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Field tests on the host range of the larvae of the Western Corn Rootworm (*Diabrotica virgifera virgifera* LeConte 1868, Chrysomelidae, Coleoptera)

Feldversuche zum Wirtspflanzenspektrum der Larven des Westlichen Maiswurzelbohrers (*Diabrotica virgifera virgifera* LeConte 1868, Chrysomelidae, Coleoptera)

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Abstract

In 2005 a field trail was carried out in Lovrin, Romania, to test the host-suitability of different weeds and one winter wheat cultivar for naturally occurring larvae of the Western Corn Rootworm *Diabrotica virgifera virgifera.* The weeds tested were *Setaria glauca, S. viridis, S. verticillata,* and *Sorghum halepense.* Maize was used as the control. For all three species of *Setaria* development of larvae of WCR was recorded. It was distinctly reduced compared to the maize control (to about 15%) and the emergence of adult beetles was delayed (about 14 days). Thus *Setaria* spp. seem to be suitable hosts for larvae of WCR in the field at least under Romanian conditions. No beetles hatched in plots with *S. halepense* and winter wheat. But wheat was ripe already at the end of June, before any beetle had hatched in the experiment.

Key words: *Diabrotica virgifera,* Western Corn Rootworm, larvae, alternative hosts, *Setaria,* crop rotation

Zusammenfassung

2005 wurden in Lovrin, Rumänien, Feldversuche zum Wirtspflanzenspektrum der natürlich vorkommenden Larven des Westlichen Maiswurzelbohrers *Diabrotica virgifera virgifera* durchgeführt. Es wurden vier verschiedene Ungräser *(Setaria glauca, S. viridis, S. verticillata* und *Sorghum halepense)* sowie eine Winterweizensorte getestet. Mais diente als Kontrolle. Die Larven konnten sich an allen *Setaria*-Arten zu Adulten entwickeln, auch wenn die Schlupfrate deutlich reduziert im Vergleich zu Mais (auf ca. 15 %) und der Schlupf verzögert (ca. 14 Tage) war. Somit ist eine Entwicklung der Larven zum adulten Käfer zumindest unter rumänischen Bedingungen an verschiedenen *Setaria*-Arten im Feld möglich. Keine Käfer wurden in den Parzellen mit *S. halepense* und Winterweizen gefunden. Letzterer war allerdings Ende Juni, deutlich vor dem ersten Käferschlupf im Versuch, abgereift.

Stichwörter: *Diabrotica virgifera,* Westlicher Maiswurzelbohrer, Larven, alternative Wirtspflanzen, *Setaria,* Fruchtfolge

Introduction

The Western Corn Rootworm (WCR), *Diabrotica virgifera virgifera* LeConte 1868, is a harmful threat to European maize cultivation. It already causes huge economical damage, especially in the eastern European countries. According to the EU Commission decision on emergency measures for WCR crop rotation is an important measure to control WCR. Branson and Ortman (1967, 1970), Clark and Hibbard (2004), and Oyediran et al. (2004) have carried out studies on alternative hosts for larvae of WCR in the US and found several suitable plant species for the larvae in laboratory experiments. Also Moeser (2003) found suitability of the roots of several grass species in tests exposing a limited life span of larvae of WCR to cut pieces of roots in laboratory trials. But field data are rare and totally missing for Europe. The role of alternative host plants, monocotyledonous weeds and cultivated grains, for larvae of the WCR is important with regard to the effectiveness of control of WCR by crop rotation. Therefore we decided to conduct the first field trials in Europe.

Material and Methods

The trials took place on a field with degraded chernozem soil in Lovrin, Romania, where maize has been grown continuously for 11 years. The field has been naturally infested with WCR for many years and no artificial introduction of WCR was used for the experiment. Four weeds *(Setaria glauca, S. viridis, S. verticillata, Sorghum halepense),* winter wheat (cultivar Josef) and a maize control (cultivar Romario) were tested. The seeds were sown by hand in four randomised, replicated plots. An area of 2 m to all sides of the plot size of 1 × 1 m (net) was kept without vegetation after the frames with the tents were established. The plots were kept free of weeds by hand as much as possible. The weeds and the wheat were sown on the 6. 10. 2004, the maize on 5. 5. 2005. Weed seeds originated in Romania. Emergence of the maize plants was on the 11. 5. 2005. All weeds, the wheat and maize developed as usual and kept growing until September 2005. The wheat was at the flowering stage in May (Fig. 1) and of ripening (ca. BBCH 75–85) already on the 21. 6. 2005. The 4 weed

Fig. 1. View of the trial site on the 26th of May 2005 with already far developed wheat and the other plants still very small. (Foto: M. ZELLNER)

species reached a height of 10–25 cm with S. *viridis* already at the stage of the inflorescence emerging.

Climatic conditions in Lovrin were as usual but with much higher precipitation in April (a total of 123 mm) and July (100 mm). The high precipitation in April with a short period of flooding resulted in a very dense soil which got very hard when dry.

On the 17. 6. 2005 first larvae were detected in the surrounding maize field and first adults of WCR were found on the 1. 7. 2005.

On 22. 6. 2005 each plot was covered with a tent of gauze (ca. 2 mm mesh width) which was fixed to a wooden frame of 1 × 1 m size dug into the soil to capture emerging adults of WCR (Fig. 2). The tents were checked weekly for hatched adults caught on sticky traps. The checking period lasted from 27. 6.–4. 9. 2005.

Significant differences in the total number of hatched beetles were analysed by using the Kruskal Wallis test ($p < 0.05$).

Results

The number of beetles that emerged in total over the whole period (27. 6.–4. 9. 2005) is given in Figure 3. Six to eight times more beetles emerged in plots with maize compared to each of the *Setaria* spp. tested. There was no beetle emergence in winter wheat and *Sorghum halepense*. The number of emerged beetles differed significantly between maize and all other tested plants and also between *Setaria* spp. and both, wheat and *S. halepense*. No differences were detectable between the three tested *Setaria* species.

The emergence of the adults in the *Setaria* spp. was delayed for about 14 days compared to the maize control (Fig. 4).

Discussion

A low suitability of *Setaria* spp. for larvae of WCR was shown in these field experiments. This was in line with first results from field test in Romania in 2004, in which some WCR adults hatched in plots without maize, but with *S. glauca* as the main weed in these plots. This finding is supported by laboratory trials in which different plants were tested for the suitability as host plants for larvae of WCR in which about 50 % of larvae developed with *Setaria* spp. as food compared to a maize control

Fig. 2. View of the trial site on the 30th of August 2005 (front left side: maize, front right side: *Sorghum halepense*, second line, right side: *Setaria verticillata*). (Foto: U. HEIMBACH)

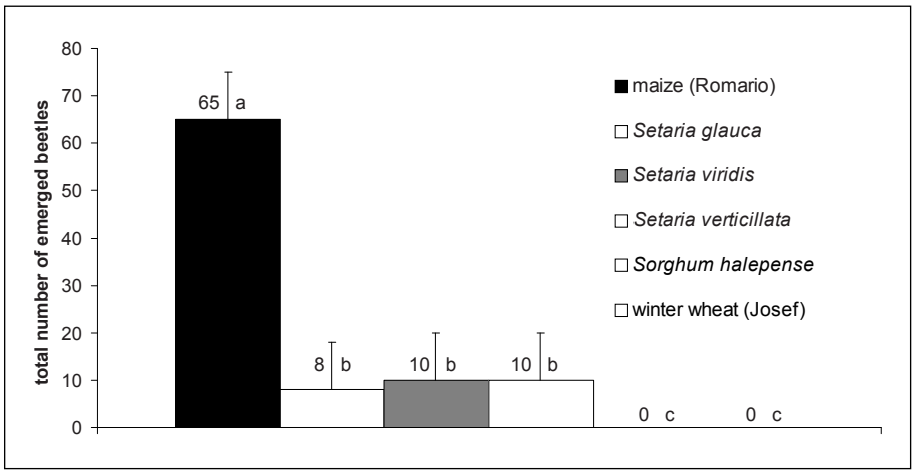

Fig. 3. Total number (± SD) of adult WCR emerged from 27. 6. to 4. 9. 2005, different letters between the variants indicate significant differences $p < 0.05$.

(BREITENBACH et al., 2004). Also BRANSON and ORTMAN (1967) were able to rear WCR larvae on *S. viridis* in the laboratory and in field trials. Also CLARK and HIBBARD (2004) reared WCR larvae in the laboratory on *S. viridis* and *S. verticillata.* But the beetles had a lower weight than the beetles emerged from maize.

The absence of any emerging beetles in *Sorghum halepense* was in line with findings of CLARK and HIBBARD (2004) and BRANSON and ORTMAN (1969) which already detected toxicity of *Sorghum* spp. for WCR larvae.

Young wheat plants have been shown in laboratory trials to allow a complete development of WCR larvae (BREITENBACH et al., 2005). Also in older wheat and other cereal plants (begin of experiments at the end of heading to full flowering, BBCH 59–65) a full development of larvae was possible in the laboratory (information of GLOYNA and THIEME, September 2005). Also BRANSON and ORTMAN (1967 and 1970) found development of WCR larvae on different cereals in the laboratory *(Hordeum vulgare, Triticum aestivum, T. spelta, Secale cereale* and *Oryza sativa)* and for *T. aestivum* in field tests. In our field test in Romania no adults hatched, possibly because the roots of the wheat cultivar tested were decaying already during the larval developmental period (ca. BBCH 75–85 on the 21. 6. 05), so that not enough food was available for the larvae. It is assumed that in our experiment feeding of larvae of earliest adult WCR in maize took place at least until the end of June and in the plots with the *Setaria* spp. even longer, taking into account the time of hatching in the experiment (see Fig. 4). Thus there was possibly no coincidence between the larvae and living roots of wheat in this experiment. But also differences in food suitability between cultivars of wheat have to be expected (information of GLOYNA and THIEME, September 2005) as it was also shown for maize (MOESER, 2003).

In the field a delay in the period of hatching was noticed in *Setaria* spp. compared to maize. Such a delay was also often found in laboratory trials in tests with different plants as host plants for the WCR larvae. This will have an influence on the population dynamics in the field which can not be quantified yet.

The results indicate that crop rotation will not hinder WCR larval development completely under certain conditions. But it is not possible to predict the extent to which the WCR population will be suppressed by crop rotation. In our experiment the fertility and body weight of the beetles, as a measure for fitness, could not be analysed because of the trapping method. Additionally the coincidence between WCR larvae and plant roots of crops such as wheat will depend on the cropping type, region and climatic conditions of the year. Thus, a situation as observed in Romania in 2005 with early harvest of wheat followed by no soil tillage and therefore resulting in the soil covered with *S. glauca* from the ripening period of wheat onwards, might be able to keep the WCR population at a higher level even with crop rotation.

Only regional field experiments using local cropping systems will allow exact prognosis for WCR population development. Further studies are needed on weeds and monocotyledonous

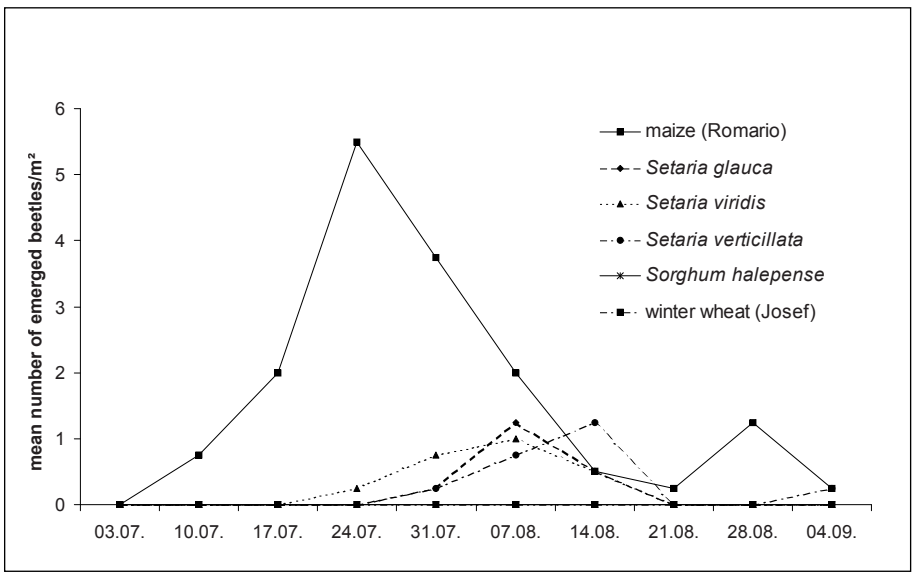

Fig. 4. Mean number of adult WCR emerged at the different checking dates (sampling always over 1 week).

crops in the laboratory and in the field, because laboratory data (BRANSON and ORTMAN 1967, 1970; BREITENBACH et al., 2004, 2005; CLARK and HIBBARD 2004; OYEDIRAN et al., 2004) and field experiments form the US (BRANSON and ORTMAN, 1967) indicate several plant species as possible alternative host plants for larvae of WCR. Under certain conditions crop rotation may not be able to eradicate populations of WCR which have reached a substantial population density.

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