the Netherlands.

Beta vulgaris L. — D_{pdf}: 4.1.1

Dutch : Biet
English : Beet
French : Bette, Betterave
German : Mangold, Bete, Rote Rübe, Betarübe

Beta vulgaris var. *conditiva* Alef.

Dutch : Kroot, Rode biet
English : Red beet, Beetroot
French : Betterave potagère
German : Rote Rübe

Beta vulgaris var. *vulgaris*; *B. vulgaris* subsp. *cicla* (L.) Arcang.

Dutch : Snijbiet
English : Spinach beet, Swiss chard
French : Bette, Poirée
German : Mangold

Beta vulgaris var. *crassa* Mansf.

Dutch : Voederbiet
English : Fodderbeet, Mangold
French : Betterave fourragère
German : Runkelrübe

Beta vulgaris var. *altissima* Döll

Dutch : Suikerbiet
English : Sugar beet
French : Betterave sucrière
German : Zuckerrübe

1. Introduction

What: Beet (*Beta vulgaris* L.; Chenopodiaceae) is an annual, biennial or perennial herb. Cultivated plants are annual or biennial, and belong to subsp. *cicla* (L.) Arcang. or to subsp. *vulgaris*. [156] Beets are used in four different ways: sugar beets (var. *altissima)* for the production of sugar[7]; fodder beets for cattle[7]; chard (var. *vulgaris*) and red beets (var. *conditiva*) for human consumption[8]; and as an ornamental plant in the garden.[15] Of these, sugar beets are most important, with fodder beets second.[7 8] The flowers, solitary or in clusters of 2–8[1 24] are perfect, but they are rarely self-pollinating, because the stigma is not fully mature when the flower opens. By the time the stigma ripens, on the second or the third day of flowering, the anthers of the same flower have withered and no longer produce pollen. Beet is usually considered to be pollinated by wind and insects, the former being the most important.[65] Some cross-pollination is also done by thrips and syrphids.[81]

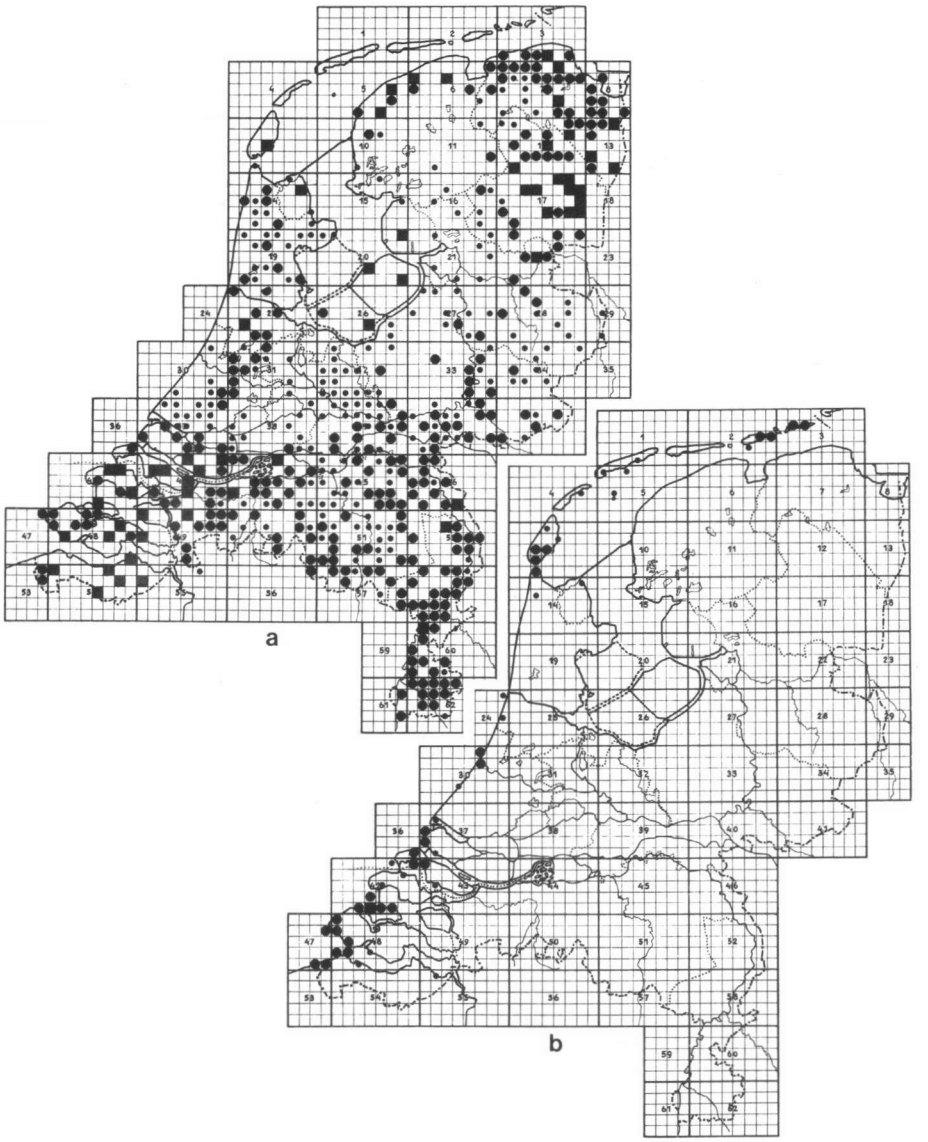

Fig. 2. Distribution of *Beta vulgaris* L.

a. cultivated. Scale of cultivation:
- • = less than 50 ha;
- ● = between 50 and 500 ha;
- ■ = more than 500 ha.

b. wild (see also general legend, page 27):
- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

Origin: The cultivated forms originate from the Mediterranean area.[15] In the sixth to fourth century B.C. the first cultivated forms were developed to be used as salad vegetables (chard).[102] Fodder beets are known since ancient times, red beets are cultivated since the 15th century, and sugar beets were not developed before the end of the 18th century.[23]

Where: Throughout the Netherlands, especially Groningen, Drenthe, Flevoland, Zeeland and western North Brabant.[12] (Fig. 2a.)

How: In the field mainly[7 8] and in home gardens except for sugar beets and fodder beets.

2. Escape

Hardy: Yes, a subspecies of the species is native to the Netherlands.[1 6]

Run wild: Possibly, but when running wild it is difficult to distinguish the cultivated beet from its wild subsp. *maritima* (L.) Arcang.[2 44]; often found outside cultivation (Herbarium); a common casual or relic from cultivation[1 156]; there are no indications (Herbarium) that such plants can establish in the wild.

Where: Throughout the Netherlands, on island Goeree[32], coast[44], dunes, river sides[87], ruderals, waysides, tips[88] (Herbarium). (Fig. 2b.)

Seen: Yes (Herbarium).

3. Wild relatives

What: *B. vulgaris* subsp. *maritima* (L.) Arcang.; a rather rare, usually perennial herb.[1 6 156]

Where: Sea-embankments, harbours, flood-marks, in the Delta region.[1] In the Mediterranean, and western European coasts up to the mouth of the East Sea.[2]

4. Hybridization

Possible: *B. vulgaris* subsp. *maritima* × *B. vulgaris* subsp. *vulgaris* is a fertile cross, formed in the wild[70]; when a sufficient number of crosses is made, most types of *Beta vulgaris* can be hybridized experimentally with the wild species of the section *Patellares*.[63]

Where: *B. vulgaris* subsp. *maritima* × *B. vulgaris* subsp. *vulgaris* is formed wherever parents grow close together[70]; other hybrids are experimental.[63]

Seen: No, a cross between parents of the same species would not be recognizable (Herbarium).

5. Conclusion

Beta vulgaris subsp. *maritima* is native to the flora of the Netherlands, especially to the Delta region. Subsp. *vulgaris*, is only found at unnatural habitats; there are no indications that it can establish in the wild (D_d). Especially in the coastal areas the cultivated beet can spread by outcrossing to the wild subsp. *maritima* (D_p).

Expectation: The D_{pdf}-code indicates a **small ecological effect** on the flora of the Netherlands, but only locally, in the coastal areas where the wild beet is found.

Brassica napus L. — D_{pdf}: 1.2.2

Dutch : Koolzaad
English: Cole-seed, Colza, Rape, Rutabaga, Winter rape
French : Colza, Navet, Navet oléifère
German: Raps

Brassica napus var. *napobrassica* (L.) Rchb.

Dutch : Koolraap
English: Swede
French : Chou-navet, Rutabaga
German: Kohlrübe

1. Introduction

What: Cole-seed or swede (*Brassica napus* L.; Cruciferae) is a herbaceous plant with long terminal racemes, considered to be self-compatible and autogamous.[42] It is grown for the honey and for the oil-containing seeds; as a vegetable for the tubers (var. *napobrassica*); as a seedling salad plant[156]; as a fodder for the leaves[7 8]; and for green manuring and soil-improvement on waysides.The oil that is low in erucid acid is used for margarine and cooking oil, that with high levels is used for lubricating jet-engines etc.[71] The pulp remaining from pressing the oil is used as a high quality fodder.[41] The seeds are also used to feed animals in the wild. Winter cole-seed is grown as a biennial, summer cole-seed as an annual.[44] Bees are main pollinators and they collect only nectar, returning with up to 60 mg loads per flight (which is roughly half the weight of a worker bee).[81] In botanical literature *B. napus* is often confused with its parent *B. rapa*.

Origin: Probably an allopolyploid hybrid between *B. oleracea* L. and *B. rapa* L.[1 3] Cultivated since Stone Age.[23]

Where: Throughout the Netherlands, especially in Flevoland and Groningen.[7]

How: In the field[7] and in home gardens.

2. Escape

Hardy: Yes, it can withstand temperatures below –5° C.[27] Per year only 20% of the seeds present will germinate, so after a good seed-set there will be seedlings coming up for many years.[67]

Run wild: Not very frequently occurring as an escape, sometimes reported to form established populations[1 107]; like *B. rapa* this species is often found on disturbed ground, growing from seed.[3] Cultivated in most European countries and naturalized in many of them.[16] Many records of escaped *B. napus*, however, turned out to be misidentifications of *B. rapa*. It appears that part of the literature is based upon these misinterpretations. Cole-seed is used to feed animals in the wild, and it is sown as a soil improver along waysides, which might also explain the occurrence of some plants outside cultivation.

Where: Throughout the Netherlands[29 32 107], on disturbed ground, waysides, open slopes[3], tips[85], near a flour factory, river sides and canal sides[76 122], in cities (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands, except for the spontaneous *B. rapa* L.[1 6], see Hybridization.

Where: —

4. Hybridization

Possible: *B. napus* itself is (probably[1]) a hybrid between *B. oleracea* and *B. rapa*, the primary hybrid is unknown in the wild[3 70]; *B. napus* × *B. rapa* occurs sporadically in crops of swede when seed-stocks have been exposed to pollination by *B. rapa* (this is also an experimental hybrid), the hybrid has much reduced fertility, although some seeds have been obtained and raised for several successive generations.[70 156] Experimental crosses of *B. napus* with *B. nigra* showed that they are hardly compatible.[68]

Where: There is no positive evidence of spontaneous hybrids in the wild (Herbarium)

Seen: —

5. Conclusion

Cole-seed is not native to the Netherlands, but it is found rather frequently outside cultivation, on disturbed ground and other unnatural habitats. It is sown in along waysides, and is used to feed animals in the wild, which implies that there is repeated introduction. Very little evidence is present of the subject of spontaneous escape from cultivation to the wild, it is not sure whether cole-seed establishes or not.

To this should be added that in literature this species is often confused with its relative *B. rapa*; many records of established escapes and hybrids can be traced back to this confusion. In this study we found no evidence that an escape of *B. napus* can lead to a second year population in the wild. See also paragraph 3.5.3. of the general introduction.

Hybridization with wild relatives is not possible, although it is observed to occur with other cultivated *Brassica* species.

Expectation: The D_{pdf}-code indicates **a small ecological effect** on the flora of the Netherlands.

Brassica oleracea L. — D_{pdf}: 1.1.1

Dutch : Kool
English: Cabbage, Brassicas
French : Chou
German: Kohl

Brassica oleracea convar. *acephala* (DC.) Alef. var. *gongylodes* L.

Dutch : Koolrabi
English: Kohlrabi
French : Chou rave
German: Kohlrabi

Brassica oleracea convar. *acephala* (DC.) Alef. var. *medullosa* Thell.;
B. oleracea convar. *acephala* var. *viridis* L.

Dutch : Mergkool, Voederkool
English: Marrowstem kale, Leaf kale
French : Chou fourrager, Chou moëllier, Chou fourrager vert, Chou cavalier
German: Markstammkohl, Futterkohl

Brassica oleracea convar. *acephala* (DC.) Alef. var. *sabellica* L.

Dutch : Boerenkool
English: Curly Kale
French : Chou frisé
German: Grünkohl

Brassica oleracea convar. *botrytis* (L.) Alef. var. *botrytis* L.

Dutch : Bloemkool
English: Cauliflower
French : Chou fleur
German: Blumenkohl.

Brassica oleracea convar. *botrytis* (L.) Alef. var. *cymosa* Duch.

Dutch : Broccoli
English: Sprouting broccoli, Calabrese
French : Chou brocoli, Brocoli branchu, Chou brocoli asperge
German: Brokkoli

Brassica oleracea convar. *capitata* (L.) Alef.

Dutch : Sluitkool
English: Head cabbage
French : Chou cabus, Chou pommé
German: Kopfkohl

Brassica oleracea convar. *capitata* (L.) Alef. var. *alba* DC.

Dutch : Witte kool
English: White cabbage
French : Chou pommé blanc
German: Weisskohl

Brassica oleracea convar. *capitata* (L.) Alef. var. *conica* DC.
Dutch : Spitskool
English: Pointed headed cabbage
French : Chou coeur de boeuf, Chou baccalau
German: Spitzkohl

Brassica oleracea convar. *capitata* (L.) Alef. var. *rubra* DC.
Dutch : Rode kool
English: Red cabbage
French : Chou rouge
German: Rotkohl

Brassica oleracea convar. *capitata* (L.) Alef. var. *sabauda* L.
Dutch : Savooiekool
English: Savoy cabbage, Savoy
French : Chou de Milan, Chou frisé
German: Wirsingkohl

Brassica oleracea convar. *oleracea* var. *gemmifera* DC.
Dutch : Spruitkool
English: Brussels sprouts
French : Chou de Bruxelles
German: Rosenkohl

1. Introduction

What: Cabbage (*Brassica oleracea* L.; Cruciferae) is a glabrous biennial to perennial herbaceous vegetable.[16] Most plants are low-growing to 30 cm, until the inflorescence is formed, then the plants may reach 40 cm to 2 m.[81] They are cultivated in different ways, as a fodder[8], as a vegetable[9]; or even as an ornamental garden plant.[1] Considerable difference in opinion exists among authorities about the exact classification of these crops into subspecies, varieties and subvarieties. Types will intercross and the subsequent generation adds to the confusion.[81] They are used fresh, dried, tinned or pickled, and consumed raw or cooked. Most are grown as annuals.[27] Many insects can reach pollen and nectar[81], but main pollinators are short-tongued Diptera and honey bees.[43]

Origin: Native on European coasts, northern Italy to France, southern England, Wales, Helgoland.[1] Wild var. *oleracea* is supposed to be the ancestor of the cultivated cabbage.[156] Cultivated since ancient times.[23]

Where: Throughout the Netherlands, especially in North Holland; Brussels sprouts mainly in South Holland.[8 9 12]

How: In the field and in home gardens; cauliflower also in greenhouses.[8 9]

2. Escape

Hardy: The literature is not clear on this subject; according to Weeda[3] and Van Soest[105] this cultivated species does not run wild, and according to Abeleven[29], Van Soest[106] and Heukels[107] this species is found running wild throughout the Netherlands. Tolerates occasional frost down to –5° C, some varieties are hardier.[27]

Run wild: Often growing on fields as a remnant of previous cultivation, also found on various other places (Herbarium); mentioned running wild in the Archives.[29 106 107]

Where: Allotments, waysides, ruderals, adventive fields, tips[34] (Herbarium); canal-sides in cities[103], unused land near a sugar-factory[104], in the IJsseldelta.[106]

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands, except for the spontaneous *B. rapa* L.[1 6], see Hybridization.

Where: —

4. Hybridization

Possible: *B. oleracea* × *B. rapa* is probably the origin of *B. napus* [3]; *Brassica oleracea* × *Raphanus sativus* is an experimental hybrid.[70]

Where: The hybrids are not found in the wild (Herbarium).

Seen: —

5. Conclusion

Cabbage is not native to the Netherlands, and when it is found outside cultivation, it is growing on former gardens, waysides and unnatural habitats only. According to the herbarium it does not establish in the wild (D_d). It has no wild relatives, so D_p seems not possible. See also paragraph 3.5.3. of the general introduction.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Brassica rapa L. — D_{pdf}: 4.4.3

Dutch : Raap, Meiraap, Knolraap, Stoppelknol
English : Turnip
French : Chou navet, Navet potager, Rave
German : Weisse Rübe, Mairübe, Stoppelrübe, Wasserrübe, Herbstrübe

1. Introduction

What: Turnip (*Brassica rapa* L.; Cruciferae) is an annual or biennial herb, cultivated on a modest scale as a fodder and for green manuring[7], and as a vegetable for the tubers or as a seedling salad plant.[8 9] They are pollinated by bees, usually cross-fertilizing[6], but usually flowering of turnips is prevented, because it reduces yield of the tubers or leaves. In botanical literature *B. rapa* is often confused with *B. napus*, see also Hybridization.

Origin: Origin not certain, presumably Mediteranean.[3] Cultivated since at least 2000–2500 B.C.[139] The name *B. campestris* L. is a synonym of *B. rapa*.[154]

Where: On sandy soils mainly[7], Westland, Over-Betuwe.[9]

How: In the field mainly, also in greenhouses.[7 8 9]

2. Escape

Hardy: Yes.

Run wild: Frequently running wild[1 136]; like *B. napus* this species is often found on disturbed ground, growing from seed.[3] Is cultivated in most European countries, and frequently occurs as an escape.[16] Because of its smaller area of cultivation than *B. napus*, and because it is not fed to animals in the wild, its distribution in the wild must be considered to be subspontaneous at least.

Where: Throughout the Netherlands (Archives), in Friesland[66 120], Zeeland[74], near Arnhem[105], Harderwijk[136], in the Dune region[141], the Wadden Islands.[142]

Seen: Yes (Herbarium).

3. Wild relatives

What: Although *B. rapa* is not yet included in the national checklist[6], we consider the subspontaneous populations in the wild to be the crossable relatives.

Where: — (No reliable information present as yet, but occurrence is (very) frequent.)

4. Hybridization

Possible: A fertile allotetraploid *B. oleracea* × *B. rapa* is probably the origin of *B. napus*[3]; *B. napus* × *B. rapa* sporadically occurs when seedstocks have been exposed to pollination by *B. rapa*; a fertile allotetraploid *B. nigra* × *B. rapa* is probably the origin of *B. juncea*.[70 140]

Where: Experimental, the primary hybrids of the above mentioned combinations are not known to occur in the wild.[70 140]

Seen: There is no positive evidence of spontaneous hybrids in the wild (Herbarium).

5. Conclusion

Turnip as yet is not considered to be native in the Netherlands, but it is found very frequently on open waysides, disturbed ground and other unnatural habitats. It seems to be establishing. To this should be added that in literature this species is often confused with its relative *B. napus*: many records of escape of *B. rapa* appear to be misidentified as *B. napus*. The escapes seem frequent enough to have some effect on the flora of the Netherlands. See also paragraph 3.5.3. in the general introduction.

According to literature[70 140] hybridization with wild *B. nigra* would be possible, but no evidence of this is found in the Herbarium. Hybridization with *Brassica napus*, which is also cultivated, is reported to occur occasionally.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Cichorium endivia L. — D_{pdf}: 3.3.9

Dutch : Andijvie
English : Endive
French : Chicorée frisée, Scarole, Trévise
German : Endivie

1. Introduction

What: Endive (*Cichorium endivia* L.; Compositae) is an annual or biennial herb, cultivated especially in the Netherlands and France for its bitter leaves, consumed cooked, or raw in salads. The plants are highly self-compatible.[27] Many different cultivars are grown, of which some are intermediates between endive and its close relative chicory.[48] No reliable information could be found on pollinating agents.[24]

Origin: Southern Europe[1 19], wild ancestor probably *C. pumilum* Jacq. from Mediterranean area.[48] Cultivated since late ancient times (Greek).[23]

Where: North Brabant and South Holland mainly.[8 12]

How: In the field and in home gardens, also in greenhouses for earlier crops.[8 9]

2. Escape

Hardy: Tolerates occasional frost down to –5° C.[27]

Run wild: Occasionally found outside cultivation[89], often confused with wild or escaped *C. intybus*.[5]

Where: On farmland, waste land[90], water sides, grassy waysides (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: *C. intybus* L.[1 6]

Where: Waysides, dry pastures and dykes, often clay; rather common on river banks[1]; along the major rivers, river forelands, dykes.[90] Common on calcareous soils.[48]

4. Hybridization

Possible: There are records of hybridizations between *C. intybus* and *C. endivia*.[101]

Where: Experimental hybrids in Northern America[101], but not in Europe.

Seen: No; a hybrid between parents that are difficult to distinguish would not be recognizable (Herbarium).

5. Conclusion

Endive is not native to the Netherlands, but it is found outside cultivation. There are indications that endive (*Cichorium endivia*) and chicory (*C. intybus*) are very closely related; they are compatible according to literature and their distinguishing characters are rather weak. In the Herbarium there are entries that combine some of them or seem intermediate. It implies that there might well be escapes of endive that remain unnoticed (D_d), there may even be unnoticed hybrids (D_p).

Before the question of their relationship is solved, it is difficult to say anything about endive running wild, establishing or hybridizing with wild (sub-?)species. See also paragraph 3.5.4. of the general introduction.

Expectation: The D_{pdf}-code is as yet doubtful, but it may well indicate **some or even a substantial ecological effect** on the flora of the Netherlands.

Cichorium intybus L. — D_{pdf}: 4.4.2

Dutch : Cichorei, Witlof
English : Chicory, Witloof chicory
French : Chicorée sauvage, Endive
German : Wegwarte, Zichorie

1. Introduction

What: Chicory (*Cichorium intybus* L.; Compositae) is a stout, deep-rooted perennial with azure-blue flowers[19], and it is one of the most important market garden vegetables. It has been cultivated since mid 19th century[5] for its etiolated bitter leaves, consumed raw or cooked.[8] Sowing is usually in spring, the roots are harvested, stored during the winter and forced in the dark, covered by sand or earth to produce white to yellow etiolated large sprouts. They are also used as an animal fodder, and as a potential source of fructose.[27] The roots were formerly used as a medicine for the inulin[92 93], in some countries for alcohol distillation[81]; or roasted as a coffee-substitute or admixture.[93] Flowers are morphologically hermaphrodite and predominantly self-incompatible[27], although most individuals will produce some self-fertilized seeds to a limited degree.[72] They are visited by Lepidoptera, Diptera, Coleoptera and Hymenoptera, of which only honey bees have been demonstrated to be effective.[81 91]

Origin: Originally Mediterranean, where most of its wild relatives occur.[5] Cultivated since ancient times (Romans).[23] The use of chicory as a salad-vegetable started in 1840, when an overproduction of chicory for coffee-substitute accidentally led to forcing of left-over roots in the spring. The fact that fresh vegetables in spring were rare in that time could account for its rapid popularity.[100]

Where: Throughout the Netherlands, especially in the Northeast Polder, North Holland, South Holland and western North Brabant, less in the Gelders and western Drents District.[8 12] (Fig. 3a.)

How: The plants are grown in the field and in home gardens; the roots are forced in greenhouses and sheds.[8]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]

Run wild: Known in the wild.[1] Widely naturalized[19], often confused with escaped *C. endivia*.[5 21]

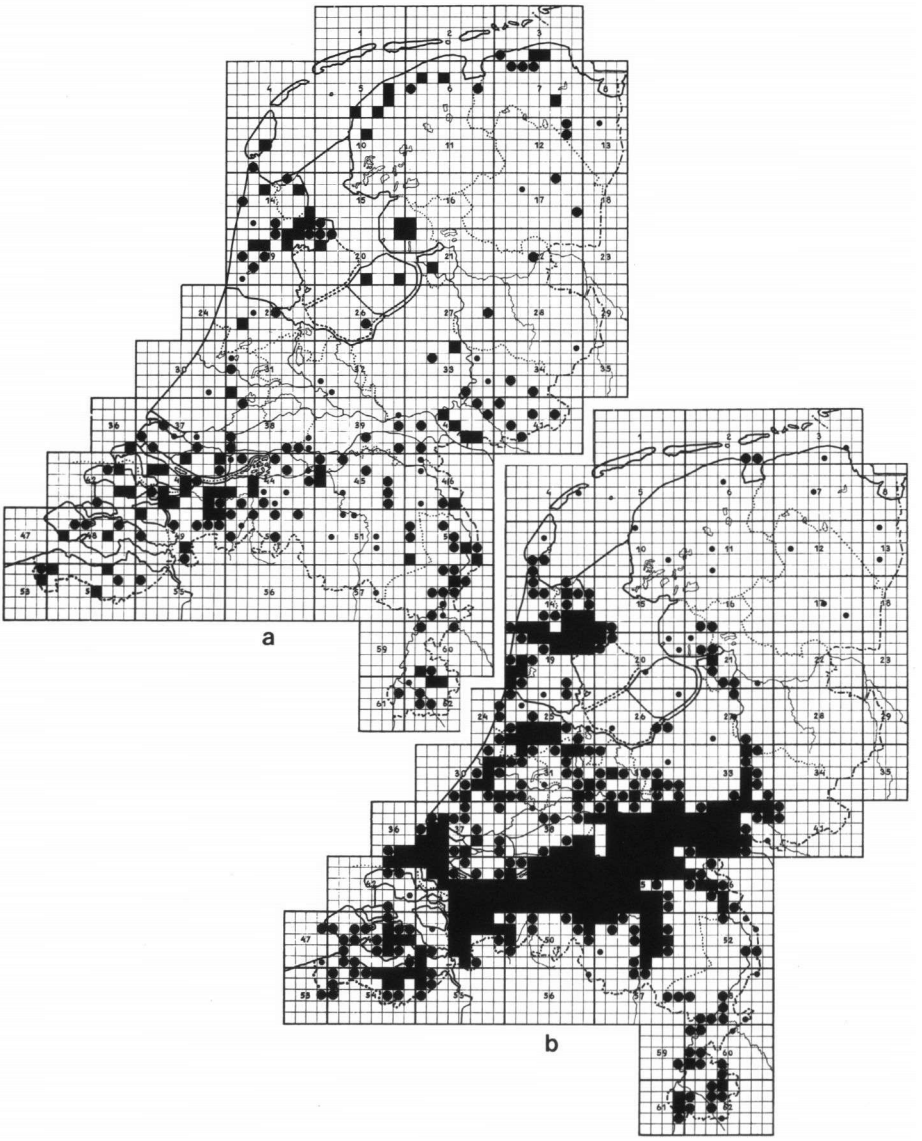

Fig. 3. Distribution of *Cichorium intybus* L.

a. cultivated. Scale of cultivation:
- • = less than 100 ha;
- ● = between 100 and 1000 ha;
- ■ = more than 1000 ha.

b. wild (see also general legend, page 27):
- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

Where: Finds on tips, waysides, flour-factory (Herbarium) outside Fluviatile area are probably escapes[5 90]; its distribution is probably largely due to cultivation.[94]

Seen: Yes (Herbarium).

3. Wild relatives

What: *C. intybus* L.[1 6]

Where: Waysides, dry pastures and dykes, often clay; rather common on river banks, especially in the Fluviatile district1[1]; along the major rivers, river forelands, dykes.[90] Common on calcareous soils.[48] (Fig. 3b.)

4. Hybridization

Possible: There are records of hybridizations between *C. intybus* and *C. endivia*.[101]

Where: Experimental hybrids reported.[101]

Seen: No; a hybrid between parents that are difficult to distinguish would not easily be recognizable (Herbarium). Crosses with wild chicory must be considered possible and undetectable.

5. Conclusion

Chicory is native to the flora of the Netherlands. The cultivated form is probably capable of running wild (D_d), but an escape would be morphologically undetectable. Crosses with wild chicory must be considered possible, and occurring (D_p). Chicory is often confused with escaped endive (*C. endivia*); in the Herbarium there are entries that combine some of their distinguishing characters or seem intermediate. See also paragraph 3.5.4. of the general introduction.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Cucumis melo L. — D_{pdf}: 0.1.0

Dutch : Meloen
English : Melon
French : Melon
German : Melone

1. Introduction

What: Melons (*Cucumis melo* L.; Cucurbitaceae) are trailing annuals, with vines spreading to over 3 m. They are cultivated for their large succulent fruits, consumed fresh, frozen or canned. The seeds may contain oil. Insects are the main pollinators, principally bees are used under commercial conditions.[27] It is an old crop, and a lot of improving by breeding has been carried out.[9] Most European cultivars are monoecious, having separate pistillate and staminate flowers.[24]

Origin: Derived from *C. agrestis* Naud. from north-eastern Africa and *C. pubescens* Willd. from central Asia, cultivated since ancient times (Egypt, India).[23]
Where: In the Westland.[9]
How: In greenhouses.[9]

2. Escape

Hardy: No, does not tolerate temperatures below 0° C[27]; frost-susceptible.[81]
Run wild: Yes, occasionally found outside cultivation (Herbarium).
Where: Almost exclusively on tips throughout the Netherlands[34]: Friesland[66], Arnhem[90], Dordrecht[109], Soest[110], Beverwijk[111]; Waalhaven Rotterdam, river side Limburg[112] (Herbarium).
Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[16]
Where: —

4. Hybridization

Possible: All forms of *C. melo* readily intercross among themselves[81] and hybridize with other *Cucumis* species, but these are not present in the Netherlands.
Where: —
Seen: —

5. Conclusion

Melons are not native to the Netherlands, and they do not have wild relatives in the flora of the Netherlands (D_p). When they are found outside cultivation, it is on unnatural habitats like harbours and refuse dumps. Because they are not hardy to the Dutch climate, they are not found to establish anywhere (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Cucumis sativus L. — D_{pdf}: 0.1.0

Dutch : Augurk, Komkommer
English: Cucumber, Gherkin
French : Concombre, Cornichon
German: Einlegegurke, Gurke

1. Introduction

What: Cucumbers and gherkins (*Cucumis sativus* L.; Cucurbitaceae) are herbaceous, prickly annuals[23], grown from seed. They are cultivated all over the world for the edible fruits, eaten raw, cooked or pickled (the smaller-fruited cultivars). In some countries the young leaves are used raw for salad or cooked as a vegetable.[25] They are monoecious, i.e. with separate

pistillate and staminate flowers on the same plant, with bees and wasps as main pollinators. The cultivars grown in the Netherlands are usually parthenocarpic: when they are pollinated accidentally, the fruits will be misshapen, resulting in a diminished commercial value.[24]

Origin: Unknown.[1] *C. hardwickii* Hook. growing wild in the Himalayas is considered the progenitor of the cultivated cucumber which has long been a cultivated plant in India. From there it went to Egypt in early times and was spread to central Europe by the Romans.[23 102]

Where: Throughout the Netherlands; under glass mainly in South Holland; in the field mainly in Limburg and North Brabant.[12]

How: In the field, home gardens and in greenhouses.[9]

2. Escape

Hardy: No, the fruits would not survive the Dutch winters; moreover, cucumbers and gherkins in the Netherlands are usually sterile.

Run wild: Not known in the wild; mentioned a few times.[34 66]

Where: A waste deposit near Wijster[34], tip in Friesland.[66]

Seen: No (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: All forms of *C. sativus* readily hybridize among themselves and with other *Cucumis* species, but these are not present in the Netherlands.

Where: —

Seen: —

5. Conclusion

Cucumbers and gherkins are not native to the Netherlands, and they do not have wild relatives in the flora of the Netherlands (D_p). When they are found outside cultivation, it is on unnatural habitats like tips. Because they are not hardy to the Dutch climate, they are not found to establish anywhere (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Daucus carota L. — D_{pdf}: 4.4.3

Dutch : Peen, Waspeen, Wortel
English: Carrot
French : Carotte, Racine jaune
German: Gelbrübe, Karotte, Möhre

1. Introduction

What: Carrots (*Daucus carota* L. subsp. *sativa* (Hoffm.) Arcang.; Umbelliferae) are annual or biennial herbs, variable in habit and branching.[17] They are important vegetables, cultivated for their fleshy, orange roots, the larger winter-carrots for storage, the finer bunched carrots for direct consumption or tinning[8]; roasted roots can be used as a coffee substitute, oil from the seeds is used for flavouring liquors etc.[71] Propagation is by seed from special seed-production fields, near which no wild carrots are tolerated, because of the possibility of hybridization.[3] Under optimal conditions carrots usually behave like biennuals in the Netherlands. Under less favourable circumstances flowering can be postponed for several years, because a minimum root diameter is required to induce flowering.[45] They are pollinated by bees, flies, wasps and beetles, but they are not very attractive to them if there are better crops around.[24 81] Nevertheless, carrots are important honey sources.[25]

Origin: Various different views are found in literature about the origin of the present-day cultivated carrot: Mediterranean to Siberia and India, cultivated since ancient times (Greek)[23]; probably from Afghanistan, distributed over Europe through Spain[45]; Neolithic discoveries of carrot seeds make it feasible that carrots were grown as a cultivated plant quite early: reliable reports exist from the first century. It might have originated from a spontaneous cross of our native wild species with the Mediterranean species *D. maximus* Desf.[102]

Where: Throughout the Netherlands.[12] (Fig. 4a.)

How: In the field[8] and in home gardens.

2. Escape

Hardy: The cultivated form has reduced hardiness.

Run wild: The cultivated form is sometimes found in the wild[28] (Herbarium).

Where: A waste deposit in Nijlamer, former garden sites in Den Haag (Herbarium); a sumak terrain in Apeldoorn[28], dykes, waysides and ruderals.[95 124]

Seen: Yes (Herbarium).

3. Wild relatives

What: *D. carota* subsp. *carota* L.[1 6]

Where: Rather dry grasslands, waysides, dykes and dunes[1 123]; common throughout the Netherlands, less common in the northern Peat-bog and Gelders districts, rather rare in the Drents district.[1 22] (Fig. 4b.)

Fig. 4. Distribution of *Daucus carota* L.

a. cultivated. Scale of cultivation:
- • = less than 100 ha;
- ● = between 100 and 1000 ha;
- ■ = more than 1000 ha.

b. wild (see also general legend, page 27):
- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

4. Hybridization

Possible: Crossing may occur when cultivated carrots are grown for seed production in areas next to habitats of wild carrots. Introgression from the cultivated carrot may cause small changes in morphological and phenological characteristics of the wild carrot.[46] Pollination between wild and cultivated carrots is possible both ways.[3 124]

Where: In fields with flowering carrots for seed-production, when wild carrots are allowed to flower nearby.

Seen: In literature.[46]

5. Conclusion

Cultivated carrots only occasionally are found in the wild, and they will hardly establish due to the lack of winter hardiness of their fleshy roots. In the Herbarium there are only three records of escaped carrots.

In spite of measurements, like mowing, taken to prevent wild carrots growing near carrot-seed production fields, sometimes wild specimens nevertheless are found flowering on waysides near such fields. And although cultivated carrots usually behave like biennials, there can always be some flowering in the first year (bolters). So there can be cross-pollination between the wild and the cultivated carrot. This implies that cultivated carrots might cause gene flow to the wild population of carrots in the flora of the Netherlands, supposedly more by outcrossing (D_p) than by escaping (D_d).

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Festuca pratensis Hudson — D_{pdf}: 5.4.3

Dutch : Beemdlangbloem
English: Meadow fescue
French : Fétuque des prés
German: Wiesenschwingel

1. Introduction

What: Meadow fescue (*Festuca pratensis* Hudson; Gramineae) is a grass used in mixtures for meadows, it is winter-hardy and tolerates mowing well. It is not a very important grass for sporting grounds or waysides.[7] Like most Gramineae it is wind-pollinated.[81]

Origin: Most of Europe, except in parts of Mediterranean region.[20]

Where: Throughout the Netherlands.

How: In the field.[7]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]

Run wild: Known in the wild.[1]

Where: Rather common, in grasslands and road-sides on moist, moderately fertilized soil.[1]

Seen: Yes (Herbarium).

3. Wild relatives

What: *F. arundinacea* Schreb., *F. gigantea* (L.) Villars, *F. ovina* L., *F. pratensis* Hudson, *F. rubra* L.[16]

Where: *F. arundinacea*: moist grass lands, watersides, dykes and waysides, especially sea-clay; *F. gigantea*: moist deciduous forests and moist, shadowed places on eutrophic soils; *F. ovina*: open, dry sandy places, waysides, dunes, dykes, railways, open spaces in heaths and forests, fairly common; *F. rubra*: many grassy places, dry as well as moist, usually little fertilized soils, also high salt marshes, dunes, and open deciduous forests.[1]

4. Hybridization

Possible: *F. arundinacea* × *F. pratensis* is a sterile hybrid, but it is formed in the wild, and is very much like *F. arundinacea* in central Europe; *F. gigantea* × *F. pratensis* is a sterile hybrid or with low fertility, it is made experimentally and also formed in the wild in western Europe, it is like *F. gigantea*; also doubtful hybridizations with *F. heterophylla*, *F. rubra* and *F. ovina* are reported; *Festulolium* is an intergeneric hybrid.[70]

Where: *F. gigantea* × *F. pratensis* and *Festulolium* in the wild (Herbarium).

Seen: Yes, the two hybrids mentioned above (Herbarium).

5. Conclusion

Meadow fescue is native to the flora of the Netherlands, both growing and grown throughout the Netherlands, so an escape from cultivation (D_d) will be morphologically undetectable. Hybridization with wild relatives of the same or other species (D_p) is possible and occurring, although some interspecific hybrids are sterile or doubtful. See also paragraph 3.5.5. of the general introduction.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

— *Fragaria* × *ananassa* (Weston) Lois., Vilm., Nois. & J. Deville —

—— D_{pdf}: 2.2.2 ——

Dutch : Aardbei
English : Pineapple strawberry, Strawberry
French : Fraise, Fraisier ananas
German : Ananaserdbeere, Erdbeere

1. Introduction

What: Strawberries are stemless, low-creeping, usually perennial herbs with numerous rooting runners. Cultivation of the European strawberry has taken place since about 1300, but long before that they were already known as edible wild fruits of the woods. The large-fruited hybrids cultivated today are chiefly cultivars of the pineapple strawberry *F.* × *ananassa* (Weston) Lois., Vilm., Nois. & J. Deville; Rosaceae).[47] Their

red, fleshy false fruits are consumed fresh, preserved in jams, deep-frozen or tinned.[27] Strawberries are almost exclusively propagated by means of rooted runners, even though the seeds are viable.[81] Although they are not overly attracted by strawberry flowers[81], the main pollinators are bees, they improve fruit-set.[27 47] Without pollination by mainly honey bees and also Diptera there would be less fruit set and more malformations.[24]

Origin: Several hybridizations between *F. chiloensis* (L.) Miller, *F. virginiana* Miller and *F. ovalis* Rydb., cultivated since 1759[23]; from Western America.[17]

Where: Southern sandy soil and river clay areas mainly, also scattered elsewhere.[12]

How: In the field and in home gardens, also greenhouses for earlier crops.[12]

2. Escape

Hardy: Yes. The leaves die off in winter, the roots sprout again in spring.[47]

Run wild: Runs wild rather frequently[3]; occasionally found far away from cultivation, sometimes locally numerous (Herbarium); but not naturalizing due to poor fruit setting in the wild.

Where: Along the sea coast, on Texel and Schiermonnikoog, waysides, scattered elsewhere (Herbarium); dunes, similar habitats as *F. vesca*, in Zeeland.[32]

Seen: Yes, also doubtful specimens under different names like *F. virginiana*, *F. chiloensis*, *F. vesca*, *F. elatior* (Herbarium).

3. Wild relatives

What: *F. moschata* West., *F. vesca* L.[1 6]

Where: *F. moschata*: deciduous forests, country-seats, rather rare[1], in Fluviatile district and southern Limburg mainly[21]; *F. vesca*: dunes, dykes, forests on limy or calcareous soil[1], scattered, mainly Fluviatile and Dune districts.[22]

4. Hybridization

Possible: *F. ananassa* × *F. vesca* is an experimental, completely sterile hybrid, often dying well before flowering.[70] Cultivated large-fruited strawberries and the species *F. chiloensis*, *F. virginiana* and *F. ovalis* intercross freely and their hybrids produce fertile seedlings, except when ploidy-levels do not correspond; *F. ananassa* × *F. moschata* is an experimental hybrid.[47]

Where: Experimental, possibly in gardens.[47]

Seen: Only in literature.[47]

5. Conclusion

Strawberries are cultivated commercially mainly in the southern parts of the Netherlands, but they are grown in many home gardens throughout the Netherlands. The possibilities for spontaneous hybridization (D_p) with wild *Fragaria* species can be considered minimal. However, *F.* × *ananassa* is escaping rather frequently (D_d); probably mostly dispersed as a false fruit by birds and man, but also escaping vegetatively by the runners. Fruit setting in the wild is poor, so the foundation of

second generation populations is unlikely. Because the plant is perennial and hardy, escaped plants can establish for quite some time, and spread (very) locally by means of their runners.

Expectation: The D_{pdf}-code indicates **some ecological effect** on the flora of the Netherlands; because the dispersal is more or less haphazard, it is unpredictable when and where *F.* × *ananassa* will have effect.on the flora of the Netherlands.

Lactuca sativa L. — D_{pdf}: 3.4.9

Dutch : Bindsla, Kropsla, Sla, Snijsla, IJsbergsla
English : Cos lettuce, Cutting-lettuce, Iceberg, Leaf-lettuce, Lettuce, Curled lettuce
French : Laitue, Laitue romaine, Salade, Laitue frisée
German : Bindesalat, Eisbergsalat, Glatte Endivie, Pflücksalat, Schnittsalat, Sommerendivie

1. Introduction

What: Lettuce (*Lactuca sativa* L.; Compositae) is a annual vegetable, cultivated for its crisp, succulent leaf-heads, usually consumed raw, sometimes cooked. They are grown in a wide range of cultivars with different leaf sizes, colours and shapes, propagated by seed.[8 9] About a month after the head forms, if the lettuce is not harvested, the stem within the head elongates and branches to produce the inflorescence, to over 1 m high.[81] Flowers are bisexual, the floral structure encourages self-fertilization and cross-fertilization rarely occurs (more than 99% of the seeds is self-fertilized). Honey bees, bumble bees, hover-flies and flies transfer pollen within and probably between the flower-heads. Wind-pollination is unlikely, because the pollen is not easily dislodged.[24 25]

Origin: Origin not certain, believed to be derived in Egypt from *L. serriola* L.[19] or from *L. virosa* L. in the Mediterranean. Sometimes seen as subspecies of *L. serriola* L.[48] Cultivated for centuries (Persians).[23] See also Oost.[100]

Where: Throughout the Netherlands, especially southern sandy soils.[12] (Fig. 5a.)

How: In the field and in home gardens, also in greenhouses.[8 9]

2. Escape

Hardy: Plant monocarpic[1]; some cultivars do not tolerate temperatures below 0° C, other cultivars can withstand temperatures down to –5° C.[27]

Run wild: Grown everywhere, and escaping relatively rarely[48]; found planted and run wild.[29 30 32]

Where: Throughout the Netherlands (Herbarium): Nijmegen[29], Zeeland[30 32], southern Limburg.[87 113]

Seen: Yes (Herbarium).

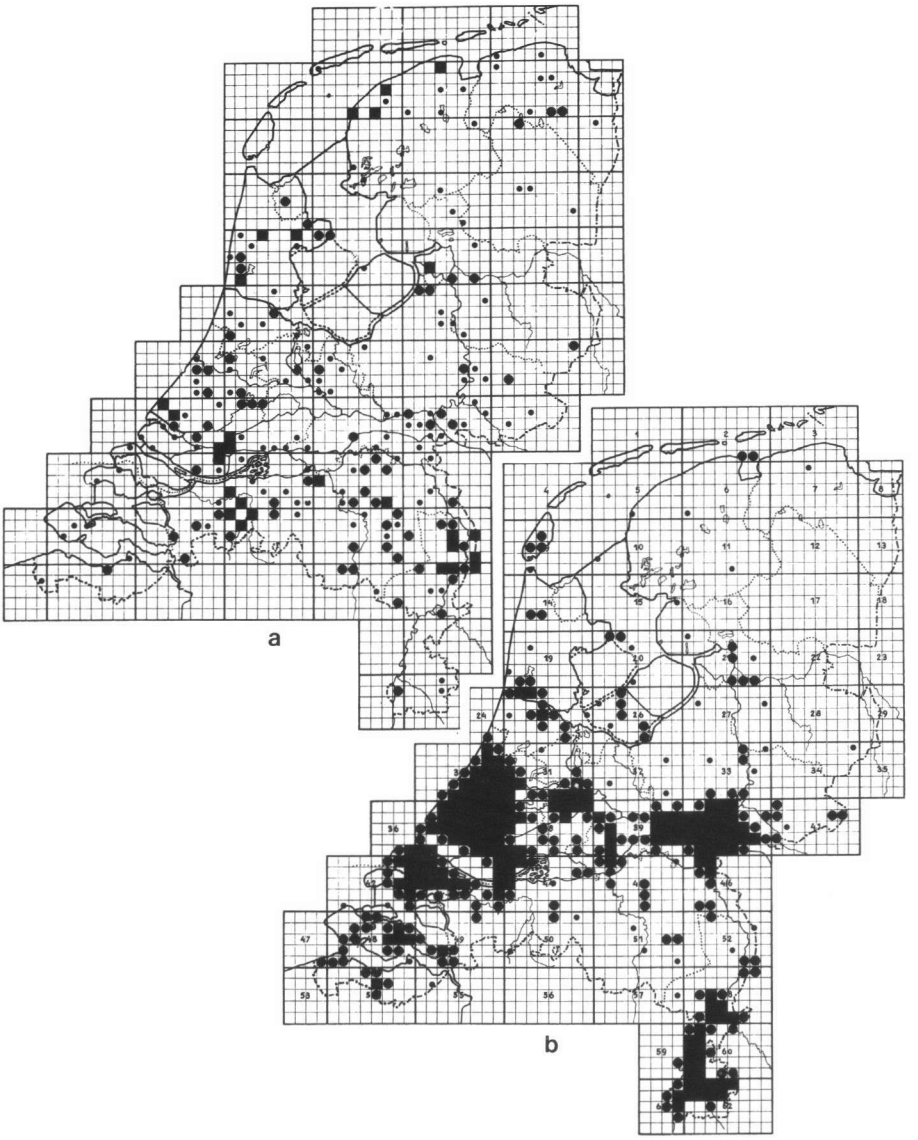

Fig. 5. Distribution of *Lactuca sativa* L. (a) and *L. serriola* L. (b)

a. Scale of cultivation:
- • = less than 50 ha;
- ● = between 50 and 500 ha;
- ■ = more than 500 ha.

b. (see also general legend, page 27):
- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

3. Wild relatives

What: *L. serriola* L.[1 6]

Where: Waysides, dykes, railways, and various ruderals, rapidly expanding especially in suburban areas after earthworks.[1 69] (Fig. 5b.)

4. Hybridization

Possible: *L. sativa* × *L. serriola* and the reciprocal crosses are experimental hybrids, vigorous and fertile, like the parents.[49 145]

Where: Artificial hybrids in greenhouses and literature.

Seen: Only in literature[49 145]; not in the Herbarium.

5. Conclusion

The garden lettuce (*Lactuca sativa*) is not native to the Netherlands, and according to the herbarium it runs wild only rarely. Its wild relative prickly lettuce (*Lactuca serriola*), however, has spread very rapidly since 1950, especially near places of lettuce cultivation. And although it is not unequivocally determined, there is reason to suppose that garden lettuce and prickly lettuce are closely related; to such an extent that they could be regarded as belonging to the same species. It is important to realize that there might be genetic exchange between wild and cultivated lettuces. See also paragraph 3.5.4. of the general introduction.

Expectation: The D_{pdf}-code is as yet doubtful, but might indicate a **substantial ecological effect** on the flora of the Netherlands.

Lilium bulbiferum L. — D_{pdf}: 4.1.1

Dutch : Oranjelelie, Roggelelie
English : Bulbil lily, Orange bulbil lily, Rye lily
French : Lis bulbifère, Lis jaune, Lis orange
German : Feuerlilie, Safranlilie

1. Introduction

What: Bulbil lilies (*Lilium bulbiferum* L.; Liliaceae) are bulbous perennials with attractive bright orange-red flowers.[10] They are is grown in a range of cultivars, often of hybrid origin, for cut-flower production or for gardens.[10] Cultivated plants often bear bulbils in the leaf axils (a character of subsp. *bulbiferum* which is wild in central Europe). They are pollinated by butterflies.[158]

Origin: Native to central Europe.[95]

Where: South Holland mainly.[12]

How: In the field[10], also in gardens.

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]

Run wild: Runs wild frequently; not known to establish.

Where: Along railways (Spaubeek, Leiden).

Seen: Yes (Herbarium).

3. Wild relatives

What: *L. bulbiferum* L. subsp. *croceum* (Chaix) Arcang.[1 6] The oldest record of *L. bulbiferum* in the Netherlands dates from mid 19th century in the northern parts of the Netherlands.[95] Sometimes the bulbs of the wild lilies would be dug out from the rye fields, and planted in gardens, leading to domestication of the lily.[5]

Where: In and near rye fields, becoming extremely rare, also cultivated in gardens, sometimes escaping.[1]

4. Hybridization

Possible: *L.* × *hollandica* (*L. bulbiferum* × *L. maculatum* Thunb.) is a hybrid grown in gardens.[5]

Where: —

Seen: No (Herbarium).

5. Conclusion

Bulbil lilies rarely escape from cultivation (D_d). Rye lilies are native rye field weeds in the Netherlands, although the original wild rye lily is becoming extremely rare because of digging out and better weed control in agriculture. The possibility of hybridization could not be ascertained (D_p).

Expectation: The D_{pdf}-code indicates a **small ecological effect** on the flora of the Netherlands, but only locally, in the few areas where the wild rye lily is found.

Lilium spec. — D_{pdf}: 1.2.1

Dutch : Lelie
English: Lily
French : Lis
German: Lilie

Including: *L. amabile* Palib., *L. auratum* Lindl., *L. brownii* F.E. Br., *L. bulbiferum* L. subsp. *bulbiferum*, *L. canadense* L., *L. candidum* L., *L. cernuum* Kom., *L. chalcedonicum* L., *L. concolor* Salisb., *L. davidii* Duchartre, *L. duchartrei* Franch., *L. formosaum* (Bak.) Wallace, *L. hansonii* Leichtl., *L. henryi* Bak., *L. humboldtii* Roezl & Leichtl., *L. lancifolium* Thunb., *L. longiflorum* Thunb., *L. maculatum* Thunb., *L. martagon* L., *L. monadelphum* M.B., *L. pardalinum* Kellogg, *L. parryi* S. Wats., *L. parvum* Kellogg, *L. pennsylvanicum* Ker-Gawl., *L. philippinense* Bak., *L. pomponium* L., *L. pumilum* Del., *L. pyrenaicum* Gouan, *L. regale* Wils., *L. sargentiae* Wils., *L. speciosum* Thunb., *L. sulphureum* Bak., *L. superbum* L., *L. szovitsianum* Fisch., *L. wardii* F.C. Stern and hybrids.[23]

1. Introduction

What: Lilies (*Lilium* L.; Liliaceae) are bulbous perennials with attractive bright-coloured flowers, grown in a wide range of cultivars of many species, mostly for cut-flower production.[10] They are generally pollinated by butterflies.[158]; *Lilium martagon* is pollinated by hawkmoths.[157]

Origin: About 100 species, native to the temperate northern hemisphere.[13] *L. martagon* L. would be native to central and southern Europe.[96]
Where: South Holland mainly.[12]
How: In greenhouses mainly[10]; also in gardens.

2. Escape

Hardy: More or less, see below.
Run wild: Yes, *L. martagon* L. is found running wild[1 96] from gardens for over a century, and locally establishing (Herbarium).
Where: Between coppices, in woods: Vogelenzang (Haarlem), Duinvliet, Elswoud, Haagse Bosch, Slochterense Bosch[96] (Herbarium).
Seen: Yes (Herbarium).

3. Wild relatives

What: *L. bulbiferum* L.[1 6]
Where: Along railways and in and near rye fields, very infrequently.[1]

4. Hybridization

Possible: *L.* × *hollandica* (*L. bulbiferum* × *L. maculatum* Thunb.) is a hybrid grown in gardens.[5]
Where: —
Seen: No (Herbarium).

5. Conclusion

Many different species of lily that are cultivated are not native to the Netherlands, but occasionally they are found outside cultivation, probably spreading vegetatively, or even establishing. The possibility of hybridization between cultivated lilies and the wild *L. bulbiferum* L. subsp. *croceum* (Chaix) Arcang. could not be ascertained, because the wild species has almost disappeared from the flora of the Netherlands.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Lolium perenne L. — D_{pdf}: 5.4.3

Dutch : Engels raaigras
English : Perennial ryegrass
French : Ivraie vivace, Ray-grass anglais
German : Deutsches Weidelgras, Englisches Raigras

1. Introduction

What: Rye-grass (*Lolium perenne* L.; Gramineae) is a perennial cross-fertilizing grass, the most important species in the grass-seed mixtures used for meadows, hayfields, sporting fields and pastures, also much used for playing fields and lawns. It grows best on clay soils and moist sand, and is not very drought resistant.[7] Like most Gramineae it is pollinated by wind.[81]
Origin: Europe.[20]
Where: Throughout the Netherlands.
How: In the field.[7]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]
Run wild: Known in the wild.[1]
Where: Grasslands and fertile or well-fertilized pastures, ruderals and well-trodden ground.[1]
Seen: Yes (Herbarium).

3. Wild relatives

What: *L. perenne* L., *L. multiflorum* Lam.[1 6]
Where: *L. perenne*: grasslands, and fertile or well-fertilized pastures, ruderals and well-trodden ground; *L. multiflorum*: cultivated widely as a fodder grass, especially on new grassland. Sometimes germinating from spilt seeds on waysides, fields and ruderal places, usually not lasting.[1]

4. Hybridization

Possible: *L.* × *boucheanum* Kunth (*L. multiflorum* Lam. × *L. perenne*) is frequently[20 156] formed in the wild and experimentally in western and central Europe, the hybrid is very fertile.[70] It is also cultivated and escapes easily. *Festuca pratensis* Hudson × *Lolium perenne* (× *Festulolium*) is an intergeneric hybrid with poorly developed pollen.[1]
Where: *L.* × *boucheanum* Kunth is cultivated widely; × *Festulolium*: often growing in old pastures on fertile soil, on watersides together with the parents.[1]
Seen: Yes (Herbarium).

5. Conclusion

Rye-grass is native to the flora of the Netherlands, both growing and grown throughout the Netherlands, so an escape from cultivation (D_d) will be morphologically undetectable. Hybridization with wild relatives of the same or other species or even another genus (D_p) is possible and occurring.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Lupinus luteus L. — D_{pdf}: 0.1.1

Dutch : Gele lupine
English: Yellow lupin
French : Lupin jaune
German: Gelbe lupine

1. Introduction

What: Yellow lupin (*Lupinus luteus* L.; Leguminosae) is a hairy annual herb[3 17], cultivated for green manuring, for soil improvement on ruderal areas and to prepare fields for sowing. The nitrates it produces while growing, will fertilize the soil when it is ploughed under completely with roots and fruits, just before the crop is sown in the field.[50] It is propagated by seed, and cross-pollinated by honey bees and bumblebees, mainly within the same cultivar. Only when a mixture of different cultivars is grown, they will cross.[24]

Origin: South-eastern Europe.[1] Western Mediterranean, cultivated since ancient times (Greek).[23]

Where: Sandy soils mainly, also cultivated in the remaining areas of the Netherlands, but to a lesser extent[12]; light acid soils.[17]

How: In the field.[7]

2. Escape

Hardy: More or less, see below.

Run wild: Sometimes running wild.[1] Widely cultivated (in Europe) for fodder and green manuring, and sometimes naturalized.[17] Lupine is often found between barley or vetch, or on the sides of or near by lupine-fields because of sloppy sowing. Sometimes planted, and then occasionally running wild, but rapidly disappearing.[33]

Where: Railway-embankments, roads, and waste places near factories[33 50 113] (Herbarium), occurring on high sands, running wild there[29], occurring on fields as a remnant of green manuring.[114]

Seen: Isolated finds of some flowering individuals at a time. There are no records of the same site over several years (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[16]
Where: —

4. Hybridization

Possible: Hybrids of *L. luteus* with any other species have not been recorded in literature, nor in the Herbarium; only intraspecific crosses have been made.[53]
Where: —
Seen: —

5. Conclusion

Lupinus luteus is not native to the Netherlands. It can escape from the field, grow for some time, and even flower and set seed, but it does not establish or even disperse independently (D_d). It is not known to hybridize with any other species of *Lupinus* in the Netherlands (D_p). See also paragraph 3.5.6. of the general introduction.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Lycopersicon esculentum Miller — D_{pdf}: 0.2.1

Dutch : Tomaat
English : Tomato
French : Tomate
German : Tomate

1. Introduction

What: The tomato (*Lycopersicon esculentum* Miller[59], *Lycopersicon lycopersicum* (L.) Karsten ex Farwell[60], or *Solanum lycopersicum* L.; Solanaceae) is an annual hermaphrodite herb, grown for the fruit, a fleshy berry.[81] It is an important vegetable in the Netherlands, mainly for export to Germany, also to other western European countries. Many different cultivars of tomato are grown, the most important in Holland being the traditional round red tomatoes and the irregular, ribbed beef-tomatoes ('boxing gloves').[9] They are sold fresh, tinned or preserved in juices, pastes, soups and sauces; used as a salad or in hot dishes.[51] The seeds can yield to 24% oil, which is used in salad oil, margarine and soap.[81] Tomatoes are used widely in genetic studies, because of the abundant variation in the species, their properties for self-pollination and easy growing conditions.[9 51] Although the absolute nutritional value is low, tomatoes can be an important source of minerals and vitamins when eaten in large quantities, which they are.[27 51] The flowers are not self-pollinating, however, if the inflo-

rescence is shaken, pollen will fall from the anthers onto the stigma, and fertilization results. Bumble bees can cause this, but growers also use various types of vibrators or other mechanical devices to shake the flower clusters.[81]

Origin: Central and South America[1], probably introduced in Europe around 1550.[51] Presumably derived from *L. pimpinellifolium* (L.) Miller[102] or from *Solanum cerasiforme* Dun. and *S. pyriforme*, cultivated since ancient times by the Indians.[23]

Where: In the Westland in South Holland mainly, also on southern sandy soils in North Brabant and Limburg.[12]

How: In greenhouses mainly[12]; also in gardens.

2. Escape

Hardy: Not really, the plants cannot withstand temperatures below 0° C[27], but the fruits might survive a mild winter and germinate[4]; seeds pass through herbivores, man included, and germinate in dung, sewage farms etc.[71]

Run wild: Yes, often found growing outside cultivation, sometimes even fruiting[4] (Herbarium). A frequent casual, but nowhere truly naturalized.[18]

Where: Refuse dumps[66], sand-paths, along rivers[87 115] (Herbarium), on dung heaps, in hot summers setting fruit[4], canal sides in Amsterdam[76] and Dordrecht[103], ruderal areas in and near cities.[116]

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: Many interspecific breeding barriers exist between the species of the genus *Lycopersicon*[61], although some spontaneous hybridization can take place, e.g. *L. esculentum* × *L. pimpinellifolium* Miller[80] In experimental hybridizations of *L. esculentum* × several *Solanum*-species, only *S. lycopersicoides* Dun. and *S. penellii* Correll yielded more or less viable hybrids[78], but none of these are found in the Netherlands.[1]

Where: —

Seen: —

5. Conclusion

Tomatoes are not native to the Netherlands, and they do not have wild relatives in the Dutch flora (D_p). However they are found growing outside cultivation, sometimes, in hot summers, even setting fruit. It is not known whether seeds from these fruits ever germinated and produced new tomato-plants.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Medicago sativa L. — D_{pdf}: 4.4.2

Dutch : Lucerne
English : Alfalfa, Lucerne
French : Luzerne cultivée
German : Blaue Luzerne, Dauerklee, Luzerne, Monatsklee, Mondklee

1. Introduction

What: Lucerne or alfalfa (*Medicago sativa* L.; Leguminosae) is a more or less pubescent, very variable perennial.[17] It was one of the first crops to be taken into cultivation as a fodder in Europe, and it is widely grown nowadays for hay and silage[3]; leaves are an important commercial source of chlorophyll. [71] Individual plants range from being completely self-fertile to completely self-sterile, but on average more seeds per pod originate from cross-fertilization than from self-pollination. Seeds from cross-fertilization usually are larger.[24]Tripping is necessary in lucerne grown for seed, few other insects than bees can trip alfalfa-flowers.[24 25] Main pollinators are honey bees, leafcutter bees, alkali bees and bumble bees.[81]

Origin: Origin not certain[17]; probably South-West Asia and North Africa.[3] Cultivated since ancient times (Greek).[23]

Where: Sea clay areas mainly; also cultivated in the remaining areas of the Netherlands, but to a lesser extent.[12] (Fig. 6a.)

How: In the field.[7]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]

Run wild: Yes, run wild and established on waysides.[1]

Where: Most of the Netherlands, except for the pleistocene sands of Groningen, Friesland, Drenthe, Overijssel and the Veluwe, summarized as the Drents and Gelders District; along rivers[33], as well as on waysides[127], on calcareous soil[128], near sites of transshipment, flour mills[125], tips, and other ruderals[126] (Herbarium). Its distribution is considered mainly to be caused by sowing and running wild.[1 22]

Seen: Yes (Herbarium).

3. Wild relatives

What: *M. falcata* L., *M. sativa*.[1 6]

Where: *M. falcata*: rather common on river dunes, dykes and waysides, rare and neophytic elsewhere (Fig. 7a); M. *sativa*: most of the Netherlands, except for the pleistocene sands of Groningen, Friesland, Drenthe, Overijssel and the Veluwe, summarized as the Drents and Gelders District.[1 22] (Fig. 6b.)

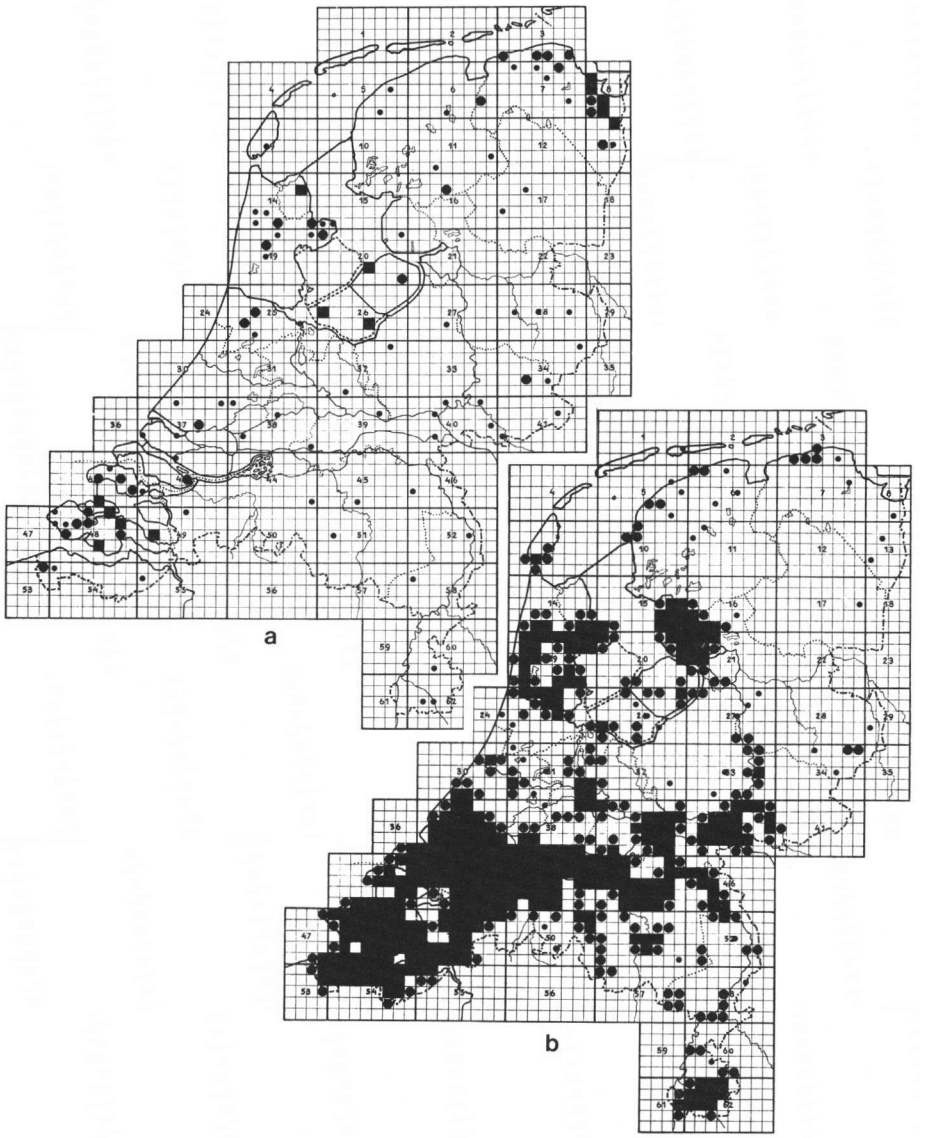

Fig. 6. Distribution of *Medicago sativa* L.

a. cultivated. Scale of cultivation:
- • = less than 10 ha;
- ● = between 10 and 100 ha;
- ■ = more than 100 ha.

b. wild (see also general legend, page 27)
- • = occurrence infrequent;
- ● = ccurrence rather frequent;
- ■ = occurrence frequent.

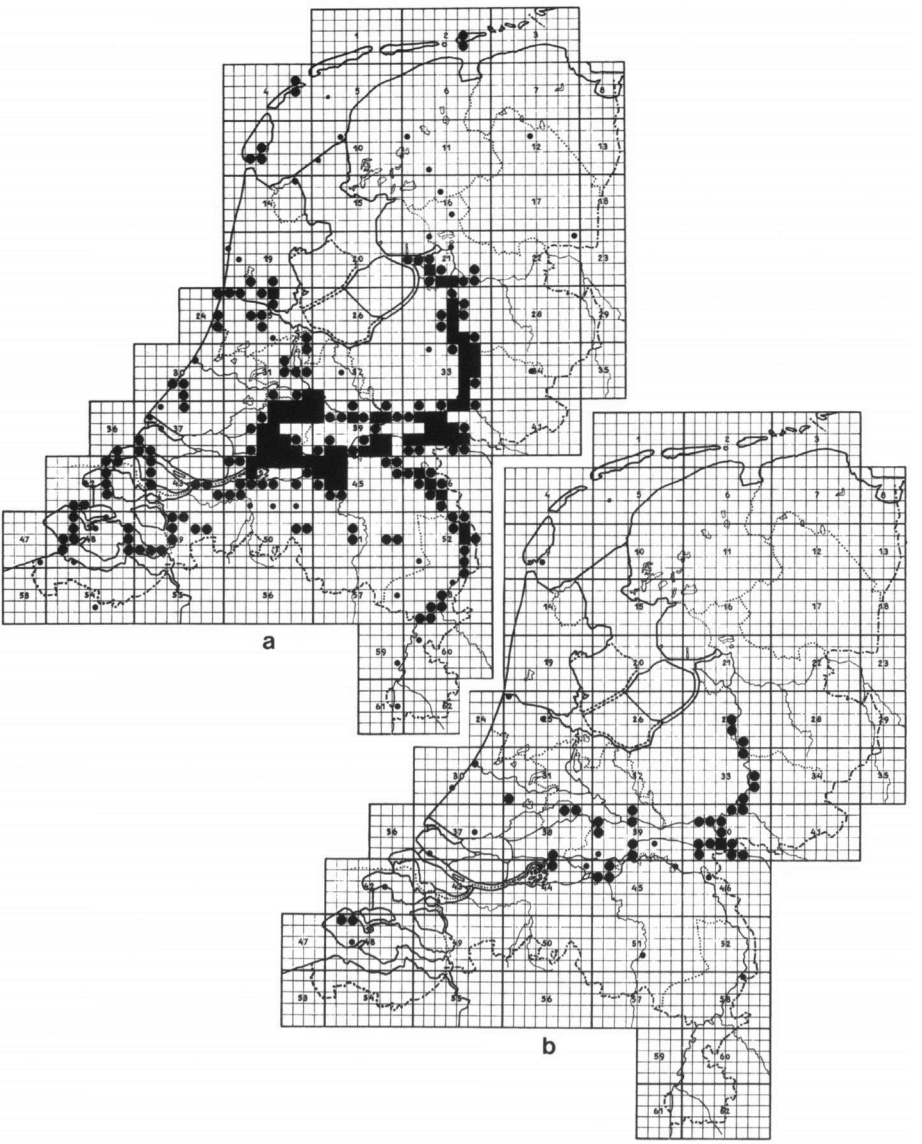

Fig. 7. Distribution of wild *Medicago falcata* and *M.* × *varia*.

a. wild *M. falcata* (see also general legend, page 27)

- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

b. wild *M.* × *varia* (see also general legend, page 27)

- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

4. Hybridization

Possible: Both *M. sativa* and *M. falcata* (also in cultivation) are often grown in mixed populations, together with their hybrid *M.* × *varia* Martyn[1]; *M.* × *varia* is formed both in the wild and experimentally and is wide-spread in Europe, the fertility of the hybrid is low[70]; *M.* × *varia* is partly[1] fertile, back-crossing with either of the parents is possible.[3 156] Because of the frequent hybridization, *M. falcata* is often considered as a subspecies of *M. sativa.*

Where: Generally found in the wild where the parent species' distributions coincide: along the major rivers, on grassy places.[1 22] (Fig. 7b.)

Seen: Yes[22] (Herbarium).

5. Conclusion

Lucerne is an archaeophyte to the Dutch flora, but it established a considerable time ago, and is now considered to be part of the flora of the Netherlands. It can escape from cultivation, establish and disperse (D_d), as well as cross freely with *M. falcata*, potentially causing hybrid swarms (D_p).

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Narcissus pseudonarcissus L. — D_{pdf}: 4.4.1

Dutch : Trompetnarcis, Wilde narcis
English : Common Daffodil
French : Narcisse faux-narcisse
German : Gelbe Märzblume, Gelbe Narzisse, Osterglocke, Rotrandiger Narzisse, Trompetennarzisse

1. Introduction

What: Common daffodils (*Narcissus pseudonarcissus* L.; Amaryllidaceae) are grown for ornament like the wide range of cultivars of the genus[31], for naturalisation on banks and slopes, and as cut-flowers.[13] They are pollinated by bumble bees.[157]

Origin: Western Europe, northwards to northern England.[13] About a century ago the originally native wild daffodils were planted over from the wild into gardens, and domesticated.[5]

Where: Grassy places, orchards[118], farm-yards in northern parts of the Netherlands, in gardens throughout the Netherlands[55] (Archives).

How: In greenhouses, parks and gardens.

2. Escape

Hardy: Yes, subsp. *pseudonarcissus* is native to the Netherlands.[1 6]

Run wild: Subsp. *major* (Curtis) Baker often establishes, and has probably naturalized locally.[1] Subsp. *pseudonarcissus* is known in the wild, it is not clear which are genuinely wild and which are not.[1]

Where: Growing outside cultivation, and establishing[1 21]; found in the dunes, near gardens and country seats (Herbarium).

Seen: Yes[118 119] (Herbarium).

3. Wild relatives

What: *N. pseudonarcissus* L. subsp. *pseudonarcissus*.[1 6]

Where: Brook dales, moist deciduous forests and grasslands in the eastern and northern parts of the Netherlands and in southern Limburg, rare; run wild elsewhere.[1 21]

4. Hybridization

Possible: *N. poeticus* × *N. pseudonarcissus* (an experimental hybrid) is cultivated[1]; it is sometimes found where both species are growing together (Herbarium).

Where: *N. poeticus* × *N. pseudonarcissus* is found in some fields near dunes with both species growing together, with many intermediate forms (Herbarium).

Seen: Yes (Archives, Herbarium).

5. Conclusion

Wild daffodils are (partly) native to the Netherlands and rather common as cultivated spring-flowering bulbs planted in parks and gardens. They are hardy, and they naturalize easily (D_d). Some hybridization with other cultivated species can presumably take place (D_p).

Expectation: The D_{pdf}-code indicates **some ecological effect** on the flora of the Netherlands, but only locally, where the wild daffodil is found.

Narcissus spec. — D_{pdf}: 3.4.9

Dutch : Narcis
English : Daffodil
French : Narcisse, Jonquille
German : Narzisse

Including: *N. asturiensis* (Jord.) Pugsley, *N. bulbocodium* L., *N. cyclamineus* DC., *N. jonquilla* L., *N.* × *medioluteus* Miller, *N. minor* L., *N.* × *odorus* L., *N. poeticus* L., *N. pumilus* Salisb., *N. tazetta* L., *N. triandrus* L. and cultivars.[138]

1. Introduction

What: Daffodils (*Narcissus* L.; Amaryllidaceae) are perennial herbs, propagated by bulbs.[20] There is a wide range of cultivars, commonly grown for ornament[31], for naturalisation on banks and slopes, and as cut-flowers.[13] *Narcissus odorum* is pollinated by bumble bees; *N. triandrus*, *N. tazetta*, *N. polyanthus*, and *N. pumilus* by bumble bees and butterflies; *N. triflorus* and *N. jonquilla* by butterflies[158]; *N. poeticus* by bees[157] or butterflies.[158]

Origin: Most originate in Europe, especially western Mediterranean area, some eastern Mediterranean or North Africa.[13]

Where: Grassy places, orchards[118], farm-yards in northern parts of the Netherlands, in gardens throughout the Netherlands[55] (Archives).

How: In greenhouses, in parks and gardens.

2. Escape

Hardy: Yes.

Run wild: Running wild[119], it is not clear which are genuinely wild and which are not.[1] About a century ago the originally native daffodils were planted over from the wild into gardens.[5] Of the innumerable hybrids now in cultivation a large number have become naturalized, at least temporarily, in a few localities.[20]

Where: Growing outside cultivation, and establishing[1 21]; *N. jonquilla*: near dunes, near gardens in Haarlem and Utrecht; *N. odorus*: near ruin of Brederode; *N. poeticus*: several finds in dunes, sandy meadows and on St. Pietersberg (Herbarium). Especially in places where daffodils are grown on a commercial scale.[20]

Seen: Yes[118 119] (Herbarium).

3. Wild relatives

What: *N. pseudonarcissus* L. subsp. *pseudonarcissus*.[1 6]

Where: Brook dales, moist deciduous forests and grasslands in the eastern and northern parts of the Netherlands and in southern Limburg, rare; run wild elsewhere.[1 21]

4. Hybridization

Possible: There are many garden-clones (thousands of hybrids[13]), of obscure origins, naturalized widely.[70] *N.* × *medioluteus* (*N. poeticus* × *N. tazetta*) (Herbarium), see also *Narcissus pseudonarcissus*.

Where: Not sufficiently known.

Seen: Yes (Archives, Herbarium).

5. Conclusion

Narcissus species are very common as spring-flowering bulbs, and they are virtually growing in every park or garden but the true taxonomic identity of most populations is unknown. They are hardy, and they establish easily; facts on naturalization are not known, also because of taxonomic problems, but it is rather probable that naturalizations occur on a wide scale in the Netherlands (D_d). It is not known whether they hybridize spontaneously or not (D_p).

Expectation: The D_{pdf}-code indicates a **unknown, but probably substantial ecological effect** on the semi-wild flora of the Netherlands, but only locally, where the wild daffodil is found.

Nerine spec. — D_{pdf}: 0.0.0

Dutch : Nerine
English : Nerine
French : Nérine
German : Nerine

Including: *Nerine angustifolia* (Baker) Will. Watson, *N. bowdenii* Will. Watson, *N. flexuosa* (Jacq.) Herbert, *N. krigei* W. Barker, *N. sarniensis* (L.) Herbert, *N. undulata* (L.) Herbert and cultivars.[35]

1. Introduction

What: *Nerine* L. (Amaryllidaceae) is an ornamental plant, cultivated because of its late, attractive pink or sometimes white flowers. Many cultivars and hybrids, often of uncertain parentage, are grown.[13] No reliable information could be found on pollinating agents; possibly pollinated by butterflies.

Origin: South Africa.[13]

Where: Throughout the Netherlands.

How: In greenhouses or in warmer climates outside, but very tender.[13]

2. Escape

Hardy: No.

Run wild: No (Archives, Herbarium).

Where: —

Seen: No (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]
Where: —

4. Hybridization

Possible: No wild relatives in the Netherlands.[1 6]
Where: —
Seen: —

5. Conclusion

Nerine is a solely ornamental greenhouse plant, with no wild relatives in the Netherlands. It is not hardy to the Dutch climate, and has never been found outside cultivation.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Nicotiana spec. — D_{pdf}: 0.1.0

Dutch : Tabak
English : Tobacco
French : Tabac
German : Tabak

1. Introduction

What: Tobacco (*Nicotiana tabacum* L., *N. rustica* L. and *N.* × *sanderae* Sander; Solanaceae) is a group of viscid annual or short-lived perennials. Tobacco is a very polymorphic species with a multitude of cultivated forms used in most modern tobaccos.[18] It is not a crop in the Netherlands anymore, but it is used as an experimental plant, especially in genetic research, because of its relatively easy growing conditions and genetic properties.[58] Tobacco is imported and used for smoking, chewing or snuffing the dried and fermented leaves, and it is grown on a modest scale as an ornamental. Some cultivation is for medicinal purposes. It was presumably taken to Europe in the 16th century by the Spanish.[56] Jean Nicot, a French ambassador of King François II, played an important role in its introduction, hence the generic name *Nicotiana*.[57] Pollinators are long-tongued moths[43], but self-fertilization usually occurs, being as effective as cross-fertilization in producing seeds.[24]

Origin: South America[56 57]; *N. tabacum* is believed to have arisen by chromosome doubling after hybridization of *N. sylvestris* Spegazz. & Comez with a species in the section Tomentosae of *Nicotiana*.[62] *N.* × *sanderae* originates from *N. alata* Link & Otto × *N. forgetiana* Hemsl.

Where: Records of cultivation from Zeeland[30 74], near Nijmegen[29], Amersfoort[75] and in south-eastern part of Utrecht.

How: In greenhouses.

2. Escape

Hardy: Yes, *N. tabacum* and *N. rustica* were grown in the field.[29 30 75]

Run wild: Not mentioned in literature as running wild, but sometimes found outside cultivation (Herbarium). Often naturalized in southern parts of Europe.[18]

Where: *N. tabacum*: ruderals, ditches, in or near gardens, tips (Herbarium); Amsterdam canal sides[76], Dordrecht[150]; *N.* × *sanderae*: tips in Wijster[34], Oosterwolde[147], Wageningen[148], and Nijmegen[151], ruderal in Bussum[153]; *N. rustica*: Wormerveer[149], ruderal in Wageningen, and near railway Eerbeek[152], tip Krommenie.[153]

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: Hybridization with other species of *Nicotiana* is possible[58], but there are no wild relatives in the Netherlands.[1 6]

Where: —

Seen: —

5. Conclusion

Tobacco used to be cultivated in the Netherlands, but its leaves are now imported. There are some records of tobacco growing outside cultivation on ruderal habitats and tips, but they apparently do not establish (D_d). They have no wild relatives in the Netherlands, so D_p seems not possible.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Phaseolus vulgaris L. — D_{pdf}: 0.1.0

Dutch : Boon, Bruine boon, Snijboon, Stamboon, Stokboon, Witte boon

English : Climbing French bean, Dwarf French bean, French bean, Kidney bean, Snap bean

French : Haricot à rames, Haricot blanc, Haricot commun, Haricot nain, Haricot grimpant, Haricot

German : Braune Bohne, Bohne, Buschbohne, Fasel, Gartenbohne, Stangenbohne

1. Introduction

What: The French bean (*Phaseolus vulgaris* L.; Leguminosae) is a bush type annual, grown in a wide range of cultivars for the protein-rich legumes, used fresh, canned, frozen or dried and usually consumed after cooking[8 71], sometimes used as forage. The plants are self-fertile. Bumble bees, honey bees and thrips sometimes visit the flowers and cross-pollinate them[24], but the percentage of crossed seeds is usually not higher

than 10%.[81] Cross-pollination does not increase yield.[24] Modern assortments of *P. vulgaris* also include *P. coccineus*, a usually cross-pollinating species. There are cultivars of *P. vulgaris* that are intermediate between *P. vulgaris* and *P. coccineus*.

Origin: South America[17], taken into cultivation by the Indians. Introduced to Europe in 1542.[23]

Where: Throughout the Netherlands.[8]

How: In the field[8], and in home gardens.

2. Escape

Hardy: Cannot withstand temperatures below 0° C.[27]

Run wild: Often occurring as a relic of cultivation[17], or from spilt seeds (Herbarium). Found outside cultivation.[33]

Where: Harbours Rotterdam several times, tip Beverwijk, Dordrecht, garden in Deventer (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[16]

Where: —

4. Hybridization

Possible: *P. coccineus* × *P. vulgaris* L.[70], but *P. coccineus* is not wild in the Netherlands[16] (Herbarium).

Where: —

Seen: —

5. Conclusion

French beans are not native to the Netherlands, and they do not have wild relatives in the Dutch flora, so D_p seems not possible. They are grown for their legumes and are sometimes found outside cultivation, growing from spilt seeds. However, they do not seem to be establishing anywhere (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Pisum sativum L. — D_{pdf}: 0.1.0

Dutch : Erwt
English: Pea
French : Petit pois, Pois
German: Erbse

Pisum sativum convar. *axiphium* Alef.

Dutch : Peul
English: Sugar pea
French : Pois sucré
German: Zuckererbse

Pisum sativum convar. *medullare* Alef.

Dutch : Kreukerwt
English: Garden pea, Wrinkled pea
French : Pois à graines ridés
German: Markerbse

Pisum sativum convar. *sativum*

Dutch : Capucijner, Doperwt, Landbouwerwt
English: Green pea, Marrowfat pea, Blue pea
French : Pois à écosser, Pois gris
German: Graue Erbse, Schalerbse

Pisum sativum convar. *speciosum* (Dierb.) Alef.

Dutch : Voedererwt
English: Field pea, Maple pea
French : Pois fourrager
German: Felderbse, Futtererbse

1. Introduction

What: Peas (*Pisum sativum* L.; Leguminosae) are glabrous, herbaceous annual vines, grown since prehistoric times[17], in a wide range of cultivars, for human consumption, as a protein-rich fodder[7], or sometimes as a soil-improver (N_2-fixation, see *Lupinus luteus* L.).[27] Flowers are usually self-pollinating in bud.[43 71]

Origin: The wild *P. humile* Boiss. & Noë of the Near East should be regarded as the direct ancestor from which the cultivated pea was domesticated.[99] Asia Minor and Egypt, at least 4000 B.C.[102], cultivated since the Stone Age.[23]

Where: Throughout the Netherlands.

How: In the field.[7 8]

2. Escape

Hardy: The flowers and fruits cannot withstand temperatures below 0° C, vegetative plants tolerate occasional frost down to –5° C.[27]

Run wild: Often found outside cultivation[17 33], recorded several times, also fruiting (Herbarium).

Where: Tips, waysides, (unused) farm-land, ruderals, harbours (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: Occasional spontaneous hybridization takes place between *P. humile* Boiss. & Noë, and the domesticated peas over most of the distribution range of *P. humile*, i.e. the Near East[99]; *P. humile* is not found in the Netherlands.[1 6]

Where: —

Seen: —

5. Conclusion

Peas are not native to the Netherlands, and they do not have wild relatives in the Dutch flora, so D_p seems not possible. They are grown for their seeds and legumes, and are often found outside cultivation, growing from spilt seeds. However, they do not seem to be establishing anywhere (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Poa pratensis L. — D_{pdf}: 5.4.3

Dutch : Veldbeemdgras
English : Smooth-stalked meadow-grass
French : Pâturin des prés
German : Wiesenrispengras

1. Introduction

What: Meadow-grass (*Poa pratensis* L.; Gramineae) is a highly variable, largely apomictic species.[20 83] It is used for sporting grounds, playgrounds, recreation areas and orchards, usually in a mixture with other grasses, also as a fodder-grass. It is drought-resistant and winter hardy.[7] Propagation is generally by underground runners and (usually apomictic) seeds. Only when plants with low chromosome-numbers (or with higher numbers

under the right circumstances) 'go sexual', some hybridization can take place. Pollination by own or related pollen is needed to stimulate the growth of an unreduced cell of the ovary to form an embryo.[82] Like most Gramineae it is pollinated mainly by wind.[81]

Origin: Europe, except Baleares.[20]

Where: Throughout the Netherlands, not on too dry, poor, sandy soil.[12]

How: In the field.[7]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]

Run wild: Known in the wild.[1]

Where: Moist to dry grasslands, dunes, walls, between pavement, deciduous forests etc., very common.[1]

Seen: Yes (Herbarium).

3. Wild relatives

What: *P. pratensis* L.; hybridization with other species uncertain.

Where: *P. pratensis*: moist to dry grasslands, dunes, walls, between pavement, deciduous forests etc.[1]

4. Hybridization

Possible: Many interspecific hybrids are recorded[70], but most are unlikely, mainly because of the apomictic nature of the species; Stace recently[156] does not mention any hybrid of *P. pratensis* with other *Poa* species for Britain.

Where: Two unconfirmed records: *P. pratensis* × *P. trivialis* in Rotterdam and near Aartswoude (Herbarium).

Seen: *P. pratensis* × *P. trivialis* in the wild (Herbarium); identity unconfirmed.

5. Conclusion

Meadow-grass is native to the flora of the Netherlands, both growing and grown throughout the Netherlands, so an escape from cultivation (D_d) will be morphologically undetectable. Hybridization with wild relatives of the same species (D_p) is possible but undetectable in the Herbarium. See also paragraph 3.5.7. of the general introduction.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Raphanus sativus L. — D_{pdf}: 3.4.9

Raphanus sativus L. var. *sativus*

Dutch : Radijs
English : Radish
French : Radis
German : Radieschen

Raphanus sativus var. *niger* (Miller) S. Kerner

Dutch : Ramenas
English : Black radish, Summer radish, Winter radish
French : Radis noir, Radis d'hiver, Raifort
German : Rettich

Raphanus sativus var. *oleiformis* Pers.

Dutch : Bladramenas
English : Fodder radish
French : Radis oleifère, Radis fourrager
German : Ölrettich

1. Introduction

What: Radishes (*Raphanus sativus* L.; Cruciferae) are grown for the crisp 'root', which is in fact the thickened white hypocotyl axis, with an often reddish or purplish skin. In Europe and America they are always consumed fresh, not cooked or pickled[9 27], the larger oriental kinds are brined.[140] Because they are ready to be harvested 3 to 6 weeks after planting, they are very popular as a home garden vegetable.[81] They are also used as a cover crop, as a fodder[27], and for green manuring on fields and waysides, usually establishing there.[1] Propagation is by seed. They are almost entirely insect-pollinated, especially by honey bees[81], just like *R. raphanistrum* L. Most commercial cultivars of radish are self-incompatible.[24]

Origin: Cultigen; illustrated in China in 450 B.C.[140]; known from Assyrian time, probably of hybrid origin with most chemical similarity to *R. landra* (DC.) Moretti from Italy.[71]

Where: In the Westland mainly.[9]

How: In greenhouses and home gardens, on waysides, also but less, in the field.

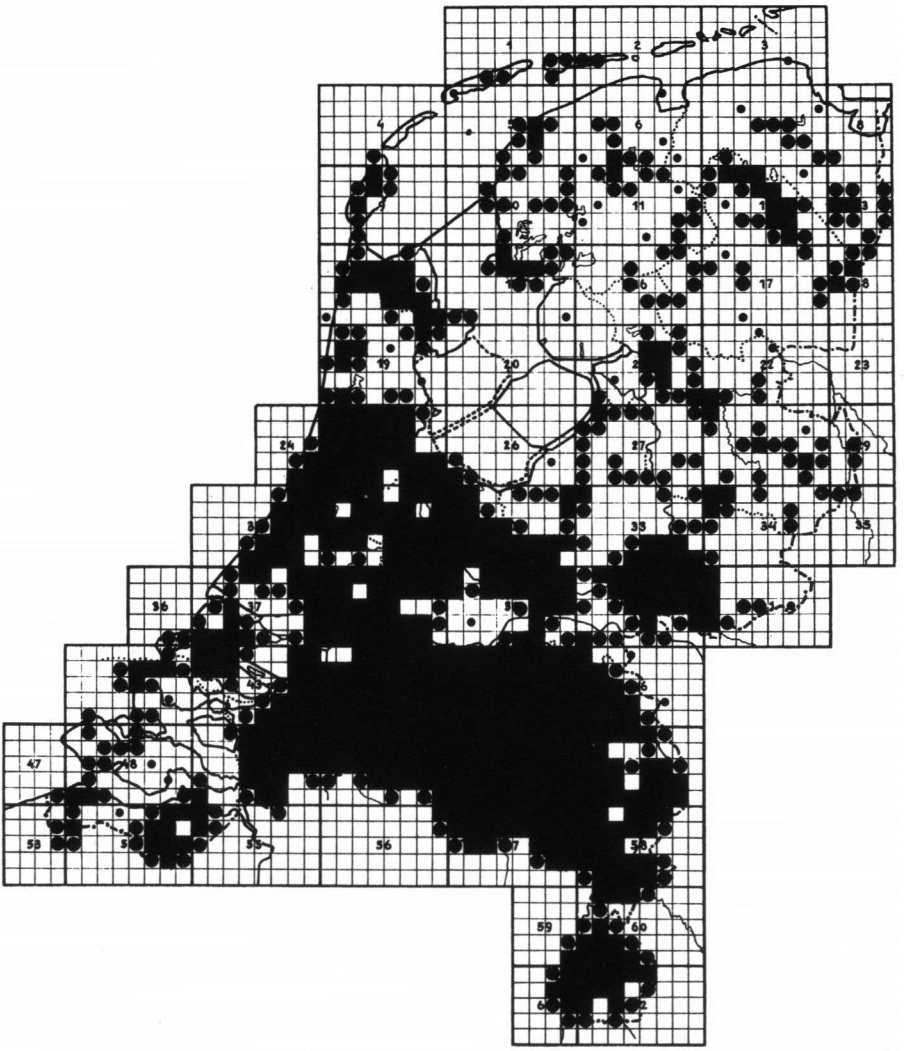

Fig. 8. Distribution of wild *Raphanus raphanistrum* L.

See also general legend, page 27)

- • = occurrence infrequent;
- ● = occurrence rather frequent;
- ■ = occurrence frequent.

2. Escape

Hardy: Annual[3], tolerates occasional frost down to –5° C.[27]

Run wild: Running wild easily.[1 3] Some variants are transitional to the wild plants in Europe[16], so they may not be easily recognized as escapes.

Where: Fields and waysides[1]; ruderals, tips[129], dunes, near factories, many kinds of disturbed, human-influenced habitats (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: *R. raphanistrum* L.[1 6]

Where: Sandy farmland, open dykes and waysides[1], on not too heavy soils, especially in the southern and western parts of the Netherlands.[3 21] (Fig. 8.)

4. Hybridization

Possible: *R. raphanistrum* × *R. sativus* is reported from Britain[156] as a rare, spontaneous hybrid in *R. sativus* cultures; it is partially fertile. *Brassica oleracea* × *Raphanus sativus* (*Raphanobrassica*) is an experimental hybrid.[70]

Where: *Raphanus raphanistrum* × *R. sativus* is reported from Britain[156], and is also an experimental hybrid, *Raphanobrassica* is cultivated.

Seen: No, only in literature (Herbarium).

5. Conclusion

Raphanus sativus is not native to the Netherlands. It is a common greenhouse and home garden vegetable, running wild easily. Some of its variants are transitional to its wild relative *R. raphanistrum*, so an escape might pass unnoticed (D_d). According to some sources it also crosses freely with its wild relative. Although we found no evidence of this in the Herbarium, we included the possibility in the D_p. See also paragraph 3.5.8. of the general introduction.

Expectation: The D_{pdf}-code is as yet doubtful, but might indicate a **substantial ecological effect** on the flora of the Netherlands.

Rheum × *hybridum* Murray — D_{pdf}: 0.1.0

Dutch : Rabarber
English: Rhubarb
French : Rhubarbe
German: Rhabarber

1. Introduction

What: Rhubarb (*Rheum* × *hybridum* Murray; Polygonaceae) is a vigorous, perennial herb with a woody rhizome. It is one of the few plants that is cultivated for the fleshy, red leaf-stalks only.[2 16] These are used in jams, cakes and compotes, for their pleasant acid taste.[8] The inflorescence contains many small flowers, of which the styles are not receptive until after the anthers have shed their pollen; self-pollination within the same flower is therefore unlikely. However flowers may receive pollen from those higher up in the inflorescence, by pollen falling down, or by visits from insects, especially Diptera.[24]

Origin: Mongolia and neighbouring territories.[16] The cultivated rhubarb is presumably derived from *R. rhabarbarum* L. and *R. raponticum* L. The habit of using the leaf-stalks dates from England in the beginning of the 19th century.[23]

Where: South Holland mainly, also in Limburg, North Brabant and North Holland.[8]

How: In the field; in home-gardens.[8]

2. Escape

Hardy: Yes, perennial.
Run wild: Sometimes found outside cultivation (Archives).
Where: Gelderland, along the major rivers (Archives).
Seen: No (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]
Where: —

4. Hybridization

Possible: No wild relatives in the Netherlands.[1 6]
Where: —
Seen: —

5. Conclusion

R. × *hybridum* is not native to the Netherlands, and it has no wild relatives in the Dutch flora (D_p). Rhubarb is hardy to the Dutch climate, but in spite of being in cultivation for some time they are only occasionally found outside cultivation. *R.* × *hybridum* is not known to establish in the Netherlands (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Scorzonera hispanica L. — D_{pdf}: 0.1.0

Dutch : Schorseneer
English : Black salsify, Serpent root
French : Salsifis noir, Scorsonère
German : Schorzonere, Schwarzwurzel, Winterspargel

1. Introduction

What: Black salsify (*Scorzonera hispanica* L.; Compositae) is a somewhat woody biennial[8] or perennial herb, extremely variable, especially in leaf-shape.[19] It is grown for the long fleshy roots, in the Netherlands mainly for processing (export), some for direct inland use.[8] The roots are cooked and eaten like asparagus; also used as a coffee substitute.[71]. No reliable information could be found about pollination.[23 24]

Origin: Central and southern Europe, and southern part of U.S.S.R.[19] Cultivated since 1576 (Italy).[23]

Where: Limburg mainly, also North Brabant and Northeast Polder.[8]

How: In the field[8] and in home gardens.

2. Escape

Hardy: Winter hardy.[8]

Run wild: Found occasionally in the Netherlands (Herbarium) but no indications of establishment; elsewhere in Europe locally naturalized.[19]

Where: Linseed-mill in Friesland, Nijkerk, Wieringermeer, refuse dumps in Nijmegen (Herbarium), Friesland.[130 131]

Seen: Yes (Archives, Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1]

Where: —

4. Hybridization

Possible: No wild relatives in the Netherlands.[1]

Where: —

Seen: —

5. Conclusion

Salsify is not native to the Netherlands, and it has no wild relatives in the Dutch flora (D_p). It is hardy to the Dutch climate, but in spite of being in cultivation for some time it is only occasionally found outside cultivation. *Scorzonera hispanica* is not known to establish in the Netherlands (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Secale cereale L. — D_{pdf}: 0.1.0

Dutch : Rogge
English: Rye
French : Seigle
German: Roggen

1. Introduction

What: Rye (*Secale cereale* L.; Gramineae) is a cross-pollinating cereal used for human consumption, in beverages (whiskey, gin, beer), and as a fodder, usually grown in winter and in spring; stems are used for straw-matting.[71]. It is sometimes used for green manuring in summer.[7] Like most Gramineae it is pollinated by wind.[25 81]

Origin: *Secale cereale* made its first appearance among the Bronze Age findings at Moravia, it then dispersed rapidly in the region north of the Alps and became the most important bread grain of the Slavs, Celts and Teutons.[102] The wild ancestor is *S. montanum* Guss., originally from central Asia.[71]

Where: Throughout the Netherlands, sand and reclaimed peat lands in Groningen and Drenthe mainly.[7 12]

How: In the field.[7]

2. Escape

Hardy: Yes.

Run wild: Yes, often found outside cultivation (Herbarium).

Where: Throughout the Netherlands, Nijmegen[29], Wieringen[121], near Arnhem[132], often near flour mills, tips in Drenthe[34], Friesland[66], Limburg[133], transshipment areas, docklands, ruderals[106 134], outside birdcages (Herbarium).

Seen: Yes (Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: *Triticale* is an experimental hybrid of *Secale* × *Triticum*.[70] There are no wild relatives in the Netherlands.[1 6]

Where: —

Seen: —

5. Conclusion

Rye is a fairly common cereal, and it is grown on a modest commercial scale on sandy and peaty soils throughout the Netherlands, especially in Groningen and Drenthe. There are quite a few records of escapes, but these are all near places of cultivation or result from spilt seeds. There are no records of established rye plants in the archives nor in the Herbarium (D_d). Rye has no wild relatives in the Dutch flora, and no hybridization takes place spontaneously (D_p).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Solanum tuberosum L. — D_{pdf}: 1.2.0

Dutch : Aardappel
English: Potato, Ware potato
French : Pomme de terre (de consommation)
German: Kartoffel

1. Introduction

What: The potato (*Solanum tuberosum* L.; Solanaceae) is a herbaceous perennial, with underground stolons bearing terminal tubers. It is a dietary mainstay for most western countries.[4] It is grown in a wide range of cultivars, for direct consumption, for starch-production or as a fodder.[7] Potatoes are always consumed cooked or processed as chips, crisps or in dehydrated forms[27], never raw, because of the poisonous solanin that breaks down only during heating. Pollinators are insects (pollination can also be autogamous). Potato flowers secrete no nectar, and little pollen is available, so insect visits are few, but they might cause some cross-pollination. Because potatoes are propagated vegetatively, flowers are of interest to plant breeders only. Therefore many commercial cultivars either rarely flower, have distorted flowers or have flowers that soon shed, sometimes in the bud stage.[24]

Origin: South America[18], Andes, cultivated for at least 2000 years, introduced in Europe in the 16th century[77], although it did not become popular before 1800.[4]

Where: Throughout the Netherlands, much less in Utrecht; starch-potatoes mainly in Groningen and Drenthe, consumption-potatoes mainly in Flevoland, Zeeland and North Brabant.[12]

How: In the field[7] and in home gardens.

2. Escape

Hardy: Not really, the tubers freeze in winter, some cultivars tolerate occasional frost down to −5° C.[27]

Run wild: Occasionally found outside cultivation (Herbarium); infrequently establishing at least at Britain.[156]

Where: Waysides, near potato-fields, farm-yards, tips[34 117], ruderals[66], canal sides[103], fringes of woods (Herbarium).

Seen: Yes (Archives, Herbarium).

3. Wild relatives

What: No wild relatives in the Netherlands.[1 6]

Where: —

4. Hybridization

Possible: In experiments no viable hybrids could be obtained with any wild relative of the European flora.[146]

Where: —

Seen: —

5. Conclusion

Potatoes are not native to the Netherlands, and they do not have wild relatives in the flora of the Netherlands. They are frequently found outside cultivation, but only on unnatural habitats like farm yards, waysides, ruderals and tips, but can possibly establish for some time. Because they are not really hardy to the Dutch climate, they are not found to establish anywhere for a longer time.

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

Trifolium repens L. — D_{pdf}: 4.4.3

Dutch : Witte klaver
English: White clover
French : Trèfle blanc, Trèfle rampant
German: Kreichklee, Weissklee

1. Introduction

What: White clover (*Trifolium repens* L.; Leguminosae) is a low-growing, shallow-rooted perennial, spreading by creeping stems that root at the nodes.[81] There is a considerable amount of variation within the species, also among wild plants.[17] Many different cultivars are used for different purposes, for instance to improve taste in grass seed mixtures for pastures grazed by livestock. Its nitrate-binding qualities also improve the yield of the grasses. Large-leafed cultivars are sometimes used for green manuring under grain.[7] The flowers are valued for their honey.[3] Main pollinators are honey bees, effecting cross-pollination. Self-pollination is not likely, because the stigma extends beyond the anthers.[81]

Origin: Originally Eurosiberian[3], now native to Europe, North and West Asia and North Africa.[52] Cultivated since 1542.[23]

Where: Throughout the Netherlands.[1]

How: In the field.[7]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]

Run wild: Known in the wild.[1]

Where: Very common in grasslands and waysides[1] (Herbarium). All soils, even high peats in south-eastern Drenthe; usually fields with variable water levels.[3]

Seen: Yes (Herbarium).

3. Wild relatives

What: *T. repens* L.[1]

Where: All soils, even high peats in south-eastern Drenthe; usually fields with variable water levels[3]; grasslands and waysides, very common.[1]

4. Hybridization

Possible: Hybrids with other *Trifolium* species are doubtful, because of strong breeding barriers between virtually all species of *Trifolium*.[70]
Where: —
Seen: —

5. Conclusion

White clover is native to the flora of the Netherlands, both growing and grown throughout the Netherlands, so an escape from cultivation (D_d) will be morphologically undetectable. Crossing with wild relatives of other than the same species (D_p) does not seem possible. See also paragraph 3.5.9. of the general introduction.

Expectation: The D_{pdf}-code indicates a **substantial ecological effect** on the flora of the Netherlands.

Tulipa sylvestris L. — D_{pdf}: 4.4.1

Dutch : Bostulp
English : Florentine tulip
French : Tulipe sauvage
German : Wilde Tulpe

1. Introduction

What: The wild tulip (*Tulipa sylvestris* L.; Liliaceae) is the only tulip native to the Netherlands. Like the cultivars it is grown for its attractive bright flowers, mainly in gardens. They are pollinated by bees and pollen-feeding flies.[158]
Origin: Southern and south-eastern Europe, established since long.[1]
Where: On a very small scale.[138]
How: In gardens and in the field.[10]

2. Escape

Hardy: Yes, native to the Netherlands.[1 6]
Run wild: Known in the wild[1]; run wild and established in Europe a long time ago.[5]
Where: Grassy places on country estates etc.[1]
Seen: Yes (Herbarium).

3. Wild relatives

What: *T. sylvestris*, others mentioned as cultivated.[1 6]
Where: Grassy places on country estates etc.[1]

4. Hybridization

Possible: No information could be found about hybridization between wild and cultivated tulips, but experimental hybridizations with cultivated tulips are very common.
Where: Not sufficiently known.
Seen: No (Herbarium).

5. Conclusion

The wild tulip is a native to the northern parts of the Netherlands, although the original wild tulip is very rare. It is not known whether the cultivated 'wild' tulips can escape, but the rareness of the species indicates that it hardly does (D_d). For the same reason the possibility of hybridization could not be ascertained (D_p).

Expectation: The D_{pdf}-code indicates a **small ecological effect** on the flora of the Netherlands, but only locally, where the wild tulip is found.

Tulipa spec. — D_{pdf}: 2.1.1

Dutch : Tulp
English: Tulip
French : Tulipe
German: Tulpe

Including: *T. acuminata* Vahl, *T. aucheriana* Bak., *T batalinii* Reg., *T. biflora* L.f., *T. chrysantha* Hort. non Boiss., *T. clusiana* Vent., *T. eichleri* Reg., *T. fosteriana* Hoog, *T. galatica* Freyn, *T. gesneriana* L., *T. greigii* Reg., *T. hageri* Heldr., *T. humilis* Herb., *T. kaufmanniana* Reg., *T. kolpakowskyana* Reg., *T. linifolia* Reg., *T. marjolettii* Perr. & Song., *T. orphanidea* Boiss., *T. polychroma* Stapf, *T. praestans* Hoog, *T. pulchella* Fenzl, *T. saxatilis* Sieb., *T. suaveolens* Roth, *T. tarda* Stapf, *T. tubergeniana* Hoog, *T. turkestanica* (Reg.) Reg., *T. urumiensis* Stapf, *T. whittallii* (Dykes) Hall and cultivars.[138]

1. Introduction

What: Tulips (*Tulipa* L.; Liliaceae) are bulbous perennial herbs, grown for their attractive bright flowers, as cut-flowers or in gardens. The cultivation of many species is long established, and selection, hybridization and subsequent naturalization have given rise to many taxonomic and nomenclatural difficulties.[20] Of all bulbiferous ornamental crops in the Netherlands it has the largest area under cultivation.[10] They are pollinated by bees and pollen-feeding flies.[158]

Origin: Northern temperate Old World, especially Soviet Central Asia[13], introduced through Turkey around 1560.[79] The majority of the garden tulip cultivars derived from *T. gesneriana*[20], *T. suaveolens* and *T. kaufmanniana*.[1]

Where: Throughout the Netherlands, especially in South and North Holland.[12]

How: In greenhouses, gardens and in the field.[10]

2. Escape

Hardy: Yes, perennial.

Run wild: *T. gesneriana* and *T. kaufmanniana* are occasionally found outside cultivation (Archives, Herbarium); introduced in western and central Europe, run wild and established there.[5]

Where: On ruderals and waste lands in South Holland, and a former bulb-field in Friesland (Herbarium); not known to establish for longer periods.

Seen: Yes (Herbarium).

3. Wild relatives

What: *T. sylvestris*, others mentioned as cultivated.[1 6]
Where: Grassy places, shadowed or not, on country estates etc.[6]

4. Hybridization

Possible: Many hybrids between *T. gesneriana*, *T. suaveolens*, *T. kaufmanniana* are cultivated.[1] No information available about hybridization with wild tulips.
Where: —
Seen: No (Herbarium).

5. Conclusion

Tulips are grown throughout the Netherlands, and they occasionally escape from cultivation. However, they seem not capable of establishing in the wild (D_d). Their possibilities for hybridization with other cultivated tulips, or with the wild tulip are not known (D_p).

Expectation: The D_{pdf}-code indicates a **small ecological effect** on the flora of the Netherlands, but only locally, where the wild tulip is found.

Vicia faba L. — D_{pdf}: 2.1.0

Dutch : Tuinboon, Veldboon
English : Broad bean, Field bean, Tick bean, Horse bean
French : Fève, Fèverole
German : Ackerbohne, Puffbohne

1. Introduction

What: Broad bean (*Vicia faba* L.; Leguminosae) is an erect, smooth-stemmed (pubescent[17]) annual, cultivated throughout Europe since prehistoric times[97 102] for the edible seeds and immature legumes and as a fodder.[7 17 52] The major part is grown for processing, and is sold canned or deep-frozen.[8] The plants are self-pollinating[25], but cross-pollination increases yield. Main pollinators are bumble bees and honey bees.[81]
Origin: The origin of this species is not known. Some authorities suggest South-West Asia, between Afghanistan and the marginal regions of the eastern Mediterranean[97], others central Asia[98], but no undoubtedly wild plants are known from these areas. The smaller-seeded field beans would originate from a central Asian gene centre, the large-seeded garden beans from a diversity centre in the Mediterranean area .[102] An alternative theory is that it has been developed under cultivation from *V. narbonensis* L., which it closely resembles in many characters.[17] The broad bean is cultivated since the Stone Age, the consumption of the young garden beans dates from the 17th century.[23]

Where: Throughout the Netherlands, especially southern sea-clay and sandy soils in North Brabant, Zeeland and Limburg.[12]

How: In the field, in home-gardens, and sometimes in greenhouses.[8]

2. Escape

Hardy: Possibly, they are tolerant to light frost.[81]

Run wild: Occasionally found outside cultivation, sometimes persisting for a few years.[52] Often occurring as a relic of cultivation and perhaps elsewhere in Europe locally naturalized.[17]

Where: At the margins of fields[52], waysides, flour factory in Wormerveer, farmland, ruderals, harbours (Herbarium); in Arnhem[33], Zeeland[135], Harderwijk.[136]

Seen: Yes (Herbarium).

3. Wild relatives

What: There are several species of *Vicia* native to the Netherlands[16], but none can be considered to be a wild relative as defined in the introduction.

Where: —

4. Hybridization

Possible: Experimental crosses have been made, the resulting hybrids having varying fertility.[70] There are no crossable relatives in the Netherlands.[16]

Where: —

Seen: —

5. Conclusion

Broad beans are not native to the Netherlands, and they have no wild relatives in the Dutch flora so D_p seems not possible. They are grown for their seeds and for their legumes, and are occasionally found outside cultivation growing from spilt seeds. However they do not seem to be establishing anywhere (D_d).

Expectation: The D_{pdf}-code indicates **no ecological effect** on the flora of the Netherlands.

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Index on common Dutch, English, French and German vernacular names

D = Dutch, E = English, F = French, G = German

Index on scientific names