

# Selection procedure to study ecological impact of GM plants: a case study of Bt-maize in Kenya

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Conceptual and methodological uncertainties of studying ecological effects of GM crop plants on non-target arthropods have raised several intriguing general problems. What species or ecosystem functions should be chosen to test? By what routes might these species or functions be exposed directly or indirectly to GM crop plant products? How can meaningful scientific hypotheses be constructed to provide rapid assessments of the magnitude of the potential risks? In contrast to ecotoxicological methods for addressing these problems, assessment of the impacts of GM crop plants must be case specific and contextualized to the environment in which they will be used. In the framework of the IOBC Global Working Group on transgenic organisms, the “Guidelines Project” ([www.gmo-guidelines.info](http://www.gmo-guidelines.info)), we developed an “ecosystem representative approach” for selecting species and ecosystem function as foci for testing. This approach combines ideas and methods from a “community approach”, which emphasizes analysis of biodiversity, a ‘functional approach’, which emphasises community reactions, a “key species approach”, which emphasizes the individuality of species, and an “indicator species approach”, which is central to ecotoxicological testing. We used classic qualitative methods of risk assessment (NRC, 1983), formalized in selection matrices and directed questions, which provide transparent summaries of scientific data and expert judgement.

The process of ranking and species selection in the above-ground functional groups (herbivores, detritivores, natural enemies and pollinators), proved useful and allowed the identification and prioritisation of non-target species for some key ecological groups; it also reflected the current state of knowledge and expertise available. An example for ranking parasitoids is on Table 1. Identification of the significance or function of the non-target species was important to prioritisation and identifying gaps in present knowledge. Species with a ranking of 1 are suggested for further testing. It was also important to consider the process of exposure (Table 2) as part of overall species selection, as this identified missing information about the expression of *Bt toxin* in different plant tissues was also crucial for the above-ground exposure analysis.

Similarly, the ranking and selection matrix for soil ecosystem functions proved useful. The species selection matrices could be modified appropriately to rank and select ecosystem functions. We concluded that sufficient ecological information existed to use qualitative ecological expertise to identify and rank soil ecosystem functions as candidates for non-target risk assessment. This selection tool was useful in identifying key interactions in a systematic and transparent way that might be most likely to be affected by Bt maize or those functions significant for maize production.

**Table 1:** A species selection matrix for parasitoids of the most important maize borer species in two ecological zones in Kenya.

| Sub-guild                      | Species                   | Occurrence    | Abundance    | Presence   | Linkage | Rank |
|--------------------------------|---------------------------|---------------|--------------|------------|---------|------|
| <b>Lowland, Kenyan coast</b>   |                           |               |              |            |         |      |
| Egg parasitoid                 | Trichogramma spp.         | Certain       | Medium       | All season | Strong  | 1    |
| Larval parasitoid              | Cotesia flavipes          | Certain       | Medium       | All season | Strong  | 1    |
| Larval parasitoid              | C.sesamiae                | Certain       | Low-medium   | All season | Strong  | 2    |
| Larval parasitoid              | Goniozus indicus          | Not completed |              |            |         |      |
| Egg & larval parasitoid        | Chelonus curvimaculatus   | Not completed | Short rains? |            |         |      |
| Pupal parasitoid               | Pediobus furvus           | Certain       | Low          | All season | Strong  | 2    |
| Pupal parasitoid               | Dentichasmias busseolae   | Occasional    | Low          | All season | Strong  | 3    |
| <b>Highland, Western Kenya</b> |                           |               |              |            |         |      |
| Egg parasitoid                 | Trichogramma spp., native | Likely        | Medium       | All season | Strong  | 2    |
| Egg parasitoid                 | Telenomus spp.            | Not completed |              |            |         |      |
| Larval parasitoid              | Cotesia sesamiae          | Certain       | Medium       | All season | Strong  | 1    |
| Larval parasitoid              | C. flavipes               | Occasional    | Low          | All season | Strong  | 3    |
| Pupal parasitoid               | Dentichasmias busseolae   | Occasional    | Low          | All season | Strong  | 3    |
| Pupal parasitoid               | Pediobus furvus           | Certain       | Low          | All season | Strong  | 2    |

**Table 2:** Summary of exposure analysis for the most common arthropod species or groups associated with maize crops in Kenya.

| Species  | Feeding category        | Significance  | Assessment of exposure  |
|--|-------------------------|---|---|
| Helicoverpa armigera                           | Silk & cob feeder       | Significant potential pest                                | Very likely by feeding behavior, susceptible to toxin   |
| Spodoptera spp.                                | Leaf feeder             | Abundant, cause heavy damage                              | Very likely by feeding behavior, susceptible to toxin   |
| Acarid spp. (mites)                            | Leaf feeder             | Abundant, cause heavy damage                              | Very likely by feeding behavior   |
| Locusts  | Leaf feeder             | Causes heavy damage when present                          | Very likely by feeding behavior   |
| Sitophilus zeamays                             | Grain feeder            | Significant potential pest, always present                | Very likely by feeding behavior   |
| Prostephanus truncatus                         | Grain feeder            | Significant potential pest, always present                | Very likely by feeding behavior   |
| Plant- and leafhoppers                         | Phloem feeder           | Cicadulina spp. vector of maize streak virus              | Likely, by feeding on mesophyll cells   |
| Carpophilus spp.                               | Saprovore               | Vector of Aspergillus flavus pathogen                     | Possible, by feeding on Helicoverpa armigera frass  |
| Honey bee (Apis mellifera)                     | Pollen feeder           | Important pollinator of other crops                       | Conditional, if Bt-toxin is present in pollen or guttation fluids   |
| Wild bee spp.                                  | Pollen feeder           | Pollinator  | Conditional, if Bt-toxin is present in pollen or guttation fluids   |
| Coccinellidae (ladybirds)                      | Pollen feeder, predator | Important natural enemy                                   | Conditional, if Bt-toxin is present in pollen or guttation fluids   |
| Forficulidae                                   | Pollen feeder, predator | Important natural enemy                                   | Conditional, if Bt-toxin is present in pollen or guttation fluids   |
| Trichogramma spp.<br>Trichogrammatoidea spp    | Parasitoid              | Important natural enemy of lepidopteran species           | Conditional, if Bt-toxin is present in pollen, phloem or honeydew, guttation fluids, or lepidopteran eggs |
| Cotesia flavipes                               | Parasitoid              | Important natural enemy of Chilo partellus                | Certain via Bt-toxin in host larvae; conditional if Bt-toxin is present in pollen or lepidopteran frass   |
| Cotesia sesamiae                               | Parasitoid              | Important natural enemy of stem borer species             | Certain via Bt-toxin in host larvae; conditional if Bt-toxin is present in pollen or lepidopteran frass   |
| Other predators: ants, anthocorids, chrysopids | Predators               | Important natural enemies of lepidopteran eggs and larvae | Certain via Bt-toxin in lepidopteran larvae, conditional if Bt-toxin is present in lepidopteran eggs      |