***EQA** – Environmental quality / Qualité de l'Environnement / Qualità ambientale, 12 (2013) 31-37*

IMPORTANCE OF HERBICIDE-TOLERANT SUNFLOWER HYBRIDS IN SUPPRESSING COMMON RAGWEED (*AMBROSIA ARTEMISIIFOLIA*) POLLEN PRODUCTION. MINIREVIEW

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Abstract

Common ragweed (*Ambrosia artemisiifolia*) is the number one weed in Hungary: it covers ca. 5% of the arable land, causing huge losses in row crops, especially in sunflowers. In addition, because of the high allergenicity of its pollen, common ragweed is a heavy burden on the health care system. This minireview discusses the importance of use of herbicide-tolerant sunflower hybrids in eliminating common ragweed from sunflower fields, with special emphasis on the efficacy of common ragweed control of two acetolactate-synthase inhibitor postemergence herbicides (imazamox and tribenuron methyl) in several sunflower hybrids that carry the resistance gene against such herbicides. Common ragweed control by these herbicides was excellent: they suppressed the growth of the weed plant until the canopy closure of the crop (8-leaf stage). Common ragweed plants germinating after this date were unable to compete with the crop: although they survived, they remained small (ca. 70% reduction in height), produced ca. 90% less male inflorescences (source of the allergenic pollen), and caused no significant reduction in the crop yield. In order to stop the seed production by the few late-germinating weed plants we recommend a mechanical common measure (row-cultivator) in late August.

Keywords: *Ambrosia artemiisifolia, acetolactate synthase, allergenic pollen, common ragweed, herbicide resistant sunflower, weed control*

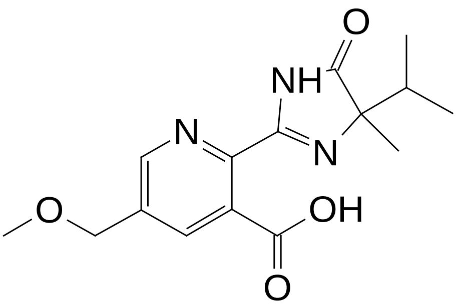
Introduction

The main cause of allergy and pollen asthma in North America and Central Europe is pollen from ragweed (*Ambrosia*) a widespread genus in the Asteraceae (Cecchi et al., 2006). In Europe short or common ragweed (*A. artemisiifolia*) is prevalent (Csontos et al., 2010). In Hungary, common ragweed infestation is heaviest in sunflower (*Helianthus annuus*), the third most important crop of the country (also an Asteraceae plant, thus, a botanical relative of common ragweed). It is important to note that about seventy percent of the global sunflower harvest is produced in the European Union, Russia and Ukraine, where ragweed spreads rapidly (Streit,

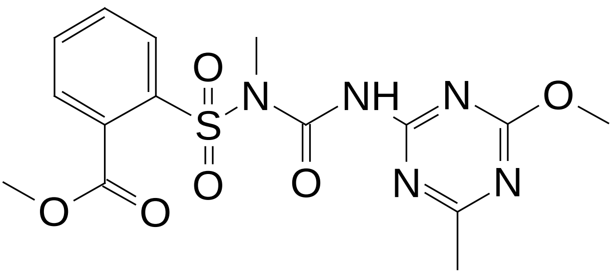
DOI: 10.6092/issn.2281-4485/4247

2012). In August-September common ragweed plants growing in sunflowers and cereal stubble produce the overwhelming majority of allergenic pollen in the air ever in urban areas (Cecchi et al., 2007). Increasing importance of bioenergy production together with recent advances in improving the dietary value of sunflower oil (Ziv et al., 2009)(Edgerton, 2009), will certainly increase the production area of sunflower in the future. Since commonly used herbicide options for sunflower do not include postemergence treatments, offer very limited broadleaf control, and have significant risk of crop plant injury, there is an urgent need for new tools to improve the control of common ragweed in this crop (Streit, 2012).

Studies from our laboratory and elsewhere show that production of recently developed sunflower hybrids may solve the above problem. These hybrids are tolerant to acetolactate synthase (ALS) inhibitor herbicides (such as imazamox [2-[(*RS*)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]-5-methoxymethylnicotinic acid] and tribenuron methyl [methyl 2-[4-methoxy-6-methyl-1,3,5-triazin-2-yl-(methyl)carbamoylsulfamoyl]benzoate], Figure 1) and were developed by traditional breeding methods (Al-Khatib et al., 1998). Thus, they are not considered as genetically modified (GM) crops (Pfenning et al., 2008)(Green and Owen, 2011), and as a result, they can be produced in Hungary (and in other EU countries) where GM plants are not allowed.



imazamox



tribenuron methyl

Figure 1

Chemical structures of the herbicides used.

Herbicide-tolerant crops were introduced into weed management practice about two decades ago. Most widely the RoundupReady™ (developed in 1994) and the

LibertyLink™ (developed in 1992) GM-based technologies are used: these are founded on the application of the herbicides glyphosate (N-[phosphonomethyl]glycine) and glufosinate (2-amino-4-[hydroxymethylposphinyl] butanoic acid), respectively (Green and Owen, 2011).

The first commercial imidazolinone tolerance trait (Clearfield™) in sunflowers (Sala et al., 2012) was developed from imidazolinone-tolerant wild sunflowers that were discovered in the USA in 1996 (Al-Khatib et al., 1998). Tolerance to sulfonylurea herbicides was obtained using induced mutagenesis (Streit, 2012) and led to the development of the ExpressSun™ technology.

Recently, several new sunflower hybrids were registered in Hungary (for example PR63E82, Pioneer, Johnston, IA, U.S.A.; and NK Meldimi and NK Neoma, Syngenta, Basel, Switzerland) that are resistant to the ALS-inhibiting herbicides tribenuron methyl and imazamox, respectively. These herbicides are known to control broadleaf weeds, such as common ragweed, efficiently (Merotto et al., 2009). It is important to note that the new sunflower hybrids were developed by traditional plant breeding methods

In this paper we summarize the research findings on the weed management of sunflower hybrids that are resistant to ALS-synthase inhibiting herbicides.

Development of the new technology

ALS-inhibitor herbicides (fist the sulfonylureas, somewhat later the imidazolinones) were discovered in the early 1980s. The new herbicides rapidly gained acceptance, because they selectively controlled a number of major weed species in important crops at surprisingly low rates of application, and they were characterized with very low mammalian toxicity [LIT].

The most important benefit of the use of ALS inhibitor herbicides in sunflower is that they can be applied post-emergence, have excellent crop safety over a wide range of crop growth stages and provide both contact and residual control of broadleaf weeds, including common ragweed (Pfenning et al., 2008). Since these herbicides have a single mode of action weed resistance is a problem that should be taken care of by designing management strategies for the individual fields in which ALS-inhibitor tolerant sunflowers are grown (Allen et al., 2001) (Busi et al., 2013) (Lamego et al., 2009).

Developers of the new technology had to address several questions: 1) insufficient weed control by the ALS-inhibitor herbicides (Sikkema et al., 2007), 2) problems related to the possible outcrossing of the resistance gene (Merotto et al., 2009), and 3) crop susceptibility to postemergence herbicide damage under certain meteorological conditions leading to the development of ClearfieldPlus™ system (Weston et al., 2012).

Efficacy of common ragweed control

We carried out weed surveys in ALS-inhibitor herbicide tolerant sunflower fields (characterized by large seed bank of common ragweed) in different locations in

DOI: 10.6092/issn.2281-4485/4247

Hungary in the period of 2006 to 2013. To prevent early competition of weeds with the crop plants seeding of sunflowers was followed by the application of a preemergence herbicide.

Both tribenuron methyl and imazamox were efficient in controlling weeds in sunflower: plots planted with the herbicide-resistant sunflower remained free of weeds until the end of June. Tribenuron methyl provided less control of barnyardgrass (*Echinochloa crus-galli*) and proso millet (*Panicum miliaceum*). Once (in 2006) extremely cold weather followed the application of the postemergent herbicides resulting in crop damage: sunflower leaves turned chlorotic (chlorophyll loss ca. 20%) and the plants ceased to grow for about two weeks. After this period, however, crop plants recovered rapidly. Typically, in July and August, a very small number of weeds (including common ragweed plants) emerged (weed cover was always lower than 0.01%). The emerging common ragweed plants were ca. 70% shorter and produced *ca*. 90% less male inflorescences than the untreated controls. Established common ragweed plants were found only in untreated sampling sites and in small ***areas where sunflower seeds germinated poorly***. In order to stop the seed production of the late emerging few weed plants, after 2009 the use of a row-cultivator in late August was included in the weed management program.

Average yields of the new hybrids were slightly but not significantly higher than that of the average local sunflower hybrids used in the region (2.33 ± 0.92 t ha^{-1}).

Excellent ragweed control was observed following postemergent treatments with tribenuron methyl and imazamox. In accord with previous studies showing that various perennial and annual grasses may be controlled poorly by some sulfonylurea herbicides (Sikkema et al., 2007) tribenuron methyl provided less control of barnyardgrass (*Echinochloa crus-galli*) and proso millet (*Panicum miliaceum*) in 2006 in the study area. Therefore, later efforts were focused on optimizing the Clearfield weed control technology based on imazamox.

Pollen production of common ragweed is at its maximum from late August to early September (Cecchi et al., 2006). Our weed survey on August 31, 2010 showed that the few common ragweed plants emerging in July and August could not efficiently compete for light, water, and nutrients in established sunflower stands. Reduced common ragweed density, plant height and number of pollen-producing flowers practically halted release of common ragweed pollens from stands of herbicide-resistant sunflowers.

We found that the application of a preemergent herbicide protects sunflowers from weeds germinating early and in mass (e.g. *Amaranthus retroflexus*, *Chenopodium album*, and barnyard grass): the effect of this weed control measure on later emerging ragweed seedlings is negligible. The use of the cultivator, however, was found to contribute significantly to ragweed control, although its primary advantage of its use lies in its beneficial effects on soil structure, water management, and overall soil health.

Conclusions

In conclusion, the new technology based on the use of sunflower hybrids resistant to ALS-inhibiting herbicides is a highly efficient tool to control common ragweed in sunflower fields and, as a result, to reduce concentrations of the plant's allergenic pollen in the air. A major key for the success of common ragweed control when using this technology will be the management of resistance due to recurrent use of ALS-inhibiting herbicides (Délye et al. 2009) and the control of volunteer sunflowers in following crops.

Acknowledgements

We thank ***t****he European Commission*, DG Environment *(HALT AMBROSIA*, 07.0322/2010/58340/SUB/B2), the EU COST Action FA1203 'Sustainable management of *Ambrosia artemisiifolia* in Europe (SMARTER)', and the Ministry of Agriculture and Rural Development of Hungary *for financial support*.

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DOI: 10.6092/issn.2281-4485/4247

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IMPORTANCE DES HYBRIDES DE TOURNESOL TOLERANT AUX HERBICIDES POUR SUPPRIMER L'HERBE A POUX (*AMBROSIA ARTEMISIIFOLIA*) LA PRODUCTION DE POLLEN. COMMUNICATION PRELIMINAIRE

Résumé

Petite herbe à poux (*Ambrosia artemisiifolia*) est le numéro un des mauvaises herbes en Hongrie: il couvre environ. 5 % des terres arables , causant d'énormes pertes dans les cultures en rangs , en particulier dans les tournesols . En outre , en raison de la forte allergénicité de son pollen , l'herbe à poux est un lourd fardeau sur le système de soins de santé . Cette mini-revue traite de l'importance de l'utilisation des hybrides de tournesol tolérant les herbicides à éliminer l'herbe à poux dans les champs de tournesol , avec un accent particulier sur l'efficacité du contrôle de l'herbe à poux de deux herbicides inhibiteurs postlevée acétolactate - synthase (imazamox et tribénuron méthyle) dans plusieurs hybrides de tournesol que transporter le gène de résistance à l'encontre de tels herbicides. Contrôle de la petite herbe à poux par ces herbicides était excellent : ils ont supprimé la croissance de la plante contre les mauvaises herbes jusqu'à la fermeture de la canopée de la culture (stade 8 feuilles). Plantes de l'herbe à poux en germination après cette date n'étaient pas en mesure de rivaliser avec la culture : mais ils ont survécu , ils sont restés de petite taille (environ 70% de réduction en hauteur) , produit environ . 90 % moins inflorescences mâles (source de pollen allergisant), et n'a pas causé de réduction significative du rendement des cultures. Afin d'arrêter la production de semences par les quelques mauvaises herbes à germination tardive, nous recommandons une commune mesure mécanique (rangée cultivateur) à la fin Août.
Mots-clés: *Ambrosia artemiisifolia , l'ALS, le pollen allergénique , petite herbe à poux , résistant aux herbicides tournesol , contrôle des mauvaises herbes*

IMPORTANZA DI IBRIDI DI GIRASOLE RESISTENTI AGLI ERBICIDI MIRATI ALLA SOPPRESSIONE DI MALERBE (*AMBROSIA ARTEMISIIFOLIA*) PRODUTTRICI DI POLLINE. COMUNICAZIONE PRELIMINARE

Riassunto

L’Ambrosia (*Ambrosia artemisiifolia*) rappresenta la malerba più diffusa in Ungheria: interessa circa il 5% delle terre coltivate, causando consistenti perdite nel raccolto delle colture in filare, soprattutto di girasole. Inoltre, a causa della elevata allergenicità del suo polline, l’Ambrosia incide pesantemente sui costi del sistema sanitario. Viene discussa in via preliminare l’efficacia di ibridi di girasole tolleranti gli erbicidi utilizzati per la eliminazione dell’Ambrosia dai campi di girasole, con particolare attenzione all'efficacia del controllo della malerba da parte di due erbicidi in trattamenti post-emergenza (imazamox e tribenuron metile) inibitori dell’acetolattato sintasi in diversi ibridi di girasole portatori di geni resistenti a tali erbicidi.

Nella maggior parte dei casi il controllo dell'ambrosia da parte di questi erbicidi si è dimostrato eccellente impedendo la crescita della malerba fino alla chiusura della ciclo colturale (fase 8 - leaf). Le piante di ambrosia germogliate dopo tale data non sono in grado di interferire con il raccolto, e se sopravvissute, subiscono una riduzione in altezza di circa il 70% di riduzione in altezza) e un diminuzione del 90 % delle infiorescenze maschili (fonte del polline allergenico); inoltre non causano riduzioni significative delle rese delle colture. Al fine di impedire la produzione di sementi da parte delle poche piante infestanti germinate in ritardo si raccomanda di intervenire con una lavorazione meccanica lungo linea alla fine di agosto .
Parole chiave: A*mbrosia artemiisifolia , sintasi acetolattato , polline allergenico , ambrosia , resistente agli erbicidi girasole, controllo delle infestanti*

DOI: 10.6092/issn.2281-4485/4247