Towards biotechnical pest management of the western corn rootworm (*Diabrotica virgifera virgifera*)

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INTRODUCTION AND RATIONALE

The western corn rootworm (WCR) (*Diabrotica virgifera virgifera*) (Coleoptera: Chrysomelidae) is one of the 10 most damaging insect pests in worldwide grain production. Damage and control costs of WCR in maize (*Zea mays*) in the USA, for example, reach 1 billion US$ annually. Following its introduction to Europe (prior to 1992), WRC populations are steadily increasing, and the pest is also greatly extending its geographical range. Ultimately, European damage levels may reach and match those in the USA. WCR is a notoriously difficult insect to control and manage, as the history of maize cultivation over the past 50 years amply demonstrates. The genetic base of WCR is very broad, and allows numerous unexpected adaptations, including 'crop rotation resistant' WCR populations. Exclusive control by pesticides is highly problematic, because of the rapid selection of resistant strains. Therefore, environmentally compatible and sustainable plant protection require novel approaches to WCR management, including biotechnical strategies with the preferential use of natural or nature-related signal compounds.

We here introduce a promising management strategy, based on the biotechnical manipulation of adults by the plant kairomone MCA (4-methoxy-cinnamaldehyde), a compound first discovered by R L Metcalf 20 years ago.

PRINCIPLE OF THE NEW STRATEGY

A novel 'MSD' or 'diversion' technique, which consists of **m**ass trapping, combined with **s**hielding and **d**eflecting of the adult beetles is now proposed. Release stations were established around the perimeter of a field at a distance of 10–20 m from one another, to create a kairomonal barrier zone (or 'curtain'),with an MCA odor plume extending from ground level to a height of c. 3 m, within which 95% of the mobile adult beetles flew. Such odor barriers can significantly reduce the flux of beetles moving in and out of a 'shielded' field section. High-capacity traps can remove the majority of beetles at a trapping spot, while the remaining beetles are deflected and are, thus, unable to orient themselves towards finding mates, traps and oviposition sites. During August and early September, in both 2003 and 2004, shielded and untreated (control) field sections were compared, at Urbana and Champaign, Illinois, USA.

MATERIALS AND METHODS

Treatments consisted of release stations of the kairomonal attractant MCA. Its release points simultaneously served as mass trapping stations, since the high-capacity traps used (see below) can perform both functions within one and the same unit. The release rate of the volatile MCA was c. 1 g/day for a field of 0.3 ha. Sensitive monitoring traps of the sticky cone-cup ('Metcalf') type, high-capacity Shaw/Hummel ('IRC') traps, and those of the 'UNI-trap' design, were baited with 0.1 mg of sex pheromone or with 10 mg of the specific kairomonal WCR attractants reviewed by Metcalf (1994), and exposed at from 1.0 to 1.2 m above ground level within fields of maize (ranging from 0.15 to 0.3 ha). Sampling for WCR consisted of: (a) visual counts of adults on maize plants, sampled along the centre line within the fields, (b) counts of beetles attracted to specific attractant traps placed along the centre line of the fields, and (c) egg counts, obtained by taking (at random) 20 soil samples, each of 1 kg, and then washing the soil away through a fine-meshed flotation machine.

RESULTS, DISCUSSION AND CONCLUSIONS

Adults were less numerous on maize plants within the treated MSD field from 19 August to 4 September 2003, compared with untreated control sections (both located at the Urbana field site) ($P < 0.05$ to $P < 0.01$); similarly, for the MCA-treated 'Champaign' field section in 2004, adult numbers from 2 to 28 August were always smaller than in the untreated control. The number of adults attracted to kairomone-baited centre traps (located inside and outside the MSD field section) differed by an average factor of 3 for the period 6–11 September 2003, with beetle counts in the 'control' field section always being greater. At the 'Champaign' field site, for all days from 6 August to 1 September 2004, fewer adults were attracted to sex-pheromone-baited Uni-traps (located at the central line of the MSD plot) than to those in the untreated control. The most decisive proof of population and oviposition reduction came from 20 randomly taken soil samples, 10 each from treated and control sections, from maize fields after harvest. Thus, in 2003, the MSD-treated field (vs. control) showed a ratio of 17 : 93 WCR eggs; the 2004 ratio of 2 : 60 was even more striking, and of greatest statistical significance ($P < 0.001$).

The novel MSD technique provides a promising biotechnical approach for the management of WCR in maize under treatment with MCA kairomone. Results obtained at two different field sites at Urbana and Champaign, Illinois (situated 6.5 km apart from each other), were mutually supportive and consistent for two consecutive years. Mass trapping can yield close to 10,000 beetles/trap/month. However, this alone cannot fully explain the effects observed, since it accounted for only 15–20% of the beetles actually present in the maize field. There must be an equally (or more) important sensory component, whose exact mechanism and nature still needs further investigation. In effect, however, the MSD approach (with a suitable barrier zone of traps spaced at a sufficient density) holds considerable promise, and should be more fully explored in the near future.

REFERENCES

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