Pesticide Action Network Europe

Forbidden fruit

The dramatic rise in the most toxic pesticides found on fruits and vegetables sold in Europe and evidence that governments are failing their legal obligations

May 2022

Executive summary

European citizens have been exposed to a dramatic rise in the frequency and intensity of residues of the most toxic pesticides on fruits and vegetables sold in the EU. This report and its primary conclusion contradict official claims that toxic pesticides use is declining and that food residue levels are under control. This report also exposes a complete failure by Member States and the European Commission to implement EU Regulation and protect consumers.

This report focuses on the residues of a category of pesticides defined as "more hazardous" by the European Commission in the context of the EU Farm to Fork Strategy. These are in fact the single most dangerous and most heavily regulated category of pesticides, linked to a range of chronic diseases including cancers, cardiovascular problems or diabetes. They can also be highly toxic to the environment, poisoning rivers and other precious ecosystems[1]. The European regulation itself identifies them as the worst pesticides remaining on the EU market, i.e., the most hazardous pesticides which should be designated as such.

This report examines not just the extent of contamination of fruits and vegetables produced in the EU with these most toxic pesticides, but, for the first time, patterns of contamination over time. Researchers analysed the results of a Europe-wide programme of government sampling large enough to be considered representative of the exposure of the public. This revealed a dramatic upward trend of fruits contaminated with the most hazardous category of pesticides between 2011 and 2019, the latest year for which their data was available for this paper. While kiwi fruits were almost free (4%) of these most toxic substances in 2011, almost a third (32%) were contaminated in 2019. Likewise, half (50%) of all cherries sampled by officials were contaminated in 2019, compared to 22% in 2011. This increase in the frequency of contaminated fruits and vegetables sold to consumers goes hand in hand with an increase in the intensity of pesticides used in mixtures. While 6,4% of fruits were found to be contaminated with at least two of these most toxic pesticides in 2011, this figure has risen to 10,2% in 2019. Although scientists warn of growing evidence that such 'chemical cocktails' amplify human health impacts, such combinations are still not assessed by authorities, despite it is required by the law[2]. Finally, this report highlights the near omnipresence of these most toxic pesticides in certain cases. By 2019, 87% of the pears produced in Belgium were contaminated with at least one of them and 85% in Portugal. Likewise, 74% of cherries grown in Spain were affected, and 85% of celery from Italy.

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[1] *Annex II point 4 of Regulation (EC) No 1107/2009.*

[2] *Article 4(3)(b) of Regulation (EC) No. 1107/2009 and Article 14 of Regulation (EC) No. 396/2005.*

Executive summary

Under the 2020 EU Farm to Fork Strategy, the use of this category of most hazardous pesticides should be halved by 2030 in the EU. Based on sales, the European Commission already claims a 12% reduction in 2019 compared to 2015-2017. However, this report, which provides evidence of the quantity of pesticides that actually end up in food daily eaten by a large majority of European consumers, is a strong rebuttal to that claim: in 2019, the proportion of fruit and vegetables contaminated with the most hazardous pesticides increased by 8.8% compared to 2015-2017. This alternative methodology reveals that the use of the most dangerous pesticides in Europe is in fact rising, not falling. Laws are being ignored and consumers are being exposed to a rising tide of chemical exposure. Europe is clearly moving away, not towards more sustainable agriculture. While authorities content themselves with unreliable indicators of progress, the observable pesticide residues, their impact on human health and rapidly declining wildlife populations tell the real story.

The analysis starts in 2011 when the use of these most hazardous pesticides should by law have started to decrease significantly. Indeed, these most dangerous substances belong to a group called 'Candidates for Substitution', defined in Regulation (EC) No. 1107/2009. In view of the very high concern for human health and the environment, Member States have been legally obliged to substitute these 'Candidates for Substitution' in pesticides with safer alternatives, since 2011. This rule must have been applied whenever possible to ensure a gradual sectoral and geographical phase-out of these pesticides. By highlighting instead a spectacular upward trend of their residues over the 10 years, this report further confirms the complete failure of Member States to implement substitution due to a complete dismissal of viable alternatives, at the expense of consumer health and the environment.

The report shows that this failure to implement substitution has led to an increase in plant and insect resistance to these most hazardous pesticides, leading in turn to an increased use of these substances year after year rather than to their phase-out. Unless a firm commitment is taken to substitute these substances with safer alternatives, in line with sustainable Integrated Pest Management, their use will continue to rise (along with further biological resistance).

Therefore, this report raises the alarm and calls for strong political action to genuinely put the EU food system on the track to sustainability. Namely, it calls for substitution of 100% of the most hazardous pesticides by Member States by 2030, in the frame of the Farm-to-Fork, with the adoption of binding reduction targets at Member State level and the reform of pesticide use indicators.

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Introduction

In 2020, the European Commission proposed the first ever EU pesticide use reduction policy in the context of its Farm to Fork Strategy and its Biodiversity Strategy towards 2030. Both call for a 50% reduction in the use and risk of chemical pesticides (target 1) and a 50% reduction in the use of "more hazardous pesticides" (target 2). These are in fact the most hazardous forms of pesticides approved in the EU. In regulatory terms, the second target refers to: "*plant protection products containing active substances that meet the cut-off criteria as set out in points 3.6.2. to 3.6.5 and 3.8.2 of Annex II to Regulation (EC) No 1107/2009 or are identified as Candidates for Substitution in accordance with the criteria in point 4 of that Annex*[3]". In other words, this target refers to pesticides that should have already been banned or phased out by EU Member States, designated as "Candidates for Substitution".

Pursuant to Regulation (EC) No. 1107/2009 on the placing of plant protection products on the market, Candidates for Substitution is a specific category that brings together under a common regulatory framework all the most dangerous substances which narrowly passed the approval criteria. This includes substances having carcinogenic, reprotoxic, endocrine disrupting effects, meeting two out the three persistence, bioaccumulative and toxic (PBT) criteria[4]. According to Articles 24 and 50 of Regulation (EC) No. 1107/2009, these most hazardous substances have their approval more strictly controlled than others.

First, Candidates for Substitution can be approved for no more than 7 years, as opposed to up to 15 years for the other active substances. More importantly, since 2011 the use of the substances must be limited as much as possible through substitution by safer alternatives at national level. To this end, when an authorisation dossier for a pesticide product contains a Candidate for Substitution, the Member State concerned is legally obliged to perform a comparative assessment of this substance with existing alternatives. As soon as possible in light of the criteria set out in Annex IV of Regulation (EC) No. 1107/2009, substitution must take place, leading to a progressive loss authorised uses of these substances for more sustainable [substances or] practices in all agricultural sectors.

However, the European Commission concluded in 2019 that the substitution obligation has never been fulfilled by Member States, which have made no attempt to cut agricultural dependence or consumer exposure to these most hazardous pesticides. Since that time, no data on the use of these most hazardous pesticides or their substitution has been published. Instead, the Commission has relied solely on sales data to declare that "there was a 12% reduction in the use of more hazardous pesticides in the European Union in 2019 compared to the 2015-2017 baseline period", and that "this reduction in the use of more hazardous pesticides is in line with the target set under the Farm to Fork strategy".

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[3] *Farm to Fork targets - Progress (europa.eu).*

[4] *See the 7 criteria in Annex II point 4 of Regulation (EC) No. 1107/2009.*

Introduction

Objective

PAN Europe sought to query the Commission's assumption and determine whether the use of the most hazardous pesticides in the European Union had in reality decreased or not. Since statistics on pesticide use are not available due to poor data collection, PAN Europe examined residues of Candidates for Substitution found in fruits and vegetables produced in the EU between 2011 and 2019. Residues are, after all, the most concerning problem from a human health perspective and the best indicator of success or failure with the EU legal obligation to substitute the most dangerous pesticides to protect citizens' health and the environment.

Methodology

In February 2022, 56 Candidates for Substitution were still approved for use in pesticides (see Annex 1). PAN Europe extracted this list from the EU Pesticides database, to investigate whether Candidates for Substitution were detected in food products on the European market and how their presence had evolved over a nine-year period (2011-2019). Data on imported products was excluded to focus only on fruit and vegetables produced in the EU.

The food residue data was taken from the EU official monitoring data (EU Multiannual Control Programme) used to produce the European Food Safety Authority's (EFSA) annual reports, for the years 2011 up until 2019[5] only on the data from the most sampled and thus most popular fruits and vegetables (see Annex 2). According to EFSA, data collected under the EU MACP are "statistically representative enough to estimate the exposure of EU consumers to these residues"[6]. To preserve this representativeness, any risk-based sampling methods (Multiannual National Control Programmes), which explicitly target the most at-risk products for pesticide contamination, were excluded.

To accurately measure change over time, the analysis only included data on most popular products that have been sampled each year. The trend for all popular fruits combined has been weighted based on the average of the trends of all popular fruits. This way, fruits that have been sampled much more often than other fruits are not overrepresented in the trend for all fruits. The trend analysis for all popular vegetables has been conducted in a similar manner.

Only residues of Candidates for Substitution that were found with a concentration level above or equal to limit of detection (0.01 mg/kg)[7] were included in the trend analysis. Indeed, over the years, the detection limit of more and more pesticides has become lower than 0.01 mg/kg.

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5 *Data available on EFSA Knowledge junction.*

6 *See EU MACP explained.*

7 *This is considered the default detection limit for pesticides in Regulation (EC) No. 396/2005.*

Finally, since 2019, Member States have been required to report their monitoring data using the new Standard Sample Description (SSD version 2 or SSD2). This entails a more detailed classification of fruit and vegetables. For example, in SSD1 only "Current" was used for a variety of currents, but since 2019, these currents can be divided into "Blackcurrants", "Redcurrants" et cetera. This is the case for dozens of other varieties belonging to the same product group. Thus, to include the 2019 data in the trend analysis, the different kinds of products were grouped together again into their main product group, analogous to former years.

The following key indicators have been calculated for each specific food (category):

- Samples taken (n)
- % Samples with Candidates for Substitution
- Average Candidates for Substitution per sample (Avg)
- Sum of different Candidates for Substitution found per category (Sum)
- Maximum number of Candidates for Substitution found in one sample (Max)

Please note that the sampling and analysis of fruit and vegetable samples by officials may have been the object of some variations over the years. This means that the number of samples collected was not completely equal among types of fruits and vegetables, countries of origin and Member States, and that not all samples were screened for all Candidates for Substitution. However, the amount of data analysed over the years makes the present assessment and its conclusions the most representative analysis possible of real-world contamination rates.

Relevance: Candidates for Substitution

Candidates for Substitution is a category of substances which deserves particular attention. It encompasses active substances, which in view of their intrinsic properties, are the most harmful for human health and the environment approved in the EU. This category includes substances which are suspected of being toxic to reproduction (Cat. 2), carcinogenic to humans (Cat. 2), endocrine disrupting or that do not fully meet the criteria for being identified as Persistent, Bioaccumulative and Toxic (PBT) for the environment.

From a regulatory point of view, it means that the current hazard suspicions cannot trigger an automatic withdrawal[8], but that the concerns are solid enough to regulate them significantly more strictly until further scientific evidence is provided. Once these suspected toxic properties are confirmed, these substances no longer meet the criteria for approval set in Regulation (EC) No. 1107/2009 to remain on the European market. This has been observed several times already, including in the case of the insecticide Thiacloprid. In 2020, the renewal from the substances was precluded by its classification as toxic for reproduction 1B. Prior to this hazard classification and deriving non-renewal, the substance was classified as a Candidate for Substitution due to its endocrine disrupting properties. Likewise, the Candidates for Substitution Dimethoate, Isoproturon or Ethoprophos could simply not be proposed for renewal after re-assessment of their health and environment properties.

In this context, the approval of substances as Candidates for Substitution bodes well for their future withdrawal from the European market. This is all the more true since the EU committed under the European Green Deal to better protect European citizens and the environment.

Although these active substances have no future in the EU, the phase out process is slowed down in different ways:

1. No national substitution in plant protection products

While substitution at national level is the core principle, the REFIT evaluation revealed that candidates for substitution are in practice never substituted by safer existing alternatives in plant protection products. No substitution took place in 2015, in 2016, in 2017 and in 2018. National data on authorisations suggest that the situation has not changed positively since then.

[8] *For instance, a substance classified carcinogen Cat 1 or meet the three PBT criteria cannot be approved. All "cut off" criteria are listed in Annex II points 3.6.2 to 3.6.5, point 3.7 and point 3.8.2.*

2. Prolongations of EU approval

Candidates for Substitution are the subject of continuous extensions of their approvals beyond the 7-year period set by Article 24(1) of Regulation (EC) No. 1107/2009. In some cases, this continuous extension 'by package' of Candidates for Substitution lead to a doubling of the approval period allowed pending the finalisation of their assessment:

- The fungicide Ziram was approved in 2004. Although there is strong scientific evidence of its endocrine disrupting and neurotoxic properties, its current approval period was extended 7 times over the years (i.e. for 7 years).
- The insecticide Pirimicarb was approved in 2007 but 6 times prolonged (i.e. for 6 years). It is suspected of being carcinogenic to humans (Cat. 2).
- The fungicide Metconazole was approved in 2007 but 6 times prolonged (i.e. for 6 years). It is suspected of being toxic for reproduction to humans (Cat. 2).

See more examples on the PAN Europe CfS Database.

[9] *See latest Commission Implementing Regulation (EU) 2022/378 of 4 March 2022 amending Implementing Regulation (EU) No 540/2011 as regards the extension of the approval periods of [...] Metconazole, Pirimicarb, Ziram.*

Upward trend of Candidates for Substitution residues in fruits and vegetables produced in Europe from 2011 to 2019

All popular fruits and vegetables

Figure 1 shows that, overall, there has been a continuous upward trend in the residues of Candidates for Substitution in popular fruits and vegetables produced in Europe. Starting with a contamination rate of 14% in 2011, this increased by 7percentage points to 21% in 2019.

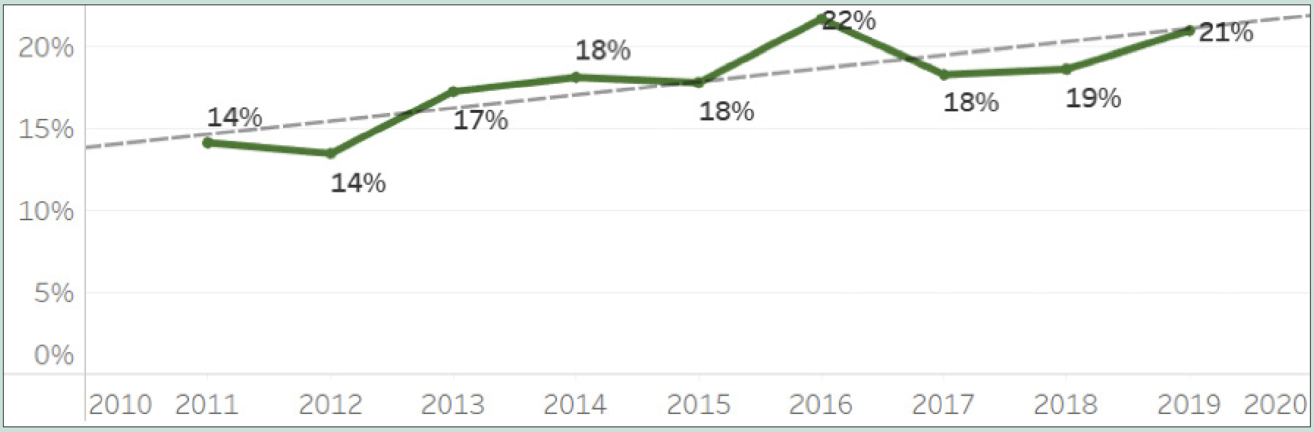


Figure 1. *Increase of the % of fruits and vegetables contaminated with Candidates for Substitution*

In 2019, the EU has started to monitor progress towards achieving the 50% reduction targets by 2030, building on a 2015-2017 baseline. Figure 1 shows +8.8% increase in the proportion of fruits and vegetables contaminated with the most hazardous pesticides in 2019, compared to 2015-2017.

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

All popular fruits

In total, 97,170 fruit samples were included in the trend analysis for the years 2011-2019. Figure 2 shows that, overall, there has been a noticeable upward trend in the residues of Candidates for Substitution in popular fruits produced in Europe. Starting with a contamination rate of 18% in 2011, this increased by 11 percentage points to 29% in 2019.

On average, the trendline indicates an increase of contamination of +53%[10] in 9 years (Figure 2).

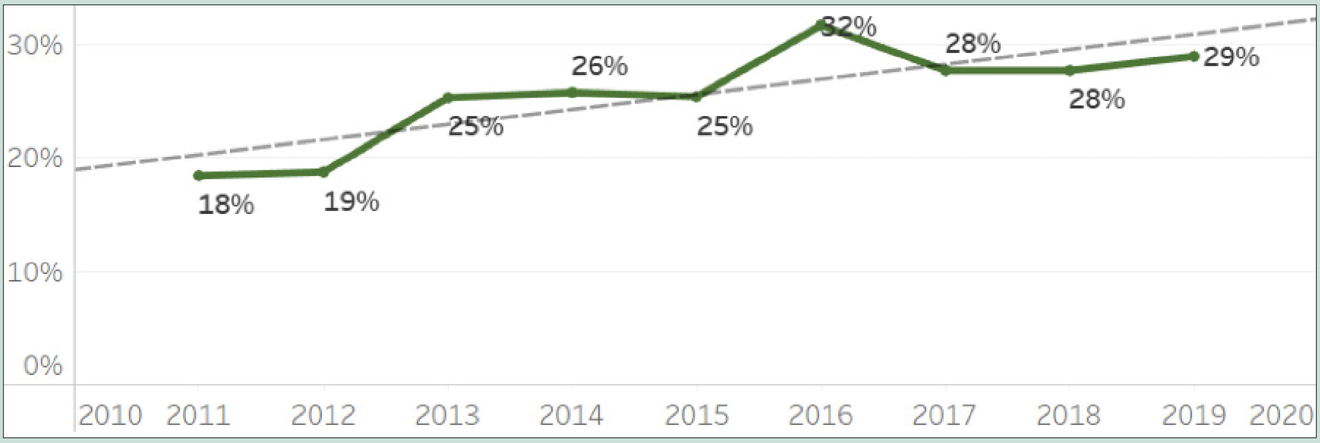


Figure 2. *Increase of the % of fruits contaminated with Candidates for Substitution*

Some fruits with a spectacular increasing trend of Candidates for Substitution contamination include kiwi fruits, cherries, apples, pears and peaches, each of which will be highlighted in the following pages.

[10] *Percentage based on the trendline.*

Kiwi fruit

Trend

Between 2011 and 2019, in total, 3,673 samples of kiwi fruit were tested for pesticides. Starting in 2011, only 4% of the kiwi fruit had Candidates for Substitution, but this increased steadily to 32% in 2019. According to the trendline, there was a fourfold increase (+397%) in the level of contamination with Candidates for Substitution (Figure 3).

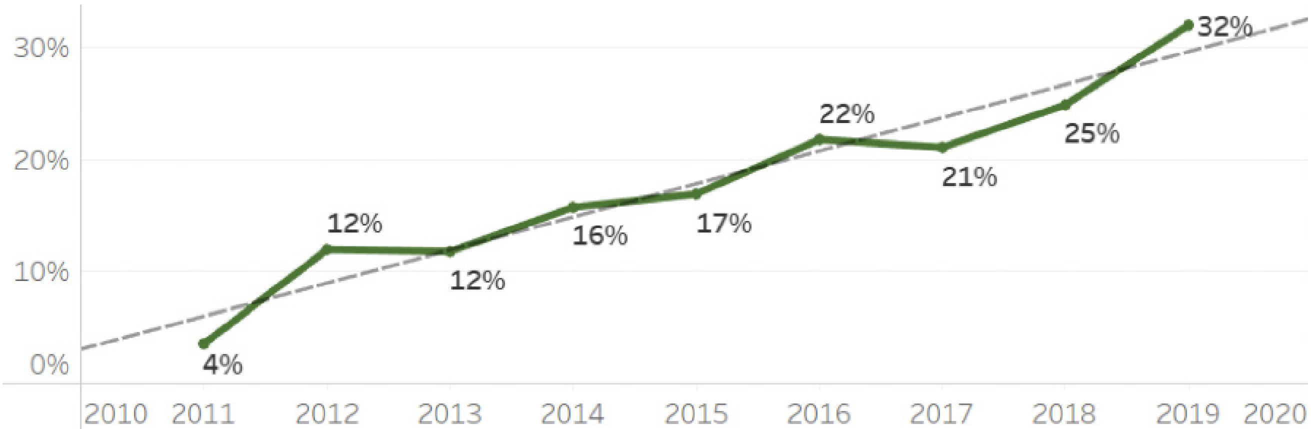


Figure 3. *Increase in the % of kiwi fruits contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 5 different Candidates for Substitution were found in 331 samples of kiwi fruit. Most prevalent were fludioxonil and etofenprox (Figure 4).

No.	CfS Pesticide	
1	Fludioxonil	76
2	Etofenprox	54
3	Tebuconazole	3
4	Cypermethrin	2
5	Cyprodinil	1
Grand Total		106

Figure 4. *Candidates for Substitution found in kiwi fruit in 2019*

Fludioxonil

Fludioxonil is a broad-spectrum fungicide authorised in all 27 EU Member States. Human health concerns include liver and kidney damages. Endocrine disrupting effects are suspected but comprehensive data is lacking. Despite this uncertainty for consumers, 176 Maximum Residue Limits (MRLs) above the Level of detection (LOD) of 0.01 mg/kg are established, ranging from 0.02mg/kg to 40.00 mg/kg per product.

Fludioxonil was classified as a Candidate for Substitution, because it meets two of three criteria of Persistence, Bioaccumulation and Toxicity (PBT). It has long lasting impacts on the soil, water, and the wider environments. It poses high risks for fish and aquatic invertebrates. Independent studies further found that the substance holds lethal and teratogenic toxicity for amphibians.

More information and sources are available on PAN Europe's PAN Europe's database.

Member States of origin

In 2019, Member States producing kiwi fruit with the highest level of Candidates for Substitution contamination were Greece and Italy (Figure 5).

No.	Country of orig..	n	Avg	Sum	Max	
1	Greece	115	0.50	5	2	41% (47)
2	Italy	193	0.39	4	2	30% (58)
3	Spain	21	0.00	0	0	0% (0)
Grand Total						32% (105)

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 5. *Countries of origin with the highest contamination of Candidates for Substitution in kiwi fruit*

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

Cherries

Trend

4,240 cherries were sampled between 2011 and 2019. In 2011, 22% of the cherries were contaminated with one or more Candidates for Substitution. In the next nine years, the level of contamination increased to 50% in 2019. The identified trend shows an increase of contamination with Candidates for Substitution of +152% (Figure 6).

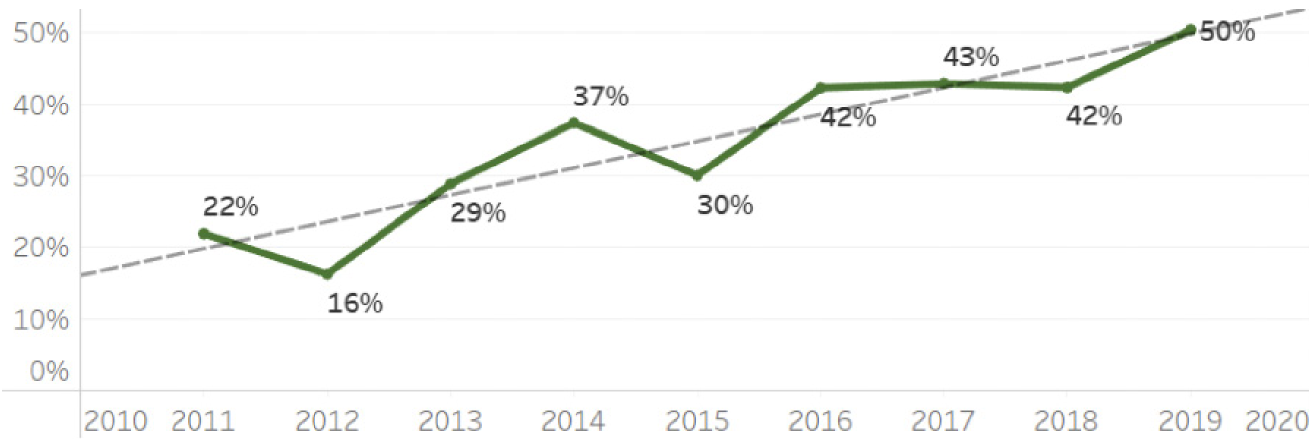


Figure 6. *Increase of the % of cherries contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 10 different Candidates for Substitution were found in 468 samples of cherries. Most notable are fludioxonil, tebuconazole, fludioxonil, lambda cyhalothrin and cyprodinil (Figure 7).

No.	CfS Pesticide	
1	Tebuconazole	152
2	Fludioxonil	66
3	Lambda Cyhalothrin	39
4	Cyprodinil	29
5	Etofenprox	15
6	Pirimicarb	15
7	Difenoconazole	7
8	Cypermethrin	3
9	Fluopicolide	1
10	Metalaxyl	1
Grand Total		238

Figure 7. *Candidates for Substitution found in cherries in 2019*

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

Tebuconazole

Tebuconazole is a fungicide authorised in all 27 EU Member States.

Tebuconazole raises serious health concerns. It is classified as Toxic to Reproduction Cat.2, as the fungicide is likely to harm foetal development, connected to malformations and pregnancy loss. For example, scientists reported decreased testosterone levels in tested male foetuses. In 2015, the EU Joint Research Centre identified the substance as an endocrine disrupting pesticide for which no safe level of exposure exists. Still, 172 Maximum Residue Limits (MRLs) above the Level of detection (LOD) of 0.01 mg/kg are established, ranging from 0.05mg/kg to 40.00 mg/kg per product.

Tebuconazole is also of major environmental concern. It meets two of the Persistence, Bioaccumulation and Toxicity (PBT) criteria and is classified as acute and chronically very toxic to aquatic life with long lasting effects.

More information and sources are available on PAN Europe's PAN Europe's database.

Member States of origin

Member States which produced cherries with the highest level of Candidates for Substitution contamination in 2019 were Spain, Greece, France, Italy and Hungary (Figure 8).

No.	Country of orig..	n	Avg	Sum	Max	
1	Spain	70	1.13	6	5	74% (52)
2	Greece	86	0.85	6	3	64% (55)
3	France	51	0.94	5	3	63% (32)
4	Italy	105	0.71	10	4	53% (56)
5	Hungary	24	0.54	3	2	50% (12)
6	Romania	44	0.30	3	2	25% (11)
7	Poland	52	0.13	2	1	13% (7)
Grand Total						52% (225)

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 8. *Countries of origin with the highest contamination of Candidates for Substitution in cherries*

Some cherries grown in Spain contain as many as 5 different Candidates for Substitution.

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

Apples

Trend

17,280 apples were sampled between 2011 and 2019. In 2011, 16% of the apples were contaminated with one or more Candidates for Substitution. In a period of nine years, this increased to 34% in 2019. The trendline shows more than a doubling (+117%) of the contamination with Candidates for Substitution (Figure 9).

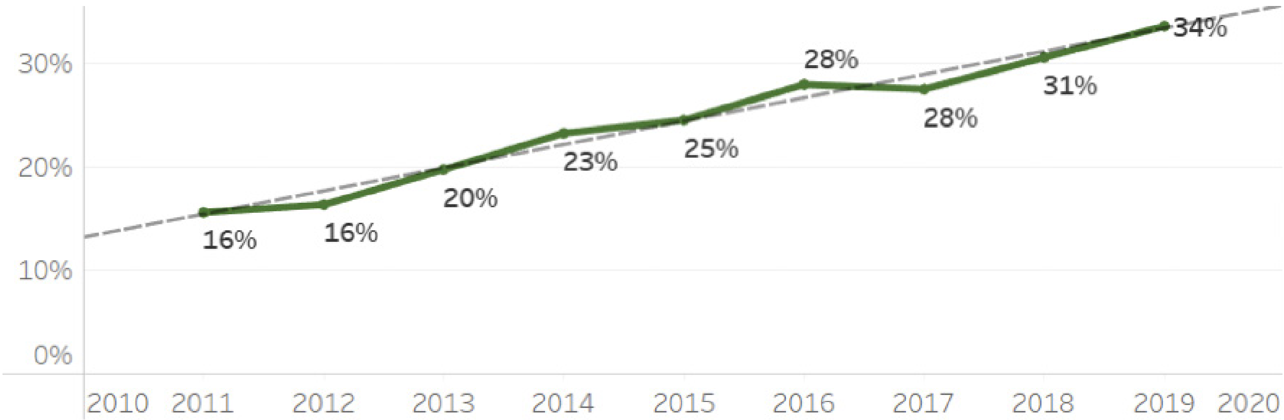


Figure 9. *Increase of the % of apples contaminated with Candidates for Substitution*

According to Eurostat, apples were the main fruit produced in the EU over the past few years, both in terms of output value (about one fifth of overall fruit production) and volume of harvested production (29% of total fruit production).

Candidates for Substitution found

As of 2019, in 2,103 samples of apples, 13 different Candidates for Substitution were found. Most notable are fludioxonil[11], methoxyfenozide, pirimicarb, tebuconazole, etofenprox and cyprodinil (Figure 10).

No.	CfS Pesticide	
1	Fludioxonil	387
2	Methoxyfenozide	111
3	Pirimicarb	108
4	Tebuconazole	107
5	Etofenprox	101
6	Cyprodinil	97
7	Difenoconazole	57
8	Lambda Cyhalothrin	23
9	Cypermethrin	19
10	Tebufenpyrad	15
11	Isopyrazam	1
12	Metalaxyl	1
13	Paclobutrazole	1
Grand Total		741

Figure 10. *Candidates for Substitution found in apples in 2019*

[11] *More information on fludioxonil can be found on the textbox p. 15; on tebuconazole p. 17.*

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

Member States of origin

Member States which produced cherries with the highest level of Candidates for Substitution contamination in 2019 were Spain, Greece, France, Italy and Hungary (Figure 8).

No.	Country of orig..	n	Sum	Max	Avg	
1	Netherlands	33	5	4	1.06	61% (20)
2	Portugal	24	6	2	0.67	58% (14)
3	Slovenia	27	6	3	0.85	56% (15)
4	Belgium	19	5	2	0.74	53% (10)
5	Austria	23	3	2	0.57	52% (12)
6	France	153	7	2	0.55	50% (77)
7	Croatia	14	3	2	0.50	43% (6)
8	Poland	198	9	3	0.58	42% (83)
9	Slovakia	12	3	2	0.58	42% (5)
10	Czechia	20	5	3	0.65	40% (8)
11	Greece	120	8	6	0.58	39% (47)
12	Germany	227	6	4	0.49	34% (78)
13	Hungary	104	6	3	0.43	34% (35)
14	Italy	694	10	4	0.41	32% (221)
15	Spain	92	9	3	0.41	28% (26)
16	United Kingdom	36	4	3	0.33	28% (10)
17	Ukraine	12	5	4	0.75	25% (3)
18	Finland	12	2	2	0.33	17% (2)
19	Romania	164	7	3	0.19	16% (26)
20	Denmark	26	1	1	0.08	8% (2)
21	Latvia	13	0	0	0.00	0% (0)
22	Norway	26	0	0	0.00	0% (0)
23	Sweden	20	0	0	0.00	0% (0)
Grand Total						34% (700)

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 11. *Countries of origin with the highest contamination of Candidates for Substitution in apples*

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

Pears

Trend

Between 2011 and 2019, 9,409 pears were tested for pesticides. In 2011, 25% of the pears were contaminated with one or more Candidates for Substitution. Contamination increased to 47% in 2019. Based on the trendline, there has been a doubling (+103%) of contamination with Candidates for Substitution (Figure 12).

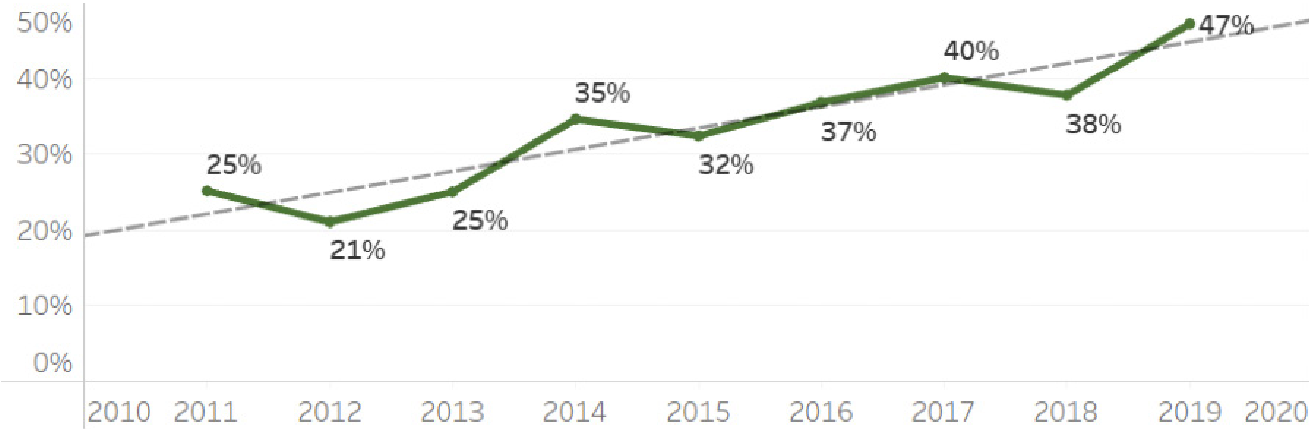


Figure 12. *Increase of the % of pears contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 12 different Candidates for Substitution were found in 670 samples of pears. Most prevalent were fludioxonil, tebuconazole, cyprodinil, etofenprox and difenoconazole[12] (Figure 13).

No.	CfS Pesticide	
1	Fludioxonil	166
2	Tebuconazole	98
3	Cyprodinil	77
4	Etofenprox	50
5	Difenoconazole	31
6	Lambda Cyhalothrin	10
7	Methoxyfenozide	8
8	Paclobutrazole	4
9	Cypermethrin	3
10	Pirimicarb	2
11	Tebufenpyrad	2
12	Metribuzin	1
Grand Total		319

Figure 13. *Candidates for Substitution found in pears in 2019*

[12] *More information on these substances is available in textboxes: on fludioxonil p. 15; on tebuconazole p. 17; on cyprodinil p. 29.*

Member States of origin

In 2019, Member States which produced pears with the highest level of Candidates for Substitution contamination are Belgium, Portugal, The Netherlands, Greece and Italy (Figure 14).

No.	Country of orig..	n	Avg	Sum	Max	
1	Belgium	23	1.39	3	3	87% (20)
2	Portugal	27	1.37	4	3	85% (23)
3	Netherlands	115	0.99	4	2	69% (79)
4	Greece	83	0.60	9	3	53% (44)
5	Italy	230	0.65	9	4	43% (100)
6	Poland	36	0.47	5	2	42% (15)
7	Spain	53	0.55	6	2	38% (20)
8	Denmark	19	0.16	2	1	16% (3)
9	Hungary	34	0.15	4	1	15% (5)
10	Romania	28	0.11	2	1	11% (3)
Grand Total						**48% (312)**

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 14. *Countries of origin with the highest contamination of Candidates for Substitution in pears*

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

Peaches

Trend

Between 2011 and 2019, in total, 9,325 peaches were tested for pesticides. In 2011, 30% of peaches were found with one or more Candidates for Substitution. Contamination increased to 46% in 2019. The trend line indicates an increase of Candidates for Substitution contamination of +52% (Figure 15).

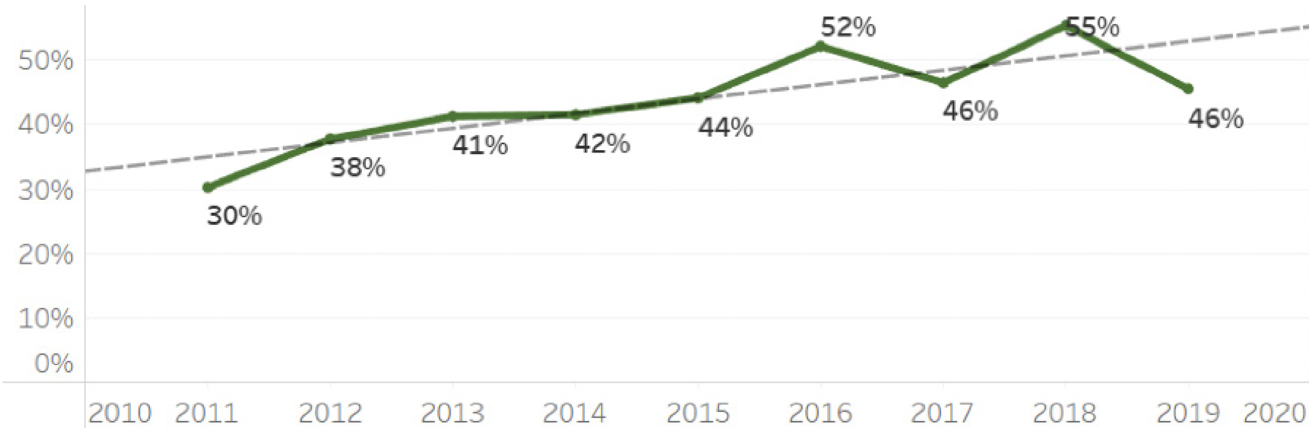


Figure 15. *Increase of the % of peaches contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 13 different Candidates for Substitution were found in 1,584 samples of peaches. Most prevalent were tebuconazole, fludioxonil, etofenprox and cyprodinil[13] (Figure 16).

No.	CfS Pesticide	
1	Tebuconazole	383
2	Fludioxonil	239
3	Etofenprox	214
4	Cyprodinil	119
5	Difenoconazole	66
6	Lambda Cyhalothrin	61
7	Cypermethrin	35
8	Methoxyfenozide	22
9	Pirimicarb	5
10	Etoxazole	4
11	Pendimethalin	4
12	Tebufenpyrad	3
13	Emamectin (benzoate)	2
Grand Total		738

Figure 16. *Candidates for Substitution found in peaches in 2019*

[13] *More information on these substances is available in textboxes: on fludioxonil p. 15; on tebuconazole p. 17; on cyprodinil p. 29.*

Upward trend of Candidates for Substitution residues in fruits produced in Europe from 2011 to 2019

Member States of origin

In 2019, Member States producing peaches with the highest level of Candidates for Substitution contamination were France, Italy and Greece (Figure 17).

No.	Country of orig..	n	Avg	Sum	Max	
1	France	48	1.15	8	4	58% (28)
2	Italy	587	0.88	11	5	55% (324)
3	Greece	152	0.91	7	4	55% (83)
4	Cyprus	17	0.53	3	2	41% (7)
5	Spain	676	0.51	8	4	37% (249)
6	Hungary	47	0.26	4	2	21% (10)
7	Romania	20	0.30	3	3	20% (4)
Grand Total						**46% (705)**

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 17. *Countries of origin with the highest contamination of Candidates for Substitution in peaches*

Upward trend of Candidates for Substitution in vegetables produced in Europe from 2011 to 2019

All popular vegetables

A total of 113,431 vegetable samples were included in the analysis. 11% of the samples contained Candidates for Substitution, while 31 different Candidates for Substitution were detected. Figure 17 shows that, overall, there has been a small upward trend in the residues of Candidates for Substitution in popular vegetables produced in Europe, from 11% in 2011 up to 13% in 2019: a relative increase of +19% (Figure 18).

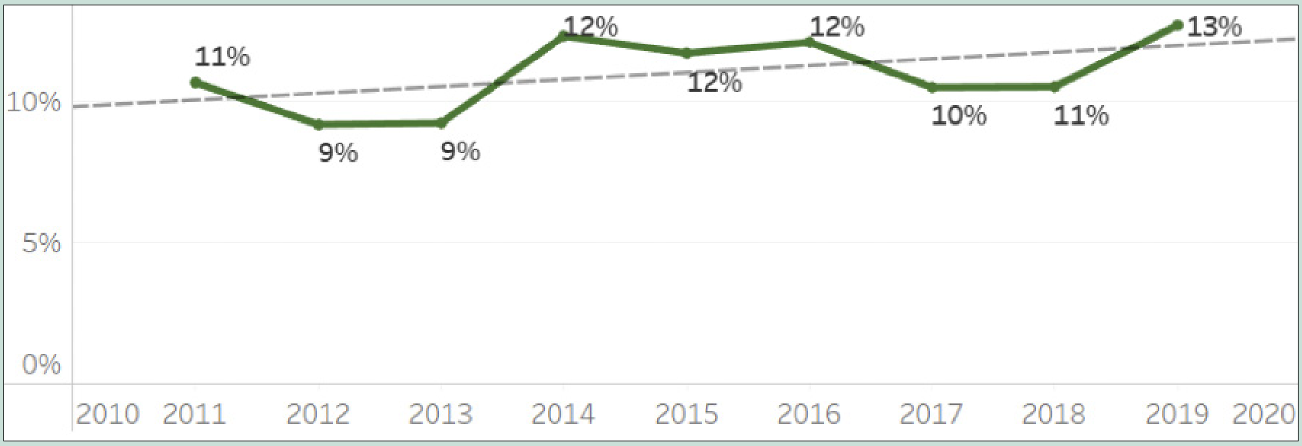


Figure 18. *Increase in the % of vegetables contaminated with Candidates for Substitution*

Although this is a small increase, some vegetables do show a notable increasing trend of contamination with Candidates for Substitution, especially celery, cucumbers, spinach and lettuce. These products will be examined more closely in the next paragraphs.

Upward trend of Candidates for Substitution in vegetables produced in Europe from 2011 to 2019

Celery

Trend

Between 2011 and 2019, in total, 9,325 peaches were tested for pesticides. In 2011, 30% of peaches were found with one or more Candidates for Substitution. Contamination increased to 46% in 2019. The trend line indicates an increase of Candidates for Substitution contamination of +52% (Figure 15).

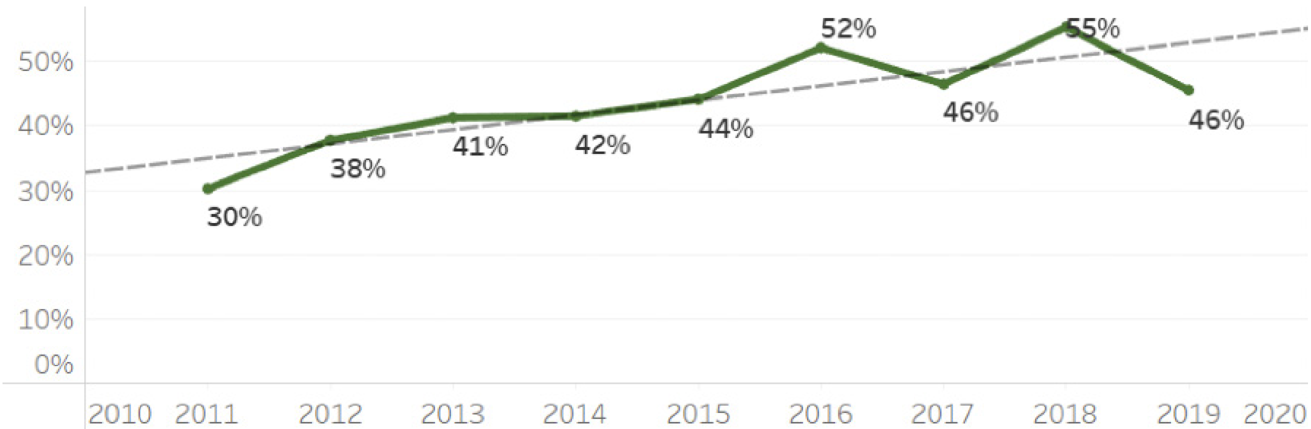


Figure 19. *Increase of the % of celeries contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 7 different Candidates for Substitution were found in 100 samples of celery. Most notable is difenoconazole (Figure 20).

No.	CfS Pesticide	
1	Difenoconazole	55
2	Lambda Cyhalothrin	9
3	Pendimethalin	9
4	Cyprodinil	3
5	Cypermethrin	2
6	Tebuconazole	2
7	Metalaxyl	1
Grand Total		59

Figure 20. *Candidates for Substitution found in celeries in 2019*

[13] *More information on these substances is available in textboxes: on fludioxonil p. 15; on tebuconazole p. 17; on cyprodinil p. 29.*

Difenoconazole

Difenoconazole is used in broad-spectrum fungicides authorised in all 27 EU Member States.

Health concerns have been highlighted by various independent studies, showing endocrine activity, developmental effects (e.g., malformations), and cardiovascular toxicity. However, comprehensive data is lacking to truly evaluate the chronic health effects. Despite this uncertainty for consumers, 264 Maximum Residue Limits (MRLs) above the Level of Detection (LOD) of 0.01 mg/kg are established, ranging from 2.00mg/kg to 20.00 mg/kg.

Difenoconazole was classified as a Candidate for Substitution, meeting two of three criteria of Persistence, Bioaccumulation and Toxicity (PBT). Its persistent metabolites in soil and water have lasting harmful impacts on the environment.

More information and sources are available on PAN Europe's PAN Europe's database.

Member States of origin

The Member States which produced celery with the highest level of Candidates for Substitution contamination in 2019 were Italy and Spain (Figure 21).

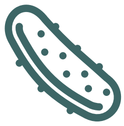
No.	Country of orig..	n	Avg	Sum	Max	
1	Italy	41	1.24	6	4	85% (35)
2	Spain	27	0.48	2	2	44% (12)
Grand Total						69% (47)

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 21. *Countries of origin with the highest contamination of Candidates for Substitution in celeries*

Upward trend of Candidates for Substitution in vegetables produced in Europe from 2011 to 2019

Cucumbers



Trend

Between 2011 and 2019, a total of 8,370 cucumbers were sampled. In 2011, 13% of cucumbers were found with one or more Candidates for Substitution. This contamination increased to 16% in 2019. The trend line indicates an increase of Candidates for Substitution contamination of +59% (Figure 22).

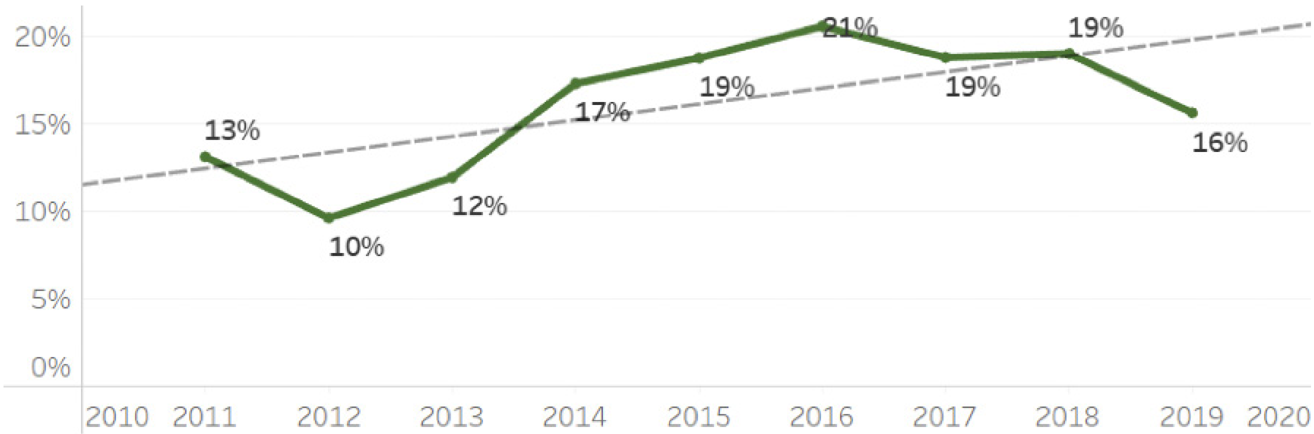


Figure 22. *Increase of the % of cucumbers contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 9 different Candidates for Substitution were found in 633 samples of cucumbers. Most prevalent were cyprodinil, metalaxyl, fluopicolide and fludioxonil (FIgure 23).

No.	CfS Pesticide	
1	Cyprodinil	39
2	Metalaxyl	38
3	Fluopicolide	31
4	Fludioxonil	14
5	Difenoconazole	5
6	Lambda Cyhalothrin	4
7	Cypermethrin	1
8	Isopyrazam	1
9	Tebuconazole	1
Grand Total		106

Figure 23. *Candidates for Substitution found in cucumbers in 2019*

Cyprodinil

Cyprodinil is used in fungicides authorised in all 27 EU Member States.

Cyprodinil poses risk to human health, demonstrated as liver toxic, impacting reproductive and developmental processes. It has long been suspected to be an endocrine disruptor due to strong evidence that it disrupts human thyroid function.

135 Maximum Residue Limits (MRLs) are set above the Level of detection (LOD) of 0.01 mg/kg, ranging from 0.02mg/kg to 40.00 mg/kg per product.

Cyprodinil also has harmful effects on the environment. It meets two of the Persistence, Bioaccumulation and Toxicity (PBT) criteria, especially raising concerns for its persistent metabolites. It is classified as acute and chronically very toxic to aquatic life with long lasting effects. It was shown as toxic to birds, most aquatic life and earthworms.

More information and sources are available on PAN Europe's PAN Europe's database.

Member States of origin

In 2019, Member States producing cucumbers with the highest level of Candidates for Substitution contamination were Hungary, Greece, Spain and Poland (Figure 24).

No.	Country of orig..	n	Avg	Sum	Max	
1	Hungary	81	0.36	5	2	32% (26)
2	Greece	123	0.20	4	2	19% (23)
3	Spain	143	0.26	6	3	18% (26)
4	Poland	45	0.27	5	3	18% (8)
5	Netherlands	49	0.14	2	2	10% (5)
6	Denmark	25	0.08	1	1	8% (2)
7	Italy	62	0.06	2	1	6% (4)
8	Romania	22	0.09	2	2	5% (1)
9	Norway	23	0.04	1	1	4% (1)
10	Sweden	21	0.00	0	0	0% (0)
Grand Total						**16% (96)**

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 24. *Countries of origin with the highest contamination of Candidates for Substitution in cucumbers*

Upward trend of Candidates for Substitution in vegetables produced in Europe from 2011 to 2019

Spinach

Trend

Between 2011 and 2019, a total of 5,514 samples of spinach were tested for pesticides. Starting in 2011, 12% of the spinach had Candidates for Substitution, but this increased to 19% in 2019. This represents an increase of +59% in the level of contamination with Candidates for Substitution (Figure 25).

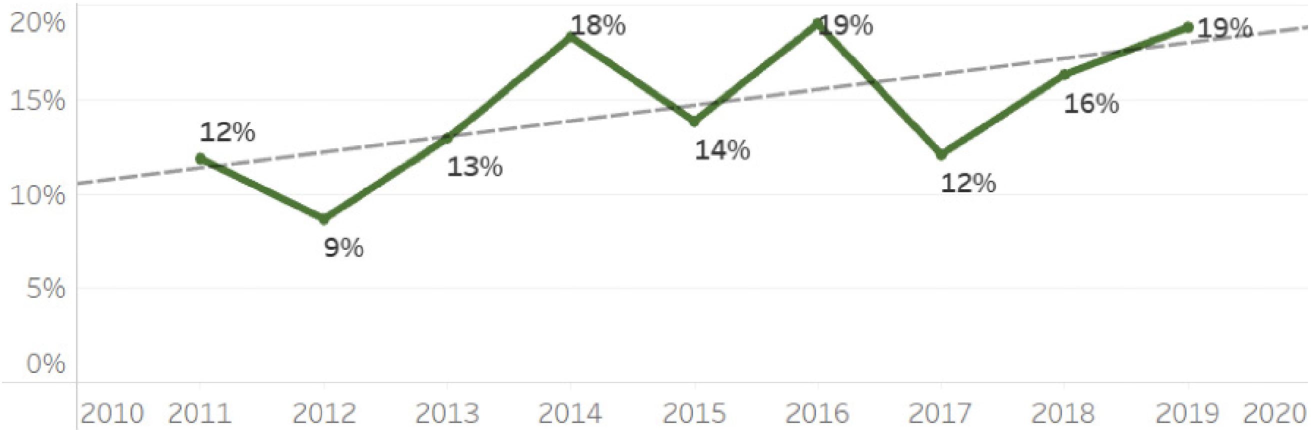


Figure 25. *Increase in the % of spinach contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 16 different Candidates for Substitution were found in 1,119 samples of spinach. Most prevalent were lambda cyhalothrin and fluopicolide (Figure 26).

No.	CfS Pesticide	
1	Lambda Cyhalothrin	130
2	Fluopicolide	65
3	Cypermethrin	19
4	Fludioxonil	16
5	Lenacil	12
6	Cyprodinil	6
7	Etofenprox	5
8	Methoxyfenozide	4
9	Difenoconazole	3
10	Metalaxyl	3
11	Pendimethalin	3
12	Tebuconazole	3
13	Aclonifen	2
14	Metribuzin	2
15	Pirimicarb	1
16	Propyzamide (aka pronamide)	1
Grand Total		224

Figure 26. *Candidates for Substitution found in spinach in 2019*

Lambda cyhalothrin

This quick-acting, pyrethroid insecticide is authorised in all 27 EU Member States.

Lambda cyhalothrin is considered acutely highly toxic. It can have short term effects, such as salivation, incoordination, postural abnormalities, hyperexcitability, or tremors. It is further highly neurotoxic. Bystanders are advised to keep at least a ten-metre distance to its spraying. Independent studies have further described interactions of lambda cyhalothrin with immune systems, endocrine disruption, and reproductive toxicity among other health impacts.

While the Acceptable Daily Intake (ADI) and the Acceptable Operator Exposure Level (AOEL) are set relatively lower compared to other active substances, 195 Maximum Residue Limits (MRLs) are set above the Level of Detection (LOD) of 0.01 mg/kg, ranging from 0.002mg/kg to 10.00 mg/kg per product.

The insecticide further raises strong concerns regarding its environmental fate and ecotoxicity. Lambda cyhalothrin is classified as acute and chronically very toxic to aquatic life with long lasting effects. It is also moderately toxic to earthworms. Despite these risks, data is lacking to assess bioaccumulation in aquatic and terrestrial food chains.

More information and sources are available on PAN Europe's PAN Europe's database.

Member States of origin

In 2019, Member States producing spinach with the highest level of Candidates for Substitution contamination are France, Spain, The Netherlands, Poland and Romania (Figure 27).

No.	Country of orig..	n	Avg	Sum	Max	
1	France	67	0.49	6	2	39% (26)
2	Spain	141	0.50	7	5	36% (51)
3	Netherlands	47	0.34	2	2	28% (13)
4	Poland	34	0.29	3	2	26% (9)
5	Romania	31	0.29	4	2	26% (8)
6	United Kingdom	58	0.22	5	2	19% (11)
7	Austria	50	0.22	4	2	18% (9)
8	Belgium	39	0.21	2	2	18% (7)
9	Germany	122	0.18	3	2	17% (21)
10	Italy	301	0.14	11	2	12% (37)
11	Czechia	10	0.10	1	1	10% (1)
12	Greece	79	0.09	3	2	8% (6)
13	Cyprus	27	0.07	2	1	7% (2)
14	Bulgaria	18	0.06	1	1	6% (1)
15	Portugal	22	0.05	1	1	5% (1)
16	Latvia	12	0.00	0	0	0% (0)
Grand Total						**19% (203)**

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 27. *Countries of origin with the highest contamination of Candidates for Substitution in spinaches*

Upward trend of Candidates for Substitution in vegetables produced in Europe from 2011 to 2019

Lettuce

Trend

Between 2011 and 2019, 13,420 lettuces were tested for pesticides. In 2011, 18% of the lettuce samples were contaminated with one or more Candidates for Substitution. This contamination has increased to 24% in 2019. Based on the trendline, there has been an increase of +19% of the contamination with Candidates for Substitution (Figure 28).

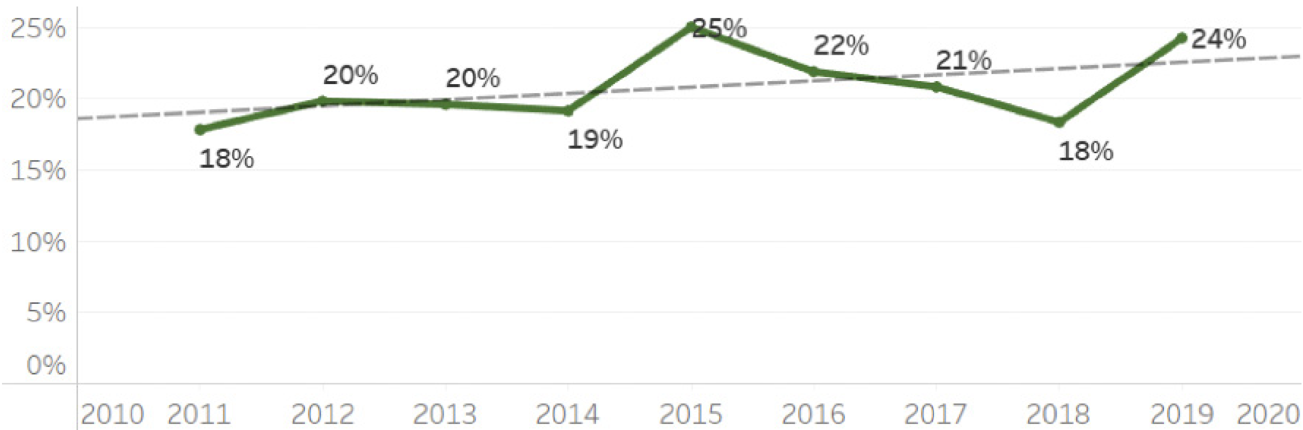


Figure 28. *Increase of the % of lettuce contaminated with Candidates for Substitution*

Candidates for Substitution found

In 2019, 15 different Candidates for Substitution were found in 1,660 samples of lettuce samples. Most prevalent were cyprodinil, fludioxonil, fluopicolide, metalaxyl en lambda cyhalothrin (FIgure 29).

No.	CfS Pesticide	
1	Cyprodinil	165
2	Fludioxonil	135
3	Fluopicolide	78
4	Metalaxyl	58
5	Lambda Cyhalothrin	49
6	Cypermethrin	42
7	Difenoconazole	39
8	Propyzamide (aka pronamide)	37
9	Pendimethalin	24
10	Pirimicarb	16
11	Etofenprox	8
12	Emamectin (benzoate)	7
13	Tebuconazole	7
14	Metribuzin	2
15	Lenacil	1
Grand Total		427

Figure 29. *Candidates for Substitution found in lettuce in 2019*

[14] *More information on these substances is available in textboxes: cyprodinil p. 22, fludioxonil p. 12.*

Upward trend of Candidates for Substitution in vegetables produced in Europe from 2011 to 2019

Countries of origin

In 2019, Member States which produced lettuces with the highest level of Candidates for Substitution contamination were Romania, Belgium, Hungary, Italy and France (Figure 30).

No.	Country of orig..	n	Avg	Sum	Max	
1	Romania	59	0.92	8	5	51% (30)
2	Belgium	46	0.48	7	2	39% (18)
3	Hungary	98	0.67	6	5	38% (37)
4	Italy	332	0.61	13	4	34% (113)
5	France	144	0.58	9	4	33% (48)
6	Croatia	16	0.81	5	4	31% (5)
7	Poland	40	0.43	8	3	30% (12)
8	Portugal	28	0.25	4	1	25% (7)
9	Norway	22	0.23	3	1	23% (5)
10	Greece	90	0.26	6	2	21% (19)
11	Spain	293	0.24	10	3	18% (54)
12	Slovenia	36	0.31	3	2	17% (6)
13	Cyprus	33	0.18	4	2	15% (5)
14	Austria	27	0.15	3	1	15% (4)
15	Bulgaria	16	0.13	2	1	13% (2)
16	Germany	183	0.14	7	3	12% (22)
17	Czechia	17	0.18	3	2	12% (2)
18	United Kingdom	46	0.13	3	2	11% (5)
19	Denmark	21	0.10	1	1	10% (2)
20	Netherlands	57	0.14	4	3	9% (5)
21	Estonia	12	0.00	0	0	0% (0)
22	Latvia	12	0.00	0	0	0% (0)
23	Sweden	17	0.00	0	0	0% (0)
Grand Total						**24% (401)**

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 30. *Countries of origin with the highest contamination of Candidates for Substitution in lettuces*

Combitox trend of Candidates for Substitution between 2011 and 2019

This section reveals that European consumers are increasingly exposed to combinations of the most hazardous pesticides in their fruit and vegetables (Figures 31 and 32).

Fruits

While 6,4% of fruits were found to be contaminated with at least two of these most toxic pesticides in 2011, this figure has risen to 10,2% in 2019. In 2019, over a third (10,21%) of contaminated fruits contained a cocktail (at least two) of the most dangerous pesticides. The most frequent mixture is the combination of two Candidates for Substitution (Figure 31).

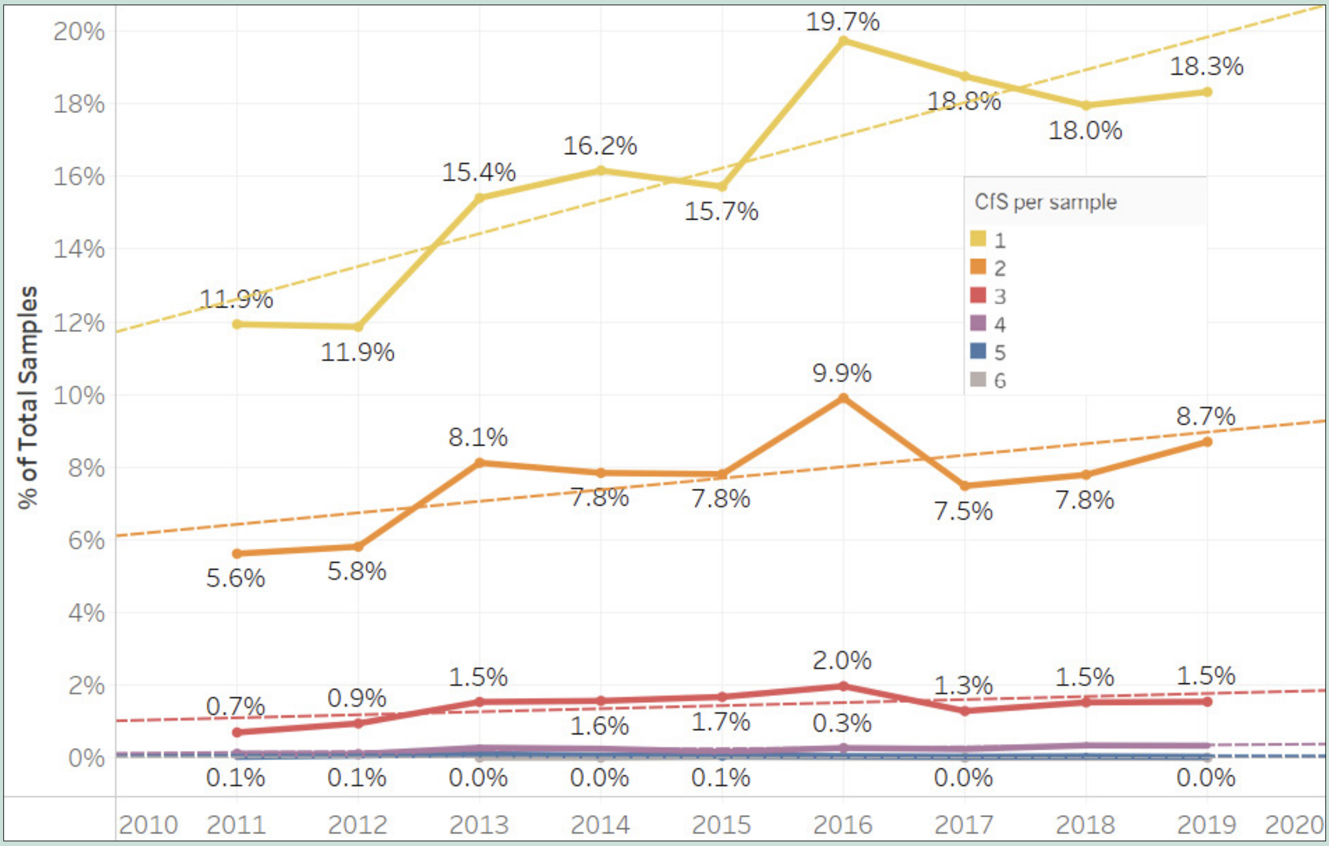


Figure 31. *Percentage of fruits contaminated with 1 (yellow) to 6 (grey) Candidates for Substitution between 2011 and 2019*

Upward trend of Candidates for Substitution in vegetables produced in Europe from 2011 to 2019

Vegetables

The results for vegetables are less significant than for fruits but are proportional to the level of contamination of vegetables (Figure 18), which is also lower than for fruits (Figure 2).

While 2.2% of vegetables were found to be contaminated with at least two of these most toxic pesticides in 2011, this figure has risen to 3,1% in 2019. The most frequent mixture is the combination of two Candidates for Substitution (Figure 32).

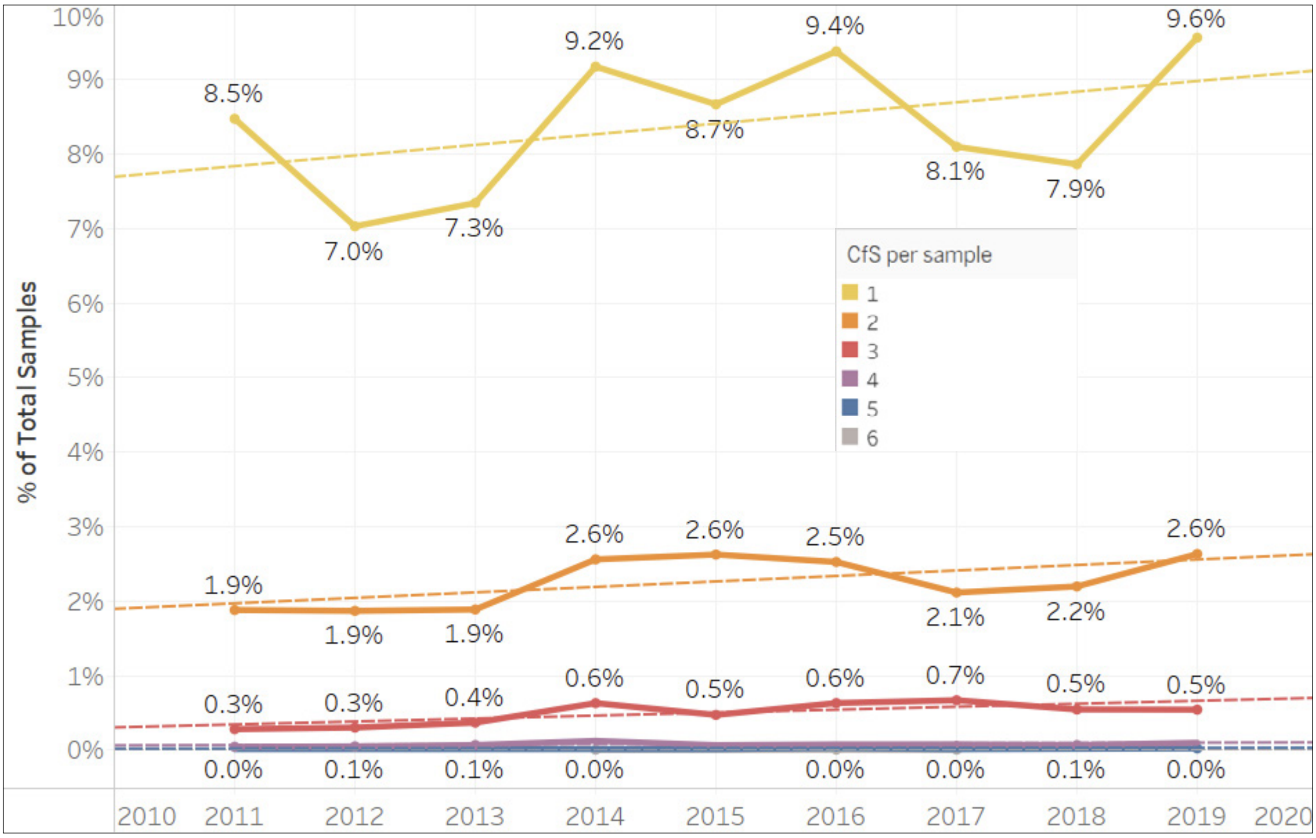


Figure 32. *Percentage of vegetables contaminated with 1 (yellow) to 6 (grey) Candidates for Substitution between 2011 and 2019*

Cocktails Effects

On their own, the most hazardous pesticides already raise significant health concerns but a combined exposure to several of them trigger harmful cumulative and synergistic effects, to an extent which remain partly unknown.

Authorities have so far failed to uphold their legal obligation to assess the effects of combined exposure to several pesticides (Article 4(3)(b) of Regulation (EC) No. 1107/2009 and Article 14 of Regulation (EC) No. 396/2005). Instead, regulators only consider substance-per-substance impacts and set exposure limits per each individual substance, e.g., No Observed Adverse Effect Levels (NOAELs). However, research showed that in cases where multiple pesticides were administered below or at the NOAEL, the cocktail effect does result in adverse effects, highlighting the insufficiencies of the officially set contamination limits.

Under the EU Chemical Strategy for Sustainability, the EU committed to better protect EU citizens and the environment from cocktail effects.

Average findings 2011 - 2019

In the period 2011-2019, a total of 210,260 samples met the selection conditions of popular fruits and vegetables that have been produced in Europe and which have been objectively sampled (Figure 33).

In these years, on average[15] 26% of the 97,170 fruit samples contained one or more Candidates for Substitution, with an average of 0.37 Candidates for Substitution per sample.

The maximum number of Candidates for Substitution found per sample is six, while in total 28 of the 56 Candidates for Substitution were found. The contamination of Candidates for Substitution in vegetables was considerably lower; on average 11% of the 113,090 samples containing one or more Candidate for Substitution, with an average of 0.15 Candidates for Substitution per sample. The maximum Candidates for Substitution found per sample was also six, while 30 different Candidates for Substitution were found. In fruits and vegetables combined, 32 of the 56 Candidates for Substitution were detected.

Product category	Samples	Samples with Candidates for Substitution	%Samples with Candidates for Substitution	Avg	Max. Candidates for Substitution per sample	Candidates for Substitution detected
Fruit	97,170	25,033	26%	0.37	6	28
Vegetables	113,057	12,633	11%	0.15	6	30
Total	**210,227**	**37,665**	**18%**	**0.26**	**6**	**32**

Figure 33. *Samples per product category included in the trend analysis for 2011-2019.*

In 2019, 67% of European consumers reported consuming at least one fruit or vegetable per day.

15 *Average of the yearly proportions.*

Most contaminated fruits

Over the years, the top 5 fruits with the highest number of Candidates for Substitution were blackberries (51% contaminated), peaches (45%), strawberries (38%), cherries (35%) and apricots (35%). The frequency of contamination ranges between 35-51%, with an average number of 0.5-1.0 Candidates for Substitution per sample. The maximum number of Candidates for Substitution found in one sample of these five fruits ranged from 4 to 6 (Figure 34).

No.	Product new grouped	n	Avg	Sum	Max	
1	Blackberries	606	1.01	12	4	51% (311)
2	Peaches	9,325	0.68	15	6	45% (4,193)
3	Strawberries	8,965	0.67	19	4	38% (3,451)
4	Cherries	4,240	0.46	13	5	35% (1,505)
5	Apricots	3,560	0.48	15	5	35% (1,239)
6	Pears	9,409	0.48	17	5	33% (3,100)
7	Table grapes	8,582	0.53	16	6	33% (2,825)
8	Raspberries	1,506	0.57	12	4	32% (480)
9	Apples	17,280	0.31	23	6	25% (4,256)
10	Plums	4,338	0.32	13	4	24% (1,022)
11	Blueberries	652	0.29	7	3	19% (124)
12	Kiwi fruits	3,673	0.20	7	2	19% (682)
13	Mandarins	5,802	0.15	14	3	13% (756)
14	Lemons	3,094	0.09	13	4	8% (237)
15	Granate apples	296	0.08	6	2	7% (21)
16	Oranges	9,203	0.07	14	3	7% (622)
17	Figs	237	0.06	3	2	6% (14)
18	Grapefruits	916	0.06	8	1	6% (54)
19	Melons	2,340	0.05	13	3	4% (101)
20	Mangoes	102	0.02	1	1	2% (2)
21	Pineapples	210	0.02	1	1	2% (4)
22	Watermelons	1,463	0.02	12	2	2% (24)
23	Bananas	1,447	0.01	4	4	1% (11)
Grand Total						26% (25,033)

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 34. *Fruits most contaminated with Candidates for Substitution in the period 2011-2019*

Most contaminated vegetables

The top 5 vegetables produced in the EU most contaminated with Candidates for Substitution were celery (50%), celeriac (45%), kale (31%), witloof (endive) (28%) and brussel sprouts (26%), with a frequency of contamination ranging between 26 and 50%. The average number of Candidates for Substitution per sample varied between 0.31 and 0.72. The maximum number of Candidates for Substitution per sample found in these vegetables ranged between 3 and 6 (Figure 35).

No.	Product	n	Avg	Sum	Max	
1	Celeries	1,349	0.72	12	5	50% (674)
2	Celeriacs	1,482	0.61	14	6	45% (671)
3	Kales	729	0.39	11	3	31% (225)
4	Witloofs	536	0.30	5	3	28% (149)
5	Brussels sprouts	1,067	0.31	8	3	26% (273)
6	Lettuces	13,420	0.31	21	6	21% (2,796)
7	Parsnips	428	0.28	8	4	20% (85)
8	Parsley roots	604	0.22	9	5	18% (108)
9	Escaroles	1,410	0.24	15	4	17% (240)
10	Chards	820	0.20	12	3	17% (137)
11	Cucumbers	8,370	0.22	16	4	16% (1,352)
12	Leeks	3,384	0.18	9	3	16% (540)
13	Spinaches	5,514	0.19	18	5	15% (850)
14	Beans (with pods)	3,856	0.17	17	3	14% (538)
15	Spring onions	1,242	0.14	9	3	12% (149)
16	Peppers	9,392	0.15	18	4	12% (1,121)
17	Carrots	8,495	0.14	19	4	11% (968)
18	Aubergines	5,643	0.10	16	4	8% (425)
19	Chinese cabbages	1,097	0.09	9	3	7% (82)
20	Broccoli	4,086	0.08	14	4	7% (304)
21	Peas (with pods)	649	0.08	9	3	6% (42)
22	Turnips	526	0.07	8	3	6% (33)
23	Radishes	1,993	0.06	13	2	5% (108)
24	Head cabbages	5,235	0.07	12	4	5% (273)
25	Globe artichokes	691	0.06	9	4	5% (34)
26	Garlic	656	0.05	6	1	5% (31)
27	Sweet potatoes	234	0.03	1	1	3% (8)
28	Table olives	435	0.03	4	2	3% (12)
29	Courgettes	4,619	0.03	14	2	3% (127)
30	Kohlrabies	650	0.02	6	2	2% (13)
31	Pumpkins	888	0.02	10	3	2% (17)
32	Shallots	332	0.02	3	1	2% (5)
33	Cauliflowers	4,072	0.02	10	3	1% (56)
34	Avocados	220	0.01	3	2	1% (3)
35	Onions	4,009	0.01	9	3	1% (54)
36	Beetroots	803	0.01	6	3	1% (10)
37	Potatoes	12,132	0.01	16	2	1% (115)
38	Asparagus	986	0.01	4	2	1% (5)
39	Sweet corn	702	0.00	1	1	0% (1)
40	Rhubarbs	266	0.00	0	0	0% (0)
Grand Total						11% (12,633)

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 35. *Vegetables most contaminated with Candidates for Substitution in the period 2011-2019*

Most found Candidates for Substitution

Between 2011 and 2019, the Candidates for Substitution that were mostly found in fruits and vegetables produced in the EU were fluxioxonil (12,579 times), cyprodinil (10,961), tebuconazole (7,461), difenoconazole (4,418) and lambda cyhalothrin (3,774)[16]. In total, 39,196 residues of Candidates for Substitution were found in the 210,260 samples analysed (Figure 36).

No.	CfS Pesticide	
1	Fludioxonil	12,579
2	Cyprodinil	10,961
3	Tebuconazole	7,461
4	Difenoconazole	4,418
5	Lambda Cyhalothrin	3,774
6	Etofenprox	3,516
7	Metalaxyl	2,965
8	Cypermethrin	2,408
9	Pirimicarb	1,973
10	Methoxyfenozide	1,692
11	Fluopicolide	1,211
12	Tebufenpyrad	774
13	Pendimethalin	702
14	Propyzamide (aka pronamide)	369
15	Etoxazole	243
16	Triallate	165
17	Aclonifen	119
18	Paclobutrazole	90
19	Emamectin (benzoate)	69
20	Lenacil	66
21	Oxamyl	44
22	Metribuzin	31
23	Isopyrazam	23
24	Esfenvalerate	13
25	Flurochloridone	12
26	Dimoxystrobin	9
27	Metconazole	7
28	Oxyfluorfen	5
29	Diflufenican	4
30	Flufenacet	3
31	Chlortoluron	1
32	Diclofop	1
Grand Total		39,196

Figure 36. *Most prevalent Candidates for Substitution found in European fruits and vegetables in the period 2011-2019*

[16] *More information on these substances is available in textboxes: fludioxonil p. 15, cyprodinil p. 29, tebuconazole p. 17, difenoconazole p. 27, lambda cyhalothrin p. 24.*

Member States of origin

The countries that most frequently produced contaminated fruits and vegetables samples during the study years were Belgium (34%), Ireland (26%), France (22%), Italy (21%) and Germany (20%). The average number of Candidates for Substitution per sample varied between 0.56 and 0.40 (Figure 37).

No.	Country of orig..	n	Avg	Sum	Max	
1	Belgium	3,243	0.56	18	5	34% (1,112)
2	Ireland	980	0.40	16	4	26% (253)
3	France	14,544	0.31	24	5	22% (3,189)
4	Italy	47,607	0.29	24	6	21% (9,822)
5	Germany	12,327	0.30	20	4	20% (2,464)
6	Spain	38,585	0.26	26	6	19% (7,247)
7	Netherlands	11,931	0.27	18	4	19% (2,217)
8	Austria	2,902	0.23	15	4	17% (503)
9	Czechia	1,353	0.23	14	4	17% (230)
10	Hungary	9,569	0.22	20	6	17% (1,595)
11	Portugal	3,539	0.24	15	5	16% (580)
12	Poland	10,041	0.22	21	5	16% (1,616)
13	Greece	17,429	0.21	22	6	16% (2,707)
14	Cyprus	1,909	0.22	13	6	16% (296)
15	Moldova	663	0.21	9	3	15% (102)
16	Croatia	980	0.23	15	6	15% (149)
17	EEA	147	0.29	11	5	15% (22)
18	Luxembourg	354	0.26	9	4	15% (52)
19	Norway	3,006	0.22	7	3	14% (419)
20	United Kingdom	5,260	0.21	20	5	14% (724)
21	Slovakia	807	0.18	15	5	13% (108)
22	Sweden	1,159	0.19	8	3	13% (149)
23	Finland	1,482	0.21	8	2	13% (190)
24	Malta	425	0.17	10	4	12% (53)
25	Switzerland	33	0.18	6	3	12% (4)
26	Slovenia	2,210	0.16	14	4	11% (239)
27	Estonia	604	0.15	7	2	10% (63)
28	Romania	11,646	0.14	17	5	10% (1,182)
29	Ukraine	179	0.16	9	4	9% (16)
30	European Union	58	0.09	2	1	9% (5)
31	Bulgaria	1,345	0.10	12	3	8% (114)
32	Lithuania	120	0.08	5	2	8% (9)
33	Denmark	2,871	0.11	9	3	7% (208)
34	Iceland	224	0.06	4	2	5% (11)
35	Latvia	592	0.03	6	2	2% (13)
Grand Total						**18% (37,662)**

n: samples taken **Avg:** average CfS per sample **Sum:** different CfS found **Max:** maximum CfS found in one sample

Figure 37. *European countries producing fruit and vegetables with the highest contamination of Candidates for Substitution in the period 2011-2019*

The level of contamination with Candidates for Substitution per Member States differs substantially, due to the difference in usage of Candidates for Substitution but also due to the different kinds of fruits and vegetables they produce.

Key findings

A rise in the frequency of residues of the most hazardous pesticides

Fruits

- In 2011, 18% of fruits were contaminated with Candidates for Substitution, which increased to 29% in 2019.
- On average, the trend shows an increase of +53% over 9 years for fruits.
- Most prominent examples are kiwi fruits (+397% increase to 30% in 2019), cherries (+152% to 50%), apples (+117% to 33%), pears (+103% to 45%) and peaches (+52% to 53%).

Vegetables

- Vegetables produced in Europe showed a moderate increase of contamination with Candidates for Substitution, from 11% in 2011 to 13% in 2019 (+19% relative increase).
- On average, the trend shows an increase of +19% over 9 years for fruits.
- Most prominent were the increased contamination in samples of celery (+68% to 63%), cucumber (+59% to 20%), spinach (+59% to 18%) and lettuce (+19% to 23%).

A rise in the intensity of residues of the most hazardous pesticides

Fruits

- While 6,4% of fruits were found to be contaminated with at least two of these most toxic pesticides in 2011, this figure has risen to 10,2% in 2019.
- In 2019, over a third (10,21%) of contaminated fruits contained a cocktail (at least two) of the most dangerous pesticides.

Vegetables

- While 2.2% of vegetables were found to be contaminated with at least two of these most toxic pesticides in 2011, this figure has risen to 3,1% in 2019.
- The most frequent mixture is the combination of two Candidates for Substitution.

A high average contamination level

In the period 2011-2019, 32 of the 56 approved Candidates for Substitution were found in the 210,260 samples of fruits and vegetables produced in Europe.

- Over these years, on average 26% of fruits and 11% of vegetables contained one or more Candidates for Substitution, with up to 6 different Candidates for Substitution per sample.
- The top 5 most contaminated fruits were blackberries (51%), peaches (45%), strawberries (38%), cherries (35%) and apricots (35%).
- The top 5 vegetables which were most contaminated with Candidates for Substitution were celery (50%), celeriac (45%), kale (31%), witloof (28%) and Brussels sprouts (26%).
- Countries which produced products with the highest frequency of contamination were Belgium (34%), Ireland (26%), France (22%), Italy (21%) and Germany (20%).

Discussion

The findings of this report highlight that EU consumers eating fruits or vegetables produced in the EU are increasingly exposed to a cocktail of the worst pesticides. A growing number of products tested every year are found to be contaminated and concerns are particularly high for fruits.

Paradoxically, consumers are less and less protected, at a time when the EU is committed to delivering a production and consumption system that is safer for human health, animal health and the environment.

How can this trend increase in the proportion of contaminated fruits and vegetables produced in the EU be explained?

This study looked at the quantity (number) of residues of Candidates for Substitution found in fruits and vegetables (different from the volume used in agriculture). Therefore, if the proportion of fruit and vegetables contaminated by the most hazardous pesticides has increased by 8.8% in 2019 compared to 2015-2017, it is because their use has also increased, at least at certain stages of cultivation.

Why are these results different from those put forward by the European Commission?

To monitor progress in reducing the use of the most hazardous pesticides, the European Commission relies on the sales data of plant protection products containing Candidates for Substitution, due to a lack of actual use data. Building on sales, it concludes a 12% reduction in the use of the most dangerous pesticides in 2019 compared to 2015-2017.

The rationale for this report is that looking at the quantity of Candidates for Substitution that are found in food can provide a more accurate overview of the actual uses on fruits and vegetable productions, while addressing consumer exposure. At the very least, it points very clearly at the insufficiency of the current indicator, which suggests a decline in risk to EU consumers and the environment, while a series of uses increases and actually puts EU citizens more at risk.

Why has the use of these most dangerous pesticides increased, rather than remained stable?

In conventional agriculture, pest control relies on the use of synthetic pesticides. Over generations, the sensitivity of a "pest" population to pesticides is decreasing due to a genetic adaptation to the substances used year after year. Once targeted populations start resisting, the effects of the pesticides become limited. To overcome this resistance and keep control of pests, the use of pesticides becomes more intensive, thereby feeding further this resistance process[17]. At a certain point, compensating for the increased resistance with a higher intensity is insufficient to maintain the same efficiency - and is very costly for farmers and society at large[18].

This phenomenon is known as the 'Pesticide Treadmill' and is defined by the Dictionary of Environment and Conservation as "the tendency of pests to become resistant to the effects of particular pesticides, as a natural part of the evolutionary process. New and more toxic pesticides then have to be used, to which pests may eventually become resistant, and the spiral continues."

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[17] *Zhang J, Lopez Jimenez L, Snelders E, Debets AJM, Rietveld AG, Zwaan BJ, Verweij PE, Schoustra SE. 2021. Dynamics of Aspergillus fumigatus in azole fungicide-containing plant waste in the Netherlands (2016 -2017). Appl Environ Microbiol 87:e02295-20. https://doi.org/10.1128/AEM.02295-20.*

[18] *Gould et al., S, Wicked evolution: Can we address the sociobiological dilemma of pesticide resistance?, Science 360 (6390), 728-732. https://doi.org/10.1126/science.aar3780.*

What does this mean for the next few years? Will this trend keep going?

Without an adequate response to break down this resistance spiral, the observed trends are very likely to keep rising due to an ever-increasing use of pesticides containing Candidates for Substitution. The EU has committed itself to do precisely the opposite and to bring this curve down in the context of the EU Farm to Fork Strategy, which calls for a reduced use of these most dangerous pesticides by 50% by 2030.

How to break free from the Pesticide Treadmill and reverse current trends?

The rising trend of the use of Candidate for Substitution should be reversed by implementing substitution practices as required by EU law for 11 years and by reinforcing the obligation incumbent on the Member States with binding quantified reduction targets (see further below in the 'PAN Europe recommendations' section). Candidates for Substitution can be replaced by preventative non-chemical alternatives (Integrated Pest Management) or by other less toxic substances.

Why has substitution not been implemented over the last 11 years?

The substitution principle has been a legal obligation for all Member States since 2011, and it became enforceable in 2015[19]. In 2019, Member States were asked why they never performed substitution for any of the 530 times where this could have been the case between 2015 and 2018. They argued[20] that no viable alternatives existed. In addition, they claimed that substitution would contradict "efforts to manage potential resistance" by depriving farmers of certain substances. The findings of this report firmly show that this theory of resistance is a myth.

What about alternatives?

Viable alternatives exist but they are constantly dismissed, including in the Guidance Document on comparative assessment and Substitution from the European Commission. This Guidance Document is the major factor blocking substitution efforts and attempts to implement Integrated Pest Management. It uncritically endorses the EPPO standard PP 1/271 entirely based on the demands from the agri-chemical industry. They claim that chemical diversity (meaning the availability of a wide range of Candidates for Substitution-based pesticides with different modes of action) is the right means to counter the risk of pesticide resistance. Candidates for Substitution should therefore not be substituted for the sake of resistance management.

This line of reasoning stands in contrast to Articles 50 and 55 of Regulation (EC) No. 1107/2009 and is clearly debunked by the result of this study. In practice, the resort to different Candidate for Substitution-based pesticides, rather than implementing true substitution, has increased pesticide resistance.

[19] *While the criteria for identifying Candidates for Substitution came into force in 2011, a first list of 77 substances on the market meeting these criteria was only established in 2015#. For four years, the provisions overseeing substitution of Candidates for substitution could simply not be implemented.*

[20] *See pages 67 and 68 of the Study supporting the REFIT Evaluation of Regulation (EC) No 1107/2009.*

Integrated Pest Management (IPM)

Integrated Pest Management is a system-based approach geared to break with the widespread (over-)reliance on pesticides by giving priority to preventative measures as well as chemical-free alternative methods. Contrary to what is often heard from conventional farmers as well as from officials, a plethora of tools is available: growing pest-resistant varieties, building on cultural practices to enhance plants' natural resistance through healthy and fertile soils, using mechanical control and weeding methods and physical barriers, as well as a biological control agent. Synthetic pesticides are only to be employed as the last resort, when all alternatives have proven ineffective. In 2009, it became a cornerstone of Directive (EC) No. 128/2009 on the sustainable use of pesticides (SUD) to emphasise "the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourage natural pest control mechanisms." The directive made it mandatory for all EU farmers to implement Integrated Pest Management since 2014. They must take "all necessary measures to promote low pesticide-input pest management, giving wherever possible priority to non-chemical methods".

In practice, IPM, including the substitution principle, has been poorly implemented since 2009, which explains the ongoing standard reliance of European agriculture on pesticides. In the current revision process of Directive (EC) No. 128/2009, it will be crucial to enable a complete implementation of IPM, including by better defining IPM in the EU regulatory context.

Conventional farmers who embrace high-level IPM manage to reduce synthetic pesticide use by more than 80% without significant reductions in yields while maintaining good farm profits[21].

Where can I learn more about Candidates for Substitution?

PAN Europe's database on Candidates for Substitution is publicly available and provides an accessible overview of all the substances in this category still approved within the EU. Users can easily find comprehensive information on each Candidate for Substitution: in which Member States they are authorised, why they are classified as Candidates for Substitution, their approval timeframes and how often their approval was already extended. Crucially, the database also contains information on the risks that these substances pose to human health and the environment, on consumer exposure and the state of play of independent scientific assessment of each substance.

[21] www.low-impact-farming.info

Recommendations of PAN Europe

This report highlights that without strong action to reverse the current trend, the EU will not deliver on its set reduction targets for pesticides.

To reverse the current trajectory, PAN recommends:

1. Implementing and reinforcing the substitution principle to reduce the use of the most hazardous pesticides

To break down the Pesticide Treadmill, the EU must address the root of the problem, i.e. the increasing use of these most dangerous pesticides. These uses must and can be eliminated by replacing Candidates for Substitution with safer alternatives.

However, this substitution framework aiming at the phase-out of these most dangerous pesticides has already existed for the past 11 years, and Member States have so far refused to comply. It would be foolish to think that things will change at Member States' level in the future on the sole basis of the political impulse of the Farm to Fork Strategy from the European Commission.

Therefore, the forthcoming proposal from the European Commission amending Directive (EC) No. 128/2009 must reinforce the substitution framework by:

- Setting binding pesticide reduction targets at national levels,
- Requiring that Member States adopt a binding review plan of all the existing authorisations of pesticides containing Candidates for Substitution by 2030. These plans should oversee the implementation of substitution in line with article 50 of Regulation (EC) No. 1107/2009.

In addition, the Guidance Document obstructing substitution must be independently reviewed by the end of 2022 to better consider non-chemical alternatives and comply with Integrated Pest Management.

2. Reform the pesticide indicators to monitor actual progress toward the pesticide reduction targets

The findings of this report confirm that the current focus on sales data to monitor pesticide use does not realistically reflect the actual use of the most hazardous pesticides and does not give any information on the crops concerned. It is indeed aberrant to observe that the communications from the European Commission on pesticide use and those from the EFSA on pesticide residues are opposed to the reality: people are more and more exposed to those most toxic pesticides!

This should be taken very seriously by the European Commission, which needs to look into indicators that can better reflect the use of pesticides. As appropriate data on pesticide use and associated health costs are lacking, focusing on substitution is not only the way to achieve pesticide reduction targets but also a more reliable way to measure progress and protect citizens.

3. Better protecting consumers

By highlighting the presence of as many as 5 Substitution Candidates in a single product (apples, peaches, pears) this report provides chilling evidence of consumer exposure to a cocktail of the most hazardous pesticides.

This finding calls for immediate action, including:

- Implementation of a Mixture Assessment Factor (MAF) to immediately start assessing cumulative effects of pesticides, as put forward in the EU Chemical Strategy for Sustainability.
- Adoption of a Zero residue policy in food: by 2035, the Maximum Residue Limits (MRLs) of all Candidates for Substitution should all be lowered to 0.01mg/kg.

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The contents of this publication are the sole responsibility of PAN Europe and do not necessarily reflect the opinion of the European Union.

Annexes

Annex 1. List of selected Candidates for Substitution

Active substance	Active substance (continued)
8-Hydroxyquinoline incl. oxyquinoleine	Imazamox
Aclonifen	Ipconazole
Benzovindiflupyr	Isopyrazam
Bromuconazole	Lambda Cyhalothrin
Chlortoluron	Lenacil
Copper Compounds	Metalaxyl
Copper hydroxide	Metam (incl. -potassium and -sodium)
Copper oxide	Metconazole
Copper oxychloride	Methoxyfenozide
Cypermethrin	Metribuzin
Cyprodinil	Metsulfuron-methyl
Diclofop	Nicosulfuron
Difenoconazole	Oxamyl
Diflufenican	Oxyfluorfen
Dimoxystrobin	Paclobutrazole
Emamectin (benzoate)	Pendimethalin
Esfenvalerate	Pirimicarb
Etofenprox	Propyzamide (aka pronamide)
Etoxazole	Prosulfuron
Fludioxonil	Quizalofop-P-tefuryl
Flufenacet	Sulcotrione
Flumethralin	Tebuconazole
Flumioxazin	Tebufenpyrad
Fluometuron	Tembotrione
Fluopicolide	Triallate
Flurochloridone	Tribasic copper sulfate
Gamma-cyhalothrin	Ziram
Halosulfuron methyl	Bordeaux mixture

Annex 2. Popular fruits and vegetables

List of most sampled popular fruits and vegetables included in the analysis.

Fruits	Vegetables	Vegetables (continued)
Apples	Asparagus	Parsley roots
Apricots	Aubergines	Parsnips
Bananas	Avocados	Peas (with pods)
Blackberries	Beans (with pods)	Peppers
Blueberries	Beetroots	Potatoes
Cherries	Broccoli	Pumpkins
Figs	Brussels sprouts	Radishes
Granate apples	Carrots	Rhubarbs
Grapefruits	Cauliflowers	Shallots
Kiwi fruits	Celeriacs	Spinaches
Lemons	Celeries	Spring onions
Mandarins	Chards	Sweet corn
Mangoes	Chinese cabbages	Sweet potatoes
Melons	Courgettes	Table olives
Mulberries (black and white)	Cucumbers	Turnips
Oranges	Escaroles	Winter squashes
Peaches	Garlic	Witloofs
Pears	Globe artichokes	Yams
Pineapples	Head cabbages	
Plums	Kales	
Raspberries	Kohlrabies	
Strawberries	Leeks	
Table grapes	Lettuces	
Watermelons	Onions	