MODELLING WINTER SURVIVAL AND POTENTIAL DISTRIBUTION OF *SESAMIA NONAGRIOIDES* UNDER CLIMATE CHANGE IN EUROPE

MODELLIZZAZIONE DELLA SOPRAVVIVENZA INVERNALE E DELLA DISTRIBUZIONE POTENZIALE DI SESAMIA NONAGRIOIDES *IN SCENARI DI CAMBIAMENTO CLIMATICO IN EUROPA*

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Abstract
The potential survival and distribution of *Sesamia nonagrioides* Lef. under current and future climate were estimated. Winter survival was simulated using an original approach based on the concept of lethal dose exposure. Two approaches were applied for simulating potential distribution. One using air temperature as weather input. The second taking into account the fraction of larvae overwintering in the soil, therefore using also soil temperature. Results showed that the approach taking into account soil temperature is the most adequate for simulating MCB distribution. The approach using air temperature only was useful to identify areas where MCB survival can occur even without overwintering in crop roots residues. In these areas the suggested practice of uprooting and exposing the stubble on the soils surface for controlling the MCB should be considered ineffective. The potential geographical spread of the MCB is expected to increase.

Keywords: sesamia nonagrioides, winter survival model, potential distribution model, climate change.
Parole chiave: sesamia nonagrioides, modello di sopravvivenza invernale, modello di distribuzione potenziale, cambiamenti climatici.

Introduction

The warming of the climate has the potential to significantly modify the distribution of the Mediterranean Corn Borer (MCB - *Sesamia nonagrioides Lef.*). The MCB is one of the most important maize borers in Europe. Gillyboeuf *et al.* (1994) reported that its distribution and population levels are primarily determined by its sensitivity to sub-zero winter temperatures. They also estimated that around 80% of MCB larvae overwinter in maize residues above the soil surface, and the remaining larvae in roots. In Europe the 45th parallel has been indicated as its northern limit (Eizaguirre and Fantinou, 2012) and its spread and development have been mainly reported from the areas where it is considered an important pest. This study estimates the potential survival and distribution of the MCB under current and future climate over Europe.

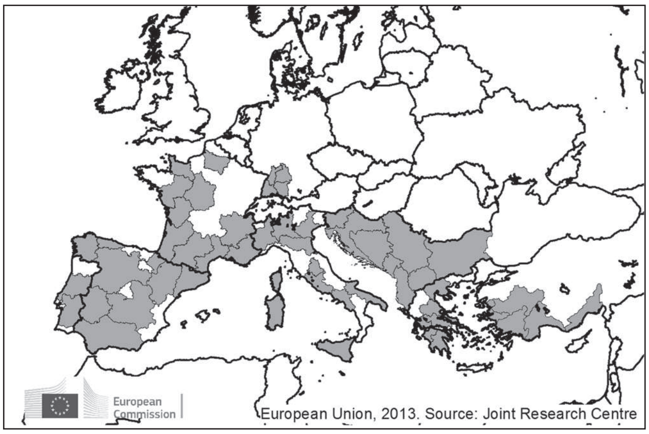

Fig. 1 - Observed distribution of S. nonagrioides in Europe. Distribution was mapped at the NUTS 2 level with the exception of the Balkans where it was mapped at the NUTS 0 level because of the absence of more specific information.
Fig. 1 - Distribuzione osservata di S. nonagroides in Europa. La distribuzione è stata mappata al livello NUTS 2, con esclusione dei Balcani, dove è stata mappata al livello NUTS 0 per mancanza di dati.

Matherials and Methods

The current distribution of the MCB was estimated using data and information from different sources, including scientific and technical literature, and webservices. The found information was used to develop a distribution map at the NUTS2 level. An original winter survival model based on the concept of lethal dose exposure was developed based on data about mortality (%) of diapausing larvae following exposure (h) to cold temperatures (°C) and different time of exposure (Gillyboeuf *et al.*, 1994; Andreadis *et al.*, 2011). Two modelling solutions were compared for the simulation of winter survival: the first one (AirMS) using as input only air temperature, the second one (AirSoilMS) using air and soil temperature, therefore accounting for the fraction of larvae overwintering in soil. Soil temperature in the first 5 cm was estimated using the model UNIMI.SoilT coupled to UNIMI.SoilW (http://agsys.cra-cin.it/tools/) for simulating water balance, being soil water content a needed input to estimate soil temperature. Based on Gillyboeuf et al. (1994), it was assumed that 20% of diapausing population was overwintering in roots, and 80% in maize stems above soils surface. The population was considered as survived if at the end of diapause survivors were ≥10% and if the phenological model reached at least the completion of the first generation. The phenological model was based on the rate summation method. The data source used for its development consisted of mean development time of immature stages of MCB at constant temperatures (López *et al.*, 2001). A dataset of weather data on scenarios of future climate (A1B, ECHAM5-HIRHAM5) was used (Donatelli *et al.*, 2012). Two climate scenarios were chosen: the baseline and 2030, representing a sample of 10 years of daily weather centred on the years 2000 and 2030. The models were implemented in a modified version of the model component MIMYCS.Borers (Maiorano, 2012; Maiorano *et al.*, 2012).

Results and Discussion

Figure 1 shows the map of the probable current distribution of the MCB in Europe according to the found sources of information. The potential distribution simulated by the AirMS approach (Fig. 2) includes regions which are already known from literature to be areas with high population levels of MCB. The potential distribution simulated by this approach shows the areas where air temperature alone can guarantee MCB survival. In these areas one of the practice that was suggested for controlling the MCB (uprooting and exposing the stubble on the soils surface for exposing larvae to winter cold) (Gillyboeuf *et al.*, 1994) should be considered ineffective. These areas are expected to increase between 2000 and 2030. Results coming from the SoilAirMS approach (Fig. 3) are more adherent to the observed distribution.

The potential geographical range is expected to increase. Comparing this distribution to the potential distribution simulated using the AirMS approach during the same time frame, since no presence is expected by this approach in these new areas, it can be argued that uprooting and exposing the stubble on the soils surface could be a sufficient strategy to control the MCB in the future.

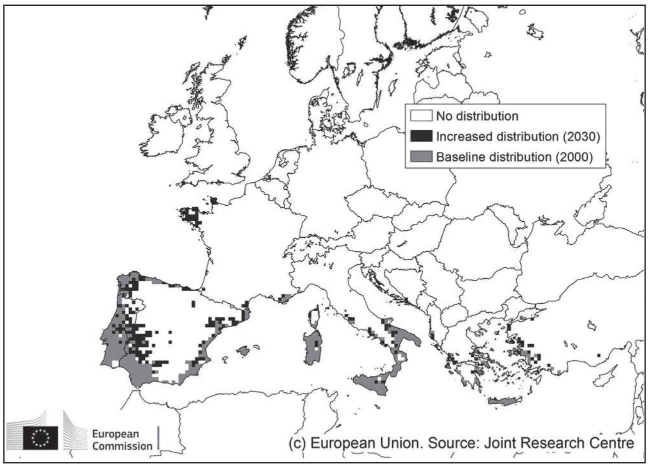

Fig. 2 - Actual (2000) and increased (2030) estimated distribution of S. nonagrioides in Europe using the AirMS approach.
Fig. 2 - Stima della distribuzione di S. nonagroides in Europa, attuale (2000) e futura (2030) usando l'approccio AirMS.

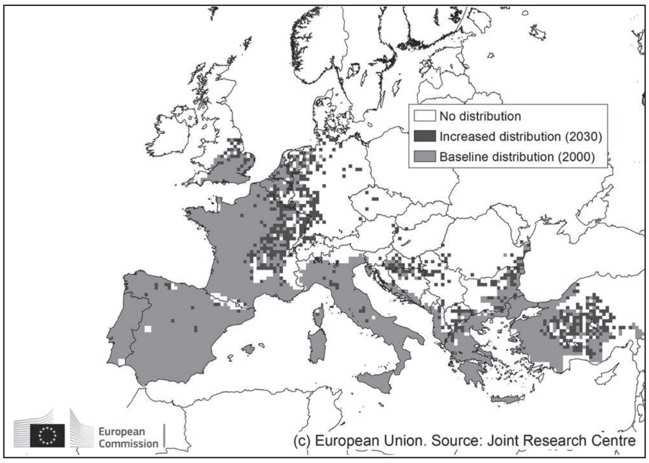

Fig. 3 - Actual (2000) and increased (2030) estimated distribution of S. nonagrioides in Europe using the SoilAirMS approach.
Fig. 3 - Stima della distribuzione di S. nonagroides in Europa, attuale (2000) e futura (2030) con l'approccio SoilAirMS.

Conclusions

This is the first study about the potential survival and distribution of the MCB under current and future climate considering overwinter survival in crop roots. Potential survival was simulated using an original approach based on the concept of dose exposure and taking into account the important role played by soil temperatures. Results showed that there is a close correlation between soil temperature and the MCB distribution. In fact MCB potential distribution was much better explained when soil temperature was taken into account. The modeling approach without soil temperature as input was also useful as it allowed identifying areas where MCB winter survival is assured even without the soil thermal buffer and where the agronomic strategy of exposing soil root to air temperatures would be not effective. Potential distribution under future scenarios allowed identifying areas of future potential invasion by the MCB. In these areas the MCB could become an important pest. In these areas exposing the root to air temperature could be a very effective measure.

Acknowledgments

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