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ORIGINAL ARTICLE

Common sowing rates of major European field crops: Results of a large-scale farmer survey

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Abstract

In the European Union (EU), pesticides can only be used by farmers after an acceptable risk to consumers, operators, and the environment has been demonstrated. Plant protection products applied as seed treatments have several environmental advantages compared with foliar spray applications, especially lower use rates and less drift to off-crop habitats. Regulatory risk assessments for seed treatment products in the EU are routinely based on maximum 'commonly used' sowing rates. Such assessments may overestimate the true risk as sowing rate distributions can be skewed by atypically high sowing rates, which are often a result of localized conditions. To have a better view of realistic worst-case sowing rates for key field crops (cereals, maize, oilseed rape, sunflower, soybean and sugar beet) grown in the EU, a large-scale farmer survey was conducted in 2020 and 2021 across a representative range of EU countries, and the United Kingdom. The total number of farmers interviewed ranged from 112 (spring oilseed rape) to 14 479 (winter wheat). The number of countries from which farmers were interviewed ranged from three (spring oilseed rape) to 17 (winter wheat). Mean and 90th percentile values of sowing rates were calculated from the survey results per crop and are proposed as more representative worst-case values for use in seed treatment regulatory risk assessments.

Densité de semis des principales grandes cultures européennes : résultats d'une enquête à grande échelle auprès des agriculteurs

Dans l'Union Européenne (UE), les pesticides ne peuvent être utilisés qu'après la démonstration d'un risque acceptable pour les consommateurs, les opérateurs et l'environnement. Les pesticides appliqués en traitement de semences présentent plusieurs avantages par rapport à ceux utilisés en pulvérisation foliaire, notamment en raison des doses d'usage plus faibles et des moindres dérives sur les habitats adjacents aux cultures. Les évaluations réglementaires de risques pour les traitements de semences dans l'UE se fondent sur les densités de semis maximales «communément utilisées». De telles évaluations peuvent surestimer le risque réel car les distributions de densités de semis peuvent être biaisées par une densité de semis atypique, qui souvent reflète des conditions très locales. Pour avoir une meilleure approche des densité de semis réalistes du pire cas pour les principales grandes espèces (céréales, maïs, colza, tournesol, soja et betterave sucrière) cultivées dans l'UE, une enquête à grande échelle auprès des agriculteurs a été menée en 2020 et 2021 dans un éventail représentatif de pays de l'UE et au Royaume-Uni. Le nombre total d'agriculteurs interrogés variait de 112 (colza de printemps) à 14479 (blé d'hiver). Le nombre de pays dans lesquels les agriculteurs

ont été interrogés variait de 3 (colza de printemps) à 17 (blé d'hiver). Les valeurs moyennes et les 90ème percentiles des densité de semis ont été calculées à partir des résultats de l'enquête pour chaque culture et sont proposées comme des valeurs plus représentatives des pires cas pour les évaluations réglementaires des risques en traitement de semences.

Общие посевные нормы основных сельскохозяйственных культур Европы: результаты масштабного опроса среди сельхозпроизводителей

В Европейском Союзе (ЕС) средства защиты растений допускаются к использованию сельхозпроизводителями только после проведения комплексной оценки их потенциального риска для потребителей, операторов и окружающей среды. Средства защиты растений, применяемые для обработки семян, обладают рядом экологических преимуществ по сравнению с опрыскиванием листвы, в частности из-за низких норм расхода и меньшей вероятности попадания в окружающую среду. Нормативные оценки риска для средств обработки семян в ЕС, как правило, основываются на максимальных «обычно применимых» посевных нормах. Подобные оценки могут переоценивать реальный уровень риска, поскольку распределение посевных норм часто оказывается искаженным в сторону аномально высоких значений, обусловленных локальными условиями. Чтобы получить лучшее представление о реалистичных худших из применяемых посевных норм для ключевых полевых культур, выращиваемых в ЕС (зерновые, кукуруза, масличный рапс, подсолнечник, соя и сахарная свекла), в 2020 и 2021 гг. был произведен масштабный опрос среди сельхозпроизводителей в ряде государств ЕС и в Великобритании. Общее количество респондентов-сельхозпроизводителей варьировало от 112 (яровой масличный рапс) до 14 479 (озимая пшеница), а география опроса охватывала от 3 (яровой масличный рапс) до 17 (озимая пшеница) стран. Средние значения и значения 90-го процентиля посевных норм были рассчитаны на основе результатов исследования по каждой посевной культуре. Предложено рассматривать эти значения как более репрезентативные показатели для наихудшего случая использования при нормативных оценках риска, связанного с обработкой семян.

1 | INTRODUCTION

Registration of pesticides in the European Union (EU) requires the demonstration of an acceptable risks to humans and the environment (including non-target organisms) for the proposed uses of the formulated plant protection products (referred to hereafter as products). Examples include risk assessments for birds and mammals as well as soil dwelling or aquatic organisms and for exposure of operators during applications, and modelling leaching of residues to groundwater (European Commission, 2014; EFSA, 2017, 2022, 2023). The risk assessment for a product takes into account both its toxicity and the potential exposure of non-target organisms to the product, for example birds feeding on contaminated food items (EFSA, 2023). Exposure estimates are based on the use pattern of the product (and its constituent active ingredient(s)), including the amount of product applied per unit area (usually hectare). The calculation of exposure estimates is relatively straightforward for products applied by foliar spray where application rates are expressed as litre or kilogram of product or active substance(s) per hectare. However, seed treatment products are applied directly to the seed, at industrial facilities or on-farm, and the application rates of seed treatment products are typically expressed as the dose (litre of product or g of active substance(s)) per unit (e.g. 100 000 seeds) or mass (e. g. 100 kg) of seed. Therefore, to express the application rate per unit area (grams of product or active ingredient per hectare) and thus calculate potential exposure of non-target organisms to the active substance used in the seed treatment product, knowledge about the representative sowing rate of the specific crop is required. In considering risks to birds and mammals, EFSA (2023) suggests use of the maximum sowing rates as presented by Lucchesi et al. (2016). EFSA (2023) however, also states that should additional information be available in a harmonized guidance document in the future, then those values should be used. The latest draft of the EU Seed Treatment Guidance Document (European Commission, 2020) recommends the use of the maximum commonly used sowing rates for risk assessment purposes. However, using the maximum commonly used sowing rate is likely to overestimate the actual risk in most situations, as maximum use rates can be restricted to limited regions, owing to local environmental and agricultural conditions. EU Regulation 546/2011 (European Union, 2011) requires the risk assessment for plant protection products to cover the 'realistic worst-case'. This realistic worst-case

can be represented by a defined percentile of a quantitative variable representing exposure levels. For example, in the EFSA report on FOCUS surface water repair (EFSA, 2020), guidance is given on how to predict environmental concentrations of pesticides in the surface water bodies; the 90th percentile (i.e. 90th percentile of occurrence in time and space of the Predicted Environmental Concentration in surface water) is considered as the operational definition of the term 'realistic worst-case'. The proposal in our paper is therefore to use the 90th percentile sowing rates to calculate representative worst-case exposure values for use in risk assessment in the EU and the United Kingdom, rather than the maximum or maximum 'most commonly used'.

In order to obtain a reliable picture of representative sowing rates of key field crops in Europe and the United Kingdom, an extensive survey amongst farmers was conducted in 2020. This paper presents the outcome of this survey regarding information on sowing rates for the following major field crops: winter and spring wheat, winter and spring barley, oats and rye, winter triticale, maize, winter and spring oilseed rape, sunflower, soybean and sugar beet. These data are compared with those currently used in risk assessments and published in Lucchesi et al. (2016) and with previously unpublished data obtained using the same survey methodology.

2 | METHODOLOGY FOR THE SURVEY

This survey was conducted by Kynetec, a company which for more than 25 years has specialized in conducting large-scale annual farmer surveys, including surveys on seed sowing. The results from the annual farmer survey from 2020 were processed specifically for the needs of this paper. Surveys were conducted via phone calls, online interviews or face to face interviews using a standardized questionnaire across the different countries (Appendix S1). For autumn-sown crops (winter cereals, winter oilseed rape) surveys were conducted from October 2020 to the end of February 2021. For spring-sown crops (spring cereals, maize, sunflower, spring oilseed rape, sugar beet, soybean) surveys were conducted from May 2020 until September 2020.

The countries in which farmers were surveyed for each of the target crops (wheat, barley, triticale, rye, oats, maize, oilseed rape, sunflower, soybean, sugar beet) are shown in Tables 1 and 2. The selection of the surveyed farmers aimed to give a representative picture of sowing rates for the different target crops. The number of countries from which farmers were interviewed ranged from three (spring oilseed rape) to 17 (winter wheat). For each crop, farmers were interviewed from countries which are major producers of the crop in Europe. Countries from which farmers were interviewed produce between 33% (spring oilseed rape) and 96% (maize) of the total production of the specific crop in the EU and the United Kingdom. For most countries in which the survey took place, the selected farmers grew 5–10% of the total area of the respective crop under examination. In order to ensure that the sample of farmers participating in the survey were representative, factors taken into account were farm size, area of crop under examination grown and crop type (e.g. maize for grain or maize for silage). Data for the crop areas per country for the year 2020 were obtained from Eurostat Data Browser (https://ec.europa.eu/eurostat/databrowser/view/apro_cpsh1__custom_12234103/default/table?lang=en) are produced annually by national statistical offices (collated by Eurostat, e.g. Eurostat, 2020), whereas data on farm size and or crop area at farm level are available from national farm census data generally collected generally on a 7 yearly basis and also published by Eurostat. The latest farm census data published by Eurostat (2020), available before the survey, were from 2016. To ensure that the crop and farm area size classes data were as representative as possible for farm selection in 2020, data from the farm surveys conducted by Kynetec were used to update the crop area and farm size census data, for each country. The number of farmers interviewed per crop and country each year and their locations were adjusted in accordance with the updated crop area in the respective country (Tables 1 and 2).

2.1 | Data analysis

To ensure the data were representative for the growing areas of the respective crops in the EU and United Kingdom, after farm interviews were completed, a weighting factor was applied to ensure that extreme values from the surveyed sown area did not have a disproportionate influence:

> Weighting factor = total surveyed area per crop ÷ area of surveyed farm.
> Weighting = weighting factor × interview data (e.g. sowing area).

For each crop, geometric mean and 90th percentile sowing rate values were calculated. Geometric mean values are generally less sensitive to outliers compared with arithmetic values and are regularly applied for other parameters in regulatory risk assessments as well (e.g. EFSA, 2023). The 90th percentile values are proposed to be used to express the realistic worst-case scenario relevant for a risk assessment.

There is a low percentage (<10%) of hybrid cereals in the EU and United Kingdom. The sowing rate for hybrid cereals is lower than open-pollinated cereals. This paper considers only the higher range sowing rate distributions and therefore, sowing rates for hybrid cereals have been excluded.

TABLE 1 Overview of total area of cereal crops grown per country in 2020 (Eurostat, https://ec.europa.eu/eurostat/databrowser/view/apro_cpsh1__custom_12234103/default/table?lang=en) and number of farmers interviewed in the 2020 survey.

	Area grown (thousand ha)							Number of interviewed farmers						
Country	Winter wheat[a]	Spring wheat[b]	Winter barley	Spring barley	Triticale	Rye	Oats	Winter wheat	Spring wheat	Winter barley	Spring barley	Triticale	Rye	Oats
Belgium	192	2	40	4	5	1	4							
Bulgaria	1192	0	127	3	14	5	13	529		219				
Czech Republic	775	24	115	217	42	31	47	462	50	257	349	93	98	132
Denmark	484	18	88	565	7	115	75	497		145	450		110	113
Germany	2759	43	1304	363	341	NA	157	2061	59	1619	505	647	744	332
Estonia	118	50	22	108	6	21	41	165	124		181		37	52
Ireland	35	12	51	142	0	0	25							
Greece	93	0	137	0	15	8	68							
Spain	1484	180	308	2441	257	138	506							
France	4226	41	1180	794	262	32	98	4000		3228		966		
Croatia	146	1	60	7	12	1	19							
Italy	501	0	263	0	13	4	103	432						
Cyprus	5	0	13	0	1	0	0							
Latvia	382	116	9	75	7	41	98	331	238		162			159
Lithuania	752	142	25	140	115	37	105	417			214		72	61
Luxembourg	11	0	4	2	5	1	2							
Hungary	902	7	236	25	74	26	26	827		386	85	183	92	96
Malta	0	0	0	0	0	0	0							
Netherlands	92	16	10	29	1	2	2							
Austria	260	3	103	31	56	43	20	455	206	257	97	120	135	54
Poland	2236	155	268	408	1391	851	506	1450	208	289	488	756	520	283
Portugal	27	0	19	0	15	14	37							
Romania	2141	10	354	88	74	11	101	1102	23	502	61	118	15	113
Slovenia	NA	NA	NA	NA	6	1	1							
Slovakia	341	12	50	80	10	12	12	344	19	161	195	10	28	46
Finland	23	176	0	392	0	19	325	71	274		499		59	455
Sweden	401	48	20	272	28	31	178	325	76		298	45	63	247
United Kingdom	1415	0	318	1096	14	30	211	1011		361		9	6	
EU27+United Kingdom	21 022	1057	5147	7286	2768	2096	2781	14 479	1277	7424	3584	2947	1979	2143

Abbreviation: NA, not available.

[a]Based on "Common winter wheat and spelt" (C1111).

[b]Based on "Common winter wheat and spelt" (C1112).

TABLE 2 Overview of total areas of maize, spring and winter oilseed rape, sunflower, soybean and sugar beet grown per country in 2020 (Eurostat, https://ec.europa.eu/eurostat/databrowser/view/apro_cpsh1__custom_12234103/default/table?lang=en) and number of farmers interviewed in the 2020 survey.

	Area grown (thousand ha)						Number of interviewed farmers					
Country	Maize[a]	Winter oilseed rape[b]	Spring oilseed rape[c]	Sunflower	Soybean	Sugar beet	Maize	Winter oilseed rape	Spring oilseed rape	Sunflower	Soybean	Sugar beet
Belgium	234	8	0	0	0	57	401					
Bulgaria	612	119	0	822	5	0	419	162		543		
Czech Republic	313	368	0	11	14	60	339	316		70		138
Denmark	195	145	1	0	0	33	200	149				
Germany	2649	954	3	28	34	386	2125	1134				801
Estonia	14	57	14	0	0	0		101	41			
Ireland	15	9	2	0	0	0						
Greece	220	6	0	98	1	2						
Spain	459	63	8	650	1	28	859			415		
France	3087	1110	3	777	187	421	2200	1001		1004	533	
Croatia	318	42	0	39	86	10	361	378				
Italy	982	17	0	123	256	27	1004					
Cyprus	0	0	0	0	0	0						
Latvia	23	130	18	0	0	0		182	52			
Lithuania	50	272	11	0	2	14		240	19			
Luxembourg	17	3	0	0	0	0						
Hungary	1043	309	1	613	59	13	851			537	123	
Malta	0	0	0	0	0	0						
Netherlands	214	0	0	1	0	81	400					
Austria	300	32	0	23	69	26	493				201	
Poland	1620	967	12	8	8	246	807	737				411
Portugal	144	0	0	6	0	0						
Romania	2588	347	16	1143	169	21	1247	432		832		73
Slovenia	71	NA	NA	0	2	0						
Slovakia	260	145	2	54	51	21	326	213		116	112	
Finland	0	2	23	0	0	11						
Sweden	22	93	5	0	0	30						
United Kingdom	232	373	15	0	0	112	304	429				
EU27+United Kingdom	15 749	5576	132	4396	943	1599	12 386	4789	112	3517	969	1423

[a]Combined value for "Grain maize and corn-cob-mix" (c1500) and "Green maize" (G3000).

[b]Based on "Winter rape and turnip rape seeds" (I1111).

[c]Based on "Spring rape and turnip rape seeds" (I1112).

3 | RESULTS

3.1 | Cereals

For winter cereals (72% of the total area of cereals grown in 2020 in the EU27+the United Kingdom), the total area for which surveys were carried out represented more than 80% of the planted area of wheat, triticale and barley. For rye, Eurostat Data Browser does not contain the growing area of this crop in Germany. Nevertheless, for rye most interviewed farmers were from Germany and therefore the percentage area represented is expected to be greater than the calculated 58.5%. For spring wheat and oats, the surveys collected information from farmers growing crops on more than 60% of the total planted area, while for spring barley the surveys corresponded to more than 30% of the planted area.

Table 3 summarizes the geometric mean and 90th percentile sowing rates for winter and spring cereals. For winter cereals geometric mean sowing rate values varied from 105 to 176 kg seed/ha and the 90th percentile sowing rate values varied from 199 to 250 kg seed/ha. For spring cereals, the geometric mean sowing rate values varied from 165 to 199 kg seed/ha and the 90th percentile sowing rates varied from 199 to 248 kg seed/ha.

3.2 | Maize

Overall, the survey covered 89–97% of the cropped area for maize in the EU27 and the United Kingdom (Table 4). There is a geographical split in the type of maize grown in the EU27. Grain maize is grown predominantly in the south of Europe, e.g. Romania, France and Hungary. These countries are also the main producers of maize seeds. Silage maize is predominantly grown in Germany and Poland. As sowing rates are expected to differ between these two types of maize, sowing rates were analysed separately. The geometric mean sowing rate for silage maize was higher than for grain maize (90 000 vs. 76 000 seeds/ha) and this was also reflected in the 90th percentile sowing rate (100 000 vs. 92 000 seeds/ha for silage and grain maize respectively).

3.3 | Oilseed rape

Data on sowing rates for winter oilseed rape were available from 10 countries, while spring oilseed rape data were only available from the three Baltic states. The survey covered 89.2% of the cropped area of winter oilseed rape and 32.6% of the cropped area of spring oilseed rape (Table 4). Geometric mean sowing rates values for winter oilseed rape were lower compared with spring oilseed rape (471 000 vs. 620 000 seeds/ha respectively).

TABLE 3 Summarized data on sowing rates for winter and spring cereals in EU27 and the United Kingdom.

	Geometric mean sowing rate (kg/ha)	90th percentile sowing rate (kg/ha)	Number of survey responses	Countries surveyed	2020 EU-27+GB area of crop grown (thousand ha) (percentage area represented by survey)
Winter wheat	176	250	32 967	FR, DE, GB, BG, DK, SE, AT, PL, CZ, SK, HU, RO, LT, EE, LV, FI	21 022 (89.9%)
Spring wheat	199	248	476	AT, CZ, SK, PL, SE, DE	1057 (60.3%)
Winter barley	147	206	7495	DK, AT, FR, GB, HU, CZ, SK, PL, DE, RO	5147 (80.5%)
Spring barley	165	199	3050	DK, AT, HU, CZ, SK, PL, SE, DE, RO	7286 (37.9%)
Winter triticale	175	225	3504	AT, HU, CZ, SK, PL, SE, DE, RO, FR, GB	2768 (82.8%)
Winter rye	105	199	2269	DK, AT, HU, CZ, SK, PL, SE, DE, RO, FR, GB	2096 (58.5%)[a]
Spring oats	174	218	1413	DK, AT, HU, CZ, SK, PL, SE, DE, RO	2781 (60.8%)

[a]Eurostat Data Browser (https://ec.europa.eu/eurostat/databrowser/view/apro_cpsh1__custom_12234103/default/table?lang=en) does not contain data the growing area of rye in Germany. Therefore, Germany was not included in the calculation of percentage of represented area. Therefore, the percentage represented area is expected to be higher.

TABLE 4 Summarized data sowing rates for maize (grain and silage), oilseed rape, sunflower, soybean and sugar beet in EU27 and the United Kingdom.

	Geometric mean sowing rate (expressed as thousand seeds/ha except soybean (kg/ha))	90th percentile sowing rate (thousand seeds/ha except soybean (kg/ha))	Number of responses	Countries surveyed	EU27 and GB area grown (thousand ha) (percentage area represented by survey)
Grain maize	76	92	18 703	ES, FR, NL, BE, DE, DK, AT, PL, CZ, SK, HR, HU, RO, BG, IT	9263 (97.3%)
Silage maize	90	100	15 627		6288 (94.8%)
Winter oilseed rape	471	620	10 701	FR, DE, DK, PL, LV, CZ, SK, HU, RO, BG	5576 (89.2%)
Spring oilseed rape	620	945	116	LT, LV, EE	132 (32.6%)
Sunflower	65	75	6256	ES, FR, CZ, SK, HU, RO, BG	4396 (92.6%)
Soybean	120	160	969	AT, FR, HU, SK	943 (38.8%)
Sugar beet	110	120	2357	DE, PL, RO, CZ	1599 (44.6%)

Also, the 90th percentile values for sowing rates of winter and spring oilseed rape indicate that sowing rates are also generally higher for spring varieties (620 000 vs. 945 000 seeds/ha respectively).

3.4 | Sunflower

The area for sunflowers across seven countries for which surveys were carried out represented 92.6% of the cropped area (Table 4). Geometric mean sowing rate was found to be 65 000 seeds/ha and the 90th percentile sowing rate value was 75 000 seeds/ha.

3.5 | Soybean

The survey of farmers in four soybean growing countries of the EU represented 38.8% of the cropped area (Table 4). The geometric mean sowing rate was 120 kg seed/ha with a 90th percentile of 160 kg seed/ha.

3.6 | Sugar beet

The survey of farmers across four sugar beet growing countries in the EU represented 44.6% of the cropped area with only a small difference between the geometric 110 000 seed/ha and the 90th percentile 120 000 seeds/ha sowing rate (Table 4).

4 | DISCUSSION

Evaluation of the extensive 2020 farmer survey data resulted in representative geometric mean and 90th percentile seed sowing rates for major European field crops. The surveys were conducted without consideration of whether the seeds were treated or not with plant protection products. Farmers may reduce sowing rates in the case of treated seeds, as seed treatments might add costs, but the survey did not allow this assessment to be made. However, it may be assumed that the majority of commercially sown seeds are treated with a pesticide. Therefore, the sowing rates presented here are expected to be suitable for use in risk assessments.

The 90th percentile sowing rate values are proposed to represent a realistic worst-case scenario for the purpose of risk assessments. The 90th percentile values of sowing rates from this survey were compared with maximum commonly used sowing rates from other publications (Lucchesi et al., 2016, SANCO, 2012; see Table 5). For the majority of surveyed crops the values were significantly lower than these previously published values. For most cereal crops the 90th percentile values were between 10 and 23% lower compared with published values. For maize, winter oilseed rape, spring oilseed rape,

TABLE 5 Comparison of maximum commonly used sowing rates reported in Lucchesi et al. (2016) and cited in the draft Seed Treatment Guidance Document (SANCO/10553/2012) with 90th percentile values reported in this study.

Crop	Maximum commonly used (Lucchesi et al., 2016)	Maximum commonly used (SANCO, 2012 v16)	90th percentile (this study)	Percentage difference
kg seed/ha				
Winter wheat	280	260	250	−4 to −11%
Spring wheat	280	280	248	−10%
Spring barley	250	250	199	−20%
Winter barley	250	250	206	−20%
Winter rye	280	280	199	−29%
Winter triticale	250	250	225	−10%
Spring oats	210	210	218	+4%
Soybean	120	120	137	+14%
Thousand seeds/ha				
Maize grain	115	110	92	−16 to −20%
Maize for silage			100	−9 to −13%
Winter oilseed rape	1500	900	620	−31 to −59%
Spring oilseed rape	2000	2000	945	−53%
Sunflower	200	200	75	−63%
Sugar beet	150	150	120	−20%

sunflower and sugar beet the 90th percentile values were 9–20, 31–59, 53, 63 and 20% lower respectively than published values. Only for spring oats and soybean were the 90th percentile values higher compared with previously reported values (14% higher for both crops). These differences indicate that using the maximum commonly used sowing rates for risk assessment purposes is likely to overestimate the risk for the majority of crops included in this paper. The use of the 90th percentile values may also, in some cases, overestimate the risk owing to regional differences in sowing rates.

Average sowing rates may be expected to show some variations year by year, e.g. related primarily to weather conditions and/or changes in varieties. This may call into question the robustness of the detailed survey data from a single year. However, average sowing rates from surveys covering the EU conducted by Kynetec over the previous 10 years, using the same survey methodology, shows minimal variations at European scale (Appendix S2).

Interviewed farmers were selected in such a way that the collected data give a representative picture of sowing rates for different crops in the European Union and the United Kingdom. Countries from which farmers were interviewed represent between 37.9 and 95.9% of the total growing area of the selected crops in the European Union and the United Kingdom. In this way possible effects of extreme sowing rates on the overall results are minimized. Effects of extreme sowing rates can significantly overestimate 90th percentile sowing rates. For example, the maximum commonly used sowing rate for sunflower reported in Lucchesi et al. (2016) was in the Netherlands at 200 000 seeds/ha. However, the total sunflower cropping area for the Netherlands is only 600 ha while sunflower is cultivated on more than 4 million ha across the EU and the 90th percentile sowing rate in this study was 75 000 seeds/ha. The high sowing rate reflects the fact that sunflower is grown in the Netherlands for cut-flower production, not for oil production as in the rest of EU. Therefore, as in this study, it is important when gathering such data to weight the sowing rate data according to the respective cultivated area of the country and in such way to match targeted protection goal, the 'realistic worst-case'. Failure to do so results in a distorted view of the sowing rates for some crops which in turn leads to unrepresentative risk assessments.

The sowing rate data presented here contribute directly to the exposure estimates used in groundwater leaching assessments, non-target organism risk assessments and operator exposure risk assessments. Using the 90th percentile values collated across EU27 + GB would better reflect the 'realistic worst-case'. The use of a sowing rate higher than the 'realistic worst-case' can lead to overestimation of the risk for specific seed treatment uses, which might result in unnecessary restrictions of the use or even non-registrations of the product.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of the html version of this article.

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