Mechanism of resistance to mesotrione in an *Amaranthus rudis* population from Nebraska

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Importance of HPPD herbicides in corn agro-systems

- HPPD herbicides: latest successful herbicide mode of action introduced with market value of over 1.5 billion USD/year

- Sales dominated by mesotrione, tembotrione, topramezone and isoxaflutole for grass and broad-leaf weed control in US corn agro-systems

- Compounds efficacious on driver weeds and can be used in mixtures with other herbicides, e.g. photosystem II (synergism)

- Extensive use has resulted in resistance in a few *Amaranthus rudis* and *Amaranthus palmeri* populations from Iowa, Illinois, Kansas and Nebraska
Evolution of resistance to mesotrione in an *Amaranthus rudis* population from Platte County, Nebraska, USA

Field history: soybean (pendimethalin followed by glyphosate) / seed corn (S-MOC + atrazine pre-emergence followed by mesotrione + atrazine post-emergence) rotation from 2001-2010
Objectives

- Confirm resistance to mesotrione in a suspected resistant *Amaranthus rudis* population from Nebraska

- Establish the cross resistance profiles to other corn-selective HPPD herbicides

- Determine the mechanism(s) of resistance to mesotrione in the Nebraska population
Materials and methods

● Plant materials
  - Suspected resistant *A. rudis* population from Nebraska (NEB: 2010 seed collection)
  - Standard sensitive population (SEN-1: Herbiseed, Twyford, UK)

● Methods
  - Glasshouse-based herbicide pot tests
  - Molecular assays
    • HPPD gene analysis via Sanger sequencing
    • HPPD gene duplication via Q-PCR analyses
  - Biokinetics assays
    • uptake and translocation - $^{14}$C mesotrione
    • metabolism - non-labelled mesotrione
Comparative responses of NEB and SEN-1 to mesotrione

Low and high levels of resistance (p<0.05) to mesotrione applied pre- and post-emergence respectively in NEB
Resistance profiles to four corn-selective HPPD herbicides

NEB is cross resistant to other corn selective HPPD herbicides
Target-site-resistance

**HPPD sequence comparison between NEB and SEN-1**

- 12 each of NEB survivors and untreated SEN-1 plants sequenced for the whole HPPD gene

- HPPD gene is 1305 bp in length consistent with previously published *Amaranthus rudis* sequence (GenBank: JX259255)

- 52 nucleotide changes identified of which 15 were non-synonymous

- Non-synonymous mutations were evenly distributed between sensitive and resistant plants

A target gene mutation is not associated with resistance to mesotrione in NEB
HPPD gene duplication is not associated with resistance to mesotrione in NEB
Non-target-site-resistance Mesotrione uptake in NEB and SEN-1

No evidence of a difference (p = 0.6089) in uptake between NEB and SEN-1
Non-target-site-resistance
Mesotrione translocation in NEB and SEN-1

Evidence ($P=0.0142$) of differential translocation between sensitive and resistant populations
Non-target-site-resistance - metabolism
Levels of parent mesotrionone (LC-MS) in NEB and SEN-1

Significantly lower levels of parent mesotrionone recovered from for NEB at 48 and 72 hours (P<0.05)
Non-target-site-resistance - metabolism
Levels of 4-hydroxy mesotrione (LC-MS) in NEB and SEN-1

Significantly higher levels of 4-hydroxy mesotrione recovered from treated area for NEB at 48 and 72 hours (p<0.05)
Conclusions

● Resistance to a range of corn-selective HPPD herbicides especially applied post-emergence is confirmed in NEB

● A target gene mutation/duplication or differential uptake is not associated with mesotrione resistance in NEB

● Resistance in NEB is (in part) due to higher levels of mesotrione metabolism via 4-hydroxylation

● Relatively lower levels of translocation observed could be due to higher levels of mesotrione metabolism in NEB
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Thank you for your attention.

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