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RESEARCH ARTICLE

Improving a method for evaluating alfalfa cultivar resistance to thrips

TU Xiong-bing[1*], FAN Yao-li[1, 2*], JI Ming-shan[2], LIU Zhong-kuan[3], XIE Nan[3], LIU Zhen-yu[3], ZHANG Ze-hua[1]

[1] State Key Laboratory for Biology of Plant Diseases and Insect Pests, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing 100193, P.R.China
[2] College of Plant Protection/Biopesticide Engineering Research Center of Liaoning Province, Shenyang Agricultural University, Shenyang 110161, P.R.China
[3] Institute of Agro-Resourse and Environment, Hebei Academy of Agriculture and Forestry Sciences, Shijiazhuang 050051, P.R.China

Abstract

The thrips quantity ratio (TQR) model is an important tool for evaluating crop resistance to thrips based on the correlation between thrips quantities and cultivars. Unfortunately, it is inaccurate, and the results appear significantly inconsistent when analysing the same cultivars in the same field study. To improve this model, we first studied the resistance of 28 alfalfa cultivars to thrips in Cangzhou, Hebei Province, north China. The results showed that the most suitable evaluation period was from May to June, as the thrips population was stable during this period. Second, we found that the natural enemy population was significantly positively correlated with the thrips population density (R=0.7275, P<0.0001), which might influence resistance estimation. Hence, we introduced a parameter 'α', corresponding to the natural enemy quantity ratio, to eliminate the effect of the natural enemy using "αTQR". Using the improved method, 28 cultivars were clustered into three classes: the resistant class, sensitive class, and median class. All numerical values were calculated for αTQR displayed as a Gaussian distribution. This information showed that all data should be divided into nine groups using a median value of 1±0.1 with an equal difference of 0.1. Based on the new standard cultivars, Gongnong 1, Alfaking, Cangzhou and Algonquin were classified as highly resistant cultivars; Zhongmu 3, Gongnong 2, Zhongmu 1 and Zhongmu 2 were classified in the resistant group; Queen was classified in the moderately resistant group; Derby, WL354HQ, KRIMA, Apex, 53HR, SARDI 5 and Farmers Treasure were classified in the median class; WL319HQ, WL343HQ and Sitel were classified as the low sensitive group; WL440HQ and SARDI 7 as the moderately sensitive group; WL168HQ and Sanditi as the sensitive group; and SARDI 10, WL363HQ, FD4, WL323 and SOCA as the highly sensitive group.

Keywords: thrips quantity ratio (TQR) model, alfalfa, cultivar resistance, thrips, natural enemy

1. Introduction

Many mathematical models utilizing pest population density are widely used in Integrated Pest Management (IPM) to evaluate variety resistance (Luginbill 1969; Funderburk 2001). Over the years, numerous researchers have worked to improve the accuracy of such models. Wu *et al.* (1990)

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TU Xiong-bing, E-mail: txb1208@163.com;
Correspondence ZHANG Ze-hua, Tel: +86-10-82109585, Fax: +86-10-82109569, E-mail: zhangzehua@caas.cn
[*] These authors contributed equally to this study.

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studied the resistance of alfalfa cultivars to thrips using the universal rate, hazard severity and pest index. Richard and James (1991) proposed a thrips damage index to evaluate pepper cultivar resistance to western flower thrips (*Frankliniella occidentalis* (Pergande)). Alabi *et al.* (2003) evaluated cowpea cultivar resistance to flower bud thrips (*Megalurothrips sjostedti* Trybom) based on the thrips population density and thrips damage index. Maris *et al.* (2003) analysed the differences in the resistance of seven capsicum accessions to thrips based on feeding damage, host preference, and host suitability for reproduction. Temuer *et al.* (2003) proposed a method to study the differences in the resistance of alfalfa to thrips using the pest index. He *et al.* (2007) proposed the thrips damage index in alfalfa to estimate cultivar resistance to thrips. Hu *et al.* (2007, 2009) analysed the tolerance of alfalfa varieties to *Odontothrips loti* Haliday based on thrips population density. Wang (2009) evaluated alfalfa (*Medicago sativa* L.) resistance to thrips using the thrips damage index and individual thrips. All of these authors made important contributions to crop variety resistance evaluation.

The thrips quantity ratio (TQR) model is not only simple but very practical. Yuan and Zhang (2006) analysed alfalfa cultivar resistance to thrips by using TQR model. This model has played a positive role in studying plant resistances to pests, but it has not revealed which factors produce resistance in cultivars (Farmer 2001; Zeng *et al.* 2008), especially for crops without absolute resistance (Schnee *et al.* 2006; Shiojiri *et al.* 2006). For instance, it is known that the presence of a natural enemy affects pest population dynamics (Dan *et al.* 1997; Ge *et al.* 2011), but the natural enemy was only a part of the intrinsic properties when we studied crop resistance to pests, and the relationship between the natural enemy and the pest was not determined (Fang *et al.* 2010).

In this study, we developed a modified TQR model for evaluating the resistance of alfalfa varieties to thrips. These pests are widespread throughout the world and cause severe damage to crops (Han 1997; Zhang *et al.* 2005). Unfortunately, the current TQR model is inaccurate, with typical discrepancies between the predicted *vs.* actual field levels (Temuer *et al.* 2005; Cheng *et al.* 2009; Liu *et al.* 2012). For this reason, we investigated development in thrips with the aim of improving the TQR model for these pests. We first investigated the occurrence period of thrips and their enemies in the field to select a suitable evaluation stage. We also investigated the population dynamics of thrips and their enemies and carefully monitored their development. Based on these results, we analysed the natural enemy effect on the TQR model and developed a new model for evaluating alfalfa variety resistance.

2. Results

2.1. Selection of the appropriate period to estimate thrips resistance of alfalfa cultivars

The TQR and improved TQR (αTQR) of the pre-period, mid-period, and late-period were calculated, and the standard errors (SE) of each period were compared (Appendix A). The results indicated that the SE of TQR in the pre-period was the lowest (F=28.67, P<0.0001), and the SE of αTQR in the pre-period was also the lowest (F=18.25, P<0.0001). Hence, the early stage (May–June) of the year was the most suitable for analysing cultivar resistance to thrips.

2.2. Resistance of alfalfa cultivars to thrips using the TQR model

The thrips quantities of each cultivar were recorded and the TQR values calculated. The results showed that the 28 cultivars could be clustered into three classes and nine groups. The classes were the resistant class, sensitive class, and median class (Fig. 1, Appendix B). The resistant class included four groups: (1) Alfaking; (2) Algonquin, Cangzhou, Gongnong 1, Gongnong 2; (3) Zhongmu 1, Zhongmu 2; and (4) Queen, Zhongmu 3 (Fig. 1). The median class included only one group, consisting of Derby, Apex, KRIMA, Sitel, WL354HQ, WL319HQ, and Farmers Treasure (Fig. 1). The sensitive class again included four groups: (1) 53HR, SARDI 5, SARDI 7; (2) SARDI 10, Sanditi, SOCA, WL363HQ, WL343HQ, WL168HQ; (3) FD4, WL440HQ; and (4) WL323 (Fig. 1).

2.3. Correlation between the natural enemy and thrips cultivars

To obtain a better understanding of the relationship between the natural enemy species and thrips cultivars, we analysed the correlation between the natural enemy and thrips, in terms of the TQR of 28 cultivars during the pre-period (May–June). The results showed a clear positive correlation between the natural enemy and thrips (R=0.7275, P<0.0001) and a lower correlation between natural enemy and TQR (R=0.1715, P=0.1191) (Table 1). As the latter represented the cultivar resistance, we speculated that the natural enemy population dynamics relies on the thrips population density, which might play an important role in using the TQR model to examine the cultivar resistance to thrips. In this study, we found that the natural enemy quantity showed a significant correlation with thrips and produced errors using the TQR model, then the value 'α' should be considered when we estimate the cultivar resistance in the field (Table 1).

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