EFFECT OF PLANT AGE AND SPECIES ON POPULATION GROWTH OF TWO RHOPALOSIPHUM MAIDIS (FITCH) LINEAGES


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SUMMARY

The corn leaf aphid Rhopalosiphum maidis (Fitch) can feed on various cereal crops and transmit viruses that may cause serious economic losses. To test the impact of host plant species and age on R. maidis, we identified the survival and reproduction rates of two R. maidis populations (Beijing and Mangshi) via a direct observation method in laboratory on 10 cm high maize seedlings (small maize), 50 cm high maize seedlings (high maize), and 10 cm high barley seedlings (barley). The Beijing (BJ) population performed significantly better than the Mangshi (MS) one on 50 cm high maize seedlings and barley seedlings, while both populations could not survive on maize seedlings in 10 cm height. As smaller maize seedlings were fatal to the corn leaf aphid, we hypothesized that it may be due to the secondary metabolites synthesized by maize seedlings and our results also give the implication for aphid control on maize which will be discussed.

Key words: corn leaf aphid, barley, maize, plant age, population

INTRODUCTION

Rhopalosiphum maidis (Fitch) is a species of a severe sap-sucking pest on maize that occurs worldwide (Foott and Timmins, 1973; Tzin et al., 2015). This insect also attacks barley and some other cereal crops such as sorghum, oats, and wheat (Carena and Glogoza, 2004; Tabikha, 2016). Except for the direct damage to the host plant, R. maidis can also transmit viruses including Maize dwarf mosaic virus (MDMV) and Barley yellow dwarf virus (BYDV) (Parry et al., 2012; Saksena et al., 1964; Thongmeearkom et al., 1976) which may lead to serious damages of maize production.

Although R. maidis can survive on different cereal crops, the aphid may perform diversely on different host plants, consequently some hosts may exhibit a certain degree of resistance. For instance, Toxoptera citricida developed slower on sour orange, Duncan grapefruit and Mexican lime than Carrizo and sweet orange (Tang et al., 1999). Also, previous studies on R. maidis showed different survival and reproductive rates on different host plants of barley and wheat.
(Hirano and Ito, 1964; Singh and Painter, 1964). Besides, compared with *Trifolium subterran-ae* cultivars and *Medicago minima*, *Aphis craccivora* Koch showed the best population growth potential on *Vicia faba* at 25 °C (Berg, 1984). In this way, resistant host plants or genotypes can be screened out to obtain a better biological control effect (Narang and Rana, 1999).

Additionally, different aphid populations can have various performances on the same host plant (Broeke *et al.*, 2013) such as *Sitobion avenae* (Barrios-SanMartin *et al.*, 2016), *Acyrthosiphon pisum* (Sandström and Pettersson, 1994), *Myzus persicae* and *A. craccivora* (Edwards, 2001), demonstrating that long-term population differentiation may endow diverse biological characters to different populations living in variant surroundings. Here we aimed at assessing the effects of plant age and species on survival and reproduction of *R. maidis* by investigating the performance of two *R. maidis* populations on barley (10 cm high), small maize seedlings (10 cm high) and high maize seedlings (50 cm high).

**MATERIALS AND METHODS**

**Aphids**

Two clones of *R. maidis*, namely MS (Mangshi population) and BJ (Beijing population) were collected from Mangshi city, Yunnan province and Beijing city of China separately in October 2014 and then reared under laboratory conditions (23±1 °C, L16: D8 photoperiod and 60-80% relative humidity) on barley seedlings for more than ten generations.

**Host plants**

Barley, small maize and high maize seedlings were used as experimental host plants for *R. maidis*. Accelerating germination treatment was used for maize seeds before sowing into the soil to ensure the germination rate and uniformity. The seedlings before inoculation were reared under condition of 20°C, L16: D8 photoperiod and 60-80% relative humidity.

**Treatment settings**

Ten replicates were set for each treatment. All the seeds were sown in 10 × 10 cm square pots. Five adult apterous aphids were inoculated to the seedlings in each pot and different pots were separated with a 10 cm diameter plastic tube covered by gauze element. Then, the survival number of aphids was observed everyday at the same time for one week.

**Statistical analysis**

Generalised linear mixed effect models (package ‘lme4’, function ‘glmer’, (Bates *et al.*, 2014)) with Poisson error distribution (log-link function) were fitted to test whether the two populations (BJ, MS) affected the number of aphids on the different host plants. The two populations were analysed as fixed effects and the observed plants (i.e., 10 replicates per crop) were included as random effects as measurements were repeated each time on the same plant. The effect of the populations on aphid abundance was tested using a likelihood-ratio test (p < 0.05). The statistical analyses were performed using R program (R Core Team, 2013).
RESULTS

Survival and reproduction on small maize seedlings

Both MS and BJ populations did not survive on 10 cm high maize seedlings (Figure 1). The aphid number of the two populations decreased rapidly from the 3\textsuperscript{rd} to 7\textsuperscript{th} day although several offspring individuals had reproduced during the first three days. There was only one survival of MS population and no survival of BJ population on the 7\textsuperscript{th} day. Hence, no statistical analyses were performed to compare these two populations.

Figure 1. Survival number of \textit{R. maidis} on small maize seedlings

Survival and reproduction on high maize seedlings

The two populations of \textit{R. maidis} survived on high maize seedlings (Figure 2), but the total aphid number increased slower than on barley (Figure 3). BJ \textit{R. maidis} had a higher fecundity than MS population ($X^2 = 937.61$, $df = 1$, $p < 0.001$) especially from the 6\textsuperscript{th} to 7\textsuperscript{th} day and the total number of BJ and MS populations reached 57 and 18 respectively on the 7\textsuperscript{th} day.

Figure 2. Survival number of \textit{R. maidis} on high maize seedlings
Survival and reproduction on barley seedlings

Both populations were able to survive and reproduce on barley seedlings (Figure 3). The two populations had similar fecundity from the 1\textsuperscript{st} to 6\textsuperscript{th} day, then BJ \textit{R. maidis} had a sharp increase on the 7\textsuperscript{th} day reaching 134 individuals whereas MS population rose more gently up to 78 on the 7\textsuperscript{th} day ($\chi^2 = 72.27$, $df = 1$, $p < 0.001$).

DISCUSSION

Although \textit{R. maidis} is one of the major pests on maize in the field, our laboratory data showed that both BJ and MS \textit{R. maidis} had the best performance on barley seedlings and a lower growing speed on 50 cm high maize seedlings, based on which, we can infer that the maize field could be surrounded by guard rows of aphid-attractive plants such as barley seedlings or through intercropping agricultural control method (Ogengalatigo et al., 1992) to reduce the losses of maize yield caused by \textit{R. maidis}. As proved previously, the survival rates of \textit{R. maidis} were different on barley and wheat and the aphid performed differently as well on wheat of variant ages (Hirano and Ito, 1964). Our study demonstrated that 10 cm high maize seedlings were fatal to both populations, the unsuccessful colonization may be due to some detrimental chemicals in young maize seedlings (10 cm high) such as DIMBOA (2,4-Dihydroxy-7-methoxy-1,4-benzoxazin-3-one). DIMBOA, a secondary metabolite in many cereals, is a hydroxamic acid that plays an important role in insect resistance (Pérez and Niemeyer, 1989; Yan et al., 1995; Klun et al., 1967). The concentration of DIMBOA varies according to the age and plant organ. For instance, DIMBOA is synthesized concurrently with germination in maize and the concentration reaches to the highest 24-36 h after germination (Ebisui et al., 2000), then decreases with plant growing, however, the biosynthesis still continues 6±10 days after germination (Cambier et al., 2000). In this study, \textit{R. maidis} was inoculated 4-5 days after germination of the 10 cm high maize seedling treatment, during this time, DIMBOA was still biosynthesized. As for maize seedlings in 50 cm height, inoculation of \textit{R. maidis} was implemented 19-20 days after germination. In addition, the barley seeds used were from a cultivar that was unable to biosynthesize DIMBOA because of the elimination of the \textit{Bx} gene (Nomura et al., 2003). However, the resistant effect of DIMBOA in small maize seedlings needs further verification.
Previous study found that the performance of different populations of *A. craccivora* were significantly different on faba bean, field pea as well as narrow-leaved lupin (Edwards, 2001). Also, when highly defended wheat seedlings were used as host plant, the population growth rate of one superclone of *S. avenae* was significantly higher than non-superclone (Barrios-SanMartin et al., 2016). Moreover, different genotypes from microsatellite analysis of *S. avenae* performed diversely on wheat (Figueroa et al., 2004). In the present research, the aphid number of the MS population increased slowly on 50 cm high maize seedlings compared with the BJ population especially after the 4th day, the total number even decreased from 19 on the 4th day to 18 on the 7th day rather than increasing. Similarly, BJ *R. maidis* showed a better performance on barley that reached a much higher number on the 7th day than the MS population, which indicated that BJ *R. maidis* had a stronger adaptability than the MS population. Nikolakakis et al. (2003) found a significant effect of ‘region / host plant origin’ based on the different performance of various *M. persicae* clones. The two populations of *R. maidis* in our study were from different regions of the same plant and the effect of “host plant origin” could be tested in the future research.

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REFERENCES


