Predicting plant community level effects of herbicides based on plant individual level responses: Testing the plant community model IBC-grass with experimental data

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1 Background

Registration of herbicide use requires evaluation of the risk to non-target terrestrial plants, based on the potential effects and exposure associated with the proposed use, and acceptance of the risk by regulatory authorities. The potential effects to non-target terrestrial plants are addressed by standardized greenhouse experiments conducted on individuals of selected plant species. Confidence in the ability to use these individual level greenhouse studies could be increased with additional data, such as field effects studies. However, due to the lack of guidance, the high natural variability that is hard to overcome or the seasonal restrictions, among other issues, the performance of empirical field studies faces limitations. Modelling approaches on the other hand are suitable tools to explore the influence various environmental scenarios have on potential herbicide effects.

2 Methods

The model IBC-grass

IBC-grass is an individual-based, spatially explicit plant community model. It simulates the dynamics of local plant communities as emerging from individual plant characteristics. Current size, neighbourhood and specific plant traits define competitive strength and growth potential of each plant individual considering trade-offs. Thus, plant species are classified into plant functional types (PFTs) according to their trait characteristics. Neighbouring individuals compete for space and resources via a two-layer (above-/belowground) Zone of Influence (ZOI) approach. Due to its structure, herbicide impacts can be integrated based on individual plant effects. Thus, effects on community-level can be estimated.

The empirical study

In order to assess the reliability of the model, we compared model results with empirical data gained from the study of Reuter and Siemonet-Gast*. In this study, herbicide impacts on monocultures as well as on artificial communities were tested under semi-field conditions.

The calibration process

We adjusted the spatial setup of the model according to the empirical study and calibrated the model against the empirical monoculture control data (Fig. 1).

Based on the monoculture effect data, we calculated dose-response curves for each of the six species (see Fig. 2 as an example).

3 Results

Community

Monoculture

Monocultures Artificial communities

Study species Bromus erectus Cynodon dactylon Lolium multiflorum Leontodon hispidus Silene nutans Trifolium pratense

Study herbicides Monosodium (sulfosulfuron) Roundup® (glyphosate)

Endpoints (measured 42 days after application) Shoot weight (Physiotoxicity)

Control community

Fig. 1: Calculated dry shoot masses for the six tested species grown in monocultures without herbicide impacts. Red dots represent experimental data (und), blue dots represent modeled data (pred).

Fig. 2: Calculated dose response curve for Bromus erectus grown in a monoculture and affected by the broad spectrum herbicide Roundup®. Dots represent the measured data.

Fig. 3: Comparison of the experimentally measured shoot weight (red dots, und) and calculated (grey dots) shoot dry masses for each species when grown in the artificial communities (Fig. 3).

1. IBC-grass was able to account for the interspecific competition within these artificial communities (Fig. 3).

2. IBC-grass described similar herbicide impacts in the monocultures over time based on the dose responses gained from the empirical monoculture data at the end of the study (Fig. 4).

3. IBC-grass predicted similar herbicide impacts for the tested species when grown in artificial communities.

4. Herbicide effects are again based on the empirical data of the monocultures (Fig. 5).

4 Conclusion

The results show that the plant community model IBC-grass was able to realistically predict short-term community level effects on plant biomass based on monoculture dose response data. It represents an approach how individual level effects measured in current standard greenhouse experiments can be integrated in a community model to estimate community level effects in ecological risk assessments of herbicides. Such validated plant community models might be especially important in the future as EFSA considers specific protection goals for non-target terrestrial plants on population and community level.

References:

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