# D5.16. Second Set of Practice Abstracts
# novIGRain

| Second Set of Practice Abstracts | |
|---|---|
| **Lead beneficiary:** | **United Experts** |
| **Main authors:** | **Egor Moshkin** |
| **Issued Date:** | **30/06/2026** |
| **Due date:** | **30/06/2026** |

| Version | Date | Contributors | Reviewers |
|---|---|---|---|
| **1** | **30/06/2026** | **Egor Moshkin (United Experts)** | **Frédéric Verwilghen (MAXILINE)** |

| Dissemination Level | |
|---|---|
| **X** | **PU = Public** |
| | **PP = Restricted to other programme participants (including the EC)** |
| | **RE = Restricted to a group specified by the consortium (including the EC)** |
| | **CO = Confidential, only for members of the consortium (including the EC)** |

This project has received funding from the European Union's Horizon 2020 research and innovation programme, under grant agreement No 101000663.

# Table of Contents

Table of Contents ..... 2
1 Introduction ..... 3
1.1 Purpose of Practice Abstracts ..... 3
2 Practice Abstracts ..... 3
2.1 From a formulation concept to an evidence-based grain protection solution ..... 3
2.1.1 Introduction ..... 3
2.1.2 Why this work matters ..... 4
2.1.3 From prototype variants to METHOGRAIN IGR 30 ULV ..... 4
2.1.4 Efficacy testing: the most visible practical result ..... 4
2.1.5 Building the safety, residue and regulatory evidence base ..... 5
2.1.6 Practical outlook ..... 5
2.2 Awareness raising and knowledge transfer for sustainable grain storage management ..... 6
2.2.1 Introduction ..... 6
2.2.2 Key Results ..... 6
2.3 Initial Survey of Insect Pest Resistance to Insecticides in Agro-Commodity Storages in Europe 6
2.3.1 Introduction ..... 6
2.3.2 Short summary for practitioners and policymakers ..... 6
2.4 Social and environmental impact assessment for new innovative plant protection product ..... 7
2.4.1 Introduction ..... 7
2.4.2 Key findings ..... 7
2.5 Assessment of market potential for new innovative plant protection product ..... 8
2.5.1 Introduction ..... 8
2.5.2 Key findings ..... 8
3 Way Forward ..... 8

# 1 Introduction

The novIGRain project aims to address a number of challenges in grain storage management. In particular it focuses on the development innovative products, technologies and utilises circular approaches to assess the impacts of these innovations. The work includes the following:

- The development of a novel product that can be applied as a ULV (ultra-low volume);
- The development of a novel application technology that should make it feasible to apply multiple insecticides at the same time;
- The development of tools and manuals for doing proper grain storage management taking into account the possible resistance of insects to substances applied. These will be based on research on insect resistance done within the novIGRain project (in combination with literature studies).
- The assessment of social and environmental impact associated with newly developed products and technologies along with market analysis, economic, legal and business potential assessment.

## 1.1 Purpose of Practice Abstracts

The practice abstracts are short summaries of various aspects of the work done in the novIGRain project. Their primary aim is to communicate the complex ideas and approaches involved in the project in a clear and concise way to a broader audience.

For the second set of practice abstracts the focus is to provide the update on the research activities in NovIGRain project.

# 2 Practice Abstracts

## 2.1 From a formulation concept to an evidence-based grain protection solution

### 2.1.1 Introduction

Stored grain protection in Europe is under growing pressure. The number of available chemical tools is narrowing, the regulatory environment is becoming more and more demanding, and resistance in key stored-product insect populations reduces the long-term reliability of some conventional solutions.

Work Package 2 (WP2) of the novIGRain project responds to this challenge by developing and testing a new plant oil-based, ready to use ultra-low-volume (ULV) larvicide (IGR: insect growth regulator) formulation containing S-methoprene. The Methograin IGR 30 ULV product is designed for post-harvest indoor use on cereal grain in closed storage systems (silo), where long-term (6-12 month) preventive control is needed.

Since the first practice abstract, WP2 has progressed from a formulation idea to a structured, evidence-based product. A final formulation variant was selected, the product name Methograin IGR 30 ULV was introduced in the project materials, and the formulation was scaled up from laboratory level to material suitable for application-technology testing. The Demo tour material presents the product concept as a ready-to-use plant oil-based ULV formulation containing 30 g/L S-methoprene, applied at 4 L per 100 tonnes of grain.

### 2.1.2 Why this work matters

Stored-product insects can multiply during storage, causing direct grain losses, quality deterioration and additional treatment costs. The visible adult insects are only part of the problem: developing stages like eggs and larvae may maintain the infestation and allow the population to rebuild after treatment. A preventive tool that interrupts insect development can therefore add value to adulticide or fumigation-based approaches, especially in long storage periods.

The WP2 concept is not introducing another adult-killing treatment. S-methoprene disrupts insect development and is designed to prevent the next generation from establishing. In practical terms, this means that the product aims to reduce the number of reproductive adults emerging from treated grain. This mode of action can broaden the available toolbox for stored-grain protection and may support resistance management by reducing dependence on approaches based only on conventional adulticides.

### 2.1.3 From prototype variants to METHOGRAIN IGR 30 ULV

The formulation work started with clear practical and safety-related criteria. The carrier had to be suitable for ULV application, compatible with S-methoprene, accessible in practice and aligned with the project goal of a more sustainable grain protection solution. Plant oils and plant-oil derivatives were therefore evaluated as carriers. The formulation strategy also followed a simple principle that is important for future users and regulators alike: keep the composition as simple as possible while maintaining technical performance and stability.

Based on preliminary assessment, analytical verification, manufacturing feasibility and initial efficacy considerations, one variant was selected for detailed development. Laboratory batches were followed by scale-up, enabling the candidate formulation to be connected with the application-technology work of the project. This connection is important because the final practical value will depend not only on the active substance, but also on reliable dose delivery, even distribution in grain and compatibility with real storage workflows.

### 2.1.4 Efficacy testing: the most visible practical result

The most visible development of WP2 is the progress in biological efficacy testing. Laboratory work on wheat treated with Methograin IGR 30 ULV focused on three important stored-grain pests: Rhyzopertha dominica (lesser grain borer), Tribolium castaneum (red flour beetle) and Oryzaephilus surinamensis (saw-toothed grain beetle). These species are relevant because they are common, damaging and difficult to manage in stored commodities.

The Demo Tour presentation of results from the Spanish laboratory efficacy work reported consistently high efficacy for the 4 L/100 tonnes treatment during the evaluated storage periods. Across the three target species and assessment points from initial testing up to 6 months, efficacy values were generally in the range of approximately 96-99.9%. The same presentation also reports that dose-range studies achieved more than 95% reduction of emergence of pets. For a practitioner, the key message is clear: under controlled test conditions, the Methograin IGR 30 ULV product strongly suppressed the development of the tested stored-grain insects over time.

### 2.1.5 Building the safety, residue and regulatory evidence base

A stored-grain protectant cannot be judged only by efficacy. It must also be supported by data on human health, environmental safety, residues and practical regulatory acceptability. For this reason, WP2 has included a broad programme of physico-chemical studies, analytical method validations, residue work, metabolism studies, toxicology, ecotoxicology and environmental fate assessment. These studies cover relevant matrices and exposure situations, including formulation, water, soil, plant material, processed commodities and animal matrices where needed for the future assessment.

Based on the studies carried out during the project, the physico-chemical properties of the active substance and the formulation have been characterised, and the analytical methods needed to support the different test programmes have been validated. The generated data also support the overall risk assessment. For example, the available results indicate a favourable acute mammalian toxicity profile, with an oral LD50 in rats above 5050 mg/kg body weight. Key aquatic toxicity endpoints have also been established, including an acute fish LC50 for Danio rerio of 4.26 mg/L over 96 hours and an acute Daphnia magna EC50 of 0.22 mg/L over 48 hours. In addition, the project results indicate that no endocrine-disrupting, immunotoxicological or neurotoxic effects were observed at the highest tested dose of 1000 mg/kg body weight per day. These findings do not replace the full regulatory evaluation, but they demonstrate that the project has generated a broad evidence base to support the assessment of safe and responsible use.

The work has therefore moved beyond product development alone. WP2 is building the data package needed to support exposure estimation, risk assessment and dossier preparation. The laboratory studies have been completed, field monitoring is expected to start shortly, and dossier assembly is in progress. In parallel, the regulatory pathway remains a multi-year process, because a new active substance and representative product use must be evaluated before registration in the relevant Member States can follow.

### 2.1.6 Practical outlook

For grain storekeepers, pest control professionals and the wider grain sector, the long-term promise of Methograin IGR 30 ULV is a preventive tool that can complement existing adulticide and fumigation-based strategies. Because it targets insect development, it may be especially useful as part of integrated stored-grain pest management, where the goal is not only to react to active infestations but also to prevent population build-up during storage.

The results achieved in WP2 show that the novIGRain concept has matured significantly. A plant oil-based ready to use ULV formulation has been selected and scaled up, the practical product concept has been defined, high laboratory efficacy has been demonstrated against three important stored-grain pests, and a wide safety and regulatory evidence base is being assembled.

The remaining work - especially field-related confirmation and completion of the dossier - will determine the final route to implementation.

Nevertheless, WP2 has already translated the original project idea into a concrete product that could help broaden and modernise stored-grain protection in Europe.

## 2.2 Awareness raising and knowledge transfer for sustainable grain storage management

### 2.2.1 Introduction

Effective grain storage management requires not only innovative technologies but also the successful transfer of knowledge to farmers, storage operators and other stakeholders. New solutions can only create impact when end-users understand their benefits, practical application and contribution to sustainable pest management. Therefore, awareness raising, communication and training activities are essential components for supporting the uptake of innovative grain protection strategies across Europe.

### 2.2.2 Key Results

The novIGRain project develops a comprehensive communication and dissemination approach to ensure that project results reach all relevant stakeholders. These stakeholders include farmers, grain storage operators, advisors, researchers, industry representatives and policy makers. A combination of communication tools such as a website (>2.500 visitors), articles (2 in scientific and 18 in specialized press), presentations (>15), infographics (5), flyers (3), videos (5), newsletters (15), posters (5) and social media posts is used to increase awareness of innovative grain storage solutions. In addition, regional workshops (9), regional conferences and demo tours (2) provide direct interaction between the project partners and grain professionals about the research, market developments as well as the newly developed technologies. The feedback from these stakeholders and the international experts (gathered yearly in the expert committee) helps to improve both the research, the technologies and their implementation. Through these activities, novIGRain contributes to a wider adoption of sustainable grain storage practices and supports the reduction of storage losses caused by insect pests.

## 2.3 Initial Survey of Insect Pest Resistance to Insecticides in Agro-Commodity Storages in Europe

### 2.3.1 Introduction

To achieve more sustainable grain storage management across Europe, it is essential to evaluate existing research and field data and translate these findings into a practical, user-friendly format. Currently, the industry suffers from a lack of transparent data and diagnostic tools for assessing the risk of insect resistance to Plant Protection Products (PPPs), which often leads silo operators to select treatments based on immediate costs rather than predictable efficacy. This historical lack of clarity has necessitated a comprehensive survey of resistance across the continent, revealing critical trends and gaps in current pest management practices.

### 2.3.2 Short summary for practitioners and policymakers

The study provides a comprehensive historical and current overview of insecticide resistance across Europe, synthesizing original experimental data with an extensive analysis of existing literature and status of testing in various countries. A key finding of this geographical assessment is that the documentation and identified presence of resistance are significantly higher in EU member states compared to non-EU European countries. This disparity suggests a critical need for more coordinated research and systematic testing across the entire continent to address existing knowledge gaps and ensure food security through evidence-based management of stored product pests. Overall, this

overview serves as a strategic reference framework for researchers, policymakers, industry stakeholders, and storage managers. This overview will aid in a clearer understanding of prevailing resistance trends, research priorities, and knowledge gaps, thereby supporting evidence-based decision-making and coordinated efforts toward sustainable stored pest resistance management regarding organophosphates, pyrethroids, and phosphine

The second part of the report details the current situation across numerous European countries, revealing that resistance to at least one type of active substance was detected in every surveyed nation. Among the species monitored, Rhyzopertha dominica (the Lesser Grain Borer) exhibited the most critical levels of resistance, particularly showing a notable 88% resistance frequency to phosphine and a significant resistance range to deltamethrin. While phosphine generally encounters the highest resistance across all species, the emergence of triple resistance in species like Sitophilus oryzae and Tribolium confusum further underscores the increasing challenge of maintaining the efficacy of traditional chemical control methods. These findings provide a crucial baseline for the development of new anti-resistance strategies and decision-making tools designed to optimize pest control interventions in agri-commodity store

## 2.4 Social and environmental impact assessment for new innovative plant protection product

### 2.4.1 Introduction

Evaluating the sustainability of new plant protection products requires a comprehensive analysis of both environmental and social impacts along the entire supply chain. Within the novIGRain project, environmental and social Life Cycle Assessments (LCA) were conducted to examine grain storage protection strategies, focusing on Methograin IGR 30 ULV and its dual application technology compared to conventional treatments like phosphine and liquid insecticides. The assessments quantified the environmental burdens and social risks associated with delivering 1 tonne of grain, combining specific foreground data for the new product with broader background data for grain cultivation, transport, and default storage operations

### 2.4.2 Key findings

The analyses reveal that the vast majority of both environmental and social impacts occur during upstream grain cultivation and transport, rather than from the grain treatment itself. Environmental impacts from grain cultivation account for approximately 98% of the supply chain's total footprint, while the specific grain treatments contribute only 0.02% to 0.13%. Similarly, the social risks associated with Methograin IGR 30 ULV production and application remain below 2% of total social impacts across all evaluated country scenarios, with the broader risk profile shaped largely by country-specific labour and governance conditions.

The dual application strategy demonstrates the highest potential for overall impact reduction, particularly under conditions of high failure probability and value degradation. Because the treatments themselves have such a limited footprint, modest reductions in quantitative and qualitative grain losses, between 0.2% and 1.3% for environmental impacts, and 0.4% to 2% for social risks are sufficient to completely offset the extra impact introduced by the new product. Ultimately, avoiding storage losses through effective protection strategies is the most critical factor in improving the overall environmental and social sustainability of the grain supply chain.

## 2.5 Assessment of market potential for new innovative plant protection product

### 2.5.1 Introduction

Assessing market potential and economic impacts are essential aspects of developing innovative plant protection products. Within the novIGRain project, an economic impact assessment was conducted to examine the cost-effectiveness of grain storage protection strategies including the Methograin IGR 30 ULV prototype across France, Germany, and Hungary at port, trader, and farm scales. Building on this, a separate analysis developed and evaluated seven alternative business models to identify the most viable pathways for bringing the new larvicide and its application technology to market.

### 2.5.2 Key findings

The economic performance of grain storage treatments is primarily driven by storage duration, fumigation costs, and the value of grain quality premiums. For short-term storage at the port level, liquid insecticides yield the highest net benefit due to low protection costs. However, for extended storage at the trader and farm levels, combined adulticide-larvicide strategies consistently outperform single treatments by keeping failure probabilities low over time. The economic case for introducing a larvicide is strongest when storage duration is long and failure costs are high.

To successfully commercialise the novIGRain innovations, seven alternative business pathways were evaluated based on value proposition, feasibility, scalability, innovativeness, and strategic fit. The most promising near-term models leverage existing professional channels and familiar application routines, such as bulk B2B sales with bundled services for large operators and direct supply to pest control companies. Online sales directly to users and on-demand leasing of ULV equipment appear to be the more relevant niche opportunities for later stages of product development and market entry. In contrast, certification schemes for IGR-treated grain do not currently appear to be strongly supported by market participants, making them a less favourable commercial pathway at this stage.

# 3 Way Forward

The second set of practice abstracts are to be published at EIP-Agri website for broad dissemination. Also all practice abstracts including the first set will be published on NovIGRain website for easy access to interested stakeholders.