

VÉGÉPHYL – 24^e CONFÉRENCE DU COLUMA
JOURNÉES INTERNATIONALES SUR LA LUTTE CONTRE LES MAUVAISES HERBES
ORLÉANS – 3, 4 ET 5 DÉCEMBRE 2019

BIXLOZONE : A NEW ISOXAZOLIDINONE HERBICIDE FOR A WIDE RANGE OF EUROPEAN CROPS

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RÉSUMÉ

Bixlozone est une nouvelle substance active découverte et développée par l'organisation recherche et développement FMC. Bixlozone est un herbicide résiduaire unique pour la maîtrise de nombreuses adventices et sélectif sur un large choix de cultures incluant les céréales d'hiver, qui apportera un nouveau mode d'action sur certaines cultures. Bixlozone peut être appliqué en pré levée de la culture, en post levée précoce ou incorporé au moment du semis pour le contrôle de graminées et dicotylédones parfois difficiles à maîtriser dans les rotations céréalières.

Mots clés : bixlozone, herbicide, isoxazolidinone, multicultures, mode d'action unique

ABSTRACT

Bixlozone is a new herbicide discovered and developed by FMC's research and development organization. It provides a new and unique selective residual weed control solution in a wide range of crops including winter cereals and will offer a new mode of action herbicide solution for many of these crops. Bixlozone provides residual control and can be applied pre-emergence, early post-emergence or incorporated by sowing and will provide control of several key grasses and broadleaf weeds.

Keywords: bixlozone, herbicide, isoxazolidinone, various crops, unique mode of action

INTRODUCTION

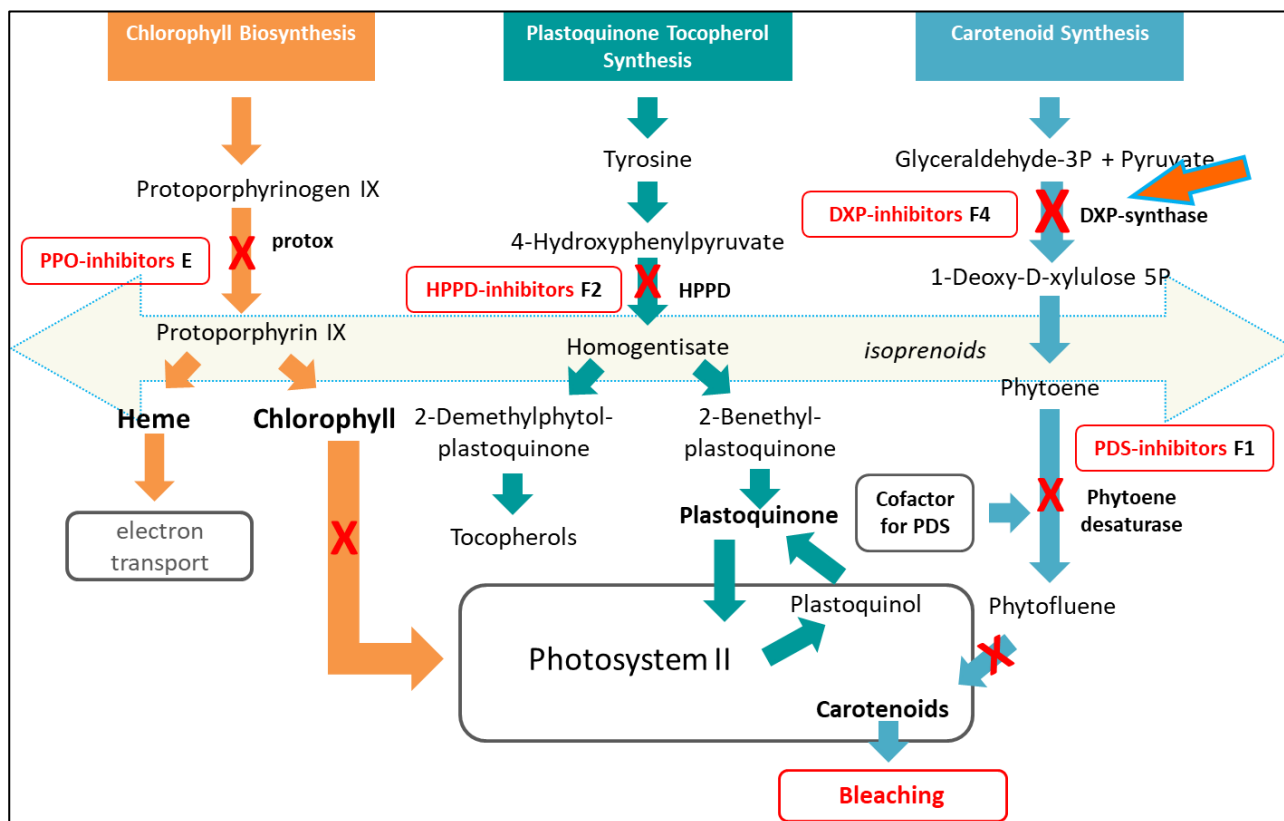
Effective control of annual grass and broadleaf weeds is essential to maintain sustainable and economically attractive crop production. Over the years, herbicide resistance has developed to most available modes of actions (HRAC, 2016). In addition, the potential loss of key herbicides and the absence of any new modes of actions means there will be greater reliance on fewer herbicides in the future and further increase of selection pressure. New weed control strategies will need to focus on herbicides that are applied pre-emergence or early post-emergence in combination with non-chemical control methods. FMC has developed the new active ingredient Bixlozone which targets important broadleaf and grass weeds. Bixlozone is selective in a wide range of crops including major arable crops as winter cereals and oilseed rape but also a wide range of spring crops and will introduce a new mode of action herbicide solution for many of these crops.

MOLECULAR PROPERTIES

Bixlozone mode of action is blocking the formation of isoprenoids which are the precursors to carotenoid biosynthesis. Inhibition of the primary target deoxyxylulose-5phosphate synthase (DXS) is induced by the keto variant of bixlozone (figure 1). Deprived of protective carotenoids, chlorophyll as well as other components of the photosynthetic apparatus are susceptible to photo-oxidation. It is the loss of this protective function of carotenoids which leads to the bleached symptoms on susceptible plants. Bixlozone is proposed to be classified as an HRAC Group F4 and will offer a new tool to farmers for efficient weed resistance management.

Figure 1: Mode and site of action in plants

Mode et site d'action dans la plante



Bixlozone has low toxicity via the oral, dermal and inhalation routes; and is only mildly irritating to skin and eyes (non-classifiable) and does not elicit allergic reaction following skin contact (in experimental species) (table I).

Table I: Toxicological and ecotoxicological main characteristics of bixlozone

Caractéristiques toxicologiques et écotoxicologiques de la bixlozone

Type of study	Results
Acute – oral LD50 (mg/kg)	>2000
Acute – dermal LD50 (mg/kg)	>2000
Inhalation LC50 (mg/kg)	>2.11
Eye irritation	Not irritating
Skin irritation	Not irritating
WHO classification	Unclassified
Bird – acute oral LD50 (mg/kg)	>2000
Aquatic invertebrates – acute 48 hour EC50 (mg/l)	0.14
Daphnia (mg/l)	13
Honeybees contact acute 48 hour LD50 (µg/bee)	>100

BIOLOGICAL PROFILE

Bixlozone provides a new and unique selective residual weed control solution. It controls many of the annual grasses and broadleaves in a range of crops (table II).

Table II: Summary of targeted weeds in key crops in EU

Résumé des adventices cibles, dans les principales cultures en Europe.

Crop	Rate, application timing	Broadleaves	Grasses
Winter cereals	Up to 200 g ai/ha Pre-emergence up to BBCH 13	<i>Veronica sp.</i> , <i>Lamium sp.</i> , <i>Stellaria media</i> , <i>Capsella bursa-pastoris</i> , <i>Galium aparine</i> *	<i>Lolium spp</i> , <i>Alopecurus myosuroides</i> *, <i>Poa annua</i>
Oilseed rape	Up to 300 g ai/ha Pre-emergence	<i>Descurainia sophia</i> , <i>Sisymbrium officinale</i> , <i>Lamium purpureum</i> , <i>Stellaria media</i> , <i>Geranium sp.</i> , <i>Veronica</i>	<i>Poa annua</i>
Spring crops	Up to 375 g ai/ha Pre-emergence	<i>Mercurialis annua</i> , <i>Veronica sp.</i> , <i>Lamium purpureum</i> , <i>Portulaca oleracea</i> , <i>Polygonum sp.</i>	<i>Echinochloa crus-galli</i> , <i>Panicum spp</i> , <i>Digitaria sp.</i> , <i>Setaria sp.</i>

*Efficacy can be variable according to soil and climatic conditions

Similar to other soil applied herbicides the uptake occurs mainly via both roots and shoots. It provides both systemic and contact activity, with residual control and can be applied pre-emergence, early post-emergence or incorporated by sowing, across a wide range of agronomic environments. It provides control of herbicide resistant grass weeds (*Lolium spp.*, *Alopecurus myosuroides*, *Echinochloa crus-galli*, *Poa annua*) and key broadleaf weeds (*Stellaria media*, *Veronica spp.*, *Lamium purpureum*) (figure 2).

Figure 2: Bixlozone activity against a range of key grass and broadleaves when applied in early post-emergence (BBCH 10-11)

Activité de la bixlozone contre les principales graminées et dicotylédones clés appliquée en post-levée précoce (BBCH 10-11)



In order to build the necessary (EU) submission dossier and the product profile an important number of field experiments to evaluate efficacy and crop safety of bixlozone formulations have been carried out over several years in Europe across a wide range of important crops including winter cereals, winter oilseed rape, maize, potato and other spring crops. For this purpose, replicated small plot field trials were laid out in randomized complete block design with 3-4 replicates per treatment and were always executed according to the relevant EPPO (*European and Mediterranean Plant Protection Organization*) guidelines: 1/093(3) weeds in cereals, 1/049 (2) weeds in brassica oil crops, 1/050 (3) weeds in maize, 1/051 (3) weeds in potato and more. Furthermore, these trials were conducted in commercially grown target crops in representative growing areas and farmers conditions; and spread in maritime, Mediterranean, north-eastern and south-eastern EPPO climatic zone to evaluate bixlozone performance under different representative field conditions

Bixlozone is an ideal complementary mixing partner for other mode of action herbicides and extends the utility of existing products by broadening the weed spectrum (table III).

Table III: Complementary summary of targeted weeds in EU

Autres adventices clés ciblées

EPPO code	Latin name	English name
ALOMY	<i>Alopecurus myosuroides</i>	black grass
CAPBP	<i>Capsella bursa-pastoris</i>	shepherd's purse
ECHCG	<i>Echinochloa crus-galli</i>	barnyard grass
GALAP	<i>Galium aparine</i>	cleavers
LAMPU	<i>Lamium purpureum</i>	red deadnettle
LOLSS	<i>Lolium spp</i>	ryegrass
MATSS	<i>Matricaria spp</i>	mayweeds
MYOAR	<i>Myosotis arvensis</i>	field forget-me-not
MERAN	<i>Mercurialis annua</i>	annual mercury
PAPRH	<i>Papaver rhoeas</i>	corn poppy
POAAN	<i>Poa annua</i>	annual meadowgrass
POLAV	<i>Polygonum aviculare</i>	knotgrass
STEME	<i>Stellaria media</i>	common chickweed
THLAR	<i>Thlaspi arvense</i>	field pennycress
VERSS	<i>Veronica spp</i>	speedwells

Bixlozone is selective in a wide range of crops including winter cereals, oilseed rape, potato, corn, sugar beet, vegetables, rice and sugarcane. In general, high level of crop safety is achieved when used according to use recommendations. Occasionally transient crop bleaching can occur especially under conditions that promote crop stress such as very wet conditions at or immediately after application and light soils (high percentage of sand and low percentage of organic matter). It will also be safe to a wide variety of rotational crops in cases of crop failure.

WEED RESISTANCE MANAGEMENT

Due to increased resistance levels the control by post-emergent ACCase and ALS based chemistry of key grass weeds such as *Alopecurus myosuroides* (Moss, 2017) but also *Lolium spp.* (Montull and Taberner, 2014) has significantly decreased in major arable crops as winter cereals and oilseed rape. This situation has resulted in greater reliance on pre-emergence herbicides. Nowadays the use of tank mixtures and/or spray sequences (stacking) of different active ingredients are frequently used by advisors and farmers. And although final efficacy of these residual spray programs is also very much dependant of factors such as adequate soil moisture, there are already signs of reduced efficacy for current available range of residual herbicides even if to a more limited extent than compared to foliar herbicides. The proposed HRAC classification for bixlozone is Group F4 (DOXP synthase inhibition). Worldwide there are very few reported cases of F4 resistance with none in Europe. Bixlozone will offer a new mode of action for control of key weeds in cereals and cereals crop rotations. Bixlozone will be developed and recommended for use in combination with other mode of action herbicides to prevent and manage the development of resistance (HRAC).

Preliminary results to date show the impact from either EMR (enhanced metabolic resistance) or TSR (target site resistance) grass weeds resistance to Bixlozone. Different type of studies in both controlled and field conditions are in progress across different geographies on populations know to express EMR and/or TSR to ALS inhibitors (Group B) or ACCase inhibitors (Group A) (table IV).

Table IV: Potential for cross or multiple resistance

Risque de résistance croisée ou multiple

Weed	Application timing	Enhanced metabolic resistance (EMR)	Target site resistance (TSR)
<i>Alopecurus myosuroides</i>	pre-emergence	Efficacy not impacted	Efficacy not impacted
<i>Alopecurus myosuroides</i>	BBCH 11-13	Limited impact on efficacy	Efficacy not impacted
<i>Lolium spp</i>	pre-emergence	Efficacy not impacted	Efficacy not impacted
<i>Lolium spp</i>	BBCH 11-13	Efficacy not impacted	Efficacy not impacted

Bixlozone is expected to be first launched in Australia in 2021 in cereals and rapeseed with subsequent launches planned in Asia Pacific, Latin America and Europe.

CONCLUSION

Bixlozone is a new isoxazolidinone herbicide with differentiated crop selectivity, weed spectrum including resistant grasses and duration of control on key weeds. The molecule will introduce a new mode of action for many of these crops and therefore presents the potential to be a valuable compound for effective and sustainable weed control in combination with alternative mode of herbicides and integrated pest management practices.

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