ESTIMATION OF APPLICATION DATES OF PLANT PROTECTION PRODUCTS FOR ENVIRONMENTAL FATE MODELLING BASED ON PHENOLOGICAL STAGES OF CROPS

Dirk Gericke[1)] Jiri Nekovar[2)] and Claudia Hörold[1)]

1) RIFCON GmbH, Im Neuenheimer Feld 517, D-69120 Heidelberg, Germany

2) Czech Hydrometeorological Institue, Na Šabatce,17, 14306 Prague, Czech Republic

Abstract

According to the EU directive 91/414/EEC potential environmental concentrations of pesticides have to be assessed with environmental fate models. For the calculation of pesticide concentrations it is necessary to provide an application date which has to match the specific BBCH stage at which the pesticide shall be applied. If these application dates are not available for a specific stage, crop and country they must be estimated, which adds an additional uncertainty to the predicted concentrations. In the present study, we therefore evaluate to which extent applications dates can be derived from phenological data. For this analysis phenological data, converted to BBCH stages, of two field crops provided by the German Weather Service (DWD) were analysed. We found a linear correlation between BBCH stages of field crops and the respective appearance dates, which can be used for interpolation of appearance dates of specific BBCH stages as well as for extrapolation of appearance dates to other European countries.

Introduction

- **Application times in the GAP tables / pesticide risk assessment are given as BBCH plant development stages**
- **Contrary, application times in the Efate tools are expressed as date or Julian day**
- **Only dates for BBCH 9 (emergence) and BBCH 99 (harvest) are implemented in the FOCUS crop calendars / EFate tools**

⟶ How to get information about the appearance date of other BBCH plant development stages of a specific crop?

Material & Methods

Phenological data:

- **The German Weather Service (DWD, [1]) provides a large database containing appearance data of phenological plant stages for the most common crops (e.g. cereals or beets) all over Germany**
- **Phenological data is stored in the numerical parameter "phase", a milestone of the plant development, which is transferable to the BBCH classification (Figure 1)**
- **Phenological phase data was only analyzed for the last decade (2000 – 2008)**

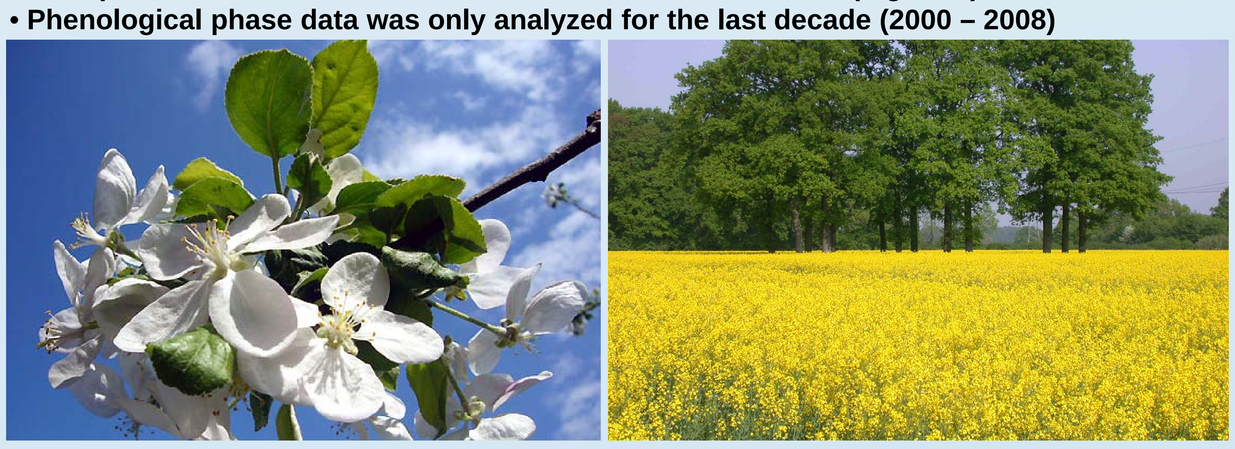

Figure 1. Flowering of apple tree (left) and oilseed rape (right) corresponding to BBCH development stage 60 as well as to the phenological phase 260 (apple) and 144 (rape)

Data for comparison:

- **Data for the crops winter wheat and maize were provided by the Czech Hydro-meteorological Institute Prague [2]. Winter wheat data were observed at the stations Doksany and Chrastava over a period of 9 years (2000 – 2008). Maize data were observed all over Czechia (81 stations) over the same time period.**
- **For a comparison of the German data with a southern European Country, data for Italy were obtained from Phenagri [3]. Data for Maize included three locations and three years (1997 – 1999).**

Statistical analysis:

- **Linear and multiple regression analysis were conducted for German appearance dates (DWD) and climate parameters contained in the MARS database [4].**
- **For this purpose mean values of phenological data were calculated by gridding the DWD data in SAGA GIS 2.0.3 [5] with the same grid size as the MARS grid (50 x 50 km).**
- **German data was extrapolated to Italian climate conditions, also derived from MARS, by using the slope of the multiple regression analysis of the parameter global radiation, temperature and evaporation, which showed significant effects on the plant development (Spearman-rank-test)**

Modelling:

- **Impact of varying application dates on PEC_{GW} was tested with PEARL 3.3.3**
- **PEC_{GW} were calculated exemplarily for the predefined test substance A varying the application date by 14 days (DT_{50} = 60 days, K_{OM} = 60 L kg^{-1}) with an identical soil load of 0.25 kg ha^{-1} for all implemented FOCUS scenarios**

Results & Discussion

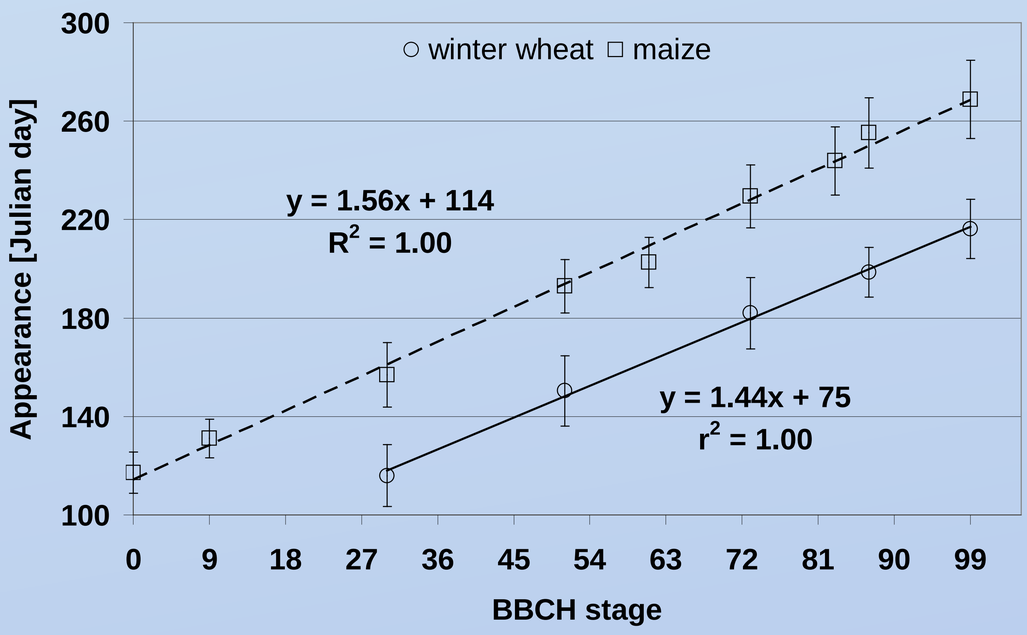

Figure 2. Appearance dates for severals BBCH stages derived from phenological phases from te DWD database for winter wheat and maize indicating an linear plant development, error bars indicate standard deviations

- **The analysis of phenological data from Germany showed that it is possible to linearly interpolate days of appearance with BBCH stages of the field crops maize and winter cereals (see Fig. 2)**
- **Comparisons with phenological data from Czech Republic showed nearly identical results whereas the comparison with Italy showed differences of up to 14 days**
- **Extrapolation of German data to Italy based on multiple regression (T_{MAX}, global radiation and evaporation) could reduce the difference to less than one week (Fig. 3)**

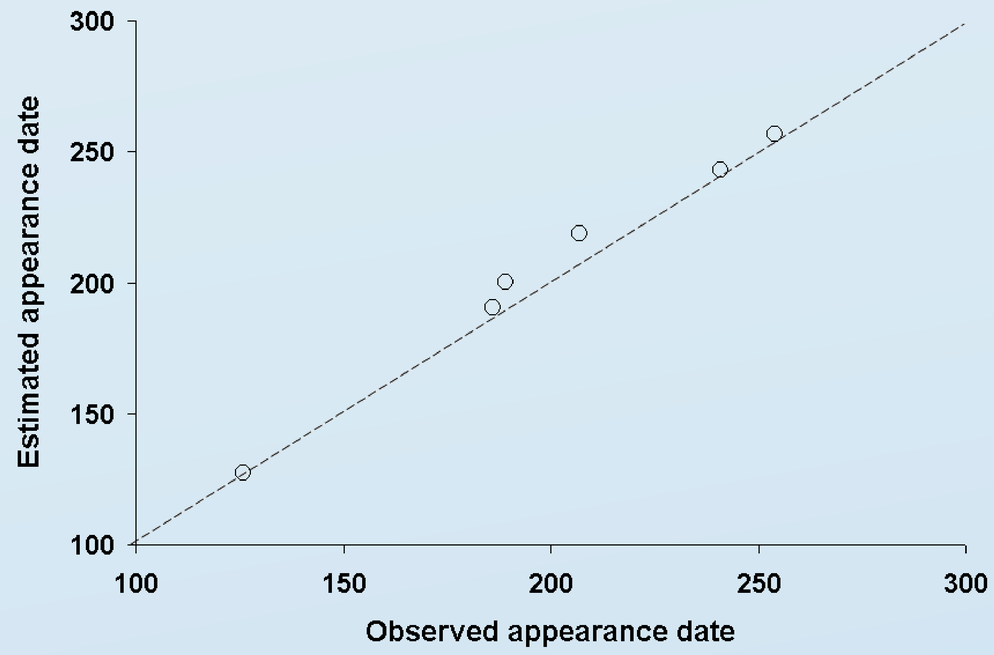

Figure 3. Observed maize BBCH stages (Italy) from phenagri in comparsion with appearance of phenological phases from the DWD (Germany) extrapolated to Italian climate conditions by using the slope from multiple regression analysis of the parameters global radiation, temperature and evaporation

- **Calculations of predicted pesticide groundwater concentrations with the commonly used pesticide fate model PEARL showed that even a variation of only the application date (common practice in the pesticide risk assessment) of up to two weeks had only a minor effect on average groundwater concentrations (<7%) or on the decision of the pesticide risk assessment (Tab. 1)**
- **An effect in bigger dimensions is expected for calculations of more sensitive compartments like surface water calculation in SWASH 3.1**

Table 1. Groundwater concentrations calculated with PEARL for maize considering two application dates (26.04. or 06.06. BBCH 30 / 01.07. or 17.08. BBCH 73) and a variation of ± 14 days, 2 days steps, test substance A

	BBCH 30		BBCH 73	
Scenario	Avg. Conc. [µg L^{-1}]	Avg. Variation [%]	Avg. Conc. [µg L^{-1}]	Avg. Variation [%]
Chateaudun	0.148	1.6	0.180	5.1
Hamburg	0.155	1.7	1.035	5.2
Jokioinen	0.696	2.8	0.199	4.1
Kremsmünster	0.942	2.9	0.759	2.9
Okehampton	0.002	2.2	0.932	2.1
Piacenza	0.012	36.6	1.427	11.2
Porto	0.129	6.1	0.005	14.1
Sevilla	0.801	2.2	0.020	7.9
Thiva	1.106	3.5	0.290	8.3
mean	**0.443**	**6.6**	**0.539**	**6.8**

Conclusion

- **The analysis of phenological data from Germany showed that it is possible to linearly interpolate days of appearance with BBCH stages for field crops**
- **Comparisons with phenological data from Czech Republic, with similar climate conditions, showed nearly identical results**
- **Contrary, phenological data from Italy indicated a difference of appearance dates of up to 14 days.**
- **However, appearance dates extrapolated from German to Italian climate conditions showed a good accordance with observed dates, with an average difference of less than one week**
- **The groundwater modelling showed that even a variation of the application date up to 14 days will influence the groundwater concentrations slightly**

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References

[1] www.dwd.de/phaenologie [2] www.chmi.cz/indexe.html

[3] www.phenagri.it/rprimopiano/bancaDati/online/inizio.asp [4] http://mars.jrc.it/mars

[5] www.saga-gis.org/en/index.html