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Which Factors Predict Stem Weevils Appearance in Rapeseed Crops?

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ABSTRACT

Stem weevils are the first pests that invade oilseed rape crops after winter period of hibernation. Rape and cabbage stem weevils are considered as a pest complex although their biological and ecological characteristics are different. The most important moment in their control is to determine optimal time of insecticide application to prevent oviposition and larvae development inside the plants. The aim of this research was to determine which climatic factors have the greatest impact on appearance of adult forms. During four growing seasons flight of adults forms were monitored by yellow water traps. Abundance and climatic factor from each location were correlated and for each species a regression tree was created. The most important factors that determine the appearance of adult forms of stem weevils are growth stage of the crop, daily sunshine hours, mean daily air temperature and mean daily precipitation. These results represent a starting point for the new prediction model within moderate climatic zone.

Key words: Oilseed rape, *Ceutorhynchus napi*, *Ceutorhynchus pallidactylus*, prediction, climatic factors.

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INTRODUCTION

Biological and ecological features of rape (*Ceutorhynchus napi* Gyllenhal, 1837) and cabbage (*Ceutorhynchus pallidactylus* Marsham, 1802) stem weevil are similar and they are often presented as a pest complex although life cycles are different and demand different approaches in their control. Adult forms of rape stem weevil hibernate between -2 and +2 °C and emerge from the soil during February and March. Activity of adult forms of rape stem weevil begins between soil temperature of 4 and 6 °C (Broschewitz, 1985) or when temperature 5 cm below soil surface exceeds 6 °C (Büchs, 1998). Flight of adult forms starts when air temperature exceeds 9 °C (Nuss, 2004) with increased activity between 12 and 15 °C when they move onto oilseed rape fields. According to Šedivy & Kocourek (1994) mass flight of rape stem weevil starts between 12 and 20 °C or when daily air temperature reaches 12.2 °C. Nuss (2004) states that highest number of adult forms of rape stem weevil was recorded when temperature threshold exceeds 12 °C and mean daily temperature was between 8 and 9 °C. According to Eickermann, Beyer, Georgen, Hoffman, & Junk (2014) flight of adult forms starts when air temperatures reach 0 °C and cumulative temperature sum form January 1st reach 74 °C. Flight activity of adult forms of cabbage stem weevil starts when air temperature reach 6 °C and cumulative temperature sum from January 1st reach 86 °C (Gratina, Apenite, & Turka, 2011). According to Johnen & Meier (2000) adult forms fly between air temperature of 12 and 14 °C and when wind speed is lower than 3 m/s. Active migration of adult forms of cabbage stem weevils occurs at average weekly temperature of 7.2 °C (Vaitelyté, Brazauskiené, & Petraitiené, 2013). Mass flight of adults occurs between 10 and 18 °C (Šedivy & Kocourek, 1994). When maximum daily air temperatures reach 15 °C and mean daily air temperatures reach 9 °C the highest number of adults can be found in yellow water traps (Nuss, 2004), which is partially confirmed by Debouzie & Ballanger (1993) and Johnen & Meier (2000). Insecticides applications are still common practice for control of stem mining weevils in oilseed rape. Thus, it is crucial to individuate the best period for insecticides treatment which should be applied before start of oviposition (Lerin, 1993). To fulfil this task various phonological forecasting systems were developed and help producers to predict the date of pest immigration to crops (Johnen et al, 2010). Critical point is to determine the optimal time of stem mining weevils migration into winter oilseed rape crops (Eickermann et al, 2014). As pest migration into fields is influenced by meteorological data, forecasting systems utilize long-term field studies and weather datasets, e.g. air temperature, soil temperature, precipitation, wind speed and sunshine hours (Johnen et al, 2010; Williams, 2010). The decision support system “proPlant expert” provides weather-based risk forecast for several oilseed rape pests (Frahm, Volk, & Johnen, 1996; Johnen et al, 2010). A series of “if-then” rules are used to provide prompt information about optimal time for insecticides application. This system relies on growth stage of the crop, on density of pest population and on climatic variables. The main precondition for utilization of the “proPlant” is to determine pest phenology at the local level. Thus, the objective of this study was to determine key climatic factors which are valuable in prediction of flight activity of rape and cabbage stem weevil in oilseed rape crops and might help to be incorporated into decision support system and validate on a local level.

MATERIALS AND METHODS

During four growing seasons (2015-2019) adult forms of rape and cabbage stem weevil were trapped at six locations within five counties presenting areas of intensive oilseed rape production (Table 1). During research period rapeseed crops were at the same growth stage at all locations. Sampling period started immediately after sowing (autumn period) and lasted till the end of senescence (BBCH 99) of the crop including fallow period between harvest and sowing in the next season.

Table 1. Counties, locations and GPS coordinate for each location during four years growing seasons where adult forms of stem mining weevils were sampled

Growing season	County	Location	GPS
1	Sisak-moslavina	Popovača	N 45°32'33.66'' E 16°34'38.87''
	Sisak-moslavina	Lipovljani	N 45°23'12.34'' E 16°51'52.66''
	Varaždin	Varaždin	N 46°21'11.19'' E 16°18'52.24''
	Požega-slavonia	Lipik	N 45°24'38.5'' E 17°08'18.96''
2	Sisak-moslavina	Popovača	N 45°31'59.41'' E 16°39'28.56''
	Sisak-moslavina	Lipovljani	N 45°24'18.54'' E 16°51'21.96''
	Varaždin	Varaždin	N 46°21'25.65'' E 16°12'46.94''
	Koprivnica-Križevci	Koprivnički Bregi	N 46°07'35.2'' E 16°53'42.79''
3	Sisak-moslavina	Popovača	N 45°34'17.99'' E 16°35'26.61''
	Zagreb	Šašinovec	N 45°50'45.45'' E 16°11'50.95''
4	Sisak-moslavina	Popovača	N 45°34'13.03'' E 16°32'56.91''
	Zagreb	Šašinovec	N 45°51'04.11'' E 16°10'58.88''

Monitoring of appearance and flight dynamics of adult forms of both species at each site was conducted by yellow water traps (34x26x7 cm) as standardized method (Williams, 2010). Four traps were installed in oilseed rape fields on metal, height - adjustable holders. Each rapeseed field was 3 ha and traps very placed diagonally through the field, from the lower left to the upper right edge, at the same distance between traps. This scheme enabled to have the representative sample of the whole field. Traps were filled with water with few drops of detergent to prevent surface tension of water. Due to height of oilseed rape plants traps were raised to be in line with the crop during to the growing period. The content of each trap was emptied once a week and collected fauna was placed into plastic bottles with 96 % ethanol. Growth stage of oilseed rape was recorded using BBCH-identification keys (Weber & Bleiholder, 1990; Lancashire et al, 1991) for every activity in the field. For both species trapping occurred from January 1st of each year to two weeks after harvest of oilseed rape.

Climatic data (minimum, maximum and mean daily air temperature, soil temperature at 5 and 20 cm depth, daily precipitation and number of daily sunshine hours) were obtained from Croatian Meteorological and Hydrological Service for each year of investigation and for each location. The maximum distance between the meteorological stations and trial locations was 20 km. Correlation between climatic factors, which have impact on appearance of adult forms of stem weevils, was determined with Pearson`s correlation coefficient. Based on determined coefficient connection between oilseed rape growth stage, daily number of sunshine hours, minimum, mean and maximum daily air temperature, daily precipitation and soil temperature on 5 and 20 cm depth were determined. To determine which factor best explains the greater abundance of each species the regression tree model was used. To predict pest abundance for each species (*C. napi* and *C. pallidactylus*) regression tree was created. Statistical analysis was performed in R software (version 3.1.2., 2014).

RESULTS AND DISCUSSION

In total, 13 832 adult forms of stem mining weevils were collected; 1 868 individuals were *C. napi* and 11 964 individuals were *C. pallidactylus*. Climatic factors that can help in prediction of appearance and abundance of *C. napi* are growth stage of oilseed rape plants, daily sunshine hours and mean daily air temperature and for prediction of *C. pallidactylus* additional important factor is mean daily precipitation. For both species wind speed was not key climatic factor in prediction of their appearance and abundance as it was proposed by Johnen et al. (2010). These factors can be utilized in decision support tools which are commercially available based on computer system (Frahm et al, 1996; Johnen & Meier, 2000; Newe, Meier, Johnen & Volk, 2003; Johnen et al, 2010), but for our area of investigation has to be adapted to local climatic conditions. Variables most influential in predicting *C. napi* abundance are present in Fig. 1 and variables most influential in predicting *C. pallidactylus* abundance are present in Fig. 2.

According to *Regression TREE* procedure the best predictor for the occurrence of *C. napi* was the growth stage of oilseed rape (Fig. 1) which is in contrast to Broschewitz (1985) who states that mean and maximum daily air temperatures and soil temperatures on 5 cm depth have the highest impact on appearance and flight activity of *C. napi*. When oilseed rape plants have more than seven leaves visible (>BBCH 27) the first *C. napi* individuals can be found. If oilseed rape plants have less than seven visible leaves (<BBCH 27) there is no possibility in appearance of adult forms in higher density, although single individuals can be found within the crop. This population size is not significant and is still under the economic threshold (Büchs, 1998; EPPO, 2014). The highest density, marked as the peak of the flight, of *C. napi* adults (36 individuals) were predicted when oilseed rape is in growth stage between seven side shoots detectable (BBCH 27) and flower buds are free and level with the youngest leaves (BBCH 52) and if daily sunshine hours are between 6.3 and 6.6. These results are partly confirmed by Broschewitz (1985) but only with respect to the relationship between growth stages of oilseed rape and number of adult forms, while

literature data dealing with the effect of daily sunshine hours on number of adult forms of *C. napi* do not exist. Higher number of adult forms (16 individuals in yellow water traps) can be expected if daily sunshine hours are higher than 6.6 and if mean daily air temperatures are less than 7 °C which is in contrast to Šedivy & Kocourek (1994) and Nuss (2004) and indicate different ecological features of both species due to different climate conditions in experimental areas. If oilseed rape is between growth stages of free flower buds levelled with the youngest leaves (BBCH 52) and full flowering (BBCH 65) and if sunshine hours are above 9.7 adult forms of *C. napi* would reach control threshold of 10 adults in yellow water trap (Büchs, 1998; Williams, 2010; EPPO, 2014).

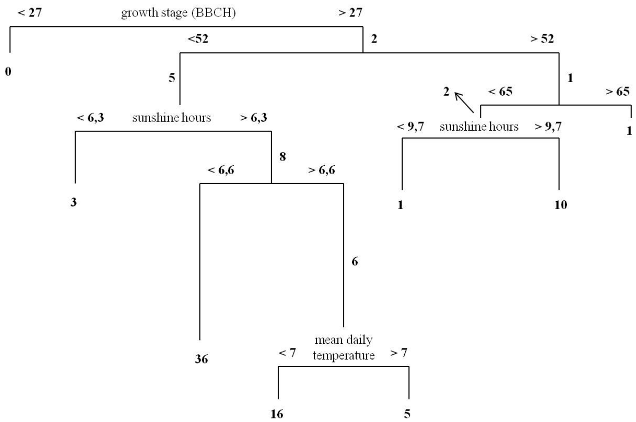

Fig. 1. Variables most influential in predicting *C. napi* abundance using the *Regression TREE* procedure.

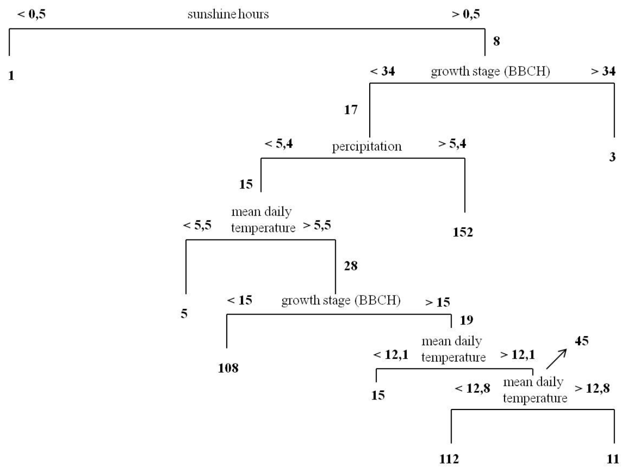

Fig. 2. Variables most influential in predicting *C. pallidactylus* abundance using the *Regression TREE* procedure.

The most important climatic factor that influences appearance of adult forms of *C. pallidactylus* is daily sunshine hours (Fig. 2). It is enough less than half an hour during the day for the appearance of the first *C. pallidactylus* individuals in yellow water traps. However, this population is not high and is below the economic threshold (Büchs, 1998; EPPO, 2014). If sunshine hours exceed half an hour per day, the next factor is growth stage of oilseed rape plants. The highest abundance of adult forms of *C. pallidactylus* (152 individuals in yellow water traps) can be expected if plants have four visible extended internodes (BBCH 34) and if mean daily precipitation exceeds 5.4 mm which is in accordance with Nolte (1957) but opposite to Šedivý & Vašak (2002) who states that activity of stem mining weevils is lower when higher amount of precipitation is present. Higher insect activity at higher amount of precipitation shows other insect species as western corn rootworm (Kozina, 2012). If mean daily precipitation is less than 5.4 mm, mean daily air temperature is below 5.5 °C and plants have less than five leaves unfolded (<BBCH 15) higher number of adult forms can be expected (108 individuals in yellow water traps) and coincides with the peak of the flight of *C. pallidactylus*. Adults can appear in greater numbers (112 individuals in yellow water traps) when oilseed rape plants are between five leaves unfolded and four visibly extended internodes (BBCH 15 - 34) and if mean daily precipitation is less than 5.4 mm and mean daily air temperature is between 12.1 and 12.8 °C.

As our results suggest climatic factors are very important for migration of stem mining weevils from the hibernation places to oilseed rape fields and together with growth stage of crop are very useful in prediction of appearance of adult forms. The time of the first appearance of adult forms in oilseed rape fields is the most critical point in their control because they have to be controlled before oviposition to prevent damages from larvae feeding inside the stems (Lerin, 1993, Eickermann et al, 2014).

CONCLUSIONS

The most important factors that determine the appearance of adult forms of *C. napi* are the growth stage of oilseed rape, daily sunshine hours and mean daily air temperature. The most important factors affecting the emergence of adult forms of *C. pallidactylus* are the daily sunshine hours, the growth stage of oilseed rape, the mean daily precipitation and the mean daily air temperature. Based on the obtained results of regression trees, the basis for the creation of new or the use of existing forecast models adapted to our climatic conditions has been developed. It will provide more accurate and timely information on the occurrence of a certain stage of stem weevils in the oilseed rape crops.

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