Biorational control options in store-product pest management with a special focus on breeding for pest-tolerance

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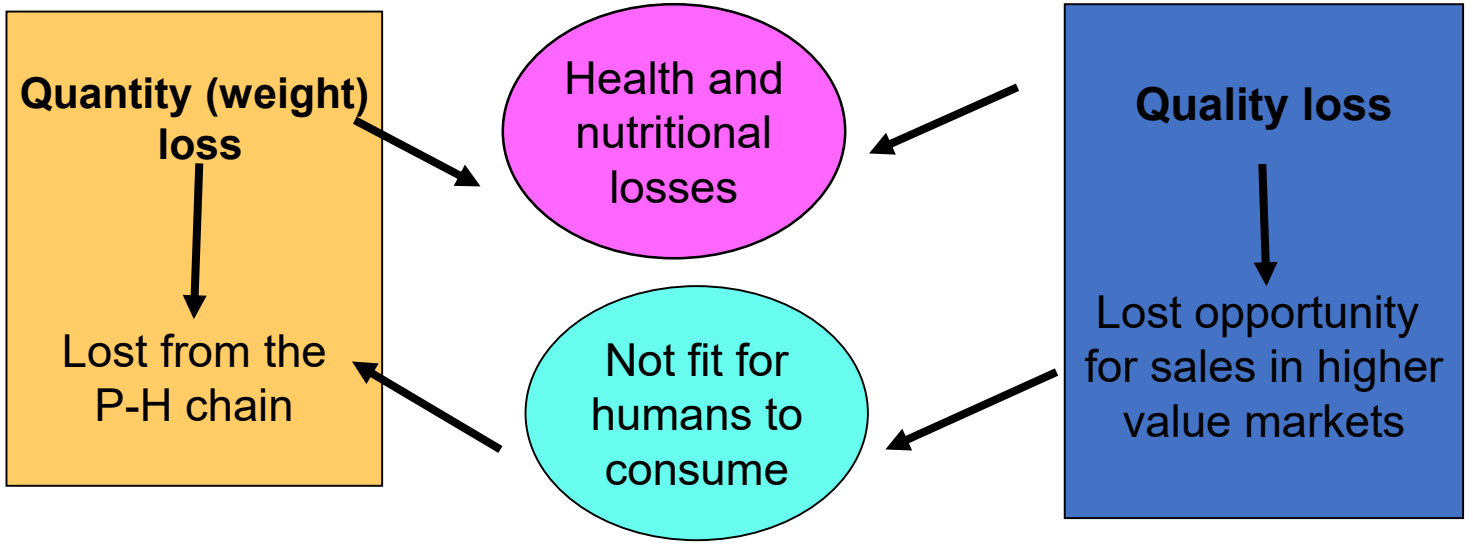
SafeSeed
New biorational methods for stored seed pest control and protection

Фонд за науку
Републике Србије

Climate Crops

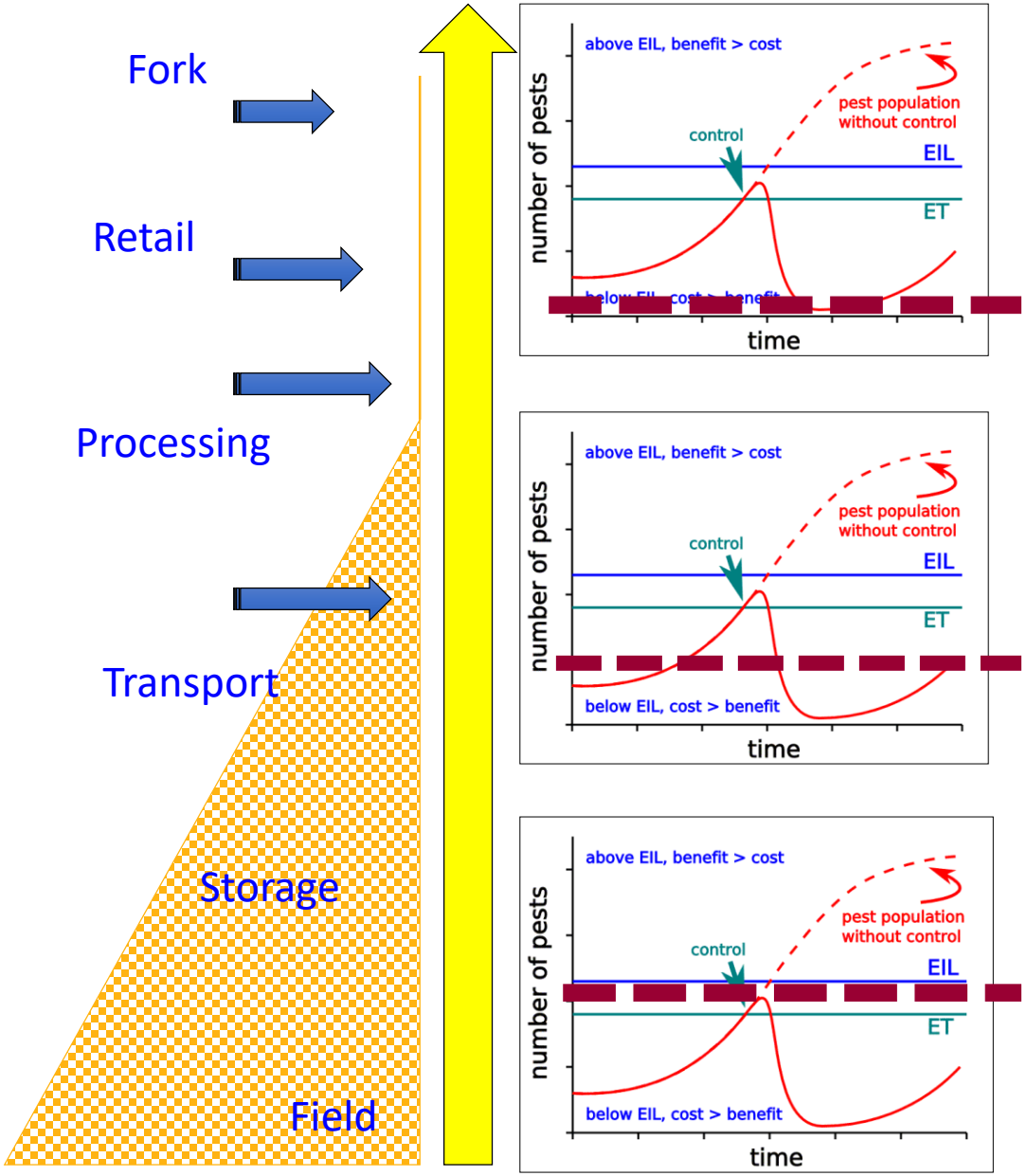
BACKROUND

- **Sufficient amounts of stored grain (seeds) are considered a backbone of food security, particularly in periods when plant production fails.**
- Stored product pests **(SPPs)** are a major cause of huge losses in commodities (raw and processed cereals, pulses, spices, dried fruit and nuts, feed, food...) during storage (10-90%).
- SPPs cause significant **QUANTITATIVE** and **QUALITATIVE** losses each year by feeding and development
- It results in reduced customer compliants, product rejection at the market, and cost associated with their management.



- In the last few decades, focus is on improving
  agricultural production,
  crop yields,
  pre-harvest implications to cope with globally increasing food demand and climate change.

- **PROTECTION of POST-HARVEST** as a vital aspect of food security are neglected.
- **PHLs** in durable agricultural commodities, especially pedigreed seeds (pre-basic and basic seed material), are **OVERLOOKED COMPARED WITH PRE-HARVEST PROTECTION** measures in practice (Fig).
- PHLs are neglected in the research sector as well, as less than **5% OF RESEARCH funding** has been allocated for research on PHL mitigation and storage technologies in previous decades



- Important aspect that contributes to **PHLs** is **climate change** as rising temperatures enhance outbreaks of SPPs.

Effects of global warming on stored product insects

- Faster insect development
- More generations per year
- Tropical pest species migrate further up north
- More infestation in the field in cooler climates

Higher infestation pressure

Adler, C; Athanassiou, C; Carvalho, MO; Emekci, M; Gvozdenac, S; Hamel, D; Riudavets, J; Stejskal, V; Trdan, S; Trematerra, P 2022: Changes in the distribution and pest risk of stored product insects in Europe due to global warming ... JSPR 97, 101977

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WG Integrated Protection of Stored Products

www.iobc-wprs.org

Past

Study group → Working group

Giorgio Domenichini

Milano1992/93
Prague 1994
Firenze 1996

Cornel Adler

Zurich 1997
Berlin 1999
Lisbon 2001

Shlomo Navarro

Kusadasi 2003
Prague 2005
Poznan 2007

Christos Athanassiou

Campobasso 2009
Volos 2011
Bordeaux 2013

Pasquale Trematerra

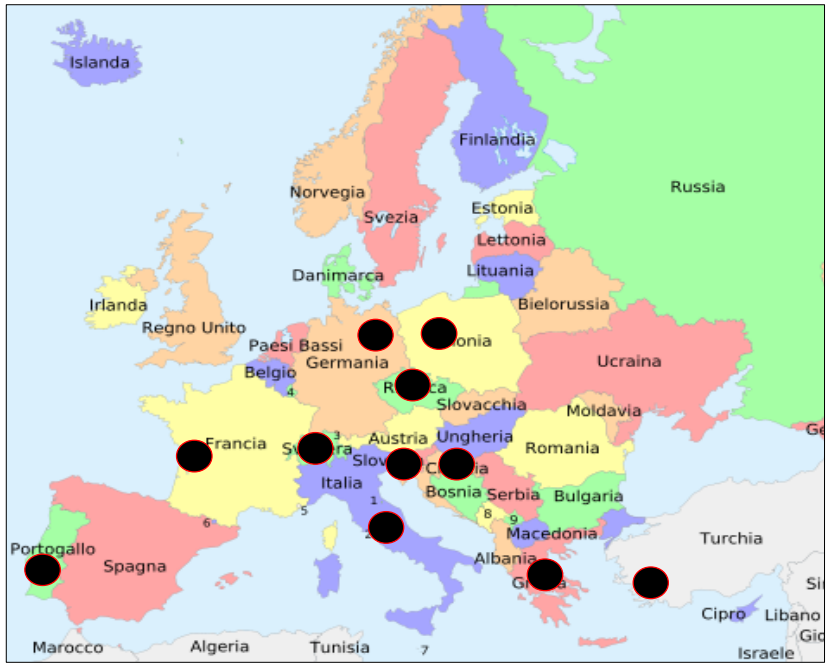
Zagreb 2015
Ljubljana 2017
Pisa 2019

Jordi Riudavets

Barcelona 2022

Marc Bardin
Liaison

Objective: To promote the use of sustainable, environmentally safe, economically feasible and socially acceptable control-methods of pests and diseases of SPPs and food industries.



Meeting venues

- ***Last meeting*** *2022 (106 participants from 32 countries) (Local Organizer Dr. Nuria Agustí, IRTA)*
- ***Scientific topics****: Pest prevention during storage and transportation, Biology of stored product pests and diseases, and insects as food, Biological control, mating disruption and natural products, Chemical pest control, Modified atmospheres and physical pest control*
- ***Activities****: Publication of the Proceedings; Co-organization, co-operations and networking (COST, EUREKA, ERA NET, IWCSPP, ICE, CAF, ECE)*

Future

- ***Next meeting:*** *Novi Sad, Serbia 16-20 September 2024*
  - *we expect a increase in the number of participants*
  - *Bulletin published before the meeting (new)*

- ***Challenges/new developments?***
  - *Decrease in the number of experts in Universities / Research Centres*
  - *Increase interest in alternative control methods. However, limited commercial development of biological control*

CORE of SPP WG – An European initiative

Jordi Riudavets, RTA, Spain

Cornel Adler, JKI, Germany

Christos Athanassiou, University of Thessaloniki, Greece

Pasquale Trematerra, University of Molise,Italy

Vaclav Stejskal, Crop Research Institute, Czech Republic

Sara Savoldelli, University of Milan

Sonja Gvozdenac, IFVCNS, Serbia

Maria Otilia Carvalho, University of Lisbon, Portugal

Stanislav TRDAN, University of Ljubljana

Developing SPP control methods

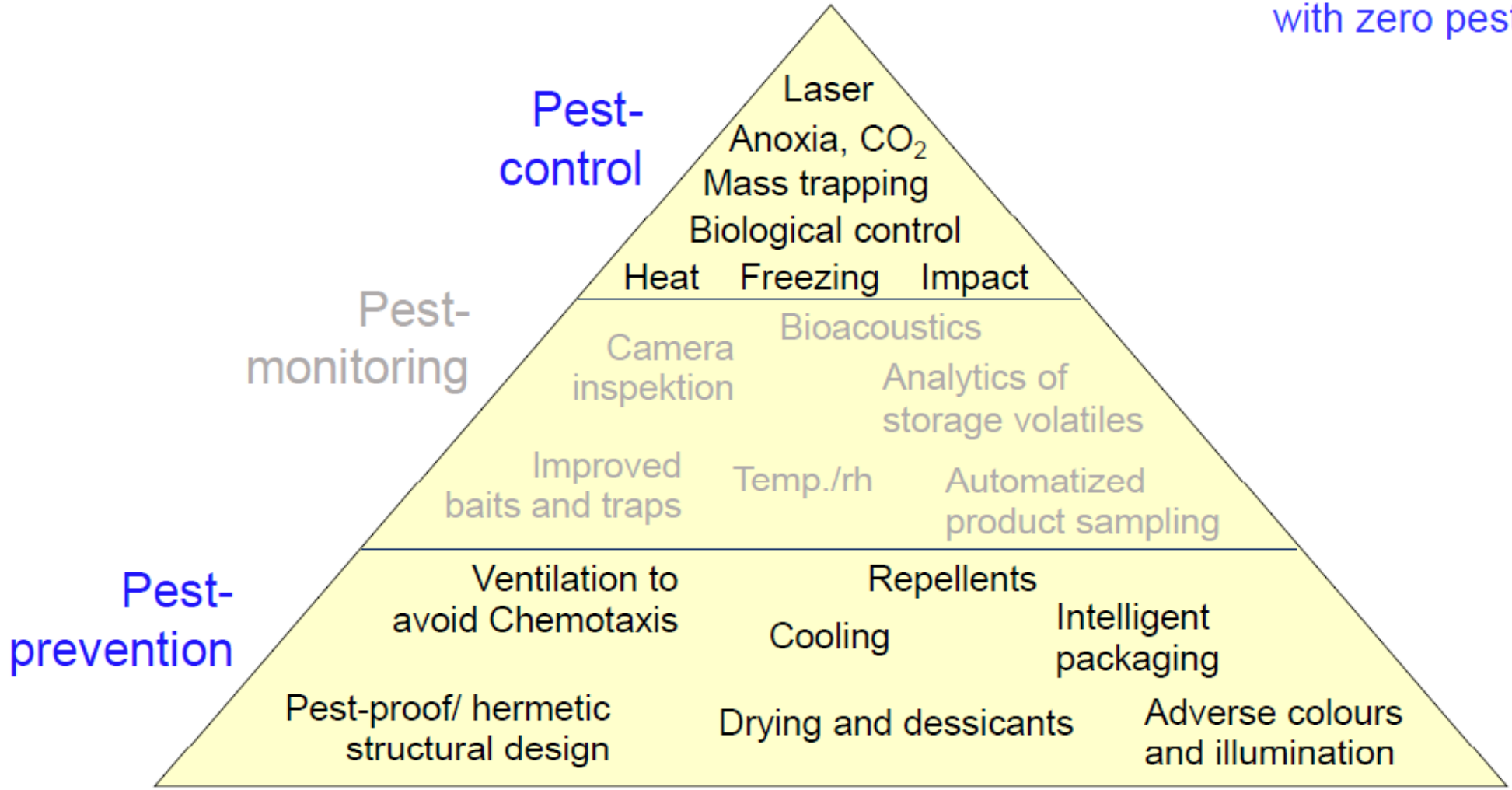
- Up to recently, SPP management was globally related to the **use of chemical insecticides**
- **Results**: environmental pollution, the occurrence of pest resistance, residues in food and feed, negative impact on the environment, etc.

- **LEGISLATIVE CHANGES** at the European level and in 2009 - EU issued Directive 128/2009,
- Restriction or ban of large number of pesticidal compounds was initiated.
- **PLANT PROTECTION in front of a big challenge: to achieve satisfactory pest control with low chemical inputs.**
- A necessity to harmonize **SPP control with IPM principles** and use alternative methods for SPP control and **improve storage technology**.
- To move away from „calendar-based„ treatments and

customize each treatment

Elements of innovative technology for stored product protection

with zero pesticides



(Adler 2018)

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DIFFERENT APPROACHES IN SPP CONTROL

Physical methods

Heating
Cooling
Controlled atmospheres
- CO_2 fumigation
- N_2 fumigation

Hermetic storage -Modified atospheres
Vacuuming
….

Biotechnical methods

Pheromones
- Mass-trapping
- Attracticide (lure and kill)
- Mating disruption
- Autoconfusion

Inert dusts

…..

Biological methods

Predators
Parazitoids
Pathogens
Botanicals

Cultivation method

Breeding for tolerance

Heat treatment

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www.biotech.at

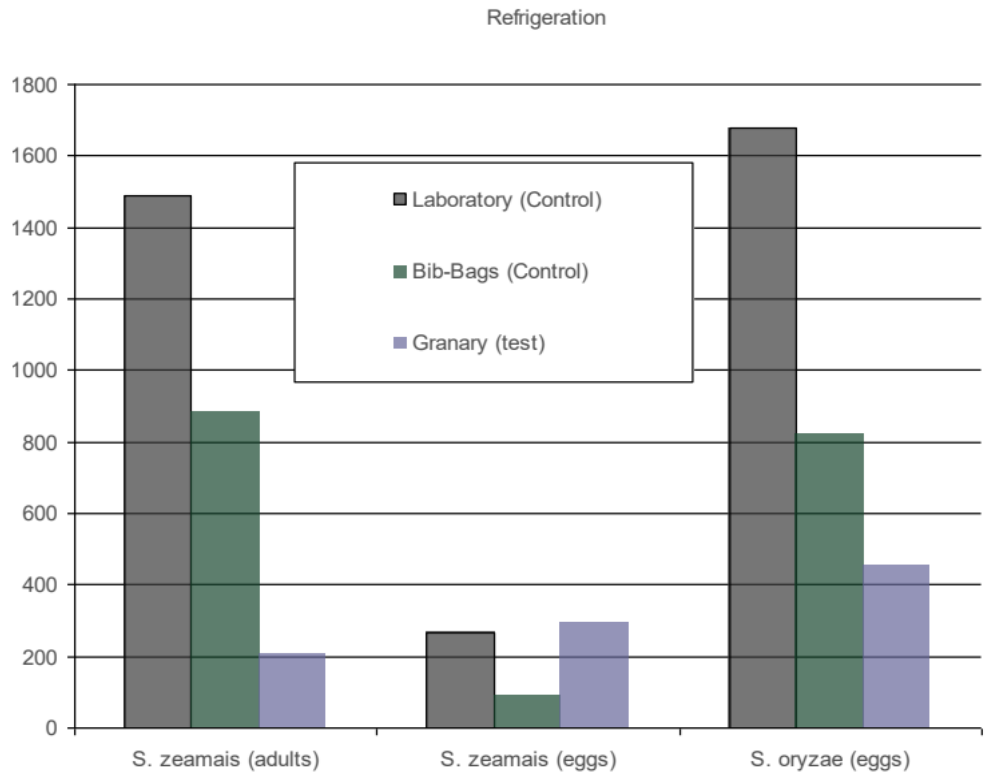
Electromagnetic IR

Cooling

Preventive strategies: the use of refrigeration for insect control and quality maintenance of paddy rice

- Testing reduction of Sitophilus spp activity
- The trials took place for 12 weeks during the hot season.
- Refrigeration was tested in a 40-ton silo
- Average temperature of 17.8 ±0.4ºC
- The results were compared under optimal pest development conditions (laboratory, 28ºC) and under real conditions (stored rice in big bags) in the rice factory (22ºC)
- Moisture content
  - Beginning 12%
  - End:
    - Treatment 13% moisture
    - Control 12% moisture

Results



- F1 adult populations were **reduced by 71% to 77%** when compared to untreated controls.
- Refrigeration of the paddy at approximately **18˚C allowed for storage for nearly three months** and caused a delay in the development of rice weevils, eliminating the need for fumigation.
- Refrigeration provided an environmentally friendly and user-friendly treatment option during the warm months of the year

Controlled atmosphere

CO_2 fumigation of sunflower and beans

- Effect on *A. obtectus* and *P. interpunctella* mortality
- CO2 conc. 62, 93 and 96%
- Exposure of 7 days
- Average temperature of 25.0 ±1 ºC
- The results: A.obtectus (93% morality at 96% after 24h)
  P. interpunctella L5 (100% mortality - 62% for 7 days and at 93% for 24 h)
- No effect on seed GERMINATOIN

Integrated Protection of Stored Products
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Biorational CO_2 fumigation of sunflower and common bean: insecticidal potential and effect on seed vitality and quality

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Abstract: Store product pests often cause high qualitative and quantitative losses to seeds of agricultural plants during storage. Damages inflicted to a high category seed result in reduced germination that practically affects agricultural production. Therefore, it is important to control insect pests and mitigate losses in storages, but at the same time to preserve the germination potential of the seeds as well as their vitality and quality. Fumigation with CO_2 is a biorational method used for controlling store product pests in a variety of commodities. Its insecticidal potential is well documented, however the information about the effect on seeds is lacking. In this work, we assessed the efficacy of CO_2 fumigation and its effect on vitality (germination energy and germination) and quality (fatty acid composition) of sunflower and common bean seeds. CO_2, (62, 93 and 96 %), was applied to sunflower seeds artificially infested with *Plodia interpunctella* larvae and common bean infested with *Acanthoscelides obtectus* adults, in gas-tight bags. The lowest concentration (62 %) caused total mortality (100 %) of *P. interpunctella* larvae after 7 days of exposure. The two highest CO_2 concentrations caused relatively high mortality after two hours of exposure (81 and 86 %), while total mortality (100 %) was achieved after 24 h. The lowest concentration caused only 62.0 % mortality of *A. obtectus* after 24 h of exposure. In treatments with 93 and 96 % of CO_2 mortality was 88 and 93 % after 24 h exposure, respectively. Fumigation with CO_2, irrespective of concentrations, showed no adverse effect on seed germination of sunflower (97.0 to 99.5 % in all treatments) or common bean (91.3-95.3 %), or on the percentage of detectable fatty acids in sunflower seeds. However,

Nitrogen (N_2) fumigation

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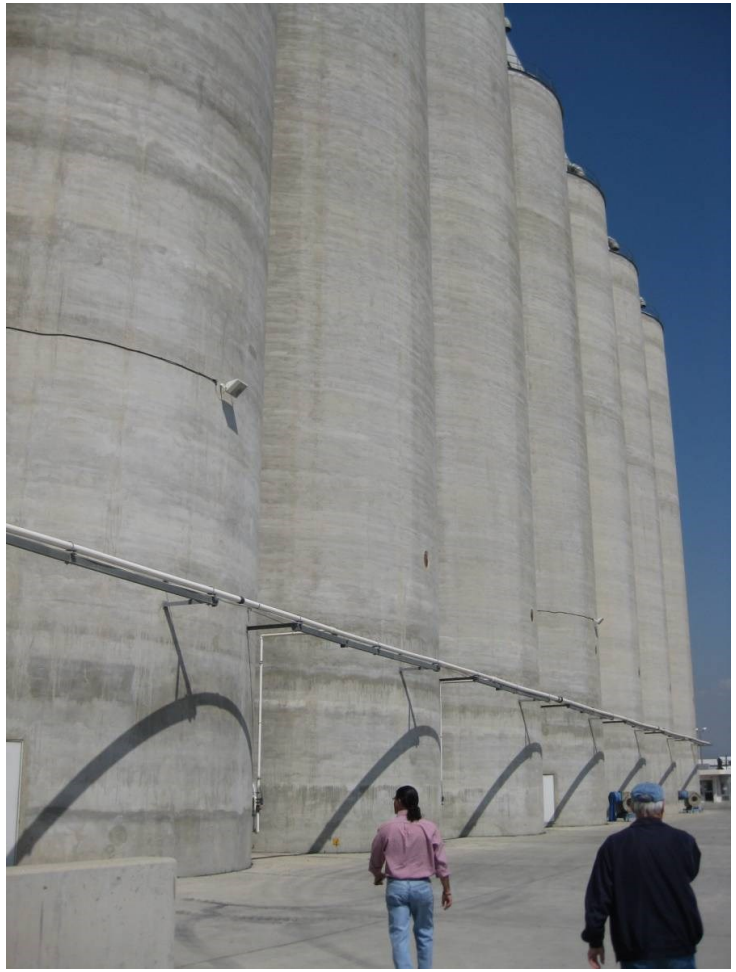
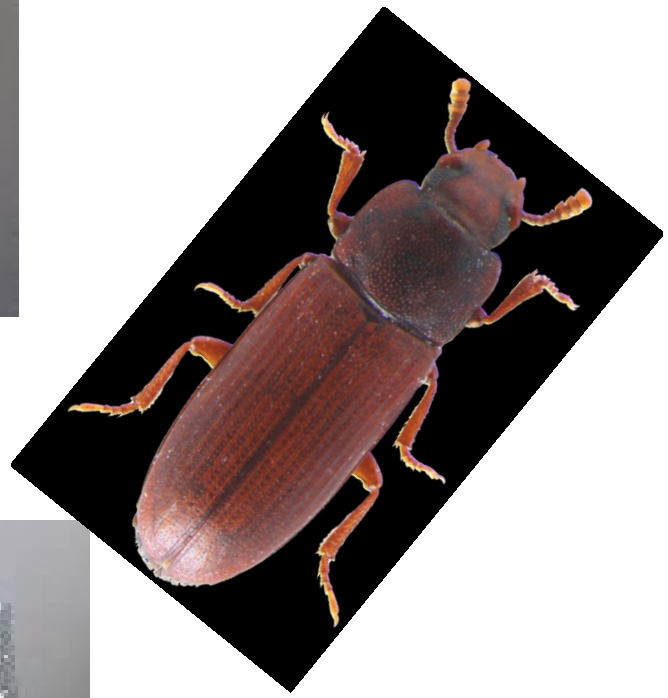


N generators in grains

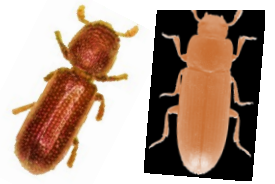
Vacuum technology

CRI

CRI helped to develop and implement new technologies of controlled and vacuum atmospheres into practice



novIGRain

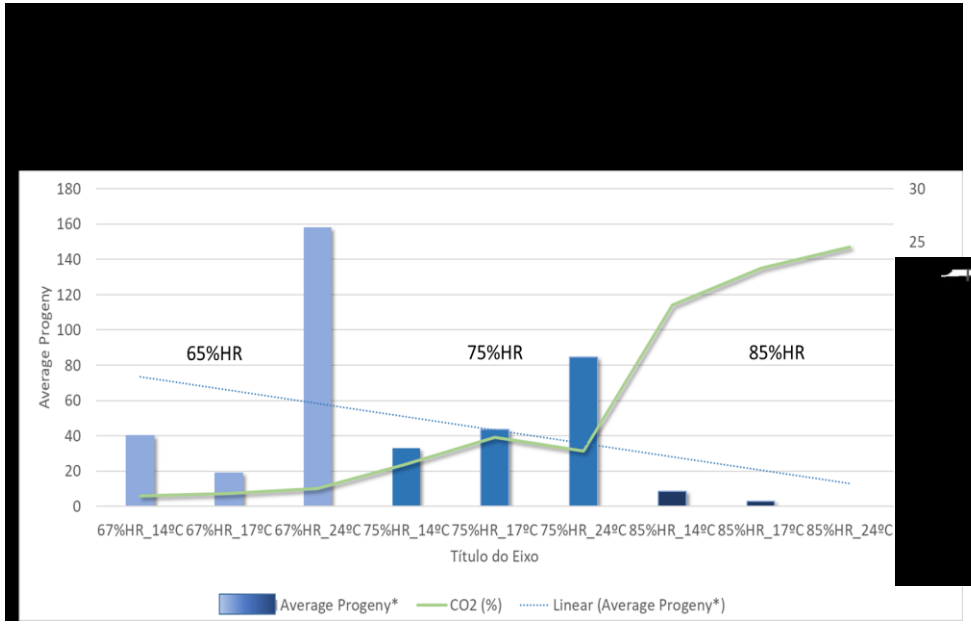


Aulicky R, Shah JA, Kolar V, Li Z, Stejskal V. Control of Stored Agro-Commodity Pests *Sitophilus granarius* and *Callosobruchus chinensis* by Nitrogen Hypoxic Atmospheres: Laboratory and Field Validations. *Agronomy*. 2022; 12(11):2748. https://doi.org/10.3390/agronomy12112748

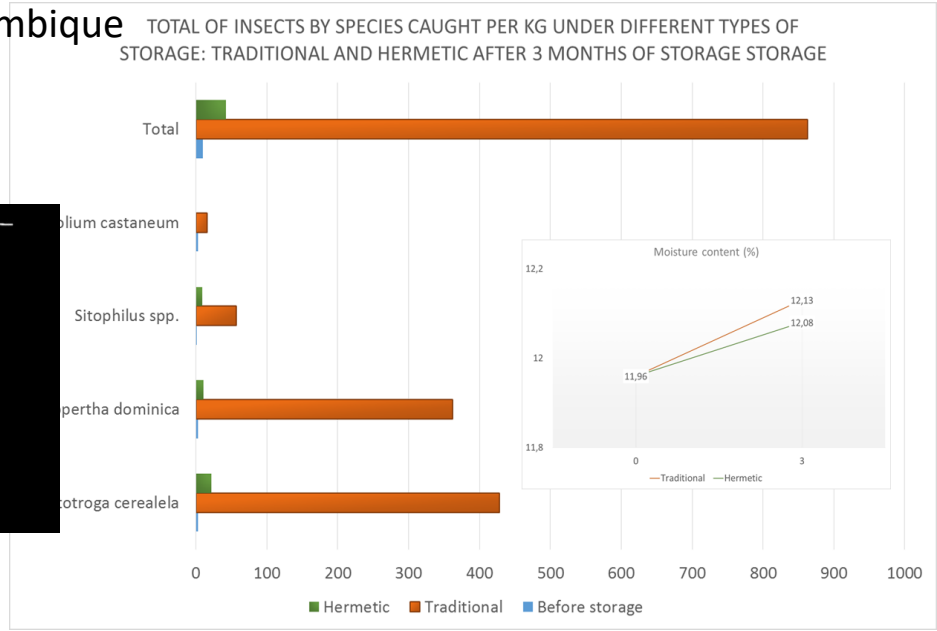
Modified atmosphere

The use of biogenerated atmospheres to control stored rice pests in Portugal and Mozambique

*«**Biogenerated atmospheres** can be created in hermetically sealed storage systems. These atmospheres result from the respiration of living organisms and lead to oxygen-depleted and carbon dioxide-enriched interstitial atmospheres».*

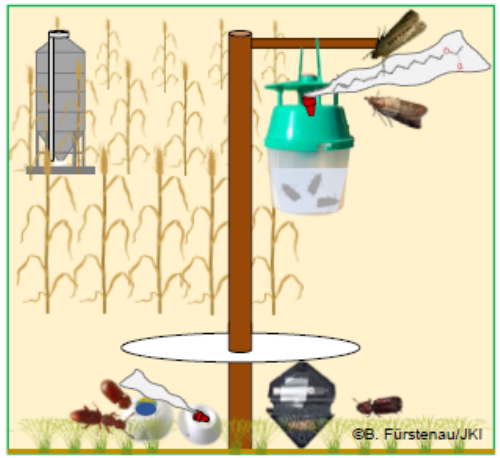


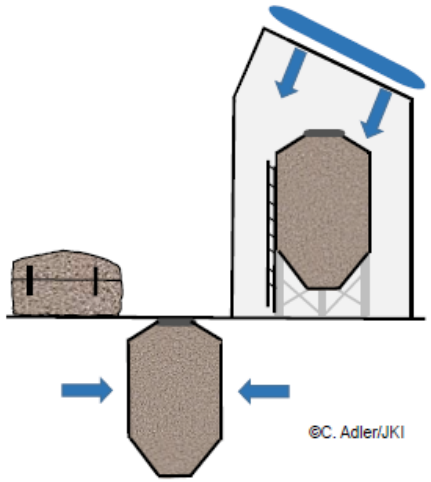
Mozambique



Portugal [24ºC under 85% RH] totally suppressed the insects, fungi didn't develop, rice flour maintained the rheological properties
Mozambique reached 96% reduction of insect population Less 50% losses compared with traditional storage

National project on field monitoring and hermetic storage: AVoiD





- Occurrence & distrib. of SP insects in storage/field
- Monitoring pest species and their dispersal

- Comparing rigid / flexible hermetic structures
- Above / underground hermetic grain storage (efficacy, economy, grain quality, sustainability)

First results may help to design EU-Horizon proposal

Thank you!

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DIFFERENT APPROACHES IN SPP CONTROL

Biotechnical methods

Pheromones

- Mass-trapping
- Attracticide (lure and kill)
- Mating disruption
- Autoconfusion

Inert dusts

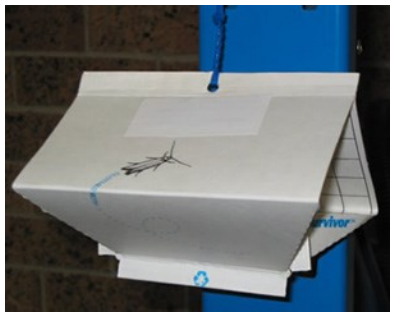
…..

Pheromones

Università degli Studi del Molise

Considerable progess has been made in the use of pheromoness for monitoring and control of SPPs by:

Mass-trapping
Attracticide (lure and kill)
Mating disruption
Autoconfusion



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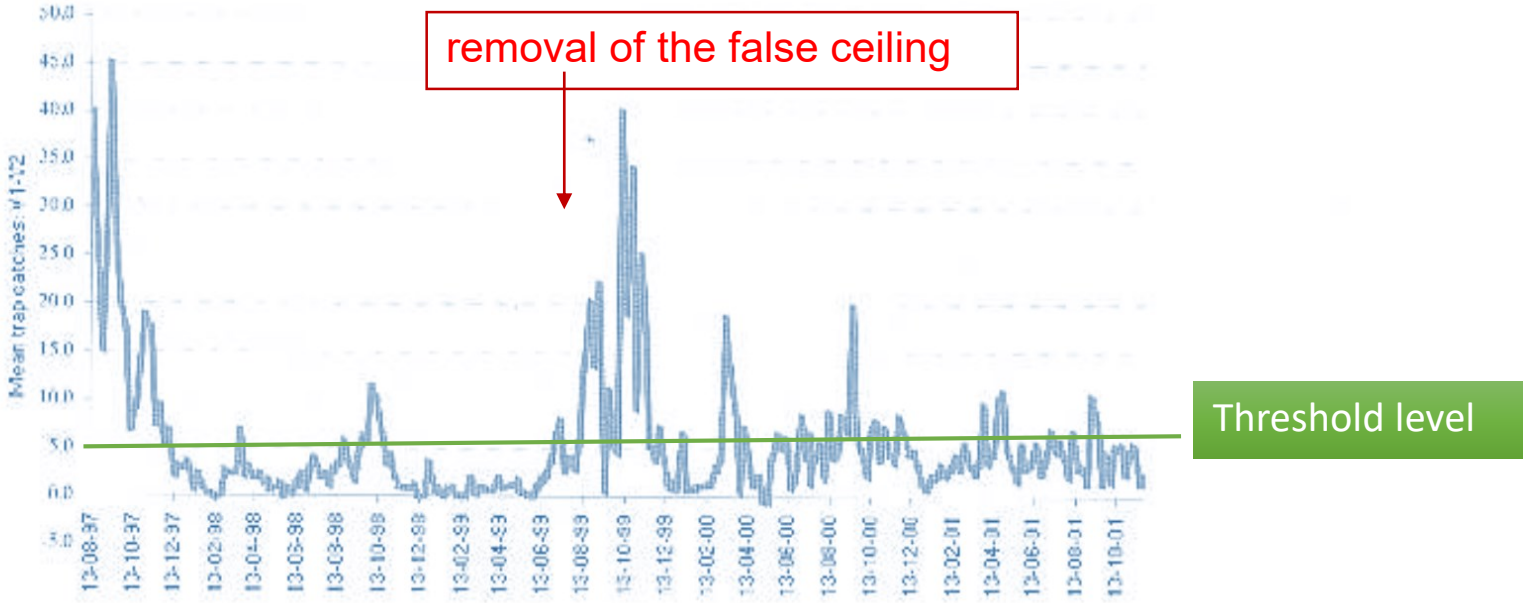
Mass trapping of *Lasioderma serricorne* in a cigarette factory



In: Carvalho MO, Mexia A. 2003. The use of pheromone traps for mass trapping of Lasioderma serricorne in a cigarette factory in Portugal. In: Credland PF, Armitage DM, Bell CH, Cogan PM, Highley E. (Eds.), Advances in Stored Product Protection. Proceed. 8th IWCSPP York, UK, CABI, 222-229.

Mass trapping trials for *L. serricorne* conducted over 223 weeks in stored tobacco facilities (no chemical control)

Threshold is 5 insects/trap/week.

After **one year**, the number of insects caught **fell below this threshold**.

When the false ceiling was removed, it took an additional two years of mass trapping to reduce the L. serricorne population below the injury level.

* Mass trapping has a **medium and long-term effect** when dealing with high infestations.

* It is **most effective** when insect populations are **lower** because the sexual pheromone's power becomes more attractive and faces less competition from the male/female gender that releases the attractant.

The **aggregation pheromone is not** as **effective**

Use of pheromone for managing *Nemapogon granellus (European grain moth)* infestations

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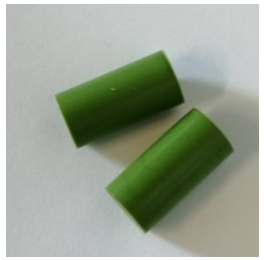
- *N. granellus* is a polyphagous species: grain kernels, flours, dried fruit, dried mushrooms, various seeds, cured meat and cheeses

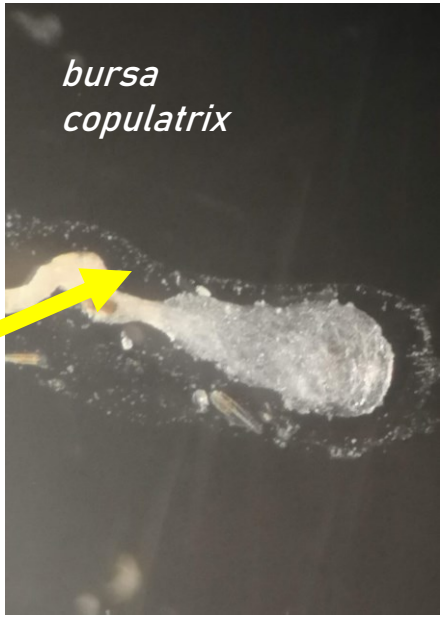


Pheromone dispensers and examples of application in the factory

- 1 dispenser/22.5 m^3

Test was made in a ham factory where *N. granellus* was present

- *N. granellus* adults were captured using water traps
- The female mating status was assessed (presence or absence of spermatophores, in the test area and control area
- The reduction (%) of couplings was evaluated



Use of pheromones reduced mated females

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Pheromone-mediated mating disruption of the European grain moth *Nemapogon granellus* in ham factories

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- Mated
- Unmated
- Unidentifiable

- Mated
- Unmated
- Unidentifiable

by reducing chemical treatments

Inert dusts

- **Inert dusts (ID)** are dry powders of different origins that are chemically unreactive in nature
- significant tool in IPM programs of **stored grain** providing insect control and preserving grain quality during storage.

➢ ADVANTAGES:

natural inert material,
health safe
effective insecticide,
physical mode of action
long persistence
NOT leaving hazardous residues

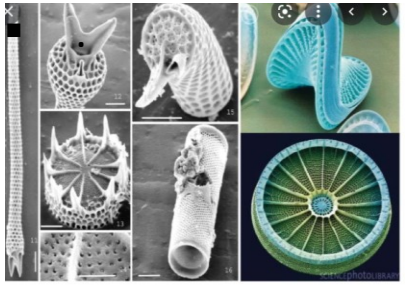
➢ DISADVANTAGES:

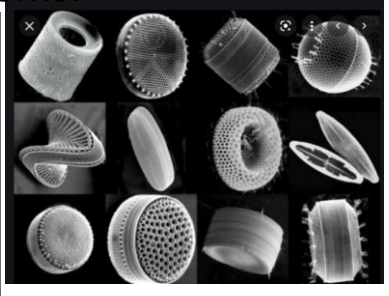
Increases hectolitar weight
Reduces flowability of seeds

Many DE dusts are commercially available and used in developed and developing countries for managing SPPs

- Jarose et al. 2016

- DE contains 80 and 95% amorphous silicon dioxide
- composed of unicellular algae fossilized bodies called diatoms.





7th INTERNATIONAL CONFERENCE **SUSTAINABLE POSTHARVEST AND FOOD TECHNOLOGIES - INOPTEP 2021,**
7. MEĐUNARODNA KONFERENCIJA **ODRŽIVE POSLEUBIRAJUĆE I PREHRAMBENE TEHNOLOGIJE - INOPTEP 2021** April 18th – 23th, 2021, Vršac, Serbia

EFFICACY OF DIATOMACEOUS EARTH IN CONTROLLING MAJOR STORE PRODUCT PESTS: *PLODIA INTERPUNCTELLA*, *TRIBOLIUM CONFUSUM* AND *ACANTHOSCLIDES OBTECTUS*

Sonja GVOZDENAC[1], Dejan PRVULOVIĆ[2], Milica VUČINIĆ VASIĆ[3], Aleksandra ILIĆ[1], Snežana TANASKOVIĆ[4], Jelena OVUKA[1], Miloš KRSTIĆ[1]

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ABSTRACT

Diatomaceous earth (DE) is an inert dust formed from fossilized skeletal remains of diatoms. Insecticidal activity is a result of desiccation that occurs after DE particles destroy lipid layers of insect cuticule. Efficacy depends on chemical composition, particle size and geographic origin. This work assessed contact efficacy of DE originating from Kolubara open-pit mine (Serbia), in comparison to SilicoSec®, against *P. interpunctella*, *T. confusum* and *A. obtectus*. DEs were applied at rates: 5, 10, 15 and 20 mg^{-2}. Mortality was recorded after 24, 48, 72 h and seven days. Significant mortality of *P. interpunctella* larvae was recorded after seven days of exposure at two higher rates of SilicoSec® (48.0 and 54%, respectively) and Kolubara DE (45.6 and 58.5%, respectively). Higher rates of SilicoSec® and Kolubara DE caused significant mortality of *T. confusum* after seven days (54.1, 84.3%, 49.2, 78.2%, respectively). High mortality of *A.obtectus* was recorded after 48 and 72 h in SilicoSec® (61.5, 82.1%, respectively) and in Kolubara DE (58.0, 78.5%, respectively) when applied at 20 mg^{-2}.

Key words: *alumina silicates, inert dusts, contact toxicity, storage pests*

INTRODUCTION

During storage, insects cause huge quality and quantity reduction of stored commodities and great economic losses (Puzzi, 2001). Therefore, the pest control is inevitable post-harvest measure that helps prevent damages and preserves the nutritional and commercial value of stored products. Concerns about rapid development of insecticide resistance, the environmental pollution and human health have intensified the search for alternative eco-friendly pest management strategies (Gvozdenac et al., 2018a). The use of materials like inert dusts, submicron and nanomaterials is one of the strategies that have been extensively tested as viable alternative to pesticides (Fields and Korunić, 2002) suitable for a long-term protection of stored products. Back in 1997, Golob fist mentions the inert dusts as potent storage protectants in grain industry, with Diatomaceous earth (DE), being the most commonly used and evaluated (Golob, 1997).

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Tofel, K.H., Nukeine, E.N., Stahler, M. and Adler, C. 2015: Insecticidal efficacy of *Azadirachta indica* powders from sun- and shade-dried seeds against *Sitophilus zeamais* and *Callosobruchus maculatus*. Journal of Entomology and Zoology Studies **3,** 100-108.

Effects of different inert dusts on *Sitophilus oryzae* and *Plodia interpunctella* during contact exposure

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DOI 10.5073/jka.2018.463.179

Abstract

The use of natural inert dusts against storage insect pests is increasing recently, as an alternative to conventional insecticides. Laboratory study was carried out to evaluate the contact effect of three inert dusts, diatomaceous earth (DE), kaoline (KA) and vermiculite (VE), at rates 5, 7.5, 10, 15 and 20 gm^{-2}, against adults of *Sitophilus oryzae* (L.) and larvae of *Plodia interpunctella* (Hubner). Insect mortality was evaluated 1, 2, 3 and 7 days after the exposure. Insect mortality varied depending on the species, concentrations and exposure periods. The DE and KA caused 86.7-98% mortality of *S. oryzae* after 2 days of exposure at the highest rates, while at 5 and 7.5 gm^{-2}, 100% mortality was achieved only after 7 days. The highest rates of inert dusts caused 42-50% (DE) and 60-75% (KA) mortality of *P. interpunctella* larvae only after 7days. The mortality of moths increased gradually with the concentration and 100% was achieved 3 days after the contact with DE and KA (10, 15 and 20 g m^{-2}). However, inert dusts induced faster pupation of *P. interpunctella*, while adult emergence was reduced and adults had smaller body-sizes, compared to control. The VE caused relatively low mortalities (7-11% of *S. oryzae* adults and 5-8% of *P. interpunctella* larvae) at all tested rates during the entire experiment. Our results have shown good insecticidal effect of DE and KA against *S. oryzae* and *P. interpunctella* at 10, 15 and 20 gm^{-2}. These products could therefore be used by small-scale farmers to protect stored grains against insect pest infestation.

Key words: Inert dusts, *Sitophilus oryzae*, *Plodia interpunctella*, contact exposure, diatomaceous earth

Introduction

In recent years, the use of contact insecticides and fumigants for controlling storage pests is under increasing restriction due to the presence of residues in food and development of insect resistance (Collins, 2000; Kljajić and Perić, 2005). These shortcomings have stimulated the need for testing and evaluation of non-toxic methods that can replace conventional insecticides in stored grains (Arthur, 1996). Recently, physical control methods, like the use of inert dusts, have become prominent (Field and Korunić, 2002). These materials are classified into different groups depending on their composition and particle size and include materials such as diatomaceous earth, silicophosphate, rock phosphate, sand, kaolinite, clay etc. (Golob, 1997). There is a growing interest especially in desiccant or absorptive dusts, among which, diatomaceous earth is the most widely used in practice worldwide (Golob, 1997; Korunić, 1998a; Subramanyam and Roesli, 2000) and in commercial storages in the developed world. On the other hand, non-silica dusts and those composed of coarse grain silicates, such as kaoline and sand, have been used traditionally as grain protectants by small-

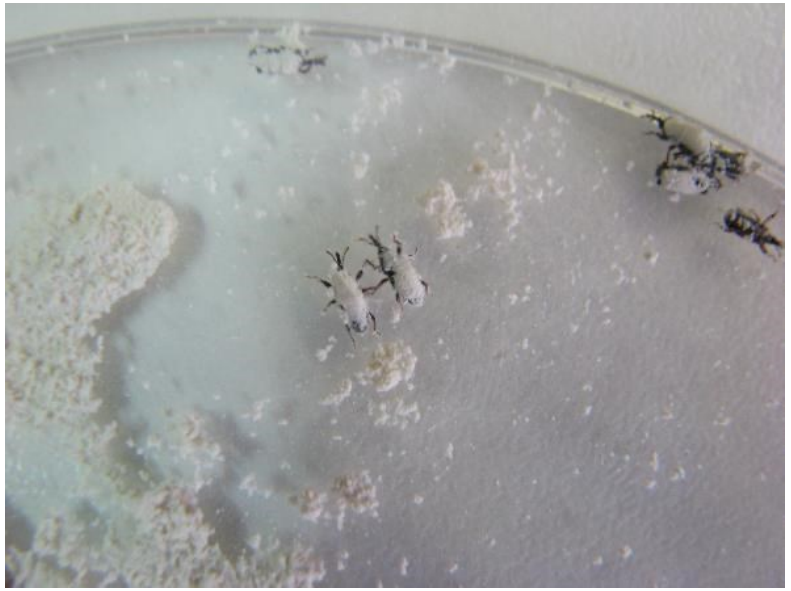
- **Efficacy of inert dusts and plant powders against adults of *Sitophilus oryzae* under laboratory conditions**

UNIVERSITY OF LJUBLJANA | BF Biotechnical Faculty

Ljubljana
Circular economy
APPLAUSE - Alien Plant Species from harmful to useful with citizens' led activities

- **Testing the insecticidal efficacy of wood ash and zeolites (LOCAL ORIGIN)**

UNIVERSITY OF LJUBLJANA | BF Biotechnical Faculty



UNIVERSITY OF THESSALY
SCHOOL OF AGRICULTURAL SCIENCES
Department of Agriculture Crop Production and Rural Environment

DiatomiteThem

- Establishment of postharvest management protocols for commodities, applying Diatoms earth
- Assessment of economic efficiency for the proposed protocol
- Survey for assessing consumers' WTA and WTP for final foodstuff being treated with Diatoms earth

Co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH - CREATE - INNOVATE (project code:T2EDK-3532)

UNIVERSITÀ DEGLI STUDI DEL MOLISE

COMBINING AND INTEGRATING DIFFERENT MANAGEMENT TOOLS…

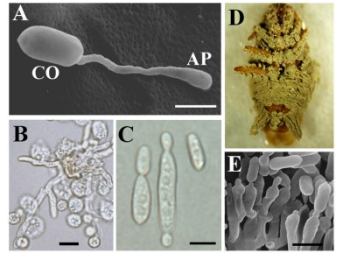
- heat combined with diatomaceous earth
- pheromones and pathogen
- diatomaceous earth and spinosad
- pheromones and food attractant oils
- push-pull strategies
- packaging + repellents....

Biological methods

Biological control has been attempted by using predators and parasitoids (Titouhi et al., 2017) or by applying plant essential oil treatments (Jemâa, 2014; Amzouar et al., 2016; Titouhi et al., 2017).

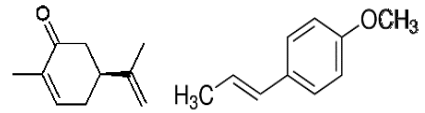
PREDATORS

PATHOGENS



PARAZITOIDS

BOTANICALS



Research objectives (II)

Field production

storage:
Silos
Warehouses

Food processing

Packaging

Distribution

Biological Control

Developing sustainable management systems compatible with the environment to allow the production of safe and high-quality food, improving the natural control of pests with the promotion of biodiversity and biological control

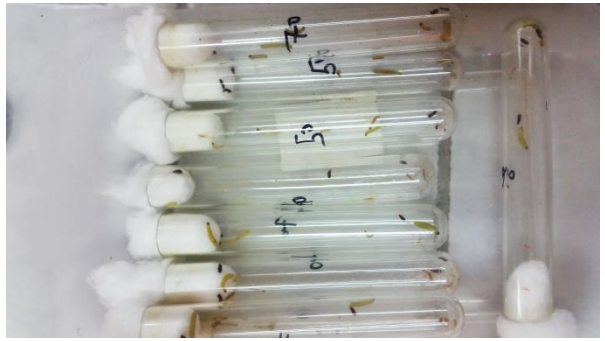
BOTANICALS

DIFFERENT RAW MATERIALS

- Invasive plants extracts
- Post-harvest residues extracts
- Essential oils
- Medicinal and aromtic plant extracts
- Minor-crops extracts

BIOLOGICAL ACTIVITY OF BOTANICALS

- Fumigant
- Repellent
- Contact toxicity
- Contact-digestive



agronomy
MDPI
Article

Phytotoxic and Insecticidal Activity of Industrial Hemp (*Cannabis sativa* L.) Extracts against *Plodia interpunctella* Hübner—A Potential Sunflower Grain Protectant

Dejan Prvulović [1,*], Sonja Gvozdenac [2,*], Dragana Latković [1], Marijana Pejić Tukuljac [1], Vladimir Sikora [2], Biljana Kiprovski [2], Aleksandra Mišan [3], Antonios Chrysargyris [4], Nikolaos Tzortzakis [4,*] and Jelena Ovuka [2]

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Abstract: The biological activity (contact and contact-digestive toxicity, repellent and fumigant effects, effect on the insect's development and life cycle parameters) of industrial hemp (*Cannabis sativa* L.) ethanolic extract was assessed against *Plodia interpunctella*, the most destructive storage pest of sunflower. Additionally, the study aimed to examine the phytotoxic activity of the extract in order to assess its potential as a sunflower grain protectant. Phytotoxicity assessment was based on the effect on germination energy and seed germination and the activity of antioxidative enzymes, enzymes of the polyphenolic metabolism, and the intensity of lipid peroxidation in sunflower seedlings. The antioxidant capacity and content of phenolic compounds (total phenolics and t… also measured in seedlings. In the experiments, 70% ethanolic extract of dried … industrial hemp (variety Helena) was applied at 0.5%, 1.0% and 2.0% concentr… sunflower seeds. Ethanol solution (70%) was the control. The hemp extract (1%… medium repellence for *P. interpunctella* larvae (L_{3-4}) while at 2% concentration it c… mortality after 72 h. Moreover, the insect's development was prolonged and fecu… reduced in hemp treatments. The extract did not exhibit fumigant activity. Germi… germination of sunflower seeds were stimulated in treatment with 2% hemp e… biochemical parameters of the seedlings were not significantly affected by the her…

check for updates

Citation: Prvulović, D.; Gvozdenac, S.; Latković, D.; Pejić Tukuljac, M.; Sikora, V.; Kiprovski, B.; Mišan, A.; Chrysargyris, A.; Tzortzakis, N.; Ovuka, J. Phytotoxic and Insecticidal Activity of Industrial Hemp (*Cannabis sativa* L.) Extracts against *Plodia interpunctella* Hübner—A Potential Sunflower Grain Protectant. *Agronomy* **2023**, *13*, 2456. https://doi.org/10.3390/agronomy13102456

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Keywords: fiber hemp; *Cannabis sativa* L.; phytotoxicity; sunflower; *Plodia interpu…*

1. Introduction

Economic loss caused by insects is one of the main problems in the po…

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DOI: 10.1111/eea.13325

Entomologia Experimentalis et Applicata

ORIGINAL ARTICLE

Effect of four plant extracts on the mortality, populatio… growth, and fluctuating asymmetry of *Sitophilus oryzae*

Jelena Ačanski[1] | Sonja Gvozdenac[2] | Marko Radenković[3] | Dejan Prvulović[4] | Snežana Tanasković[5] | Mladen Horvatović[3]

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Abstract
Management of storage pest insects relies heavily on chemical contr… a need to develop more sustainable management practices. Here, w… impact of 2% ethanol plant extracts of *Ajuga reptans* L., *Ajuga pyra…* Lamiaceae), *Urtica dioica* L. (Urticaceae), and *Cannabis sativa* L. (Canna… on mortality, population growth, and developmental stability [measu… asymmetry (FA)] of the rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: C… worldwide stored product pest. FA refers to small, random deviation… tween the left and right sides of bilaterally symmetrical organisms; t… increase in response to environmental stress, making FA a reliable m… ure the impact of stress. FA was measured by means of geometric m… a method that allows for analyzing the whole landmark configuratio… rather than taking single measurements. Extracts of the mentioned pl… to treat maize (*Zea mays* L., Poaceae) kernels on which experiment… of the rice weevil were grown, and we assessed mortality after 24–7… growth after 30–90 days, and developmental stability after 90 days. S… says showed that *S. oryzae* adults were most affected by *Ajuga extra…* especially *A. reptans*, significantly reduced population growth. In conc… extracts increased FA. The effects of *U. dioica* and *C. sativa* extract… nounced. None of the extracts significantly affected insect mortality. C… concluded that *A. reptans* and *A. pyramidalis* are potential sources of… pounds that may be further used for *S. oryzae* control. The results ob… that variation in body shape asymmetry can be used as an indicator of population disturbance when insects are exposed to different types of stressors.

sciendo
Contemporary Agriculture
Serbian Journal of Agricultural Sciences
Faculty of Agriculture, University of Novi Sad, Serbia
www.contagri.info

Original scientific paper

UDC: 665.5
DOI: 10.2478/contagri-2021-0020

REPELLENT ACTIVITY OF *CYMBOPOGON CITRATUS* ESSENTIAL OIL AGAINST FOUR MAJOR STORED PRODUCT PESTS: *PLODIA INTERPUNCTELLA, SITOPHILUS ORYZAE, ACANTHOSCELIDES OBTECTUS* AND *TRIBOLIUM CASTANEUM*

SONJA GVOZDENAC[1], BILJANA KIPROVSKI[1], MILICA AĆIMOVIĆ[2], JOVANA STANKOVIĆ JEREMIĆ[2], MIRJANA CVETKOVIĆ[2], VOJISLAVA BURSIĆ[3], JELENA OVUKA[1]*
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SUMMARY

The purpose of this study is to assess the repellent activity of lemongrass (Cymbopogon citratus) essential oil (EO), grown in Serbia under greenhouse conditions, against four prevalent stored product pests: Plodia interpunctella (larvae), Sitophilus oryzae, Acanthoscelides obtectus and Tribolium castaneum (adults). The lemongrass EO repellency was tested using filter paper in Petri dishes and a Y-tube olfactometer. According to the repellency index (RI), the lemongrass EO repellency was divided into 5 classes. Prior to biotesting, the chemical characterization of lemongrass EO was performed and the following main compounds were detected: myrcene (31.0%), geranial (30.0%), and neral (23.6%). The C. citratus EO considered was found to exhibit the Class III repellent activity against P. interpunctella larvae only at the highest concentration (namely 0.5%). This is the very first report on the C. citratus EO repellent activity against this pest. The lemongrass EO examined showed strong repellency (Class IV) against S. oryzae (0.2% and 0.5% of EO), A. obtectus (0.1% and 0.2%), and T. castaneum (0.05-0.1%). Moreover, higher lemongrass EO concentrations (0.5%) were found to exhibit extreme repellency (Class V) against A. obtectus and T. castaneum. The results obtained were confirmed in the bioassays performed, indicating the great potential of lemongrass EO as a bio-repellent when applied in higher concentrations to all the insects considered, regardless of the exposure period.

Key words: essential oil, lemongrass, biological activity, repellency, storage pests

Abbreviations: essential oil (EO); relative humidity (r.h.); repellency index (RI)

INTRODUCTION

Stored product pests have unique attributes that justify the need for specific control measures. Chemically synthesized insecticides have been used for decades to control harmful insects in storage facilities. However, these compounds have caused a number of negative effects such as environmental pollution, food and feed residues, ozone depletion, insecticide resistance, as well as human and animal health issues (Zettler & Arthur, 2000; Prado, 2003; …

- **Insecticidal Potential of Plant Powders from Invasive Alien Plants against Rice Weevil under Laboratory Conditions**

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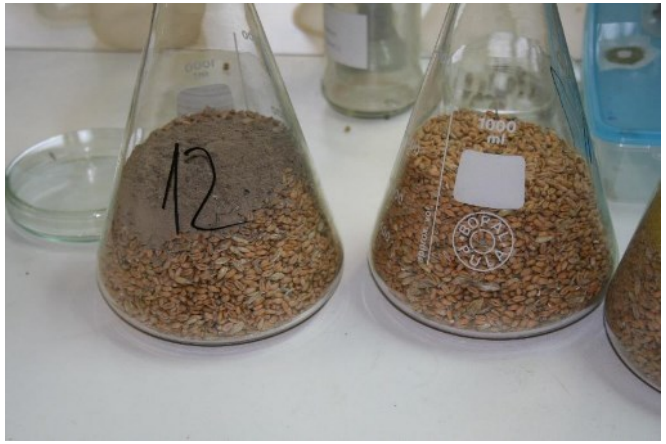


CRI

CRI is conducting research on **protective packaging** of commodities and food: plant extracts as repellents

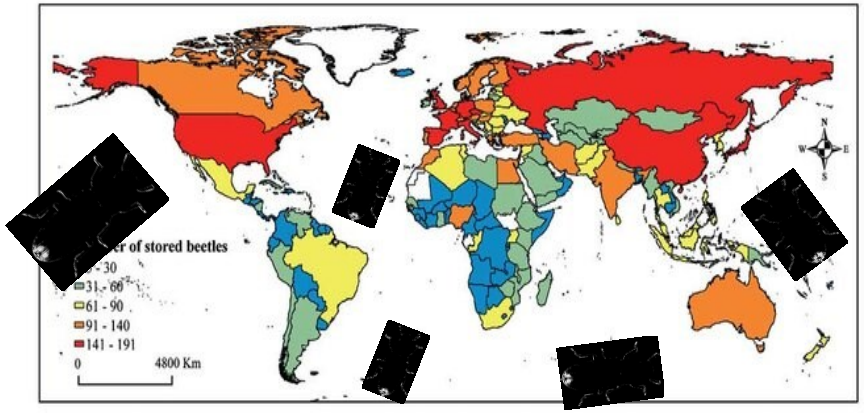
Fumigation of grain with essential oils in containers

Treatment of primary, secondary, and tertiary packaging with repelent plant oils

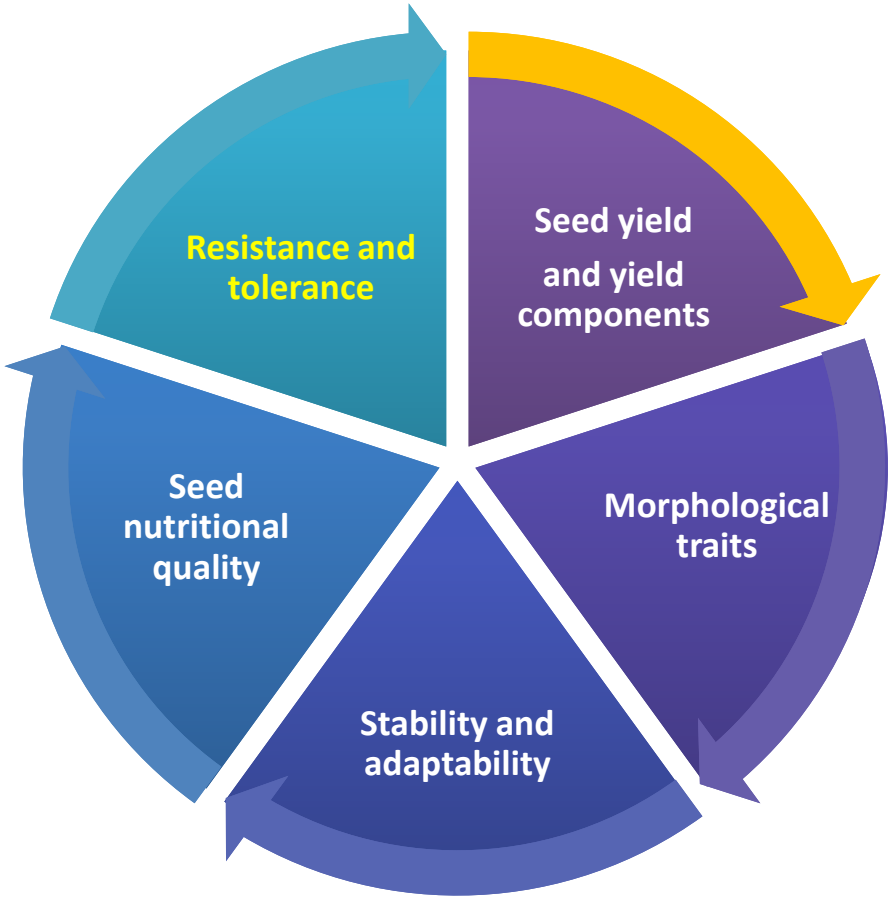
Vendl, T., Stejskal, V., Kadlec, J., & Aulicky, R. (2021). New approach for evaluating the repellent activity of essential oils against storage pests using a miniaturized model of stored-commodity packaging and a wooden transport pallet. *Industrial Crops and Products*, 172, 114024.

CAU (Beijing) and CRI elaborated maps of worldwide distribution of storage pests and risks of their future geographical spread

Qin, Y., Stejskal, V., Vendl, T., Zhang, Y., Li, T., Ullah, F., ... & Li, Z. (2023). Global analysis of the geographic distribution and establishment risk of stored Coleoptera species using a self-organizing map. *Entomologia Generalis*, 337-347.



Breeding for tolerance



Breeding objectives

Genetic variability

WEAK POINTS OF CULTIVATED CROPS:

- NARROW GENETIC VARIABILITY
- DEFFICIENCY OF DESIRABLE GENES

INCREASE OF GENETIC VARIABILITY:

a) Using wild species

b) Open pollinated varieties

c) Mutations

d) Target crossing

Induced mutations

- changes in the genetic material caused by different chemical or physical means
- mutation breeding
- Mutagens: physical (X, γ, neutrons)
  chemical (ems, dms, sa)
- Mutational analysis:
  - Phenotype to gene (forward genetics): a wide array of characterised morphological mutants
  - Gene to phenotype (reverse genetics): until now no widely available resources

NEW GENETIC VARIABILITY IN SUNFLOWER INBRED LINES CREATED BY MUTAGENESIS

ABSTRACT

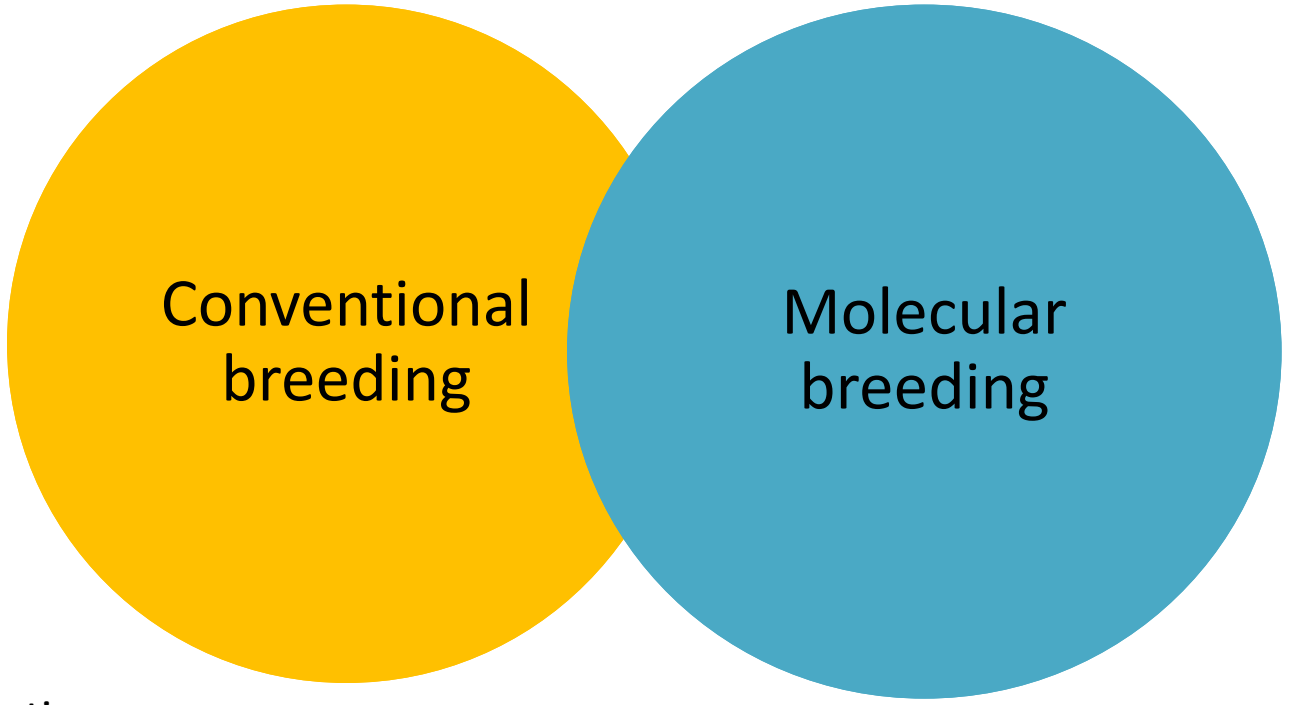
RESEARCH ARTICLE

The challenges of maintaining a collection of wild sunflower (*Helianthus*) species

Scientia Horticulturae

Genetic variability for concentrations of essential elements in tubers and leaves of Jerusalem artichoke (*Helianthus tuberosus* L.)

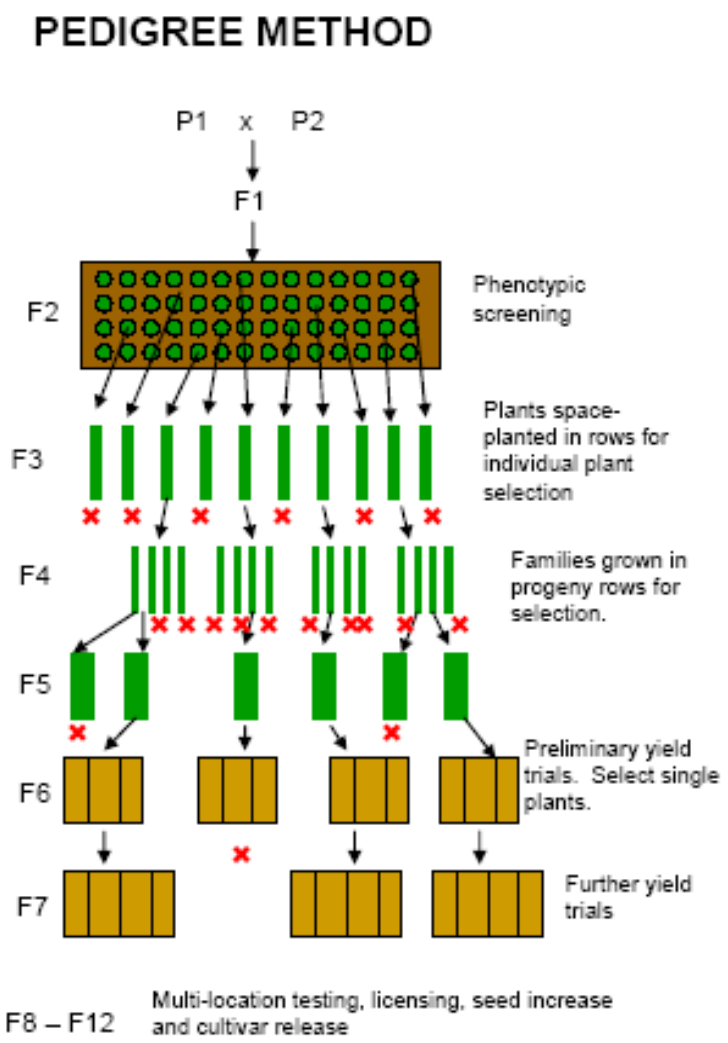
Breeding methods

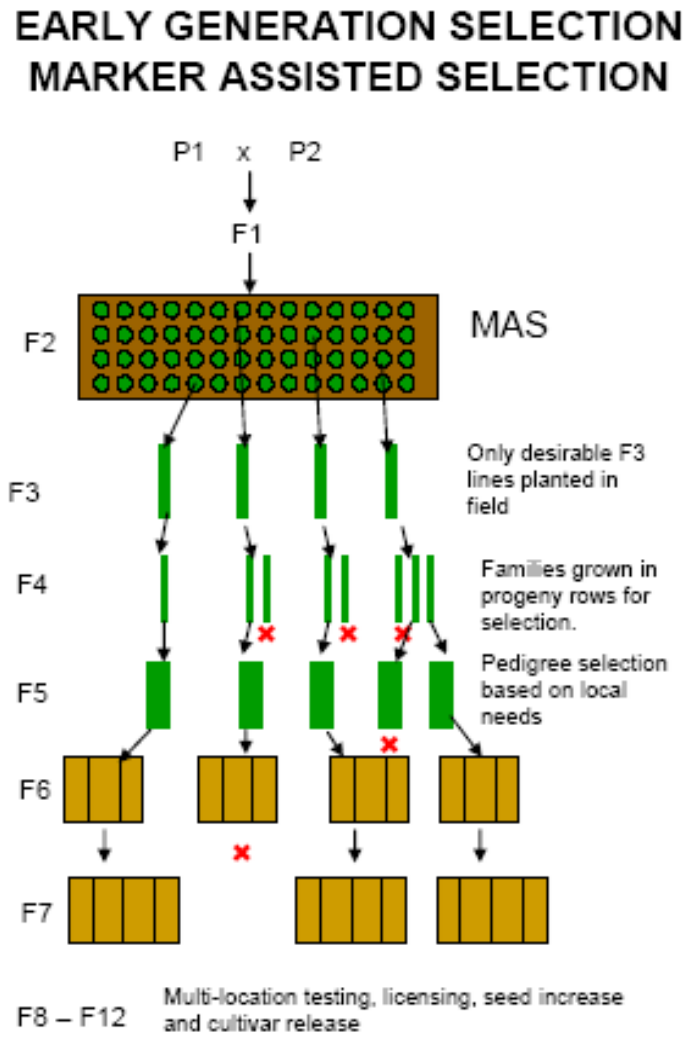


- Mass selection
- Individual selection
  - Bulk selection
  - Pedigree method
  - Single seed descend
  - Back-cross method

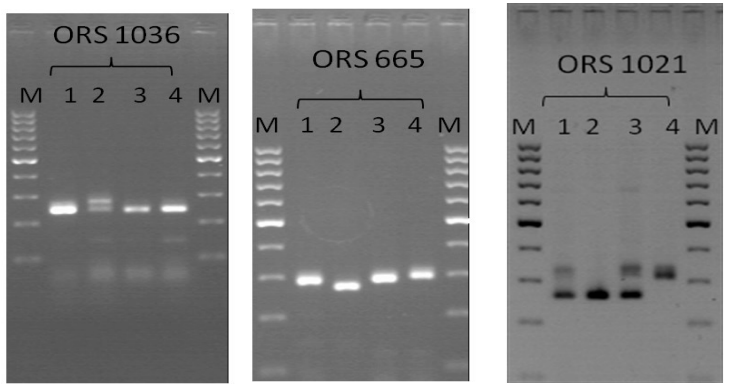
- Marker assisted selection (MAS)
- Genomic selection (GS)
- Genome editing
- Genetic modification –Transgenic plants

MAS – identification of genotypes with specific gene



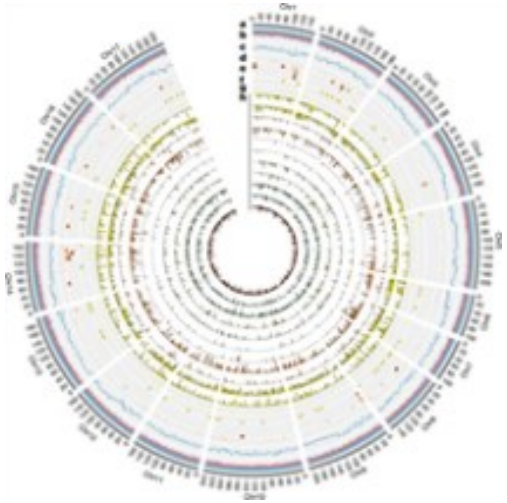


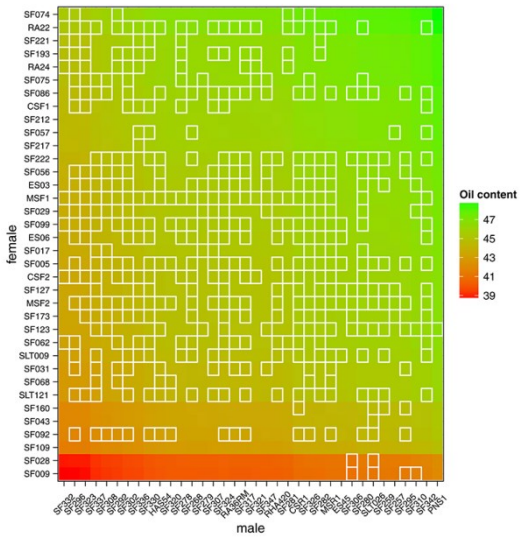
- Mapping a new gene that controlles tolerance
- Reliable only for mongenic tratis
- SSR , SNP
- AFLP., RFLP., CAPS markers

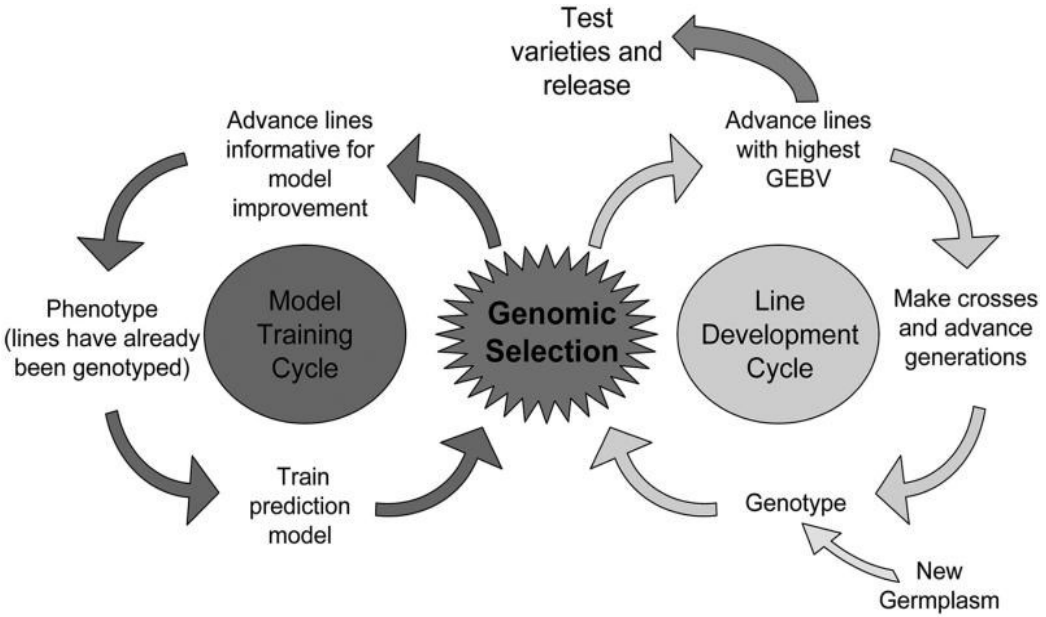


Genomic selection

- GS = Genome-wide prediction
- Method for improvement efficacy of selection of plant quantitative traits
- GS uses genotypic and pheontypic data from the population to calculate quantitative value of each individual as a parent for future breeding cycles – it is called genome-estimated **breeding value**
- **Suitable for poligenic traits** (Quantitive Trait Loci -QTL markers)
- MAIZE genom sequenced
- BEAN genom sequenced
- SUNFLOWER genom sequenced (used to predict hibrid performances (Reif et al. 2013), oil content in hybrids (Mangin et al. 2017) and *Sclerotinia* tolerance (Livaja et al. 2016).

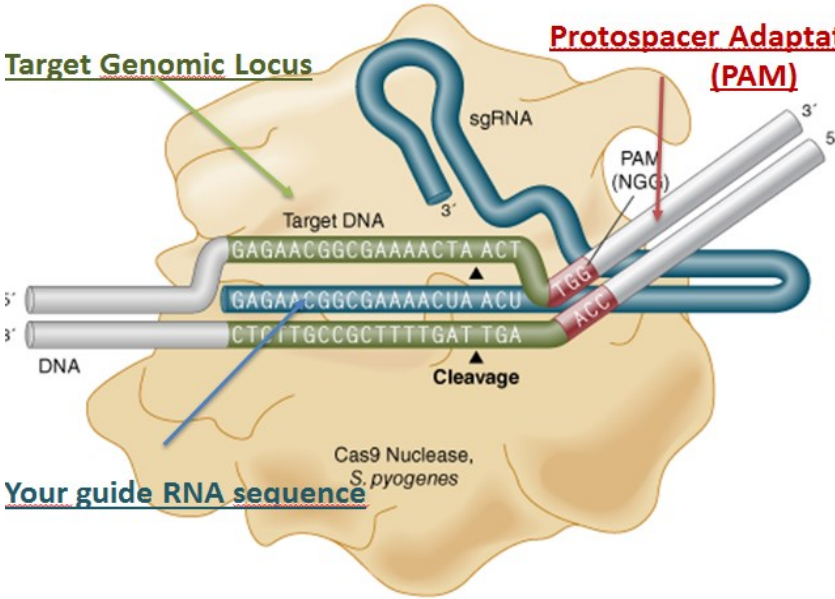






Genome editing

- In 2016 Nobel prise (in Medical sciences)
- Group of laboratory techniqes that change DNA structure (insert gene of interest in DNA structure) at a molecular level
- CRISPR-CAS9 – new genomic tool for locating a region of interest
- In EU the application and even research was arguable



Cas9 nuclease:

- Recruted by sgRNA complementary to specific region of interest
- Generates double strand break DNA

E. Charpentier/J. Doudna

Breeding for SPP tolerance

Antixenosis (a non-preference) - a plant characteristic poses a chemical or biophysical barrier that deters or repels the insect without causing it harm.

Antibiosis is a process of biological interaction between two or more organisms that is detrimental to at least one of them.

It reduces the survival and reproduction of the insect or prolongs the time between generations; reduces the rate of initial insect population.

Tolerance - plants have the ability to grow and yield even when attacked by the pest (or a resistance in which a plant is able to withstand or recover from damage caused by insect pest equal to that damaging a plant without resistance characters (susceptible).

Breeding for SPP tolerance in practice – Maize case

Genetic bases

- Maize weevil resistance has been reported to be under the control of ADDITIVE and NON-ADDITIVE GENE ACTION
- The involvement of GENES WITH ADDITIVE EFFECTS for resistance suggests that grain weevil resistance is controlled by **minor polygenes** and CAN BE improved by selection
- differences of 16–49% for maize weevil resistance between divergently selected maize populations, demonstrating the possibility of improving grain weevil resistance by selection
- Promising inbred lines and experimental crosses identified can be effectively utilized in the resistance breeding programme

Breeding for SPP tolerance in practice – Bean case

Genetic bases

- Detected markers that are common for bean resistance to weevils.
- The researchers found **three regions of bean DNA** important for weevil resistance.
- Three QTL for resistance to *A. obtectus* were identified on chromosomes Pv04 and on Pv06
- One of the QTL on Pv04, named as AO4.1^{SA}, was previously reported as the arcelin, phytohemagglutinin and α-amylase, (APA) resistance locus

Key steps prior to breeding proces

- Identify and define traits responsible for seed tolerance to SPPs
- Identify which genes are responsible for certain trait
- See if a trait is regulated by one or more gene (monogenic or poligenic trait)
- Choose/ Define tolerant lines/genotypes as candidates for breeding
- Make genome-wide prediction if possible

SafeSeed
New biorational methods for stored seed pest control and protection
Фонд за науку Републике Србије

UDC 633.15:631.563
632.782
Original research paper
doi:10.5937/AASer1845003G
Acta Agriculturae Serbica, Vol. XXIII, 45 (2018): 3-13

Acta Agriculturae Serbica
FACULTY OF AGRONOMY ČAČAK

Suitability of different maize hybrids for development of *Plodia interpunctella* (Hübner)

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Abstract: *Plodia interpunctella* (Hübner), the Indian meal moth (IMM), is a major lepidopteran storage pest worldwide. IMM larvae can be found in high abundance in stored maize and cause huge losses in seed germination and seed viability. This work aimed to assess the susceptibility of six maize hybrids (NS 6140, NS 640, NS 1090, NS 444 - dent type, NS 620k - pop-corn type, Red-aleurone maize - maize with an altered aleuron color) to IMM attack and suitability for pest's development. Standard laboratory diet (SLD) was used as a positive control. Under laboratory conditions, the following IMM life history parameters were monitored: larval mortality, mean developmental duration (egg to adult), [illegible] susceptibility was deter[illegible] mortality of IMM larvae [illegible] (11.2–19.5%). The highes[illegible] and the lowest on NS 62[illegible] NS 6140 and NS 640 (8.[illegible] on SLD (115.8 eggs), on

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Life history of *Plodia interpunctella* Hübner on sunflower seeds: Effects of seed qualitative traits and the initial seed damage

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ABSTRACT

Sunflower seeds are regularly infested by *Plodia interpunctella* d
damaged seeds, in practice it can infest undamaged seeds as wel
the sunflower seed type (oil, protein for human consumption an
during post-harvest processing (dehulled kernels, 10, 20, 30% o
on development of *P. interpunctella* (larval mortality, larval deve
adult emergence and fecundity). Biochemical analysis of seeds
content of phenols in the seed and hull and tocopherols in the
oxidative activity was the highest in the seed, kernel and hul
shortest development (39.5 days) and the highest fecundity (91
longest development (42.1 days) and the lowest fecundity (68.1)
bird feed. The highest mortality of larvae was on the undamage
and human consumption (21.3% and 14.0%, respectively). The t
damage affected larval mortality, developmental duration ar
duration and the number of emerged adults were dependent o
component analysis detected strong positive correlation betwe
tocopherol content on the undamaged seeds while fecundity wa
the amount of tannins, proteins and oil content in the seed. The
the bird feed were the least suitable for the development of this
most suitable.

Suitability of three different legumes for *Acanthoscelides obtectus* development and population growth

Pogodnost tri različite vrste leguminoza za razviće i rast populacije *Acanthoscelides obtectus*

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ABSTRACT

Legumes are a rich source of valuable nutrients thus represent important component in human and animal nutrition. The most important and often a limiting factor in legume production is the presence of seed pests, such as the bean weevil *Acanthoscelides obtectus* (Say, 1831). This work tested the suitability of three different legume species (common bean, faba bean and grass pea), the species with a growing interest in the human diet, for the development of the bean weevil, aiming to provide a reliable forecast of its population growth. After four months, been weevils consumed the highest percentage of the common bean kernels (70.79%), followed by the grass pea (53.13%), and faba bean (0.42%). [illegible] growth were significantly affected by the tested legume species. After each [illegible] the highest on the common bean, indicating its best suitability for the weevil's [illegible] the emerged specimens after each month of the observation, the bean weevil [illegible]ntinuous also on the grass pea. The lowest number of emerged adults, in all [illegible] indicating its low preference and suitability for the weevil's development. The [illegible] as the highest on the common bean, followed by grass pea, and it fitted best to [illegible]led the prediction of the population growth of the bean weevil for each legume

Suitability of Poaceae seeds for *Plodia interpunctella* development

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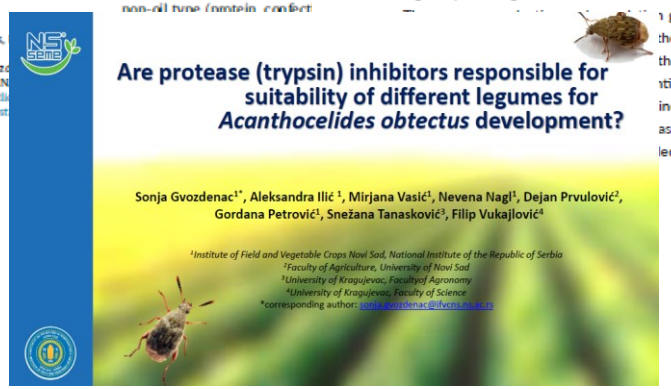
Abstract

One of the most important pests of stored grains is *Plodia interpunctella* (Hübner), whose larvae feed primarily on germinal part of the kernels, causing a reduction of seed germination and seed viability. This is detrimental for seeds of high category. However, seeds of different species within the same taxonomic family have different morphology (thickness of seed-coat, presence or absence of palea, palea loose or firmly attached to the seed etc.), which affects the susceptibility of seeds to *P. interpunctella* attack. The hypothesis was that seed hardness and the absence of palea could also significantly influence the life history of this pest. We assessed the suitability of different seeds from family Poacae (maize, wheat, barley, oats, ray, forage sorghum (variety), forage sorghum (hybrid), Sudan grass and millet) for *P. interpunctella* development and seeds susceptibility to pest attack (expressed in Susceptibility index –SI). The following parameters were monitored: larval mortality, adult emergence, mean developmental duration (from egg to adult) and female fecundity. Observations were carried out weekly, for 49 days. Data were statistically analyzed using Duncan's multiple range Test. The highest larval mortality, the lowest number of emerged moths and the lowest fecundity were recorded on millet, Sudan grass

[illegible]uus L.) is the most important oil [illegible] one of the four major oil crops in [illegible]; Balalić et al., 2012). According to

FAO estimates, it is cultivated [illegible] than 70 countries (FAOSTAT, [illegible] duction in 2016 was 34.0 m [illegible] compared to 2014, followed b [illegible] and 2016 (FAOSTAT, 2016). Tw [illegible] cultivated: the oil type for the [illegible] non-oil type (protein confect

[illegible]sid and Vegetable Crops, [illegible]ad, Serbia. [illegible]vcns.ns.ac.rs (S.M. Gvozd[illegible] [illegible]dovanovic@kg.ac.rs (M.N[illegible] [illegible]Ovuka), vladimir.miklic[illegible] [illegible]n (J.M. Acanski), st[illegible] [illegible]. Vukajlović).

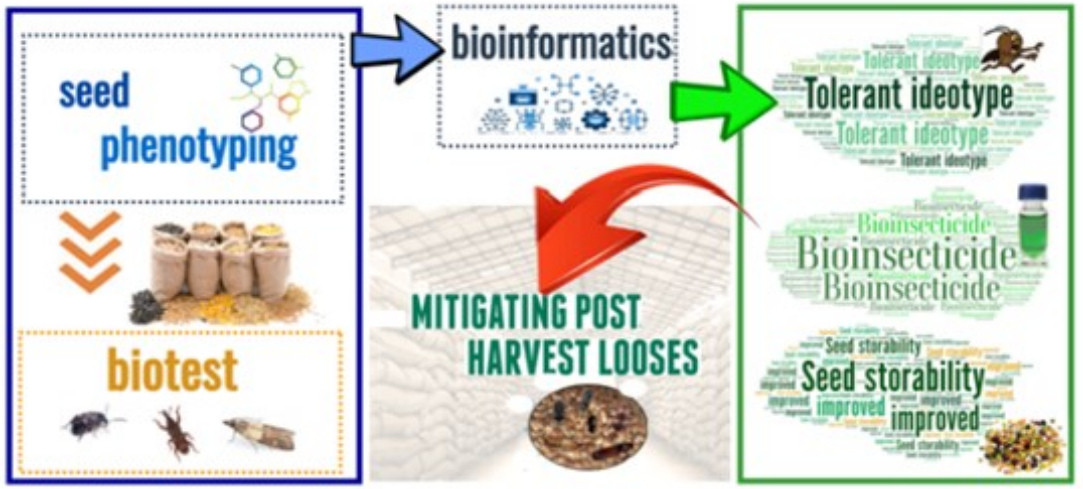


- **The suitability of wheat grain and grain of three less common cereals as hosts for the rice weevil**

UNIVERSITY OF LJUBLJANA | BF Biotechnical Faculty

SafeSeed

New biorational methods for stored seed pest control and protection



Climate Crops

CONCEPT

- 10 crop species (maize, whear, barles, oat ,rye , pselt, sunflower, bean, faba bean, grass pea)
- Over 30 genotypes of each crop species
- Detailed biochemical analysis (macromolecule cotnent, micromolecule cotnetn, antiox. stress componenets...)
- Phenotipization (mprphological and anatomical characteristics)
- Genetic analiysis
- Metabolomic and proteomic analyis (poliains and protease inghibitors, protein composition)
- Machine learning and artifical networks - TOLERANT IDEOTYPE
- Insects (*S. oryzae, P. interpunctella, A. obtectus, T. castaneum, R. dominica*)
- TRAITS: life cycle parameters (MDD, fecundity, progeny production...), feeding indices, mortality, population growth models etc.

Фонд за науку Републике Србије

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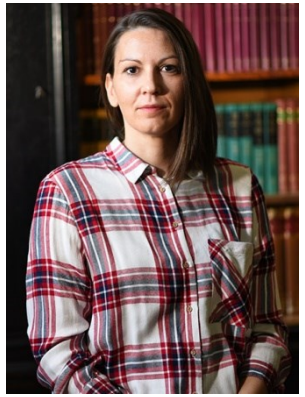





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Фонд за науку
Републике Србије

Climate Crops

Future Prospects in Breeding for SPP toleranace

On improved phenotypic strategies and analytics:

- sequencing and genotyping costs continue to drop, phenotyping has been highlighted as one of the most costly and major limitations to the precise mapping of traits in plant breeding
- Need to develop and utilize next-generation phenotyping platforms that facilitate the accurate, low-cost, and timely acquisition of phenotypic data for enhancing the data quality
- The application of modern analytics is vital to maximizing phenotypic data outputs. For instance, the analysis of data using mixed models would enhance the heritability values for genomic analyses, ML ad AN.

Advances in plant bio-chemistry:

- the use of plant biochemistry for revealing the basis of pest resistancee to SPPs
- low-cost analysis throughput platforms such as near-infrared spectroscopy (NIRS) are required, since wet chemistry platforms like liquid chromatography mass spectrometry (LC-MS) are still costly for chemical resistance profiling.

Advances in genomics:

- It is currently more important than ever that more molecular markers, particularly SNPs, are identified since this would fasten genomic breeding for SPP resistance
- The completion of the whole-genome sequencing of cultivated crops in the near future will further enable the maximum exploitation of the genomics-assisted selection

Take away massage!

- Host plant resistance is a very promising approach for SPP management.
- Attempts to develop resistant cultivars have yielded in case of maize (USA) and legumes (Asia and Africa)
- The underlying genetic and bio-chemical basis for resistance has been understood to some extent and molecular markers such as SNPs have been developed, though still not being fully utilized in breeding.
- More effort will be needed by breeders to develop additional markers for mapping SPP resistance to facilitate marker-assisted selection and genomic selection.
- Moreover, the global advancements in seed phenomics, protemics, biochemistry and matabolomicas will eventually bring forth cutting-edge approaches for seed improvement that will eventually lead to accelerated genetic gains in breeding for resistance to SPPs.

Thus breeding of resistant cultivars is the most appropriate approach to achieve durable and efficient levels of resistance that meet the requirements of the agri-food sector and promote sustainable agriculture.

Thank you for your attention

SafeSeed
New biorational methods for stored seed pest control and protection

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