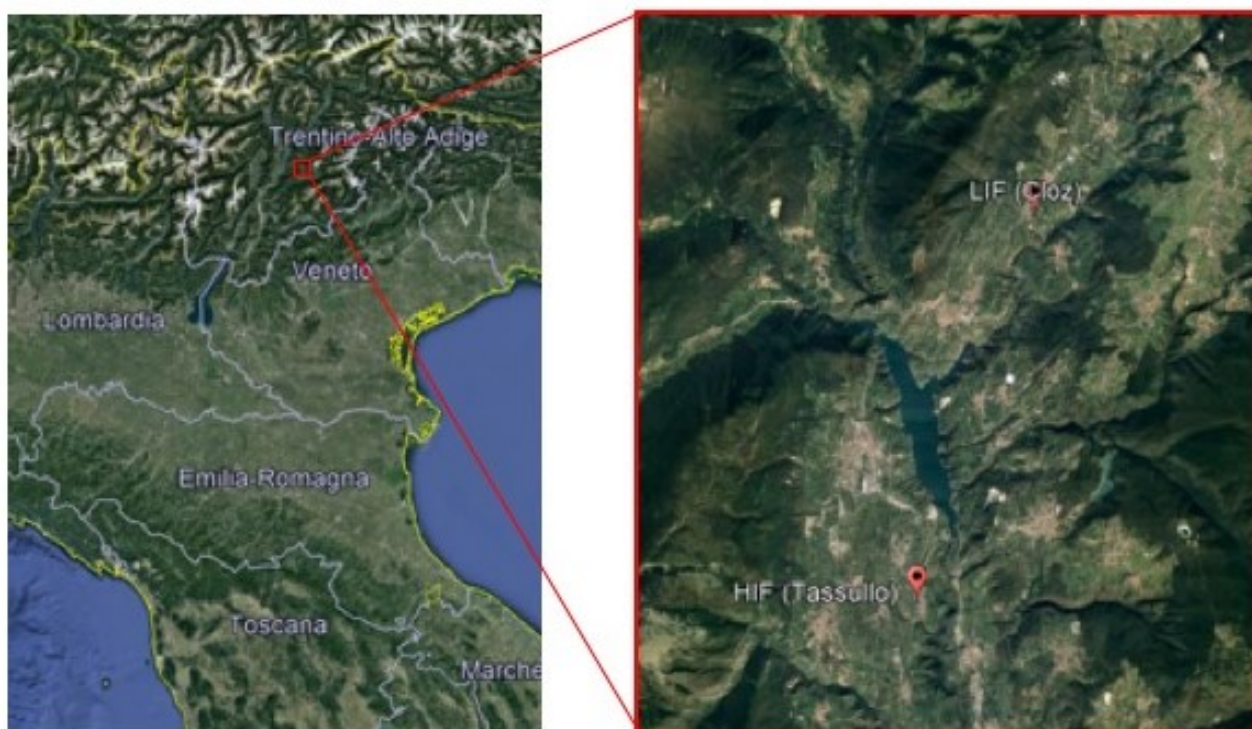


Title: **Review on imidacloprid diffusion route and a case study: from apple orchard to the honey bee colony matrices**

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**Supplemental material S1.** Location of the two apiaries (3 hives each) in "Non Valley" (Trentino, Italy). The two areas are separated by an airline distance of 9.3 km (Google Earth®). Low Imidacloprid Field (LIF), in the municipality of Tassullo on an altitude of 546 m a.s.l. (GPSS-coordinates: 46.333333°, 11.05°) and High Imidacloprid Field (HIF) in the municipality of Cloz on an altitude of 792 m a.s.l. (GPSS-coordinates: 46.421389°, 11.089444°), both in an agricultural landscape of Trentino-Alto Adige Region (Northern Italy). In the LIF municipality, most of the apple orchards were treated with imidacloprid (Confidor), but some were treated with spirotetramat (Movento), while in the HIF municipality only imidacloprid (Confidor) was used.

**Supplemental material S2.** Pesticides used in the apple orchard context of IPM in both experimental fields (LIF and HIF); in bold the treatment with Imidacloprid. For the treatment with imidacloprid (Confidor 200 SL) 15 hl/ha were used.

Treatment time	Commercial product	Category	Active ingredient	Dose used	Field
Late March to early April	Grado 66 WG	Fungicide	Dithianon	50 g/hl	HIL/LIF
	Tianon WG	Fungicide	Dithianon	50 g/hl	HIL/LIF
	Nimrod 250 EW	Fungicide	Bupirimate	50 g/hl	HIL/LIF
	Trebon Up	Insecticide	Etofenprox	25 ml/hl	HIL/LIF
	Teppeki	Insecticide	Flonicamid	8 g/hl	HIL/LIF
Late April to early May	Grado 66 WG	Fungicide	Dithianon	50 g/hl	HIF
	Score 10 WG	Fungicide	Difenoconazole	37 g/hl	HIF
	Colosseo	Insecticide	Flufenoxuron	60 ml/hl	HIF
	Delan WG	Fungicide	Dithianon	50 g/hl	LIF
	Topas 200 EW	Fungicide	Penconazole	12.5 ml/hl	LIF
	Delan WG	Fungicide	Dithianon	40 g/hl	LIF
	Chorus	Fungicide	Pymetrozine	30 g/hl	LIF
Thiopron	Fungicide	Sulfur	200 g/hl	LIF	
Mid May	Grado 66 WG	Fungicide	Dithianon	50 g/hl	HIF
	Dursban 75 WG	Insecticide	Chlorpyrifos	50 g/hl	HIF
	Hubertex		Kaolin	200 g /hl	HIF
	<b>Confidor 200 SL</b>	<b>Insecticide</b>	<b>Imidacloprid</b>	<b>40 ml/hl</b>	<b>HIF</b>
	Topas 220 EW	Fungicide	Penconazole	12.5 ml/hl	HIF
	Delan WG	Fungicide	Dithianon	50 g/hl	LIF
	<b>Confidor 200 SL</b>	<b>Insecticide</b>	<b>Imidacloprid</b>	<b>30 ml/hl</b>	<b>LIF</b>
	Affirm	Insecticide	Emamectin benzoate	220 g /hl	LIF
	Delan WG	Fungicide	Dithianon	50 g/hl	LIF
	Alisè 75 WG	Insecticide	Chlorpyrifos	50 g/hl	LIF
Thiopron	Fungicide	Sulfur	200 g/hl	LIF	
Late May to early June	Topas 220 EW	Fungicide	Penconazole	12 ml/hl	HIF
	Thiopron	Fungicide	Sulfur	200 g/hl	LIF
	Ohayo	Fungicide	Fluazinam	60 ml/hl	LIF
	Hubertex		Kaolin	100 g/hl	LIF
	Delan WG	Fungicide	Dithianon	40 g/hl	LIF
	Hubertex		Kaolin	100 g/hl	LIF
Mid-June	Daithan	Fungicide	Dithianon	50 g/hl	HIF
	Score 10 WG	Fungicide	Difenoconazole	37 g/hl	HIF
	Affirm	Insecticide	Emamectin benzoate	230 g/hl	HIF
	Ohayo	Fungicide	Fluazinam	60 ml/hl	LIF
	Nimrod 250 EW	Fungicide	Bupirimate	50 g/hl	LIF
	Prodigy	Insecticide	Methoxyfenozide	35 ml/hl	LIF
	Score 10 WG	Fungicide	Difenoconazole	37.5 g/hl	LIF

**Supplemental material S3.** The province of Trento is a mountainous district of Trentino-Alto Adige Region (Northeast of Italy) and an important apple producer (10,200 hectares) with an annual production of approximately 504,278 tons accounting for about 22.82% of Italian productions (Source: Istituto Nazionale di Statistica). Cultivated varieties include Golden Delicious (60% of production), Fuji, Red Delicious, Royal Gala, the local Renetta Canada and others. The most notable factor is the small average size of farms - about 2.5 hectares. The reduced size of farms has made it imperative for growers to band together into cooperatives to organize marketing. Today, almost 95% of the apples produced are assigned to the cooperatives. In 1989, the Public Administration of Trento approved a program for Integrated Production standards, so farmers could benefit from a market position with clearly defined quality standards.

Growers are obliged to sign agreements and the cooperatives are responsible for their members' activities. Since 1991, Integrated Fruit Production (IFP) guidelines have covered all aspects of production, including inspection for compliance and fines payable for infractions. The guidelines, which are updated every year, include the choice of varieties, pruning systems, grass cover, nutrition, thinning, irrigation, harvest time, farm records, and pesticide use. The list of approved chemicals is integrated with newly registered compounds judged consistent with IFP. Impacts on beneficial organisms and resistance management requirements are taken into consideration. Considering the high participation in cooperatives, the apple crop in Trentino is almost entirely managed by IFP standards. A minor portion of the orchards is organic (641 hectares) with a trend of increase over the years. Management of insects and pests according to IFP guidelines for apples, is achieved by combining sampling, thresholds and pest forecasts with biological and cultural control methods and the use of presumed selective pesticides. In the last twenty years, the use of more selective insecticides has facilitated the biological control of spider mites by predatory phytoseid mites and typically no miticide treatment is now applied.

Apple scab is managed with 12-18 treatments using preventative and curative fungicides. Codling moth has two generations per year and mating disruption is sometimes combined with insecticides (high-pressure orchards, 30%). The most common situation includes two aphicide applications at pre- and post-flowering stages and one additional treatment using insecticides with a different mode of action against leafrollers. Also, a spring insecticide treatment (pre-flowering stage) against psyllids is mandatory because they are vectors of Apple Proliferation (AP) disease. AP occurs in all countries of Central and Southern Europe, but its highest incidences are in Trentino and southwestern Germany.

The AP disease causes important economic losses due to small size of fruits and impoverished taste. In Trentino, uncontrolled aphids, codling moth, leafrollers and apple scab would likely damage 100% of the apples. By preventing damage from insects and pathogens, fungicides and insecticides play an essential role in defending productions, although nowadays efforts are directed towards a rationalization of their use in favour of more sustainable techniques and natural biological control.



