4 Dying of ash in the Netherlands

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Summary

Around 1985 growing concern about a previously unknown disorder in common ash (*Fraxinus excelsior L.*) instigated a preliminary inventory. The disorder was reported from all parts of The Netherlands, with the notable exclusion of Limburg, from different soil types and from all kind of ash plantations. In some plantations up to 20% of the trees were affected.

The first and most important symptom is wilting of (part of) the crown, combined with premature leaf fall; other symptoms may follow. The wilting process can be very quick, a few days till a few weeks, and may lead to complete dead of the tree, which may take less than one till several years. Normal growth till the moment of symptom expression can occur.

Various fungi were isolated, one not yet identified fungus relativily often. Wood anatomical investigations showed dark colourations and many tyloses in both early and late wood vessels. A comparison with dying of ash in other countries gave also no definite solution. More research is needed.

4.1 Introduction

The importance of ash (*Fraxinus excelsior* L.) in Dutch forestry has increased considerably since 1950 as a result of the availability of better sites, the planting of more broadleaved forests and the occurrence of such problems as Dutch elm disease in elms and watermark disease in tree willows.

The increased use of ash in roadside, recreational and amenity plantations, and in the newly established forests in the IJsselmeerpolders has resulted in approximately 5000 ha ash forest (CBS, 1985) and about 5000 km roadside and line plantations (SBB, not publ.) by 1980. As foreseen in the long term planning of the Dutch government (Anonymus, 1986), this area will be doubled by the year 2050.

However, since the end of the 1970's a previously unknown disorder of ash – commonly called 'essensterven' (dying of ash) – has been observed at several places in the country. The rapid increase of this disorder instigated a preliminary investigation during the summer of 1986. This article deals with the results of that survey and with some of the provisional results of a more comprehensive investigation started in the summer of 1987.

4.2 Methods

A questionnaire was sent to all district officers of the State Forest Service in order to obtain more detailed information about the distribution and the seriousness of the disorder and the symptoms occurring. Several questions aimed

at tracing possible relations with abiotic factors as soiltype and groundwater level while relations with management practices were also included.

Based on the results of this inquiry two permanent plots were selected: one near Zeewolde, the other near Heiligerlee. In order to obtain a detailed description of the development of the disorder these plots have been assessed several times during the summer of 1986. Two affected trees and one apparently healthy tree have been felled to enable initial anatomical examinations of the wood to be undertaken.

In the same year five other trees were felled for initial phytopathological examinations. Observations were continued in 1987. The permanent plots have been described again several times and phytopathological examinations have been repeated with some affected trees from other locations.

4.3 Results

Distribution of the disorder

Dying of ash occurs in a large part of the country. Only in very few cases could a directly demonstrable cause e.g. a strong rise of the groundwater level or a site not suitable for ash, be indicated. A vast part of the reported dying of ash seems to be due to a so far unknown factor.

Figure 4.1 shows the places where dying ash trees have been reported up to September 1987. Although this map certainly is not complete, the absence of reports on dying ash in the province of Limburg is conspicuous because of the considerable amount of ash in this province (557 ha closed ash forest or 11% of the total area in the country; CBS, 1985).

The disorder has been found in all kinds of ash plantations: roadside, amenity and recreational plantations as well as forest stands, both pure and mixed stands. Only coppice seems to escape. The disorder affects *F. excelsior L.* and several cultivars ('Westhof's glorie', 'Diversifolia', 'Atlas'). No reports of the disorder in *F. ornus L.* and other *Fraxinus*-species have been received. The age of the affected trees was less than 30 years. In most affected areas, however, older ash stands are rare. Very young trees also are affected. In 1987 the disorder has been found in some nursery beds with saplings between 4 and 6 years old.

Symptoms

The first and only symptom which is always present is wilting of the entire crown or part of it, followed by necrosis and premature leaf fall from the wilted parts of the crown (Figs. 4.2 and 4.3). Later on symptoms can include:

- appearence of reduced new shoots with very small pale green till chlorotic leaves and very short internodes (Fig. 4.4);
- dying (partially or completely) of the crown;
- appearence of a dead and discoloured sector in the stem;
- appearence of epicormic shoots on the still living parts of the tree, often followed by a partial dieback of these shoots;
- dying of the whole tree.

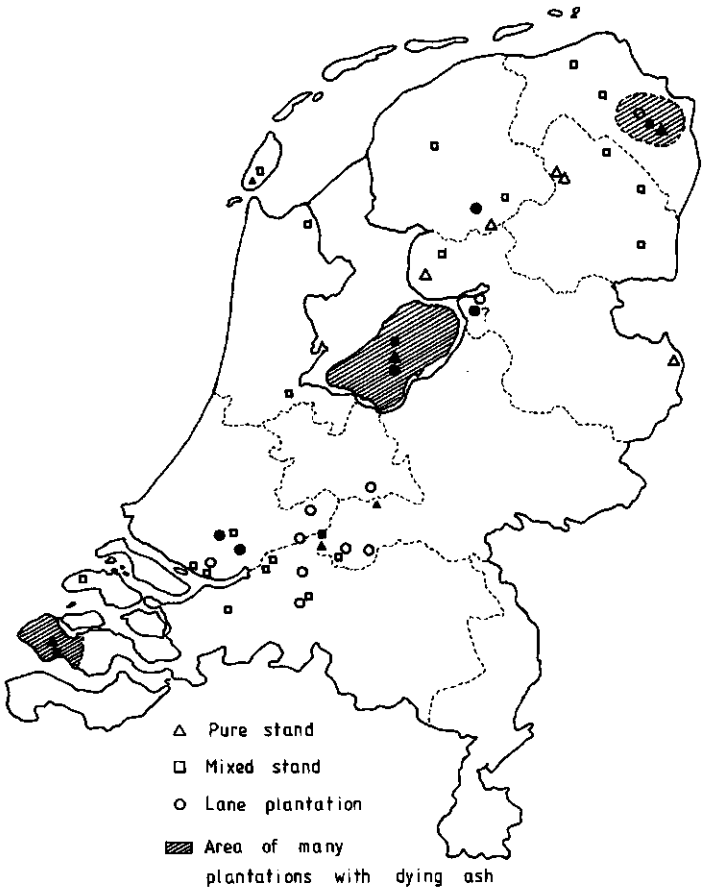

Fig. 4.1. Reports of dying ash (*F. excelsior L.*) in the Netherlands till September 1987. Open signs represent individual plantations with dying ash, dark signs represent several plantations with dying ash.

Other symptoms which have been observed are:
- partial dying of the bark of stem and branches;
- discolourations as browning of the pith of one and two year old twigs, small brown streaks at various places in the wood and a caramel discolouration in the cambial zone or the outer wood of the stem;
- the appearence of long cracks in the bark.

Development of the disorder

The above described symptoms manifest themselves in the growing season, quite often after a period of normal growth. In 1986 and 1987 especially in the months August and September many newly affected trees were observed. The

Fig. 4.2. Development of the disorder.
Left: Healthy ash tree. Note the regularly outspread position of the leaves and leaflets in the upper crown. Middle: A tree with early wilting symptoms. Particularly in the upper crown all leaves droop. Right: A tree which lost almost all leaves after wilting. The trees are 12 years old and have been removed from the stand carefully to enable a picture to be taken. (Horsterwold afd. Pz5-a1, 1 September 1987).

Fig. 4.3. Detail from the crown of a severely wilted ash tree. The plantation has been established in 1977, picture taken 1 September 1987 (Horsterwold Pz5-a1).

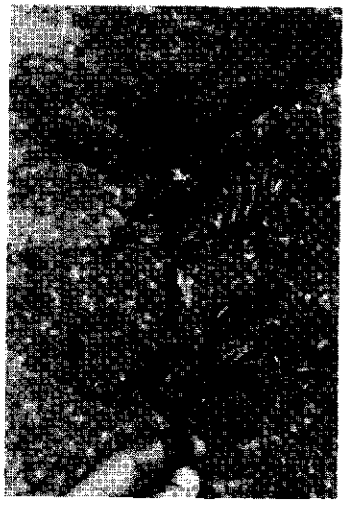

Fig. 4.4. Detail of regrowth after wilting and leaf fall. Reduced new shoots with very small pale green till chlorotic leaves and very short internodes. (1 September 1987, Horsterwold Pz5-a1).

wilting process takes place within a few weeks and sometimes even within a few days and can lead to complete death of the tree within the same year. Sometimes the trunk and the lower parts of the crown of affected trees die only after several years of lingering including the generation of epicormic shoots and a gradual dieback. So far, complete recovery has not been observed.

Especially in young trees (up to 15 or 20 years old) the process of wilting and loss of the foliage can occur very suddenly. In these trees no signs of a decreased growth before the wilting symptoms appear, have been found. Measurement of the shoots of some affected trees showed normal growth until the moment of symptom expression (Table 4.1).

It would appear that in trees of 20 years and older, as well as this acute process, a more chronic process can occur. These trees do not show the sudden complete wilting and leaf fall as described earlier. Instead a much more gradual decline happens. In 1987 in the city of Rotterdam some 20 year old trees were reported

Table 4.1. Shoot length (cm) of leader and topmost branches – in order of affection – of tree 7 (reduced new shoots after wilting and complete leaf fall), 1 (almost bare after wilting), 2 (wilted, early leaf fall), 6 (early wilting), and 5 (appearently healthy); and rainfall between 1.VI and 31.VIII in 1985-1987. For description of symptoms see text. Location: Horsterwold.

	shoot length (cm)					
tree number, (date)	leader			topmost branches		
	1985	1986	1987	1985	1986	1987
7, (1.IX)	114	84	81	63	96	72
				57	57	34
1, (6.VIII)	–	56	71	63	53	34
				46	38	30
				47	38	23
2, (6.VIII)	–	55	90	–	40	70
6, (1.IX)	–	77	144	67	42	53
				58	46	60
5, (1.IX)	110	56	209	73	55	147
				84	62	174
				–	24	110
				–	40	113
	Rainfall (mm)					
period	total			deviation to the mean		
	1985	1986	1987	1985	1986	1987
1.VI till 1.IX	370	225	362	+76	−69	+68

showing a gradual decline including early leaf fall in 1986, extremely late flushing in 1987, sparse and light- coloured foliage, gradual wilting, partial leaf fall and a partial dieback of the topmost twigs during the growing season of 1987. More recently this kind of dieback has been reported in other parts of the country too.

Especially in plantations where the disorder has been present for several years, the dying of ash seems to occur more or less in groups.

Seriousness of the disorder

The percentage of affected trees per plantation varies from a few trees per plantation up to 20% of the trees in some plantations in the province of Flevoland.

The disorder is widespread, the number of affected plantations is still growing and the percentage of affected trees in those plantations is still increasing. The disorder, therefore, seems to have become a serious threat, especially as it already occurs frequently in some areas where many ash plantations are to be found (e.g. Flevoland, Eastern-Groningen).

Results of the phytopathological examinations

In 1986 samples were taken from five affected trees (Hiemstra, 1987): three with a crown partially died back and a stained sector in the wood of the stem (trees probably affected in 1985 or even earlier) and two showing severe wilting (first affected in 1986). From the discoloured sector in the stem of the first three trees two *Fusarium* sp. and two *Phoma* sp. were isolated. All isolations from the wood outside this sector were negative. From the twigs and small branches of the trees with severe wilting almost every attempt led to the isolation of the same, *Cephalosporium* - like fungus. The places of isolation and the results are summarized in Table 4.2.

In 1987 the isolation experiments were repeated with samples from four recently wilted trees from three different locations. Isolations from wood samples taken from the stems of these trees (even when the stem contained a discoloured sector) in almost all cases proved to be negative. From one and two year old twigs of these trees however, one fungus was very consistently isolated. This fungus has not yet been identified properly but it shows a great resemblance to the fungus that has been isolated from the twigs of affected trees in 1986.

Results of the wood anatomical investigations

For this purpose three ash trees were felled:

(1) A tree (probably affected first in 1985) with the crown partly dead and the other part completely wilted. The bark of the stem was partly dead and sunken. The living part of the bark on the stem was adjacent to the wilted part of the crown.
(2) A tree (affected first in 1986) dying with severe wilting.
(3) A healthy looking tree.

Macroscopical, microscopical and SEM examinations of wood samples from

Table 4.2. Results of the 1986 isolation experiments with 5 affected ash trees (*Fraxinus excelsior* L.) from Horsterwold.

nr. tree	condition of the tree / place of isolation; number of isolations, results		
I	Crown partly dead, stained sector in the stem, bark on that sector dead. (Affection probably started in 1985).		
	discoloured wood sector;	6,	6 pos.: Fusarium sp. 1
	margin of this sector;	6,	--
	not discoloured wood;	6,	--
	dark spots in wood;	9,	--
	twig partly dead, dead part;	3,	--
	margin living/dead;	3,	--
	living part;	3,	--
II	As tree I		
	discoloured wood sector;	6,	6 pos.: Fusarium sp. 1, 2x Fusarium sp. 1, 3x Phoma sp.1
	margin of this sector		
	wood not discoulored;	6,	--
III	As tree I		
	spots in wood small branch;	6,	1 pos.: Phoma sp. 2
	'normal' wood same branch;	6,	--
IV	Completely bare after wilting (affection started in 1986)		
	wood of small branch;	6,	4 pos: Cephalosporium - like sp.
V	As IV, twigs partly dead		
	twigs, superficial;	3,	2 pos.: 1 Schizothyrella sp. 1 Cephalosporium- like sp.
	just under the woodsurface;	3,	3 pos.: Cephalosporium - like sp.
	deeper in the wood;	3,	3 pos.: Cephalosporium - like sp.

these trees led to the following results (Miller & Hiemstra, 1987): In tree nr. 1 many vessels showed dark colourations caused by a considerable tylose activity. These thick-walled tyloses most frequently were found in the early wood but were often present in the late wood. The vessels in the late wood also often contained granulated deposits.

In tree nr. 2 tyloses were much less abundant and appeared to be limited to the last growth rings. Unlike the tyloses found in tree nr. 1 these tyloses, which were found in a few of the early wood vessels, were thin-walled. Wood

samples from the healthy tree appeared to be free of tyloses.

In addition to this, the part of the stem with sunken bark of tree nr. 1 was further examined. This revealed that a large part of the secondary wood growth had ceased to develop during the summer of 1985. At this side of the stem the bark was dead and therefore appeared sunken (in comparison with the still living and growing part of the stem). At the other side of the stem, where wood growth had continued, a disturbance in the late wood of 1985, characterized by large groups of parenchymatous cells, followed by a continuation of normal wood growth, could be shown. The cause of the zonal colouration in the sector where radial growth ceased in 1985 is not known, but dead or dying tissue can be stained by certain fungi (Hibben & Silverborg, 1978).

4.4 Discussion

One of the primary goals of the 1986 investigation was to collect more information on possible causes of the problem. Hence, some questions on possible causes such as site (soil type and groundwater level), climate (dry periods), management practices and the involvement of pathogenic organisms were included in the inquiry. The answers received lead to the following presumptions, but it should be remembered that the data resulting from this inquiry are incomplete and not detailed.

Site

The disorder seems to occur on sites with very different soil types. Affected trees were reported on clay, loam, sand and even peat soils. The groundwater level may vary from high to very low. Some of the sites with affected trees are known to be unsuitable for ash, but the vast majority of affected trees grow on sites regarded as suitable. A site unsuitable for ash trees as a general cause of the current problem therefore is unlikely.

Climate

As the ash is known to be a species with a high water requirement and because wilting appears to be the primary symptom of the disorder, the occurrence of dry periods during the growing season was considered to be important. Comparison of mean precipitation values for May to September for the years 1970 to 1986 with the year of outbreak of the disorder, however, did not show a relationship between a shortage of precipitation and an increased appearence of affected trees. Moreover, in 1987, a year with a particular wet summer, many new cases of dying ash have been observed. Drought periods as a direct cause of the disorder, therefore, can probably be rejected. The precipitation rate, however, surely acts upon shoot growth, as is clearly visible in Table 4.1.

The influence of other climatic aspects (e.g. extreme cold winters) has not yet been studied.

Management practices

Attention was given to site preparation, plantation type (monoculture, mixed stand, roadside trees), provenance of the affected trees, weed control after planting (chemical, mechanical or not at all), pruning and thinning practices. The results of the inquiry seem to indicate that none of these factors bears a direct relation with the onset of the disorder. Affected trees are reported in all plantation types, independent of former management practices.

As far as a possible relation with the provenance of affected trees is concerned, no conclusion can be reached as in most plantations the exact provenance is unknown.

Pathogenic organisms

As the disorder appears under very different conditions, the involvement of a pathogenic organism would appear to be probable. This possibility gains support by the fact that the symptoms are similar to those of some well known fungal wilt diseases such as Dutch elm disease, oak wilt and *Verticillium* wilt (caused by *Ophiostoma ulmi, Ceratocystis fagacearum* and *Verticillium sp.* resp.).

The results of the wood anatomical investigations can also be explained, at least partially, by the involvement of a pathogenic organism as tyloses are very common with fungal wilt diseases.

Culture of samples taken from affected trees has led to the isolation of some fungi. The *Phoma-* and *Fusarium sp.* isolated seem to be unlikely as causal factors. They are very commonly associated with dead and decaying wood and they could only be isolated from the discoloured parts of some stems. The fungus which has been isolated consistently from the wood of small branches and twigs of affected ash trees on the other hand, could be of much more importance.

Nevertheless it is pointless to make further predictions until further identification and inoculation experiments have been carried out.

Dying of ash in other countries

In Great Britain and in the United States of America a very similar disorder is known.

In Great Britain the disorder called 'ash dieback', has been known to affect common ash (*F. excelsior L.*) since the 1950's. Several suggestions have been made regarding its causes, including moisture stress caused by adverse site and climatic conditions, pollution, scale insect attack and virus infection. Until now however, no certainty as to the cause exists. A first study of the problem showed a strong, but variable, positive correlation between incidence and severity of ash dieback and the intensity of arable farming in the area, but no specific causal factor was determined (Pawsey, 1983; 1984).

In the USA white ash (*F. pennsylvanica Marsch.*) have been affected by a mysterious disorder called 'ash-dieback' or 'ash decline' for more than half a century. Research into this disorder has been carried out since the 1950's, even so the problem is not yet fully understood (Holmes, 1986). Part of the problem can be explained by the involvement of fungi like *Cytophoma pruinosa* (Silver-

borg & Brandt, 1957), of fungi in combination with drought periods (Ross, 1964; Tobiessen & Buchsbaum, 1976), of virusses (Hibben & Silverborg, 1978; and of mycoplasma-like organisms (Matteoni & Sinclair, 1985). Air pollution, particularly ozone, has also been suggested as a possible factor involved (Hibben & Silverborg, 1978).

One of the main problems in clarifying the results of the preliminary investigations and in solving the 'essensterven' problem is the fact that the composition of and the interaction between the components of the forest ecosystem concerned are to a large extent still obscure (see also Oldeman, this volume), e.g. the nematode population in forests and in ash forests in particular. A preliminary investigation of the nematode populations in forests showed a high density of plant parasitic nematodes in some affected ash plantations (Bongers, 1985). In 1987 this was confirmed at the site of some recently affected ash trees. The meaning of this fact, however, is not yet apparent. Research of nematode populations in forests can perhaps clarify these observations.

Conclusion

Summarizing, there are many gaps in our results. Important questions to answer in solving the 'essensterven'-problem concern:

- The nature and the role of the isolated fungi.
- The influence of different factors that affect the trees' internal water balance, such as drought periods and of water supply in general.
- The condition and the functioning of the root system.
- The cause and meaning of the tyloses, found in the vessels of some severely affected ash trees.

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