Neth. J. Pl. Path. 96 (1990) 227-236

Surveys of cereal diseases and pests in the Netherlands. 1. Weather and winter wheat cropping during 1974-1986

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Accepted 25 May 1990

Abstract

During 1974-86, systematic annual surveys of diseases and pests in winter wheat were conducted. In a series of papers the occurrence of diseases and pests will be reported in relation to weather and cropping practices. In this paper, an introduction to the series of papers, the weather and the the changing winter wheat cropping practices are described. Grain yields and pesticide use in the surveyed fields are reported.

Additional keywords: Triticum aestivum, production, cultivars, pesticides.

Introduction

The adoption of short-strawed wheat cultivars together with the application of growth regulators and the increased use of fertilizers and pesticides, highlighted the agronomic importance of cereal diseases and pests and the variation in their occurrence (Dilz et al., 1982). Linked to the footrot survey in the Netherlands (Van der Spek et al., 1974) and stimulated by the surveys of cereal diseases in England and Wales (King, 1977), systematic annual surveys of diseases and pests in commercial cereal fields were conducted from 1974 to 1986, to describe the occurrence of these biotic constraints to yield. The results of these annual surveys have been described by Van der Beek (1975, 1976, 1977 and 1978), Borm (1978), Daamen et al. (1980, 1981 and 1982), Daamen and Wietsma (1983 and 1984), Stol (1985), Versluis (1985) and Van den Hoek (1986). Analysis of the surveys over years to determine possible causes of the annual fluctuations in disease and pest intensity was not yet done.

This paper is an introduction to the following papers. It describes the winter wheat cropping practices in the Netherlands. The grain yields and pesticide use in the surveyed fields during 1974-86 is reported. As this paper is descriptive, it lacks a method, result and discussion structure.

Weather

Mean monthly temperatures and total monthly precipitation during 1974-86 are given in Fig. 1a,b, together with averages of the period 1950-80. Data were derived from the monthly reports of the Royal Netherlands Meteorological Institute (KNMI), from five main stations for temperature, and from all meteorological stations for precipitation.

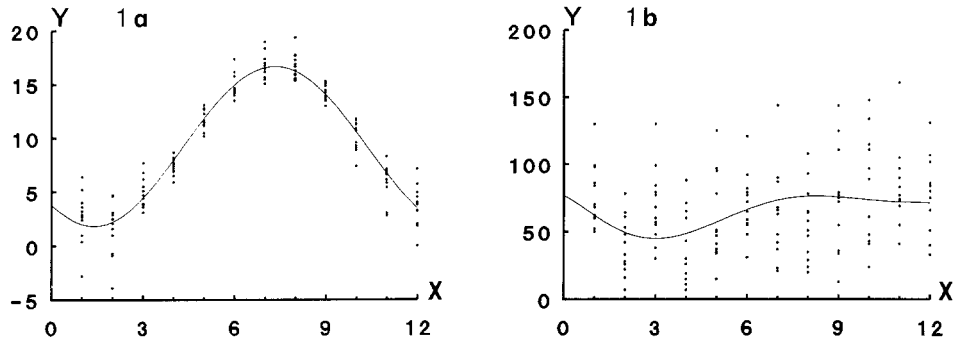

Fig. 1a,b. Mean monthly temperature (Fig. 1a, Y in °C) and total monthly precipitation (Fig. 1b, Y in mm) in the years 1974-1986, X is number of month. The lines are averages over the years 1950-1980.

On average, temperature is lowest in January-February and highest in July-August, but Fig. 1a illustrates that the mean monthly temperature varies considerably. Precipitation shows an annual trend, superseded by the annual variation (Fig. 1b).

Winter wheat cropping and production

In the Netherlands, small grains are most often grown in rotation with the cash crops potatoes and sugar beet, and sometimes with pulses (mainly peas), grass seed, oilseed rape and flax (Fig. 2). Fodder crops, predominantly maize, are usually grown on sandy soils in areas where animal production is intensive so that maize is usually not grown in arable rotations. In the period 1974-86, the area under small grains decreased by one third. The dominant small grains were winter wheat and spring barley, with 120 000 and 40 000 ha, respectively. When weather conditions in autumn were bad, as in 1974, the harvest of potatoes and sugar beet and the seedbed preparation was delayed and winter wheat was partly replaced by spring cereals (Fig. 2). Winter wheat is mainly grown on marine clay soils in the northern, central and southwestern parts of the Netherlands. Other minor areas of winter wheat cropping are 3000 ha on river clay soils in the central

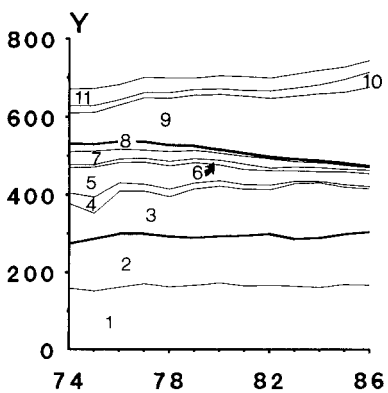

Fig. 2. Cumulative area of agricultural crops (Y, in 1000 ha) during 1974-1986.
1. Potatoes; 2. Sugar beet; 3. Winter wheat; 4. Spring wheat; 5. Spring barley; 6. Winter barley; 7. Oats; 8. Rye; 9. Fodder crops; 10. Pulses; 11. Other corps.

part of the country, 4000 ha on loess soils in the south, 5000 ha on improved peat soils in the northeastern and 4000 ha on sandy soils in the eastern part of the country. Winter wheat yield has increased from 5 to 8 t/ha. The annual national wheat production has increased from 0.7 to 1 megatonne (Mt) in these years. The national production is negligible compared to the annual world production of 519 Mt (CIMMYT, 1989). In these years, about equal amounts of the national production were used as human food, as animal feed or for export (Annual reports, Netherlands Grain Centre). Annual net import of bread wheat and wheat products amounted 0.6 Mt on average. This import was mainly used to fulfil the national wheat consumption of 1 Mt food and partly to fulfil the national wheat consumption of 0.4 Mt feed (Annual reports, Produktschap voor Granen, Zaden en Peulvruchten).

Cropping practices. After ploughing and seedbed preparation, winter wheat is usually sown in the second half of October. In any year, however, some fields are sown very early, in September, and some fields very late, in December. The average seed rate was 170 kg/ha in 1974. In response to the improvements of seed certification and seed disinfection, the seed rate decreased to 130 kg/ha in 1980 (Noordam and Van der Ham, 1979) but it increased afterwards to 155 kg/ha, indicating the gradually intensification of wheat cropping. The row distance was circa 25 cm, to enable mechanical weeding and growth of an undersown crop (Darwinkel, 1979), but it decreased to 10-15 cm during 1974-86.

The use of nitrogen fertilizer increased from 100 to 160 kg N per ha during 1974-86 (Noordam and Van der Ham, 1979). Phosphate and potassium fertilizers are usually applied in the potato crop. The estimated uptake of these fertilisers by wheat increased from 40 to 70 kg P_2O_5 and 20 to 80 kg K_2O on clay soils in this period.

Weeds were mainly controlled by herbicides. Fungicides have become commonly used since 1974, growth regulators since 1977 and aphicides since 1979. An indication of the costs of winter wheat cropping, expressed as percentages of gross financial returns, averaged for marine clay soils, is given in Fig. 3. In this period, the direct extra costs, without the costs of labour and machinery, increased from circa 20 to 30% of the financial returns. Costs of weed control and crop protection were negligible in 1973 but amounted to 10% of the financial returns in 1986.

Cultivars. Data on cultivars were obtained from the cultivar lists of the Government Institute for Research on Varieties of Cultivated Crops (RIVRO). In 1974, the dominant winter wheat cultivar Clement became susceptible to yellow rust (*Puccinia striiformis*). After the yellow rust epidemic of 1975 it was replaced by the older, but more yellow rust resistant cultivars Caribo, Lely and Manella (Fig. 4; R.W. Stubbs, pers. comm.). 'Lely' became susceptible to yellow rust in 1975. In 1976, yellow rust was nearly absent due to the dry and warm summer. 'Lely' was replaced, after the yellow rust epidemic of 1977, in 1978 by cv. Okapi, moderately yellow rust resistant and by cv. Arminda, yellow rust resistant at the adult plant stage. 'Okapi' and 'Arminda' were dominant during the decade whilst their resistances lasted. These cultivars were replaced by the complete yellow rust resistant cv. Obelisk in 1987.

During this period the crop stature also changed. The tall cultivars Manella and Caribo and the rather tall cvs. Lely and Clement were replaced by the tall cv. Okapi and the semi-dwarf cv. Arminda, which in turn were replaced by the semi-dwarf cv. Obelisk

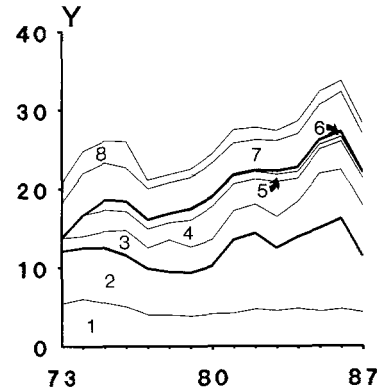

Fig. 3. Cumulative direct extra costs (Y) of winter wheat production as percentages of gross financial returns in 1973-1987, excluding costs of labour and machinery.
1. Seed; 2. Fertilizers; 3. Herbicides; 4. Fungicides; 5. Growth regulators; 6. Insecticides; 7. Rope, drying and cleaning; 8. Insurance and interest.

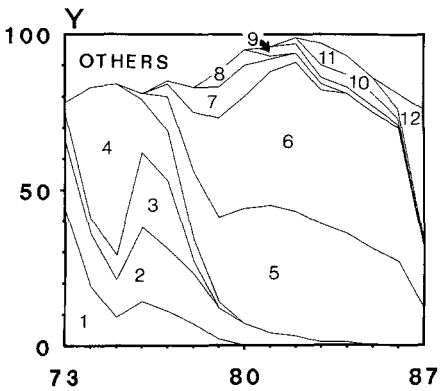

Fig. 4. Area of winter wheat cultivars (Y, as percentage of total winter wheat area) during 1973-1987.
1. Manella; 2. Caribo; 3. Lely; 4. Clement; 5. Okapi; 6. Arminda; 7. Nautica; 8. Durin; 9. Marksman; 10. Saiga; 11. Citadel; 12. Obelisk.

in 1987. Total production of biomass of tall or semi-dwarf cultivars is about the same. Grain yields of semi-dwarfs are on average higher than that of tall cultivars, as semi-dwarfs have on average a higher harvest index (Van Dobben, 1962) and they can endure higher levels of nitrogen before they lodge. The dwarf cultivars Durin, Marksman and Donata were highly susceptible to ear blight (*Fusarium* spp. and *Monographella nivalis*) and to a lesser extent also to *Septoria* spp. (Ubels et. al., 1980), which limited their agricultural value. These dwarfs never exceeded more than ten percent of the winter wheat area in this period.

Surveyed fields

It was not possible to make a random selection from all fields in the country, as the resources available for the survey amounted to only one man-year annually. The surveys were therefore carried out in cooperation with other institutes and projects, so that estimates may be biased. However, it is the opinion of the author that this bias is smaller than that introduced by the visual scoring of disease symptoms by different observers in different years and by differences in crop development at the time of the observations. In Table 1 the number of fields and the number of times the fields were surveyed are given. If the survey was carried out more than once during a year, usually the same

Table 1. Number of winter wheat fields surveyed.

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
May	143	88	94	105	–	305	219	132	123	107	176	–	–
June	143	88	94	105	124	321	223	–	–	–	–	–	–
July													
1st half	143	88	94	105	124	174	408	–	–	–	–	–	–
2nd half	–	–	–	–	124	129	164	138	152	143	123	94	94
August	143	88	94	105	–	–	–	–	–	–	–	–	–

fields were visited. Except in the years 1979 and 1980, when the survey was also used in the EPIPRE advisory system (Zadoks, 1981 and 1984; Rijsdijk, 1983; Rijsdijk et al., 1989; Rabbinge and Rijsdijk, 1983 and 1984; Blokker, 1983; Reinink, 1984 and 1986; Rossing et al., 1985, Drenth et al., 1989; Drenth and Stol, 1990) for trouble shooting, when each time the observers visited different fields. In following papers, the occurrence of diseases and pests at first-second node stage and at milky-ripe will be reported.

Fields were selected more or less proportional to the areas of winter wheat in the various districts and proportional to the areas of different cultivars sown. Fields were selected by the extension service during 1974-77 and from the fields in the EPIPRE advisory system during 1978-86. Estimates of average annual grain yield and pesticide use in the fields surveyed in the period 1974-84 are given in Table 2. These data were derived from the surveyed fields in the period 1974-1977 (D. van der Beek, pers. comm.) and from the EPIPRE fields (Rijsdijk and Hoekstra, 1979, Rijsdijk et al., 1980a, 1980b,

Table 2. Estimates by farmers of average annual grain yield (ton ha^{-1} at 16% humidity) and of pesticide use in the fields surveyed.

Year[1]	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Number of fields	141	78	66	102	136	389	746	831	911	896	845
Yield	6.6[2]	5.4	6.1	5.9	7.2	6.5	6.9	7.4	8.0	7.6	8.6
Percentage of fields sprayed to control[3]:											
Eyespot	28	9	4	9	–[4]	3	14	10	8	9	22
Leaf diseases	9	41	21	63	–[4]	51	19	55	22	86	51
Leaf & ear d.[5]	60	77	79	89	140	48	80	84	113	160	145
Aphids[5]	4	10	51	36	17	81	76	84	101	100	100

[1] 1974-1978: data derived from the fields surveyed, 1989-1984 data derived from fields in the EPIPRE system from which a limited number were surveyed.

[2] Based on 82 fields of the survey.

[3] Chemical control of eyespot usually takes place in the first half of May, of leaf diseases in May, of leaf and ear diseases and of aphids in June or July. For active ingredients see Table 3.

[4] Sprays to control diseases were not separatedly recorded and were lumped under leaf & ear diseases.

[5] Sprays to control leaf & ear diseases and aphids are most often combined in one treatment.

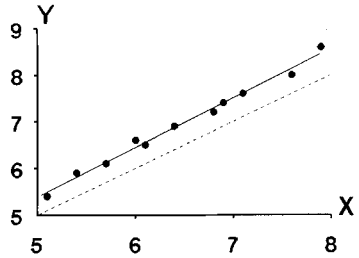

Fig. 5. Estimates of average annual grain yield of the fields surveyed (Y, t/ha at 16% moisture content) in relation to average annual national yield (X, t/ha at 17% moisture content), in the period 1974-1984. The drawn line is the regression line, the broken line is the 1 : 1 relation.

1981, Drenth and Reinink, 1982 and 1984 and Reinink, 1985) and from the data-bases of the EPIPRE advisory system. Such data are not available for the years 1985 and 1986 when the data-bases were not updated after the harvest. An increase of grain yield and an increase of chemical crop protection during 1974-84 was found. Comparison of the average annual yield recorded for the surveyed fields (Table 2) with the national average yield (Statistical Yearbooks, CBS-LEI) is given in Fig. 5. It shows that the surveyed fields yielded slightly above the national average.

In the period 1974-84, circa 12% of the fields were sprayed, mainly during the first half of May, to control eyespot (*Pseudocercosporella herpotrichoides*), in 42% of the fields leaf diseases before ear emergence were controlled, and in 94 % of the fields leaf and ear diseases after ear emergence were controlled. On average, 60% of the fields were sprayed to control aphids, mainly *Sitobion avenae*. Sprays against leaf and ear disease and aphids consisted most often of a mixture of a fungicide and an insecticide. In this period, it was also common practice in the Netherlands to add the fungicide maneb as a tank mix with other pesticides, especially with insecticides. During 1974-84, the number of tank mixes applied per field increased from 1 to more than 2 per field.

The use of fungicides to control eyespot has not significantly increased. Decisions to control eyespot are based on field inspections and an economic threshold. The use of fungicides to control leaf or leaf and ear diseases increased, but shows variation between years. To illustrate this effect, the use of fungicides to control leaf and/or leaf and ear diseases is plotted against an estimate of average annual damage. This was estimated as the effect of one fungicide application at flowering in the RIVRO trials in these years (Fig. 6). The figure shows that in years when fungicides were highly profitable in the RIVRO trials, especially in 1983 and 1984, the use of fungicides in the surveyed fields was high. Thus, the gradual increase of chemical crop protection, as indicated in Table 2, was confounded with high disease intensities in the years 1983 and 1984.

The use of insecticides to control aphids increased but also showed variation between years due to pest management (Rabbinge and Carter, 1984). Aphids are relatively more damaging in high yielding crops compared to low yielding crops (Roermund et al., 1986; Rossing, submitted).

Pesticides. In Table 3, the percentage of fields is given in which certain active ingredients of fungicides and insecticides were used in the surveyed fields during 1974-84. These data were derived from the surveyed fields during 1974-1977 (D. van der Beek, pers. comm.) and from the data-bases of the EPIPRE advisory system during 1980-1984. The benzimidazoles benomyl, carbendazim and thiofanate-methyl were gradually re-

Table 3. Pesticide use in winter wheat as percentage of fields in which the specified pesticide (a.i.) was sprayed. Mixtures are counted twice or more depending on the number of compounds, see Table 2.

Year	1974	1975	1976	1977	1980	1981	1982	1983	1984
Number of fields[1]	141	78	66	102	746	831	911	896	845
Fungicides:[2]									
Benomyl	52	24	15	13	6	3	2	5	8
Benodanil	0	0	0	18	0	0	0	0	0
Carbendazim	35	50	67	84	51	27	31	13	17
Captafol	0	0	0	3	1	16	40	78	77
Captan	0	0	0	0	0	1	2	4	0
Ethirimol	0	1	3	5	0	0	3	1	0
Fenpropimorph	0	0	0	0	0	5	4	34	55
Maneb	60	87	80	121	90	108	118	141	149
Mancozeb	7	8	11	3	+	+	+	+	0
Prochloraz	0	0	0	0	0	0	0	2	1
Propiconazole	0	0	0	0	0	+	+	26	22
Pyrazophos	0	0	0	0	2	2	3	+	1
Sulphur	11	12	15	17	3	3	4	5	4
Thiabendazole	0	0	0	0	1	1	+	0	0
Thiophanate-methyl	3	4	8	7	5	2	1	1	+
Triadimefon	0	0	0	1	59	73	40	82	66
Triadimenol	0	0	0	0	0	0	0	0	+
Tridemorph	1	39	6	56	+	0	0	0	0
Triforine	0	0	0	1	1	1	+	+	1
Zineb	1	0	0	4	6	3	+	+	0
Ziram	1	3	0	0	0	0	0	0	1
Insecticides:									
Demephion	0	0	3	2	4	2	1	0	0
Dimethoate	1	1	27	12	30	33	42	39	36
Formothion	0	5	0	0	+	+	1	1	1
Fosfamidon	0	0	0	0	1	1	1	1	1
Heptenophos	0	0	0	0	0	0	+	1	1
Oxydemeton-methyl	1	1	15	2	4	2	3	4	4
Parathion	1	3	0	1	1	1	2	1	1
Pirimicarb	1	1	11	14	36	43	47	45	51
Thiometon	0	0	0	0	1	3	4	4	4

[1] 1974-1977, surveyed fields; 1980-1984, all EPIPRE fields from which survey fields were selected and data were complete.
[2] +: used in < 0.5 % of the fields.

placed by the ergosterol biosynthesis inhibitors, the morpholines tridemorph and later fenpropimorph, and by the triazoles triadimefon and propiconazole. The hydroxypyrimidine ethirimol, a selective mildew fungicide, was not commonly used in winter wheat. The carboxamide benodanil was only used in 1977 when rusts were widespread. Sulphur and the dithiocarbamates mancozeb, zineb and ziram but not maneb were

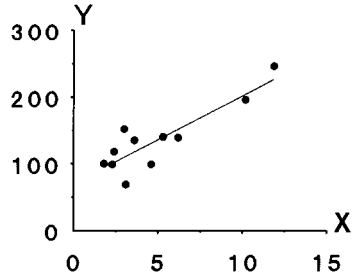

Fig. 6. Estimated annual use of fungicides to control leaf and/or leaf and ear diseases (Y, use in percentage of fields treated, see Table 2) in relation to an estimate of damage (X, kg/are), the effect of one fungicide application at flowering on clay soils in RIVRO trials (H. Bonthuis and K. Roodenburg, pers. comm.), in the period 1974-1984.

replaced by the above mentioned ergosterol biosynthesis inhibitors and by the phtalimide captafol. The use of the dithiocarbamate maneb increased, despite its negligible agricultural value (Ten Heggeler, 1985). Maneb was cheap and because of its manganese content it was only partly regarded as a fungicide and partly as a fertilizer, so it persisted.

Application of ethirimol and tridemorph to control mildew was low. Tridemorph was mainly used to control rusts in 1975 and 1977. After 1978, triadimenol was mainly used to control mildew before heading and to control mildew, brown rust and speckled leaf blotch after heading. Before heading, rusts were nearly absent after 1977. Mildew strains less sensitive to triadimefon were found from 1981 onwards in the Netherlands (De Waard et al., 1986). In 1989 mildew strains resistant to fenpropimorph were found (De Waard et al., 1990). A decrease over time in sensitivity of the mildew population to current fungicides is a common phenomenon (Wolfe, 1984). To retard this development, Dutch farmers were advised after 1981 to alternate the use of triazoles with the morpholine fenpropimorph (Hollomon, 1982).

Insecticides came into general usage to control aphids. The use of cheap organophosphorous compounds, mainly dimethoate, decreased slightly in favour of the more expensive but selective aphicide, the carbamate pirimicarb.

Samenvatting

Inventarisaties van ziekten en plagen in granen. 1. Het weer en de teelt van wintertarwe

Wintertarwe werd systematisch geïnventariseerd op ziekten en plagen in de jaren 1974-86. In een serie artikelen zal het optreden van ziekten en plagen worden besproken in relatie tot het weer en cultuurmaatregelen. Dit artikel is daarop een inleiding. Het jaarlijkse weer werd gekarakteriseerd door de gemiddelde maandtemperaturen en de totale hoeveelheid neerslag in een maand. De teelt van wintertarwe gedurende 1974-86 wordt kort besproken. De behaalde opbrengsten en het gebruik van chemische bestrijdingsmiddelen in de geïnventariseerde percelen wordt gerapporteerd.

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