16. Gene Flow between Selected Swiss Crops and Related Weeds: Risk Assessment for the Field Releases of GMOs in Switzerland.

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The objective of this study was to develop a convenient classification of gene dispersal probability from transgenic crops to the wild flora, adapted to Switzerland.

Twenty-two important Swiss crops have been studied at a bibliographical level in order to assess the possibility of gene flow. Gene flow can occur by three ways: l) by pollen dispersal, 2) by diaspore dispersal or 3)by the plant itself.

Swiss dispersal indices have been developed based on the reports of several Dutch authors (De Vries *et al.*, 1992; Frietema-De Vries, 1996). Here we describe only the first three indices, but we consider that a fourth index should be introduced in the future: we need to assess also the risk of the inserted transgene itself.

The three indices are: 1) Dp: Hybridization and pollen dispersal index; 2) Dd: Diaspore dispersal index and 3) Df: Distribution frequency index (presently).

Each index is subdivided into five levels with a sixth one for data too scanty or lacking at all. In this last case no evaluation is possible. They are summarized as follows :

Dp: Hybridization and pollen dispersal index

DpO: No wild relatives in Switzerland
Dpl: No compatible wild relatives in Switzerland.
Dp2: No records of spontaneous hybrids in Switzerland.
Dp3: Occasional natural hybridization, no backcrosses observed in Switzerland.
Dp4: Natural hybridization occurs and hybrids are fertile, and backcrossing takes place.
Dp5: Natural hybridization occurs fairly often, hybrids are fertile and backcrossing takes place frequently.

Dd: Diaspore dispersal index

Dd0: No chance for diaspore dispersal (seeds are sterile or deficient).
Ddl: Diaspore dispersal possible occasionally under very favorable and exceptional conditions.
Dd2: Diaspore dispersal possible under favorable conditions.
Dd3: Diaspore dispersal occurs, fruiting is usually undesirable and is normally suppressed by various methods.
Dd4: Diaspore dispersal is important, fruiting occurs normally during cultivation.
Dd5: Diaspore dispersal is the rule, fruiting occurs very frequently and is very abundant.

Df: Dispersal frequency

Df0: Wild relatives not known in the wild or as feral populations in Switzerland.
Dfl : Wild relatives extremely rare in the wild and do not occur as feral populations in Switzerland.
Df2: Wild relatives very rare in the wild and/or they occur sporadically as feral populations in Switzerland.
Df3: Wild relatives and/or their feral populations not very common in the wild in Switzerland.
Df4: Wild relatives and/or their feral populations not frequent in the wild but well distributed over the whole

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plateau in Switzerland.
Df5 : Wild relatives and/or their feral populations common in the wild and well distributed over the whole Swiss plateau in Switzerland.

After evaluation of the three single factors, their combination enables to estimate the impact of a transgenic species on the environment. Six categories of risk probability have been identified :

1 *No effect*

- No related species or no compatible related species of the crop are known in Switzerland. Field releases of species belonging to this category are possible without any containment or short term monitoring.
- Certain transgenes have to be tested in medium-term field experiments regarding their secondary effects on ecosystems: Sustainable resistance must be achieved. To reach this goal long-term monitoring is required.

2 *Minimal effects*

- No records of spontaneous hybridization between the crop and the wild relatives are known in Switzerland. Field releases are possible after a thorough clarification of the biogeographical situation. Short-term monitoring under confinement conditions should be performed prior to large scale field releases.
- Certain transgenes have to be tested in medium-term field experiments regarding their secondary effects on ecosystems (pest and insect resistance genes).

3. *Low but local effects*

- Gene flow occurs towards wild or feral species outside of the agricultural environment and is controlled. Release experiments should first be carried out under confinement and afterwards in small scale releases closely monitored.
- This statement is restricted to transgenes not causing enhanced competitiveness outside agricultural environment, such as herbicide tolerance. Any other transgenes should be carefully tested under confinement conditions.

4. *Substantial but local effects*

- Gene flow is high and substantial, but still locally controllable.
- Field releases could be performed under strict confinement conditions. A case by case analysis including the potential effects of the transgene is required before any field releases are performed.
- Long-term monitoring of field releases under strict biological or geographical confinement conditions is necessary in order to study the competitiveness of the transgenic crop. Risky transgenes have to be avoided.

5. *Substantial and widespread effects*

- Gene flow is high, substantial, and widespread and will not be controllable by any means.
- No field releases of species belonging to this fifth category are possible.
- Medium-term monitoring under strict confinement conditions is necessary in order to determine the competitiveness of the transgenic varieties.
- Experiments with less risky crop varieties (e.g. with male sterility) having the same favorable effect should be carried out.

6. *Unknown (one of the three indices is unknown)*

More studies are needed before any field releases are performed.

Risk codes for the species taken into consideration in this study are summarized in Table 1.

Most of the species belonging to the high-risk class are grasses. Generally, cereals and vegetables belong to the low-risk class. Only four species (alfalfa, oilseed rape, lettuce and barley) have also been covered by field studies including morphometrical and molecular methods.

More combined field and laboratory studies are needed in order to assess precisely the pollen dispersal index (DP) at the Swiss level. An important part of this evaluation is based on hybridization experiments or observations on natural hybridization and also on the results of studies carried out in foreign countries. For certain crops and their wild relatives we need more recent and more detailed distribution data, since maps in Switzerland date basically to 1972.

References

1) Frietema-De Vries, F.T. (1996) : Cultivated plants and the wild flora. Effect analysis by dispersal codes. PhD thesis, Rijksherbarium, Hortus Botanicus, Leiden, 222p.

2) De Vries, F.T., Van der Meijden, R. and Brandenburg, W.A. (1992) : Botanical files. A study of the real chances for spontaneous gene flow from cultivated plants to the wild flora of the Netherlands, Gorteria Supplement, Rijksherbarium Leiden.

Table 1 Dispersal indices for some important Swiss crops

Species	English name	Dispersal index Df. Dd. Dp.	Risk category
Festuca arundinacea	Fescue	5. 5.5	Substantial and widespread
Festuca pratensis	Meadow fescue	5.5.5	Substantial and widepread
Lolium multiflorum	Italian ryegrass	5.5.5	Substantial and widepread
Lolium perenne	Perennial ryegrass	5.5.5	Substantial and widespread
Medicago sativa	Alfalfa	5.4.5	Substantial and widepread
Daucus carota spp. *sativus*	Carrot	4.2.4	Substantial but local
Brassica napus	Oilseed rape	2.5.3	Low but local
Brassica rapa	Turnip	2.4.3	Low but local
Raphanus sativus	Radish	3.3.3	Low but local
Cichorium intybus	Chicoly	4.3.3	Low but local
Secale cereale	Rye	4,3.2	Minimal effect
Hordeum vulgare	Barley	4,2.2	No effect
Triticum aestivum	Wheat	4.2.2	No effect
Trifolium pratense	Red clover	5.3.1	No effect
Trifolium repens	White clover	5.3.1	No effect
Beta vulgaris	Sugar beet	1.2.1	No effect
Lycopersicon esculentum	Tomato	0.1.0	No effect
Zea mays	Maize	4.0.0	No effect
Solanum tuberosum	Potato	5.1.0	No effect
Brassica oleracea	Cabbage	3.3.3	Minimal effect
Cichorium endivia	Endive	2.2.3	Minimal effect
Lactuca sativa	Lettuce	2.5.5	Substantial but local