1.8 Weeds in the treated field - a realistic scenario for pollinator risk assessment?

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Abstract

In July 2013 the European Food Safety Authority (EFSA) released its final guidance on the risk assessment of plant protection products (PPPs) to bees[1]. One objective of the guidance was to produce a simple and cost effective first tier risk assessment scheme to ensure that the appropriate level of protection is achieved. However, recent impact analyses have indicated that the first tier of this risk assessment does not act effectively as a screen for compounds of low risk to bees. For example substances showing no toxicity to bees often fail the tier 1 risk assessment based on a worst-case exposure to flowering weeds inside the treated field. If realistic farming practices (e.g. tillage and herbicide applications) are considered, weeds are not usually prevalent in arable fields. It is therefore suggested that the scenarios in the guidance could be considered overly conservative and in some instances unrealistic. The EFSA guidance states that if <10% of the area of use is flowering weeds then the exposure route is not relevant in the 90th %ile case, and thus does not need to be considered. However, despite this, the option to generate data or refine assessments based on available data is questioned as no guidance for the assessment of the abundance of weeds is available. As part of an industry-led initiative we present and discuss the use of empirical evidence (i.e. occurrence and growth stage of weeds in control plots from herbicide efficacy field trials conducted for regulatory submission) to illustrate that the scenarios in the guidance document could be modified using currently available data to create a more effective tier 1 risk assessment and still ensure that the appropriate level of protection is achieved.

We have demonstrated here that less than 2% of all weeds recorded in arable crop trials (represented here by wheat, oilseed rape, sugar beet, sunflower, potatoes, maize, peas and beans) are at a flowering growth stage; therefore in arable crops the flowering weeds scenario is not applicable for the 90th %ile exposure. For permanent crop trials (represented here by orchards and vines) 37% of weeds were recorded at a flowering growth stage. When the attractiveness and density data are considered, the percentage of attractive, flowering weeds which cover >10% of the ground area is only 12.3%, indicating that for permanent crops further investigation may be required as to whether this scenario is relevant.

1. Introduction

In recent years the European Food Safety Authority (EFSA) has increased its programme of preparing guidance and opinions in the field of environmental risk assessment. In July 2013 the EFSA released its final guidance on the risk assessment of plant protection products (PPPs) to bees. This was followed by an amended version (July 2014), intended to clarify the assessment procedures[1].

The EFSA bee risk assessment scheme requires a first tier assessment through various exposure scenarios, one of which is exposure to bees through foraging on attractive weeds within the treated field. The guidance suggests, as a refinement option, that if <10% of the area of use is covered in attractive weeds then the exposure route is not relevant in the 90th %ile case. However, despite this, the option to refine this scenario is denied as no guidance for the assessment of the abundance of weeds is available[1].

Efficacy trials for herbicides follow common practices throughout Europe, are designed to measure weed coverage in-field, and are of a standard suitable for regulatory submissions (Biological Assessment Dossiers). Therefore it is considered here whether such efficacy trials not only represent available data to identify whether such weeds are prevalent in treated fields but also guidance for measuring weed abundance. Such field trials are conducted frequently by industry to support submissions throughout Europe and thus a significant quantity of data are available considering worst case weed distribution within crops. This project aims to, using this empirical evidence, answer the question posed by the EFSA bee guidance document regarding the relevance of the weeds in the treated field scenario: "*Is a significant fraction of the surface area of treated fields covered by attractive weeds for >10% of the area of use?*"

2. Materials and methods

2.1 Data collection

A cross-industry group (Syngenta, Bayer, BASF, Dow AgroSciences and Monsanto) collected herbicide efficacy trials data from the control plots of 9 different crop groups (wheat, oilseed rape, sugar beet, sunflower, potatoes, maize, peas, beans and permanent crops (orchards and vines)). Trials were selected from internal databases held at each company. Some companies keep a database of all trials, some only keep those trials for registered products. Each company collected data from either all or a sufficiently high number of trials available on the crop allocated to them and thus there is not anticipated to be any bias during data collection. The data collected includes, but was not limited to crop type, crop growth stage, application date, trial location, tillage information, weed species, growth stage, and ground coverage.

Weed and crop species were recorded using both the latin species (or common) names and the approriate EPPO code[2] (previously known as BAYER codes). The use of such codes ensured that spelling differences or alternative or previous names of species of weeds were standardised. EPPO codes were also used for crop idenitification. Growth stages of both weeds and crops were recorded using the standardised BBCH scale[3]. Ground coverage data tended to be recorded (if available) using one of two methods: percentage ground cover or number of plants/m^2. For one crop, oilseed rape, weed density data was almost exclusively recorded as number of plants/m^2. Trial locations were recorded as country, GPS co-ordinates and/or postal/zip codes where available.

2.2 Data analysis

In order to answer the question posed in the EFSA guidance document it is important to establish whether weeds are present, whether they are attractive to bees, and how much area any attractive weed covers. A three stage assessment process was used for analysing the data, to attempt to quantify the coverage of relevant attractive weeds in the in-field area of use.

1. First the quantity of weeds recorded within the field at a flowering growth stage was defined as those observed with a growth stage of BBCH ≥60[3]. These weed recordings were initially filtered from the dataset in order to give a percentage of weeds which were 'flowering' and thus have potential to be attractive (Table 1).

2. Secondly these weeds highlighted as being present and potentially attractive were then assessed for attractiveness to bees. No known definitive list is available for non-crop species and attractiveness to bees, so the species were categorised based on monoctyledonous as a surrogate for non-attractive plants, and dicotyledonous as a surrogate for attractive plants.

3. Finally the data on ground coverage can be combined with that of the above and used to establish the percentage coverage of attractive weeds throughout the area of use.

The data analysis presented here is not completed with all crops at this early stage; however, focused analysis has been conducted on particular crops in order to demonstrate whether attractive flowering weeds are of concern in these crops when considering exposure to bees. This publication also acts as a demonstration of the methodology which could be used to refine the risk assessment scenarios in future guidance.

3. Results and discussion

3.1. Percentage of weeds recorded at a flowering growth stage

Initial simple analysis of those weeds recorded at a potentially attractive growth stage (BBCH ≥60) indicate that attractive weeds generally account for a very small percentage of those weeds recorded in-field (Table 1).

Table 1 Database size for each crop and the % of weed recordings which were above a flowering growth stage.

Crop	Total number of trials examined	Total number of weed recordings in all trials	% weeds recorded at BBCH ≥60
Wheat	1024	9113	0.86%
Maize	7669	38421	1.94%
Oilseed Rape	1022	3587	1.28%
Sunflower	388	1435	1.11%
Potatoes	182	1159	1.04%
Sugar Beet	156	5006	0.12%
Peas	650	5780	0.48%
Beans	203	1807	1.49%
Permanent Crops	233	552	37.0%

In the first assessment step it can clearly be demonstrated that for the arable crops studied, weeds at a flowering growth stage account for less than 2% of the weeds present in these trials. In permanent crops, likely due to the difference in agricultural practices, around 37% of the weeds present are at or above a flowering growth stage. However it is important to emphasise that many of these weeds are species which are not attractive to bees.

3.2 Percentage of weeds assessed to be attractive

Weeds which are observed as flowering can be analysed in terms of potential attractiveness to bees. As an initial screening step assessment, the weed species were split into mono- and di-cotyledon species as a surrogate for non-attractive and attractive weeds, respectively. This step of analysis has been demonstrated below for permanent crops for all those weeds observed at a BBCH ≥60. This indicates that of the 37% of individual weed recordings which have been identified to be observed at a flowering growth stage around quarter of these are likely to be unattractive to bees. Thus this reduces the percentage of potentially attractive weeds from 37% to 28.5%.

Table 2 Data for permanent crops (orchards and vineyards) showing number of mono- and dicotyledonous species and the respective percentages in terms of species diversity and abundance in the investigated trials.

Permanent crops (Vineyards/Orchards)	Total weed species at BBCH ≥60	Monocotyledonous	Dicotyledonous
Number of species	77	15	62
Number of recordings	204	47	157
Percentage of recordings (n=552)	37%	8.5%	28.5%

The classification of attractiveness of weeds in arable crops has not yet been conducted as the percentage of weeds has been shown to be low enough to be of little concern even if all weeds are attractive.

3.3 Percentage ground coverage of weeds

It is essential to investigate the density and thus the area covered by these weeds: data which are commonly available as part of these trials. Figures 1-5 show initial example plots for some crops showing weed BBCH stage and measurement of % ground cover where these data are available. Reference lines have been added to highlight the area of the graph which indicates weeds of BBCH ≥60 and ≥10% ground coverage, with the shaded area denoting the area where individual recordings exceed these values. It is important to note that not all trials conducted recorded density data and not all of those that did, recorded the data as '% ground cover', therefore figures 1-5 represent a smaller dataset than presented above, but does give a good indication of the incidence of flowering weeds present in treated fields.

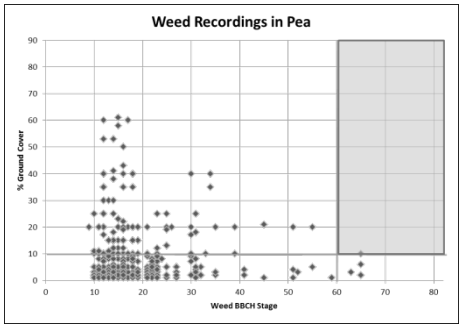

Figure 1 Plot of individual weed recordings observed in pea trials

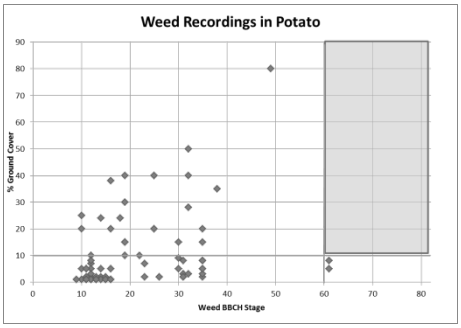

Figure 2: Plot of individual weed recordings observed in potato trials

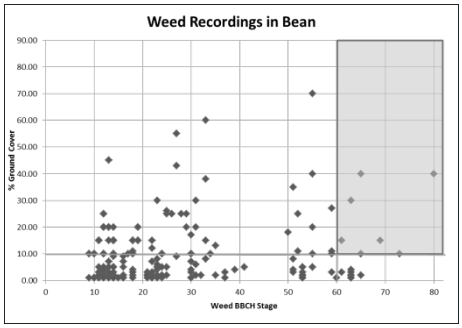

Figure 3: Plot of individual weed recordings observed in bean trials

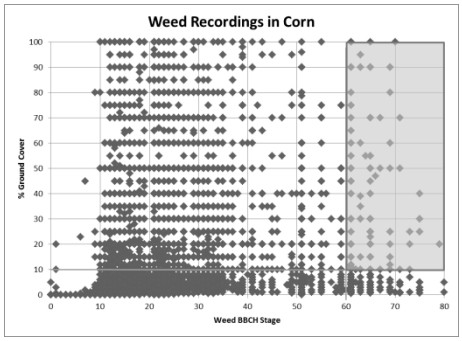

Figure 4: Plot of individual weed recordings observed in corn trials

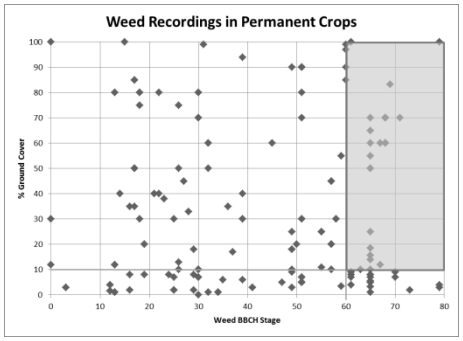

Figure 5: Plot of individual weed recordings observed in permanent trials

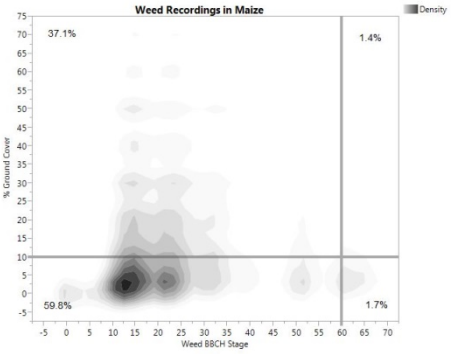

Figure 6 Density plot of individual weed recordings observed in corn and permanent crop trials. The darker areas of the graph indicate more dense collections of data points, while lighter areas indicate sparse recordings. The percentages given in each section of the graph are the % of data points in each section.

This data presentation allows the weed recordings of concern to be highlighted, and demonstrates that the majority of incidences of weeds are either at a pre-flowering stage or are below 10% ground cover and therefore do not trigger concern for the 90th %ile exposure case. Athough it appears in some instances that a large incidence of weeds are present at a flowering growth stage and above 10% ground cover it is important to consder the size of the entire data set and the relative percentages in each sector of such a graph. Figure 6 shows a density plot for the maize trials (prepared using JMP® statistical software[4]) and highlights how the data are spread and visually highlights that the majority of data points are not of concern for exposure to bees.

3.4. Combination assessment – Attractive, flowering weeds, at ≥10% ground coverage

When the identification of weed recordings which are BBCH ≥60 and ≥10% ground coverage are combined with the identification of mono- and dicotyledonous species we can see that even for crops of high weed coverage attractive species are not abundant at flowering growth stages and above 10% ground cover (Table 3). For permanent crops we can demonstrate that, considering weeds at a flowering growth stage and present at ≥10% ground cover, only 12.3% are also potentially attractive to bees.

Permanent crops (Vineyards/Orchards)	Total weed species at BBCH ≥60 and ≥10% ground cover	Monocotyledonous	Dicotyledonous
Number of species	12	5	7
Number of recordings	35	14	21
Percentage of recordings (n=177)	20.5%	8.2%	12.3%

Table 3 Data for permanent crops (orchards and vineyards) showing number of mono- and dicotyledonous species present at flowering growth stage and above 10% ground coverage and the respective percentages in terms of species diversity and abundance in the investigated trials.

3.5. Discussion

Herbicide efficacy field trials have been used here for the first time to address the question of potential exposure of bees to plant protection products from attractive flowering weeds in the treated field. The trials used are those submitted during registration of plant protection products within the biological assessment dossier. The data extracted from these trials were considered to

represent an extreme worst-case scenario as the data were taken from control plots and had no treatment or agricultural practices to control weeds. In addition the plots used for such trials are often in locations with known high weed pressure, as the target is to demonstrate efficacy against such weeds. In reality farming practices aim to reduce weed pressure through, amongst other techniques, crop rotation strategies, appropriate tillage, mowing or mulching and herbicide applications. Therefore, the plots used here for this data collection should be considered as worst-case examples of agricultural environments in terms of weed abundance.

Particularly for the arable crops studied (wheat, maize, oilseed rape, sunflower, potatoes, sugar beet, beans and peas), flowering weeds were not generally observed in the field trial plots. The percentage of weeds which were observed at a 'flowering' growth stage (BBCH ≥60) were less than 2% of all the weeds recorded. Therefore, the percentage of those weeds which would be attractive would always be <10% and the weeds in the treated field scenario would not be relevant for the 90th %ile exposure in the area of use. In permanent crops the agricultural practices are different and therefore in this instance the percentage of weeds at a 'flowering' growth stage is unsurprisingly higher. Current risk assessment practices (EPPO 2010[5]) already account for this, and this scenario is considered by using a worst-case of an attractive treated crop for such uses. Plant protection products for use in orchards or vineyards which indicate a risk, e.g. some insecticides, may also have extensive field or tunnel based effects tests. Such effects testing is conducted on attractive flowering crops and therefore would adequately cover the risk to bees from such a scenario as abundant flowering weeds in the treated field. Where a risk assessment using standard or higher tier effects based testing demonstrates acceptable risk to bees, the risk from exposure via weeds is covered. However, current guidance also allows for mitigation of this risk through removal of weeds from the treated area (e.g. mowing in orchards).

In addition, the methods shown here have demonstrated that using other data available in efficacy trials can demonstrate that weeds are not a relevant exposure scenario. An example of such data is weed density information. In a number of the trials investigated here, weed density was recorded as percentage ground coverage of each weed species in each trial. This information usefully allows for a direct comparison to the proposed trigger of 10% coverage in the EFSA guidance document[1]. However, in many cases the majority of the trials investigated have weed density information recorded using the measure of number of plants/m^2. There is currently no available conversion of this measure to a useful percentage coverage measure and thus this data has not been analysed here. Some of the trials contain information on the diameter of weed species at the various growth stages present. Thus it is thought that this may be a useful way of utilising more of the available density data for future analyses.

Some initial analysis has been conducted on the potential attractiveness of the observed weed species. As no definitive list of attractive and non-attractive non-crop plant species is known to the authors, initial analysis focused on distinguishing between mono- and di- cotyledonous species as a surrogate for non-attractive and attractive weeds respectively. Clearly this is not a definitive or comprehensive definition of atractiveness as there are attractive monocotyledonous species and non-attractive dicots; however, it was considered that this was suitable for this initial analysis. Further work is planned on those weeds observed in these trials, and establishing whether further weed species can be eliminated as non attractive (e.g. wind pollinated dicotyledonous plants) or included as attractive (e.g. attractive monocotyledonous plants).

There are still many parameters available in this database to help distinguish when and where the scenario of flowering weeds is applicable for exposure of bees to plant protection products. Other possible parameters for further investigation include, but are not limited to, investigation of GPS trial location, EU zone, crop BBCH stage, application timing (calendar timing) and pre-application tillage information. Further analysis is proposed and will be presented in future publications.

4. Conclusions

For the arable crops assessed in this study, the data analysis presented has demonstrated conclusively that the 'weeds in the treated field scenario' is not applicable. For the arable crops: wheat, oilseed rape, sugar beet, sunflower, potatoes, maize, peas and beans, less than 2% of all weeds recorded were found to be at a flowering growth stage (BBCH ≥60); despite the data being recorded in control trial plots with no weed control measures. When further investigations into the ground coverage of such weeds it is clear that the weeds in arable fields do not present a 90th %ile exposure scenario for bees.

For permanent crops a maximum percentage of 12.3% of the recorded weeds were potentially attractive (dictyledonous) flowering weeds (BBCH ≥60) and present at greater than 10% ground coverage. This inidicates potential concern for the flowering weeds in the treated field for this crop; although again it is noteworthy that the data examined here represent a very worst-case scenario. Due to current risk assessment schemes, extensive field and semi-field testing and precautionary risk mitigation measures available to risk managers, it is considered that the risk to bees is appropriately controlled using current practices for permanent crops. However, further work focusing on the use of larger datasets including other measures of ground coverage and more extensive investigation of the attractiveness of the recorded weed species will likely clarify the position with permanent crops and strengthen the case for arable crops.

5. References

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