Invasion and persistence of feral transgenic crops: analysis of a stochastic matrix model

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Transgenes in plants affect life history traits such seed survival, germination and growth [1]. We use stochastic matrix population models to predict population-level consequences of transgene-induced life history changes [2]. With this approach we can address important issues in risk assessment of transgenic crops likes invasiveness and persistence, as well as fitness effects in case of introgression. We apply our method to oilseed rape, which persists as a weed inside and as feral patches outside cultivated fields. Like many other annual weeds, oilseed rape depends critically on disturbance. The associated inherent variability and unpredictability render deterministic models inappropriate [3]. With a stochastic model we study population growth rate, elasticities, and quasi-extinction times.

Elasticity analysis of stochastic matrix population models is often used in population management issues such as conservation and pest control. The consensus about elasticity analysis of stochastic matrix models appears to be that stochasticity has little effect on elasticity, unless the variability of the environment is sufficiently large. The critical level of variability has, however, not been specified. Here we show that the *structure* of the matrices, in terms of life cycle pathways, is critical in determining the match between stochastic and deterministic elasticity. We identify conditions under which correspondence between the deterministic model (of the average environment) and the stochastic one breaks down. If this occurs, a full stochastic analysis becomes necessary. Loop analysis provides a useful tool in identifying such conditions. In our model of oilseed rape we find that often the order of importance of vital rates is reversed in stochastic and deterministic environments. This has obvious and important consequences for population management, since focusing on a deterministic model would lead to an ineffective or counterproductive management strategy.

By considering known effects of transgenes on life history in oilseed ape, we conclude that the effect of transgenic oil-modifications on seed survival and dormancy could slow population decline and thereby increase persistence of transgenic feral and volunteer populations. *Bt* transgenes increase performance through plant survival and fecundity, which are predicted to have less impact on fitness. It will therefore depend to a large extent on the unintentional effects on seed survival and dormancy whether *Bt* transgenes increase or decrease fitness.

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