



Comparative sustainability assessment of the impact of GM plants in Swiss conventional, integrated and organic farming systems. A project funded by NRP 59.

Agronomic consequences of the use of GM crops. Part 2: apple orchards

Revised internal document

Version of: 10 February 2010

Workpackage 3

Description in project proposal (p. 23): «Workpackages 3-5 will assess the impact of the production system scenarios on (i) agronomy, (ii) biodiversity and agro-ecology and (iii) socio-economics at the farm and the regional level. Baseline and alternative scenarios will subsequently be submitted to a comparative technology impact assessment. The assessment will include changes in agronomic parameters, expected differences in yield, quality and input usage (e.g. land use, pesticide use etc.). The potential environmental benefits of GM plants will be assessed, with a special focus on pesticide use, crop yields, weed control, soil tillage and soil protection. The environmental risk assessment will take the impact on biodiversity and the soil ecosystem into account.

The central assessment tool in workpackages 3-5 will consist of semi-quantitative assessment matrices. The proposed comparative sustainability assessment matrix is a combination of the Swiss approach to assess sustainability of agriculture (BLW Agrarbericht 2005, ARE Nachhaltigkeitsbeurteilung) and the CSA-Matrix method proposed by ACRE (2006). The detailed criteria and parameters will be prepared during the project by the project leader and refined by the competence teams in workshop 3. The overall baseline for comparison is the state-of-the-art integrated production with good agricultural practice.»

Document history: This report was prepared by the competence team «farming systems».

The general agronomic consequences of the use of GM crops were outlined in workshop 3 on 1 – 2 October 2008. In workshop 4 on 30 April 2009, agronomic practices and consequences were discussed in detail for apple orchards. This document was discussed during workshop 4, and amended by E-Mail correspondence after the workshop. In workshop 7, the experts suggested several amendments and questioned the spraying schemes. A subsequent consultation of experts by E-Mail showed that some experts considered the spraying scheme rather intensive, others considered it rather extensive, and still other considered it adequate. It was therefore decided to keep the originally proposed spraying schemes.

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1 Introduction

This document is prepared as a project-internal tool. It assesses the agronomic consequences of the use of GM crops in selected Swiss agricultural systems (apple orchards). The agricultural systems and conditions are described in detail in the document «Model farms and scenarios», while the GM crops are described in detail in the document «List of GM plants and traits».

2 Baseline

The indicators to be used in the impact assessments have been described in a general way in the project-internal document «Criteria for sustainability assessment».

The agricultural systems and conditions, for which the impact of GM crops will be assessed, are described in detail in the project-internal document «Model farms and scenarios». They will not be repeated here. The following general assumptions are made for the model farm:

- The farm is assumed to be a family farm without employees.
- The farm is assumed to be a pure pome fruit growing farm, consisting mainly of the 10 ha of apples and pears.
- The 10 ha of fruit trees are arranged in four orchards.
- Unless explicitly specified otherwise, the values of the Excel-based programme «Arbokost Apfel» and «Arbokost Apfel Bio» will be used. The main features are described there under the headings «Systembeschreibung» and «Geometrische Daten».
- The orchard is assumed to be a high density orchard with fence around.
- The tree form is spindle.
- The turning area is assumed to be 10% of the orchards' surface.
- Ecological compensation area: For the integrated orchard, 3.5 % of ecological compensation area are assumed. However, this is often outside the orchard and is therefore not included in the model. For the organic orchard, 7 % of ecological compensation area are assumed. This is inside the orchard and therefore included in the model.
- The number of rows per hectare is 23 for the integrated orchard and 21 for the organic orchard.
- The tree distance is 1.1 m.
- Total orchard lifetime: 15 years (3 years of build-up; 12 years of full yield).
- Production of table apples; delivery to: retailers and co-operatives.
- The varietal composition of the orchards to be assessed is illustrated in figure 1 (integrated farming system) and figure 2 (organic farming system).
- For new varieties, it is assumed that they will be immediately planted on 100% of their final surface (100% replacement of previous varieties).

Figure 1: GM scenarios for integrated 10 ha orchard. Colours: yellow=equilibrated to sweet apple; red=spicy to tart apple; green=predominantly tart apple; white=pear. **TOL** = scab tolerant; **RES** = scab resistant; **SUS** = susceptible to scab. **Sc** = Scab resistant GM cultivars (scenario 1); **Sc-Fb** = scab and fire blight resistant GM cultivars (scenario 2). Elliot is a pear cultivar which is fairly robust against fire blight, but not yet well-known on the market.

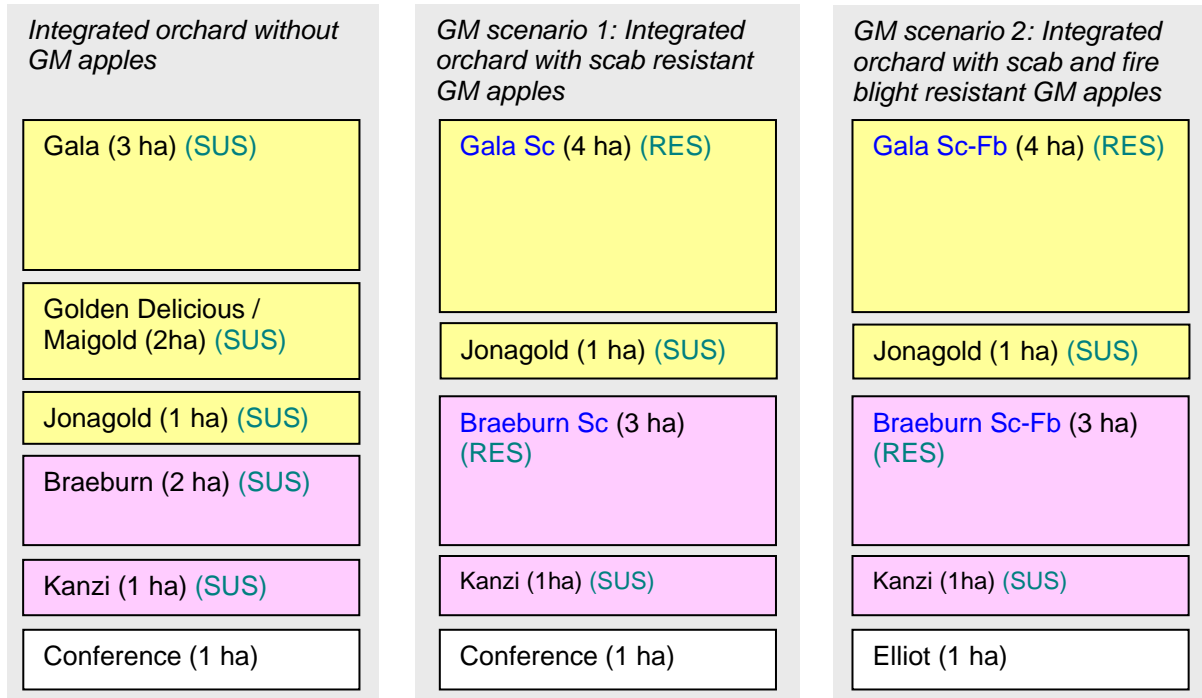
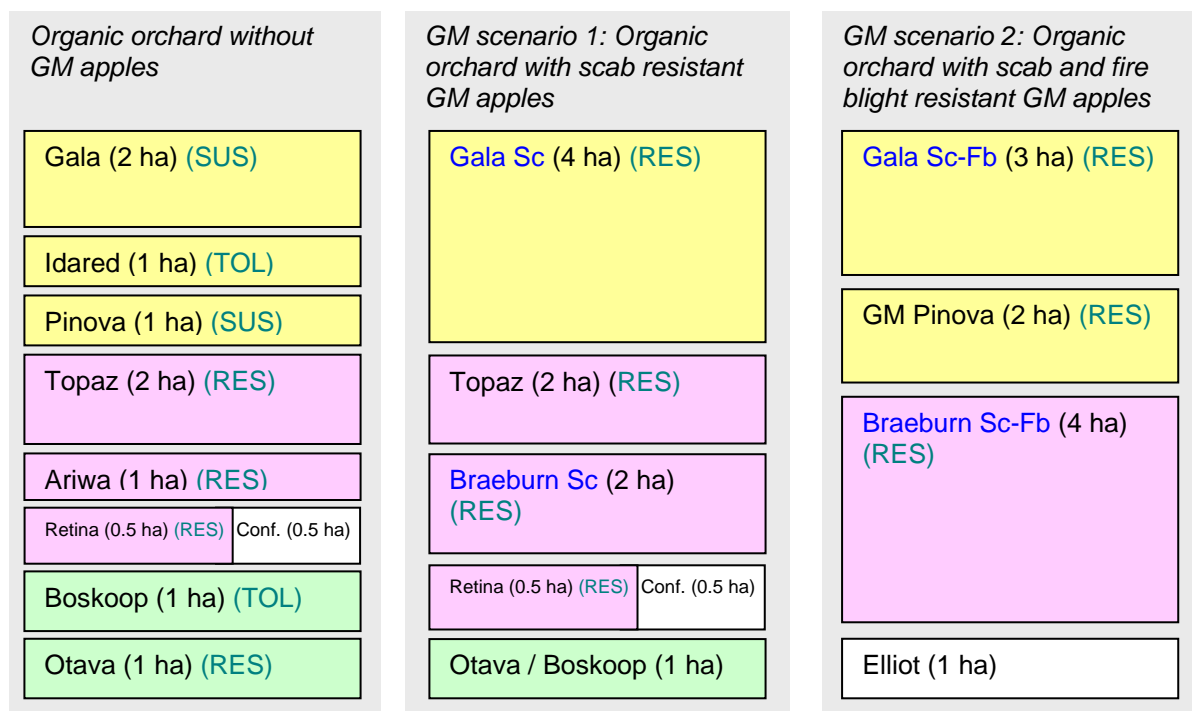


Figure 2: GM scenarios for organic 10 ha orchard. **TOL** = scab tolerant; **RES** = scab resistant; **SUS** = susceptible to scab. **Sc** = Scab resistant GM cultivars (scenario 1); **Sc-Fb** = scab and fire blight resistant GM cultivars (scenario 2).



3 Agronomic considerations regarding apple diseases

3.1 Complex of fungal diseases

Although scab is the most important fungal disease of apples, there are a number of «secondary diseases» which are normally controlled by the fungicide treatments against scab. In the case of scab resistant apples, secondary diseases may lead to yield losses and/or fungicides need to be applied for their control. The most important secondary diseases are:

- Mildew (*Podosphaera leucotricha*)
- Sooty blotch (*Gloeodes pomigena*)
- Fly speck (*Schizotyrium pomi*)
- «Frog eyes» (*Alternaria*)
- *Gloeosporium* (storage disease)
- *Botrytis cinerea*
- *Botrytinia fuckeliana*

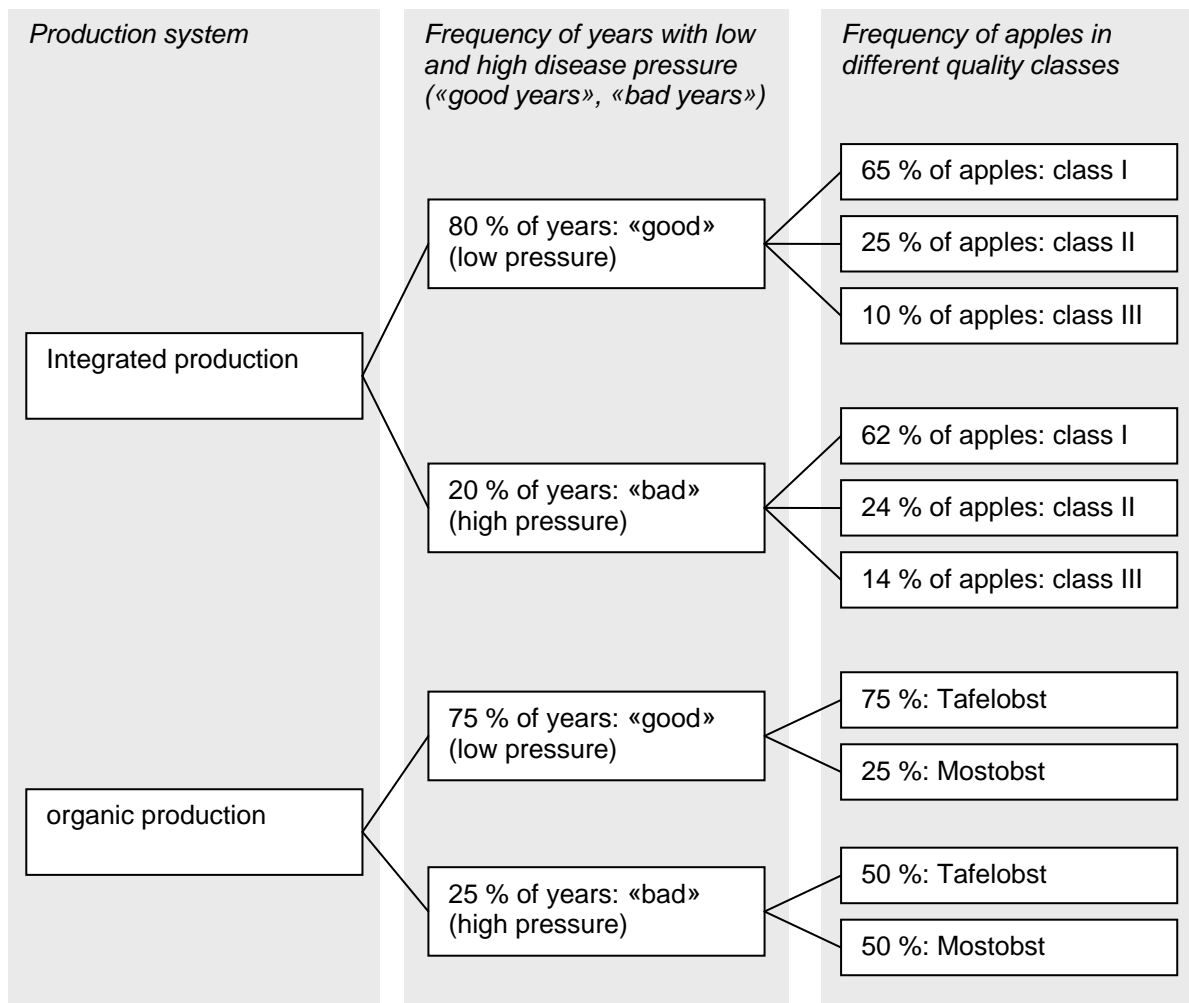
3.2 Incidence and impact of scab

Integrated farming: 80% of all years are estimated to be «good scab years» with a low disease pressure. In such years, ca 65% of all apples can be marketed as class I. 35% of all apples do not reach the quality of class I for various reasons, but usually not because of scab infection.

20% of all years are estimated to be «bad scab years» with a high disease pressure. In such years, ca 3% of the apples show scab infections and therefore have to be marketed in class II or III. This reduces the proportion of apples in class I from 65% to 62%. For details, see figure 3.

Organic farming: 75% of all years are estimated to be «good scab years» with a low disease pressure, and 25% of all years are estimated to be «bad scab years» with a high disease pressure. In a bad scab year, the consequences of scab are much more severe than in organic farming. Experience from recent years shows that organic apples can hardly be marketed as class II. However, the quality requirements for class I are less rigorous than in integrated apples.

Figure 3: Incidence of scab in years with different disease pressure, and its impact of marketable yield. The impact is shown for *scab susceptible* apples. For *scab resistant* apples, no scab infection is assumed in good and bad years.



3.3 Durability of scab resistance

Unless proven otherwise, all scab resistance currently used is based on Vf genes. Durability of scab resistance is inversely proportional to the surface of scab resistant varieties grown. The experts concluded that during the lifetime of the model orchard, scab resistance can be maintained, if the recommended sanitary measures are carefully carried out. As part of the resistance management, resistant and susceptible varieties should be grown in separate orchards. These statements are true for GM and non-GM scab resistant varieties.

3.4 Incidence and impact of fire blight

Incidence: Fire blight is a new disease in Switzerland, therefore its incidence and severity have to be estimated in this study. In recent years, temperatures at flowering have increased continuously. This trend will likely aggravate the risk of fire blight infections. As a rough estimate, 80% of all years are estimated to be «good fire blight years» with a low disease pressure, and 20% of all years are estimated to be «bad fire blight years» with a high disease pressure. For details see figure 4.

Avoidance: Infections can be avoided by netting of the orchards (to prevent access by honey bees; pollination by bumblebees living inside the net).

Direct control: in *integrated farming*, 3 treatments with streptomycin are currently authorized. Its effectivity is judged to be 60 – 80%. It is unclear whether streptomycin will still be authorized in ten years time, and if not, whether an equally effective substitute will be available. Application technology and prognosis can be improved. In *organic farming*, streptomycine is not allowed. Instead, microbial biocontrol agents like BlossomProtect can be used. Their effectivity is judged to be 30 – 70%. It is unclear whether more effective substitutes will be available in ten years time. Effectivity of all products is likely to rise because of improvements in application technology and prognosis.

Impact: fire blight has several kinds of impact:

- **Visual controls** of the entire orchard are needed to detect infections. Independently from disease pressure (i.e. in good and bad years), 4 visual controls are needed per season. Each control requires 1 h/ha.
- In the case of infections, robust varieties can often be saved by **sanitation pruning**. This causes high labour costs, and may also lead to reduced yields. For integrated farming, the labour for sanitation pruning is estimated at 100 h/ha in a bad year. In organic farming, fire blight infections are likely to be more severe than in integrated farming. As a consequence, the labour for sanitation pruning is much higher (150 – 400 h/ha). Besides the labour costs, this may cause labour bottlenecks on the farm.
- Sensitive varieties usually cannot be saved by sanitation pruning, and have to be **grubbed**. This causes material costs (new trees), labour costs (replanting) and yield losses.

In the scenarios, we assume that 80 % of robust varieties can be saved with sanitation pruning, while 20 % have to be grubbed. For sensitive varieties, we assume that 20 % could be saved with sanitation pruning, while 80 % have to be grubbed.

The sensitivity of different apple varieties is described in (Anonymous, 2008). For the varieties used in the scenarios (figure 1 & 2), the sensitivity is as follows:

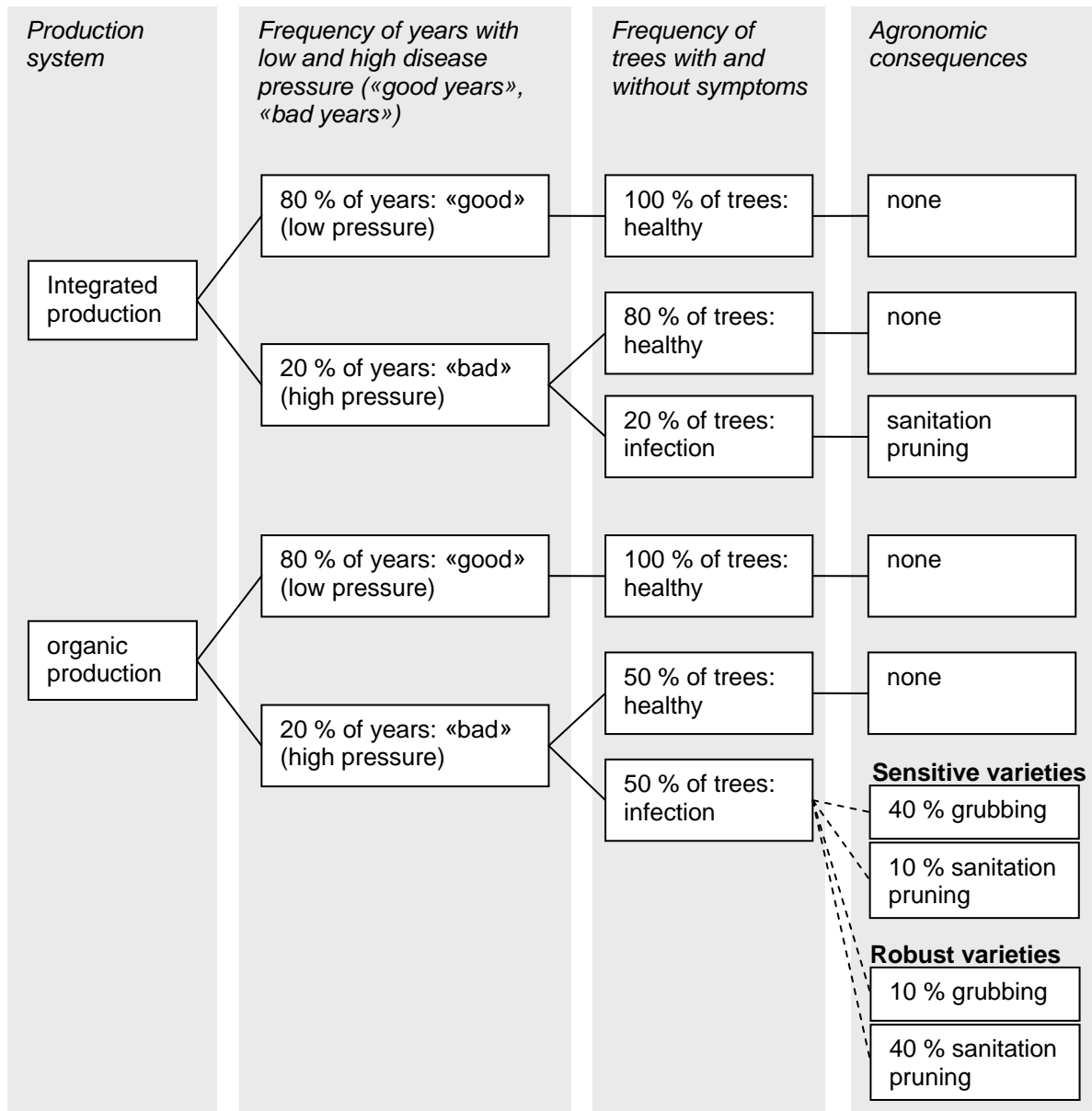
Robust: Ariwa; Boskoop; Pinova¹; Retina

Sensitive: Braeburn; Conférence; Gala; Idared; Jonagold; Otava; Topaz

Sensitivity unknown: Golden Delicious; Kanzi; Maigold

¹ Pinova is not described in Anonymous (2008), but its robustness was confirmed by P. Triloff in workshop 4.

Figure 4: Incidence of fire blight in years with different disease pressure, and its impact on apple trees. For sensitivity of varieties to fire blight, see Anonymous (2008).



3.5 Fire blight resistant rootstocks

Some non-GM fire blight resistant rootstocks have been developed, but are not yet commercialized on a large scale (e.g. Geneva 11). If fire blight resistant varieties are used, or if pesticides are sprayed against fire blight, there will be no inoculum, and therefore resistant rootstocks are not necessary. However, if there are other sources of inoculum near the orchard (e.g. standard trees [Hochstämme]), resistant rootstocks are necessary. The experts assume that resistant rootstocks are unlikely to be used in integrated orchards, but likely for organic orchards.

3.6 Level and durability of fire blight resistance

For this project, the level of resistance in the fire blight resistant GM varieties is estimated at 100 %. It is further estimated that resistance can be maintained for the lifetime of the orchard with the standard practices of resistance management and sanitation recommended today.

4 Plant protection measures in the different scenarios

Note: For the purpose of this project, it is assumed that the GM varieties vary only in their resistance to scab and/or fire blight, but not in other agronomic traits. Therefore, other agronomic treatments such as fertilization and also yield are assumed to be constant in all scenarios.

4.1 Plant protection on different cultivars

Plant protection measures vary for susceptible and resistant cultivars. In Table 1 and 2, the surface of different varieties is given, together with their resistances. In tables 2 and 3, plant protection measures are given for susceptible and resistant cultivars.

Table 1: Surface of varieties in the integrated orchard, and their disease resistance. Scab resistance is shown in **blue**, fire blight tolerance in **green**. Background colours indicate taste groups (see Figure 1).

Variety	Surface under scenario (ha)			Scab resistance	Fire blight tolerance
	Baseline	Scenario 1	Scenario 2		
Equilibrated to sweet apples					
Gala	3			susceptible	susceptible
Gala GM 1		4		resistant	susceptible
Gala GM 2			4	resistant	tolerant
Golden Delicious / Maigold	2			susceptible	susceptible
Jonagold	1	1	1	susceptible	susceptible
Spicy to tart apples					
Braeburn	2			susceptible	susceptible
Braeburn GM 1		3		resistant	susceptible
Braeburn GM 2			3	resistant	tolerant
Kanzi	1	1	1	susceptible	susceptible
Pears					
Conference	1	1		susceptible	susceptible
Elliot			1	susceptible	tolerant
Total	10	10	10		

Table 2: Surface of varieties in the organic orchard, and their disease resistance.

Variety	Surface under scenario (ha)			Scab resistance	Fire blight tolerance
	Baseline	Scenario 1	Scenario 2		
Equilibrated to sweet apples					
Gala	2			susceptible	susceptible
Gala GM 1		4		resistant	susceptible
Gala GM 2			3	resistant	tolerant
Idared	1			tolerant	susceptible
Pinova	1			susceptible	susceptible
Pinova GM 2			2	resistant	tolerant
Spicy to tart apples					
Topaz	2	2		resistant	susceptible
Ariwa	1			resistant	susceptible
Retina	0.5	0.5		resistant	susceptible
Braeburn				susceptible	susceptible
Braeburn GM 1		2		resistant	susceptible
Braeburn GM 2			4	resistant	tolerant
Predominantly tart apples					
Boskoop	1			tolerant	susceptible
Otava	1	1		resistant	susceptible
Pears					
Conference	0.5	0.5		susceptible	susceptible
Elliot			1	susceptible	tolerant
Total	10	10	10		

4.2 Plant protection scheme in the integrated orchard

The plant protection scheme for the integrated orchard is shown in table 3.

Baseline: On scab and fire blight susceptible cultivars, 28 spray passages are made.

Scenario 1: On scab resistant (but fire blight susceptible) cultivars, there is a reduction of 3 spray passages. The spraying scheme against fire blight, insects and weeds, and for thinning remains unchanged. Although fungicide applications are reduced, some applications are needed for resistance management of scab, and some applications are targeted at diseases which are normally controlled as a side-effect of scab control.

Scenario 2: On scab and fire blight resistant cultivars, there is a further reduction of 3 spray passages. The spraying scheme against insects and weeds and for thinning remains unchanged.

Table 3: Plant protection scheme for the integrated apple orchard (timing, targets & pesticides). Dates are examples based on the year 2008. Each line represents a separate application (e.g. the treatments on May 3 against rust mites and against fire blight are not mixable). All products are applied at the recommended rates. **Green:** Targets and/or applications which differ in the scenarios.

Abbreviations: **Fungicides:** Ca=Captan 80 (captane); De=Delan WG (dithianone); Fli=Flint (trifloxystrobin); Reg=Regalis (prohexadione-calcium) Str=streptomycine. **Insecticides:** Al=Alanto (thiacloprid); Ki=Kiron (fenpyroximate); Ma=Madex 3 (granulosis virus); Py=Pyrinex (clorpyrifos); Sli=Slick (difenoconazole). **Herbicides:** Ba=Basta (glufosinate); Ro=Roundup (glyphosate). **Growth regulators:** Et=Ethephon (ethephone); Rh= Rhodofix (2-(1-naphthyl) acetic acid). «Scab (res man)»: Fungicide applications on scab resistant cultivars, which are made for resistance management.

Timing (date, stage, BBCH code)			Baseline (scab susceptible, fire blight susceptible)		Scenario 1 (scab resistant, fire blight susceptible)		Scenario 2 (scab resistant, fire blight resistant)	
Apr 1			Apple blossom weevil	Al	Apple blossom weevil	Al	Apple blossom weevil	Al
Apr 4	C3	54	Scab	De	--	--	--	--
Apr 8			Apple blossom weevil	Al	Apple blossom weevil	Al	Apple blossom weevil	Al
Apr 13	D	56	Scab	De	Scab (res man)	De	Scab (res man)	De
Apr 18			Scab & Mildew	De	--	--	--	--
Apr 22	E2	29	Scab & Mildew	De	Scab (res man) & Mildew	De	Scab (res man) & Mildew	De
Apr 23			Rosy apple aphid	Py	Rosy apple aphid	Py	Rosy apple aphid	Py
Apr 24	F	61	Scab & Mildew	Sli+Ca	Scab (res man) & Mildew	Sli+Ca	Scab (res man) & Mildew	Sli+Ca
Apr 25			Weeds	Ro	Weeds	Ro	Weeds	Ro
Apr 29	F		Scab & Mildew +& Thinning	Sli+Ca+Et	Scab (res man) + Mildew + Thinning	Sli+Ca+Et	Scab (res man) + Mildew + Thinning	Sli+Ca+Et
Apr 29	F		Fire blight	Str	Fire blight	Str	--	--
May 3	G		Rust mites	Ki	Rust mites	Ki	Rust mites	Ki
May 3	G		Fire blight	Str	Fire blight	Str	--	--
May 8	H		Aphids	Py	Aphids	Py	Aphids	Py
May 8	H		Fire blight	Reg	Fire blight	Reg	--	--
May 13	H	69	Codling moth	Al	Codling moth	Al	Codling moth	Al
May 15			Weeds	Ba	Weeds	Ba	Weeds	Ba
May 19			Scab & Mildew & Thinning	Ca+Rh	Thinning	Rh	Thinning	Rh
May 27			Scab & Mildew	Ca	Mildew	Ca	Mildew	Ca
June 2	I	71	Scab & Mildew	Ca	--	--	--	--
June 12			Scab & Mildew	Ca	Mildew	Ca	Mildew	Ca
June 21	J	74	Codling moth	Ma	Codling moth	Ma	Codling moth	Ma
June 29			Scab & Mildew & Sooty blotch & Codling moth	Fli+Ma	Mildew & Sooty blotch & Codling moth	Fli+Ma	Mildew & Sooty blotch & Codling moth	Fli+Ma
July 14			Scab & Mildew & Sooty blotch & Codling moth	Fli+Ma	Mildew & Sooty blotch & Codling moth	Fli+Ma	Mildew & Sooty blotch & Codling moth	Fli+Ma
July 31			Codling moth	Ma	Codling moth	Ma	Codling moth	Ma
Aug 8			Scab & Mildew & Sooty blotch & Codling moth	Fli+Ma	Mildew & Sooty blotch & Codling moth	Fli+Ma	Mildew & Sooty blotch & Codling moth	Fli+Ma
Sept 6			Codling moth	Ma	Codling moth	Ma	Codling moth	Ma
Sept 25		81	Scab & Mildew & Sooty blotch	Fli+Ca	Mildew & Sooty blotch	Fli+Ca	Mildew & Sooty blotch	Fli+Ca
Spray passages			28		25		22	

4.3 Plant protection scheme in the organic orchard

The plant protection scheme for the organic orchard is shown in table 4.

Baseline: On scab and fire blight susceptible cultivars, 29 spray passages are made.

Scenario 1: On scab resistant (but fire blight susceptible) cultivars, there is a reduction of 12 spray passages. The spraying scheme against fire blight and insects remains unchanged (note: in organic farming, there is no spraying against weeds and for thinning). Although fungicide applications are reduced, some applications are needed for resistance management of scab, and some applications are targeted at diseases which are normally controlled as a side-effect of scab control.

Scenario 2: On scab and fire blight resistant cultivars, there is a further reduction of 3 spray passages. The spraying scheme against insects remains unchanged.

4.4 Management flexibility

Scab resistance: In scab susceptible varieties, a large number of fungicide applications are currently made. Often, the timing for these applications is very critical, which gives little management flexibility to apple growers. As a consequence, orchards are often sprayed when the soil is wet, which leads to soil compaction. For the control of secondary diseases, the timing of applications is much less critical.

Fire blight resistance: As for scab control, the timing of applications against fire blight is very critical. As a consequence, orchards are often sprayed against fire blight when the soil is wet, which leads to soil compaction.

Table 4: Plant protection scheme for the organic apple orchard (timing, targets & pesticides). All products are applied at the recommended rates; Kocide Opti is applied at 1670 g/ha (equivalent to 500 g/ha of pure copper). For further explanations, see table 3. Abbreviations:

Fungicides: Ko=Kocide Opti (copper hydroxide); S=Schwefel Stulln (sulphur); My=Myso-Sin (acidified clay); Ar=Armcarb (potassium bicarbonate); BP=BlossomProtect (*Aureobasidium pullulans*).
Insecticides: Iso=Isomate-C Plus (pheromone); Ma=Madex 3 (granulosis virus); NA=NeemAzal-T/S (azadirachtine); QU=Quassan (quassia extract).
Herbicides: none. **Growth regulators:** none. All products are applied at the recommended rates. Note: under scenario 1 and 2, the omission of sulphur late in the season necessitates an additional application of Armcarb on June 12 for the control of sooty blotch.

Timing (date, stage, BBCH code)			baseline (scab susceptible, fire blight susceptible)	scenario 1 (scab resistant, fire blight susceptible)	scenario 2 (scab resistant, fire blight resistant)			
Apr 3	C3	54	Scab	Ko	--	--	--	--
Apr 8			Scab	Ko	--	--	--	--
Apr 13	D	56	Scab	Ko	--	--	--	--
Apr 18	E	59	Scab & Mildew	S+My	Scab (res man) & Mildew	S+My	Scab (res man) & Mildew	S+My
Apr 22	E2	59	Scab & Mildew	S+My	--	--	--	--
Apr 23			Rosy apple aphid	NA	Rosy apple aphid	NA	Rosy apple aphid	NA
Apr 24	F	61	Scab & Mildew	S+My	Scab (res man) & Mildew	S+My	Scab (res man) & Mildew	S+My
Apr 29	F	63	Codling moth	Iso	Codling moth	Iso	Codling moth	Iso
Apr 29			Scab & Mildew	S+My	Scab (res man) & Mildew	S+My	Scab (res man) & Mildew	S+My
Apr 29			Fire blight	BP	Fire blight	BP	--	--
May 3	G	67	Scab & Mildew	S+My	--	--	--	--
May 3			Fire blight	BP	Fire blight	BP	--	--
May 8	H	69	Scab & Mildew	S+My	Scab (res man) & Mildew	S+My	Scab (res man) & Mildew	S+My
May 8			Fire blight	BP	Fire blight	BP	--	--
May 13	H	69	Scab & Mildew & Sawfly	S+My+Qu	Scab (res man) & Mildew & Sawfly	S+My+Qu	Scab (res man) & Mildew & Sawfly	S+My+Qu
May 19			Scab & Mildew	S+My	--	--	--	--
May 27			Scab & Mildew	S+My	--	--	--	--
June 2	I	71	Scab & Mildew & Codling moth	S+Ma	Codling moth	Ma	Codling moth	Ma
June 12		73	Scab & Mildew	S	Mildew & Sooty blotch	Ar	Mildew & Sooty blotch	Ar
June 21	J	74	Scab & Mildew	S	--	--	--	--
June 29			Scab & Mildew & Sooty blotch	S+Ar	Mildew & Sooty blotch	Ar	Mildew & Sooty blotch	Ar
July 8			Scab & Mildew	S	--	--	--	--
July 14			Scab & Mildew & Sooty blotch	S+Ar	Mildew & Sooty blotch	Ar	Mildew & Sooty blotch	Ar
July 22			Scab & Mildew	S	--	--	--	--
July 31			Scab & Mildew & Sooty blotch	S+Ar	Mildew & Sooty blotch	Ar	Mildew & Sooty blotch	Ar
Aug 8			Scab & Mildew	S	--	--	--	--
Aug 24			Scab & Mildew & Sooty blotch	S+Ar	Mildew & Sooty blotch	Ar	Mildew & Sooty blotch	Ar
Sept 6			Scab & Mildew	S	--	--	--	--
Sept 25		81	Scab & Mildew & Sooty blotch	Ar	Mildew & Sooty blotch	Ar	Mildew & Sooty blotch	Ar
Spray passages				29		17		14

5 Licenses, royalties and other fees

Currently, apple growers in Switzerland have to pay **licenses** (on a per-tree basis) for most apple varieties. A license of ca 1 – 2 CHF is charged from the tree nursery when the tree is sold to the farmer.

In the case of so-called «**club varieties**», the owners of the club variety make considerable marketing efforts, for which they charge additional money from the growers. If a farmer wants to grow and sell apples under the club's brand name, he has to join the club. The **accession fees** for the clubs are highly variable, with a maximum up to several 10'000 CHF. In addition, the growers have to pay **royalties** (on a yield basis) of ca 0.1 – 0.3 CHF/kg.

5.1 Licenses and royalties for scab resistance

The experts assume that no additional licenses or royalties will be charged for scab resistant GM crops. Thus, a GM Gala will cost a similar license as a conventional Gala, and a GM club variety will cost a similar license as a conventional club variety. A potential model crop is GM papaya in Hawaii, for which no additional licenses are charged.

5.2 Licenses and royalties for scab and fire blight resistance

The experts assume that no additional licenses or royalties will be charged for scab and fire blight resistant GM crops. Again, a GM Gala will cost a similar license as a conventional Gala, and a GM club variety will cost a similar license as a conventional club variety.

For fire blight resistant rootstocks, a license of CHF 1 – 2 is assumed (for non-GM rootstocks such as Geneva 11, as well as for GM rootstocks).

6 Comparison with GM arable crops

Section 6 recapitulates the findings for GM apple orchards under the same headings as used for GM arable crops.

6.1 Persistence of GMO as tubers or in seed bank

This aspect of the evaluation criteria is not applicable to apples.

6.2 Alterations in crop development, soil cover, planting & harvest time etc.

The experts do not foresee relevant changes in crop development, planting or harvest time associated with the genetic modification to be studied.

6.3 Stress tolerance (e.g. heat, draught), need for irrigation

The experts have no information on these aspects. They are therefore assumed to be unchanged.

6.4 Alterations in fertilization

The experts do not foresee relevant changes in fertilization associated with the genetic modification to be studied.

6.5 Crop management practices

The experts have no information on these aspects. They are therefore assumed to be unchanged.

6.6 Management flexibility

Management flexibility is discussed above.

6.7 Use of herbicides

The genetic modifications to be studied are not relevant for herbicide use (in contrast to the arable crops studied).

6.8 Fungicide and insecticide treatments

The use of fungicides and insecticides is discussed above.

6.9 Durability of resistances

Durability of resistances is discussed above.

6.10 Changes in orchard composition

The changes in orchard composition are illustrated in figure 1 (integrated farming system) and 2 (organic farming system).

Integrated farming: If a scab-resistant GM-Gala becomes available, it will not only replace conventional Gala, but also Golden Delicious/Maigold. A similar pattern is expected for the spicy to tart apples. For fire blight resistant cultivars, no additional change in the composition of the orchard is anticipated. For details see figure 1.

Organic farming: If a scab-resistant GM-Gala becomes available, it will not only replace conventional Gala, but also Idared and Pinova. A similar pattern is expected for the spicy to tart apples. However, Topaz and Retina, which are scab resistant non-GM varieties, may remain in the orchard. If fire blight resistant cultivars become available, the composition of the orchard is simplified. For details see figure 2.

6.11 Marketable yield, yield security and longevity of trees

Marketable yield, yield security and longevity of trees are discussed above.

7 References

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8 Acknowledgements

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