Co-existence
(sameksistens)
The Norwegian Biotechnology Advisory Board is an independent body appointed by the Norwegian government and was established in 1991. The Board is founded in the Act relating to the application of biotechnology in medicine and the Act relating to the production and use of genetically modified organisms. The main tasks of the Norwegian Biotechnology Advisory Board are to identify and examine the ethical questions raised by applications of modern biotechnology on humans, animals, plants and microorganisms, provide advice that can assist policy-making and stimulate public debates on the issues. The Board consists of 24 members and has observers from six ministries. The Board’s secretariat has five to eight employees. For 2004 the budget of the Biotechnology Advisory Board is 6.8 million NOK (appr. 825,000 Euro).
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Dear friends and participants, as chairman of the Norwegian Biotechnology Advisory Board, I would like to welcome you to this conference on co-existence between GMOs and traditional plants in agriculture. At present there are many important issues on co-existence that need to be discussed, and surely this topic will be high on the agenda in the EU and many other countries in years to come.

GM plants have been grown for many years, especially in the US, Canada and some Latin American countries, but also in some parts of Europe. Although Norway is not a member of the EU, the situation in the EU is of course of great importance to us as we are so closely linked to the EU.

As you can see from the program, we have a number of very interesting speakers and we are trying to shed some light on the issue of co-existence from different perspectives. We are sorry that our speaker from the EU parliament, Friedrich-Wilhelm Gräfe zu Baringdorf, had to cancel in the last minute, but we are very happy that Werner Müller from Vienna will describe GMO-free zones and the ongoing processes of developing a regulatory framework in the EU.

The issue of co-existence is how to keep genetically modified crops separate from traditional and organic farming. This issue is biologically complex and at the same time very political. The fundamental issues of separation and distance, however, are not at all new, not even for me. I myself have been a farmer and seed producer for 13 years. The issue of handling genetic drift has a long tradition in plant breeding and several of the speakers will address that.

To me, another question also becomes important: What is the difference between a genetically modified plant and a plant that is based on conventional breeding? Is it first of all a difference in the technology, or in the traits that the breeds carry? Probably a bit of both. I think the reason this issue has become so political is based on the fact that we so far only have limited knowledge of the consequences after the “new genes” have been introduced in nature and agriculture. We know that the introduced genes may have irreversible impact, irreversibly, and in the worst cases the consequences may be serious.

It is important to know what the new genes and traits do, how they may contribute to sustainable and sound agriculture with reduced applications of pesticides, and possibly with less use of fertilizer that pollutes our environment. Let me remind you that one of the most widely used principles in GM farming today is growing GM plants that make their own insecticidal toxins from Bacillus thuringiensis genes. This is actually inspired by organic farming where bacterial spores containing the same Bt toxins are used extensively as pesticides.

With this conference, the Norwegian Biotechnology Advisory Board is trying to prepare the grounds for a debate on the issue of co-existence in Norway. I am grateful to my colleagues in the secretariat and fellow members of the board who have been able to put together a very interesting program.

Before we start I would like to introduce to you my co-chairman for this meeting, my colleague from the Norwegian Biotechnology Advisory Board, Aina Bartmann, who is also a former farmer. Previously, she was working with goats in the northern part of Norway and at present she is developing farmers markets selling specialized foods. Finally, let me introduce our first speaker, Dr. Suzanne Warwick from Agri-Food Canada.
Gene flow between canola varieties and to other wild species

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Summary
Gene flow between canola (oilseed rape) varieties and to other wild species will be reviewed in this paper. Both Brassica napus and B. rapa are grown as canola in Canada. However, since the introduction in 1995 of herbicide-resistant (HR) B. napus lines, grower preference has resulted in a decline in B. rapa production from 50% in 1995 to ca. 5% in 2003. All subsequent reference to canola in this paper will refer to Brassica napus. By 2003, HR canola cultivars accounted for approx. 80% of the 4.0 million ha of B. napus grown in Canada: 47% glyphosate-resistant, 13% glufosinate-resistant, and 20% imidazolinone-resistant [non-transgenic]. The large-scale use of HR B. napus canola has provided researchers an opportunity to test current models of intraspecific (i.e., between canola varieties) and interspecific (between canola and other species) pollen flow on a realistic field scale. The HR trait is easy to monitor, provides accurate assessments, and is highly suited for large-scale screening programs. Recent Canadian studies utilizing the HR trait to evaluate pollen-mediated gene flow in Brassica napus on a commercial field scale, and the effect of gene flow on HR volunteers (feral canola) in subsequent years, are described. These studies have shown that both pollen and seed movement are important means of escape for the HR trait in canola. Unintentional gene stacking of HR traits in B. napus canola cultivars resulting from intraspecific pollen flow is common. Data from two recent studies indicate that the adventitious presence of off-types (contaminants) in certified seed lots often exceeds stipulated thresholds. Recommended control measures for multiple HR volunteer canola in commercial fields are reviewed. Interspecific hybridization, on the other hand, is a less likely consequence of gene flow. Results from a 3-yr gene flow study between B. napus and four related weedy species (B. rapa, Raphanus raphanistrum, Erucastrum gallicum, and Sinapis arvensis) in Canada are summarized. These results include data from experimental field trials and commercial HR B. napus canola fields. Hybridization between HR B. napus and natural wild populations of B. rapa was confirmed in two commercial HR B. napus canola fields in the eastern region of Canada (Québec), thus representing the first documented occurrence of transgene escape into a natural weed population. These sites are currently being monitored, in order to confirm if introgression of the trait into the B. rapa genome has occurred. stewardship plans need to be in place to mitigate agronomic problems associated with HR B. napus canola, widespread implementation of which depends on greater awareness among growers (both adopters and non-adopters of the technology) of best management practices (Van Acker et al., 2003).

Introduction
During the period from 1995 to 2003, herbicide resistance (HR) has consistently been the dominant trait of global commercial transgenic crop production. In 2003, HR canola or oilseed rape (Brassica napus L.) ranked as the third most abundant transgenic crop, accounting for approximately 5% of the global transgenic crop area; A total of 2.7 million hectares of canola grown was transgenic (James, 2003). Brassica napus (genome AACC, chromosome number 2n = 38) and B. rapa L. (genome AA, chromosome number 2n = 20) are both grown as canola in Canada. Commercial production of glyphosate- and glufosinate-resistant B. rapa cultivars was limited in western Canada in 1998; however, these cultivars are no longer registered. Since its introduction in 1995, HR B. napus canola...
has been rapidly and widely adopted by Canadian growers for several reasons, including easier and better weed control, higher seed yields and higher financial net returns based primarily on the higher yield, reduced dockage (i.e., percentage of weeds seeds as a weight basis in harvested *B. napus* that reduces crop value), and lower herbicide costs (Devine and Buth, 2001). HR *B. napus* canola has allowed growers to reduce annual herbicide usage by 6000 tonnes, reduce tillage previously required for weed control and incorporation of soil-applied herbicides, and consequently reduce fuel consumption by 3.2 million litres (Canola Council of Canada, 2001). In 2003, of the 4.0 Mha of *B. napus* grown in Canada, 20% were non-HR, 47% were glyphosate resistant, 13% were glufosinate resistant, and 20% were imidazolone resistant. Transgenic bromoxynil resistant lines were grown for two years (2001-2002) on a small scale (< 1%), but were not grown in 2003. The imidazolone-resistant cultivars are non-transgenic, derived by chemically induced genetic mutation.

Regulations that permit the production of HR *B. napus* vary greatly from country to country. In Canada, all four HR types of *B. napus* are regulated identically as ‘plants with novel traits’ (PNTs). The Canadian Food Inspection Agency (CFIA) defines PNTs as ‘plant varieties/genotypes that are not considered “substantially equivalent”, in terms of their specific use and safety both for environment and for human health, to plants of the same species in Canada, having regard to weediness potential, gene flow, plant pest potential, impact on non-target organisms, impact on biodiversity, anti-nutritional factors and nutritional composition’. PNTs may be produced by conventional breeding, mutagenesis, or more commonly, by recombinant DNA techniques (Canadian Food Inspection Agency, 2002). This procedure has scientific merit, because it is the impact of the trait that requires regulation rather than the process by which the trait is introduced into the crop.

**Potential environmental impact**

The introduction of HR crops can potentially have both direct and indirect effects on other species (Warwick *et al.*, 1999, 2004). These effects would primarily be restricted to the agroecosystem where herbicides are regularly applied. The HR trait (or transgene) may escape either via seed or pollen flow. The HR trait may be confined to the crop, but the crop itself may become a weedy volunteer through seed escape. Gene flow can be problematic to control in a crop, such as canola, that forms volunteer (feral) populations. The persistence of the HR trait in the seed bank and subsequent pollen flow from the volunteer populations can result in escape of the HR trait to adjacent non-HR canola fields or to other HR cultivars resulting in gene stacking, i.e., the combining of two or more independent genes in a single plant. Seed escape via farming operations (e.g., seeding and harvesting equipment, trucks, storage facilities) may contribute to seed admixtures. Alternatively, the HR trait may escape to wild relatives via pollen flow and inter-specific hybridization, potentially increasing the weedingness of the recipient species. Thus, the potential environmental impact of HR *B. napus* canola is of particular concern, as the crop is partially outcrossing, forms a persistent seed bank and volunteer weed populations in subsequent crops, and has several wild relatives present in cultivated areas in Canada (and Europe). Even when the HR trait is confined to the crop species, non-related weed species may be affected indirectly as a result of herbicides used in the production of such HR crops, namely evolution of HR weed biotypes or shifts in weed communities to more tolerant species [this topic will not be covered in this paper, but is reviewed in Warwick *et al.*, 1999, 2004].

**Intraspecific pollen flow**

Canola is self-fertile, with pollen movement by both wind and insects. Several Canadian studies have indicated inter-plant outcrossing rates averaging 30% (e.g., Rakow and Woods, 1987; reviewed in Table 1 and Beckie *et al.*, 2003). The degree of outcrossing between populations of canola is sharply reduced as the distance between the pollen source and the recipient population increases. Although the vast majority of pollen produced by canola plants falls within a few meters, pollen flow from fields of canola by wind and insects can be substantial and extend over long distances. Studies have found evidence of pollen flow in Canada up to 800 m (Beckie *et al.*, 2003); in the United Kingdom at 400 m (Scheffler *et al.*, 1995), 2.5 km (Timmons *et al.*, 1995) and 4 km (Thompson *et al.*, 1999); and in Australia up to 3 km away from the pollen source (Rieger *et al.*, 2002). Pollen flow in canola is affected by many variables, including canola variety (male fertile versus sterile lines), the relative size of pollen donor and recipient populations, presence of a pollen trap or border row, environmental conditions (temperature, wind speed and direction, relative humidity, etc.), and presence of insect vectors (Ingram, 2000; Staniland *et al.*, 2000).

To test pollen flow models on a realistic field scale, gene flow between adjacent commercial fields of glyphosate- and glufosinate-resistant canola was examined at 11 locations in Saskatchewan, Canada in 1999 (Beckie *et al.*, 2001, 2003). Seed was collected from 0 to 800 m along a transect perpendicular to the field border and screened for HR in the greenhouse. Resistance arising from pollen flow was confirmed with laboratory tests (protein test strips and/or
molecular polymerase chain reaction (PCR) analyses). In 1999, *ex situ* estimation of gene flow between the paired fields ranged from 1.4% at the common border to 0.4% at 400 m, with no gene flow detected at 600 or 800 m. *In situ* estimates of gene flow were assessed in three of the 11 paired fields by mapping double HR volunteers that survived sequential herbicide applications the following spring. Gene flow as a result of pollen flow in 1999 was orders of magnitude higher (2.5-10%) and detectable to the limits of the study areas (800 m). Large variation in gene flow levels and patterns were evident among the three sites. Such variability will make modelling and the accurate prediction of gene flow in canola grown on a commercial scale very difficult.

**Weedy canola crop volunteers**

Volunteer canola is often a common weed in subsequent crops as a result of shattering and seed loss during harvesting operations. In a study in Saskatchewan in 1999 and 2000, average *B. napus* yield losses of 5.9% (3000 viable seeds / m²) were measured in 35 growers' fields (Gulden et al., 2003) and ranged from 3.3 to 9.9% yield loss or 9- to 56-times the normal seeding rate of canola. In western Canada, volunteer canola occurs in 11% of cropped fields and is ranked 18th in relative abundance of all weeds (Beckie et al., 2001; Légère et al., 2001). Comparative weed survey data (1997, 2002) from the provinces of Manitoba and Alberta in western Canada (Leeson et al., 2002a, b) indicated an increase in both the frequency of occurrence and relative abundance of volunteer canola since the introduct of HR *B. napus* canola. Volunteer canola densities in the following crop can be high prior to herbicide control, often exceeding 100 plants / m². Volunteer canola can persist for a minimum of 4-5 yr after production in Canada (Légère et al., 2001; Simard et al., 2002), compared with up to 10 yr in Europe (Lutman, 1993; Lutman and López-Granados, 1998; Pessel et al., 2001). Volunteers can serve as a potential pollen source for wild relatives and canola crops that follow in rotation or are located in nearby fields, and thereby extend the potential for gene flow spatially and temporally (Warwick et al., 1999, 2004; Beckie et al., 2003).

The potential weeddiness of HR volunteer canola is obviously affected by any associated fitness cost to herbicide resistance. In contrast to triazine-resistant canola, which is less fit than susceptible plants (Beversdorf et al., 1988), no associated fitness cost has been observed in the four HR *B. napus* canola types grown commercially in Canada (Kumar et al., 1998; Cuthbert et al., 2001; Simard et al., 2003).

Following the introduction of different HR *B. napus* canola types, the possibility of gene stacking increases over time. Hall et al. (2000) reported that pollen flow between cultivars with different HR traits had resulted in canola volunteers with multiple resistance at a field site in western Canada. In this instance, a field of glyphosate-resistant canola was grown adjacent to a field containing both glufosinate-resistant and imidazolinone-resistant canola. Volunteers from the latter field were selected with glyphosate the following year. The surviving volunteers flowered and produced seeds that contained individuals resistant to glyphosate and glufosinate, glyphosate and imazethapyr, and glyphosate, imazethapyr, and glufosinate. Two triple-resistant individuals were detected, with one of these plants located 550 m from the glyphosate-resistant pollen source. The results of the above study and that of Beckie et al. (2003) suggest that gene stacking in *B. napus* canola volunteers in western Canada may be common.

Multiple HR volunteers have, to date, not caused problems to the average Canadian grower, with the exception of those who elect not to grow HR *B. napus* canola (non-adopter) or organic growers. The management of HR volunteers does require a specific stewardship plan, particularly when broadleaf crops with few in-crop herbicide options are grown in a rotation. Herbicides with alternative modes of action, such as phenoxy herbicides (e.g., 2,4-D, MCPA) or photosystem II inhibitors applied alone or in a mixture, provide effective control of canola volunteers with single or stacked HR traits, such that yield of subsequent crops is not affected. There is no
evidence for altered herbicide sensitivity of single- or multiple-resistant plants to herbicides of alternative modes of action due to the genetic transformation (i.e., pleiotrophic effects) (Senior et al., 2002; Beckie et al., 2004). However, effective control of target weeds by a herbicide is defined in Canada as >80% efficacy and by that definition, HR B. napus canola volunteers are not eliminated. Where initial volunteer density is high (the year following B. napus cultivation), a substantial number of individuals can survive to maturity resulting in replenishment of the seed bank.

Seed purity

The presence of off-types in certified seed lots of canola must be expected as a result of pollen and seed movement. In Canada, a maximum of 0.25% off-types or adventitious presence is permitted in commercial certified canola seed (Canadian Seed Growers Association, 2002). Prior to the introduction of the HR trait, there were no definitive genetic markers to precisely quantify levels of genetic purity in canola cultivar seed lots. By definition, off-types in non-HR B. napus canola seed lots may include individual seeds that contain HR genes, singly or stacked; in the case of HR B. napus canola cultivars, non-HR seed or another HR type would be considered an off-type. In order to reduce pollen flow, an isolation distance of 800 m is required for growers of certified seed of hybrid B. napus canola in Canada, whereas a 100-m isolation distance is currently stipulated for certified seed growers of pedigree-derived cultivars (Canadian Seed Growers Association, 2002). However, these distances do not preclude gene flow (as discussed above) and it is not surprising that data from two recent studies in Canada have provided evidence that off-type levels (in particular stacked HR) in certified seed frequently exceed the stipulated threshold. Downey and Beckie (2002) found that 35 of 70 certified B. napus seed lots tested from 14 herbicide-susceptible, open-pollinated cultivars produced in 2000 contained the gene conferring glyphosate resistance, and 41 seed lots (59%) contained the glyphosate- or glufosinate-resistance gene. Only two cultivars were free of both genes. Frieseen et al. (2003) also found that 14 of 27 commercial certified seed lots tested had contamination levels above 0.25%.

Unexpected contamination, even at 0.25%, can cause problems for growers that practice direct seeding and depend on glyphosate for non-selective broad-spectrum weed control. The consequence of the presence of a 0.25% contamination level in certified seed in two adjacent glyphosate- and glufosinate-resistant commercial fields was documented by Beckie et al. (2003). In the subsequent spring, putative double HR volunteers that survived sequential herbicide applications were mapped in these two fields using GPS (global positioning system) and resistance in sampled plants was characterized. Double HR adventitious seed was known to be present in the glyphosate-resistant seedlot at 0.30%. The adventitious seed had a different gene (pat gene) for glufosinate resistance compared with the adjacent glufosinate-resistant field (bar gene). It was therefore possible to separate double HR plants that grew as volunteers in these two fields in the subsequent year into two categories: those with the bar gene and therefore produced as a result of pollen flow between the two fields and those with the pat gene and therefore derived from the adventitious seed. Results from this study indicated a rapid buildup of the double HR adventitious seed in the volunteer seed bank in the subsequent year. They also showed that the HR adventitious plants in the glufosinate-resistant field served as a pollen source in gene flow events to the adjacent glufosinate field.

Gene flow or hybridization to related species

A major concern about the agricultural release of genetically-modified organisms (GMO’s) is the escape of transgenes in the environment through hybridization with their wild relatives (Warwick et al., 1999, 2004; Snow, 2002). Canola has numerous wild relatives present in cultivated areas in Canada and worldwide (reviewed in Chèvre et al., 2004). Several studies have indicated the possibility for genetic exchange between Brassica species and related weedy species found in Canada, including crossing of B. napus with B. rapa (Jørgensen and Andersen, 1994; Bing et al., 1996; Landbo et al., 1996; Hansen et al., 2001; Halffill et al., 2002, 2003; Wilkinson et al., 2000, 2003) and Raphanus raphanistrum L. (Darmency et al., 1998; Chèvre et al., 2000, 2004; Rieger et al., 2001) under field conditions.

Results from a 3-year Canadian gene flow study between B. napus and four related weedy species [B. rapa, Raphanus raphanistrum, Erucastrum gallicum (Willd.) O.E. Schulz, and Sinapis arvensis L. -Note: these four also occur in Norway] are summarized below (Warwick et al., 2003). These results include data from experimental field trials and commercial HR B. napus canola fields. Sinapis arvensis is a major weed in canola-growing areas in western North America, whereas the other three weed species have more limited distributions. Gene flow was inferred by screening seed collected from the wild populations for the presence of the herbicide resistance trait found in adjacent HR B. napus canola fields.

Hybridization between B. rapa and B. napus was expected, and indeed, occurred at a frequency of ca. 7% in two field experiments where plants of B. rapa were grown at a density of one plant / m² with
HR B. napus. B. rapa x B. napus F₁ hybrids were also detected in two B. rapa populations growing in or near commercial HR B. napus canola fields in the province of Québec in eastern Canada. This represents the first case of transgene escape into a natural weed population (monitoring studies to confirm introgression of B. napus traits into the B. rapa genome are in progress). An even higher frequency of hybridization (13.6%) was observed in one of the wild B. rapa populations and was likely due to greater isolation distance between B. rapa plants. All F₁ hybrids were morphologically similar to B. rapa, but hybrid were confirmed by the presence of the herbicide resistance trait, triploid ploidy level (AAC, 2n = 29 chromosomes) and presence of B. napus- and B. rapa-specific AFLP molecular markers. The hybrids had reduced pollen viability (ca. 55%) and segregated for both self-incompatible and self-compatible individuals (the latter being a B. napus trait). In contrast, gene flow between R. raphanistrum and B. napus was rare. A single R. raphanistrum x B. napus F₁ hybrid was obtained in an HR B. napus field plot experiment where R. raphanistrum plants were grown at a density of one plant / m² with HR B. napus, and no hybrids were detected in HR commercial fields in Québec and Alberta (22,114 seedlings). Except for the presence of a B. napus trait “opening of the seed pod by valves” and distortion of the seed pods, the hybrid was morphologically similar to R. raphanistrum. This hybrid had a genomic structure consistent with the fusion of an unreduced gamete of R. raphanistrum and a reduced gamete of B. napus (RrRrAC, 2n = 37), both B. napus- and R. raphanistrum-specific AFLP markers, and <1% pollen viability. No S. arvensis or E. gallicum xx B. napus hybrids were detected (42,828 and 21,841 seedlings, respectively) from commercial HR B. napus canola fields in Saskatchewan. These findings suggest that the probability of gene flow from B. napus to R. raphanistrum, S. arvensis or E. gallicum is very low (<2.5 x 10⁻⁷). Our results are in accordance with gene flow predictions based on previous studies.

The two natural populations of B. rapa, where B. rapa x B. napus F₁ hybrids were found, will be monitored for persistence of the glyphosate-resistance trait and for evidence of introgression of the HR transgene into the B. rapa genome (Warwick et al., studies in progress). Previous studies have shown that a HR transgene can be passed between the two species and be active in successive generations (Mikkelsen et al., 1996; Metz et al., 1997). Such HR transgenic hybrids would have an obvious selective advantage in an agroecosystem where the herbicide is applied. Similar to HR volunteer canola, these hybrids may require altered or additional control measures but can generally be controlled in subsequent crops with herbicides with different modes of action. Also, we may assume no fitness cost (as discussed above) in the acquisition of herbicide resistance to glyphosate and glufosinate in an hybrid, and therefore persistence of these genes in the weedy populations in the absence of herbicide selection pressure. Snow et al. (1999) showed that fitness costs associated with transgenic glufosinate resistance introgressed from B. napus into weedy B. rapa were negligible. Danish studies of non-transgenic B. napus and B. rapa by Hauser et al. (1998a, b), indicated that fitness varies with the hybrid generation; F₁ hybrids were intermediate to the two parents, and a slight fitness depression occurred in F₂ and BC₁ hybrid generations, but some of the individuals were as fit as the parents. Other hybridization studies involving these two species (Stewart et al., 2003) have suggested that the transfer and crop-specific genes, that would accompany the transfer of a transgene, and their retention in a weedy wild relative would likely result in a reduced fitness.

References


hybridization between transgenic oilseed rape and wild radish under normal agronomic conditions. *Theoretical and Applied Genetics* 100, 1233-1239.


Gene flow between canola varieties and to other wild species
by Suzanne Warwick
Agriculture and Agri-Food Canada
Ottawa, Canada

Brassica Crop Species

Canada 1995–2003
B. napus 50% 96%
B. rapa 50% 5%

Genomes:
- A, B, C

HR Brassica napus in Canada

Total HR
Glyphosate 30%
Imidazolinone
Glufosinate
Bromoxynil

Year

Economic Benefits
(Canola Council of Canada 2001;
Devine and Buth 2004)

- higher seed yields and higher financial net returns
- easier and better weed control
  - reduced docking
  - lower herbicide use
  - reduced tillage
  - reduced fuel consumption

Outline
- Introduction
  - Brassica crop species
  - Canola - HR
    - Canada / Globally
- Gene flow
  - Between canola varieties (intra-specific gene flow)
    - Distance
    - Gene stacking
    - Contamination
  - To wild species
    (inter-specific gene flow)

HR crops - Globally
- HR(HT) dominant trait in commercial transgenic crops
- HR canola – 3rd most abundant transgenic crop in 2003
- 5% of global transgenic crop area
- 2.7 of 25 million ha of canola grown is transgenic

Large-scale use of HR canola
- provided an opportunity to test current models of intra-specific and inter-specific pollen flow on a realistic field scale
- HR trait:
  - easy to monitor
  - provides accurate assessments
  - highly suited for large-scale screening programs
**B. napus Breeding System**

- 30% outcrossing
- Insect and wind pollinated
- Pollen flow up to 1-3km
- Gene flow is possible by both pollen and seed escape

**Canola is a Volunteer Weed**

- Seed loss due to shattering and harvest loss (5-10%)
- 3C-60% greater than sowing rate [Gulden et al 2003]
- Contaminate seed lots
- Avenue for dispersal transgenes
  - non-HR canola
  - weedy relatives

**Intra-specific pollen flow: HR B. napus**

[Beckie et al 2003 Ecological Applications]

- To assess gene flow in space and time in adjacent commercial fields of glyphosate- and glufosinate-HR B. napus canola
  - pollen flow distance
  - frequency and distribution of volunteers, and effect on gene flow
  - compare various marker systems for tracking gene flow

**Intra-specific pollen flow: HR B. napus**

- one transect
- 0, 50, 100, 200, 400, 600, 800 m
- 10 plants per distance
- 100 seedlings/plant sprayed

**Molecular: Presence of HR genes**

- Glyphosate resistance
  - HOR gene
- Glufosinate resistance
  - pat gene
  - bar gene

**Pollen Flow: 1999**

- Glyphosate-resistant fields
- Glufosinate-resistant fields

**Ecoregions**

- boreal Transition
- Aspen Parkland
- mixed Mixed Grassland
- Mixed Grassland

**Identification double HR**

Sprayed with glyphosate and glufosinate
Test strips for HR
The Norwegian Biotechnology Advisory Board: Co-existence

Pollen Flow: 2000
3 Paired Adjacent HR fields

Volunteer *B. napus* pre-spray densities
(mean no./m²)

<table>
<thead>
<tr>
<th>Site</th>
<th>Glyphosate-HR Field</th>
<th>Glufosinate-HR Field</th>
</tr>
</thead>
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<tr>
<td>#1</td>
<td>350</td>
<td>510</td>
</tr>
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<tr>
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Adventitious Presence
[off-type or impurity or contamination]

- Glyphosate original certified seedlots
  - 2HR genotypes present
    - Site #1: 0.15%
    - Site #10: 0.30%
  - Homozygous and hemizygous for two genes
  - 2HR gene and ***pat gene
- Glufosinate original certified seedlots
  - no 2HR genotype
  - ***bar gene

SUMMARY
Intra-specific pollen flow: HR *B. napus*

- Distance: 400 m (year 1) and 800 m (year 2)
- Adventitious presence of 2HR seed in glyphosate-R seedlots contributed to the occurrence of 2HR volunteers in 2000
- Gene stacking in canola volunteers in western Canada is common
  - pollen flow between different HR canola
  - presence of 2HR off-types in seedlots
  - agronomic practices typically employed by growers
Seed Purity

- HR markers allow for precise quantification of seed purity
- Two recent surveys have shown that adventitious presence in certified seed lots is common and often exceeds stipulated threshold (0.25%)
  - Downey and Beckie 2002
  - Friessen et al. 2003

Control of Multiple HR Volunteer canola

[Beckie et al. Weed Sci. 2004]

- Multiple-HR volunteers have to date not caused problems to the average Canadian producer, with the exception of:
  - non-adopters of the technology
  - organic growers
  - No-Till areas (rely on glyphosate)
- Generally controlled by auxinic herbicides
  - Need effective stewardship plan
  - Crop and herbicide rotation is key

Inter-specific gene flow to wild species

Brassica rapa  
Raphanus raphanistrum  
Sinapis arvensis

Inter-specific gene flow in canola: 4 related species in Canada


- Greenhouse experiments
- Field plot trials
- Commercial fields

Inter-specific gene flow in canola: 4 related species in Canada

Comparison of markers

HR B. napus Gene flow: Field trials (Ottawa 2000)

<table>
<thead>
<tr>
<th>Species/Population</th>
<th>No. seedlings</th>
<th>No. hybrids</th>
<th>% hybrids</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brassica rapa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QC-1</td>
<td>13423</td>
<td>911</td>
<td>6.9%</td>
<td>0-27%</td>
<td></td>
</tr>
<tr>
<td>QC-2</td>
<td>15850</td>
<td>1039</td>
<td>6.5%</td>
<td>0-36%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>29273</td>
<td>1949</td>
<td>6.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raphanus raphanistrum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEI</td>
<td>11111</td>
<td>1</td>
<td>0.009%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>1554</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QC</td>
<td>16512</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>8324</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>132921</td>
<td>1</td>
<td>0.003%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Gene flow: Commercial HR canola fields in Canada

<table>
<thead>
<tr>
<th>Location/Year collected</th>
<th>No. sites</th>
<th>No. seedlings</th>
<th>No. hybrids</th>
<th>% hybrids</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Brassica</em> napus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QC-5 2000</td>
<td>1</td>
<td>5393</td>
<td>810</td>
<td>15.6%</td>
</tr>
<tr>
<td>QC-4 2000</td>
<td>1</td>
<td>4279</td>
<td>1</td>
<td>0.023%</td>
</tr>
<tr>
<td>TOTAL 2001</td>
<td>2</td>
<td>9670</td>
<td>811</td>
<td></td>
</tr>
<tr>
<td><em>Raphanus</em> sativus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QC 2000 and 2001</td>
<td>8</td>
<td>1722</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>AB 2000 and 2001</td>
<td>11</td>
<td>4129</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Simulis arenaria</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SK 1959 and 2000</td>
<td>79</td>
<td>12538</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><em>Eucosma</em> galliiculm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SK 1959 and 2000</td>
<td>30</td>
<td>21541</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Summary

- **Gene flow to canola varieties** (intra-specific hybridization)
  - Pollen (up to 400 m) and seed escape
  - Gene stacking of HR genes is common
- **Gene flow to wild species** (inter-specific hybridization)
  - A less likely source of gene flow
  - No evidence of gene flow to 3 of 4 wild species studied
  - Gene flow to *Brassica* napus – inevitable
  - Follow-up in 2002 and 2003 – persistence of hybrid swarm
  - Effect of HR trait restricted to agro-ecosystem

Hybrid Characterization

<table>
<thead>
<tr>
<th>Trait</th>
<th>B. napus x B. napus</th>
<th>R. raphanistrum x B. napus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphology</td>
<td>like B. napus</td>
<td>like R. raphanistrum,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fruit with valves</td>
</tr>
<tr>
<td>Chromosome No.</td>
<td>2n=10, bipolar</td>
<td>2n=17, unreduced gametes</td>
</tr>
<tr>
<td>Generic structure</td>
<td>A/C</td>
<td>R/RAG</td>
</tr>
<tr>
<td>canola AFLP markers</td>
<td>90% canola markers</td>
<td>65% canola markers</td>
</tr>
<tr>
<td>Weed AFLP markers</td>
<td>40% weed markers</td>
<td>20% weed markers</td>
</tr>
<tr>
<td>Polen identity</td>
<td>mean 50%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Self-compatibility</td>
<td>22% self-compatible</td>
<td>self-incompatible</td>
</tr>
<tr>
<td>Backcrosses</td>
<td>with B. napus</td>
<td>with R. raphanistrum and B. napus</td>
</tr>
</tbody>
</table>

Canola (*L.A.CD, 2n=38*), *B. napus* (*L.A., 2n=20*), *R. raphanistrum* (*B/R, 2n=18*)
Potential for gene flow in important crop plants for Norwegian agriculture

Odd Arne Rognli
Associate Professor, Agricultural University of Norway

Norway has about 1 mill ha land that is currently under cultivation (Statistisk sentralbyrå 2004). Crops grown on this land are distributed as follows (%): Cereals 31.5, oilseed crops 0.7, root crops for fodder 1.9, potato 1.4, vegetables 0.6, gardens and other field crops 1.0, meadows and pastures 47.1, and permanent grasslands 15.8. The total acreage of field crops thus constitutes 37.1% of the land while grasslands occupy as much as 62.9% of the land. In the Northern part of Norway, grasslands constitute more than 95% of the cultivated land. A discussion of the potential for gene flow in important crop plants in Norway must be based on the scale of cultivation, the reproductive biology and the spatial distribution of these species.

Based on the acreage planted, the most important agricultural and horticultural species are: cereals (barley, wheat, oat, rye); forage grasses (timothy, meadow fescue, perennial ryegrass); forage legumes (red clover, white clover); oil-seed crops (spring oil-seed rape, spring turnip rape); root crops (swede, turnips); potato; and vegetables (carrot, cabbage, brussels sprout, onion, peas). In addition there are small acreages of fruit and berry species (apple, pear, plum, cherry, strawberry, raspberry, red currant, black currant). These species are also common in most gardens together with a number of other horticultural species. The spatial distribution of the major crop plants is very uneven due to the highly heterogeneous soil and local climatic conditions within Norway. The cereal production is therefore concentrated in two regions; in the Southeast (Østlandet) and in the middle of Norway (Trondheim region), while the forage grasses and forage legumes are mainly grown in the Western part, in the North and at higher altitudes in the valleys in the Eastern part. Oil-seed crops are only planted in the Southeast of Norway. The other crops are usually grown very concentrated in certain regions, like the fruits and berries grown in the fjords of the West-Coast of Norway.

One of the most important factors determining the potential for gene flow is the reproductive biology of the species. Pollination is of two forms, wind-pollination or insect-pollination, and the breeding system of species is classified as outbreeding (open pollination) or inbreeding (self-fertilization). Some species, like wheat, barley and oat, are completely inbreeders, while many forage grass species have genetic self-incompatibility systems that secure complete outbreeding. Other species, like many Brassica-species, have a mixture of inbreeding and outbreeding. Typical wind-pollinated species, like grasses, usually release a large amount of pollen. Although pollen can be transported by wind over large distances, such pollen has a low probability of successful fertilization because of competition with local pollen (Rognli et al. 2000). Despite this, the potential for gene flow in wind-pollinated species can be difficult to predict. At relatively short distances (up to 300 m), it is highly dependent on the relative sizes of the donor and the recipient populations and variation in flowering time within varieties. Variation in flowering time is common in varieties of for example grasses since they are heterogeneous populations, and variable flowering time will enhance the possibility for gene flow. Pollination by insects is probably even more difficult to control than pollination by wind since insects can transport pollen over large distances. This is also reflected in the requirements for isolation by distance during multiplication of certified seeds of vegetable species of the Brassica family, e.g. swedes (600 m).

There are three types of gene flow that is of interest in relation to crop plants: i) between species (interspecific hybrids), ii) between populations (varieties of the same species), and iii) between varieties and natural/feral populations of the same species. In relation to problems of gene flow between genetically modified plant (GMP) varieties and non-
GMP varieties co-existing in the same area, it is of course gene flow between populations (varieties) of the same species that is most important to focus on in the short term. The two other events are dealing with the escape of transgenes via interspecific hybridization or gene flow through pollen or seed into natural populations of the same species. These events may create more long-term problems, e.g. herbicide resistant weedy populations of closely related species like in the Brassica-complex and feral/natural populations that could transfer the transgene back into non-GMP varieties.

Gene flow through pollen is commonly regarded as the most important route for the escape of transgenes. This type of gene flow only becomes a direct problem in crops where the seeds (grains) or fruits are the product used for food or feed, like in cereals, oil-seed crops, fruits and berries. The two major cereal species in Norway, barley and wheat, are practically 100 % self-pollinated but very low frequencies of outcrossing have been observed (see Nurminiemi and Rognli 1994). Oat has a higher rate of outcrossing than barley and wheat, and rye is an outbreeding species. Certified seed of different varieties of barley, wheat and oat can be grown at 2-3 m distance, however, a larger distance would probably be needed in order to completely prevent contamination by pollen if GMP- and conventional varieties were grown in close proximity.

In forage grasses, root crops, potatoes and vegetables, where the vegetative parts of the plants are the products used for food or feed, gene flow through pollen will not pose a direct problem. In these crops, gene flow via pollen might happen during the generations of seed multiplication, especially during the production of certified seeds. Professional farmers, mainly in the Southeastern part of Norway, are producing seed of most of the major crop species on contract but due to the small domestic market the acreage is rather small. This production is highly regulated by the competent authority and species-specific requirements for isolation by distance are imposed. However, these distances are not sufficient to guarantee 100% pure seed, and multiplication of GMP-varieties might require the establishment of zones in order to prevent contamination by pollen. The topography of Norway, with a lot of isolated valleys and fjords, would make it easier to establish geographic isolation compared with many other countries. Even if it could be possible to control this for Norwegian varieties, seed lots of a number of foreign varieties that have been produced in other countries are being sold in Norway every year, and these seed lots could be contaminated.

For all crops established through seeds, contamination from the seed banks or volunteers in the soil or accidental mixture through seed multiplication and handling, probably pose a higher risk than contamination from pollen. This is especially the case if GMP-varieties and conventional varieties are being grown in rotation in the same field, whether this happens during seed multiplication or during crop production. Seeds might also be spread by other means, e.g. birds, and although the frequency might be low, it could still be a significant route for gene flow.

References
Open meeting 29. April 2004

**Area and distribution of crops in Norway**

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>23.5%</td>
</tr>
<tr>
<td>Barley</td>
<td>44.6%</td>
</tr>
<tr>
<td>Oat</td>
<td>25.8%</td>
</tr>
<tr>
<td>Wheat</td>
<td>7.2%</td>
</tr>
<tr>
<td>Rape</td>
<td>1.4%</td>
</tr>
<tr>
<td>Oilsed crops</td>
<td>0.7%</td>
</tr>
<tr>
<td>Root crops</td>
<td>11.9%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>0.6%</td>
</tr>
<tr>
<td>Vegetables</td>
<td>0.5%</td>
</tr>
<tr>
<td>Garden plants</td>
<td>1.3%</td>
</tr>
<tr>
<td>Meadow, pastures</td>
<td>0.3%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Important species**
- Cereals: barley, wheat, oat, rye
- Forage grasses: timothy, meadow foxtail, perennial ryegrass
- Forage legumes: red clover, white clover
- Oilsed crops: spring oilseed rape (B. napus), spring turnip rape (B. rapa)
- Root crops: swede, turnips
- Potato
- Vegetables: carrot, cabbage, brussels sprout, onion, pea
- Fruit and berries: apple, pear, plum, cherry, strawberry, raspberry, red currant, blackcurrant

**Spatial distribution**

- Cereals:
  - South Norway (Oslandet)
  - Middle Norway (Telemark)
- Forage grasses and Forage legumes:
  - Western Norway (Hordaland)
  - Northern Norway (Nordland)
- Higher altitudes in eastern part
- Oilsed crops:
  - South Norway (Oslandet)
- Fruit and Berries:
  - Western Norway
- Other crops:
  - Scattered distribution with local hotspots

**Reproductive biology**

**Pollination systems**
- Wind pollination
- Insect pollination

**Breeding systems**
- 'Complete' outbreeding (open pollination) - e.g. forage grasses
- 'Complete' inbreeding (self-fertilization) - e.g. wheate and barley
- Mixed in- and outbreeding - e.g. swedes, oilseed rape (Brassica napus)

**Gene flow in crop plants (1)**

**Between species (interspecific hybridization)**
- Relevant if progeny from crosses between the crop species and closely related species are viable and can establish.
- Probability highly dependent on scale and spatial distribution
- Potential cases:
  - Brassicaceae - wild brassicaceae
  - Oat - wild oat (Avena Tarda)

**Gene flow in crop plants (2)**

**Between populations (varieties of the same species)**
- Most important in relation to coexistence of GM and conventional varieties

**Between varieties and natural/feral populations of the same species**
- Relevant for all crops with natural/feral populations in close proximity to cultivated fields
- Forage grasses, forage legumes
- Trees - highest risk
- Gene flow in both directions possible

**Possible routes for gene flow (1)**

**Pollen**
- Most important factor for escape of transgenes and contamination of conventional crops
- Outcrossing species - highest risk
- Direct problem in crops where the seed is the product, e.g. cereals, oil-seed crops

**Possible routes for gene flow (2)**

**Seed**
- Seed shedding/spillage - seed banks
- Dispersal by water, wind, animals and human activity
- Contamination by accidental mixing of seed lots or crop harvests

**Vegetative parts**
- Likely event only for specific crops
- Possible through transport of agricultural machinery, soil etc.
Gene flow experiment in meadow fescue (outbreeding, windpollinated, self-incompatible)

Pollination measured using isoenzymes as genetic markers.
- Donor plants in the centre (430 plants) and acceptor plants (544) in concentric circles.

Effect of pollen competition was studied using single acceptor plants alternating with pairs of acceptor plants along the circles, opened 8 in apart.

Conclusions

Potential for gene flow:
- Very variable.
- Reproductive biology very important.
- Larger for outbreeding species like grasses and legumes.
- Direct effect on product quality depends on which part of the plant that is harvested.
- Gene flow during seed multiplication constitute an important route for contamination.
- If gene flow is possible, albeit at low frequency, it will probably happen and 100% purity is not possible to guarantee.
- Isolation by geographic distance between GM varieties and conventional varieties might be possible in Norway.
Discussion I

[Extract]

NN
I want to refer to Suzanne Warwick's last slide: I doubt that the effect of the herbicide resistance trait is restricted to the agro-ecosystem. A gene may have a strong effect in one ecosystem and only a minor effect in another. Would you say that the herbicide resistance trait may have an effect also in another ecosystem?

Suzanne Warwick
What we know so far is that there is no obvious fitness effect of an herbicide resistance gene in the plant for an herbicide resistance gene. It will persist as it is of neutral selective value, unless there is strong selection pressure by the application of herbicide. This is in contrast to genes for disease resistance or insect resistance traits, which may also have a strong selective value outside the agro-ecosystem where wild relatives may be growing.

Anne Sissel Pundsnes
I wonder if one can produce plants with seeds that are infertile?

Suzanne Warwick
Yes, that concept was introduced 15 years ago, with much controversy. The new abbreviation for this is GURT, gene use restriction technology. Lots of research is going on that involves mitigation measures in order to reduce pollen flow.

Inger Nordal
In Canada you have created a new herbicide resistant weed, the rape volunteer plants. This creates a potential for a new superweed, particularly when it becomes double resistant against the commonly used herbicides glyphosate and glufosinate. Is this regarded as a problem in Canadian agriculture?

Suzanne Warwick
Volunteer canola has always been there, wherever the crop is grown, for instance in the UK and in France. So this is not a result of the introduction of herbicide resistant lines. The double resistant plants are not superweeds in the sense that they are out of control. With one exception, that is where farmers use glyphosate in areas of no till to control volunteer canola plants and would, therefore, have to use another herbicide. There is no increase in fitness and they (volunteer canola) can still be controlled by alternative herbicides. Normally, cereals follow canola in rotation, and cereal crops use different herbicides altogether. But volunteer canola plants do persist and require special control and special attention. It is very important to rotate herbicides and to be aware of the volunteers that exist in a farmer’s field. And I think the producers should have very good knowledge of this and be informed and made aware that a volunteer should be controlled.
Marina Bleken
One thing is to look for gene flow from herbicide resistant transgenic plants; another aspect is to consider how much herbicide that has to be applied in that type of agriculture. Agriculture based on transgenic herbicide resistant plants is actually using much more herbicides than other practices. That’s just a comment.

Werner Christie
Yes, what is the overall effect of these new techniques on agriculture and breeding? I think that is an interesting question that could be commented further.

Trond Skaftnesmo
You haven’t mentioned one major source of gene flow, and that is horizontal gene transfer. What is your opinion on that? And have you examined the possibility of horizontal gene transfer from canola?

Suzanne Warwick
I personally have not done that kind of research. There are researchers that have looked at horizontal gene transfer, particularly the glyphosate resistance gene in canola to animals, in particular gene transfer to rumen bacteria in cattle. That work is done by a colleague of mine in Alberta and their results have certainly not shown that there is an effect on the growth of these animals. They have detected the presence of this gene in the feed, but no evidence of transfer of that gene to the bacteria in the rumen. I am not aware of any studies that have shown the transfer of various genes like the Bt gene to soil microorganisms. But, for sure, it is possible, for instance the transfer of antibiotic resistance genes.

Trond Skaftnesmo
There is a tendency in this discussion to talk about gene flow as just pollen flow in flowering plants. But there is research done also on horizontal gene flow that is very disturbing. Professor Terje Traavik from the University of Tromsø has shown that genes can survive as naked DNA in the soil and then be taken up by bacteria and viruses. This means that vector elements, like the cauliflower mosaic virus promoter 35S, can be transferred, integrated and reorganize in the host genome. What is the vector that was used for making transgenic, herbicide-resistant canola?

Suzanne Warwick
I am not the biotechnologist here, and I do not develop these plants, so maybe someone from the industry can answer that? (Editor: The soil bacterium Agrobacterium tumefaciens was used to transform Roundup Ready canola line GT73. The vector used was plasmid PV-BNGT04, the inserted T-DNA contains functional transgenes and the promoter 35S from Figwort Mosaic Virus (FMV)).

Trond Skaftnesmo
These (vector sequences that rearrange) are inherent problems with the GMOs and should be addressed.

Suzanne Warwick
Absolutely. I was asked to talk about pollen flow and seed escape in canola, but I am sure there will be other persons here that can answer some of these other aspects. However, there are also other concerns. I also work on how herbicide resistant weeds are selected when you change patterns of herbicide use. Because when you grow these herbicide resistant crops, you do change the way you do agriculture. You reduce the use of certain types of herbicides, but
you also increase the use of others. Hopefully, one is choosing herbicides that are more environmentally friendly than the herbicides that were previously used. And hopefully the amount of herbicide that is applied is also reduced. Generally that is also the case.

NN

There are several theoretical ways to stop gene flow and pollen flow. Do you see any benefits from such technology?

Suzanne Warwick

Many years ago, Monsanto introduced such a technology. It was called the terminator technology. Many people were upset by the idea that you could make seed that was infertile, meaning that the farmer was not able to save the seed and resow their seeds. Now the technology has resurfaced under a new acronym, GURT (gene use restriction technology), and there are many methods developed by many researchers who try to contain pollen flow. It is not necessary to produce seeds that are viable. Think for instance of how F1 hybrid seeds are made, some of which are also sterile. The farmers are then forced to buy the seed again each year.

Werner Christie

This of course has two aspects, the first is that the farmers cannot use the seed again the next year, but at the same time it is easier to control the spread of the seeds.

Odd Arne Rognli

I would like to comment a bit on this. For the Brassicas (kålslekten i korsblomstfamilien) there is a discussion on how to place the transgenes into the chloroplast genome so that the genes do not follow the pollen. The problem with all these technologies however, is to convince those opposing the use of such technologies. As a scientist, you cannot say that something works 100% all the time. This is the problem. In a certain environment, under certain conditions, the technology might break down. In most cases it will work just fine, but as a scientist you cannot rule out that a bad scenario might happen.

Werner Christie

We have had seminars before in the Norwegian Biotechnology Advisory Board about the risk assessment of transgenic plants. When we talk about transgenic plants, it is important to keep in mind that we should consider the risk imposed by GM plants and compare it to the “background” risk related to traditional farming.

Inger Nordal

What is happening at the Agricultural University at the moment in this field? We know that you are actually producing transgenic plants at your university, for instance a begonia plant that flowers from Christmas to Easter. What will the first GM products be in Norway?

Odd Arne Rognli

The research we are doing using transgenic plants is not aimed at product development. However, at Planteforsk, The Norwegian Crop Research Institute, they are engineering Fusarium resistance into barley, a very interesting project aimed at reducing the mycotoxin levels due to fungal infections in seeds. The transgene conferring resistance is expressed in one cell layer in the seed where the fungus attacks. The promoter that controls the expression of this gene was isolated in our department. But as I said, we are only using GMOs for research purposes.

Hilde Helgesen

I have been listening with interest to the discussion here today and would like to say that farmers must have a right to produce seed for their own specific needs. We have to bear in mind that this is a fundamental right for a farmer. It should not be a matter of economic discussions. This is, however, a slightly different discussion involving ethical considerations.
Co-existence of genetically modified, conventional and organic crops

Søren A. Mikkelsen

Deputy director of the Danish Institute of Agricultural Sciences (Danmarks JordbrugsForskning)

Co-existence

The topic in question is co-existence between different kinds of crops. More specifically, this is about the measures needed in order to ensure that genetically modified, conventional and organic crops may be grown under Danish conditions in accordance with specified threshold values for levels of adventitious presence of GM-material in non-GM crops.

The underlying philosophy of co-existence is that there should be a freedom of choice for producers and consumers alike regarding agricultural practice and type of product. This does not imply taking a pro- or contra- stand concerning GMOs. Rather, the basic scenario is that GM-crops may be grown in Denmark in accordance with the approved laws. That has also been the starting point for the co-existence project as we have analysed possible sources and routes of gene-spread from GMOs and proposed measures in order to ensure co-existence.

The project

The Danish work on co-existence has been in progress for nearly two years. The Minister of Food, Agriculture and Fisheries, Mariann Fischer Boel, appointed an expert working group in the summer of 2002 consisting of representatives from the Danish Plant Directorate, Riso National Laboratory, National Environmental Research Institute, The Royal Veterinary and Agricultural University, Food and Resource Economics Institute and The Danish Institute of Agricultural Sciences with myself as chairman.

The expert working group has primarily based its work on Danish experiences from certified seed production and on Danish and international reports and model calculations. The preliminary results of the working group were presented in January 2003 at a public hearing at Christiansborg and also at the EU Commission’s so called Round Table Conference on co-existence in Bruxelles, April 2003. The report from the working group has been published in Danish in August 2003 and may be found at DJF’s webpage (www.agrsci.dk). The report has later been translated into English and was presented at the GMCC-03 conference, The 1st European Conference on the Co-existence of Genetically Modified Crops with Conventional and Organic Crops, held at Comwell Borupgaard, Snekersten, DK, 13.-14. November 2003.

The Danish work is the first of its kind in Europe and has therefore received a great deal of attention from the international community.

Parallel with the expert working group the Ministry of Food, Agriculture and Fisheries has established a contact group with a broad stakeholder representation from amongst others agriculture, the food industry, consumers, nature organisations and organic farming. The Ministry has developed a strategy for co-existence that deals with questions such as regulations and liability when ensuring co-existence. The Danish Minister of Food, Agriculture and Fisheries presented the Danish Parliament (Folketing) with a proposed Act on Co-existence in February 2004 (Editors note: the Danish Parliament adopted the”Act on the Growing etc. of Genetically Modified Crops”, Act No. 436, on the 9th of June 2004).

Dispersal and management

Regardless of the crop that is grown, either conventional, organic or GM-crops, gene dispersal to neighbouring crops will exist to a certain degree.

The major sources of dispersal as identified by the working group:

- Seed
- Pollen
- Straw
- Seed within the crop rotation (seed banks)
- Seeding and harvesting equipment
- Transport equipment and storage facilities

The extent of dispersal depends on e.g.:

- Crop biology including choice of variety
- Extent of cultivation
- Field size, position and shape
- Weather and wind conditions
- Human handling
Conclusions
Loosely formulated the conclusions are that co-existence as a rule and with a limited production of GM-crops, is possible within the defined threshold values as long as the suggested measures are adopted. The prerequisite, however, is showing a consideration during the production process that exceeds good farming practice, and compliance to specific measures designed to limit dispersal. For some crops that are cross-pollinating and/or with long seed survival in the soil, there are some exceptions to this rule:

- Presence of wild relatives
- Pollinating insects

Dispersal may be limited by several means depending on the crop. The most efficient means are:

- Control and safeguarding of seed
- Separation distances, buffer zones and size of the field
- Cropping intervals (rotation frequency between crops of same species)
- Control of volunteers and possible wild relatives
- Cleaning of seeding, harvesting, transport equipment and storage facilities, along with safeguarding of straw use

Recommendations
The co-existence work has been very extensive task for the working group during the last year. The topic is very complex, the specific knowledge on co-existence is limited and the recommendations of the group are in many cases based on evaluations and assumptions with varying degrees of uncertainty.

Therefore the working group recommends that, based on the proposed measures, co-existence is introduced for a limited period and with a continuous evaluation and updating of the control measures. This should be done according to the results from a proposed monitoring, research and development programme meant to re-evaluate and refine the control measures ensuring co-existence.

Finally it is recommended to introduce a course for farmers growing GM-crops – to obtain a "GM-driver's licence".

Science and politics
In the light of the ongoing debates on GMOs the co-existence work has naturally been watched quite closely by both the public and politicians.

In the working group we have done our best to maintain a high scientific integrity and concentrate on the evaluation task. We have of course had various discussions about GMOs, but we have been true to the work and the science at hand throughout the assignment.

Our meetings with the contact group were of great use through our dialogue with the various stakeholders and their specific comments. But after the meetings we have always made an independent evaluation based on a strict scientific viewpoint. We have tried to the best of our abilities not to mix issues of science and politics.

References
"Report from the Danish Working Group on the Co-existence of Genetically Modified Crops with Conventional and Organic Crops" ("Rapport fra udredningsgruppens vedrørende Sameksistens mellem genetisk modificerede, konventionelle og økologiske afgrøder", DJF-rapport nr. 94). The authors are Karl Tolstrup, Sven Bode Andersen, Birte Boeth, Merete Ruus, Morgen Gylling, Preben Bach Holm, Gesta Kjelsson, Svend Pedersen, Hanne Østergaard and Søren A. Mikkelsen.
Why GMO-free zones?

Werner Müller
Global 2000

Based on the European Commission recommendations on coexistence, there is a need to regulate coexistence crop specifically and step by step, from management at the farm level to management at the neighbourhood level up to measures with region-wide dimension.

Based on analyses on cross-pollination, seed dispersal, seed viability in the soil and in accordance with the European Commission recommendation, as well as the small-scale structure of Austrian Agriculture, there will be a need to regulate the cultivation of GM maize and GM oil seed rape at a regional level. In some regions, the agricultural structure may allow management of maize at the neighbourhood level, although a detailed analyses to identify such regions was not the subject of this study. While voluntary regions will not provide a proper conflict solution potential, legally binding regions (GM regions or GM-free regions) will be necessary. From a management perspective, only minimum isolation distances would serve as a practically feasible decision tool. Hedges, for example, are very difficult to handle in the management of coexistence, as exact knowledge on the efficient reduction of the rate of cross-pollination at certain distances is lacking. Varieties with different flowering time will not provide sufficient security to avoiding cross-pollination. Besides these recommendations on the management of coexistence, the author points out that there are huge gaps of knowledge in the underlying basic science of risk assess-

Werner Müller holds a university degree (Dipl. Ing.) in “advanced ecology and environmental sciences farming at the University of Agricultural sciences (BOKU) - Vienna-Austria. Since 2003 he has been Scientific advisor of GLOBAL 2000/Friends of the Earth Austria.

ment of GMOs, e.g. with regard to cell biology, genetics. Moreover, the current practice of risk assessment does not provide sufficient information to conclude that GMOs for food and feed use are safe. GMO crops which have the potential for outcrossing should not be approved because there would be no (or at least very limited) options for mitigation measures in the case of error, which cannot be ruled out for risk assessment methods. Besides the problems with coexistence, an approval of GMOs would still be premature.

References


A selection of recent articles and studies, and presentations can be downloaded from www.eco-risk.at
Why GM free Regions

W. Müller

"We are in a data-rich environment, but the fact is we are information poor. You look at biological systems with much more complexity than before."

"We really have a poor understanding of what a gene actually does and where and when it should do it. You can understand the entire genome and still understand less than 1 percent about what is going on in a cell."

Late lessons from early warning – the precautionary principle 1998 - 2000

EEA – European Environment Agency 2002

http://reports.eea.eu.int/environmental_issue_report_2001_22

Toxicology

GM Food consumption

3 x day
7 days a week
Full lifespan young and old, 1st and 3rd

Chronic Exposure Chronic Effect Testing

Obligation

Tests

- Not only short/mid term but also
- Long term
- Effects for future generations
- Potential cumulative effects
- Sensitive consumers

Studies

- 2002 Spoek et al
- 2003 Gaugitsch et al
- 2004 Müller, Dolezel

Historical review of the risk identification and regulation of three pesticides in Austria

DDT

- Approval (batches 1947)
- Resistant insects (1947)
- DDT to mother milk
- Accumulation in soil & fat tissue (1951)

Methyl Bromide

- Approval (1996)
- Human toxic (1979)
- Depletion of the ozone layer (1994)
- Estrogenic effects (1994)

Vinclozolin

- Approval (1994)
- Depletion of the ozone layer (1994)
- Estrogenic effects (1994)

**Toxicology risk assessment**

<table>
<thead>
<tr>
<th>Tests</th>
<th>SCDF</th>
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<th>Scientific relevance</th>
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</tr>
<tr>
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</tr>
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<tr>
<td>cumulative</td>
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**Allergenicity**

*In vitro* The game called “sound science”

- Proof in a test-tube design that Bt-Protein is digested within seconds to minutes

*In vivo*

- Detected Bt-Protein in intestine, rectal content of cows, pigs and chicken

Use of outdated models

No allergy

**Late lessons from EPREX**

*Why are Biological Products Different?*

- All Biological Products possess the potential for immunogenicity
- Antibody formation may be inconsequential, reduce efficacy, or impact safety
- Even small, sometimes undetectable, alterations in a biological product can create immunogenicity

*Source: Jimenez 2003 / Bioinnovation (Biotech industries organisation)*

**General principles**

- Step by step
- Crop by crop
- Purpose by purpose

**The failure to recognize the importance of introns/RNA may well go down as one of the biggest mistakes in the history of molecular biology**

*John S. Mattick, Director of Institute of Molecular Bioscience, University Queensland (Australia)*

RNA in risk assessment of GMO disregarded
step by step (4 levels)

- seed
- Farm (hedges)
- Neighbour (management by farmers)
- Region

level 4 – region wide measures

- Voluntary GM free zones
  - Austria since 2 years of proclamation no single signature
  - Souverainatsverzicht muss abgegeben werden
- Legally binding GM-free Zones
  - it seems for Austria the only way to get coexistence solved maize/oil seed rape

GM-prohibition act 2003
blanket ban for 3 years to solve coexistence problem

- Not in force
- Government asked Commission for Notification
- Commission rejected in September 2003
- No new evidence for environmental damage
- Austria repeals a EUROPEAN court
- 28 April 2004 Conference of GM free regions

Precautionary principle side by side not possible (coexistence)
blanket ban
No toxicological test
No allergological test
blanket approval

GMO free – Regions
EC-Parliament
80% EC citizens/Bürger

right of self-determination

a simple ceculation
Farmers 3 crops per crop rotation, 3 fields

farmers combinationen for the management of crop rotation

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<tr>
<td>10</td>
<td>59.049</td>
</tr>
</tbody>
</table>

„GM free Regions is the best measure to solve coexistence problem".
Oliver Pagard from French Cereals Cooperative CAC.
APK 03/02 2003-09-12

GM free Regions initiative

- Austria: OÖ, Salzburg.
- Tuscany, Marche, Basque country, Schleswig-Holstein, Wales, Limousin, Thrace-Rhodopi, Aquitaine
- New: Scotland, Burgenland
Knut Berdal
We learned today from Suzanne that there are four major herbicide tolerant canola lines in Canada, three of which are made by gene technology and one is formed by mutagenesis. In Canada these four plants are regulated by the same acts. In Europe, the regulation is very different, as there is no regulation that applies to lines made by mutagenesis. The scientific basis for co-existence, is that the same for a GM crop as for a non-GM crop that has gone through mutagenesis?

Søren Mikkelsen
The answer to this question is a simple one: The work we are doing on co-existence is related to GM crops. We haven’t broaden this discussion further.

Åsmund Bjørnstad
Concerning the very good question regarding GMOs versus mutations: The speaker (Mikkelsen) mentioned transgenic phytase wheat from his institute which has gotten a new gene from Aspergillus. I would like to mention that a Danish group in Risø (Søren Rasmussen) has developed functionally identical lines in rice and barley, not by transgenics, but by induced mutations.

Werner Christie
Which indicates that traits, more than techniques, may be important here!

Inger Nordal
In your conclusion you said that there probably will be only limited GM production in Denmark in the future. But if the GM crops become increasingly popular among the farmers, what do you do then?

Søren Mikkelsen
In our report we are dealing with different scenarios: Zero, 10 % and 50 % GMO-scenarios for different crops. Another aspect, however, is the distribution of a given crop in a country or a region. We have about 50 crops that are grown to a certain extent in Denmark. The four cereals take up approximately 50 % of the total area. So far there is no sign of a single variety of a cereal crop dominating the market.

Suzanne Warwick
I was interested in your farmer’s “driver’s license”. I think it is very good to inform people of the best farming practices, another thing is to actually get people to follow it! Does your scheme take into consideration how inspectors should visit these farmers and ensure that they are following the procedures that you are going to be recommending?

Werner Christie
Just a short comment on that. In Norway we already have a “driver’s license” for using pesticides. So in order to buy pesticides you have to show your “pesticide driver’s license”. This type of safeguard is something that the farmers are used to.
In a way, this is already in place. There are many inspectors from the plant directorate who visit farms in Denmark. They ask for fertilizer plans and your pesticide driver’s license and count animals in relation to regulations. Farmers do not like it, but they accept it!

When you give the estimated costs of the precautionary measures you have proposed in percentages, what percentage is that?

That is the percentage of the total costs of production. There is at present a cost of about 5000 DKK pr. ha but if you have to go on with the proposed co-existence precautions the costs may be up to 20 % higher in “worst case”, cf. our calculations.

Thank you for an interesting talk. I thought it was interesting to learn more about the Danish process where all the stakeholders were involved in consultations and discussions. I hope that the Biotech Advisory Board and other players and stakeholders will continue the discussion we have started here today.

Thank you, we strongly endorse that comment and the Biotech Advisory Board will do its best to support those kinds of efforts also in the future.

It is not only the issue of gene flow that matters. Predatory insects like ladybirds can get killed by the Bt toxins in the pollen from Bt transgenic crops. Did you consider the effects on insects in your co-existence work?

The role of bees in particular was a topic in our discussions. We have included entomologists in the discussions, especially for the “difficult” crops, like clover. Bumblebees are very important for the pollination of clover. One of the prerequisites for our work, however, is that we were only dealing with GMOs that had been approved by ordinary procedures. In our group we have not discussed environmental and health related questions. Our work is based on plants which have passed the approval systems with a favorable risk assessment report.

We have to bear in mind, like Werner Müller told us today, that with the introduction of GM crops, zero thresholds are not achievable. This means that we will also have gene flow and we may get products with unexpected effects in the end. I think we have to acknowledge the right of farmers and consumers to be able to avoid GM crops and GM products. That is more important than being able to grow GM crops.

Maybe a bit on the side, but I would like to ask: Are there any clear benefits from using GM crops, either related to health, yield or the environment?

The Danish pig producers deliver 24 million pigs per year at competitive market prices, internationally. At present, there is much debate in Denmark on how this activity influences society and especially environment. Some time ago, however, a pig was marketed in Denmark that was fed on a specific non-GM diet. This product was stopped, however – I believe because the premium price was between 10-20 % and too few consumers wanted to buy it.

Just a comment to the phytase story mentioned. The diet fed to pigs is of course important, but what might be of even greater importance are cereals in the human diet. Phytate present in whole grain cereals, amongst others wheat, is an inhibitor of minerals. It is therefore an issue to get rid of phytate through enzymatic breakdown with phytase. This enzyme
is naturally present in whole grain cereals, but in some cases the concentration is too low. An increased degradation of phytate would result in higher availability of important minerals like iron and zinc. So this type of wheat with increased phytase content could also be good for human consumption. It is also possible to break down the phytate by using yeast during the fermentation process when baking bread and making other cereal products. These kinds of projects are going on in Sweden for instance. There are also other positive effects of using GMOs. In Asia, scientists have been able to make GM rice that is not allergenic. Allergies towards rice are of course a big problem affecting many people in that part of the world.

**Odd Arne Rognli**
As far as I understood, your data did not provide estimates on the expenses of monitoring in the field. Is that right?

**Søren Mikkelsen**
You are right; our estimates do not include monitoring expenses.

**Werner Müller**
It also important to ask: Who benefits? On the farmer level there are some benefits. A farmer has to make some calculations. Do I use a certain pesticide twice? Maybe if the economy allows it he decides to spray twice, just to have a better safeguard. Some farmers perceive GM crops as an insurance against certain pests. It is a personally perceived insurance. For the consumer side we do not see any benefits at the moment.

**Hilde Helgesen**
When dealing with coexistence it is of vital importance to establish a system that places the burden of proof on the producers of GM plants. We should follow the “polluter pays” principle. There should be no additional costs for farmers who do not wish to grow GM plants, nor for the consumers.

**Sjur Erik Kvåle**
In the EU there are guidance documents on coexistence that can serve as a starting point for making national legislations. In Denmark you have now proposed a new act on coexistence. Do you find any controversy regarding trade between member states, considering that you are adopting different acts?

**Søren Mikkelsen**
I am not sure whether I can answer that question. However, you are right that the EU has issued guidelines on coexistence from July 2003. I think they still leave much to the member states. EU accepts that local issues may be important.

**Hilde Helgesen**
Measures must exist to separate GM and non-GM products in the transportation chain from the farm to the storage facilities and supermarkets. That also costs money. Are such figures part of your studies?

**Søren Mikkelsen**
I have to warn you not to draw to many conclusions from our report. These studies are desk studies. Many assumptions were made before the calculations were carried out. Please do not overinterpret these data!
Co-existence of organic and GM farming in Norway

Liv Birkeland
The Norwegian Centre for Ecological Agriculture

Co-existence of organic farming and other farming systems is not an entirely new challenge. Farmers, the processing industry, retailers and public authorities have had to deal with the issue of co-existence in order to both define and distinguish organic production and products from conventional and GM agriculture.

The launching of genetically modified crops (GMC) unfolds new challenges for both conventional and organic agriculture. This article handles topics such as environmental and health risks, market communication, agronomic practice, trade and processing problems from the viewpoint of organic agriculture in Norway.

Genetically modified organisms (GMOs) are surely an efficient answer to many questions, but to questions that have never been asked by the movement of organic agriculture. Nevertheless, the fact that GM crops are neither required nor wished for from the organic movement, gives no exemption from dealing with the issue. It rather calls for a very liable and thorough handling of the situation brought by the introduction of GMOs in agriculture.

All organisms co-exist, genetically modified or not, conventionally or organically grown, with or without the brilliant qualities we would like them to have. The question is what the consequences might be and how to defend the eco-system, that also human beings are a part of, against harmful effects like instability, unfairness and health damage.

Characteristics of the organic sector in Norway

International regulations and guidelines for organic agriculture are compatible with the organic practice we find in Norway. Thus, the question of co-existence in Norway will in general not differ very much from what we find in other Western nations. Some aspects of our country and agriculture that might be of specific relevance to the question are:

- consumer awareness and attitudes towards conventional and organic agriculture and their products
- extent and importance of organic agriculture
- topography and climate
- distribution, the process industry and the agricultural co-operatives

The Norwegian Centre for Ecological Agriculture.
Tingvoll gard, N-6630 Tingvoll, Norway (+ 47) 71 53 20 00

The confidence of Norwegian consumers in the quality of its nations’ agricultural production is high, and they tend to believe that all Norwegian food products are “as good as organic”. This makes it hard to communicate the difference, i.e. to make the consumers distinguish organic from conventional products. This makes it hard to communicate the difference; to make the consumer distinguish organic from conventional products. A comparative study between two Norwegian and four European towns shows that Norwegian consumers buy less organic products than consumers in the other countries. Then again, access is a far more important obstacle for the Norwegian consumer (Methi et al, 2002).

The confidence in Norwegian agricultural products is the result of farming practices and control measures, and due to the fact that we have not had any big food scandals like the ones experienced in other parts of Europe.

In 2003 the total agricultural area in Norway was about 1 million hectares (SSB, 2004). 38 179 hectares are organically farmed, both licensed and conversion area (Debio, 2004). This is equivalent to 3.7 % of our total agricultural area. The authorities have launched that 10 % of our arable land shall be approved as organic by the year 2010.

Topography in Norway promotes relatively small units of production and agricultural activities are normally not concentrated. In a few areas one can find intensively run farms, but the general impression is that Norwegian farms are run on a rather small scale. The Norwegian climate varies a lot from south to north but can be generally characterised as humid and temperate.
Agricultural activities are highly regulated through political decisions, regulations and due to the strong position of agricultural co-operatives.

Co-existence today – organic and conventional farming

Debio-regulations set standards for co-existence of organic and conventional farming. Organic and conventional production might take place at the same farm or production unit. Specific requirements are set in order to distinguish the products and avoid influence from conventional practice on the organic products from field to fork. Buffer areas and release dates are methods applied to the latter.

Many find it controversial that a restricted use of manure/compost from conventional production is allowed in organic agriculture (Debio-regulation 3.3.3). Regulation 3.3.4 prohibits the use of manure from the production of fur-bearing animals and battery chicks.

The main principle for parallel production is that it should be easy to distinguish the two productions from each other, during the entire production chain. E.g. one is not permitted to use the same plant variety, and the varieties should be easy to distinguish from each other (Debio-regulation 3.1.3). Parallel production in animal husbandry requires separate rooms for the conventional and the organic herd and fodder (Debio-regulation 4.1.3).

Farmers and farmland are mutually dependent on each other and conventional and organic farming do have some mutual interests. Weed harrowing and the development of biological pest control are examples of areas with common interest and joint efforts.

Organic seed

Organic agriculture in Norway is presently dependent on conventional seeds and imported plant material. 2004 is the first year where organic seed is compulsory, provided that such seed is available. The Norwegian production of seeds is very limited, and even more so when it comes to organic seeds.

Table 1. Estimated percentage of Norwegian produced organic seed to the total need for organic seed in Norway (2004).

<table>
<thead>
<tr>
<th>Culture/ species</th>
<th>Contribution percentage</th>
</tr>
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<tbody>
<tr>
<td>Barley</td>
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<tr>
<td>Oats</td>
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<tr>
<td>Wheat</td>
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<tr>
<td>Rye</td>
<td>0</td>
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<tr>
<td>Red clover</td>
<td>28</td>
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<tr>
<td>Meadow fescue</td>
<td>26</td>
</tr>
<tr>
<td>Timothy</td>
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</tbody>
</table>

Organic farming is affected by genetic engineering

Products of genetically modified plants are being traded globally and many derivates of genetically modified micro-organisms are used in the food and feed industry. Possible entries for GMOs in organic agriculture are therefore many (FiBL, 2003):

- Contamination of seeds.
- Entry of GMO pollen, seeds, plant parts and plants.
- Residues in shared machines.
- Permitted conventional production aids with critical ingredients.
- Permitted conventional feed or contaminated feed.
- Permitted GMO pharmaceuticals.
- Intermixing or contamination at collection points, during global transport, at transfer points or during processing.
- Conventional ingredients, additives and processing aids contaminated with GMOs.

Defining and self-defining

Every farmer in Norway has to fulfil several standards to be entitled to agricultural grants from the government. In addition, organic agriculture has to meet official requirements based on the Debio-regulations, in order to be approved as organic producers and achieve premium prices and grants specific for organic agriculture.

Organic agriculture is described through goals, regulations and international standards. The production is based on certain principals, such as recycling, the pre-cautionary principle, the importance of contact between agriculture and the rest of the society, animal welfare and a fair distribution of our common resources.

Conventional farmers do not to the same extent need to define their role as nature managers and food producers, and the values that these activities are based on. This might turn into a problem as many conventional farmers seek for arguments against GMC. With what credibility can conventional farmers argue against this, when they already have approved the principals behind the development of GMO, like the acceptance of unforeseen ecological risks in favour of increased production and improved profits? Conventional farmers have already approved this through the use of pesticides.

It is too optimistic to predict positive consequences for organic agriculture through the introduction of GMO in agriculture. Still, the result may be that more conventional farmers turn to organic agriculture in order to find help in re-defining themselves as farmers; as food producers and nature managers.
With regards to the Norwegian consumers having problems in distinguishing organic products from other products, the introduction of GM-farming might enhance the consumers’ capability and willingness to choose organic products.

The weed problem
Due to our humid and cold climate, weeds are a well-known problem in Norwegian organic farming. It is one of the main challenges and a major reason for organic vegetable production being at such a modest level.

Biodiversity is considered an important production factor in organic agriculture. The more bio-diverse organic farms, with high weed diversity, might have a potential as reservoirs for transgenes inter-crossed from GMC nearby. As shown by Jørgensen (2003), oilseed rape is a culture with such a potential, with 45% introgression between oilseed rape and wild turnip (Brassica rapa L).

There is a need to examine each culture and evaluate the risk of organic fields serving as sinks of transgenes from neighbouring GMC. In addition to environmental and biological consequences, issues related to legislation and economic costs have to be examined.

Additional costs
EC Regulation 178/2002 requires full traceability for the whole food and feed production chain. This applies for conventional, organic and GM-farming. The EC Regulation 2092/91 on organic farming sets standards to avoid mixing with crops from other agricultural systems.

GM-farmers and processors have to ensure that no contamination takes place. This means establishing a separate system for GMO production, as organic farmers and processors have done in the past. Furthermore, an inspection system has to be implemented. This might lead to reduced costs for organic farmers and processors (Müller 2003).

The “polluter pays” principle must apply when dealing with co-existence of GM and non-GM farming. This should include compensation for any contamination and reduced agricultural area due to isolation distances.

Dependence, vulnerability and plant varieties
In many ways, farming in Norway is a high risk activity where performance ability is put to the test. We are highly dependent on plant varieties that are able to utilize the harsh conditions and perform well in marginal areas. Qualities such as good nutrient uptake at low temperatures and winter hardiness are important. In several productions Norway depends on breeding and seeds from other European countries. Our own breeding activities are difficult to finance due to the present low market potential for our varieties. This is situation is particularly unfortunate for organic farming.

The white clover and red clover are good examples to illustrate our vulnerability. These plants play a vital role in organic agriculture, due to their symbiotic relationship with Rhizobium bacteria that has the ability to fixate nitrogen from the air. In areas with warmer climates, the efficiency of biological nitrogen fixation is higher and a number of plants and culture mixes may be used to provide this vital nutrient.

In our climate the choices are more limited. Thus, the chance of success as an organic farmer depends very much on your success as a clover cultivator and meadow manager.

The Norwegian organic clover seed production in 2003 consisted of the red clover varieties ‘Nordi’ and ‘Betty’ and the white clover variety ‘Norstar’. These varieties are winter hardy and have efficient nutrient uptakes that make them relevant for organic agriculture. Still the Norwegian seed production is not large enough to provide for all organic farms, so in 2004 we have to supplement with imported seed and varieties. Unfortunately, the trend is that traits that are appreciated by Norwegian organic farmers have decreased international interest and market potential.

The freedom of choice
Providing a high degree of consumer choice seems to be the most important argument for impelling GMOs in the EU (The Commissions of the European Communities, 2003). This is a questionable argumentation as the consumers’ desire for GM-products is hard to determine.

The really important choice at stake is that of the farmer; whether he or she wants to be an organic, conventional or GM-farmer. The introduction of genetically modified organisms in agriculture strongly influences and reduces this choice. It may lead to organic agriculture being preserved in limited areas thereby reducing any further expansion, or even making it impossible.

Less credibility for all agricultural production
Organic products are generally sold at a higher price than conventional products. Many consumers find it reasonable to pay a higher price for organic products, even when they are up to 20% more expensive than comparable conventional products.

The Swedish company Arla used organic dairy products as an instrument to improve their credibility in the marked. By focusing on the quality of organic milk and thereby justifying the higher price, Arla
increased the consumer’s willingness to pay a fair price also for Arla’s conventionally produced milk.

This is a positive and future-oriented strategy that unfortunately is hard to find in Norwegian companies and also internationally. It is rather a dominating trend that food production has a low status and that food should be very cheap. The entry of GMOs in agriculture seems to speed up this development. Whereas organic agriculture contributes to increased status and credibility to all agricultural activities, GM-farming stimulates the opposite development.

Health and environmental risks
According to many scientists, the consumers’ lack of confidence in GM-products is not in proportion to the actual risk for human health and the environment. However, it is important to take this scepticism seriously and not disregard the fear many people have for the potential harmful effects of GMOs. There might be a very low probability that a single GMO will have a harmful effect on human health or environment, but the consequences could be disastrous if it turns out to be true. That is why the risk of using GMOs in agriculture should be taken seriously. The historical evaluation of environmental and health hazards connected with the use of pesticides might serve as an interesting parallel to the development and promoting of GM-crops.

Development and resources
An important question for the organic movement is: Can we afford to downgrade other challenges directly connected to the development of organic agriculture in order to focus on challenges brought on by the GMO issue?

We face tremendous challenges in order to develop a more sustainable agriculture. The demand for food will be hard to meet in the future. The answers of the biotech industry to this problem are higher yielding varieties and less expensive growing methods through the use of GMOs. But the underlying problem is not our low-yielding varieties and growing methods. The focus on higher production only offers a simple and seductive answer to a very complex and profound question.

Loss of focus
So, instead of using resources to develop a breeding program for organic agriculture, the focus is on how to prevent GMO contamination of organic seeds. Instead of working on how the Debio-regulations and grants can be used to increase the number of organic growers, regulations for co-existence have to be made and resources used to implement the regulations and monitor farming practise. Instead of highlighting our excess consumption and the unfair distribution of global resources, we are tempted by the golden prospects of GMC.

Conclusions
GMOs in agriculture...
• …represent unforeseen risks to health and environment that are not consistent with organic agriculture.
• …undermine the credibility and sustainability for agriculture in general and especially conventional agriculture.
• …will require great resources to avoid contamination of surrounding agriculture and to provide full traceability from field to fork.

And finally: A ban on cultivation of GMOs in Norway is the above all the best means to safeguard the interests of both consumers and agriculture.

References

Contacts and resources at the Internet
Agropub: www.agropub.no
Norsk senter for økologisk landbruk (The Norwegian centre for ecological farming): www.norsok.no
Planteforsk: www.planteforsk.no
Oikos – økologisk landelag: www.oikos.no
GenØk – Norwegian Institute of Gene Ecology: www.genok.org
Co-existence today between organic and conventional agriculture

- Mix is accepted to some extent
- Parallel production
  - Regulations
  - Conventional seeds and manure
  - Restrictions

How organic farming is affected by genetic engineering

Dependence, vulnerability and plants

- Climate
- Variety traits
  - Nutrient uptake
  - Winter hardiness
  - Marked potential
  - Import
  - Relevant varieties for marginal areas

Freedom of choice

- EU argument for GMOs in agriculture: Providing a high degree of consumer choice
  - The choice really at stake is the farmer's, whether she wants to be an organic, conventional or GMO farmer

Degradation

- Organic farming contributes to increased status and credibility to agriculture
- GMO farming stimulates the opposite development

Focus and resources

Instead of focusing on the development of organic agriculture, we have to focus on:

- Practical means to prevent contamination and entry of GMOs in organic farming
- Rules, regulations and control
- Mapping future problems caused by GMOs

Conclusions

GMOs in agriculture...

- ... represent unforeseen risks to health and environment that are not consistent with organic agriculture.
- ... undermine the credibility and sustainability for agriculture in general and especially conventional agriculture.
- ... will require great recourses to avoid contamination of surrounding agriculture and to provide full traceability from field to fork.

Conclusions

A ban on GMOs for cultivation in Norway is the above all best means to safeguard the interests of both consumers and agriculture.
Co-existence – Strategic thinking within a feed company

Hans Abrahamsen
Managing Director, Skretting Norway

I will try to give you a flavor of how we evaluate and discuss GMO issues in a multinational company like Nutreco. Nutreco is the largest privately owned agriculture company in Europe and is based in Holland. I am Managing Director in Skretting, a Norwegian company that is owned by Nutreco, and purchasing the raw materials for Nutreco and Skretting. We are producing around 200,000 tons of salmon a year and 1 million tons of feed, mainly for fish farming.

For sure, aquaculture will be increasingly important. It is clear that traditional fisheries are about to reach its limits, so we can not expect a further growth in fish consumption based on wild fisheries. The only way to substantially increase fish consumption - which is considered quite healthy due to for instance omega-3 fatty acids - is to develop the aquaculture industry.

In fish farming, the feed constitutes around 50% of the total production costs. So far, we have mainly been using fish meal and fish oil in feed for fish farming, but due to limited resources and the vulnerable sustainability of the fisheries, we have to use more plant proteins and plant oils in the future. Although we have demonstrated that we can substitute up to 50-60% of the fish oil in the feed, for instance with rape seed oil, a shortage of fish oil in the feed industry is predicted by the year 2015. As I see it, we have two possibilities. Either we can harvest krill in the Antarctic, or we can ask the rape seed producers to develop a variety including the right fatty acid composition for the fish diets.

Issues regarding GMOs are already important for our industry. If the consumers accept raw materials based on GM plants with omega-3 fatty acids, the producers will be able to deliver varieties that are very suitable for our fish feed purposes. At the same time, we have to listen to the consumers. It was mentioned earlier today that the majority has a negative perception of GM material in food and feed. At the same time, surveys show that most people are not willing to pay the premium for GMO-free material.

It is important to bear in mind that some of the problems that we are facing in the world's food supply
today, and also in our industry, in part can be solved by GM technology. For instance, levels of pesticides in the raw materials that we use for feed products can be reduced. We are facing a lot of dilemmas and it is very important to have a holistic and realistic view in the GMO debate.

The feed industry has limited amounts of documented non-GMO raw materials available. Over the years we have seen a tremendous increase in the GMO production. In the beginning, the countries with GM production were USA, Canada and Argentina, but now also Brazil will start to grow GM varieties. In addition, China is going full speed into the GM era. So, basically, I see the world wide production going towards GM production. In our Norwegian company Skretting we are using material that is 100 % GMO-free. In other European countries several companies in the agri-business are using up to 40-50 % of GM material.

On the 18th of April this year, EU got new legislation on GM products. In the EU one has to label material containing more than 0.9 % GM. Today, it is very difficult to get hold of documented raw materials containing less than 0.9 % GMO. In Norway, we have our own GM legislation that in some cases is less strict than in EU at the moment. But the signals from the Norwegian authorities is that we will have a similar legislation in the near future.

In our company, we will not take a definite stand on GM or non-GM for the whole chain from soil or sea to the plate. In the end it is all up to people like us, in this room, and the consumers to decide what we want.
Open meeting 29. April 2004

Aquaculture "wave of the future"

- According to the FAO, harvesting of wild fish has met its natural constraints as 70% of the world’s oceans are overexploited.

- The FAO also estimates that the cost of catching fish in the wild, on a global basis, is about 25% higher than the value of the catch.

Fish oil

- Limited non-GMO raw materials available
- Demand from consumers (EU) of non-GMO
- New EU legislation on GMO
- Confusion around implementation of new legislation
- Norwegian Salmon vs Scottish Salmon

Legislation

<table>
<thead>
<tr>
<th>Norway:</th>
<th>EU:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed must be labelled if adventitious presence of GMO in raw material is &gt; 2%</td>
<td>Before April 18, 2004 – no legislation on labelling feed (only food)</td>
</tr>
</tbody>
</table>

New EU legislation

- Same labelling requirements for feed and food.
- Not dependent on identification of modified DNA (traceability important).
- Labelling if adventitious presence of GMO > 0.9% (authorised GM material)
- Macro- and micronutrients.

Uncertainty about

- Analyse methods.
- Micronutrients.

We can not take a stand on GMO/non-GMO for the whole value chain. End consumer (supermarkets) is the key.
Growing GMO-free soya in Mosambique – a Norwegian pilot project

Kai Roger Hennum
Felleskjøpet (importer of ingredients for food and feed)

In the following, I would like to describe a project that Felleskjøpet started on how to get GMO free raw materials for our animal feed production.

Norway has a considerable import of food. Almost nothing originates from the least developed countries, most of it comes from the EU. Currently, Felleskjøpet imports 250 000 tons of protein and up to 300 000 tons of carbohydrates, depending on the annual production of grain in Norway.

As mentioned earlier in this meeting by several representatives from both the Farmers Union and the salmon industry, the current decision in Norway is that GMO products should be avoided. Today, Felleskjøpet is importing all of its soya from Brazil, but there is a growing problem to assure that the soya material is GMO free.

The Norwegian Government has provided a duty preference for the least developed countries of the world. Starting July 2002, grain meal and feed imported from the least developed countries were duty free. This legislation makes it interesting for Felleskjøpet to organize activities in those countries. We chose to make a start in Mozambique for the import of GMO free soya for our feed production.

From the pilot project in Mozambique our ambition is to import 50 000 tons of GMO free soya annually. For Mozambique, and countries alike, there is a potential to serve the markets for GMO free material because at present many of them do not have GMOs in their production systems.

However, there are many problems that need to be overcome, for instance the presence of salmonella or aflatoxins in the products. Also, there is a severe problem with logistics, regularity and lack of guarantees.

The board of Felleskjøpet has decided on ethical guidelines for all trade with developing countries. These guidelines are as follows (citation), and are some of the requirements the study had to consider when discussing import of raw materials for the animal feed industry:

For animal feed production, Felleskjøpet shall not buy raw materials that are suited for human food from countries or regions that are struck by hunger. When trading with developing countries Felleskjøpet shall contribute to a positive economical development in the countries and not directly or indirectly contribute to weakening these countries food-supply-security.

Felleskjøpet shall prefer:

- Suppliers that contribute to development and just distribution of welfare in the land of origin
- Suppliers that attend to the environment during production, transport and processing of the raw materials
- Raw materials that are produced, transported and processed in a way that comply with the basic human rights
- Raw materials that are produced in countries and by suppliers that not will give negative response or boycott from consumers of Norway
- Raw materials that not are produced with technology that are ethically disputable

The agricultural cooperations of Norway also have decided a no-tolerance policy of GMO.

Initially, Felleskjøpet investigated the possibilities for import of raw materials from four developing countries. After having decided to start a pilot in Mozambique, soya production for Felleskjøpet was initiated in November 2003. The pilot project was supported by NORAD and it has been involving more then 5000 farmers. On average, their farm size is 20 hectares (da) and each farmer grows around 5 hectares (da) of soya for us. A written contract guarantees a good price for their harvest and should provide many opportunities for the farmers in the years to come.

The pilot project is now about to be finished. The farmers in Mozambique are harvesting within the next month, and we hope to receive our first shipment
of soya to Norway later this summer. In this initial phase, the plan is to import 300 tons of soya, which is enough for us to test for the production of animal feed at Felleskjøpet. The rest of the harvest will be kept locally and serve as seeds for the next season.

Although we have had a few problems with this pilot project, we think we can solve them within the next year. An identity preservation program will be introduced (better labeling and traceability) and hopefully we will be able to scale up the production by involving around 20 000 farmers and import 10 000 tons of soya next year from Mozambique.

It is very hard to compete with the large-scale farmers of Brazil. Still, the small-scale soya producers in Mozambique have a sincere wish to explore this new opportunity of exporting contract grown soya and to provide GMO free materials for the world market. What we are doing at Felleskjøpet is to help them to get started.

Growing GMO-free Soya in Mozambique - a Norwegian pilot project

Kai Roger Hennum

The business idea

- Make use of the duty preference on import of raw materials to FK feed production
- Ensure a resource of GMO-free raw-materials
- Import today
  - Up to 250.000 tons of protein
  - Up to 300.000 tons of carbohydrate
- LDC-ambition
  - 50.000 tons of Soya from Mozambique

Least developed countries duty preference

- From July 2002
  - Full duty freedom for grain, meal and feed
  - No quota
  - Safety-mechanism (severe market disturbance)
- 50% of Norwegian calorie-consumption is import - almost non from LDC
- 63% from EU

LDC-import some challenges

- Hygiene
  - GMO
  - Salmonella etc
- Logistics
  - Price/regularity/safety (GMO-guarantee)
- Ethical
  - Food/feed

LDC-project

Soya in Mozambique

- Evaluation of LDC started in Nov. 2001
- Mozambique was chosen June 2003
- Pilot-production was started Nov. 2003
  - NORAD-support to an NGO
  - 5150 farmers, 0,5 ha each
  - Contract with FK, fixed price and guaranteed market access

GMO-situation

- No legislation has been approved in Moz.
  - GMO is prohibited until a law is decided
- Same situation in most neighbouring countries
  - South Africa has accepted GMO
- Supervision-system in Mozambique?
The LDC-project

- **PILOT is about to be finished**
  - Prices are good, but the yields are low
  - 200 tons export to Norway, the rest to be kept locally as seeds

- **Phase II plans 2004/2005**
  - 20,000 farmers, 0.5 ha each
  - IP program (Identity Preservation program)
  - Target for export = 5-10,000 tons of Soys
  - Economy is the major challenge
    - Specially logistics inland and sea freight

Ambitions and conditions

- Be able to pay a fair price to the farmers and make a profit for partners in Mozambique and for Felloskjøpet
- The premises are lasting duty preference systems for LDC
Following the incident with GMO contamination in canola grain samples: How do we monitor and control our imported seed material?

Magne Gull lord  
Graminor (seed supplier in Norway)

Graminor is the only plant breeding company in Norway. We are breeding wheat, barley, oats, forage grasses and legumes, potatoes, fruit and berries. Graminor is not involved in developing GM varieties in any crops. However, through the years the company has supported research related to gene technology. Graminor is also representing foreign plant breeders in the beforementioned crops in addition to winter rye, triticale, turnip oil rape, oil rape and peas. Breeding material may in a few cases originate from Canada, the rest of the breeding material originates from Northern Europe.

In 2000 we imported 200 grams of seeds of the rape variety Hyola 38 from MiIdoa Oy in Finland for official testing in Norway. The seed samples were sown in two 10 m² plots at 13 locations in the southern part of Norway. Later, from our cooperator in Sweden, we were informed that seed from the same seed lot contained 0.4% genetically modified rape of the type Roundup Ready (GT 73). We were also informed that the seed originated from Canada. At that time we had no procedure for how to handle imported seed with respect to GMO contamination.

Unfortunately, instead of informing the Ministry of Environment, we contacted a newspaper about our problem. The Ministry of Environment immediately took action after reading the notice in the newspaper. All the plants of the 26 plots had to be destroyed before flowering and the remaining seed material had to be discarded. All rape plants, the GMOs included, were successfully destroyed and we had learned a lesson.

For the import of seed samples for yield and quality testing, Graminor has now developed a procedure on how to prevent seed lots that are contaminated with GMOs. To start with, we try to avoid seed material that originates from the US and Canada. For all crops we require documentation that the breeding lines for yield and quality testing are not genetically modified. For turnip oil rape and oil rape we additionally require that seed material is tested for GMO and that no GMO seed is found.


In 2000 we imported 200 grams of seeds of the rape variety Hyola 38 from MiIdoa Oy in Finland for official testing in Norway. The seed samples were sown in two 10 m² plots at 13 locations in the southern part of Norway. Later, from our cooperator in Sweden, we were informed that seed from the same seed lot contained 0.4% genetically modified rape of the type Roundup Ready (GT 73). We were also informed that the seed originated from Canada. At that time we had no procedure for how to handle imported seed with respect to GMO contamination.

Unfortunately, instead of informing the Ministry of Environment, we contacted a newspaper about our problem. The Ministry of Environment immediately took action after reading the notice in
Objectives

- Graninor shall supply the Norwegian agriculture and horticulture with high yielding, well adapted and healthy varieties of cereals, peas, oil seed crops, forage crops, potatoes, fruits and berries through plant breeding and representation of foreign plant breeders.
- Graninor shall supply the seed companies with pre basic and basic seed of our own varieties and varieties we are representing.

Plant breeding and representation of foreign plant breeders

- Cereals: Winter wheat, spring wheat, barley, oats, winter rye, triticale, peas, turnip oil seed rape and oil seed rape.
- Forage crops: Timothy, meadow fescue, red clover, white clover, festulolium, other grasses and legumes.
- Potatoes.
- Fruits: Apples, pear and plum.
- Berries: Strawberry, raspberry and cloudberry.

Experiences with GMO contaminated oil seed rape

- In 2000 Graninor imported 200 grams of the oil seed rape variety Hydra SV from Finland for official testing in Norway.
- The seed was sown in two 10 m² plots in a location in the southern part of Norway.
- In early summer we were informed that the seed, originating from Canada, contained 0.4% genetically modified oil seed rape of the type Roundup resistance (RT 73).
- The Ministry of Environment was informed and necessary action was immediately taken.
- All the plants of the 25 plots had to be destroyed before flowering and the remaining seed had to be discarded.
- All the oil rape plants, GM-plants included, were successfully destroyed and Graninor had learned an important lesson.

Procedures to control imported seed - Breeding material

- Graninor require documentation from the foreign plant breeders:
  - That varieties/lines are conventionally bred from parent components, which have not been genetically modified.
  - That the methods used in the breeding, development and production of these varieties/lines include procedures aimed at avoiding the adventitious presence of GMOs.
- For imported seed of maize, turnip oil seed rape and oil seed rape varieties, Graninor require that the seed has been sampled and tested for the adventitious presence of GMOs which are used in the breeding of these crops. None of these GMOs can be found in these tests.
- The Norwegian Food Safety Authority (NFSA) require a list of all lines and varieties imported of maize, turnip oil seed rape and oil seed rape.

Procedures to control imported seed - Pre basic and basic seed of registered varieties

- Graninor require a certificate showing that the seed of maize, turnip oil seed rape and oil seed rape varieties has been produced in accordance to international seed legislation including stipulated isolation distances.
- For imported seed of maize, turnip oil seed rape and oil seed rape varieties, Graninor require that the seed has been sampled and tested for the adventitious presence of GMOs which are used in the breeding of these crops. None of these GMOs can be found in these tests.
- A list of all varieties imported of maize, turnip oil seed rape and all seed rape are required sent to NFSA. NFSA will sample and test the seed for the GMOs which are used in the breeding of these crops.

Procedures to control imported seed

- Graninor avoids to yield test varieties or lines of turnip oil seed rape and oil seed rape bred in countries with an excessive GMO breeding activity in these crops.
- Graninor will not import pre basic or basic seed of varieties increased in Canada or USA of oil seed crops or maize.

Future developments

- Increased international breeding activities on GM potatoes, cereals and forage grasses and legumes and other relevant crops are expected.
- Graninor will, however, follow closely these activities and when necessary, develop appropriate procedures to prevent import of seed of GM varieties or seed contaminated with GMO.
Discussion III
[Extract]

NN
There is an interesting point about labeling regarding aquaculture and farmed salmon: Almost all salmon in the stores are farmed, how many consumers know that? It is not labeled.

Hans Abrahamsen
We do not try to hide that the salmon we sell is farmed. But you are right, everybody does not know everything about our products, the GMOs, pesticides etc. How we picture the future is getting more complicated. For instance, producing feed today is very different from what we did ten years ago. However, I myself am willing to eat the feed we make. The Dioxin scandal in Belgium, for instance, triggered a lot of activity in our company. Although our company was far from the source, we established tracing systems so that everybody could get information about the source of the raw materials we were using.

Hilde Helgesen
Isn’t it a paradox for you as a producer that on one hand you say that you are make an effort to avoid GM-material in your production chain, but then in the end you do not have to provide information on what the salmon was fed? So, in principle there is no incentive for you not to use any GM feed since you don’t have to label?

Hans Abrahamsen
I think that it is the supermarkets today that decide what kind of fish they should sell and whether the fish should be fed GM-free feed or not. We have full traceability in our company. If the supermarkets ask us to use GMO-free feed, we will do that. In Norway we now use GMO-free feed or feed that is below the 2% threshold for labeling. So this is not a paradox for us, and we provide our customers what they want and we will be able to do that in the future also.

Åsmund Bjørnstad
You, Liv Birkeland, have been quite simplistic when dealing with GM plants. Why does organic farming want to use biodiversity when it comes to variety and species mixtures, nitrogen fixation and crop rotation? You want to use biological information and biodiversity as much as you can, but you stop at the chromosome level! Why do you do that? There is no logic; you should embrace GM plants because they are in line with the way you think.

Liv Birkeland
It is not according to the principle of organic farming to use genetic information (genes) and put it everywhere. The principle is to use the biological information in its own context. That is why I think your argument is not valid.

Åsmund Bjørnstad
I agree that it is an important issue to think about the context, but it is better to discuss the crop and the gene, and not the technique as such. Rather, you should concentrate your arguments around issues on who owns the genes, who controls the business, and so on.

Anders Næs
As an economist I would like to ask whether we are willing to pay the price of co-existence in Norway. It can be very expensive and we are not able to predict the externalities. First of all, for Norway it is a question of co-existence of organic and GM farming. Because Norway is a small scale agronomic producer what we know today as conventional farming would become GM-farming. I would like to focus differently and ask: Are we willing to pay the price of co-existence? What about the economic benefits of defining Norway as a GMO-free zone instead?
Closing remarks

Aina Bartmann
Member of the Norwegian Biotechnology Advisory Board and Project Manager for “Bondens marked”

On behalf of the organisers, I would like to thank the speakers for very valuable contributions to this seminar. You have all shared your experience and your knowledge with us, and hopefully we are better prepared now for discussing the challenges that lie ahead of us.

In agriculture, Norway is currently a GMO free zone and we have barriers both by political means through our regulation, but also as a result of our geography, being located in a corner in the northern part of Europe.

Still, as we have heard here today, we have to handle the challenges presented to us by co-existence because we import large amounts of foods, seeds and feed. Co-existence is not only an issue of biological importance and about commercial interests and economic compensations. It raises questions about our long term freedom to choose what to consume and how to produce.

When it comes to the risks and benefits of GMOs, the opinions are diverse, but I hope we all agree that it is important to avoid that the introduction of new regulatory frameworks for co-existence is used solely as a political instrument to introduce GM crops further, especially in the developing countries.

There is no doubt that the regulation and handling of co-existence will be expensive and bureaucratic and will require substantial resources in both risk assessment and monitoring. From my point of view, it should be every nation’s free choice whether to replace a GMO moratorium with regulations on co-existence or to maintain a ban on GMOs.

The time has come to close this meeting. As we have said before, this seminar serves as a starting point of the public debate on the topic of co-existence in Norway. We as organizers, together with several of the organizations present here today, must commit ourselves to continue this very important debate.

Once again I want to thank the speakers, and I want to thank Casper Linnestad in the secretariat of the Norwegian Biotechnology Advisory Board, who has done most of the preparations. Thank you all for participating at this meeting and for being so active.
Co-existence (sameksistens)
Thursday 29. April 2004, 10.00 - 16.15
Felix Conference Centre, Aker Brygge, Bryggetorget 3, Oslo

09.30 - 10.00  Registration
10.00 - 10.10  Welcome
   Werner Christie, chair of the Norwegian Biotechnology Advisory Board
10.10 - 10.50  Gene flow between canola varieties and to other wild species
   Suzanne Warwick, Agriculture Canada, Ottawa
10.50 - 11.20  Potential for gene flow in important crop plants for Norwegian agriculture
   Odd Arne Rognli, Agricultural University of Norway
11.20 - 11.45  Discussion
11.45 - 12.30  Lunch
12.30 - 13.15  The Danish approach to co-existence: Report from the Working Group on the co-existence of genetically modified crops with conventional and organic crops
   Søren A. Mikkelsen, Danish Institute of Agricultural Sciences
13.15 - 14.00  GMO-free zones, why and how
   Werner Müller, Global 2000
14.00 - 14.45  Coffee, fruit, discussion
14.45 - 15.00  Co-existence - also with GMOs?
   Liv Birkeland, NORSØK (Organic farming center)
15.00 - 15.15  Co-existence - Strategic thinking within a feed company
   Hans Abrahamsen, Skretting (fish feed producer)
15.15 - 15.30  Growing GMO-free soya in Mosambique - a Norwegian pilot project
   Kai Roger Hennum, Felleskjøpet (importer of ingredients for food and feed)
15.30 - 15.45  Following the incident with GMO contamination in canola grain samples: How do we monitor and control our imported seed material?
   Magne Gullord, Graminor (seed supplier in Norway)
15.45 - 16.15  Discussion
16.15  Closing remarks
   Aina Bartmann, member of the Norwegian Biotechnology Advisory Board, formerly a farmer, now developing farmers markets in Norway.

Chair persons: Werner Christie and Aina Bartmann
List of participants

Abate, Berhanu; NLH, Department of Plant and Environmental Sciences
Abrahamsen, Hans; Skretting
Amlie, Thor; Bioteknologimestna
Andersen, Elisabeth Kirkeng; Forskning.no
Andersen, Line; Forbrukerrådet
Anne Sissel Pundsnes
Asefa, Dereje Teklehaimanot
Assefa, Dereje; NLH, Department of Plant and Environmental Sciences
Bartmann, Aina; Bioteknologimestna
Berdal, Knut G.; Veterinærinstituttet
Birkeland, Liv; NORSØK
Bjørnstad, Bell Batia
Bjørnstad, Åsmund; NLH
Bleken, Marina Azzaroli; NLH, IPM
Borge, Ole Johan; Bioteknologinemnda
Brynildsen, Lisbeth I. B.; Landbruksdepartementet
Christie Werner; Bioteknologinemnda
Ditlefsen, Anne; Norges forskningsråd
Eidet, Heide
Eieland, Astrid; Avd. for matpolitikk, Landbruksdepartementet
Eikeberg, Beate B.; Miljøverndepartementet
Evenrud, Erik; Biologisk-dynamisk Forening
Evjen, Grethe; Landbruksdepartementet
Feet, Endre
Foss, Grethe; Bioteknologinemnda
Fosliebch, Wenche; Bioteknologinemnda
Gedebo, Andargachew; NLH, Department of Plant and Environmental Sciences
Geraud, Esteve
Gilst, Daniel van; Landbruksrådgiver Norad
Gran, Hanne Marit; Mattilsynet
Gran, Jorunn; eØ Natur & miljø
Grønsbol, Sigrun
Gullord, Magne; Graminor
Hagen, Aslaug; Mattilsynets hovedkontor
Hameillon , Olivier; student NLH
Haugsten, Egil
Heide, Bjarte
Helgesen, Hilde; Norsk Landbruksamvirke
Helland, Ellinor
Hennum, Kai Roger; Felleskjøpet
Hogstad, Solbjørn; Mattilsynets hovedkontor
Hokstad, Ove; Miljøverndepartementet
Holm, Aage; Oikos
Husby, Jan; Direktoratet for naturforvaltning
Hostmælingen, Erik
Hågvar, Eline; NLH
Isabelle, Tache
Ivars, Birthe; Miljøverndepartementet
Johnsen, Torgun; Mattilsynet
Jørgensen, Ragna Ribe
Kolbeinsen, Mia
Kristiansen, Leif-Arne
Kvåle, Sjur Erik; Landbruksdepartementet
Langeland, Åsmund
Lehuger, Simon; NLH
Liland, Kolbjørn; Forbrukerrådet
Linnestad, Casper; Bioteknologinemnda
Lorentzen, Michael
Magnus, Trine; Norsk senter for bygdeforskning, Mentzoni, Toril
Murray, Hani
Müller, Werner; Global 2000
Myrset, Espen Andreas
Nordal, Inger; Bioteknologinemnda
Næs, Anders
Næs, Brita
Odlo, Bente; Landbruksdepartementet
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Pundsnes, Anne Sissel
Reistad, Ragnhild
Ribe, Harald; Landbruksdepartementet
Rogne, Sissel; Bioteknologinemnda
Rognli, Odd-Arne; Agricultural University of Norway
Rålm, Per Christian; Oikos
Skattsnesmo, Trond
Smith, Marianne; Avd. for matpolitikk, Landbruksdepartementet
Solberg, Svein; Biologisk-dynamisk Forening
Spilde, Ingrid
Sunde, Linda; Bondebladet
Svanemyr, Steinar; Landbruksdepartementet
Swærd, Kristin; Styring i DEBIO
Søren A. Mikkelsen; Danish Institute of Agricultural Sciences
Ulltveit-Moe, Marte Rostvåg; Bioteknologinemnda
Varland, Elisabeth
Veie-Rosvoll, Brit; Direktoratet for naturforvaltning
Wallem, Tore; Bioteknologinemnda
Warwick, Suzanne; Agriculture Canada
Wilhelms, Bente; Landbruksdepartementet
Waags, Karen; Direktoratet for naturforvaltning
Østreng, Ole-Christian
Aamodt, Randi; Norges forskningsråd
Aasen, Solveig; NLH
Previous meetings organized by The Norwegian Biotechnology Advisory Board

2004
- Fosterdiagnostikk 29. januar 2004, Trondheim

2003
- Biobanker. 18. desember 2003, Oslo
- Fosterdiagnostikk og verdier. 31. oktober, Oslo
- Bioterrorisme og biologiske våpen. 10. juni, Oslo
- Regulering av DNA-vaksiner og genterapi på dyr. 24. april, Oslo
- Biopatenter og EU’s patentdirektiv. Åpent møte 10. februar, Oslo
- Benefit or harm? Power and politics behind GM food. Åpent møte 5. februar, Oslo
- Assessing the risk from transgenic plants – The next step forward. Åpent møte 3.-4. februar, Høvik

2002
- Gentester i arbeidslivet. Åpent møte 9. september, Oslo
- Debattmøte om bioteknologiloven, 4. juni, Oslo
- Risiko og GMO. Åpent møte 13. mars, Oslo

2001
- Lekfolkskonferanse om stamceller, 23.-26. november, Oslo
- DNA i rettssalen. Åpent møte 24. september, Oslo
- Forsikring og DNA-tester. Åpent møte 18. april, Oslo

2000
- Oppfølgingskonferansen om genmodifisert mat. Åpent møte 15.-16. november, Oslo
- Biopatenter. Åpent møte 29. september, Oslo
- Kloning og humane stamceller. Åpent møte 15. juni, Oslo
- Post HUGO-æraen. Åpent møte 14. juni, Oslo

1999
- Genteknologi i et Nord–Sør-perspektiv. Åpne møte 13. oktober, Oslo
- Har vi alle rett til å få barn? Åpen høring 7. april, Bergen

1998
- Xenotransplantasjon – transplantasjon fra dyr til mennesker – vil vi ha det? Åpent møte 30. september, Oslo
- Fra kjøkkenbenk til fabrikk. Genteknologi og industri. Åpent møte 18. mars, Oslo

1997
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