Simulated Long Term Accumulation of Plant Protection Products in the Soil of $FOCUS_{SW}$ Run-Off Scenarios

Patterson, D.[1], Callow, B.[1], Watson, S.[2]

[1] TSG Consulting, Knaresborough, UK (david.patterson@tsgconsulting.com)

[2] Syngenta, Jealott's Hill Research Station, Bracknell, UK

Introduction

For EU regulatory purposes, predicted environmental concentrations (PEC) of plant protection products (PPP) in surface water (PEC_{SW}) and sediment (PEC_{SED}) as a result of run-off is currently modelled using four scenarios according to the FOCUS surface water report [1]. Currently some run-off scenarios have longer model warm-up periods than others (ranging from 0 – 14 years) whilst all scenarios employ a 1 year assessment period. However, it has been demonstrated that the existing warm up and assessment period may not be sufficiently protective [2, 3]. Therefore a recent draft scientific report of the European Food Safety Authority [4] proposes that simulations should in future include a 6 year warm up period for all scenarios followed by a 20 year assessment period. As a result it is likely that some PPPs will accumulate to a greater extent in the soils of the PRZM simulated adjacent field which can in turn result in increased PPP input to the receiving water body.

We investigate the suitability of the proposed 6 year warm up period and the impact of these proposed changes on simulated accumulation of PPPs in the soil of run-off scenarios.

Methods

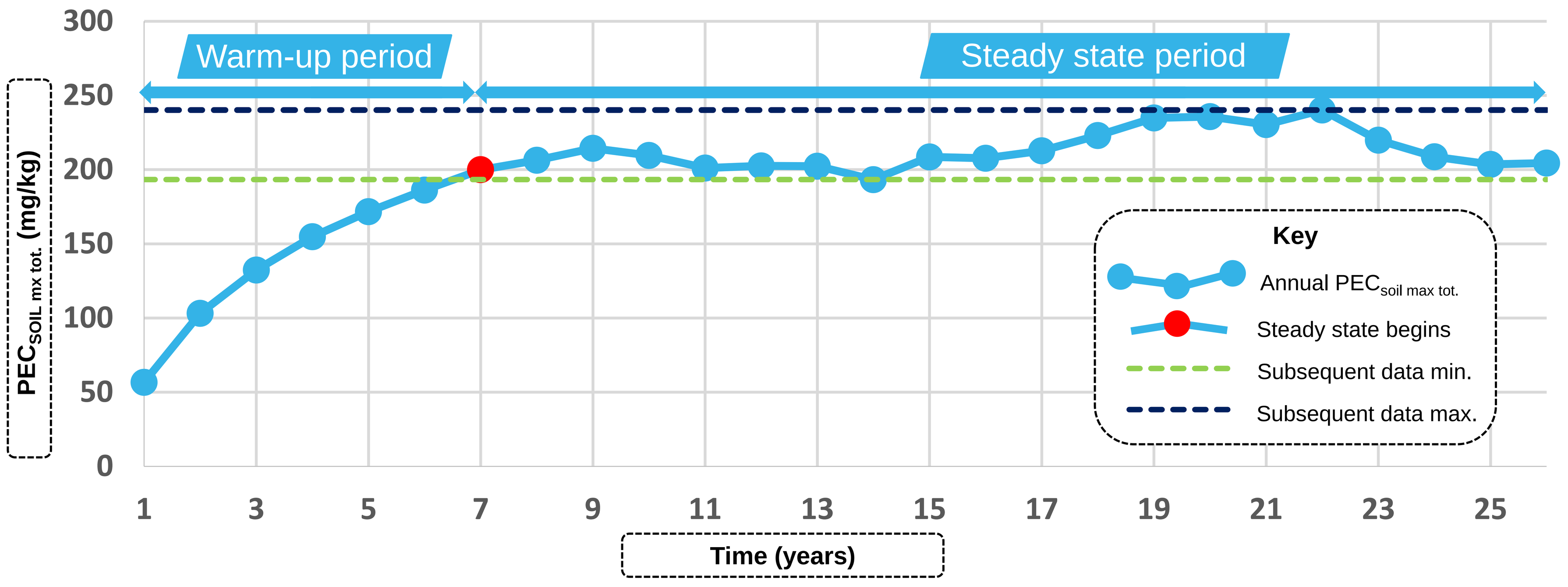
The behaviour of a range of 25 hypothetical PPPs (DT_{50} 100 – 1000 d, K_{OC} 100 – 10000 ml/g) was simulated across all four FOCUS run-off scenarios using the FOCUS PRZM (v4.3.1) model. Applications were made at emergence to crops covering a range of run-off susceptibilities (winter cereals, maize and leafy vegetables) every year for 26 years. The annual maximum concentration of each PPP (aqueous + adsorbed) available for run-off and erosion in the upper 2 cm of soil ($PEC_{SOIL\ max\ tot.}$) was calculated each year for all simulations. To determine if a 6 year warm up period was suitable the $PEC_{SOIL\ max\ tot.}$ time course was analysed for each compound in all scenarios to determine when "steady state" was achieved (*i.e.* when a plateau concentration had been reached). This was determined using the Conway rule [5] which defines steady state as commencing at the datapoint which is neither the minimal nor maximal value of all subsequent datapoints.

The draft proposals for longer simulations [4] do not yet contain detailed information on deriving a representative PEC from 20 year simulations, therefore a pragmatic means of comparing PECs using differing simulation lengths was required. The annual $PEC_{SOIL\ max\ tot.}$ values were averaged for the final 20 years of the simulation for each compound in each scenario ($PEC_{SOIL\ max\ ave.}$). This $PEC_{SOIL\ max\ ave.}$ was then compared with the $PEC_{SOIL\ max\ tot.}$ calculated in the existing FOCUS assessment period to determine the impact of longer warm up and simulation periods.

Results

Analysis of time to steady state

Figure 1: Conway rule steady state definition example[a]

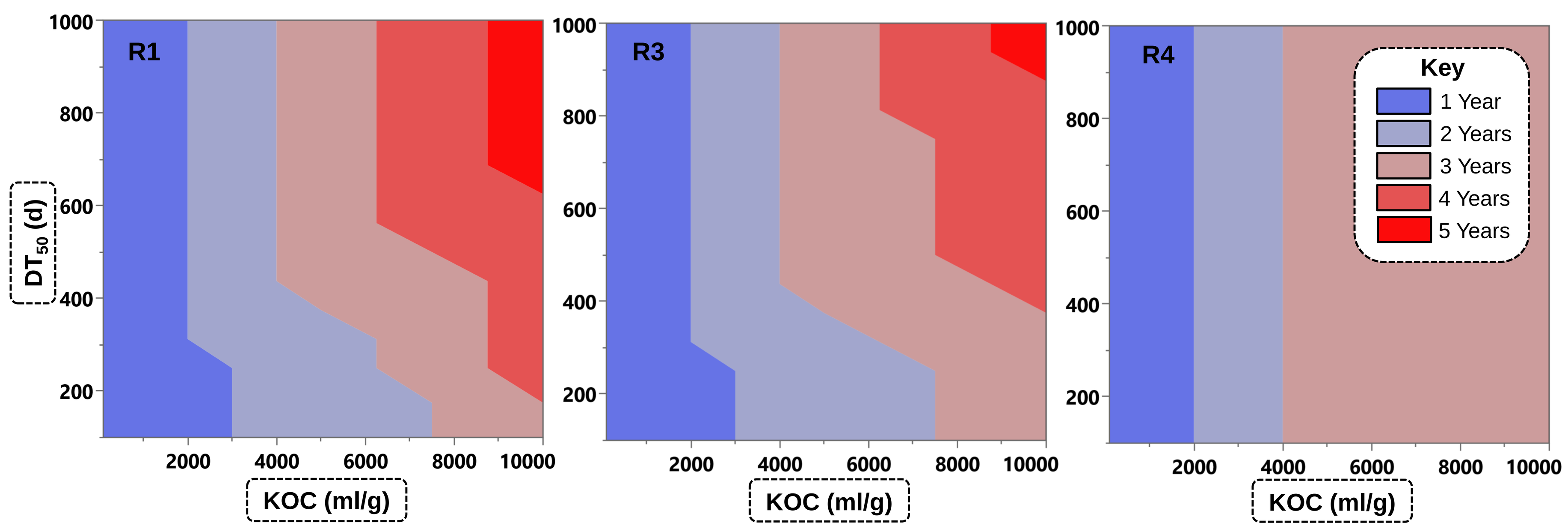


[a] Selected example is compound with DT_{50} 1000 and K_{OC}10000 on leafy vegetables in R2 scenario

The time to steady state as determined by the Conway rule was calculated for all simulations and was found in agreement with a visual inspection of the data. The maximal time to achieve steady state was 6 years in the R2 scenario for a compound with DT_{50} of 1000 days and K_{OC} of 10000 ml/g (see Figure 1). Plotting the maximal time to steady state for all scenarios and crops (see Figure 2) indicates that whilst there is significant variation between scenarios, there is no significant effect of crop type within scenarios.

As would be expected, time to steady state was longest for long DT_{50}, high K_{OC} compounds (see Figure 3). In general, time to steady state varied between scenarios for any given compound but there was only limited effect of crop type. It is interesting to note the significantly different behaviour of the R4 scenario exhibited in Figures 2 and 3. In general R4 achieves steady state faster than other scenarios and behaviour appears dominated by K_{OC}.

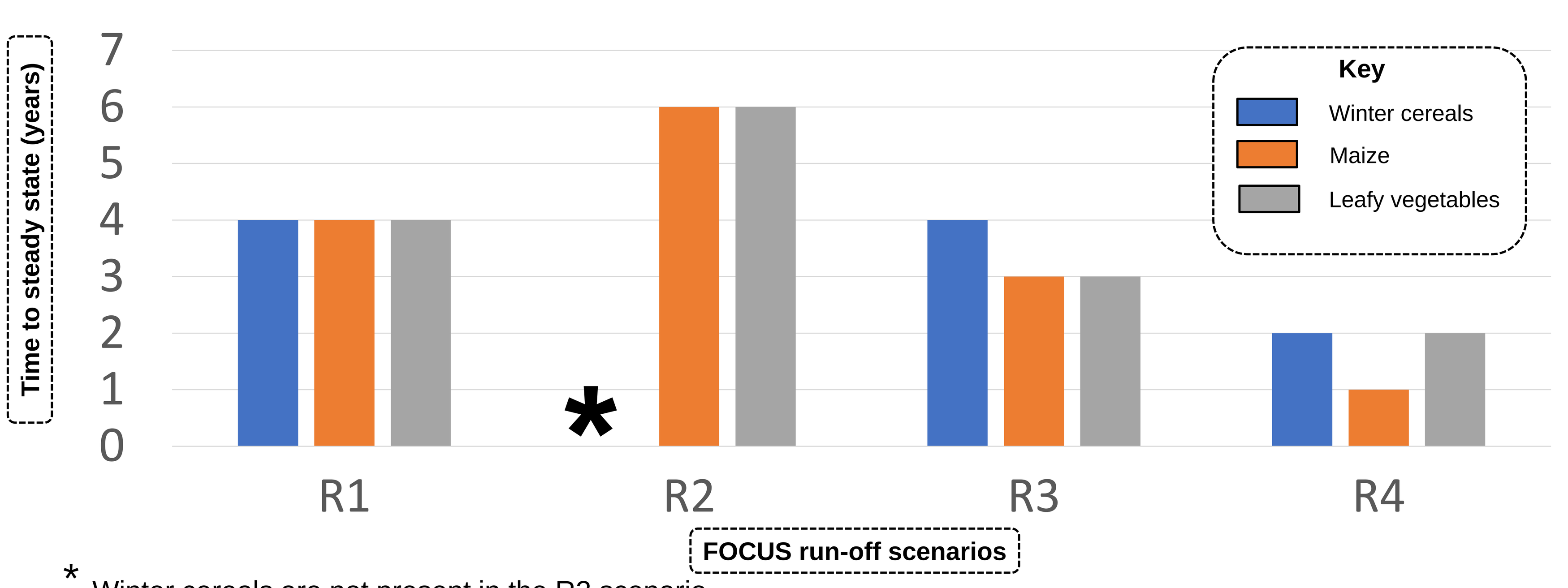
Figure 3: Effect of chemistry and scenario on time to steady state for winter cereals



Impact of 26 year simulations on $PEC_{SOIL\ max\ tot.}$

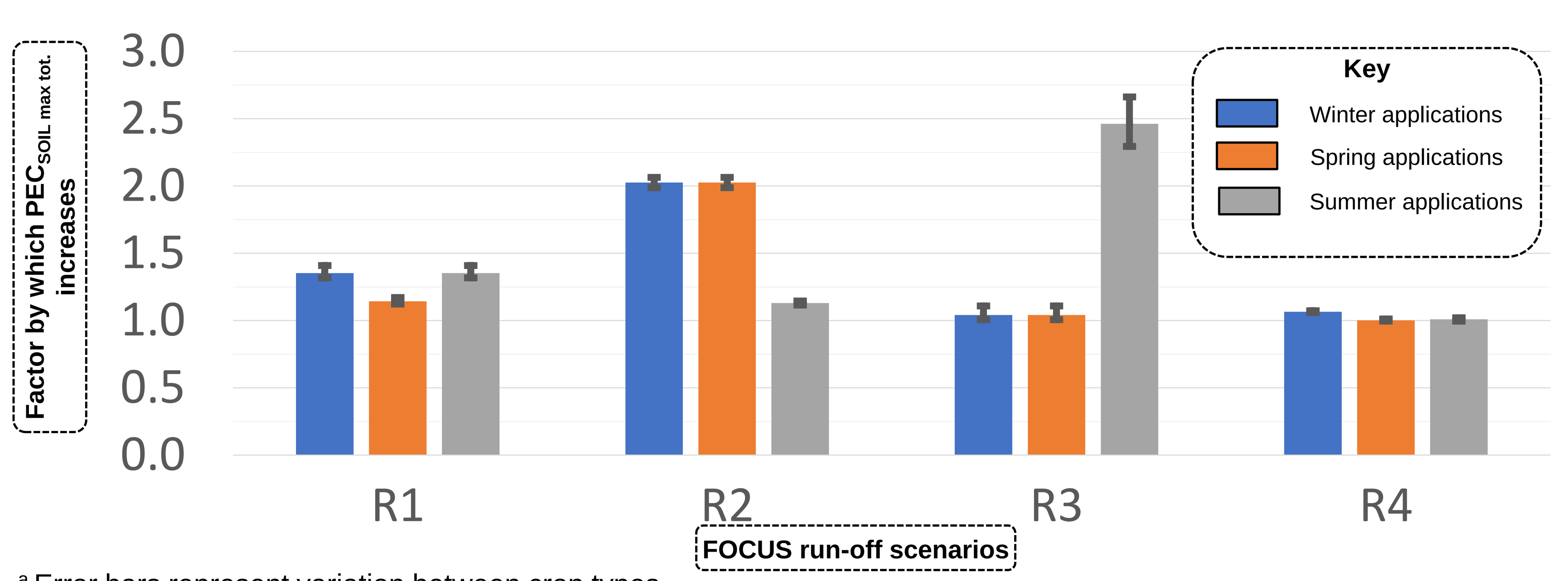
The duration of the warm up period in FOCUS PRZM is currently determined by the year selected for the assessment from a 20 year chronology. This varies due to application season and scenario from 0 years (R3 summer) to 14 years (R4 winter). Therefore in existing modelling some scenarios are at steady state $PEC_{SOIL\ max\ tot.}$ whilst others are not. 26 year modelling will therefore affect different scenarios and application timings to a greater or lesser extent. This heterogeneity is presented in Figure 4 where $PEC_{SOIL\ max\ ave.}$ from 20 year simulation periods are compared to $PEC_{SOIL\ max\ tot.}$ from the current FOCUS simulation year.

Figure 2: Maximum time to steady state for all compounds, scenarios and crops



* Winter cereals are not present in the R2 scenario

Figure 4: Potential increase in $PEC_{SOIL\ max\ tot.}$ as a result of 26 year simulations[a]



[a] Error bars represent variation between crop types

Conclusions

1. **The proposed 6 year warm up period is long enough to achieve steady state in all scenarios for the compounds and crops tested.**
2. **PPP accumulation potential varies significantly between run-off scenarios.**
3. **The significantly different crop dependant run-off and erosion in FOCUS PRZM did not significantly affect PPP accumulation potential.**
4. **26 year modelling will result in significantly increased $PEC_{SOIL\ max\ tot.}$ in some run-off scenarios, but not others.**
5. **This heterogeneity is driven by current warm up periods varying between 0 – 14 years depending on scenario and season.**

References

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