Efficacy Crop Guide 03 - Maize

Interpretation of efficacy data requirements for the authorisation of a plant protection product in all varieties of *Zea mays* (ZEAMX) including grain maize, forage maize, and sweetcorn in GB and NI

Contents

Introduction

This document is intended to assist applicants in addressing and interpreting current efficacy data requirements, and relevant accompanying EPPO standards, with specific focus on maize. It provides supplementary information on GB and NI agronomy, including relevant GB/NI targets and trials numbers for a GB/NI-only authorisation.

Trials should be carried out under Good Experimental Practice (GEP) and using all the relevant general EPPO Standards. Effectiveness and selectivity trials should be performed according to the EPPO standard 'PP 1/181 - Conduct and reporting of efficacy evaluation trials including good experimental practice' (available from the EPPO website).

All trials should be carried out with the final formulation for which authorisation is being requested. If other formulations were used such data may still be useful support for the proposed formulation, however bridging data or a sound scientific justification should be supplied to demonstrate comparability of the formulations and allow bridging between formulations. Further details on supporting formulation changes can be found in EPPO 'PP 1/307 Efficacy considerations and data generation when making changes to the chemical composition or formulation type of plant protection products'.

Area of maize in the UK

In the UK in 2023 there were approximately 17 million hectares of utilised agricultural land, of which 4.5 million hectares (26%) was used for arable crops. Of the land used for arable crops in the UK, 240,000 hectares (5%) were used to grow maize. In NI specifically, around 2,000 hectares were used to grow maize in 2021, which equates to 4% of the NI land used for arable crops. The area grown has gradually increased over the years and was over 50% higher overall in 2023 compared to the 158,000 hectares grown in 2012. Forage maize is the second greatest non-cereal arable crop by hectarage grown in the UK after oilseed rape. It is also the second greatest noncereal arable crop by hectarage grown in NI after potatoes (Sources: Agricultural Census, Pest status review in arable and horticultural crops of Northern Ireland and Great Britain).

Types of maize

Maize (ZEAMX) includes all varieties of the species Zea mays, and encompasses forage maize, grain maize and sweetcorn. Although these types of maize are all the same species, in terms of the CRD Crop Definitions (2020) they are considered separate crops:

"Grain maize: Maize (Zea mays) grown for the harvesting of mature cobs / grain for animal or human consumption."

"Forage maize: Maize (Zea mays) grown for forage. Not for human consumption"

"Sweetcorn: Varieties of maize (Zea mays) grown for harvest when the endosperm is still soft and sweet for consumption as a vegetable. Includes baby corn."

Grain maize

Grain maize is a minor crop and represents around 5% of all maize grown in GB and NI. Grain maize is harvested later than other maize crops when the cob is mature.

The grains are stripped off the cob and used for either human or animal consumption.

Forage maize

Forage maize is a major crop and represents the vast majority of the maize grown in GB and NI. Forage maize is grown predominantly for animal feed, including as silage. Around 30% of the maize grown in the UK is grown for energy production in biogas plants via anaerobic digestion (AD). This 'energy maize' falls under the forage maize umbrella as this covers maize that is not grown for human consumption.

Sweetcorn

Sweetcorn is a minor crop in GB and NI. Unlike grain and forage maize, sweetcorn is harvested for consumption as a vegetable, which can be consumed on the cob, or as smaller 'baby corn', or as fresh or frozen kernels removed from the cob.

Maize production in the UK

General information

Maize, a member of the grass (Poaceae) family, is naturally adapted to growing in hotter and drier climates. Unlike most other grass crops such as wheat and barley, which are in the Pooideae subfamily, maize is in Panicoideae subfamily. Maize, along with relatives from its subfamily such as sorghum and sugar cane, has evolved a different form of photosynthesis, 'C_4', compared to most plant species (including the Pooideae), which use 'C_3' photosynthesis.

'C_4' plants are generally more drought tolerant and have a higher photosynthesis efficiency, approximately 50% higher than 'C_3' plants such as wheat. However, 'C_4' plants such as maize, sorghum, and sugar cane have evolved in warmer and drier climates than the UK and do best where those conditions are met.

Maize needs a defined amount of heat to reach maturity. Ontario Heat Units (OHUs) are an internationally recognised system, based on minimum and maximum air temperatures, to show if maize can be grown successfully in a particular location. Maize should not be grown in areas that receive <2100 OHUs, 2100-2200 OHUs is marginal, and anything >2200 is suitable. However, to consistently grow maize successfully, >2900 OHUs are required. Most of England is suitable for growing maize except areas of higher altitude, the exposed and wetter west and the cooler north, all of which are marginal. Air temperature drops as altitude increases, resulting in lower OHUs and yield potential; therefore, low lying fields are preferable. Most of Scotland, Northern Ireland and Wales are either marginal or unsuitable, but there are some suitable or favourable areas, particularly the south and west of Wales.

Soil type and field aspect are other factors that can affect the viability of growing maize in a particular field. South-facing fields receive more heat than others; however, steep slopes increase the risk of soil erosion and should be avoided. North-facing slopes will receive lower OHUs and are a poor option for maize. In terms of soil, maize does poorly in heavy

and wet soils, which take a longer time to warm up, delay drilling and germination, shorten the growing season, and result in later harvests. Later harvests on heavy, wet soils can also be problematic with machinery access and soil compaction. However, soils that are too light pose a higher risk of soil erosion and for this reason medium soils are best for maize.

Due to the specific growing conditions required for maize and its preference for warmer and drier climates, the varieties of maize that are suitable to maize are far more limited in the UK compared to other areas of the world. The shorter summer and lower OHUs means that earlier maturing varieties are required. Recent introductions of earlier maturing hybrid varieties have increased the areas of the UK where maize can be successfully grown. Later maturing varieties are generally viable options for farms south-east of a line drawn from the Wash at the north end of Norfolk to the Severn Estuary and onwards through Devon. The use of plastic films may also increase the viability of later maturing varieties by providing an earlier harvest.

Maize is a monoecious plant and contains both male (tassel) and female (ear) reproductive structures. Pollination occurs when pollen is transferred from the tassels to the ears. 4-5 ears are initiated but usually only 1 matures (and forms a cob) per plant.

Sowing

Soil temperature is the most important criteria for determining the sowing date of maize, as the seed remains dormant and will not germinate until the soil temperature reaches 10°C. The longer the seed remains dormant in the soil, the higher the risk of disease. The sowing date will vary based on location, variety, and weather/soil conditions. In general, the 15th of April is the earliest sowing date in the UK and will typically extend to the first week of May, although drilling is possible into June. Sweetcorn is drilled from April to July.

Maize is sometimes grown under biodegradable plastic film. This is very common in sweetcorn, as it is a high value crop, but it is sometimes used in other maize crops as well, particularly in areas with marginal OHUs. This is done using highly specialised 3in-1 machinery, which sows the maize seed, sprays a residual pre-emergence herbicide, and applies a thin layer of compostable plastic film over the soil. The plastic film increases the air and ground temperature, protecting the maize seedlings from adverse weather and late frosts. Benefits of this system include a higher yielding, better quality crops, accelerated growth and earlier sowing and harvest dates, which can result in better soil conditions at harvest and more time to drill a following crop before winter. However, the system is costly and requires an additional 7.5-12 t/ha yield increase to recoup the investment (forage maize yield is variable, but the average fresh weight yield is roughly 45 t/ha). Additionally, it limits weed control options and only certain varieties can be grown in this manner as they must be able to pierce through the plastic film.

The following factors must be met prior to sowing maize:

- Soil temperature consistently ≥8°C – measured for 5 consecutive days at a depth of 8-12 cm*
- Favourable forecast (i.e. the risk of frost has passed)

- Ground conditions are suitable for machinery to travel on

*On heavier soils, the soil temperature should be consistently ≥10°C. If grown under plastic, 6°C is sufficient.

Maize is typically precision drilled at a depth of 2.5-10 cm, with rows 75/76 cm apart and 10-13 cm between each seed, targeting a final plant population of 90,000-110,000 per ha (9-11 plants/m^2). A lower seed rate of 89,000-94,000 seeds/ha can be used for grain maize rather than 103,000-111,000 seeds/ha for forage maize. Sweetcorn is typically grown with ~65,000 seeds per ha, with ~5,800 seeds per kg, equating to ~11 kg seed per ha.

Most fields are ploughed prior to sowing maize, but minimum–tillage or strip tillage (cultivating only the rows where seed is drilled into) is also used. Medium soil is best with a fine seedbed and good moisture level around the seed. Maize has a poor tolerance of acidic soils.

Growth stages

The application time of a PPP in the Good Agricultural Practice (GAP) and on the product label should follow the BBCH-scale to define the growth stages of maize.

Crop protection

Rotations of maize with other crops can negate or at least reduce the need for some fungicide and insecticide treatments in maize. Some pests (frit fly (OSCIFR), wireworm (AGRISP)) can be a significant problem when maize is sown after grass. Fungicides are used mostly for the control of eyespot (KABAZE), but they are not applied as ‘routine sprays’ as machinery going through the crop at the required time can cause damage. Therefore, the crop will only be treated if the disease is identified.

There are currently no Plant Growth Regulators (PGR) used on maize in the UK.

Most crops of maize require 1 or 2 herbicide treatments, as maize is widely spaced and poorly competitive against weeds in its early growth stages.

Typical water volumes for plant protection products used on maize tend to be in the range of 200-400 L/ha.

Harvesting

The harvest time of maize depends mostly on the dry matter content (DM%) of the maize but will also depend on the type and variety of maize and the weather. In the UK, harvest generally starts from mid-September and can run throughout October and into November. The DM% increases over time so it is necessary to wait until the desired DM% has been reached. Weather is also important and harvesting in wet conditions should be avoided.

Grain maize

Grain maize is also known as ‘corn’ and is harvested when the grain is at about 30% moisture. It needs to be dried to 14-15% moisture within 48 hours after harvest. It is not commonly grown in the UK due to the harvest date, which is later than for forage maize. There are, however, some varieties which can be grown in certain parts of the UK. The UK market for grain maize is greater than 1m tonnes a year, with two main end markets: Livestock feed (red spindle varieties) and premium market for pet food and wild bird feed (white spindle varieties).

Grain maize is also grown for crimping or as whole cob maize (ground ear maize). This is ensiled to feed as a concentrate, either conventionally combined with a maize ‘header’, or the whole cob is foraged through a forage harvester for livestock feed. It is harvested once the DM% has reached 65-70% (crimping) or 60-65% (ground ear maize). This is much higher (drier) than forage maize and as a result, grain maize is harvested 3-6 weeks later than forage maize, at about BBCH 87-89. In addition to the DM% increasing over time, the starch content increases, resulting in grain maize having considerably higher starch levels than forage maize (e.g. 65-70% starch in the DM of crimped grain maize vs. 25-35% in the DM of forage maize silage), slightly higher protein, and higher metabolisable energy. Grain maize is harvested using a conventional combine with a specialised ‘stripper-header’ attached to harvest only the cob. This can result in lower soil damage due to the machinery travelling on a mat of chopped maize stalks.

Forage maize

Forage maize should be harvested as a whole crop when the crop is at 28-35% DM, with the optimum being 32-34%, which is a compromise between quantity and quality. This is typically when the grain is yellowing but there is still some green in the leaves, from when it is doughy (‘milk line’ 1/3 down grain) until the top is hard and glassy/shiny (‘milk line’ 1/2 down grain). If the ‘milk line’ has reached the bottom of the grain then the DM% will be too high. This equates to about BBCH 85-87; the kernels themselves will have a high dry matter content (e.g. 55-60%) at this point, but it is the whole plant DM% that is important for forage maize. The whole forage maize plant is harvested apart from a short section of stem and the roots which are left in the ground. A forage harvester is used which cracks the corn and chops the maize into 12-18 mm pieces. As the ground is left mostly bare after forage maize harvest, there is a high risk of compaction, run-off and soil erosion if a new crop is not drilled before winter.

Sweetcorn

Sweetcorn is a specialist vegetable crop which requires a dedicated harvester and specific varieties of maize, bred to retain high sugar levels. It is harvested earlier than other types of maize, when the grain is still soft and before the sugars have been converted to starch. This will typically be in August and September in the UK at around BBCH 73-75. Sweetcorn is harvested with specialist machinery, which takes only the cobs. ‘Baby corn’ is harvested much earlier almost immediately after silks emerge, before pollination occurs.

Rotation

In the UK, maize is mostly grown as a 'break crop' in rotation with cereals. As with other spring-sown crops, growing maize offers growers an opportunity to deal with black-grass problems that can develop due to an over-reliance on winter cereals. However, returning to wheat after a maize crop can result in a greater risk of Fusarium and the associated mycotoxins. Maize can feasibly be grown continually; however, it benefits from rotation which reduces the build-up of pests, weeds, and diseases, and improves soil nutrient content. 'Trash' from previous crops of maize can be a source of disease infection in successive crops of maize. Eyespot for example overwinters on infected maize stubble and therefore, ploughing maize stubble or rotation with other crops can reduce the risk.

Growing maize, in particular forage maize, can lead to soil and environment issues post-harvest, particularly where appropriate action is not taken. Due to whole-crop harvest, wide rows and low-density planting, there is a large amount of bare soil after harvest of forage maize. Leaving soil bare over winter can potentially lead to soil erosion and run-off, resulting in leaching of nutrients and pesticides, sedimentation of rivers, and flooding, along with the associated environmental and drinking water problems. This is exacerbated by the late autumn harvest time of maize, which can result in machinery compaction of the soil and make it difficult to establish a following crop before winter. These problems can be overcome by sowing a new crop or an over-wintering cover crop soon after harvest or by using a companion crop with the maize.

The maize market in the UK

Only 5% of the UK maize crops are grain maize. It can be used both in human food, but is also a high-quality animal feed, with higher DM% protein and metabolisable energy than forage maize. It can be ensiled and fed to animals as a concentrate. However, it is harvested later (November) and requires higher temperatures and longer summers, so grain maize is typically confined to the most southern areas of the UK.

Sweetcorn is only grown on a small area of the UK by specialist growers. The cobs are harvested and sold as fresh vegetables in supermarkets. They are cooled and packaged quickly after harvest to extend their shelf-life. Waste material from the cob (e.g. the husk and cob ends) can be used in AD plants to make gas and energy.

Most of the maize grown in the UK is forage maize, as its earlier harvest date and lower heat requirement makes it more suitable for the climate. Forage maize is grown for animal feed which involves harvesting the whole plant and ensiling it. Silage is a product made from a crop that has been preserved in acid. The harvested maize undergoes anaerobic fermentation, whereby, in the absence of air, bacteria present in the plant material convert plant sugars into acid (primarily lactic acid). The ensiling increases the digestibility and starch content over time. There are multiple benefits to maize silage over other types of silage, including high palatability compared to grass only silage and high energy and starch contents. Additionally, whole crop maize is very high yielding per hectare (e.g. compared to whole crop wheat), only requires a single harvest compared to 2-3 cuts for grass, produces consistent silage feed quantity and quality, has reduced additive needs, and if

harvested at the correct DM% it produces minimal effluent. However, maize silage does have low protein content and should be combined with other high-protein feeds.

Around 30% of the UK maize consists of 'energy maize' (forage maize grown for energy production). The whole plant is harvested as for usual forage maize and is used in AD plants in the biogas industry. Maize is the largest crop grown for biogas in the UK as its high starch content helps it produce a high quantity of methane per tonne of fresh weight. A hectare of maize can produce up to 10,000 m^3 of biogas, which contains roughly 50-75% (typically 60%) methane and 25-50% (typically 40%) CO_2, although there are other gases at lower quantities, such as nitrogen (2-8%), ammonia, and hydrogen sulphide. The biogas produced can be used in heat and energy production and the remaining liquid digestate can be used as a fertiliser.

Addressing Efficacy Plant Protection Product Data Requirements (IIIA 6)

(IIIA 6.1) Preliminary data

Results of preliminary tests and early screening studies can provide useful information on, for example, dose justification and evidence of safety to potential following crops.

(IIIA 6.2) Minimum Effective Dose

Trials should be conducted in accordance with EPPO standard 'PP 1/225 - Minimum effective dose'. Minimum effective dose trials should be conducted to demonstrate that the proposed dose is justified for the chosen representative use(s). Most of the data should be generated where target pressure is highest, but a proportion of trials should still include areas of more variable target pressure. A justification for the number of applications applied may also be required if multiple applications are proposed. Minimum effective dose should be based on the key targets or representatives of them, and these are presented below.

(IIIA 6.2) Effectiveness

For the purposes of effectiveness, all types of maize (grain, forage, and sweetcorn) are considered the same crop and extrapolation between the types is acceptable.

Location of trials

As a general principle, data generated from outside of the UK may be used to support a UK authorisation. The acceptability of the data will be dependent on detailed evidence and an appropriate case on the comparability to the UK agricultural, plant health and environmental (including climatic) conditions, relevant to the use of the product, in the reference country. EPPO standard 'PP 1/241 - Guidance on Comparable Climates', provides more detail on this approach. (In addition, EPPO standard 'PP 1/269 - Comparable climates on a global level' discusses the climatic relevance of data generated outside the EPPO region. This will be relevant as part of an appropriate case, which should follow the principles above and additionally consider the conduct of trials in relation to EPPO standards).

Further, EPPO standard 'PP 1/278 - Principles of zonal data production and evaluation' discusses the various factors involved in considering trials planning on a more regional basis and ensuring all relevant conditions are tested. This may also be useful in considering the reasoned arguments on the relevance of data to the UK, as well as if an authorisation in the UK may be sought as part of a wider, regional regulatory submission.).

Trials reporting

Trials should be conducted in accordance with EPPO standards 'PP 1/181 Conduct and reporting of efficacy evaluation trials including good experimental practice' and 'PP 1/152 - Design and analysis of efficacy evaluation trials'. The key information should be presented in appropriate summary tables which should include (but is not exclusive to):

For all product types: crop growth stage (BBCH) at time of application and calendar timing range; pest population levels at time of application and at each assessment; number of trials; mean percentage control/effect and the range of minimum and maximum levels, for both the test product and also for the reference products, at each assessment timing.

For weeds: weed species; weed growth stage (BBCH) at time of application and time of assessment; weed numbers at application and at the time of assessment (percentage ground cover or number/m²).

Results should only be included from trials conducted in accordance with EPPO Standards and where there are agronomically relevant pest populations present. It is not appropriate to have a prescriptive list of 'minimum populations' for all possible target organisms but indicative levels for weeds, pests and diseases are given below:

Target	Minimum population
Weeds	Broadleaved weeds – 5 plants/m^2 or 2% ground cover Grass weeds – depending on the growth stage at application and assessment: • 5 plants/m^2 or 2% ground cover • 20 heads/ears/tillers per m^2
Diseases	5% leaf area or 5% plants infected
Pests	Specific agronomic threshold (or case) – provide an appropriate published reference where possible

Number of trials

EPPO standard 'PP 1/226 - Number of efficacy trials' indicates that for authorisation in a single country/climatic zone, 6 to 15 fully supportive results are required over two years for each major use.

Where a major target is appropriately supported, it may be possible to have a reduced number of trials for minor targets (see tables below for specific targets). Typically, a minimum of 3 supportive trials are required per minor target in a single season. If, however, relevant major targets have not been supported then the primary target for that product should as a minimum be supported by 6 trials results (over two seasons).

EPPO 'PP 1/226' also states that "In some situations, there may be the opportunity to reduce the number of trials done, and a case may be made for this as follows". It then describes the situations where a reduced number of trials may be acceptable.

(As indicated above, if a UK authorisation is sought as part of a wider, regional regulatory submission, EPPO standard 'PP 1/278 - Principles of zonal data production and evaluation' may be relevant when considering trials numbers).

In determining the number of trials required for each target, the following information should be considered, relating to the major or minor status of that pest/weed/disease in the UK. In addition, reference should be made to the UK differential labelling scheme, outlining appropriate label claims supported by the effectiveness trials data (For further information, see 'GB and NI efficacy advice and product labelling' on the HSE website).

Pests of Maize in the UK

Where there are no existing data to extrapolate from, 6 trials are required for each major species, for example Frit fly and European corn borer. Extrapolation possibilities are described below. It is anticipated that general group claims for 'aphids' or 'caterpillars' will typically be requested (rather than individually named species). In such cases, a representative range of species should be included (at least 2 species per group) with a total minimum of 6 appropriate results. Individually named aphid or caterpillar species can be supported as described above.

Major foliar pests:

- Frit fly, Oscinella frit, (OSCIFR)
- Aphids, including Bird-cherry aphid (RHOPPA)

Major stem pests:

- European Corn Borer, Ostrinia nubilalis (PYRUNU)

Major soil pests:

- Wireworms, Agriotes spp. (AGRISP)

Minor soil pests:

- Western corn rootworm, Diabrotica virgifera virgifera (DIABVI)

- Cutworm, Agrotis spp. (AGROSP)

- Nematodes:

    - Cereal cyst nematode, Heterodera avenae (HETDNA
    - Root knot nematodes, Meloidogyne spp. (MELGSP)
    - Migratory, Pratylencus spp. (PRATSP)
    - Ditylenchus dipsaci (DITYDI)

Other UK pests of maize include slugs, leatherjackets (when grown after grass leys), and birds (rooks in particular).

Principles of extrapolation for pests

As stated above, for major pests, a minimum of 6 fully supportive results are required, with a minimum of 3 results for minor species unless a case for extrapolation has been made as described below.

It may be possible to reduce the number of required supportive results, or directly extrapolate from an existing data set, provided an appropriate reasoned case is made. This may be a relevant approach either for the same species on a different host crop; or extrapolating between closely related species. The reasoned case must consider all relevant factors, including sufficient information on the pest biology and crop agronomy.

For major pests, if there are sufficient data on cereals and/or grassland, then 3 appropriate trials results are sufficient for each pest/pest group in maize.

The EPPO Minor Use Extrapolation table for soil pests (e.g. Wireworm) indicates extrapolations can be made between any crops. In this case, wheat or barley may be an appropriate crop where data already exist. In the absence of available data from other crops, 6 appropriate results are required.

Cereal cyst nematode is a minor pest of cereals, and direct extrapolation from available cereal data may be possible. For other nematode species, a case should be made for relevance, and again it may be possible to extrapolate from other crops for each nematode group. Refer to the EPPO Minor Use Extrapolation tables for nematodes to identify key indicator groups. In the absence of available relevant data from other crops, 3 appropriate results are required.

Diseases of Maize in the UK

6 fully supportive trials are required for each major disease in maize. No extrapolation is possible from other crops, as the pathogens causing the diseases in maize, including eyespot, are different species to those in other crops.

Major diseases:

- Northern Leaf blight, Setosphaeria turcica (SETOTU)

- Eyespot, Kabatiella zea (KABAZE)

Minor Diseases:

- Damping-off, caused by Pythium spp. (PYTHSP)
- Fusarium ear rot, Fusarium spp. (FUSASP)

For any diseases other than those listed above, evidence would need to be provided to demonstrate that the target disease is present in the UK at levels that justify treatment. Furthermore, a benefit from the proposed use must be demonstrated.

Weeds of Maize in the UK

Maize is grown with large row widths and is poorly competitive against weeds in the early growth stages, during the first 6 weeks post-emergence. Once the maize plants are larger, weeds are shaded out and become less of an issue. As a result of its poor early competitiveness, there are a large number of important weed species in maize the UK. The following table shows the major weeds in maize in the UK. This is not an exhaustive list of all relevant weeds that occur in maize; all species not included in the table below are minor and will generally require 3 appropriate trials results to support a claim.

Black-grass (Alopecurus myosuroides (ALOMY)) and other competitive grass weeds (e.g. Bromus spp. (BROSS)) are not a major weed in maize itself, but are very important weeds within rotations, particularly those growing primarily winter cereals.

Growing maize can present a good opportunity to control these problematic weeds and reduce their population in successive crops.

Major Weeds: 6 appropriate trials results for each:		
Broad-leaved weeds		
Common chickweed	Stellaria media	(STEME)
Fat hen	Chenopodium album	(CHEAL)
Black bindweed	Fallopia convolvulus	(POLCO)
Redshank	Polygonum persicaria	(POLPE)
Cleavers	Galium aparine	(GALAP)
Mayweeds	Matricaria spp.	(MATSS)
Knotgrass	Polygonum aviculare	(POLAV)
Pale persicaria	Persicaria lapathifolia	(POLLA)
Volunteer oilseed rape	Brassica napus	(BRSNN)
Charlock	Sinapis arvensis	(SINAR)
Grass weeds		

Annual Meadow-grass	Poa annua	(POAAN)
Ryegrass species	Lolium spp.	(LOLSS)
Wild oats	Avena spp.	(AVESS)
Cockspur grass	Echinochloa crus-galli	(ECHCG)
Common couch	Elymus repens	(AGRRE)

Some extrapolations between related weeds in the table above may be possible (see below), allowing a claim to be supported with a reduced number of trials, particularly where comparable control of each related species has been demonstrated.

Principles of extrapolation for weeds

For major weeds a minimum of 6 acceptable trial results are required, with 3 results required for minor species.

In many cases it will be possible to make a well-argued case for extrapolation from one crop to another if there is sufficient information on the weed control required, the competitiveness of the crop and the factors affecting acceptable weed control in both crops. An example of where extrapolation to maize may be possible is where control of a weed has been sufficiently demonstrated in a similarly or less competitive spring crop. All requests for extrapolation should be supported with an appropriate reasoned case.

There is also some scope to extrapolate from one weed species to a related species, if one of the species is treated as a major weed and is supported by sufficient data i.e. at least 6 trials.

The steps below provides useful general guidance on extrapolation possibilities for maize:

Step 1

There is:

- evidence from major agricultural or horticultural uses
- public domain or overseas evidence

Is maize as competitive as the crops where weed control data already exists?

If yes, maize is more or equally as competitive, go to step 2

If no, maize is less competitive, go to step 5

Step 2

Are the same weeds claimed?

If yes, go to step 3

If no, go to step 4

Step 3
No new data required

End of steps

Step 4
In general 6 trials for major weeds and 3 trials for minor weeds

End of steps

Step 5
Are the same weeds claimed?

If yes. go to step 6

If no, go to step 7

Step 6
2 to 3 trials across range of weed species required, including moderately susceptible species

End of steps

Step 7
In general, 6 trials for major weeds and 3 for minor weeds

End of steps

(IIIA 6.3) Resistance

Reference should be made to EPPO standard PP 1/213 Resistance Risk Analysis and to any current CRD guidance on resistance.

(IIIA 6.4) Adverse effects on treated crops

For the purposes of crop safety, the different types of maize (grain, forage, and sweetcorn) are in some situations considered separate crops due to differences in growing, harvest dates and the harvested commodity itself. Extrapolation between the types of maize is on a case-by-case basis and a justification for any extrapolation is usually required. Specific crop safety data on each type may be required in some cases (e.g. for herbicides in sweetcorn, which is known to be a more sensitive crop, specific data are usually required). See point 6.4.2 below for further details.

(IIIA 6.4.1) Phytotoxicity to target plants (including different cultivars), or to target plant products

The tests should provide sufficient evidence to permit an evaluation of the possible occurrence of phytotoxicity or other harmful effects after treatment with the plant protection product. Reference should be made to EPPO standard 'PP 1/135 Phytotoxicity assessment'.

Relevant assessment parameters should be chosen on a case-by-case basis, depending on the product tested, mode of action, application time, etc. but may include:

- Delay in emergence
- Thinning (by counting or estimating the number of plants)
- Delay in growth (to a particular stage)
- Growth inhibition (reduced number of plants tasselling)
- Discolouration
- Necrosis
- Deformations

Evidence should be largely provided by conducting field experiments under conditions as near as possible to commonly accepted practice and which reflect the proposed GAP. Where soil type, geographic location or planting date can affect safety to crops, products should be tested on a range of sites/situations.

Observations on phytotoxicity should be made in both effectiveness (at the proposed dose) and any specific crop safety trials (for herbicides at the proposed dose (N) and 2N doses). Phytotoxicity can depend on BBCH growth stage at application, climatic conditions and the varieties grown.

It is known that soil type can affect the crop safety of a product, and knowledge of the safety of the active substance from other uses and situations may be beneficial in developing appropriate label text.

Crops covered with plastic mulch tend to be more prone to phytotoxicity than crops grown without plastic mulch. Therefore, confirmatory crop safety data are usually required to support the authorisation of a herbicide on maize grown under plastic. This applies to both new products and products with an existing authorisation on uncovered maize crops. An exception to this rule is PPPs based on pendimethalin, which has been shown to be safe to maize grown under plastic.

(IIIA 6.4.2) Effects on the yield of treated plants or plant products

For insecticides and fungicides, in line with EPPO PP 1/135, yield data are not normally required. Data for insecticides and fungicides are needed only for new active substances where a case for crop safety cannot be made.

For herbicides, specific crop safety trials in the absence of weeds must be conducted, including applications at N and 2N doses and trials should cover the range of proposed

growth stages and treatment times for each use. The tests should provide sufficient evidence to permit an evaluation of the possible occurrence of yield reduction after treatment with the plant protection product.

Specific crop safety trials should be located across the EPPO climatic zone in areas representative of maize cultivation. EPPO standard ‘PP 1/226 Number of efficacy trials’ indicates that for authorisation in a single country/climatic zone, typically, at least 8 trials per major crop are required in an area of similar conditions, to cover the range of conditions of use, including soil types, weather conditions that are likely to be encountered.

The number of crop safety trials required for a herbicide will also depend on the types of maize which are requested. Forage/silage maize is the most important type in GB/NI and is considered a major crop, whereas grain maize and sweetcorn are minor crops. If use on all types of maize is requested, it would usually be necessary to include some crop safety trials on all maize types. At least 8 yielded crop safety trials in forage maize, 3 in grain maize, and 3 in sweetcorn, but this number may be reduced where there are clearly no adverse effects and/or for active substances known to be crop safe in maize (e.g. if the PPP only has activity against dicotyledonous plants). Different assessments of yield and/or quality are required for each maize type, and phytotoxicity, where it affects the cob, will be more important in sweetcorn.

It is essential that symptoms of phytotoxicity are clearly linked to any subsequent yield effects. Evidence of no unacceptable adverse effects on yield (quantity) is particularly important in instances where use of the product has caused phytotoxicity.

In line with EPPO PP 1/50 ‘Weeds in maize' and EPPO PP 1/135 the following assessments are typically required:

- Grain maize: Total grain yield in kg/ha adjusted to a relevant fixed moisture level
- Forage maize: Fresh and dry weight of forage
- Sweetcorn: Total fresh weight of cobs without husks

Yield should also be presented as a % of the untreated control.

(III 6.4.3.) Effects on the quality of plants or plant product

Taint

This is not relevant to maize.

Quality

No specific quality data are required for maize. The phytotoxicity and yield assessments are the important aspects of crop safety in maize.

(IIIA 6.4.4) Effects on transformation processes

EPPO standard PP1/243 ‘Effects of plant protection products on transformation processes’ indicates that an assessment of the effects of plant protection products on crops for silage could be appropriate. If the applicant can demonstrate that residues are undetectable, or

that any residues will not affect yeasts/lactic bacteria, a reasoned case may be sufficient to address these requirements. Data from preliminary screening tests for biological activity may provide valuable evidence of the absence of effects on yeasts or lactic bacteria.

(IIIA 6.4.5 Impact on treated plants or plant products to be used for propagation

Maize grown in the UK is not commonly grown for seed; however, an authorisation maize does not preclude the use on seed crops, unless the label specifically advises against it. Therefore, potential effects on germination of harvested seed must be considered to demonstrate an acceptable risk. Table 2 in EPPO standard PP 1/135 outlines where, if any, data are required. For fungicides, insecticides, and molluscicides, data are only required if a product has systemic activity, is applied close to harvest and phytotoxic effects are seen on the treated crop. For herbicides, data are only required for post-emergence foliar applied treatments, where applications are made at or after inflorescence initiation, which for maize is BBCH 30. PGRs are not currently used on maize, so a justification for the benefit of a PGR would be needed in addition to germination data. For any use where safety to germination has not sufficiently been addressed, a label warning such as ‘Do not use on maize seed crops’ may be needed.

(IIIA 6.5.1) Impact on succeeding crops

Maize is typically harvested in the UK from mid-September until early November. As a result, it can be followed by both winter and spring-sown crops in a rotation, depending on the conditions after the maize harvest. Over-wintering cover crops are also sometimes sown after maize.

A step-wise approach should be taken following EPPO standard ‘PP 1/207 Effects on succeeding crops’, starting with the herbicidal activity of the active substance, through glasshouse screening, laboratory bio-assays of treated field soils, field screening, monitoring of effectiveness/crop safety field trials and if necessary, specific following crop ‘replanting’ trials using risk mitigation measures such as different cultivation techniques. It is important to consider crops which are likely to be present in rotation with maize. For testing the biological activity of the test product, the product should be incorporated into the soil and the activity given as an EC (effective concentration). Endpoints from seedling emergence non-target plants tests presented in the Ecotoxicology Section of the dossier may be used to assess this risk to succeeding crops provided they incorporated the substance in the soil and are representative of the crops normally planted after maize.

(IIIA 6.5.2) Impact on other plants, including adjacent crops

A step-wise approach should be taken following EPPO standard ‘PP 1/256 Effects on adjacent crops’ and should be fully presented. It is important to consider crops which are likely to be present as adjacent crops to maize (either already emerged or yet to emerge) in the UK. Endpoints from the vegetative vigour and seedling emergence nontarget plants tests presented in the Ecotoxicology Section of the dossier may be used to assess the risk to adjacent crops, provided they are representative of the crops normally found adjacent to maize. In addition to spray drift, other routes of exposure (e.g. volatilisation) should be considered for the formulated product as this may also affect sensitive adjacent crops.

(IIIA 6.5.1) Effects on beneficial and other non-target organisms

Visual observations in the field and relevant data produced for the Ecotoxicology section 9.5 may be used. However, if there are any specific positive claims of safety to beneficial organisms used in IPM systems, these must be supported. For specific guidance, discussions with CRD are recommended.

References and Useful Information

Better Returns/AHDB - Growing and feeding maize silage for Better Returns
KWS Maize Field Guide
The Agricultural Notebook 20th Edition, R Soffe
BSPB Forage maize descriptive list
Growth stages of mono-and dicotyledonous plants – German Federal Biological Research Centre for Agriculture and Forestry, U. Meier

Relevant EPPO standards

Target Specific

PP 1/050 Weeds in maize
PP 1/144 Reduction of lodging in cereals and maize
PP 1/187 Sesamia nonagrioides on maize
PP 1/245 Aphids on maize
PP 1/272 Foliar diseases on maize
PP 1/217 Oscinella frit
PP 1/285 Fusarium ear rot of maize

General Standards

PP 1/135 Phytotoxicity Assessment
PP 1/152 Design and analysis of efficacy evaluation trials
PP 1/181 Conduct and reporting of efficacy evaluation trials (including GEP)
PP 1/207 Effects on succeeding crops
PP 1/213 Resistance risk analysis
PP 1/223 Introduction to the efficacy evaluation of PPPs
PP 1/225 Minimum effective dose
PP 1/226 Number of efficacy trials
PP 1/241 Guidance on Comparable climates
PP 1/242 Taint tests
PP 1/256 Effects on adjacent crops
PP 1/278 Principles of zonal data production and evaluation

PP 1/292 Cleaning pesticide application equipment (PAE) – efficacy aspects

EPPO guidance on zonal efficacy assessments

Zonal efficacy assessments (eppo.int)

Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this guidance, visit www.hse.gov.uk.

This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory, unless specifically stated, and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance.

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