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Outbreak of *Nysius cymoides* on second crop soybean *Glycine max* and proposal for Integrated Pest Management

Davide Scaccini[1], Lorenzo Furlan[2]
[1]*Department of Agronomy, Food, Natural Resources, Animals and Environment, University of Padova, Legnaro, Padova, Italy*
[2]*Veneto Agricoltura, Legnaro, Padova, Italy*

Abstract

The present paper describes an outbreak of the false chinch bug *Nysius cymoides* (Spinola) (Hemiptera Lygaeidae) in a second crop soybean, *Glycine max* (L.) Merr. (Fabales Fabaceae), in the Veneto region (northern Italy), which occurred during summer 2017. Pest presence was also recorded in the same area the following year. In 2017, the massive presence of this pest (up to 250 specimens/plant) caused severe damage to the soybean crop, such as underdeveloped plants, dead spots on the leaves or dead plants. Pest outbreaks occur in droughty and warm periods; they can be related to ground litter and depend on the previous crop, as described for other species of the same genus. While canola increased the population of *N. cymoides* that damaged the following soybean crop, no false chinch bug presence was found in the soybean after winter wheat in the same area. Considering field observations, a provisional threshold for second crop soybean based on pest presence in previous crop litter is provided (10 *N. cymoides* specimens/250 mL of litter). Finally, a specific Integrated Pest Management procedure is suggested for this pest.

Key words: false chinch bug, outbreak, soybean, threshold, canola, litter, IPM.

Introduction

In agriculture, Lygaeidae (Hemiptera Heteroptera) are considered to be pest that may damage many different crops due to their feeding activity (Hori, 2000; Sweet, 2000). In environmental conditions such as warm summers, some species may give rise to outbreaks (Maistrello *et al*., 2006; Ferracini and Alma, 2008) that cause damage to crops as in the case of the false chinch bug, *Nysius cymoides* (Spinola) (Hemiptera Lygaeidae) (Parenzan, 1985; Bocchi *et al*., 2016; Chapelin-Viscardi *et al*., 2017).

N. cymoides belongs to Orsillinae, a thermophilic subfamily, and it is widespread in Europe, North Africa and the Middle East (Péricart, 1998; Aukema, 2013). More than 100 species of the genus *Nysius* Dallas are described worldwide, and about 15 occur in the Palaearctic Region (Ashlock, 1967; Péricart, 1998).

N. cymoides probably has one generation per year, with the adult overwintering (Péricart, 1998; Sweet, 2000). The false chinch bug has caused economic losses to crops across the Mediterranean basin. In fact, *N. cymoides* develops on different plant species, with a remarkable preference for cruciferous plants such as cabbage and cauliflower, *Brassica oleracea* L., canola, *Brassica napus* L., and wild mustard, *Sinapis arvensis* L. (Brassicales Brassicaceae) (Rivnay, 1962; Péricart, 1998; Sweet, 2000). Its feeding activity is also reported on leguminous plants, such as alfalfa, *Medicago sativa* L. (Fabales Fabaceae) (Rivnay, 1962; Alsuhaibani, 1996; Razmjoo *et al.*, 2011), but also on many other families (Péricart, 1998; Sweet, 2000; Bocchi *et al*., 2016).

Recently, outbreaks of the pest on quinoa, *Chenopodium quinoa* Willd. (Caryophyllales Amaranthaceae), and canola were also reported in Italy and France (Bocchi *et al*., 2016; Chapelin-Viscardi *et al*., 2017). In southern Italy, an outbreak of *N. cymoides* caused damage to jojoba, *Simmondsia chinensis* (Link) C. K. Schneid. (Euphorbiales Buxaceae) (Parenzan, 1985). The damage is caused by immature stages and adults, and consists in desiccation and wilting of plant tissue that often turns yellow-brownish and develops necrosis; weight loss of seeds can also occur (Parenzan, 1985; Sweet, 2000; Bocchi *et al*., 2016; Chapelin-Viscardi *et al*., 2017).

The aim of the study is to describe an outbreak of *N. cymoides* in fields of a second crop soybean, *Glycine max* (L.) Merr. (Fabales Fabaceae), in the Veneto region (northern Italy), which occurred during summer 2017 and caused severe damage to the crop. The relationship with canola as the previous crop is also stated. Based on these observations and those made in 2018 in the same area, an Integrated Pest Management (IPM) procedure for *N. cymoides* on second crop soybean is proposed, including a provisional damage threshold for the pest.

Materials and methods

Site

Year 2017

The outbreak of *N. cymoides* was observed on Olmo farm near Caposile, San Donà di Piave, Venice (Veneto region, Italy; 45.574288, 12.577276, -2 m a.s.l.) where a plot of about 30 ha had been planted with canola in autumn 2016 (hybrid PR44D06). The canola had been harvested on 14-15 June 2017 and the soybean variety Regir sown as a second crop on 18-19 June using a Vadestag sowing machine for sod-seeding (670,000 seeds/ha, interrow width 37 cm). In early July 2017, the same soybean variety was planted after winter wheat, *Triticum aestivum* L. (Poales Poaceae), using the same sod-seeding sowing machine on a 50 ha plot just opposite the plot previously planted with canola. The same agronomic practices (e.g. tillage, fertilization, weed control etc.) were applied to all of the plots.

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Identical agronomic procedures (including the same canola hybrid) were applied the following year in neighboring plots where the same rotation system is being used. The soybean (variety Dukat - Carla Import Sementi, 550,000 seeds/ha) was sown on 18-19 June 2018, after the canola had been harvested on 16-17 June. Minimum tillage was performed at a depth of about 20 cm on field strips close to no-tillage areas after canola. Minimum tillage caused complete litter incorporation.

Nysius cymoides population assessment

Each large plot was divided into fields of about 1 ha. In each field, canola and winter wheat litter samples of 250 mL were taken quickly (in few seconds) from the soil surface on a grid (60 m × 20 m) on 2 and 3 August 2017, and on 6 and 7 July 2018; six samples were collected per field, and the sample area varied between 0.5 and 1 ha. Fifteen fields per previous crop were sampled. In total, 180 samples were collected. Collected litter was put in a freezer (-18 °C) and then the number of specimens was recorded by observing the material under a stereo-microscope. Adults were identified following the identification keys by Péricart (1998), and the species was confirmed by mtDNA analysis, cytochrome c oxidase subunit I (Hebert *et al*., 2003), which was performed on both mature and immature stages.

Plant damage

In order to study the effect of the pest on soybean, two sub-plots of 1.5 m × 2 adjacent rows of soybean were chosen at random per monitored field and the plants observed from 3 to 5 August 2017 and 11 to 13 July 2018, both on no-tillage and minimum-tillage land (1511 plants). Plants were divided into two classes:

(1) damaged plants: dead plants or small plants bearing leaves with plenty of dead spots (figure 1A-C) due to sucking by the pest. Many individuals moving on the leaves and the stems;

(2) slightly damaged and undamaged plants: normal plants with no or few *N. cymoides* individuals on the leaves.

Figure 1. A) Several individuals of *N. cymoides* on a soybean leaf; **B)** Soybean with heavy damage, such as wilting, yellow-brownish tissue and dead spots caused by *N. cymoides* feeding activity; **C)** Dead and small soybean plants due to *N. cymoides* infestation (August 2017, San Donà di Piave, Venice, Italy).

Furthermore, the number of *N. cymoides* specimens on the leaves of four plants were counted on each plot by direct observation in the field. The plants were chosen at random from the sub-plot.

Statistical analysis

The association between the number of *N. cymoides* specimens collected from the litter and the percentage of damaged plants was evaluated using a regression analysis. The hypotheses of the linear model on residuals were graphically tested. Data were processed using SAS 9.3 (SAS Institute, 2012).

Results

During the first year of observation, more than 200 individuals per soybean plant were often observed in the field with the highest *N. cymoides* densities. They included all the mobile stages (figure 1A) and, in some cases, peaks of up to 250 individuals were observed. The high density of *N. cymoides* caused damage to soybean plants, such as wilting and yellow-brownish tissue (figure 1B) or size reduction, even resulting in plant death in some cases (figure 1C). The harmfulness of *N. cymoides* to soybean is clearly demonstrated, with association between damage and population density (i.e. specimens in the litter) being highly significant (table 1, figure 2).

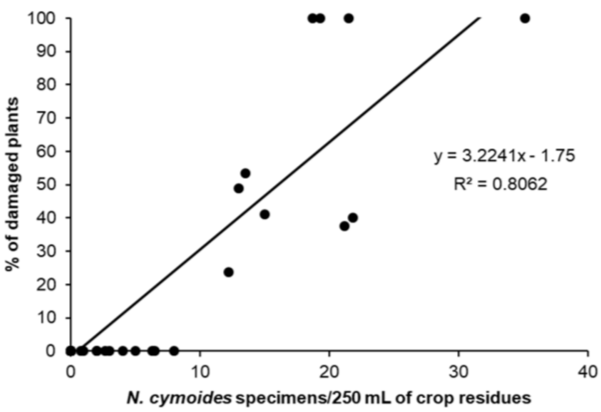

Figure 2. Relationship between *N. cymoides* specimens on crop residues and the percentage of heavily damaged soybean plants in 2017 and 2018 ($F = 241.26$; $P < 0.001$). Estimates of parameters: $a = -1.75$, $s_a = 1.75$, $b = 3.22$, $s_b = 0.21$ (where a, b, s_a and s_b are intercept, regression slope and standard errors of estimates, respectively). Root means square error of the model = 12.07, $R^2 = 0.81$.

A rotation effect was also detected, as the pest population level was negligible in fields with winter wheat as the previous crop, while in some fields the pest was capable of destroying the second soybean crop when it followed canola (table 1).

In the observed conditions, a density of 10 specimens/250 mL of litter may be considered a practical damage threshold for establishing the risk of economic damage to soybean plants (table 1, figure 2). Below this population level, no significant effects on the plants were recorded, thus no negative effects on soybean yield and quality can be expected.

The outbreak reported herein occurred in northern Italy in 2017 and followed a droughty and warm period from May-August. More rain events and lower temperatures (in particular referred to maximum temperature) occurred in May-July 2018 compared to the same period in 2017 (figures 3-5). In 2018, there was no *N. cymoides* outbreak (population levels were below the threshold in all monitored fields), and once again no pest presence was detected after winter wheat. In fields where minimum tillage was performed, no *N. cymoides* individuals and no damage symptoms were found on the plants.

Discussion and conclusions

The outbreak of *N. cymoides* in north-eastern Italy and the damage to second crop soybean were most probably related to a combination of the previous crops (i.e. canola, but not winter wheat), its residuals on the ground, and the warm, dry weather in 2017 (figures 3-5). Indeed, the warm, dry summer may have contributed to the outbreak, as no similar reports were recorded in the same area in the previous years (L. Furlan, personal observation), or the following summer. *Nysius* species have been known to pullulate during warm periods, as documented for *Nysius huttoni* White (Farrell and Stufkens, 1993) and *Nysius raphanus* Howard (Demirel and Cranshaw, 2006a). Outbreaks of *N. cymoides* were sporadically reported on crops in Italy (Parenzan, 1985; Bocchi *et al*., 2016) and on canola in France (Chapelin-Viscardi *et al*., 2017). *N. cymoides* thrives in warm climates and Mohaghegh-Neyshabouri (2009) reported an increase in specimens with a rise in temperature (from

Table 1. Effect on soybean as second crop of densities of *N. cymoides* specimens collected from previous crop residues on the ground in no-tillage soil management (including data collected in 2017 and 2018, San Donà di Piave, Venice, Italy).

N. cymoides specimens/250 mL	no. of fields		Average of *N. cymoides* specimens/250 mL		Total no. of plants		Average (%) of damaged soybean plants	
	Canola	Winter wheat	Canola	Winter wheat	Canola	Winter wheat	Canola	Winter wheat
<10	20	30	2.10	0	1975	2932	0	0
10-19.9	6	-	15.27	-	597	-	61.23	-
≥20	4	-	24.91	-	399	-	69.42	-

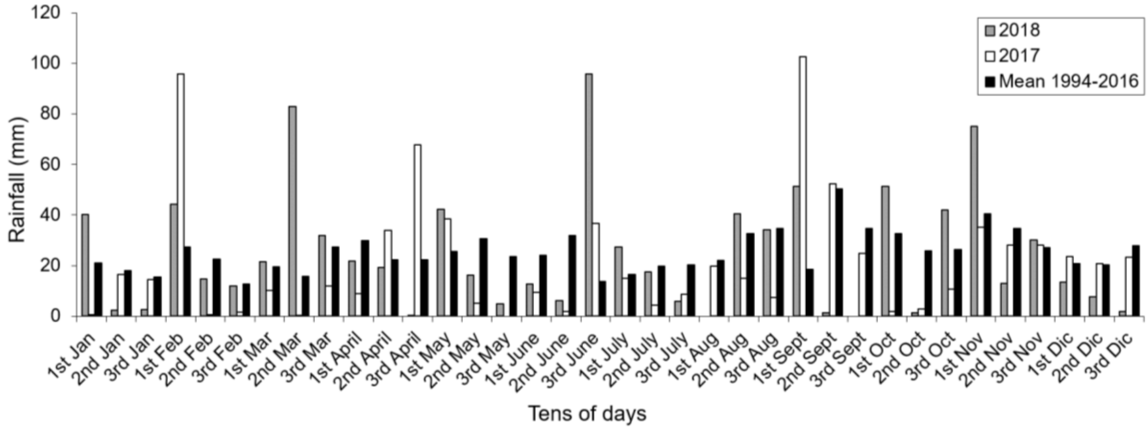

Figure 3. Long-term rainfall patterns in the studied area compared with precipitations (mm) recorded in 2017 and 2018.

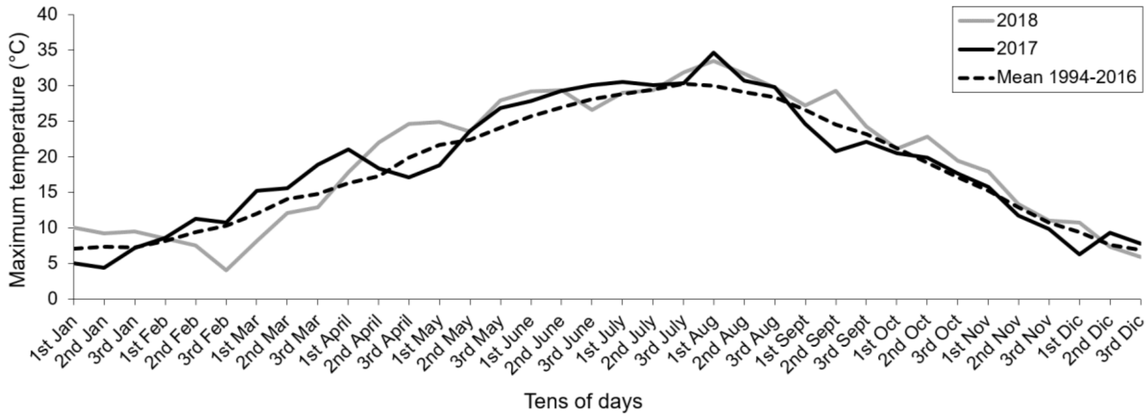

Figure 4. Long-term maximum temperature patterns in the studied area compared with temperatures (degrees Celsius) recorded in 2017 and 2018.

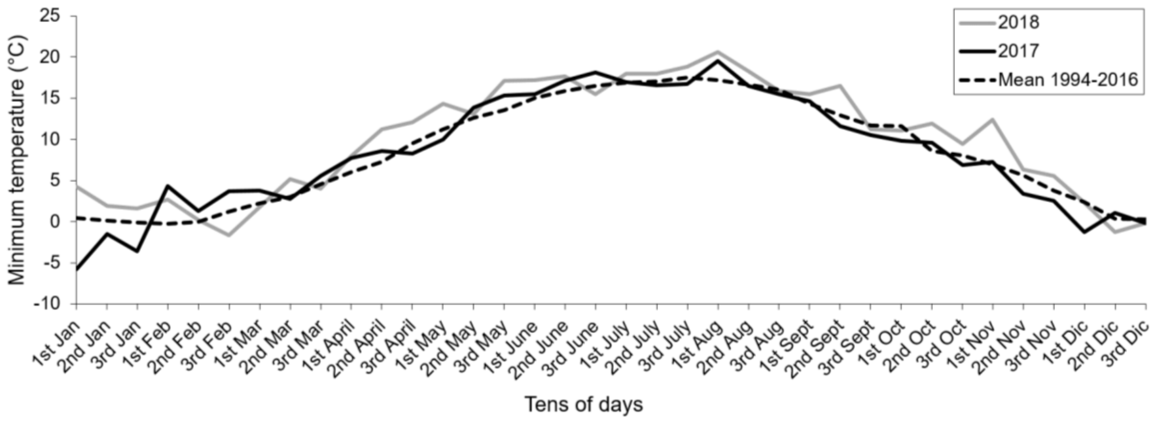

Figure 5. Long-term minimum temperature patterns in the studied area compared with temperatures (degrees Celsius) recorded in 2017 and 2018.

17.5 °C to 37.5 °C). Similar reports have been made for other *Nysius* species (He *et al*., 2003; du Plessis *et al*., 2011). Attia and Elshafie (1974) also demonstrated the preference of *Nysius vinitor* Bergroth females for ovipositing in dry conditions, which enhanced egg survival (Attia, 1982).

N. cymoides individuals were observed in the litter and on soybean plants, and a remarkably higher presence on plants cultivated after canola, rather than after winter wheat, was detected (table 1). *N. cymoides* is well-known as a canola pest in the Middle East (e.g. Mohaghegh *et al*., 2016; Mohaghegh-Neyshbouri *et al*., 2016; Mollashahi *et al*., 2016) and, less frequently, in the West (Chapelin-Viscardi *et al*., 2017). Crop-sequence and rotational effect were detected on populations of *N. raphanus*, which showed higher infestation levels on pearl millet, *Pennisetum glaucum* (L.) R. Br. (Poales Poaceae), and soybean following canola cultivation (but not winter wheat; Buntin *et al*., 2007). The presence of litter may also increase false chinch bug populations, as it is a suitable place for overwintering (Farrell and Stufkens, 1993; Sweet, 2000; Mohaghegh *et al*., 2015).

In the study area, the damage to second crop soybean was remarkable, with wilted and desiccated tissues (figure 1B), as well as reduced plant size, including plant death in some cases, being observed (figure 1C). To our knowledge, this is the first report of such damage by *N. cymoides* on soybean in Europe, even though the pest has been found on the same crop in other countries (in Iran; Aminikhalafbadam *et al*., 2006), along with other false chinch bugs (Buntin *et al*., 2007; Dalazen *et al*., 2014; Pall *et al*., 2016). Damage to second crop soybean was significant, with densities exceeding 10 individuals/250 mL of litter (table 1, figure 2), which we propose as a provisional threshold for *N. cymoides* infestation on second crop soybean. Samples were taken quickly (in few seconds) from the soil surface on both canola and winter wheat residuals, as previously described. However, visual sampling of litter and crop is also recommended for monitoring false chinch bug populations (Hangartner and McDonald, 2015). Other examples of 'visual' thresholds are comparable and should be carried out on crop plants. The thresholds reported here refer to the most sensitive stages and to *N. vinitor*, on canola: 5 individuals/head (Demirel and Cranshaw, 2006a), or 10 adults or 20 nymphs/plant; on *Sorghum* sp. (Cyperales Poaceae): 20-25 individuals/head; on sunflowers: 10-15 adults/plant (Hangartner and McDonald, 2015); and on *Vigna* sp. (Fabales Fabaceae): 50 individuals/plant (Williams 2017).

In the risk assessment of false chinch bug in second crop soybean, the previous crop plays a key role, with canola appearing to cause a greater increase in pest population than winter wheat. When there is a risk of pest outbreaks due to the previous crop and suitable environmental conditions (i.e. warm and droughty periods), litter monitoring just before soybean sowing, as described in this paper, allows the presence of harmful pest populations to be established. Visual observations are also suggested to detect and monitor the pest during the growing season. In cases of no or low presence of *N. cymoides* specimens in the litter (below the provisional threshold of 10 specimens/250 mL), soybean can be sown without precautions for this pest. When the population density exceeds the threshold, it is advisable not to sow soybean or other crops that foster this pest.

According to previous literature, incorporating soil tillage with residuals of the previous crop, as in the case of canola, has been shown to be an effective approach for preventing *N. cymoides* infestations. In fact, unploughed fields led to a massive infestation of *N. cymoides* in France (Chapelin-Viscardi *et al*., 2017), and Mohaghegh *et al*. (2015) include ploughing among the possible methods for reducing pest population. This was confirmed by observations made in Italy. Management practices, such as sprinkle irrigation, can also help to control *Nysius* (Demirel and Cranshaw, 2006b; Chapelin-Viscardi *et al*., 2017).

In cases of a high pest presence in late season (i.e. when soybean is already established), management options include agronomic practices and/or chemical application (Sweet, 2000), but IPM principles must be taken into account before farmers decide whether to treat crops with chemicals (Barzman *et al*., 2015). Finally, insurance cover under the mutual fund approach (Furlan *et al*., 2018) may make farmers more comfortable with the implementation of IPM against *Nysius* populations since mistakes and unpredictable events would be compensated.

IPM procedure for second crop soybean can be summarized as follows:

a) risk assessment: when canola is the previous crop, estimate population levels by monitoring litter after harvesting;
b) when population levels are below the threshold: sow soybean as the preferred crop and till or do not till before sowing according the most convenient farm solution;
c) when population levels exceed the threshold: till the soil before sowing soybean, or move the second crop to non-risk fields.

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Authors' addresses: Lorenzo Furlan (corresponding author: lorenzo.furlan@venetoagricoltura.org), Veneto Agricoltura, viale dell'Università 14, 35020 Legnaro, Padova, Italy; Davide Scaccini (davide.scaccini@phd.unipd.it), University of Padova, Department of Agronomy, Food, Natural Resources, Animals and Environment, viale dell'Università 16, 35020 Legnaro, Padova, Italy.

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