Environmental Impact Quotient

Field Rate EIQ Calculation with Agro Advanced Software

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Introduction

The Environmental Impact Quotient (EIQ) is a composite model developed by Cornell University, to evaluate the environmental impact of pesticides. The Agro Advanced Software by FoodCare AgroData incorporates this model to calculate the Field Rate EIQ, offering a robust, data-driven methodology for sustainable agriculture as also for measuring the impact of pesticides to the environment.

Environmental Impact Quotient (EIQ)

The EIQ is calculated using the following formula:

As described by Kovach et al. [1] the EIQ is calculated as follows:

$$\mathbf{EIQ}=\{[\mathbf{C}*((\mathbf{DT}*5)+(\mathbf{DT}*\mathbf{P}))]+[(\mathbf{C}*(\mathbf{S}+\mathbf{P2})*\mathbf{SY})+\mathbf{L}]+[(\mathbf{F}*\mathbf{R})+(\mathbf{D}*(\mathbf{S}+\mathbf{P2})*3)+(\mathbf{Z}*\mathbf{P}*3)+(\mathbf{B}*\mathbf{P}*5)]\}/3$$

where: **DT** = dermal toxicity, **C** = chronic toxicity, **SY** = systemicity, **F** = fish toxicity, **L** = leaching potential, **R** = surface loss potential, **D** = bird toxicity, **S** = soil half-life, **Z** = bee toxicity, **B** = beneficial arthropod toxicity, and **P** = plant surface half-life. **The first component which includes C, DT, and P is called "farm worker risk." The second component is called "consumer risk" and includes C, S, P, SY, and L. The third component is called "ecology" and includes F, R, D, S, P, Z, and B**. In the EIQ formula, the three main components are not given equal weight when it comes to individual risk factors. For instance, skin toxicity (DT) is counted twice under the farm worker category, while chronic toxicity appears in both the farm worker and consumer categories. Plant surface half-life is a factor in all three categories and is even triple-counted in the ecology section. On the other hand, the risk factor for leaching potential (L) is only considered once and has a straightforward additive effect on the EIQ, without being multiplied by any other factor. Risk factors in the EIQ are categorized into one of three values: "low" risks receive a score of 1, "medium" risks get a score of 3, and "high" risks are given a score of 5. After calculating the EIQ for a pesticide, it's suggested by Kovach et al. (1992) to multiply this value by the rate of application. This gives the EIQ Field Use Rating (Field EIQ), which can be used to compare the environmental impacts of different pesticide applications.

Once the EIQ for the pesticide is determined, Kovach et al. (1992) suggest multiplying the EIQ value of the pesticide by the application rate to calculate the **EIQ Field Use Rating (Field EIQ)** to compare the environmental impact of various pesticide treatments.

$$\textit{Field EIQ} = \textit{pesticide EIQ} * \textit{pesticide use rate}$$

Conversions from acre to stremma and lb to kgr is automatically made by the software Agro Advanced where:
1 lbs = 0.45359237 kgr, 1 acre = 4,04685642 stremma

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In general:

- **Toxicity:** Includes factors like dermal and oral LD50, chronic toxicity, and more.
- **Soil Behavior:** Considers soil half-life, leaching potential, etc.
- **Ecological Impact:** Takes into account toxicity to birds, fish, and bees.

Core Module Capabilities

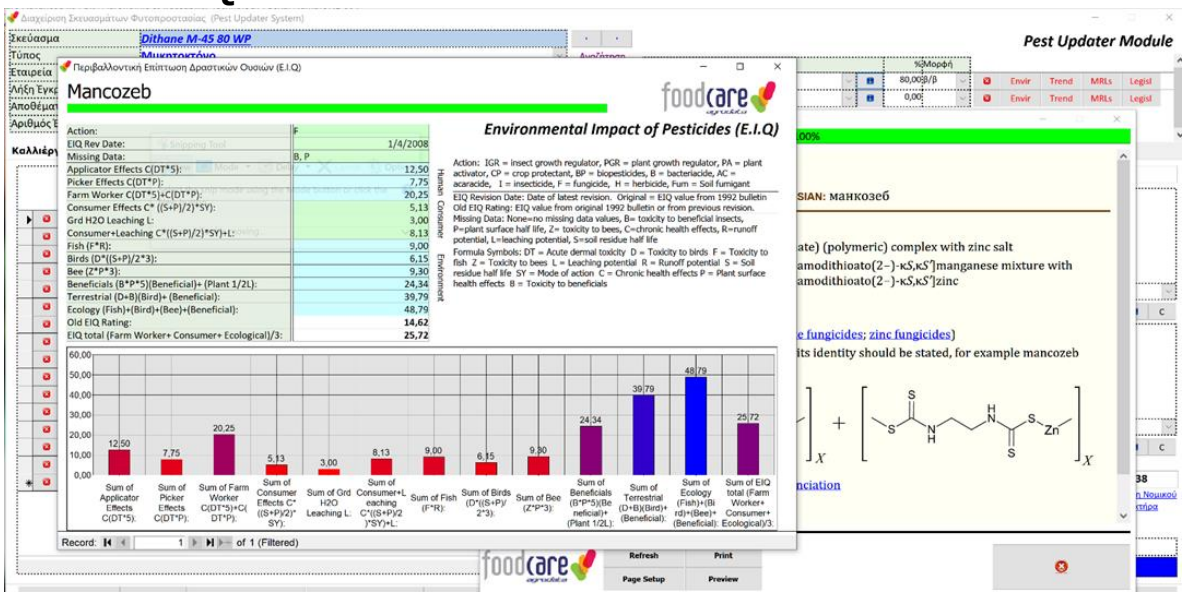
The Core Module is the central unit of the Agro Advanced Software and supports the application of pesticides per field and producer, wth the following capabilities:

- **Data Interoperability:** Facilitates data exchange with other modules and external systems through APIs.
- **Agricultural Data Recording:** Captures granular data, including GPS coordinates of fields, soil pH levels, and irrigation schedules.
- **Legal Compliance:** Manages legal documents, certificates, and compliance checklists.
- **PestUpdater Access:** Enables access to the PestUpdater Module for real-time EIQ data and pesticide approval status.

PestUpdater Module Capabilities

The PestUpdater Module specializes in:

- **Database Updates:** Automatic synchronization with regulatory databases for real-time updates on pesticide approvals.
- **EIQ Data Hosting:** Maintains a comprehensive database of EIQ values for each pesticide, updated in real-time.
- **Pesticide List Management:** Utilizes machine learning algorithms to filter and restrict the list of approved pesticides per crop, based on historical data and current regulations.
- **Field Rate EIQ Calculation Process**



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The Field Rate EIQ is calculated through a multi-step, data-driven process

- **Data Collection:** The Core Module collects data points such as pesticide type (P), application rate (R), and treated area (A).
- **Pesticide Approval Verification:** The PestUpdater Module cross-references P against its real-time database to confirm its current approval status.
- **EIQ Retrieval:** The EIQ value (E) for pesticide P is retrieved from the PestUpdater's database.
- **EIQ Computation:** The retrieved EIQ value is validated using the Cornell EIQ formula.

Benefits of Using Agro Advanced Software for Measuring Field Rate EIQ

For the fruit Exporters

- **Data-Driven Decision Making:** Enables production managers to optimize pesticide usage based on real-time data.
- **Regulatory Compliance:** Ensures alignment with local and international regulations, reducing legal risks.
- **Quality Assurance:** Contributes to meeting certification standards like GLOBALGAP, especially with Biodiversity and Spring addons, IFS FOOD, BRCGS FOOD and other GFSI aprooved schemes.

For the Producer:

- **Sustainable Practices:** Promotes environmentally responsible farming by providing tools to minimize pesticide impact.
- **Cost-Efficiency:** Optimizes pesticide usage for cost savings without compromising crop quality.
- **Market Access:** Demonstrating low Field Rate EIQ values can open up environmentally conscious markets.

For the Farm Employees:

- **Safety:** Real-time updates on pesticide toxicity levels contribute to a safer work environment.
- **Training and Awareness:** Serves as an educational tool for workers.

For the Environment:

- **Reduced Ecological Impact:** Encourages the use of pesticides with lower environmental impact.
- **Resource Optimization:** Helps in optimizing other resources like water and fertilizers.
- **Long-Term Sustainability:** Facilitates responsible pesticide use for sustainable agriculture.

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A real case study in industrial tomato

During the application of GLOBALG.A.P. Scheme for the cultivation years 2015-2016-2017-2018, agronomists added to Agro Advanced software – Core module, the pesticide applications of the Producers.

With a single click, Agro Advanced calculated the Field rate E.I.Q per application per field and producer. Then summarized each field rate E.I.Q and divided the summaries of each pesticide, to the sum of the hectars of all the producers. This is an average method to evaluate the participation of each pesticide to the total cultivation area of tomato.

$$\text{AVG Field Rate EIQ} = \frac{\text{Sum([Field Rate EIQ = E.I.Q x \% Active Ingredient x Total Rate per application])}}{\text{Total Cultivation Area of all the Participating Producers (in stremma)}}$$

1 stremma = 10^{-1} hectares

The average Field Rate E.I.Q. results per stremma for the whole tomato cultivation area is the following (some pesticides are not registered anymore since these data are from 2015-2018:

Take a look of the Summaries of Field Rate E.I.Q per pesticide (year 2018):

Category	Pesticide	EIQ_Total	Birds_Total	fBees_Total	Beneficials_Total	ADI	ARfD	AOEL
Fungicide	Azoxystrobin	134,51443	45,71526	46,46469	165,72405	0.2	Not appl.	0.2
Fungicide	Boscalid	151,16922	69,46257	53,16888	88,61480	0.04	Not appl.	0.1
Fungicide	Copper hydroxide	97,74714	107,31576	27,38098	45,63496	0.15	Not appl.	0.072
Fungicide	Cymoxanil	204,32988	35,41795	53,55885	267,79424	0.013	0.08	0.01
Fungicide	Difenoconazole	138,47511	50,05125	50,05125	136,80674	0.01	0.16	0.16
Fungicide	Dimethomorph	396,33645	151,02985	153,50575	401,67339	0.05	0.6	0.15
Fungicide	Fluxapyroxad	6,85086	3,85421	2,89066	4,81777	0.02	0.25	0.04
Fungicide	Fosetyl-Al	2779,02098	694,75524	694,75524	3473,77622	3	Not appl.	5
Fungicide	Mancozeb	3120,94451	746,26006	1128,49082	2952,88432	0.05	0.6	0.035
Fungicide	Metalaxyl-M	99,01137	47,51507	48,29401	80,49001	0.08	0.5	0.08
Fungicide	Metiram	4171,07731	939,77624	955,18241	4775,91205	0.03	Not appl.	0.016
Fungicide	Propamocarb	63,92909	16,46070	24,89180	77,16457	0.29	1	0.29
Fungicide	Zoxamide	9,57843	2,63371	3,98269	6,63781	0.5	Not appl.	0.3
Fungicide	Pyraclostrobin	105,24072	35,65611	36,24063	99,05773	0.03	0.03	0.015
Herbicide	Rimsulfuron (Renriduron)	4,27639	1,61985	2,74564	5,22400	0.1	Not appl.	0.07
Acaricide/Insecticide	Abamectin (Avermectin)	61,49141	7,71228	50,52874	50,52874	0.0025	0.005	0.0025
Insecticide	Acetamiprid	35,88939	5,43337	21,35877	59,32991	0.07	0.1	0.07
Insecticide	Chlorantraniliprole	34,84325	19,66702	35,74267	18,05185	1.56	Not appl.	0.36
Insecticide	Emamectine benzoate	5,68063	3,89035	3,24196	1,69662	0.0005	0.01	0.0003
Insecticide	Indoxacarb	130,78031	54,71892	119,50108	74,09067	0.006	0.125	0.004
Insecticide	Spirotetramat	81,01556	50,62038	13,08554	109,04616	0.05	1	0.05

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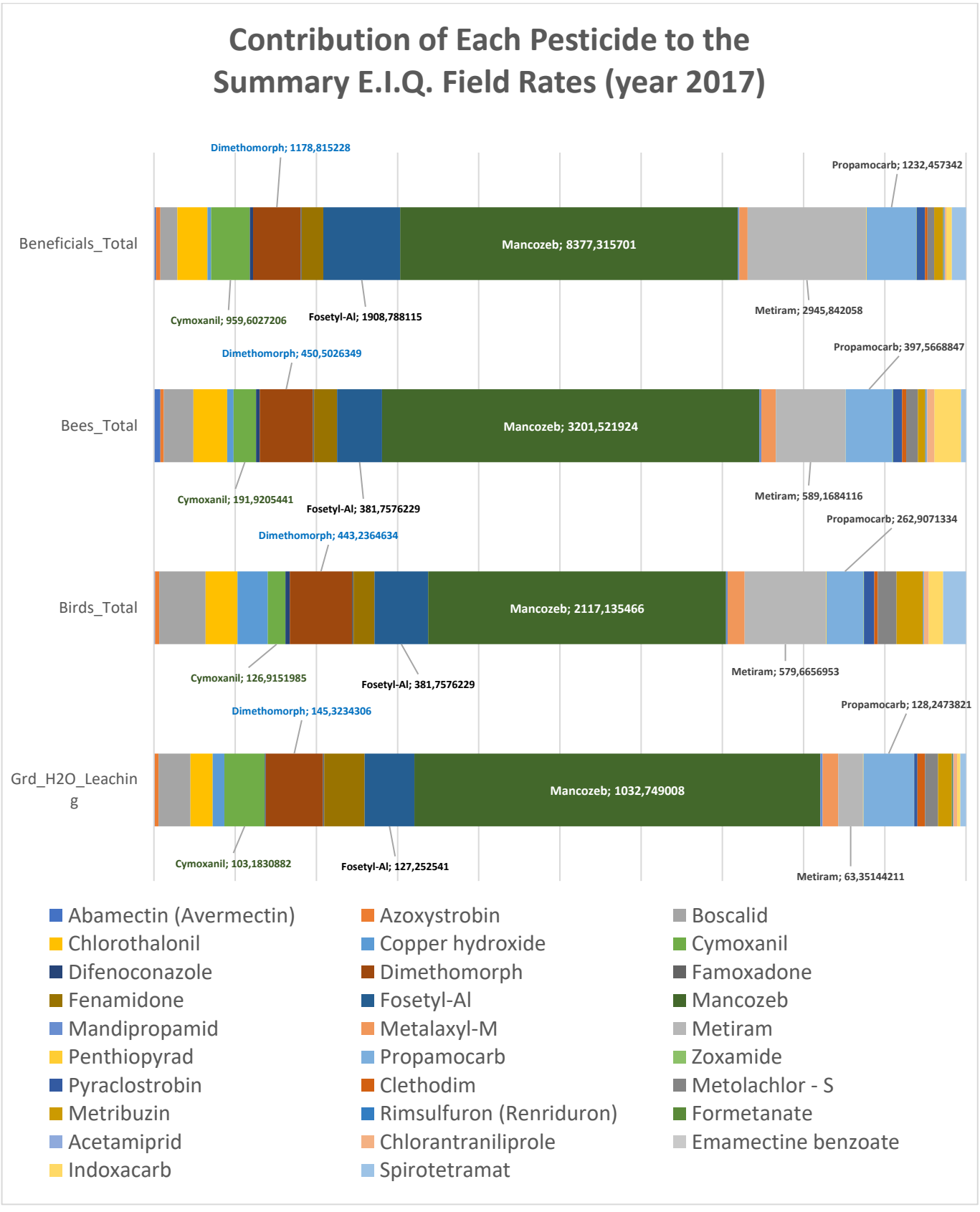

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Since the Module PestUpdater has prepared the previous Avg Field Rate E.I.Q. Calculations, we see that Mancozeb, Fosetyl-AL and Metiram that used to be registered and applied were also having the biggest effect against all E.I.Q (environmental) parameters.

Lets compare the field rate E.I.Qs with some other pesticides **at their registered doses:**

Pesticide	Category	Target	Field Rate E.I.Q. Evaluation at registered doses		
			Birds_Total	Bees_Total	Beneficials Total
Fosetyl-Al	Fungicide	*Alternaria solani*	3,21184	3,21184	**16,05922**
		Phytophthora infestans	3,58656	3,58656	**17,93280**
Mancozeb	Fungicide	*Colletotrichum spp.*	8,77904	13,27562	**34,73788**
		Phytophthora infestans	7,09376	10,72715	**28,06938**
Metiram	Fungicide	*Phytophthora infestans*	10,01382	10,17798	**50,88989**
Bifenthrin	Incecticide/Acaricide	*Trialeurodes vaporariorum*	0,09234	0,25427	0,42379
Cypermethrin	Incecticide/Acaricide	*Frankniella occidentalis*	0,32788	1,27136	1,27136
Formetanate	Incecticide/Acaricide	*Thrips spp.*	1,16429	1,52563	8,36552
Oxamyl	Incecticide/Nematicide	*Meloidogyne sp*	52,39322	114,42197	**168,96310**
Acetamiprid	Insecticide	*Trialeurodes vaporariorum*	0,31048	1,22050	3,39028
Azadirachtin	Insecticide	*Tuta absoluta*	0,16059	0,96355	0,99567
Cyfluthrin, beta-	Insecticide	*Frankniella occidentalis*	0,06792	0,44497	0,74162
		Bemisia sp., Trialeuroides vaporarium	0,06792	0,44497	0,74162
Cyhalothrin, Lambda-	Insecticide	*Leptinitarsa decemlineata*	0,04021	0,15590	0,19591
		Lepidoptera larvae	0,13115	0,50854	0,63907
Deltamethrin	Insecticide	*Thrips spp.*	0,03346	0,16728	0,24702
		Lepidoptera larvae	0,03011	0,15056	0,22232
Fosthiazate	Nematicide	*Meloidogynae sp., Heterodera rostochiensis*	34,92881	15,25626	**25,42710**
Dazomet	Nematicide/Fungicide/Herbicide/Soil treatment	*Meloidogynae sp., Heterodera rostochiensis*	1291,4292	1291,4292	**2152,38201**

According to this table, we are able to understand the following:

- That PestUpdater module can provide us Real Time Calculations of Field Rate E.I.Q at registered dose, so we can select the pesticides with the lowest environmental impact.

- Dithiocarbamates, according to EFSA, are categorized as 1B reproductive toxicants and an endocrine disruptors and are banned from E.U with a possitive effect also for then environment. Imagine the environmental impact of Mancozeb the last two decades, since the quantities that were applied were extremely big. To remember, Mancozeb was participating to many pesticides against *Phythophthora infestans*.

- It can help you set Enviromental targets that involve pesticides, that are really measureable. From 2015 up to 2019 (where 2014 was the reference year), we managed to reduce the environmental impact from the applied pesticides of industrial tomato

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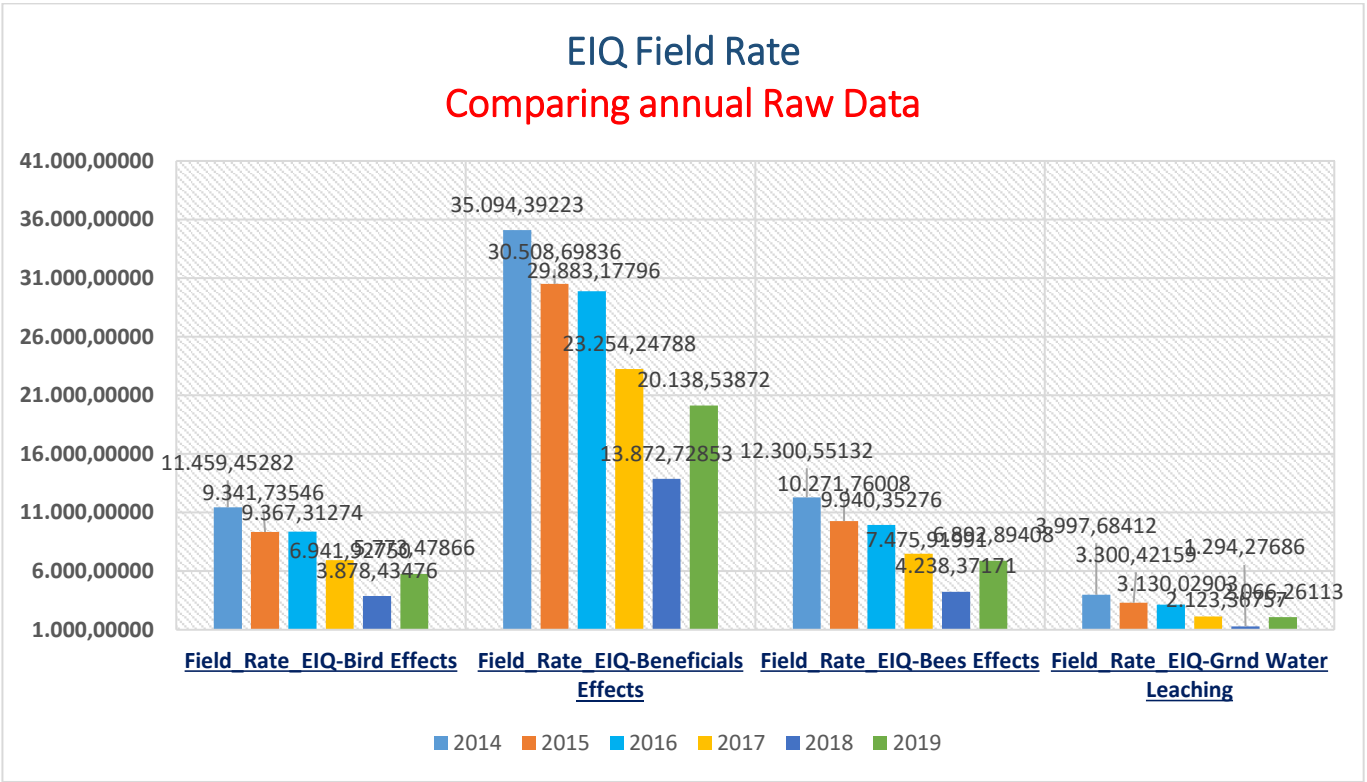
TOTAL FIELD RATES	TOTAL AVERAGES {Field rate EIQ per pesticide} / Summary of Stremma

Factor	2014	2015	2016	2017	2018	2019	2014	2015	2016	2017	2018	2019
Field_Rate_EIQ-Bird Effects	11.459,45282	9.341,73546	9.367,31274	6.941,92750	3.878,43476	5.773,47866	2,11117	1,48423	1,58822	1,40525	0,87847	1,49003
Field_Rate_EIQ-Beneficials Effects	35.094,39223	30.508,69836	29.883,17796	23.254,24788	13.872,72853	20.138,53872	6,46544	4,84727	5,06666	4,70734	3,14218	4,35334
Field_Rate_EIQ-Bees Effects	12.300,55132	10.271,76008	9.940,35276	7.475,91991	4.238,37171	6.892,89408	2,26613	1,63199	1,68538	1,51334	0,95999	1,49003
Field_Rate_EIQ-Grnd Water Leaching	3.997,68412	3.300,42159	3.130,02903	2.123,36757	1.294,27686	2.066,26113	0,73649	0,52438	0,53069	0,42983	0,29315	0,44666

Reduction of average Field Rate E.I.Q:

Field Rate EIQs	Total Reduction 2014-2019 %
Field_Rate_EIQ-Bird Effects	29,4216
Field_Rate_EIQ-Beneficials Effects	32,6675
Field_Rate_EIQ-Bees Effects	34,2477
Field_Rate_EIQ-Grnd Water Leaching	39,3528



Conclusion

The Agro Advanced Software provides a scientifically rigorous and real-time solution for calculating the Field Rate EIQ, by using the pesticide application data that are already added by the users. Its benefits extend beyond mere compliance and data recording, offering tangible advantages for production, growers, workers, and the environment. Its integration with the Cornell EIQ model and real-time database updates make it an indispensable tool for modern, data-driven, and environmentally responsible agriculture.

For further technical details, consult the Core Module and PestUpdater Module documentation.

Citations

Kovach, J., Petzoldt, C., Degni, J., & Tette, J. (1992). A method to measure the environmental impact of pesticides. New York's Food and Life Sciences Bulletin, (139), 1-8.

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