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novIGRain

Market Study	
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Dissemination Level	
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MARKET STUDY H2020 – STEP 1

Stored grains cereals – 6 European countries

France, Germany, Spain, Italy, Hungary, Romania

Resume

Study dedicated to BABOLNA BIO
H2020 Program
Development of a new solution against stored grains cereals insects

STEP 2 Update

Done on 28 October 2024

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Context of the study

- Babolna is implicated in European Program H2020, program used to promote R&D projects
- In this program, Babolna would like to develop a new active substance in the field of plant protection in EU, more precisely in the protection of grains stored cereals against some invasive insect species
- The project is double and consists in an innovation of a less toxic, novel stored grain protectant and a versatile application system

Objectives of the study

- Babolna needs to perform a market study in the grains stored cereals domain
- This market study will give an overview of the economic potential of the new solution application system developed as part of the project

Plan of the study

- The plan of the market study is well established and valid for 6 countries:

France, Germany, Spain, Italy, Hungary, Romania

- The plan is the following one per country:

1) STORED GRAINS CEREALS GENERAL DATA

a) Volume of cereals produced
b) One big cereals producer
c) Volume of stored grains cereals
d) Volume of treated stored grains cereals
e) Storage sites + how are stored the grains (on-farm, off-farm, export shipments)

2) FOCUS ON SPECIFIC STORED GRAINS CEREALS: WHEAT, BARLEY, OAT, MAIZE, RICE

a) Estimated volumes of each stored grains variety
b) Treatment used for each stored grains variety
c) Speed of grain rolling (incoming, stored, outgoing)

3) STORED GRAINS CEREALS INVASIVE SPECIES

a) Occurrence & Percentage of damages
(Sitophilus oryzae, Sitophilus granarius, Sitophilus zeamais, Rhyzopertha dominica, Oryzaephilus surinamensis, Indian meal moth)

4) STORAGE ON BIGGER SCALES

a) Types of storage facilities
b) Biggest site of storage for the exported cereals
c) Several non-EU countries from where cereals come from (=import)
d) Industry mapping in grains storage

5) POTENTIAL USERS OF THE NEW SOLUTION

a) List of companies buying the product (appliers, users)

6) CONTROL MEANS AVAILABLE (+ BOUNDARY CONDITIONS)

a) Focus on insecticides used within the market for indoor, post-harvest grain treatment
b) Focus on fumigation and powder formulation
c) Alternative methods and possible solutions in the future
d) Boundary conditions = specific limitations & restrictions

Methodology of the study

In order to conduct the market study asked by Babolna Bio (novIGRain Consortium) to IZInovation, IZInovation constituted a working group composed of 3 people. The working group performed the market study according to the following methodology to collect the different data:

- Existing literature on the topic: articles, surveys, ministries
- Interview of people (experts, researchers, consultants, business organizations, ministries) on the topic
- Private sources on the topic

The SWOT written by IZInovation for the market study is available because some data will be missing in the report, or too old, however authors attempted to update these in 2024.

Contents of the study report

- A general part with European data will be described even if it's not asked by Babolna.
- Babolna asked for 2021 data but IZInovation added also previous periods in order to be more complete.
- The report will include the data asked in the proposed plan.
- The report will be divided in 3 PARTS, based on the map below (Figure 1):
  - √ **PART 1: FRANCE, GERMANY**
  - √ **PART 2: SPAIN, ITALY**
  - √ **PART 3: HUNGARY, ROMANIA**

Figure 1 : Presentation of a map with the 3 PARTS of the report

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Preface

Cereal production is one of the oldest achievements of the agricultural mankind in Europe. It has been a matter of life and death, well-being and tragedies of hungers. By time, the cultivated area, the yield, the varieties of cereals have increased and even today are increasing. On the other, hand more and more chemicals are being used to keep up and increase the quantities and shelf life of unprocessed cereals.

Today's active substances used for **post harvest crop protection**, are organo-phosphates, syntehtic pyrethroids, pyrethrins, phosphides, Spinosad and diatomaceous earth. Although their mode of action differs, all of these actives have a strong killing effect, in most cases from early stages up until the mature stages.

Because of the periodical review of active substances in the EU, one may never know in advance if an active and its formulations will pass the rigorous re-evaluation of the authorities. It is most likely that one, or two actives will be lost within a short period of time. The smaller number of active remains available, the more is used, that increase the speed and build-up of insecticide tolerance and resistance.

Since the introduction of Spinosad no novel active ingredient has appeared in crop protection.

One of the foremost aims of the **novIGRain** project and consortium is to prepare the later introduction of a new class of insecticidal control, based on **S-methoprene** insect growth regulator. IGRs have no killing effect on mature stages, but are very effective in preventing the development of the earliest stages of a number of insects to mature and sexually viable adults. The circulation of reproduction hence interrupted which breaks the infestation, or keep the infestation at bay. Using S-methoprene based formulation alone or in parallel treatment with other adulticide gives an outstandingly better chance for crop protection after harvest.
The toxicological and environmental profile of **S-methoprene** is more favourable than the currently used insecticides and fumigators.

S-methoprene IGR based crop protectants are widely used in the USA, Australia, New Zealand. We believe that the European Union, even if having quite a number of adulticide available, it is the right time to broaden the range and have a larvicide introduced.

The current market study draws a background of the European cereal production, warehousing, transporting, treatments etc. in order to give ideas where and how the novel insecticide and spraying technology will fit.

EUROPE

Introduction

EUROPE (EU) is one of the world's largest producer and trader of cereals.
More than half of the cereals grown in the EU are wheat. The other half is made up of one third maize and one third barley. The remaining third includes cereals grown in smaller quantities, such as rye, oats and spelt.
Cereals grown in the EU are mainly used for animal feed (almost two thirds); one third is used for human consumption, while only 3% is used for biofuels.

Regarding the rice: About two-thirds of the rice consumed by Europeans is grown in the EU. The rest is supplemented by imports of different varieties, for example from India or Cambodia. A small amount of EU-grown rice is exported.

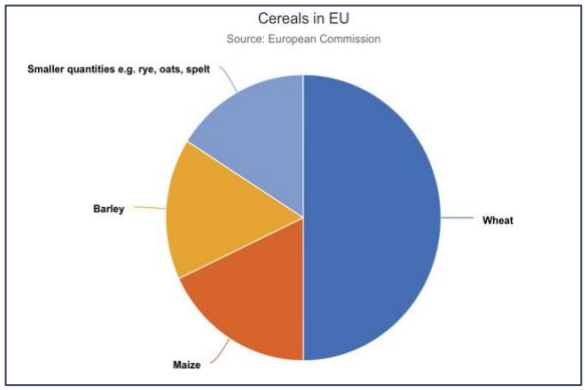


Figure 2: Cereals Production in EU

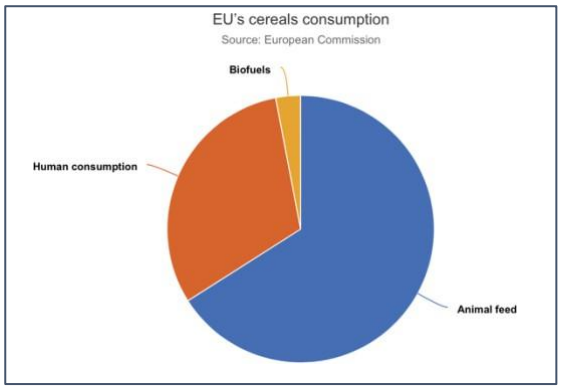


Figure 3: EU's cereals consumption

The EU exports about 20% of its wheat production annually and imports large quantities of oilseeds, animal feed and rice.[1]

1) Cereals Production in Europe

The Figure 4 below presents the distribution of cereals production in Europe.
France is the largest producer of common wheat (=soft wheat) & barley, Romania for the grain maize production, Germany appears as the largest producer of rye and winter cereals, Poland for the oats production.

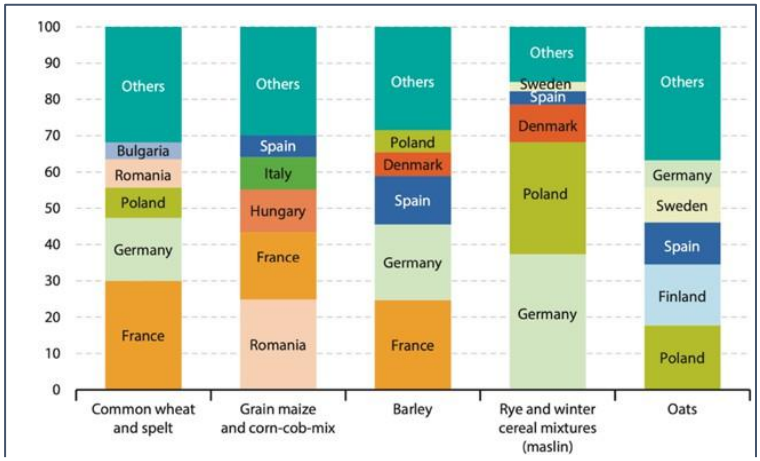


Figure 4 : Cereals production by main producing European Member States, 2019 (% share of EU-27 totals)

Here below are presented the COP (Cereals, Oilseed complex, Protein crops) production for EU27 & EU28 (Table 1 & Table 2). As an interesting document (*2014-2015 data*)[2] mentioned the storage capacity for COP but not for Cereals only, it was interesting to insert production data.

Table 1: COP Production for EU28

Production EU28 (Thousand T)	2014/15*	2015/16*	2017/18	2018/19	2019/20	2020/21	2021/22
Cereals	330 942	314 351	307 959	292 357	322 532	n.a	n.a
Oilseed complex	35 466	32 143	35 225	32 930	30 214	n.a	n.a
Protein crops	2 845	4 402	5 183	3 586	3 969	n.a	n.a
Total	369 253	350 896	348 367	328 873	356 715	n.a	n.a

Table 2: COP Production for EU27

Production EU27 (Thousand T)	2014/15*	2015/16*	2017/18	2018/19	2019/20	2020/21	2021/22
Cereals	306 503	289 626	284 960	271 272	297 015	280 365	295 108
Oilseed complex	32 967	29 572	33 012	30 875	28 435	27 922	30 402
Protein crops	2 271	3 482	4 252	3 078	3 262	3 541	3 737
Total	341 741	322 680	322 254	305 225	328 712	311 828	327 247

**(EU27 is without UK)*[3]

2) COP importations vs COP exportations in EU[2]

The Table 3 below presents the trade position in COP sector of the 6 studied countries. France, Romania & Hungary are mainly exporters compared with Germany, Spain & Italy, which are mainly importers.

Table 3: Trade positions in COP sector for the 6 studied countries

Member states	Net Trade Position
FRANCE	EXPORTER
GERMANY	IMPORTER
SPAIN	IMPORTER
ITALY	IMPORTER
ROMANIA	EXPORTER
HUNGARY	EXPORTER

The Table 4 below presents approximately the repartition of COP imports & COP exports for EU28.

Table 4 : Repartition of COP imports & COP exports for EU28

	Average annual COP IMPORTS in EU (2005-15)	Average annual COP EXPORTS in EU (2005-15)
Total	125 million T (mT)	107 million T (mT)
Extra-EU	42%	70%
Intra-EU	58%	30%
	LEADING COP IMPORTER COUNTRIES	LEADING COP EXPORTER COUNTRIES
Extra-EU	Netherlands, Spain, Italy	France, Germany, Romania
Intra-EU	Netherlands, Germany, Belgium	France, Germany, Netherlands

This repartition shows that EU exports more in intra-EU countries (70%) compared with exportation to extra-EU countries (30%). Regarding the importations, it's a little bit more important in intra-EU countries compared with extra-EU countries.

The Figure 5 below presents the repartition of COP Import (left) compared with the repartition of COP Export (right) for the 6 studied countries & for the EU28.

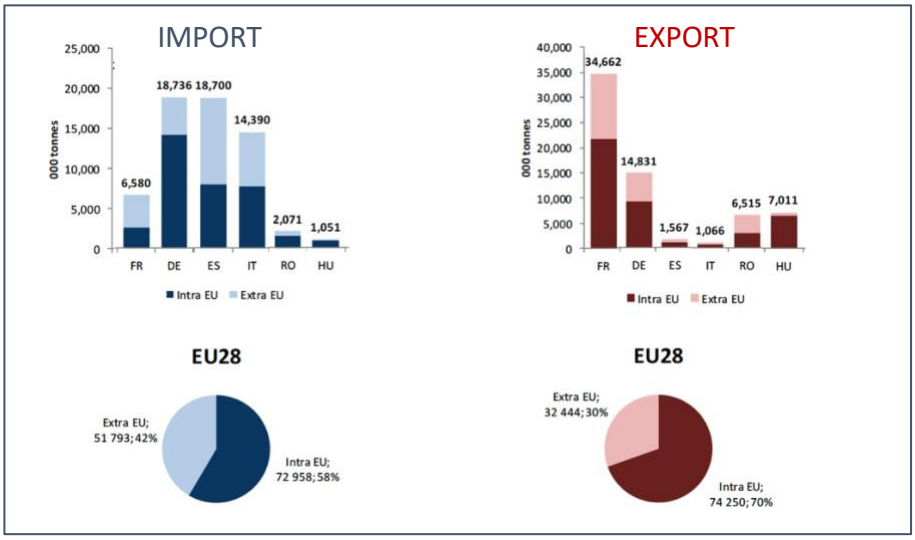


Figure 5 : COP Import (left) vs COP Export (right) – 6 countries vs EU28

EU is a net exporter for certain cereals but is a net importer of maize and oilseeds.
Adequate availability of storage capacity and logistical infrastructure can facilitate trade and, in particular, further promote the EU's export competitiveness on the global cereals market.

3) Mapping of COP storage capacity[2]

The data proposed are from 2014-2015 years, but we make the hypothesis that 2015 data are the same than 2020-21 data. These data are proposed for COP, not only for cereals.

The current total storage capacity for COP in the EU28 was quantified at around 359 million tons (*up to 20% from around 300 million tons in 2005*).
Over the same period, **EU production of COP crops increase and reached 346 million tons** (*up to 11% from around 312 million tons in 2005*).

The increase in storage capacity was therefore greater than the increase in production, as some Member States fully or partially addressed the storage capacity shortages that they faced in 2005.

The Table 5 presents the COP storage capacity for the 6 studied countries.
France is by far the Member State with the greatest storage capacity (*around 91 million tons in 2015*), followed by Germany (*48 million tons*) and Spain (*30 million tons*). Among the Eastern EU Member States, Poland (*24 million tons*), Romania (*23 million tons*) and Hungary (*20 million tons*) also stand out.
Member States which have increased COP exports have often also improved their availability of storage capacity compared to their theoretical needs.

Table 5 : COP storage capacity for the 6 studied countries

Country	Storage capacity (million T) for COP
France	**91**
Germany	**48**
Spain	**30**
Romania	**23**
Hungary	**20**
Italy	**Between 10 & 20 *(exact data unavailable)***

The repartition of COP storage capacity in EU28 **(359 mT)** was quantified ***for 18 000 facilities mapped***. Different types of storage are presented below in the Figure 6.

- individual farms,
- farming cooperatives,
- operators processing COP into food/feed products,
- traders and wholesalers of grains,
- transportation hubs *(seaports, inland waterway ports, railway terminals, inland logistical hubs)*

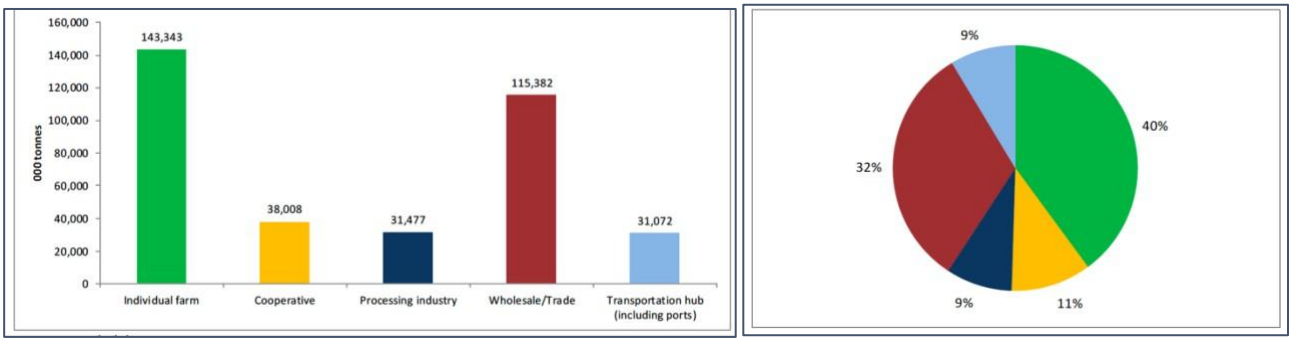


Figure 6 : Different types for the COP storage capacity and % of distribution of each type in EU

It's also important to note that **cooperatives** operate as traders and in transportation hubs. It's the case for France where majority of the traders are cooperatives, same remarks for transportation hubs. It's for that there is no "yellow color" for France in the Figure 7 below. Thus, the repartition of types of COP storage capacity for the 6 countries studies is presented (Figure 7).

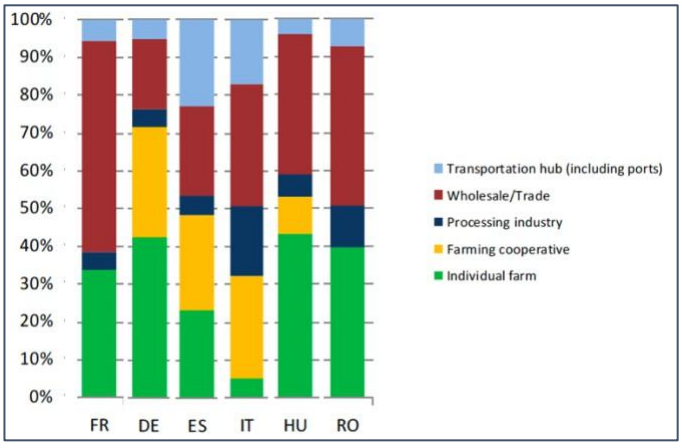


Figure 7 : Repartition of storage capacity type for the 6 countries studied

According to the different countries: the storages by wholesale/trade, farming cooperatives and individual farms are the most important.

The Table 6 below presents an overview of the minimum and the maximum storage capacity needs:

Table 6 : Available storage capacity at Member State level vs. storage needs (minimum/maximum)

Member states	2005 mapped storage capacity (T)	2015 mapped storage capacity (T)	Minimum needed storage capacity (T)	Maximum needed storage capacity (T)	Shortage situations vs expected total capacity
FRANCE	82 685 986	**90 870 486**	67 320 000	76 930 000	OK
GERMANY	46 520 775	**48 104 734**	55 087 000	60 705 000	+ +
SPAIN	22 464 548	**29 905 814**	23 858 000	29 985 000	+
ITALY	14 649 689	**15 683 826**	12 219 000	24 270 000	+
ROMANIA	16 138 355	**23 377 236**	13 995 000	22 232 000	OK
HUNGARY	14 714 427	**20 144 534**	10 460 000	18 196 000	OK
EU 28	**299 633 454**	**359 282 264**	**317 204 000**	**391 965 000**	

Under the base scenario, the maximum and the minimum storage needs are quantified with respect to the peaks in production recorded for each Member State and each individual COP crop over the 2005-2015 period: for this reason, the situation represented in Table 6 is likely to overestimate the presence and extent of storage capacity shortages.
Findings from interviews at EU and national level suggest that no Member State currently suffers from serious structural shortage of storage capacity for COP.

UPDATE 2024: New sources of production presented in the table 6 is below.

Table 6 bis : Available storage capacity at Member State level vs. storage needs (minimum/maximum)

Member states	TOTAL GRAIN PRODUCTION (IGC)	FOR YEAR	PREVIOUS YEAR	
FRANCE	57,6 M tonnes	2020-21	71 M tonnes	Focus on France | World Grain (world-grain.com)
GERMANY	45,7 M tonnes	2019-20	37,9 M tonnes	Focus on Germany | World Grain (world-grain.com)
ITALY	14,5 M tonnes	2021-22	14,9 M tonnes	Focus on Italy | World Grain (world-grain.com)
ROMANIA	20,2 M tonnes	2022-23	27,2 M tonnes	Focus on Romania | World Grain (world-grain.com)

A number of storage solutions fell out of the scope of the mapping of permanent storage facilities carried out for the study, including:
a. Silobags, used for temporary (from a few weeks to a few months) storage of grains. Their use is rather widespread in some Member States/Regions (e.g. in Germany and in the Tuscany region of Italy).
b. Flat storage facilities with or without roof which are normally used for other purposes (and therefore fall outside the scope of the study). These facilities can also be used as "emergency solution" for the storage of COP28.
c. In some Member States, temporary storage capacity is also granted by floating barges and/or ships moored at ports. Operators in the Netherlands especially rely on such solution, which accounts for a significant portion of the available storage capacity at ports and logistical hubs on inland waterways in the country.

4) Transport

The transportation constitutes one of the leading success factors in agribusiness systems by

enabling a flow of agricultural goods (including COP) from agricultural holdings to final users/consumers.

Transportation of COP is performed by different types of transport modes: road, rail, or inland waterways (IWW henceforth). In the EU, COP are usually transported in bulk via truck, rail wagon and inland vessel.

Inland waterways and railways handle almost all long-distance COP tonnage in the EU (60-70% for inland waterways, 30-40% for railways).

Trucks play a marginal role in long-haul transportation of COP and are only used in the few areas where railway and/or inland waterway networks are not very well developed, or as an emergency solution. Transport by truck, trailer or farm tractor is solely used for short-distance transportation.

The Figure 8 presents the main ways of COP transportation in Europe.

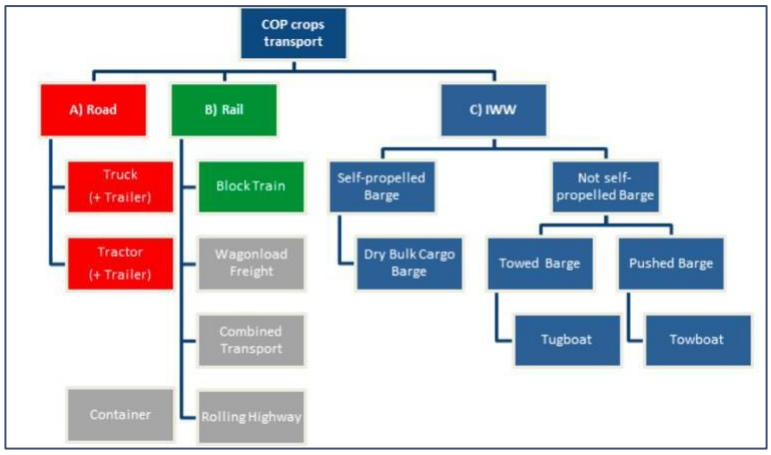


Figure 8 : Main ways of COP transportation in Europe

Here a precise description by type of transportation:

- **Road**

COP crop producers are usually not directly connected to the main transport infrastructures such as motorways, railways, or navigable rivers/canals. For road transportation, tractors with trailers are used in the field, while on motorways: COP are transported on trucks of varying capacity. In the light of their ***lower performance in terms of ton-kilometers compared to freight trains and IWW vessels, trucks are mainly used for short-haul transportation of COP.***

Local COP transportation within a maximum distance of 30-50 km is often performed by farm tractors pulling trailers of different capacity. Farmers often cooperate and merge their orders and their quantities to reduce the cost of transportation of their products. Efficient long-haul transportation of large volumes of COP requires the use of transport modes with greater capacity, such as rail and inland waterway transportation.

- **Rail transportation**

Its better performance in terms of ton-kilometers allows rail transportation to be more efficient than road transportation in long-haul moves. Large quantities of COP crops are shipped by block trains or unit trains without being split up on route (several wagons of 80m3). These trains are specially used for COP transportation from Eastern Europe to the main ports in Central Europe for export. In many EU Member States, large quantities of goods are transported by rail, which has the advantage of generally being cheaper than road transportation especially in long-haul moves. Nevertheless, a serious disadvantage of rail transportation is the often-unavoidable moves by truck to the departure terminal, and from the destination terminal to the final customer. The **most serious drawback of rail transportation** are the **limitations in interoperability**.

- **Inland waterways transportation**

IWW transportation has the highest transport performance in terms of ton-kilometers and the

best relative energy efficiency compared to road and rail transportation. The advantage for IWW in long-haul bulk transportation of COP derives from a combination of factors: large loading capacity compared to trucks and railway wagons; absence of time restrictions, absence of costly transit permits in international transport, differently from rail transport; no need for complex route planning and infrastructure (signal lights, tunnels, bridges, etc.); all combined with a better environmental performance.

- **Description of the COP transport process**

The Figure 9 below presents the logistics of a classic agricultural supply chain in international trade.

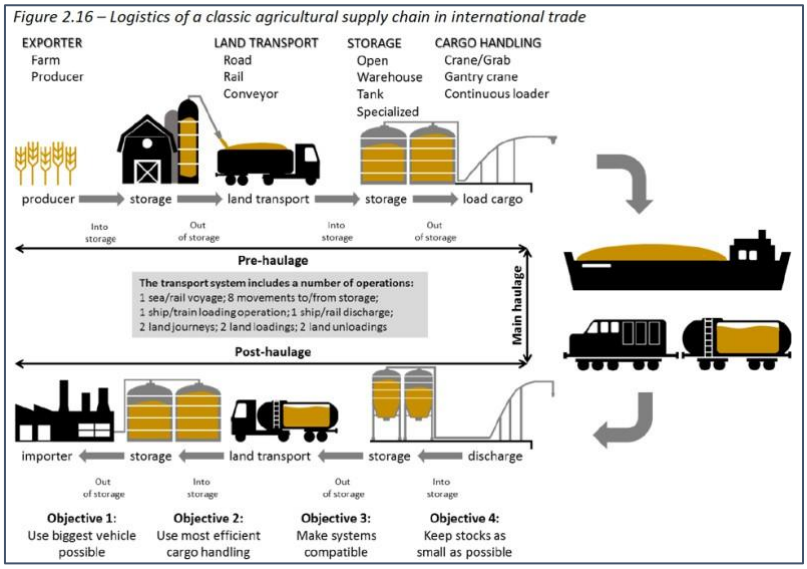


Figure 9 : Logistics of a classic agricultural supply chain in international trade

1) COP crops harvested at farm level are either stored on site or transported to nearby storage facilities, mostly by truck or farm tractor and trailer.
2) The COP logistic chain continues with the **pre-haulage** process via land transportation (predominantly by road) to a key logistical hub, where COP crops are transhipped on the transport mode used for **main haulage:** COP crops can be loaded onto a barge at an IWW port, or on a block train at a road-to-rail terminal. Trucks are generally preferred for direct short haul moves from COP cultivation areas to local customers, whereas rail and/or IWW transportation are only relevant for long-haul moves.
3) After the main haulage, COP are discharged and stored at a port or at a rail-to-road terminal.
4) The **post-haulage** usually continues with road transportation to the final customer's storage facilities.

Seven types of intermodal supply chains for COP can be identified, with the two most prominent types applied in the EU for export to third countries highlighted:
1. Field-(Road)-Storage-(Road)-Railway-Port-Customer (international level) : long distance
2. Field-(Road)-Storage-(Road)-IWW-Port-Customer (international level) : long distance
3. Field-Storage-Road-Port-Customer (regional level)
4. Field-Road-Port-Customer (regional level)
5. Field-Road-Customer (local level)
6. Field-Road-Rail-(Road)-Customer
7. Field-Road-IWW-(Road)-Customer

The first and the second type of intermodal supply chains are usually characterized by long distances and are found in international COP traffic connecting Eastern EU cultivation areas with the main EU seaports handling COP, such as the "ARA" ports (Amsterdam, Rotterdam and Antwerp).

Types 3 and 4 are characterized by a relatively short distance between cultivation areas and ports at regional level, whereas type 5 is applied at local level. Types 6 and 7 are comparable to Types 1 and 2 but lack in-transit storage processes.
Logistic costs for COP include tariffs for transportation, handling and storage costs and the margins of each actor in the logistic chain. Costs and rates depend on the type of COP crops, on the type of operation, on energy efficiency of transportation services, on transportation distance and on other factors.

In most cases, storage is needed at least for a short period before and/or after loading. Terminals have hence to be equipped with storage facilities, which provide "in-transit" storage.

The current state of road, inland waterways and railway transportation is investigated to provide an overview of the core European logistical infrastructure used for COP transportation.

- **Road transportation**

There is no official classification for trucks used to transport COP. It is hence difficult to estimate the availability of road transport services for COP in the EU. The investigation mainly focused on structural aspects such as motorway density and distribution of rail-to-road (RR) terminals. (Figure 10)

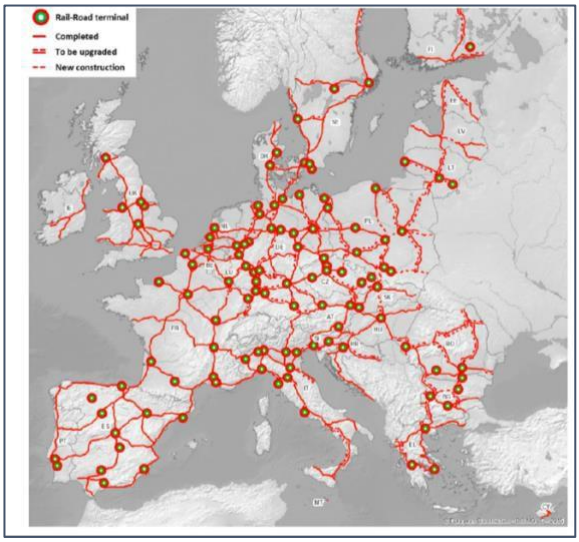


Figure 10 : EU road transportation core network

Rail-to-Road (RR) terminals enable the modal shift from rail to road and vice versa. Road transportation of agricultural products can be divided into two components:

- The first component is the initial transportation from the field to the first storage or pre-processing facility.
- The second component is the transportation from storage facilities to destination (either local customers or ports for export).

Transportation from fields to the first storage facility is done by truck only (usually in smaller trucks). Transportation from the first storage facility to the final destination can be done by rail and/or inland waterway and/or road (usually in larger trucks).

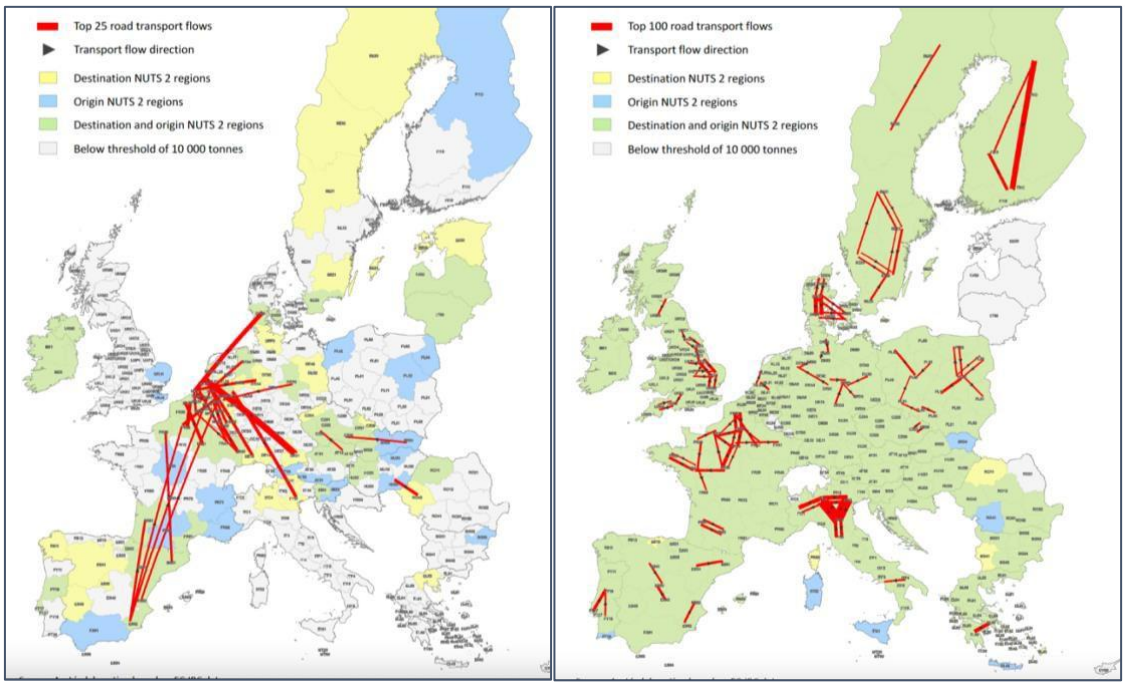


Figure 11 : Top25 international road (left) and Top100 national road - for transportation flows of agricultural goods in 2015

- **Inland waterway transportation**

The Figure 12 presents the map of the European inland waterway for the COP crop ports

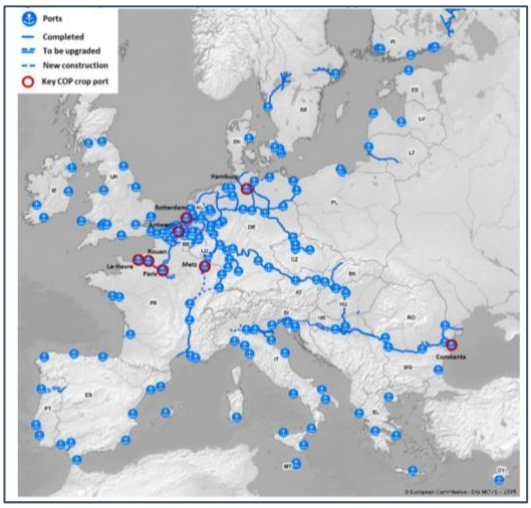


Figure 12 : European inland waterway core network and main COP crop ports

The main traffic axes for inland navigation are the following: a) Rhine, b) Moselle, c) North-South axis, d) East-West axis, and e) Danube.

Focus on ports: There are Seaports and Inland ports. The 3 leading seaports in Europe are: **Rotterdam, Hamburg, Antwerp**

- Port of Rotterdam: More than 10 million tons of cereals and ligno-cellulosic products are annually traded, stored and transshipped in the port.
- The dry cargo traffic in the port of Hamburg reaches a volume of 20 million tons, of which around 5.7 million tons are cereals, feedstuffs and oilseeds
- The port of Antwerp handles around 1.2 million tons of cereals annually.

The port of Paris is among the three leading inland ports in Europe. Cereals account for a substantial share of the 20 million tons of yearly traffic. The cereals harvested in Ile-de-France, Normandy and Picardy regions are often exported via the inland port of Rouen primarily to Spain, North Africa and China.
Rouen is the EU leading port for the export of cereals and, together with Paris and Le Havre, is organized within a port network. The IWW network between Rouen, Paris and Le Havre is a key transportation infrastructure for the shipment of cereals. With around 9 million tons of grains exported yearly, the Port of Rouen represents a key terminal, transhipment and consolidation point for COP traffic in West and Central Europe.

Inland waterways handle from 60% to 70% of long-distance COP traffic volume in the EU

- **Railway network**

Railways play an important role in long-distance COP transportation in the EU, with a share of 30 to 40% of total long-haul COP traffic (Figure 13).

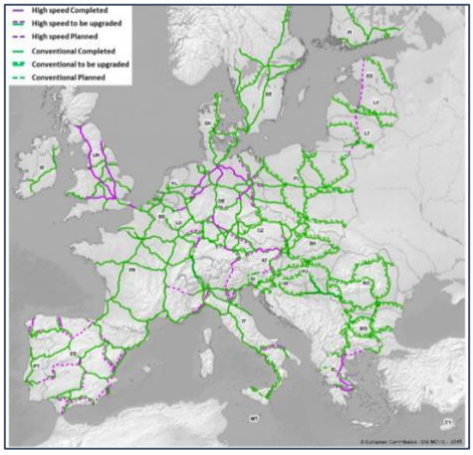


Figure 13 : European core railway network

The key destinations for COP international rail traffic are the ARA Ports and the German seaports

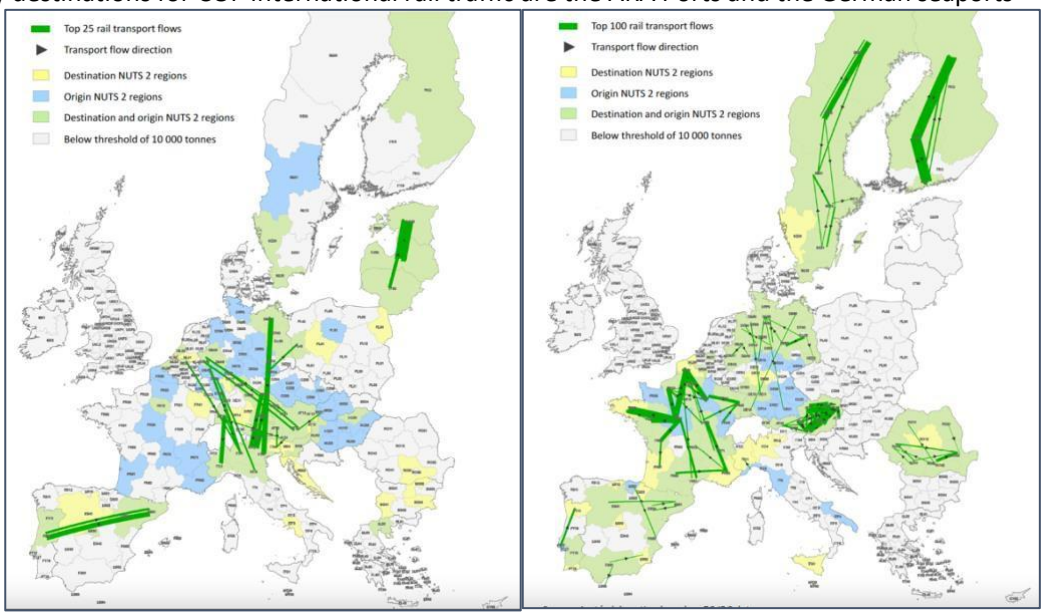


Figure 14 : : Top25 international rail transportation (left) and Top100 national rail transportation - for transportation flows of agricultural goods in 2015

Inland waterways and railways handle almost all long-distance COP tonnage (60-70% for inland waterways, 30-40% for railways) along the four main COP transportation corridors (Baltic-Adriatic, North Sea-Baltic, Rhine-Alpine and Rhine-Danube).

5) European regulatory status of active substances used in grains stored protection (PPP European regulations)[4]

The Table 7 presents the European regulatory status of the main active substances used in the stored grains protection. The 6 studied countries were detailed for the regulatory status. The main observation is that sulfuryl fluoride and Diatomaceous Earth are not authorized in Hungary & Romania. Pirimiphos-methyl is forbidden in Germany.

Table 7 : List of active substances used in grains stored protection in Europe

Active substance	*Date of approval*	*End of approval*	*Authorized countries among the 6 listed*
Deltamethrin (IN)	01/11/03	31/10/21	DE, ES, FR, HU, IT, RO
Cypermethrin (AC, IN)	01/03/06	31/10/21	DE, ES, FR, HU, IT, RO
Pirimiphos-methyl (IN)	01/10/07	31/07/22	~~DE,~~ ES, FR, HU, IT, RO
Pyrethrins (IN)	01/09/09	31/08/22	DE, ES, FR, HU, IT, RO
Aluminium phosphide (IN)	01/09/09	31/08/22	DE, ES, FR, HU, IT, RO
Magnesium phosphide (IN)	01/09/09	31/08/22	DE, ES, FR, HU, IT, RO
Sulfuryl fluoride (IN)	01/11/10	31/10/23	DE, ES, FR, ~~HU~~, IT, ~~RO~~
Spinosad (IN)	01/02/07	30/04/22	DE, ES, FR, HU, IT, RO
Kielselgur (Diatomaceous Earth) (IN)	01/01/21	31/01/36	DE, ES, FR, ~~HU~~, IT, ~~RO~~

**IN: Insecticide, AC: Acaricide*

**DE: Germany, ES: Spain, FR: France, HU: Hungary, IT: Italy, RO: Romania*

Conclusion:

The 6 studied countries were detailed precisely in the following parts. Some data are missing because there are no existing sources to provide these data or maybe they don't exist.

FRANCE

FRANCE

Introduction[5,6]

France is the Europe's leading producer of cereals. In 2020, France produced around 57 million of tons of cereals. Every year, it exports more than 45% of its harvest. With more than 34 million tons exported, the cereal industry makes a positive contribution to the French agricultural and agri-food trade balance.

In France, cereal crops cover 10 million hectares (Mha), i.e. nearly 20% of the total surface area of metropolitan France. They are present in all regions, without exception: they shape the landscape, contribute to territorial identity and local heritage, and provide income for 256 000 farms. In addition to this purely agricultural dimension, there is a long list of activities and trades directly related to cereals (cooperatives and companies of all sizes).

1) Stored grains cereals general data

a) Volume of cereals produced[7,8]

The production of cereals in France for the last 5 marketing years is described below (Table 8).

Table 8 : Cereals production in France for the last 5 marketing years

Cereals / Year (th T)	2017/18	2018/19	2019/20	2020/21	2021/22
Type	*	*	*Estimate*	*Forecast*	*Projection*
Soft wheat	36 559	34 045	39 516	29 073	34 619
Durum wheat	2 119	1 795	1 566	1 286	1 373
Barley	12 087	11 173	13 725	10 482	12 481
Oat	537	428	407	383	406
Maize Grain	14 535	12 728	12 996	13 503	13 259
Rice*	90*	72*	84*	78*	n.a
Total cereals FR	**68 433**	**62 495**	**71 123**	**57 318**	**64 938**
Total cereals EU-28	**307 959**	**292 357**	**322 532**	**n.a**	**n.a**
Total cereals EU-27	**284 960**	**271 272**	**297 015**	**280 365**	**295 108**
% FR / EU-27 prod	**24%**	**23%**	**24%**	**20%**	**22%**

**For all cereals: marketing year from 1st July N to 30th June N+1 - th: thousand*

b) One big cereals producer[9–11]

More than 75% of French cereals (wheat, barley, rapeseed...) are produced, collected, and sold by cooperatives. Among the French cooperatives: **In Vivo (+ Soufflet), Vivescia, Axereal and Limagrain** are the biggest cereals cooperatives in France. **Dijon cereals** is also a big cooperative group.

c) Volume of stored grains cereals

At the interface of the agricultural world and the processing industries, collect and storage form a key link in the cereal sector, ensuring the commercialization of agricultural production. These activities are spread throughout the country and are anchored in the production areas, helping to maintain a local economy while contributing to the performance of the sector, including for export.

As soon as they are harvested, the cereals are stored in silos, protected from humidity, insects, and rodents. The storage organization also has a role in marketing the cereals to mills, food and chemical industries. Thus, each batch, after numerous tests and controls, is certified and its traceability guaranteed.

The storage capacity is estimated around 93 million. For the same period, the production of cereals + oil + protein seeds is around 75 million of tons (2014-2015 data).
The storage capacity of the farms is around 31 millions of tons (1/3 of the national storage capacity)[12]

d) Volume of treated stored grains cereals

This data is unavailable and difficult to get because depending on different parameters.

e) Storage sites + How are stored the grains (on-farm, off-farm, export shipments)[2]

Capacity of storage in France (2014-15 data):
> 40 million tons => Around 93 million of tons, probably more nowadays

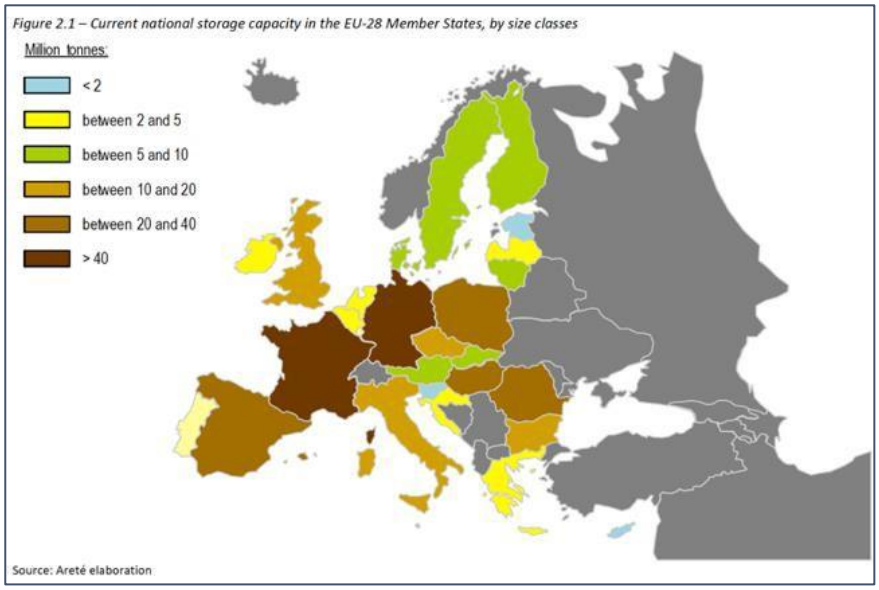


Figure 15 : Current national storage capacity in the EU-28 Member States, by size classes

The storage is divided in 3 types of storage:

- Storage on-farm
- Storage off-farm: cooperatives & traders
- Storage off-farm => Export shipments (harbors)

The Table 9 proposes an overview of the repartition of the storage in France according to different types of storage. It's important to note that the value of 0% for cooperatives is not relevant, because cooperatives are found in processing industries, wholesale and transportation hub.

Table 9 : Repartition of the total share in France according to different types of storage

Type of storage (2015 data)	Share in total storage (%)	Estimation of storage capacity
Individual farms = on-farm	34%	31 millions tons (estimation Arvalis) *Represents 1/3 of the national capacity of storage*
Farming cooperatives = off-farm	0%	0 millions tons (calculation estimation)
Processing industries = off-farm	4%	3.7 millions tons (calculation estimation)
Wholesale/trade = off farm	57%	53 millions tons (calculation estimation)
Transportation hub (including ports)	5%	4.7 millions tons (calculation estimation)
Storage capacity	**100%**	***93 millions tons (estimation Arvalis)***

In France, cereals are exported by road, rail, or waterway, thanks to France's central position for the export of cereals in particular to Europe. 88% of cereals are transported by road; 10% are transported by rail; 2% are transported by waterway.

According to the different type of storages, here is presented rapidly how are stored the cereals:

- Storage on-farm: plate, external cells (silos)
- Storage off-farm: cooperatives & traders => external cells (silos)
- Exports shipments: => external cells (silos)

2) Focus on specific stored grains cereals: wheat, barley, oat, maize, rice

a) Estimated volumes of each stored grains variety

This part is listed in the part *2)c) "speed of grain rolling"*

b) Treatment used for each stored grains variety

This part is related to the part *6) "Control means available*".

c) Speed of grain rolling (incoming, stored, outgoing)

France is the only country where there is available data (Table 10 to Table 14) (France Agrimer)

The following formulation allows to get the speed of grain rolling.

IMPORT 2020 + INCORPORATIONS 2020 + PROD 2020 + FARMS STORAGE 2019 + STORAGE INITIAL IN THE MARKET 2020

=

EXPORT 2020 + MARKET USE 2020 + FARMS USE 2020 + FARMS STORAGE 2020 + STORAGE FINAL IN THE MARKET 2020

Table 10 : Market balance – SOFT WHEAT

	SOFT WHEAT (1000 T)	2017/18	2018/19	2019/20	2020/21
	YEAR N	*2017*	*2018*	*2019*	*2020*
1	Production N	36 559	34 045	39 551	29 157
2	*Storage on-farm N-1*	*687*	*826*	*400*	*400*
3	*Storage on-farm N*	*826*	*400*	*400*	*400*
4	*Usage on-farm N*	*3 116*	*3283*	*3019*	*2197*
5	Production available N to sale (1+2-3-4)	33 305	31 188	36 532	29 960
6	*Store initial N-1*	2 922	3 006	2 670	3 028
7	Importations N	341	292	232	250
8	Incorporations or adjustments N	50	50	50	50
9	Total available to sale N (5+6+7+8=9)	36 617	34 537	39 484	30 288
10	*Domestic uses N = sales*	*15 896*	*14 472*	*15 211*	*14 075*
11	*Cereals Exportations (grains & mills) N = sales*	*17 715*	*17 394*	*21 245*	*13 512*
12	Total sales N	33 611	31 867	36 456	27 587
13	Store final N in the market (9-12)	3 006	2 670	3 028	2 701
	Including "stock of collectors"	*2 250*	*1 867*	*2 258*	*Data unavailable*
	Including "stock of animal feed manufacturers"	*145*	*148*	*163*	
	Including "stock of millers"	*374*	*394*	*375*	
	Including "stock of starch producers"	*49*	*83*	*68*	
	Including "stock of harbour silos"	*189*	*178*	*163*	

Table 11 : Market balance – DURUM WHEAT

	DURUM WHEAT (1000 T)	2017/18	2018/19	2019/20	2020/21
	YEAR N	*2017*	*2018*	*2019*	*2020*
1	Production N	2 119	1 795	1 563	1 286
2	*Storage on-farm N-1*	*102*	*208*	*183*	*146*
3	*Storage on-farm N*	*208*	*183*	*146*	*125*
4	*Usage on-farm N*	*50*	*50*	*20*	*50*
5	Production available N to sale (1+2-3-4)	1 963	1 771	1 579	1 257
6	*Store initial N-1*	276	398	364	187
7	Importations N	96	67	43	50
8	Incorporations or adjustments N	288	273	328	230
9	Total available to sale N (5+6+7+8=9)	2 622	2 510	2 314	1 723
10	*Domestic uses N = sales*	*559*	*606*	*557*	*547*
11	*Cereals Exportations (grains & mills) N = sales*	*1 664*	*1 540*	*1 571*	*970*
12	Total sales N	2 224	2 146	2 128	1 517
13	Store final N in the market (9-12)	398	364	187	207
	Including "stock of collectors"	*342*	*270*	*107*	*Data unavailable*
	Including "stock of animal feed manufacturers"	*1*	*14*	*1*	
	Including "stock of semolina manufacturers"	*51*	*76*	*73*	
	Including "stock of harbour silos"	*5*	*5*	*5*	

Table 12 : Market balance - BARLEY

	BARLEY (1000 T)	2017/18	2018/19	2019/20	2020/21
	YEAR N	*2017*	*2018*	*2019*	*2020*
1	Production N	12 087	11 173	13 749	10 384
2	*Storage on-farm N-1*	*251*	*200*	*200*	*200*
3	*Storage on-farm N*	*200*	*200*	*200*	*200*
4	*Usage on-farm N*	*1 932*	*1 913*	*2 198*	*1 659*
5	Production available N to sale (1+2-3-4)	9 936	9 259	11 551	8 725
6	*Store initial N-1*	1 072	1 496	1 327	1 388
7	Importations N	45	85	72	70
8	Incorporations or adjustments N	0	0	0	0
9	Total available to sale N (5+6+7+8=9)	11 054	10 840	12 950	10 183
10	*Domestic uses N = sales*	*2 162*	*1 895*	*2 360*	*2 067*
11	*Cereals Exportations (grains & mills) N = sales*	*7 396*	*7 618*	*9 203*	*7 054*
12	Total sales N	9 558	9 513	11 563	9 121
13	Store final N in the market (9-12)	1 496	1 327	1 388	1 061
	Including "stock of collectors"	*1 226*	*1 054*	*1 109*	*Data unavailable*
	Including "stock of animal feed manufacturers"	*62*	*41*	*63*	
	Including "stock of malt manufacturers"	*93*	*114*	*103*	
	Including "stock of harbour silos"	*114*	*118*	*113*	

Table 13 : Market balance - MAIZE

	MAIZE (1000 T)	2017/18	2018/19	2019/20	2020/21
	YEAR N	*2017*	*2018*	*2019*	*2020*
1	Production N	13 951	11 754	12 038	12 437
2	*Storage on-farm N-1*	*X*	*X*	*X*	*X*
3	*Storage on-farm N*	*1 579*	*1 258*	*1 712*	*1 779*
4	*Usage on-farm N*				
5	Production available N to sale (1+2-3-4)	12 012	10 496	10 325	10 659
6	*Store initial N-1*	1 950	2 575	2 118	2 025
7	Importations N	605	866	673	450
8	Incorporations or adjustments N	X	X	X	X
9	Total available to sale N (5+6+7+8=9)	14 567	13 938	13 116	13 134
10	*Domestic uses N = sales*	*6 679*	*7 463*	*6 770*	*6 509*
11	*Cereals Exportations (grains & mills) N = sales*	*5 313*	*4 357*	*4 320*	*4 611*
12	Total sales N	11 992	11 820	11 091	11 120
13	Store final N in the market (9-12)	2 575	2 118	2 025	2 015
	Including "stock of collectors"	*2 384*	*1 911*	*1 816*	*Data unavailable*
	Including "stock of animal feed manufacturers"	*91*	*108*	*110*	
	Including "stock of starch manufacturers"	*67*	*65*	*75*	
	Including "stock of semolina manufacturers"	*7*	*6*	*unavailable*	
	Including "stock of harbour silos"	*27*	*27*	*24*	

Table 14 : Production of rice

	RICE (1000 T)	2017/18	2018/19	2019/20	2020/21
	YEAR N	*2017*	*2018*	*2019*	*2020*
1	Production N	90	72	84	unavailable

**Data on rice are difficult to found because rice production is tow low compared with the other cereals listed*

- **<u>Focus on France exportations</u>**

FRANCE exports:

- 1/3 of its CEREALS PRODUCTION in EU countries
- 2/3 of its CEREALS PRODUCTION in NON-EU countries

- **<u>Focus on the characteristics of the French freight transportation</u>**

France a central place for the cereals transportation (Figure 16)

Strengths	Weaknesses
• The central position of France in the EU offers relatively short routes to neighbouring Member States. • France has one of the best logistical infrastructures worldwide (it ranks eighth in the world for its overall quality). • France has access to the Atlantic Ocean and the Mediterranean Sea. French seaports are important transhipment points for inward and outward global trade flows. • France invests more in its domestic transportation infrastructure than its closest European neighbours.	• The centralized structure of the logistical network, converging towards Paris, results in a higher risk of failure due to the bottlenecks in and around the city. • In order to sustain the high quality level of the logistical infrastructure, permanent maintenance and infrastructural development are necessary.

Figure 16 : Strengths and weaknesses of the french freight transportation

3) Stored grains cereals invasive species

a) Occurrence of species

The species of interest are: Sitophilus oryzae, Sitophilus granarius, Sitophilus zeamais, Rhyzopertha dominica, Oryzaephilus surinamensis, Plodia interpunctella = Indian meal moth

The following data: *Percentage of presence of each insect species in each stored grains varieties, percentage of damages of each insect species in each stored grains variety,* are impossible to get. Indeed, these data depend on different other parameters.
Consequently, we decided to present a table of each insect stored grains species and their parameters of biology development and if each insect is present or not in France (Table 15).

It exists 2 different types of stored grains insects species:[13,14]

- **PRIMARY PESTS: DEVELOPED IN GRAINS**

RICE WEEVIL = *SITOPHILUS ORYZAE*
GRAIN (or WHEAT) WEEVIL = *SITOPHILUS GRANARIUS*
MAIS WEEVIL = *SITOPHILUS ZEAMAIS*
GRAIN CAPUCHIN = *RHYZOPERTHA DOMINICA*

- **SECONDARY PESTS**: **DEVELOPED OUTSIDE GRAINS**

"SILVAIN" = *ORYZAEPHILUS SURINAMENSIS*
INDIAN MEAL MOTH = *PLODIA INTERPUNCTELLA*

Table 15 : Description of the stored grains insects mentionned in the market study

Insect	Description	Development conditions	Adults longevity	Multiplication - in 1 months	Attacked cereals
BEETLES (COLEOPTERES) attacking whole grains					
Rice weevil (Sitophilus oryzae)	*Dark brown *Presence of a rostrum *4 reddish spots on the elytra *Length 2-4 mm	*Temperature: 15 to 34 °C *Ambiant humidity: >40% *Grain humidity : > 12%	4 to 12 months	Data unavailable	*Wheat *Barley *(Corn) *Rice
Grain weevil (Sitophilus granarius)	*Uniform dark brown *Presence of a rostrum *Length 2-4 mm	*Temperature: 12 to 35 °C *Ambiant humidity : >40-45% *Grain humidity : > 11 (to 12%)	4 to 6 months	per 20	*Wheat *Barley *Corn
Mais weevil (Sitophilus zeamais)	It has not been spotted in France: it is more frequently found in tropical regions New Caledonia and Guyana for example:				*Corn (but also: Wheat, Rice..)
Grain capuchin (Rhizopertha dominica)	*cylindrical shape *dark brown * length 2.2 to 3 mm	*Temperature: 22 to 38°C *Ambiant humidity : 40 to 70% *Grain humidity:	4 to 8 months	per 20	*Wheat *Barley
BEETLES (COLEOPTERES) attacking broken grains					
Silvain (Oryzaephilus surinamensis)	*Dark brown *Length 3 mm	*Temperature: 31 to 38°C *Ambiant humidity : >50% *Grain humidity: >10%	6 to 10 months	per 50	*Wheat *Barley *Corn
LEPIDOPTERA (LEPIDOPTERES) attacking broken grains					
Indian meal moth (Plodia Interpunctella)	*wingspan 16 to 20 mm *bicolored wings *yellowish-white caterpillar with brown head 10-20 mm	*Temperature: 17 to 37°C *Ambiant humidity : 40 to 75% *Grain humidity: >10%	1 to 3 weeks	per 20	*Corn *Wheat *Barley

b) Percentage of infestation: French Study on stored "Soft Wheat" Cereals[15,16]

This data is very difficult to get. Some articles say that *Sitophilus Oryzae* can destroy up to a third of the grains in silos. However, one interesting french scientific study was published in 2014 to identify percentage of insects' infestation in "soft wheat" grains for a period from 2010 to 2011. It's the only study available from now in France which is complete for this item.

Thus, a vast campaign of sampling and analysis of grains in French silos was performed during 2 years in order to determine the level of insects' infestation (free forms and hidden forms) of stored soft wheat but also to measure the insecticides residues found in grains (*Free forms mean visible insects = larvae & adults* vs *Hidden forms mean eggs or larvaes hidden in the grains).* This study is based on the EcoprotectGrain project (Data collected from 190 grain elevators).

The study showed several interesting remarks:

- **Frequency of insects found:**
  - More than 25% of the samples are infested (at least with one insect)
  - *Sitophilus Oryzae* is the most frequently encountered species in storage facilities and the second one is *Rhyzopertha Dominica* (Table 16). Indeed, *Sitophilus Oryzae* was detected in 24% of the samples. *Sitophilus granarius* is observed five times less frequently than *Oryzae* (between 4 and 5% of samples depending on the year)
  - A same study was conducted in 1977-1978 years. In this study, S*itophilus granarius* was present in 20% of the lots, proof that its occurrence is decreasing in France.
  - Conversely, *Rhyzopertha Dominica*, absent from the 1977-78 study, was present in 8% of the samples of 2010-11 years.

Table 16 : Total frequency of insects species – detection in 190 lots of grains extracted from 95 wheat silos (EcoprotectGrain 2010 and 2011)

Species	Frequency in 2010 (%)	Frequency in 2011 (%)
Sitophilus oryzae	**24**	**23**
Tribolium castaneum	**12**	**11**
Cryptolestes spp.	**10**	**14**
Oryzaephilus surinamensis	**8**	**15**
Rhyzopertha dominica	**7**	**8**
Sitophilus granarius	**5**	**4**
Mycetophages	**4**	**5**
Tribolium confusum	**2**	**1**
Frequency of samples getting at least 1 stored insect	**27.4%**	**40%**

- **Residues analysis**

The sampling grains were also analyzed to detect residues of insecticides.

Table 17 : Frequency of residues detection of one or several insecticides substances in 190 lots of grains extracted of wheat silos

Substance	Frequency in 2010-2011 (% of concerned lots)
Pyrimiphos-methyl	26.9
Deltamethrin	13.4
Chlorpyriphos-methyl	7.5
Cypermethrin	0.5
2 or 3 substances	17.2
Total of samples with residues detectable	65.5*
Total of sample with NO residues detectable	34.5

The pirimiphos-methyl was the active substance the most frequently used by the French stored organisms to fight insects in 2010-11. The active substance is still authorized nowadays in France, but we can't say if it's the most active substance used. On the other hand:

- Traces found on the grains are more frequent for products preferentially used to treat grains at the entrance of the silo, such as pirimiphos-methyl and deltamethrin.
- For chlorpyrifos-methyl, the operators surveyed tend to reserve it for the treatment of empty premises. In fact, it is found much less in grains. This confirms that the treatment of empty rooms does not significantly increase the level of residues in the grains themselves.

- **Impact of practices = infestation risks factors:**

The two years of investigation relate the impact of certain practices on infestations.
The major risk factors associated with pest infestation were identified: *elevator design (flat storage are more often infested); lack of temperature monitoring system; lack of sanitation of empty bins. Interview with the technical staff of grain elevators revealed that insect pest control is still today based on the use of contact insecticides.*

- **Building design => Flat storage are more infested than vertical cells.** 43% of the samples are infested in flat storage against 26% for vertical cells (whether concrete or metal).
- **Silothermometry => The absence of a tool for monitoring grain temperature increases the risk of infestation:** only 26% of cells with fixed thermometry are infested, compared to 41% of those with mobile thermometry and 47% of those without equipment.
- **Empty premises cleaning => Cleaning the cells before the grain arrives helps to reduce the risk of infestation, especially if it is accompanied by an insecticide treatment of the premises**. Without any cleaning, nearly 45% of the cells are infested, compared to 30% for those that are completely cleaned (including the frames).

Moreover, the study reveals also that Storage Organisms (OS) perform more curative treatments (treatment of premises and grains) than preventive treatments.
The control against insects is essentially based on contact insecticides uses. Here below some propositions of curative & preventive measures:

- Proposition of preventive measures: optimization of the ventilation system for cooling the grains in the cell, early detection via traps systems
- Proposition of curative measures: Fumigation (still limited potential of extension in France due to lack of gas tightness of French elevators & lack of trained staff), heat disinsectization (remedial action)

- **Costs of control against insects** (energy, insecticides, staff) in several OS (14 audits)

The cost of control against insects varies between 0.17 euros/T à 1.19 euros/T. (Figure 17)Figure 1

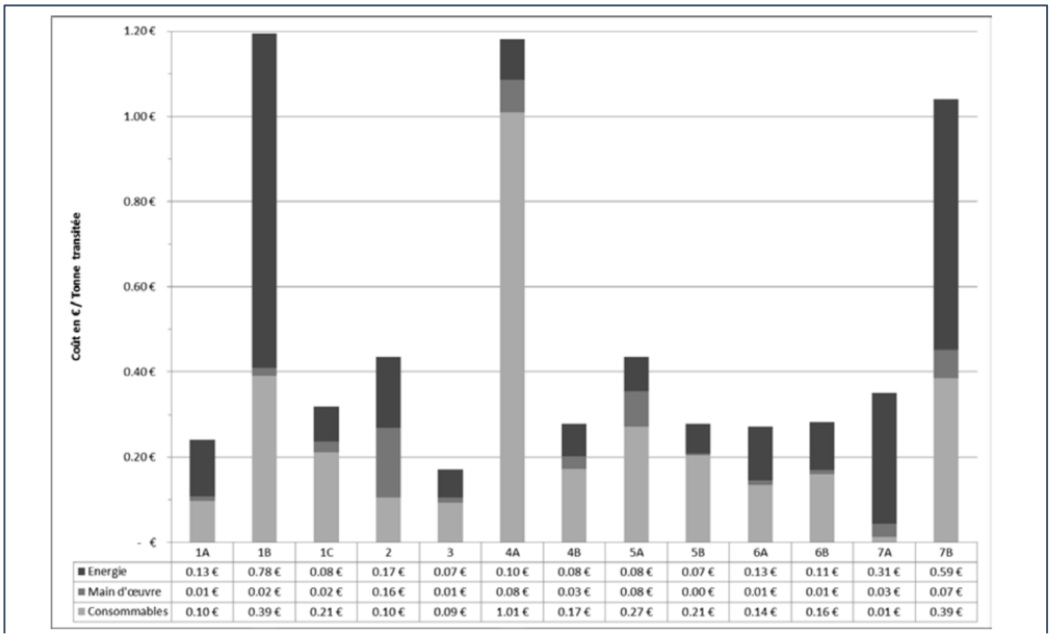


Figure 17 : Costs of control against stored grains insects

To conclude: the % of loss for OS is difficult to say as it depends on a lot of parameters.

4) Storage on bigger scales

a) Types of storage facilities

3 big types of storage are possible even if products are stored on-farm or off-farm: **flat (à plat), in covered cells outside of a building or in cells under a building.** We will explain if there is predominance of one type of storage according to the type of storage organizations.

- Flat storage: the easiest to put implement, the least expensive (especially when the building is existing). But it's not always easy to put in batches ***(allotement)*** in flat storage because it's necessary to constitute 4-wall boxes and the farmers often forget the fourth wall. Consequently, the edge of the pile (tas) is leaking. So, the farmers can't regularly level the pile to a uniform height, which prevents it from being properly ventilated. The flat storage involves a lot of handling, which cannot be automated. Moreover, the farmers must think early enough to the ventilation mode and often the farmers forget it.

By the way, the flat storage can be: ventilated or not, equipped with thermometers or not.

- Cells storage: Silos => the advantage to get an automated handling system which receipt while the harvester is working but is twice as expensive as flat storage.
- Cells storage outside: corrugated cells with roofs are currently the most popular for cost reasons as they require less civil engineering and are easier to install.

The technical aspects of the silos are the following[17]:
- Materials of silos: Often used: metal (steel or aluminum), concrete – less often used (fiberglass, plastic, tissue)
- Forms of silos: conical or flat bottom; round, square or rectangular structure

French Manufacturers of silos: Agriconsult, Hermex, Silos France, Gillouaye SA, BSI

In every case: the ventilation is mandatory. Cleaning and automation are appreciable.

To resume:
- **on-farm:** The two types of storage are used: plate and with silos.
- **off-farm:** More often used: Cells storage outside => See same information above
- **export shipments:** More often used: Cells storage outside => See same information above

b) Biggest site of storage for the exported cereals[2]

- **Focus on the ports**

In France, a clear pattern of rail traffic heading towards the regions where the main seaports in the North-West of France are located, is identified: Bretagne (Brest and Saint Malo); Nord – Pas de Calais (Dunkerque); Haute-Normandie (Rouen and Le Havre); Pays de la Loire (Nantes); Poitou-Charentes (La Rochelle). A substantial part of this traffic should consist of COP tonnage moving to these ports for export. Similar considerations can be made for rail traffic flows heading towards Provence-Alpes-Cote d'Azur region, where the port of Marseille is located. Significant COP tonnage should also be present in traffic flows heading towards Alsace, including traffic to transshipment terminals at Rhine ports for further transportation via IWW vessels.

The harbor silos are considered to be the biggest storage dedicated to the cereal's exportation. The harbor silos receive, store, treat and ship the grains. Grain processing includes cleaning to meet shipping standards, drying, de-stoning and, if necessary, fumigation.

The 3 biggest French ports for the cereals handling are: Rouen, La Rochelle, Dunkerque.

- Rouen: First French & European port for the exportation of cereals[18,19]

4 cereals ports operators in Rouen port: *Group BZ (BZ Grains), Senalia, Simarex, Soufflet Négoce (SOCOMAC)*

→ ***2019-2020 Campaign:*** 9.87 MT of exported cereals // Storage capacity: more than 1 MT

Focus on Senalia & Beuzelin

-Senalia[20]: Senalia UNION is the agricultural cooperative which deals with the logistics of the cereals (storage, loading, transport) in the Rouen Port => Exportation of 5 MT of cereals every campaign

-Beuzelin: BZ Grains[21,22] :Exportation of 1.5 MT of cereals every campaign // Silos "Maison Bleue"

- La Rochelle: Second French port for the exportation of cereals[23]

2 main cereals ports operators in La Rochelle port: Sica Atlantique, Socomac

→ ***2019-2020 Campaign:*** 3.7 MT of exported cereals

Focus on Groupe Sica Atlantique and Socomac – Groupe Soufflet
-Groupe Sica Atlantique (cooperative group)[24,25] :
=> Storage capacity: 0.3 MT (300 000 T)
=> Capacity of exported cereals: 3 MT
-Socomac - Groupe Soufflet (private group)[26]
=> Storage capacity: 0.2 MT (188 000 T)
=> Capacity of exported cereals: 2 MT

- Dunkerque: Third French port for the exportation of cereals

1 main cereal port operator : Nord Céréales

-Nord Céréales (cooperative group = SICA : Société d'Intérêt Collectif Agricole)[27]:
This company manages the 3rd largest cereal silo in France after Rouen & La Pallice.
→ ***2019-2020 Campaign***[28]*:* 2.8 MT of exported cereals & 0.25 MT of imported cereals
=>Storage capacity: 330 000 T

Figure 18 presents the maritime traffic of cereals of the 3 first French ports since 2000 years.[29]

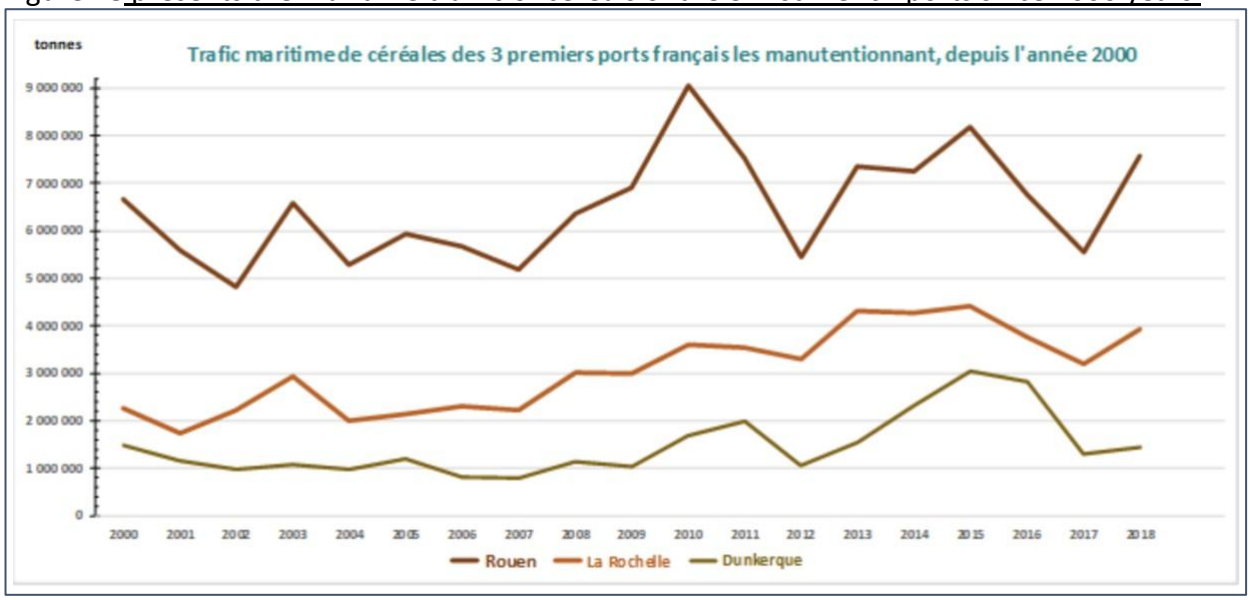


Figure 18 : Maritime traffic of cereals of the 3 first french ports since 2000 years

- **Focus on the countries where France exports (outside the European union)**[30]

In this part (Table 18), it's also interesting to describe the countries where France exports the most cereals (non-EU countries).

Table 18 : Exportation of cereals from France in non-EU countries

EXPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice[31]
2017/2018	Algeria: 4.3M Morocco :899.5k SaudiAfrica :620.2k Ivory Coast :415.0k Cuba : 401.3k	Tunisia : 86.4k Morocco : 74.4k Ivory Coast : 69.5k Algeria : 64.1k SaudiArabia :44.9k	SaudiArabia :749.9k China : 410.3k Tunisia : 389.0k Morocco : 306.1k Algeria : 270.8k	Switz : 76.9k Cameroon:21.5k Norway : 15.0k Russia : 9.9k Ukraine : 6.9k	Switz : 13.7k Morocco:722 .8k UnitedArab:0.069k Oman : 0.008k Tunisia : 0.004k	Unavailable data
Total	**8.3M**	**392.7k**	**3.2M**	**176.4k**	**14.5k**	
2018/2019	Algeria : 5.2M Morocco : 1.3M Egypt : 499.8k Cuba : 414.9k Ivory Coast :352.8k	Ivory coast : 90.5k Tunisia : 77.0k Algeria : 61.5k Mali : 23.8k SaudiArabia :15.8k	China : 726.2k SaudiArabia :699.3k Tunisia : 217.9k Morocco : 168.1k Algeria : 159.1k	Switz : 114.2k Morocco : 19.6k Russia : 6.3k Ukraine : 3.8k Philippines: 3.6k	Switz : 15.2k Morocco : 0.754k United Arab : 0.178k Uruguay : 0.027k Oman : 0.016k	
Total	**9.8M**	**328.8k**	**3.1M**	**173.2k**	**16.1k**	
2019/2020	Algeria : 5.6M Morocco : 1.8M China : 1.6M Egypt : 936.4k Ivory Coast :576.3k	Morocco : 97.1k Ivory Coast : 82.9k Tunisia : 55.8k Mauritania : 39.4k UK : 28.1k	China : 1.6M SaudiArabia :723.9k Morocco : 666.6k Mexico : 287.4k Algeria : 191.0k	UK : 109.4k Switz : 0.076k Algeria : 0.017k Congo : 0.010k Russia : 0.006k	Switz : 13.0k Morocco : 0.905k UK : 0.100k Qatar : 0.026k Djibouti : 0.023k	
Total	**13.6M**	**429.4k**	**4.6M**	**269.4k**	**14.1k**	
2020/2021	China : 1.8M Algeria : 1.2M Morocco : 468.1k Cuba : 329.6k Ivory Coast :270.1k	Ivory Coast : 49.3k UK : 34.9k Mauritania : 20.1k Algeria : 19.3k SaudiArabia : 7.8k	China : 2.0M Mexico : 154.8k Brazil : 63.0k Nigeria : 60.3k Vietnam : 50.8k	UK : 256.7k Switz : 29.7k Congo = 12.0k Russia : 5.3k Norway : 4.9k	Switz : 9.7k Morocco : 0.357k UK : 0.046k Qatar : 0.026k Uruguay : 0.024k	
Total	**5.4M**	**167.5k**	**2.7M**	**333.2k**	**10.2k**	**3.4k**
Main countries	Algeria Morocco China	Tunisia Morocco Ivory Coast	China Saudi Arabia Morocco	Switz UK	Switz	

**: Switz: Switzerland*

- **<u>Total exportation cereals (grains & flours) intra UE & extra UE</u>**[7]

The following tables presents the data of french exportations. Unfortunately these data do not match the data found above (all data should be taken with caution).

- <u>Soft wheat</u>

Table 19 : Soft wheat exportations from France

EXPORT	*Grains (in 1000 T)*				*Flours (in grains value) (in 1000 T)*			
	INTRA UE	*EXTRA UE*	*DOM TOM*	*Total*	*INTRA UE*	*EXTRA UE*	*DOM TOM*	*Total*
2017/2018	8 944	8 326	125	17 395	116	174	30	320
2018/2019	7 184	9 852	120	17 156	115	93	30	238
2019/2020	7 346	13 542	111	20 998	123	94	30	247
2020/2021	5 883	7 550	124	13 557	115	65	30	210

- <u>Durum wheat</u>

Table 20 : Durum wheat exportations from France

EXPORT	*Grains (in 1000 T)*				*Semolinas & Flours (in grains value) (in 1000 T)*			
	INTRA UE	*EXTRA UE*	*DOM TOM*	*Total*	*INTRA UE*	*EXTRA UE*	*DOM TOM*	*Total*
2017/2018	1 180	380	No data	1 560	104		No data	104
2018/2019	1 129	312	No data	1 441	99			99
2019/2020	1 099	353	No data	1 452	119			119
2020/2021	650	185	No data	835	100			100

- Barley

Table 21 : Barley exportations from France

EXPORT	Grains (in 1000 T)				Malt (in grains value) (in 1000 T)			
	INTRA UE	EXTRA UE	DOM TOM	Total	INTRA UE	EXTRA UE	DOM TOM	Total
2017/2018	2 462	2 567	24	6 053	708	634	No data	1 342
2018/2019	3 776	2 403	15	6 194	740	684		1 424
2019/2020	3 917	3 932	13	7 682	690	650		1 340
2020/2021	2 428	3 300	17	5 745	720	630		1 350

- Maize

Table 22 : Maize exportations from France

EXPORT	Grains (in 1000 T)				Semolinas & flours (in grains value) (in 1000 T)			
	INTRA UE	EXTRA UE	DOM TOM	Total	INTRA UE	EXTRA UE	DOM TOM	Total
2017/2018	4 447	595	92	5 135	178		No data	178
2018/2019	3 595	514	105	4 214	143			143
2019/2020	3 688	402	97	4 186	134			134
2020/2021	4 092	500	120	4 712	130			130

c) Several non-EU countries from where cereals come from (=import) [30]

- **Global Importation : Total importations cereals (grains & flours) intra UE & extra UE**

Table 23 : Cereals importations from France[7]

IMPORT (1000 T)	Common wheat	Durum wheat	Barley	Maize
2017/2018	341	96	46	605
2018/2019	292	67	85	866
2019/2020	232	43	72	673
2020/2021	200	45	85	450

- **Importation in non-EU countries**

In this part (Table 24), it's also interesting to describe the countries where France imports the most cereals (non-EU countries).

Table 24 : Importation of cereals from France in non-EU countries

IMPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice[31]
2017/2018	Mauritius: 8.4k Ukraine: 2.2k India: 0.830k Argentina: 0.462k Vietnam: 0.330k	Canada: 40.7k Pakistan:0.044k India: 0.038k Algeria: 0.019k Japan:0.018k	Egypt: 1.6k United Arab: 0.003k China: 0.003k China: 0.003k New Zealand: 0.003K	Ukraine: 4.3k SouthAfrica: 4.1k Turkey: 0.616k US: 0.444k Madagascar: 0.437k	Uruguay: 0.137k Argentina: 0.023 China: 0.003 US: 0.0006	Data unavailable
Total	**12.7k**	**40.5k**	**1.6k**	**11.9k**	**0.164k**	
2018/2019	Mauritius: 9.6k Ukraine: 4.9k India: 0.671k Argentina: 0.540k Vietnam:0.389k	Canada: 0.159k Morocco: 0.110k Pakistan: 0.067k China: 0.027k Japan: 0.019k	Switz: 0.047k New Zealand: 0.019k China: 0.003k US: 0.001k India: 0.0001k	Ukraine: 112.9k SouthAfrica: 5.2k Serbia: 1.8k Moldova: 0.848k Turkey: 0.794k	Brazil: 0.024k Uruguay: 0.008k China: 0.002k US: 0.0003k	
Total	**16.9k**	**0.436k**	**0.071k**	**124.3k**	**0.035k**	
2019/2020	Mauritius: 7.9k Ukraine: 2.5k India: 1.0k UK: 0.608k Vietnam: 0.369k	Morocco: 0.356k Canada: 0.206k India: 0.098k US: 0.086k Mauritius: 0.066k	New Zealand: 0.105k UK: 0.103k China: 0.020k US: too low Japan: too low	SouthAfrica: 6.6k UK: 4.1k Switz: 3.0k Turkey: 2.5k Chile: 1.4k	Uruguay: 0.543k UK: 0.264k Chile: 0.069k Brazil: 0.010k China: 0.002k	
Total	**12.9k**	**0.935k**	**0.229k**	**20.0k**	**0.889k**	
2020/2021	Mauritius: 5.2k UK: 0.720k India: 0.589k Canada: 0.500k Vietnam: 0.267k	Canada: 12.4k Morocco: 0.334k India: 0.079k UK: 0.052k Tunisia: 0.043k	UK: 24.4k Lebanon: 0.137k China: 0.047k Countries: 0.013k Argentina: 0.006k	UK: 4.9k SouthAfrica: 3.5k Serbia: 2.1k Turkey: 1.7k Argentina: 0.285k	Uruguay: 0.130k UK: 0.093k Chile: 0.023k China: 0.004k Canada: 0.0006k	
Total	**7.8k**	**13.0k**	**24.6k**	**13.1k**	**0.251k**	**146.2k**
Main countries	Mauritius Ukraine	Canada Morocco	UK	Ukraine	Uruguay UK	

d) Industry mapping in grains storage

In this part, the sites of storages organizations (farms, cooperatives, ports) are presented:

- List of « storages organisms »: Farms & Cooperatives (Left) : 929 "storage organisms" in this map for France – update in 2020 : 1220 [32]
- List of "ports": (Right) : in Blue => where we can find storage sites[33]

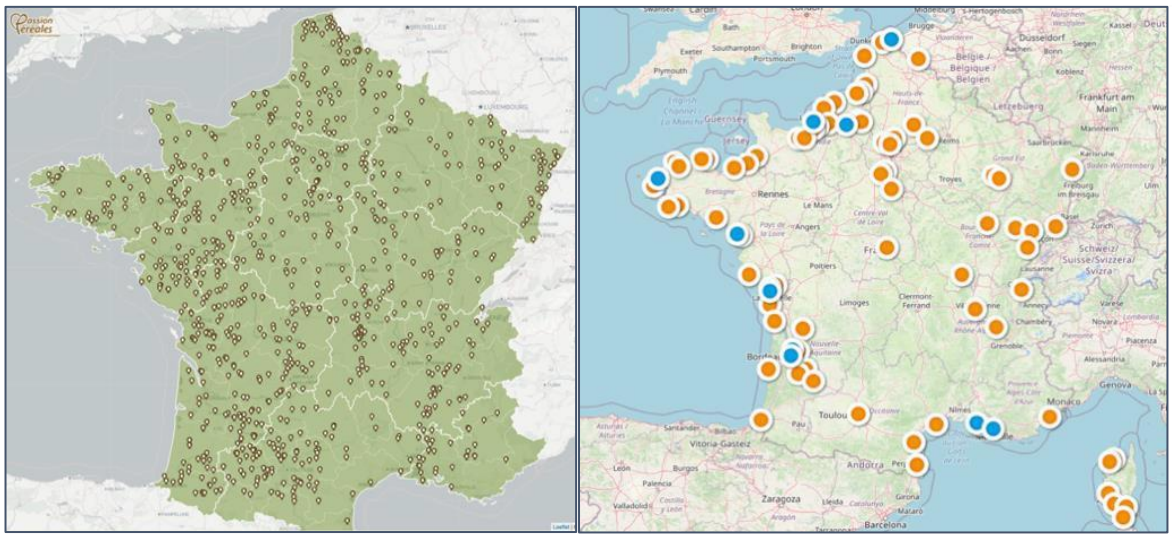


Figure 19 : List of « storage organisms » in France (Left) and List of ports (Right)

5) Potential users of the new solution

a) List of companies buying the product (appliers, users)[34, 35]

The activities of "storage" is mainly done by the "agricultural cooperatives" and the "agricultural traders":

- **Agricultural cooperatives** = (in charge of 2/3 of volumes collected), *made up of farmer members who pool the resources necessary for the operation of the cooperative.*
- **Agricultural traders** = (in charge of 1/3 of volumes collected). *are mostly represented by family-owned small and medium-sized enterprises, to which are added a few large groups, some of which have an international dimension.*

In order to carry out their activities, French agricultural cooperatives and French agricultural traders must be declared as "organisme collecteur= organisme stockeur=storage organism" to FranceAgriMer in accordance with the provisions of the rural code.

The "storage organisms", are dedicated to the collection, storage, and commercialization of grains. Located in the heart of crop-growing areas and at strategic logistics sites (river and seaports, rail hubs), the "storage organisms" (agricultural cooperatives, trading companies, etc.) provide a fine and tight network of the territory, bringing the cereals directly to their users. This sector alone employs 40,000 people.

There are more than 7,000 collection and/or storage centers spread throughout the country, mainly in the heart of cereal production areas, but also on strategic sites such as the cereal terminals of river and seaports: Dunkerque, Nantes-Saint-Nazaire, Rouen-Le Havre, Bordeaux, La Rochelle, Fos-sur-Mer, Metz, Corbeil-Essonne, etc.
1220 "collecteurs" of cereals listed are listed officially in October 2020.[36]

The following list (Table 25) presents some key figures of potential buyers of the new solution.

Table 25 : List of potential buyers of the new solution

List of potential buyers of the new solution	Description
Agricultural cooperatives (the main customers) [35]	Around 151 cooperatives in the cereals sector for the collect & the supply **Top 10 of "collect organisms" in 2015**[37]**:** Soufflet Agriculture – Axéréal – Vivescia – Advitam – Terrena – Cap Seine – Agrial – Océalia – Acolyance – Noriap
Agricultural traders[35]	Around 400 companies
Farmers dedicated to cereal crops[38]	The number of farms dedicated to cereal crops amounts to 110 000 units, i.e. one third of the so-called "professional" farms. / Around 400 000 farmers (breeders & cereal farmers)
Cereals Ports	7 big ports, mainly Rouen, La Rochelle Pallice, Dunkerque
Distributors of phytopharmaceutical products	Sojam, Lodi Group, Neodis, Edialux

6) Control means available (+Boundary conditions)

The control method the most current used is the treatment of grains by contact insecticide. In order to describe precisely the control means available and the boundary conditions: several type of products will be defined according to 2 types of treatments:

- **Treatment to disinsectize the stored grains (directly on the grains)**

*(1) : Céréales*Trt Prod. Réc.*Ravageurs des denrées stockées*

=> Cereals*Treatment Production, Harvest* Pests of stored products

- **Treatment to disinsectize the premises where are stored the grains (when grains are not present)**

*(2) : Traitements généraux*Désinsectisation*Locx Struct. Matér. (POV)*

=> General Treatment*Disinsectisation*Premises Structure. Equipments (POV)

a) Focus on insecticides used within the market for indoor & post-harvest grain treatment[39]

The treatments here are of PROFESSIONNAL use and based on "synthetic chemistry".

The following list (Table 26) presents the authorized insecticides in France used to treat the stored grains and the premises of storage, these insecticides are used with pulverization or nebulization system.

It appears that 3 types of active substances are authorized:

- *Pirimiphos-methyl*
- *Deltamethrin (+PBO which is a synergist)*
- *Cypermethrin (+PBO for one product)*

Table 26 : List of insecticides (« synthetic chemistry") authorized in France to treat stored grains and the premises of storage – Used with pulverization or nebulization

Product	Manufacturer	Active substance	Concentration	Formulation type	*(1)*	*(2)*
Actellic liquide	Syngenta France	Pirimiphos-methyl	250 g/L	Emulsifiable concentrate (insecticide)	0,002L/q - 1 appli	0,001 L/m2 -
Pirigrain 250	Sojam	Pirimiphos-methyl	250 g/L	Emulsifiable concentrate (insecticide)	0.002 L/q - 1 appli	0.001 L/m2 - 1 appli
Pirigrain 50	Sojam	Pirimiphos-methyl	50 g/L	Product for cold nebulization (insecticide)	0.008 L/q - 1 appli	X
PirigrainSLD	Sojam	Pirimiphos-methyl	72.5 g/L	Product for cold nebulization (insecticide)	0.006L/q - 1 appli	X
Pirigrain aerosol	Sojam	Pirimiphos-methyl	50 g/L	Aerosol (insecticide)	X	0.077L/100 m3
Bank	Sharda Cropchem Espana	Deltamethrin PBO	6 g/L 54 g/L	Liquid for application at ultralow vol (insecticide)	0,084 L/t -1 appli	X
Granprotec	Sharda Cropchem Espana	Deltamethrin PBO	25 g/L 226.6 g/L	Emulsifiable concentrate (insecticide)	2L/100t - 1 appli	X
Deltagrain CE 25 PB	Bayer	Deltamethrin PBO	25 g/L 225 g/L	Emulsifiable concentrate (insecticide)	0,02 L/t -1 appli	0,04-0,06L/100m2 - 1 appli
K-Obiol CE 25 PB	Bayer	Deltamethrin PBO	25 g/L 225 g/L	Emulsifiable (insecticide)	0.02 L/t - 1 appli	0.06 L/100 m2 - 1 appli
K-Obiol ULV 6	Bayer	Deltamethrin PBO	6 g/L 54 g/L	Liquid for application at ultralow vol (insecticide)	0.084 L/t - 1 appli	X
Talisma EC	Arysta lifescience	Cypermethrin	80 g/L	Emulsifiable concentrate (insecticide)	0.02L/t 1 appli	0.06 L/100m2 1 appli
Talisma EL	Arysta lifescience	Cypermethrin PBO	20 g/L 57 g/L	Liquid for application at ultralow volume (insecticide)	Post-Harvest	X

**PBO based products are not authorized in Organic Agriculture (since 2017).*

**1 appli = 1 application ; L/q : Liter per m^2*

b) Focus on fumigation and powder formulation

- **FUMIGATION**

The treatments here are of PROFESSIONNAL USE and based on "synthetic chemistry".[39]

The following list (Table 27) presents the authorized insecticides in France used to treat the stored grains et the premises of storage.

It appears that 3 types of active substances are authorized:

- *Pirimiphos-methyl*
- *Phosphide : Aluminium or Magnesium*
- *Sulfuryl fluoride*

Based on our experience, products with aluminium and magnesium phosphide are the common ones used for the fumigation.

Table 27 : List of insecticides (« synthetic chemistry") authorized in France to treat stored grains and the premises of storage – Used with fumigation system

Product	Manufacturer	Active Substance	Concentration	Formulation type	*(1)*	*(2)*
Quickphos pellets 0.6G New	UPL Europe	Aluminium Phosphide	56%	Gas generating product (insecticide)	20 g/t - X	X
Quickphos tablets 3.0G New	UPL Europe	Aluminium Phosphide	56%	-Gas generating product -Tablet (insecticide)	20 g/t- X	X
Delicia Gastoxin	Detia Degesch Gmbh	Aluminium phosphide	560 g/kg	Gas generating product	X	-15 g/m3 -1 appli
Phostoxin Pellet	Detia Degesch Gmbh	Aluminium phosphide	560 g/kg	Gas generating product	X	15 g/m3 25 pills per m3
Phostoxin Tablet	Detia Degesch Gmbh	Aluminium Phosphide	560 g/kg	Gas generating product	X	30 g/m3 10 tablets per m3
Actelic smoke generator	New pharm SRL	Pirimiphos-methyl	225 g/kg	Fumigant	X	2 appli
Degesch plate	Detia Degesch Gmbh	Magnesium phosphide	560 g/kg	Gas generating product	X	-19.4 g/m3 -1 plate for 6.25 m3
Degesch strip	Detia Degesch Gmbh	Magnesium phosphide	560 g/kg	Gas generating product	X	-10.6 g/m3 -3 strips of 20 bags assembled for 660 m3.
Profume	Douglas BLG BVBA	Sulfuryl fluoride	99.8% in compressed gas	Compressed gas	X	1 500 g.hour/m3 -2 appli

- **POWDER FORMULATIONS**

The treatments here are of PROFESSIONNAL USE (for some which are authorized in the PPP regulation).[40] This list (Table 28) presents 3 types of active substances used (Diatomaceous Earth, Sodium Bicarbonate, Chabazite)

Table 28 : List of insecticides based on "powder formulations" authorized in France to treat stored grains and the premises of storage

Description			Authorized dose		
Product	**Manufacturer**	**Active substance of main constituent**	**Preventive Treatment of empty premises**	**Preventive Treatment of grains**	**Curative Treatment of grains**
SilicoSec	Biofa AG	**Diatomaceous Earth**	10 g/m2	1 kg/t	2 kg/t
PROCropS* (it exists a liquid version also)	Neodis	**Sodium bicarbonate**	20 g/m2	No use	No use
Force Grain MN*	Lodi Group	**Chabazite**	80 g/m2	8 à 10 kg/t	8 à 10 kg/t

**Not classified as phytopharmaceutical products.*

c) Alternative methods and possible solutions in the future[39]

The following list (Table 29) presents some alternative methods: products based on powder formulations (listed in the Table 28 above) and a product based on Spinosad.

Table 29 : List of "alternative methods" authorized in France to treat stored grains and the premises of storage

Product	Manufacturer	Active substance	Concentration	Formulation type	*(1)*	*(2)*
Silicosec	Biofa AG	**Kieselgur**	920 g/kg	Contact powder (insecticide & acaricide)	2 kg/t 1 appli	10 g/m2 1 appli
Topgrain = Orgrain	Corteva Agriscience France SAS	**Spinosad**	24 g/L	Suspension concentrate (insecticide)	41.6 mL/t – 1 appli	X

Procrop Liquid, Procrop S & Force Grain MN are also alternative methods.

On the other hand, there are different biopesticides that can be used to treat stored grains but most of the time, they are used during an uncontrolled infestation: Bacillus thuringiensis, Phyto-insecticides and plant essences (pyrethrins, terpenes...), Insect Development Regulators (I.D.R.).
Insect growth regulators are compounds derived from, or inhibitory to, insect hormones and include methoprene, a juvenoid or juvenile hormone mimic, which disrupts the synthesis of chitin and kills insects when they molt. Juvenile hormone analogue as methopren, kinopren, hydropren are interesting ones. But now, they are not authorized in the PPP European regulations.
To conclude, these biopesticides mentioned above are not "effective", it's better to prefer physical processes.

However, there are also other potential solutions in the future like:
- Entomopathogenic fungus: Repellent added at storage time and removed at processing time.[41]
- Parasitoids: seem to be a potential future solution to chemical insecticides. Indeed, parasitic wasps were studied to disinsect storage rooms of cereals. There are specific to larvaes.[42]
- Irradiation+essential oil: A team from the "Institute national de la recherche scientifique" (INRS) would have discovered a combined treatment of irradiation (X-rays & Gamma-rays) and essential oil vapors (eucalyptus oil or tea tree oil) that would effectively destroy insects, bacteria and molds in stored grains. The essential oils increase the sensitivity of insects to radiation. This process was tested on rice insects.[43]
- Essential oils: Treatment with essential oils can be a good alternative to chemical insecticides because they are volatile and consequently the residues are very low compared with chemical insecticides (which are very powerful) but unfortunately the price of essential oils is very expensive, so the right dosage must be identified.

d) Boundary conditions = specific limitations & restrictions[39]

Some active substances have been banned in France and consequently the products based on these active substances are not authorized for the grains stored treatment (Table 30).

- **BAN OF ACTIVE SUBSTANCES**: chlorpyrifos-methyl, malathion, dichlorvos, bromophos, 1,2-dichloroéthane, tetrachlorure of carbon (fumigation), Gamma-HCH, bioresmethrin, bifenthrin
- **BAN OF PRODUCTS SINCE 2015:** A large proportion of chlorpyrifos-methyl based products have recently been banned.

Table 30 : List of insecticides banned in France to treat stored grains and the premises of storage

Product	Manufacturer	Active substance	Concentration	Ban date
Actellic 2	Sopra	Pirimiphos-methyl	20 g/L	2015
Pirigrain H30	Compagnie Générale des insecticides	Pirimiphos-methyl	30 g/L	2015
Pirigrain poudre	Compagnie générale des insecticides	Pirimiphos-methyl	1%	2015
Badineb	LODI	Pyrethrins PBO	20 g/L 160 g/L	2019
Badineb bio pulvé	LODI	Pyrethrins PBO	20 g/L 160 g/L	2019
Pirigrain Bio	Compagnie Générale des insecticides	Pyrethrins (in the form of vegetal pyrethres extracts)	25 g/L	2015
Predex PB*	Edialux	Pyrethrins PBO	25 g/L 250 g/L	2015
Neorel UL	Arysta Life Science	Chlorpyrifos-methyl Cypermethrin	30 g/L 20 g/L	2020
Nuvagrain	Neodis	Chlorpyrifos-methyl	25 g/L	2015
Nuvagrain 225 EC*	Neodis	Chlorpyrifos-methyl	225 g/L	2020
Nuvagrain concentré	Neodis	Chlorpyrifos-methyl	225 g/L	2015
Nuvagrain nebulisation	Neodis	Chlorpyrifos-methyl	25 g/L	2020
Reldan 22	Dow Agrosciences SAS	Chlorpyrifos-methyl	225 g/L	2015
Reldan GS*	Dow Agrosciences SAS	Chlorpyrifos-methyl	225 g/L	2020
Phosfinon C	Unipex	Aluminium phosphide	57%	2014
Phosfinon P	Garda GMBH	Aluminium phosphide	57%	2014
Phosfinon S	Unipex	Aluminium phosphide	57%	2014

Note: products banned and which were also used for disinsectisation of premises.*

e) Short focus on Biological Agriculture (BA) in France

The Biological Agriculture is also important for the cereals crop in France. The use of products to treat the grains is stricter.[44] The list of insecticides used in BA for the stored grains treatment is getting shorter. Indeed, since the end of 2017: The « Comité national de l'agriculture biologique » = CNAB, removed products containing piperonyl butoxide (PBO) from the guide of crop protection products that can be used in BA. Consequence for insect control in storage: synergized natural pyrethrum (PBO) will no longer be usable starting from September 30, 2017. This ban concerns both the treatment of stored foodstuffs and the treatment of premises, structures and materials for products of plant origin.

Since 2018, disinsectisation treatments for BA premises can only be carried out with Silicosec or with prophylactic solutions based on sodium bicarbonate like: ProCrop (liquid) and ProCrop S (powder).

Regarding the products used to treat directly the stored grains in BA, the list is below [45]:

- **Silicosec®** : insecticide & acaricide = contact powder - 920 g/kg
- **Topgrain®** = Orgrain : insecticide = concentrate suspension – 24 g/L

f) Short overview of active substances efficacy

The following results are related to the study described in the PART 3). The study compared the efficacy of 5 synthetic authorized substances in France in **2010-2011**: ***pyrimiphos-methyl, chlorpyriphos-methyl, deltamethrin, cypermethrin & natural pyrethrins*** VS bio-substances authorized abroad or under evaluation (***Spinosad, Diatomaceous Earth, Neem oil, Sodium bicarbonate, silica gel***).
The protocol consisted in the measurement of the efficacy on healthy grains infested with a secondary infestation (preventive control) & on infested grains (curative control).
The 2 species *S oryzae et R dominica* were the objects of the study.

The Figure 20 shows the mortality of *S. Oryzae* (left) & *R Dominica* (right) 56days after "curative" treatments.

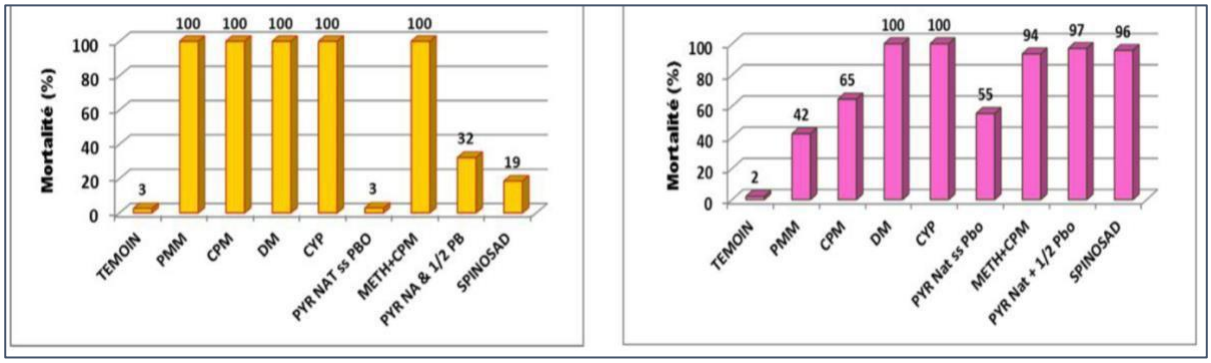


Figure 20 : Efficacy of insecticides substances applied in "curative" treatment of an infestation already set up of the 2 species the most pest to stored cereals in France: observation of mortality 2 months after treatment of infested grains

**Legend: TEMOIN: control – PMM: pyrimiphos-methyl – CPM: chlorpyrifos-methyl – DM: deltamethrin – CYP: cypermethrin – PYR NAT ss PBO: natural pyrethrins without PBO – METH + CPM: metophren + cypermethrin*

According to the Figure 20*:*

- *PMM & CPM are effective against S Oryzae but much less in R Dominica (resistance)*
- *DM & CYP show the best efficacy against the 2 insect species.*
- *PYR NAT without PBO : not effective against S Oryzae but little more effective against R Dominica => The action of PBO is important in term of synergism.*
- *METH + CPM: good efficacy against the 2 insect species.*
- *SPINOSAD: not effective against S Oryzae but good efficacy against R Dominica*

The

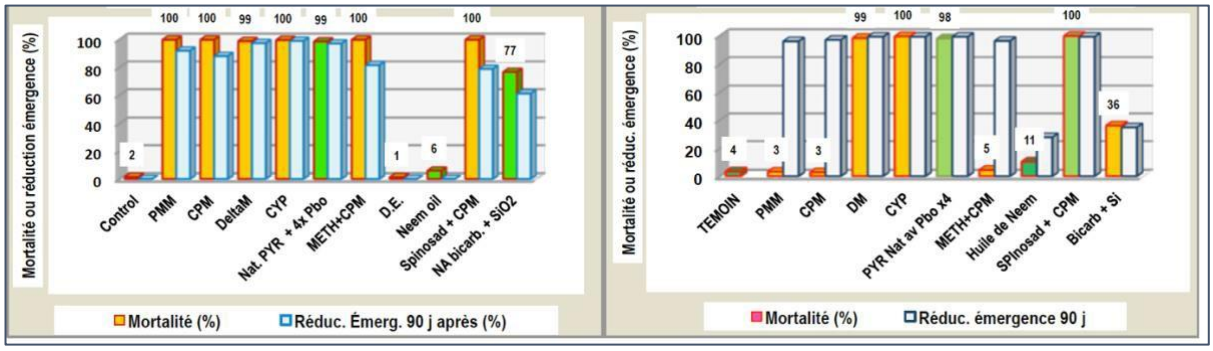
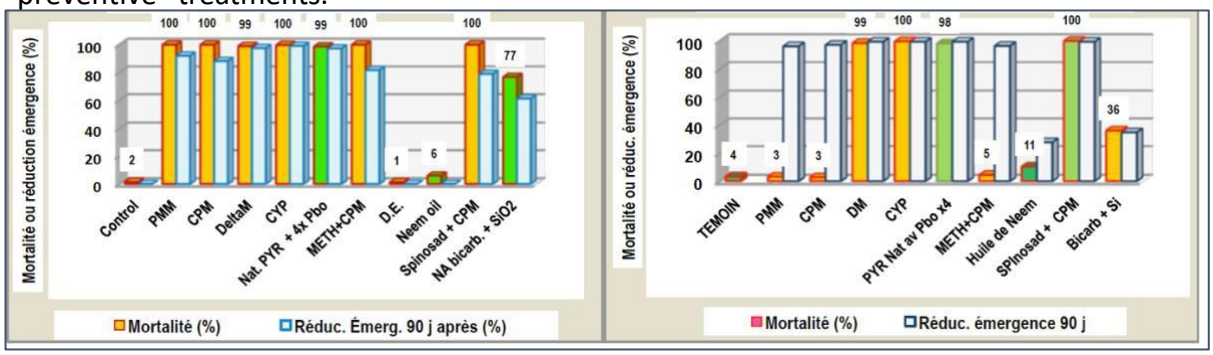


Figure 21 shows the mortality of *S. Oryzae* (left) & *R Dominica* (right) 90days after "preventive" treatments.



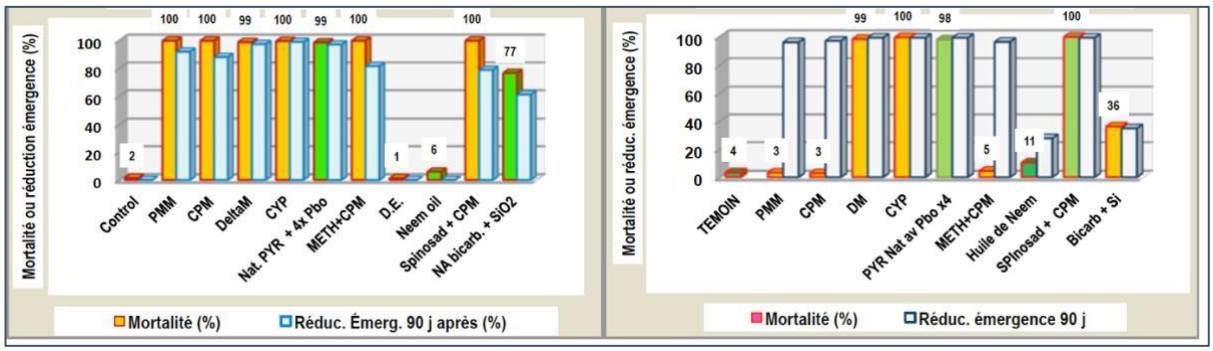


Figure 21 : Efficacy of insecticides substances applied in "preventive" treatment of an extern infestation of the 2 species the most pest to stored cereals in France: observation of mortality 7 days after the introduction of "new" insects in the wheat batches treated 2 months previously

**Legend: TEMOIN: control – PMM : pyrimiphos-methyl – CPM: chlorpyrifos-methyl – DM: deltamethrin – CYP: cypermethrin – PYR NAT ss PBO: natural pyrethrins without PBO – METH + CPM: metophren + cypermethrin*

According to the Figure 21*:*

- Among the bio substances tested: only Spinosad show an interesting efficacy when it's associated with a reduced dose of CPM.

These results are interesting to say that alternative substances are less effective than the traditional chemical ones. This study is from 2010, obviously, nowadays, techniques have evolved and alternatives substances are more and more developed (the diatomaceous earth is an effective way of biocontrol, Spinosad too even if it's little used at the moment).

GERMANY

GERMANY

Introduction [34,46]

Behind France, Germany is the second biggest producer of cereals in Europe. Indeed, cereals are grown on one third of the area used for agriculture in Germany. Wheat is by far the most cultivated cereal, ahead of barley and rye. Moreover, Germany is the most populous and economically powerful country in the European Union. It is influential in agricultural policy, both within the EU and globally. Germany is the second-largest importer and third-largest exporter of consumer-oriented agricultural products worldwide and by far the most important European market for foreign producers.

1) Stored grains cereals general data

a) Volume of cereals produced [7,8]

The production of cereals in Germany for the last 5 marketing years is described (Table 31).

Table 31 : Cereals production in Germany for the last 5 marketing years

Cereals / Year (th T)	2017/18	2018/19	2019/20	2020/21	2021/22
Type	*	*	*Estimate*	*Forecast*	*Projection*
Soft wheat	24 311	20 125	22 908	21 993	22 025
Durum wheat	170	138	155	177	165
Barley	10 853	9 584	11 592	10 852	11 241
Oat	577	578	519	714	574
Maize Grain	4 548	3 344	3 665	3 877	3 725
Rice*	0	0	0	0	0
Total cereals GE	**45 569**	**38 004**	**44 399**	**43 239**	**43 307**
Total cereals EU-28	**307 959**	**292 357**	**322 532**	**n.a**	**n.a**
Total cereals EU-27	**284 960**	**271 272**	**297 015**	**280 365**	**295 108**
% GE / EU-27 prod	**16%**	**14%**	**15%**	**15%**	**15%**

**For all cereals: marketing year 1st July - 30th June*
**th : thousands*

a) one big cereals producer [47]

The cereals are largely produced by farmers. The farmers are part of a large cooperative group in Germany named: **ZG Raiffeisen**, which is in charge of bringing farmers' grains in the market and other several tasks for the farmers.
For example, there are 317 agricultural cooperatives in Baden-Württemberg, and in 2019, the Baden-Württemberg Raiffeisen cooperatives recorded around 549 709 tons of wheat, barley, rye, oats and other crops.
The German cooperatives essentially include the ZG Raiffeisen Karlsruhe, the purchase and sales cooperatives (BAG) and the warehouse cooperatives. In 2019, these cooperatives over 1.1 billion Euro implemented. Around 13 300 farmers in the country have joined forces in one of these cooperatives.

Moreover, there also several other actors in cereals field as[48]: **CARGILL DEUTSCHLAND GMBH (headcount >500), WESTMECKLENBURGER GETREIDE GMBH (headcount >500), TREDE & VON PEIN GMBH, DEUTSCHE SAATVEREDELUNG AG.**

b) Volume of stored grains cereals

Before presenting the stored grains volume, it's necessary to present a map of Germany, which is divided in Land. This is important because each region has its own crop and storage. This is presented in the following map (Figure 22).

Figure 22 : Map of Germany divided in several Lands

4 Main regions exist in Germany:

- Region 1: Baden-Württemberg, Bayern, Brandenburg: South of Germany (Except for Brandenburg in North)
- Region 2: Hessen, Mecklenburg-Vorpommern, Niedersachsen: Middle-North of Germany
- Region 3: Nordrhein-Westfalen, Rheinland-Pfalz, Saarland: West of Germany
- Region 4: Sachsen, Sachsen-Anhalt, Schleswig-Holstein, Thuringen: East of Germany (Except for Schleswig-Holstein in North)

The Table 32 presents the cereals storage in Germany for 2019 year, no data are available for 2020.

Table 32 : Presentation of cereals storage in Germany for 2019 year

LAND = REGIONS	Total wheat (included spelt and durum wheat)		Rye & Winter cereals		Winter & Summer barley		Oats & Summer cereals		Triticale		Grain corn & Corn for maturing (incl. corn-cob mix)		Total	
	Stocks	Share in the total harvest of 2019	Stocks	Share in the total harvest of 2019	Stocks	Share in the total harvest of 2019	Stocks	Share in the total harvest of 2019	Stocks	Share in the total harvest of 2019	Stocks	Share in the total harvest of 2019	**Stocks**	**Share in the total harvest of 2019**
	1 000 t	%	1 000 t	%	1 000 t	%	1 000 t	%	1 000 t	%	1 000 t	%	1 000 t	%
Baden-Württemberg	491.5	*29.9*	8.5	15.7	319.3	*30.9*	41.8	*44.7*	73.9	*47.0*	151.4	*25.0*	**1 086.3**	*30.3*
Bayern	1 491.9	*39.8*	73.1	*34.0*	889.0	*42.0*	43.0	*48.6*	162.3	*39.6*	548.7	*43.0*	**3 208.0**	*40.8*
Brandenburg	370.3	*37.8*	185.0	*25.8*	124.1	*22.1*	11.6	*35.1*	44.9	*30.4*	21.9	*20.7*	**757.8**	*29.8*
Hessen	484.9	*38.2*	25.7	*24.9*	217.9	*36.2*	21.7	*43.4*	51.1	*36.7*	32.0	*28.5*	**833.3**	*36.6*
Mecklenburg-Vorpommern	963.9	*37.2*	74.5	*20.2*	140.2	*12.2*	10.3	*29.6*	27.9	*33.1*	16.7	*46.6*	**1 233.5**	*28.9*
Niedersachsen	1 216.7	*36.4*	118.9	*15.2*	286.6	*21.1*	13.9	*27.9*	86.6	*21.3*	214.2	*42.0*	**1 936.8**	*30.0*
Nordrhein-Westfalen	657.1	*31.8*	51.9	*33.9*	333.1	*28.4*	9.1	*26.1*	160.2	*39.7*	398.6	*55.0*	**1 610.0**	*35.4*
Rheinland-Pfalz	187.8	*23.9*	11.8	*19.5*	100.9	*18.9*	9,6	*42.2*	35.1	*32.2*	1.5	*1.8*	**346.8**	*21.7*
Saarland	3.9	*7.3*	0.7	*4.3*	4.2	*16.2*	2,1	*33.4*	4.1	*33.9*	/	/	**15.0**	*13.0*
Sachsen	526.4	*38.5*	64.4	*36.2*	263.3	*32.2*	17,3	*36.5*	31.1	*33.0*	28.0	*27.8*	**930.5**	*35.7*
Sachsen-Anhalt	496.3	*24.0*	60.9	*19.1*	107.9	*14.3*	11,2	*51.4*	18.0	*21.7*	24.0	*33.8*	**718.2**	*21.6*
Schleswig-Holstein	375.4	*24.4*	33.0	*16.2*	155.2	*22.8*	10,2	*21.9*	18.5	*29.9*	0.8	8.3	**593.2**	*23.3*
Thüringen	485.0	*30.5*	15.1	*23.1*	221.2	*28.5*	6,7	*33.1*	22.0	*26.0*	8.7	*31.5*	**758.7**	*29.6*
GERMANY [1)]	**7 751.2**	***33.6***	**723.6**	***22.4***	**3 162.7**	***27.3***	**208.5**	***37,9***	***735.6***	**33.5**	**1 446.4**	**39.5**	**14 028.0**	**31.6**

**No data on rice is available*

An estimation of the stored cereals in 2020 can be proposed based on the elements above:

- *2019 : Calculation of the ratio storage vs production :* 14 028 000 * 100 / 44 399 000 = 31,6%
- *2020 : Estimation of the total cereals stored based on the hypothesis that the share of the stocks in the total harvest in 2019 is equivalent to 2020*

⇨ **Estimation of quantity of cereals stored in 2020: 43 307 000 * 31,6 / 100 = 13 685 012 T**

c) Volume of treated stored grains cereals

This data is unavailable and difficult to get because depending on different parameters.

d) Storage sites + How are stored the grains (on-farm, off-farm, export shipments)

Capacity of storage of Germany (2014-15 data):
> 40 million tons => Around 48 million of tons, probably more nowadays

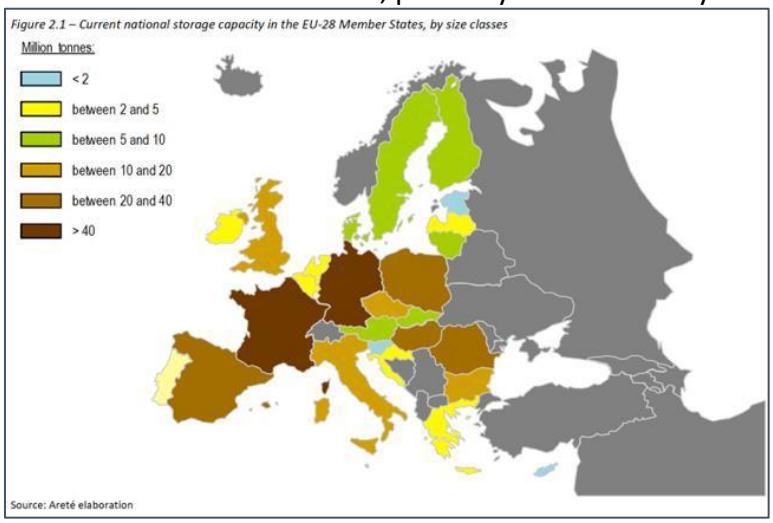


Figure 23 : Current national storage capacity in the EU-28 Member States, by size classes

The storage is divided in 3 types of storage:

- Storage on-farm
- Storage off-farm: cooperatives & traders
- Storage off-farm: Export shipments: harbors

The Table 33 proposes an overview of the repartition of the storage in Germany according to different types of storage.

Table 33 : Repartition of the total share in Germany according to different types of storage

Type of storage (2015 data)	Share in total storage (%)	Estimation of storage capacity (mT)
Individual farms = on-farm	42%	**20.1 million** (calculation estimation)
Farming cooperatives = off-farm	29%	**14 million** (calculation estimation)
Processing industries = off-farm	4.7%	**2.3 million** (calculation estimation)
Wholesale/trade = off farm	19%	**9.1 million** (calculation estimation)
Transportation hub (including ports)	5.3%	**2.5 million** (calculation estimation)
Storage capacity	**100%**	**48 millions**

According to the different type of storages, here is presented rapidly how are stored the cereals (same as for France):

- Storage on-farm => plate, external cells (silos)
- Storage off-farm : cooperatives & traders => external cells (silos)
- Exports shipments => external cells (silos)

2) Focus on specific stored grains cereals: wheat, barley, oat, maize, rice

a) Estimated volumes of each stored grains variety

This part is listed in the *part 1)c) "Volume of stored grains"*

b) Treatment used for each stored grains variety

This part is related to the *part 6) "Control means available"*

c) Speed of grain rolling (incoming, stored, outgoing)

This data is unavailable.

3) Stored grains cereals invasive species

a) Occurrence & Percentage of damages

Globally, the same species are found in France & Germany even if the percentage of presence can vary from a country to another.

A study more specific indicated the following comments: *Oryzaephilus surinamensis* and *Cryptolestes ferrugineus* were the predominant species, but *Sitophilus oryzae* had increased since 1976. Several species of moths *Ephestia elutella, Plodia interpunctella*, *Nemapogon granellus* and *N. personellus* damaged the surface layer of some heaps. Other thermophilous beetle species such as *Tribolium castaneum*, *Cryptolestes pusillus* and *Rhyzopertha dominica* occurred occasionally in several years. Infestation by these species is best prevented by ventilation of the grain. *Sitophilus zeamais* was found on imported maize in several instances but did not become established. Control measures can be prescribed by the National Plant Protection Service if necessary, but the increasing use of ventilation and cooling facilities in storage premises together with other measures is expected to lead to a further fall in infestation in coming years.[49]

However, a German study dating from 2013 presents the **stored-product insects by orders** found in mills and stores in Germany. The study is based on a checklist (Schöller, 2013) compiled mainly from data in the Entomofauna Germanica (Klausnitzer, 2003). It was completed by own determinations of 28 specimens sent to Biologische Beratung (Berlin) by companies and private households, and field work in stores, mills, bakeries and food-processing plants. For the classification according to ecological guilds, the overview in Haines (1991) was followed. Imported species were not included in case they were only once or sporadically recorded.

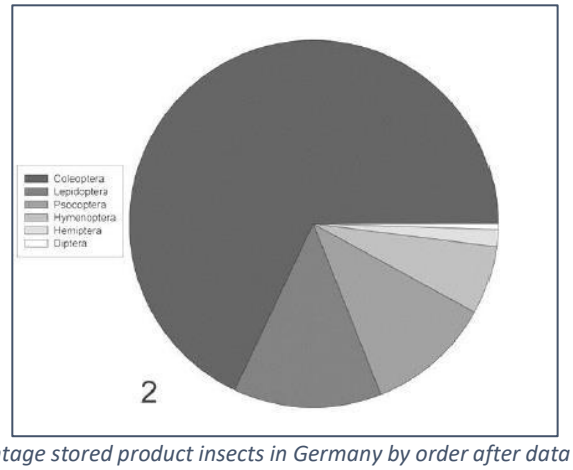


Figure 24 : Percentage stored product insects in Germany by order after data in Schöller (2013)

Consequently, Figure 24 presents:

- 145 beetles
- 28 moths
- 23 psocids
- 13 hymenoptera
- 3 hemiptera
- 1 diptera

Beetles are the most frequent species found in stored stuff.

4) Storage on bigger scales

a) Types of storage facilities

The types of storage are the same as for France:

- Storage on-farm => plate, external cells (silos)
- Storage off-farm: cooperatives & traders => external cells (silos)
- Exports shipments => external cells (silos)

Here below some manufacturers of silos/grains storage in Germany

- **Bühler Gmbh** [50]:

-Corrugated steel storage bin (grain, rice, raw paddy), for long-term storage: aeration & cooling can be added. Used in warehousing, handling, processing, transshipping grain.
-Flat-bottom silos: grains & mealy products – at collection points and in warehouses

- **LIPP Gmbh**[51]*:*

-Stainless steel storage / Round or Rectangular Silos – External or Internal Silos

- **HIMEL Maschinen Gmbh**[52]*:*

-Indoor installation : Round silo made with galvanized corrugated sheets & a high zinc coating / system of ventilation included
-Outdoor installation: Round silo made with steel (from 5 to 15000T)
-Rectangular storage silos: for indoor installation: Compared to round silos, they offer up to 35% more space

- **And several other manufacturers of silos***: general Silotec GmbH, Horstkötter GmbH & Co, Gruber maschinen GmbH, CBS Beton GmbH, Buschhoff GmbH & Co, Riela Getreidetechnik*

There is not a lot of information about ventilation equipment or temperature equipment.

b) Biggest site of storage for the exported cereals

- **Focus on ports**

The ports of Hamburg and Bremen are among the biggest ports for exportation of cereals from Germany.

- Hamburg [53]

The Port of Hamburg has silo and storage capacity for about 700 thousand tons of cereals, oil seed, fodder, and other agricultural products and about 700 thousand square meters of storage areas for ores, coal, fertilizers, and other dry bulk cargoe.

- Bremen[54]

For decades, J. Müller has supported Europe's coffee, cacao, and agricultural industries. The Port of Bremen is the entry point for the stocks of worldwide trade houses. This Port of Bremen terminal has capacity to store 90 thousand tons of products in silos or flat storage. The rail traffic flow is important in Germany. This traffic should include COP tonnage moving from the South-East and from the Central regions towards the Northern ports of Hamburg and Bremen for export.

- **Focus on the countries where Germany exports cereals (outside the European union)[3]**

In this part (Table 34), it's also interesting to describe the countries where Germany exports the most cereals (non-EU countries).

Table 34 : List of non-EU countries where Germany exports cereals

EXPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice
2017/2018	Saudi Arabia :1.1M South Africa: 384.4k Nigeria 336.5k Guinea: 241.5k Cuba: 193.9k	Switz: 1.02k Ukraine: 0.064k Serbia: 0.046k Stores & prov: 0.046k Maldives: 0.028	SaudiAfrica: 1.01M Iran: 138.6k US: 0.081k Switz: 0.061k Japan: 0.058k	Switz: 23.9k Belarus: 1.27k Ukraine: 515.9k Russia: 418.6k Japan: 398.6k	Switz: 9.5k Japan: 0.040k Russia: 0.033k Unit Arab: 0.014k Ukraine: 0.010k	Data unavailable
Total	**2.96M**	**1.35k**	**1.68M**	**27.4k**	**9.7k**	
2018/2019	Saudi Arabia: 741.2k South Africa: 487.4k Sudan: 182.3k Guinea: 177.1k Switz: 124.7k	Switz: 3.82k Ukraine: 0.103k Stores & prov: 0.075k SaudiArabia: 0.039k Serbia: 0.037k	Iran: 257.2k SaudiAfrica: 132.0k Kuwait: 77.0k US: 76.5k Japan:64.0k	Switz: 14.2k Iceland: 5.5k Belarus: 2.2k Russia: 0.522k Japan: 0.382k	Switz: 14.9k Norway: 1.2k Japan: 0.160k Chile: 0.035k Ukraine:0.020k	
Total	**2.67M**	**4.21k**	**1.07M**	**23.95k**	**16.5k**	
2019/2020	Iran: 1.0M SaudiAfrica: 542k Morocco: 468.3k South Africa: 447.6k Turkey: 424.0k	Switz: 5.25k UK: 0.920k Stores & provisions: 0.182k Ukraine: 0.094k Thailan: 0.038	SaudiAfrica: 837.7k Iran: 219.4k Japan:160.4k Morocco: 71.2k Switz: 67.1k	Switz: 25.98k Iceland: 6.3k UK: 6.3k Belarus: 2.5k Russia: 0.604	Switz: 11.2k UK: 0.102k Japan: 0.080k Russia: 0.023k Ukraine:0.023k	
Total	**5.26M**	**6.72k**	**1.84M**	**43.7k**	**11.5k**	
2020/2021	Algeria: 1.1M UK: 612.1k Pakistan: 246.8k Iran: 134.5k Morocco: 121.9k	UK: 1.57k Switz: 0.137k Ukraine: 0.100k Israel: 0.042k Thailand: 0.030k	Iran: 436.1k SaudiAfrica: 250.9k Morocco: 120.9k Algeria: 92k Turkey: 83.6k	Switz: 9.67k UK: 1.79k Belarus: 0.899k Russia: 0.616k Japan: 0.523k	Switz: 13.3k UK: 0.134k Japan: 0.080k Chile: 0.027k US: 0.014k	
Total	**2.78M**	**2.04k**	**1.4M**	**15.1k**	**13.6k**	
Main countries	Saudi Arabia Iran Algeria	Switzerland UK	Saudi Africa Iran	Switzerland Iceland Belarus	Switzerland	

** M: Million Tons – k: thousand tons*

**Stores & prov: Stores & provision / Switz: Switzerland*

c) several non-EU countries from where cereals come from (=import)

In this part (Table 35), it's also interesting to describe the countries where Germany imports the most cereals (non-EU countries).

Table 35 : List of non-EU countries where Germany imports cereals

IMPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice
2017/2018	Russia :38.4k Ukraine : 7.8k Kazakhsta: 0.845k India : 0.834k Serbia: 0.824k	Nepal: 0.321k Turkey: 0.319k India: 0.311k Switzer:0.105k Lebanon:0.075k	Australia: 0.482k Argentina:0.346k Ukraine: 0.329k Serbia: 0.309k Liecht: 0.016k	Ukraine: 340k Russia: 43.2k Argentina:19.6k Serbia:1.8k Turkey: 1.4k	Ukraine: 0.464 Uruguay: 0.131 Serbia: 0.131 Switz: 0.003 Russia: 0.0004	Data unavailable
Total	**49.1k**	**1.3k**	**1.5k**	**407.8k**	**0.729k**	
2018/2019	Serbia : 28.5k Russia : 19.9k Ukraine:4.6k India:1.0k Kazakhstan: 0.746k	India: 0.638k Nepal: 0.409k Turkey: 0.383k Switzer: 0.079k Lebanon 0.076k	Ukraine: 0.265k Serbia: 0.050k Canada: 0.014k New Z: 0.005k Korea: 0.003k	Ukraine: 1.6M Serbia: 24.6k Argentina:18.2k Russia: 17.6k Turkey: 1.3k	Ukraine: 0.645k Chile: 0.445k Uruguay: 0.243k Canada: 0.199k Russia:0.150k	
Total	**55.9k**	**1.7k**	**0.343k**	**1.7M**	**1.79k**	
2019/2020	UK: 3.4k Ukraine:2.7k India: 2.0k Switz: 0.540k Serbia: 0.371k	India: 0.710k Nepal: 0.530k Turkey:0.398k UK: 0.248k Lebanon 0.080k	UK: 4.3k Canada: 0.013k New Z: 0.011k USA: 0.003k Korea: 0.002k	Ukraine: 697.8k Russia: 25.2k Argentina: 16.6k Turkey: 2.1k Serbia:1.7k	UK: 3.07k Chile: 0.800k Uruguay: 0.714k Ukraine: 0.208k Argentina: 0.150k	
Total	**9.8k**	**2.2k**	**4.3k**	**747.6k**	**5.0k**	
2020/2021	Ukraine: 4.4k India:1.8k Serbia: 0.310k Kazakhstan: 0.220k UK: 0.104	India: 0.500k Turkey: 0.282k Nepal: 0.147k UK: 0.125k Lebanon 0.032k	UK: 39.6k Canada: 0.015k Korea: 0.010k USA: 0.003k New Z: 0.002k	Ukraine: 161.8k Russia: 6.2k Turkey:1.5k UK: 0.796k US: 0.369k	UK: 5.8k Chile: 0.424k Ukraine:0.375k Uruguay: 0.060 Switz: too low	
Total	**7.3k**	**1.2k**	**39.6k**	**171.7k**	**6.7k**	
Main countries	Russia Serbia Ukraine	India Nepal Turkey	UK	Ukraine	UK	

** M: Million Tons – k: thousand tons*
**Liecht: Lichtenstein / Switz: Switzerland/ New Z: New Zealand*

To resume, Table 36 presents the main countries where Germany exports and imports to non-EU countries.

Table 36 : The main non-EU countries where Germany exports and imports since the 4 last years

TOTAL	Common wheat	Durum wheat	Barley	Maize	Oat	Rice
EXPORT	*Saudi Arabia* *Iran* *Algeria*	*Switzerland* *UK*	*Saudi Africa* *Iran*	*Switzerland* *Iceland* *Belarus*	*Switzerland*	Data unavailable
IMPORT	*Russia* *Serbia* *Ukraine*	*India* *Nepal* *Turkey*	*UK*	*Ukraine*	*UK*	

d) Industry mapping in grains storage

In this part, the sites of storages organizations are presented.
A map of "storage organisms" doesn't exist **but there is around 1984 cooperatives spread out in the country.**
A map of ports spread out in Germany is presented below (Figure 25). The ports in blue are representative of "storage sites" where large flows of goods circulate.

Figure 25 : List of ports in Germany

A description of the German freight transportation is not asked in the study but is important in order to understand more the key points (target locations) for the storage sites. Germany has a central position and good access to the sea, which permits to get strategic position for cereals export (Figure 26).

Strengths	Weaknesses
• Germany is located in Central Europe. Transport routes are relatively short to all other neighbouring countries. • Germany has access to the sea. German seaports are important transhipment points for inward and outward global trade flows. • The dense inland waterway network with numerous channels connects Germany to neighbouring countries • Germany has the densest railway infrastructure in the EU. • Germany as a transit country gains tolls from crossing shippers.	• Because of the central position in Europe, Germany is a transit country. Obviously not every transport chain starts or ends in Germany: this implies that many traffic flows cross Germany from North to South and West to East, or vice versa, and transport infrastructure is heavily utilised. • Permanent maintenance and infrastructural development are necessary to overcome the increasing transport flows in the future. The gained road toll should cover such investments, but the toll is uncommitted.

Figure 26 : Description of the freight transportation in Germany (strengths and weaknesses)

5) Potential users of the new solution

a) List of companies buying the product (appliers, users) [34, 55,56,57]

The potential "buyers" of the future product developed by Babolna Bio in Germany are presented below (Table 37).

Table 37 : List of potential buyers of the new solution in Germany

List of potential buyers of the new solution	Description
Agricultural cooperatives	Cooperatives are the organisms who stores the most in Germany. -Agricultural cooperatives Raiffeisen: 698 (2019 year source) -Number of total cooperatives: 1984 (2019 year source) List of big agricultural cooperatives in the cereals field:[58] BayWa, AGRAVIS, RWZ Rhein Main, ZG Raiffeisen, RWZ Kurh Thur
Agricultural traders	No data available
Farmers dedicated to cereal crops (exploitations agricoles)[57]	-Number of farms: 83 900 (2016 year source) -Number of farms specialized in cereals, oilseeds, protein crops among farms: 39 800 (2016 year source)
Cereals ports [59]	-Hamburg (the biggest), Bremen and Rostock are the 3 main ports where circulate the most of grains.
Distributors of phytopharmaceutical products	Difficult to get this data, different sites where phytopharmaceutical products are sold exist: Biohelp, Avagrar, BayWa, PPS
Companies influencing in the cereals field[60]	Bunge, Cargill, Glencore, Louis Dreyfus

6) Control means available (+ Boundary conditions)

The control method the most current used is the treatment of grains by insecticide. In order to describe precisely the control means available and the boundary conditions in Germany, the BLV database is well described but there is no information about treatment difference between "treatments used directly on the grains" and "treatments used for storage premises". In the BLV database, you can choose:

Vorratslagerndes Getreide : Cereals in storage
Vorratsschutz : Protection of stores

a) Focus on the insecticides used within the market for indoor & post-harvest grain treatment[61]

The treatments here are of PROFESSIONNAL use and based on "synthetic chemistry".

The following list (Table 38) presents the authorized insecticides in Germany used to treat the stored grains and the premises of storage, these insecticides are used with pulverization or nebulization system.
It's important to note that Pirimiphos-methyl products are forbidden in Germany compared with France for example.

Table 38 : List of insecticides (« synthetic chemistry ») authorized in Germany to treat stored grains and the premises of storage – Used with pulverization and nebulization

Product	Manufacturer	Active substance	Concentration	Formulation type	*(1)*	*(2)*	*End admission*
BANK	Sharda Cropchem Espana S.L.	Deltamethrin PBO	50.7 g/L 6 g/L	ULV solution (insecticide)	4.21/100t 1 appli (6 months protection) Except for triticale : no use	Data unknown	31/10/21
GRANPROTEC	Sharda Cropchem Espana S.L.	Deltamethrin PBO	213 g/L 25 g/L	Emulsionnable concentrate (insecticide)	Special conditions for wheat	Data unknown	31/10/21
INSEKTENIL-VoraProtectULV-Profi	Bayer CropScience	Deltamethrin	6 g/L	ULV solution (insecticide)	4.21/100t 1 appli (6 months protection)	Data unknown	31/12/21
INSEKTENIL-VORAProtect	Bayer CropScience	Deltamethrin	25 g/L	Emulsionnable concentrate (insecticide)	1L in 99L / 100L of water (6 months protection) 1 appli	Data unknown	31/12/21
K-Obiol EC25	Bayer CropScience	Deltamethrin	25 g/L	Emulsionnable Concentrate (insecticide)	1L in 99L / 100L of water (6 months protection) 1 appli	Data unknown	31/12/21
K-Obiol ULV6	Bayer CropScience	Deltamethrin	6 g/L	ULV solution (insecticide)	up to 6 months of protection 4.2l/100 t 1 appli	Data unknown	31/12/21
Microsol-SP 3000 ULV-RTU	Bayer CropScience	Deltamethrin	6 g/L	ULV solution (insecticide)	up to 6 months of protection 4.2l/100 t 1 appli	Data unknown	31/12/21
Microsol-SP-3000	Bayer CropScience	Deltamethrin	25 g/L	Emulsionnable concentrate (insecticide)	up to 6 months of protection 1l in 99 l/100 t water 1 appli	Data unknown	31/12/21
Talisma EC	Arysta LifeScience Benelux Sprl.	Cypermethrin PBO	228 g/L 80 g/L	Emulsionnable Concentrate (Insecticide)	2L/100t in 10 to 250L/100t of water -1 appli -Except: Maize, millet, buckwheat	30ml or 60ml/100 m2 in 3.3 to 5 l/100 m2 of water -1 appli	31/10/21
Talisma UL	Arysta LifeScience Benelux Sprl.	Cypermethrin PBO	57 g/L 20 g/L	ULV solution (insecticide)	8.41/100t -1 appli -Except: Maize, millet, buckwheat	Data unknown	31/10/21

b) Fumigation and powder formulation[61]

- **FUMIGATION**

The treatments here are of PROFESSIONNAL USE and based on "synthetic chemistry".

The following list (Table 39) presents the authorized insecticides in Germany used to treat the stored grains and the premises of storage based on fumigation system.

Table 39 : List of insecticides (« synthetic chemistry ») authorized in Germany to treat stored grains and the premises of storage – Used with fumigation system

Product	Manufacturer	Active Substance	Concentration	Formulation type	(1)	(2)	End admission
Delicia-Gastoxin-Tabletten	Detia Freyberg Gmbh	Aluminium phosphide	560 g/kg	Gas generating product (insecticide)	15 pieces/t 1 appli Except: corn	Data unknown	31/12/25
Detia-gas-EX P	Detia Freyberg Gmbh	Aluminium phosphide	560 g/kg	Gas generating product (insecticide)	50 pieces per m3 1 appli Excpt : Emmer	50 pieces per m3 1 appli Excpt: Emmer	31/08/23
Detia-gas-EX T	Detia Freyberg Gmbh	Aluminium Phosphide	560 g/kg	Gas generating product (insecticide)	15 pieces per t 1 appli Except : Corn	Data unknown	31/12/25
Gastoxin Pellet	Detia Freyberg Gmbh	Aluminium phosphide	560 g/kg	Gas generating product (insecticide)	50 pieces per m3 1 appli Except:Emmer	50 pieces per m3 1 appli	31/08/23
Phostoxin Bag	Detia Freyberg Gmbh	Aluminium phosphide	570 g/kg	Gas generating product (insecticide)	34 g/t 1 appli	Data unknown	31/12/27
Phostoxin Bag Blanket	Detia Freyberg Gmbh	Alumnium phosphide	570 g/kg	Gas generating product (insecticide)	0.009 pieces per m3 1 appli Excpt emmer	Data unknown	31/08/23
Phostoxin Pellet	Detia Freyberg Gmbh	Aluminium phosphide	560 g/kg	Gas generating product (insecticide)	50 pieces per m3 1 appli Except: Emmer	50 pieces per m3 1 appli	31/08/23
Phostoxin Tablet	Detia Freyberg Gmbh	Aluminium phosphide	560 g/kg	Gas generating product (insecticide)	15 pieces per t 1 appli Except: corn	Data unknown	31/12/25
Quickfume Presskörper	UPL Europe Ltd	Aluminium phosphide	570 g/kg	Gas generating product (insecticide)	36 g/t 1 appli Excpt: corn	Data unknown	31/12/25
QuickPhos Pellets	UPL Europe Ltd	Aluminium phosphide	570 g/kg	Gas generating product (insecticide)	36 g/t 1 appli Excpt: corn	Data unknown	31/12/25
QuickPhos Tabletten	UPL Europe Ltd	Aluminium phosphide	570 g/lg	Gas generating product (insecticide)	36 g/t 1 appli Excpt: corn	Data unknown	31/12/25
Degesch-Magtoxin	Detia Freyberg Gmbh	Magnesium phosphide	660g/kg	Gas generating product (fumigen)	Tablet 6pieces per t 1 appli OR Pellet 30 pieces per t 1 appli	Data unknown	31/12/25
Degesch plate	Detia Freyberg Gmbh	Magnesium phosphide	560 g/kg	Gas generating product (insecticide)	X	-117g each 6m3 1 appli	31/08/23
Degesch strip	Detia Freyberg Gmbh	Magnesium phosphide	560 g/kg	Gas generating product (insecticide)	X	-117 g each 6m3 1 appli	31/08/23
Detia-Magphos	Detia Freyberg Gmbh	Magnesium phosphide	660 g/kg	Gas generating product (insecticide)	6 or 30 pieces per t 1 appli	Data unknown	31/12/25
Frisin	S&A Service und Anwendungstechnik GmbH	Phosphane	20.6 g/kg (hydrogen phosphorus)	Gas	3.7 g/m3 1 treatment	Data unknown	31/12/26
Aligal 2	Air liquid	Carbon dioxid	999g/kg	Gas (in print pack) (insecticide, acaricide)	30kg/t 1 appli	Data unknown	31/08/22

Based on the table above, Germany is a common user of fumigation-based products because there is a big list of products.

- **POWDER FORMULATIONS**[61]

The treatments here are of PROFESSIONNAL USE. This list (Table 40) presents the powder formulations. The 2 products are based with Diatomaceous Earth.

Table 40 : List of insecticides based on « powder formulations »

Product	Manufacturer	Active Substance	Concentration	Formulation type	*(1)*	*(2)*	*End admission*
Silicid	Biofa Gmbh	Diatomaceous Earth	1000 g/kg	Contact powder (insecticide, acaricide)	1 kg/t 1 appli	Data unknown	31/08/22
SilicoSec	Biofa Gmbh	Diatomaceous Earth	1000 g/kg	Contact powder (insecticide, acaricide)	1 kg/t 1 appli	Data unknown	31/08/22

c) Alternative methods and possible solutions in the future

Based products with Diatomaceous Earth are considered as alternative solutions to "synthetic chemistry". Spinosad is also an active substance considered as alternative solution to "synthetic chemistry" and authorized in Germany but at the moment, there is no commercial product based on this substance in the German database.

Here below a list of the common methods used for the treatment of stored grains is presented for Germany (classical, physical, and alternative methods). A classification based on the "most appropriate use" is proposed with a hierarchy from I {very good} to V {not suitable}.
This Table is dated 2013 but still available nowadays because there is not a lot of evolutions since this date except the reduction of contact insecticides and increase of the alternative methods.[62]

Table 41 : Methods used for the treatment of stored grains

	11	12	13	14
Biological control, parasitic wasps	**IV**			**V**
Trapping with pheromon/food attractant baited traps **as monitoring support**				
Physical control with heat				
Physical control with cold				
Irradiation				
Application of contact insecticides e.g. pirimiphos methyl, deltamethrin	**I***	**II***	**III**	**II**
Application of pyrethrum				
Use of diatomaceous earth	**II***			
Fumigation with phosphine		**III**	**I**	**I**
Fumigation with CO_2/N_2	**III**		**II**	
Intensive inspection and sanitation				
Optimization of construction				
Rejection of the load		**I**		

Legend: **11) Grain storage in silo bins: during loading, no insects visible; 12) Grain storage in silo bins: during and shortly after loading, insects visible; 13) Grain storage in silo bins: heavy infestation plenty of time until unloading; 14) Grain storage in silo bins: heavy infestation close to unloading.*

According to the Table 41, the application of contact insecticides is the most appropriated use (I to III).
Based on the "alternative methods":

- Use of diatomaceous Earth is marked II
- Use of fumigation (phosphine or CO_2/N_2) is market from I to III

- Use of biological control and parasitic wasps is market from IV to V (not really suitable)…

On the other hand, some other solutions proposed for France can be available also in Germany (IGR, essential oils, fungus…) but there is not a lot of information about this item.

d) Boundary conditions = specific limitations & restrictions

The same active substances banned in France are also banned in Germany.

BAN OF ACTIVE SUBSTANCES: chlorpyrifos-methyl, malathion, dichlorvos, bromophos, 1,2-dichloroethane, carbon tetrachloride (fumigation), Gamma-HCH = Lindane, bioresmethrin, bifenthrin

Pirimiphos-methyl is authorized in FRANCE, SPAIN, ITALY, ROMANIA, HUNGARY but not in GERMANY. Consequently, Actellic liquid (Syngenta) & the Pirigrain range (250, 50, SLD, aerosol) (Sojam) sold in France are not used in Germany.
On the other hand, PBO which is a synergist banned in FRANCE is authorized in GERMANY.

Some products based on deltamethrin and cypermethrin have an end admission at the end of 2021 year. It's unknown if these products will be maintained or not after this time in Germany. This is due to the fact that the active substance in the European regulations gets and end date in 2021 October.

SPAIN

SPAIN

Introduction

The study *Cereals 2020* [1] and Table 42 (Eurostat) show that Spain is one of the main cereal's consumer worldwide and this country is a huge net importer too. We can say that the volume of imports during 2019/2020 is around **17Mt**. The volume was equal to 14.7 Mt during 2018/2019. Moreover, Spain consumes daily around **99 000 tons** of cereals. The study *Cereals 2020*[1] focuses also on the fact that the global demand of cereals worldwide is very high. The sector needs to gather the number of cereals through cooperatives in order to centralize it and to be more efficient on the global market. In Spain, cooperatives are very important because they can guarantee a sufficient offer according to the growing demand.

1) Stored grains cereals general data

a) Volume of cereals produced [1]

It is important to have an overview of the global amount of cereals harvested in Spain. The Table 42 shows a constant increase of cereals production in Spain except for the season 2020/2021 and 2021/2022. It is important to highlight that the first global results are very encouraging in June 2020.

Table 42 : Cereals production in Spain for the last 5 marketing years - Eurostat

Cereals / Year (th T)	2017/18	2018/19	2019/20	2020/21	2021/22
Type	*	*	*Estimate*	*Forecast*	*Projection*
Soft wheat	3 769	6 707	5 097	7 120	6 153
Durum Wheat	1 062	1 282	704	819	770
Barley	5 786	9 130	7 400	10 961	9 345
Oat	843	1 487	808	1 290	1 143
Grain Maize	3 776	3 843	4 184	4 130	4 148
Triticale	356	649	577	763	681
Rye	*139*	*388*	*251*	*389*	*306*
Sorghum	*30*	*26*	*25*	*25*	*28*
Other cereals	*63*	*171*	*108*	*108*	*120*
Total cereals ES	**15 824**	**23 683**	**19 154**	**25 604**	**22 693**
Total cereals EU-28	**307 959**	**292 357**	**322 532**	**n.a**	**n.a**
Total cereals EU-27	**284 960**	**271 272**	**297 015**	**280 365**	**295 108**
% ES / EU-27 prod	**5.5%**	**8.7%**	**6.4%**	**9.1%**	**7.7%**

**For all cereals: marketing year from 1st July N to 30th June N+1*

The following figure Figure 27 underlines the fact that the 3 regions producing the most cereals in 2020 are:

- Castilla-Leon (9 450 567 T),
- Castilla-Mancha (4 857 919 T)
- Aragon (3 744 582 T).

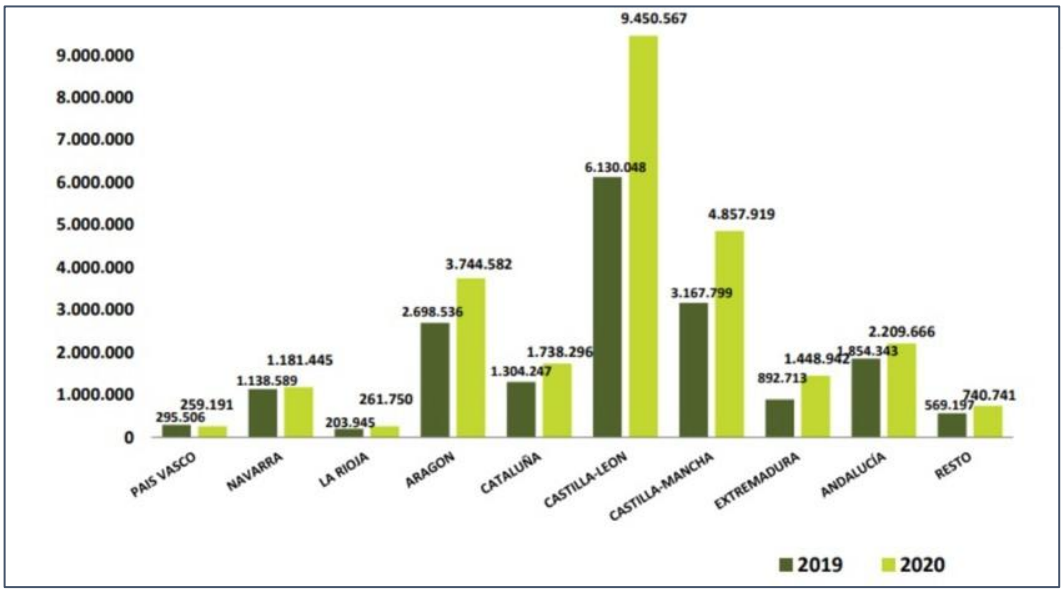


Figure 27 : Total production of cereals in 2020 (in T) in Spain (Agrifood cooperatives of Spain)

España estimación Producción de cereales							
t.	2020	2019	2018	2017	2016	media 3 años	20/19
PAIS VASCO	259.191	295.506	234.251	206.202	311.860	245.319	-12,29%
NAVARRA	1.181.445	1.138.589	966.835	918.525	1.065.037	1.007.983	3,76%
LA RIOJA	261.750	203.945	239.248	167.269	261.497	203.487	28,34%
ARAGON	3.744.582	2.698.536	3.568.637	2.929.815	3.441.524	3.065.663	38,76%
CATALUÑA	1.738.296	1.304.247	1.535.935	1.366.357	1.503.228	1.402.180	33,28%
CASTILLA-LEON	9.450.567	6.130.048	8.716.534	3.442.823	9.000.007	6.096.468	54,17%
CASTILLA-MANCHA	4.857.919	3.167.799	4.099.787	2.634.103	4.458.777	3.300.563	53,35%
EXTREMADURA	1.448.942	892.713	1.394.648	1.186.185	1.255.526	1.157.849	62,31%
ANDALUCÍA	2.209.666	1.854.343	2.718.889	2.175.130	2.007.709	2.249.454	19,16%
RESTO	740.741	569.197	599.294	499.063	747.264	555.851	30,14%
ESPAÑA	25.893.099	18.254.923	24.074.056	15.525.471	24.052.428	19.284.817	41,84%

España estimación Producción de cereales				
2020	Trigo Blando	Trigo Duro	Cebada	Maíz
PAIS VASCO	144.108		82.140	
NAVARRA	429.000	19.400	440.000	206.710
LA RIOJA	120.000	0	132.500	2.750
ARAGON	589.568	221.373	2.132.909	558.665
CATALUÑA	387.230	0	972.219	330.951
CASTILLA-LEON	3.646.800	15.120	3.782.140	1.269.763
CASTILLA-MANCHA	968.144	12.385	2.941.156	228.755
EXTREMADURA	341.500	25.750	240.000	590.442
ANDALUCÍA	481.852	600.242	508.968	181.800
RESTO	147.302		316.072	149.695
ESPAÑA	7.255.504	894.269	11.548.104	3.519.532

Figure 28 : estimation of the overall production of cereals in Spain in function of the regions (Agrifood cooperatives of Spain)
**Trigo = wheat ; avena = oat : centeno = rye ; cebada = barley*

b) One big cereals producer[2–5]

Several big cereals producer are interesting in Spain:

Grupo AN is a reference in the Spanish Agri-food cooperative. Indeed, with a social base of about 42 000 farmers and ranchers, this group allows to its members to benefit from a strong ability to produce and optimize their activities. There is a total control of their cycles and a commercial security in the management of their productions and the collection of the merchandise.

Grupo AN works in:

- Analytical control in harvest
- Certified and organic production of durum wheat (for the semolina industry), common wheat (for animal consumption or organic flour) and barley (for the manufacture organic feed)
- Oleaginous plants for extracting oil; rapeseed (oil for biodiesel) and sunflower (for the production of oil for human consumption)

Some following datas about the Grupo AN:

- 1.457 million of euros billed per year
- 41 912 farmers and ranchers
- 1.712 employees
- 161 cooperative members
- 125 million (own and similar funds)

The ACCOE *(La Asociación de Comercio de Cereales y Oleaginosas de España - The Spanish Cereals and Oilseeds Trade Association)* is an interesting organization because many cereals producers of cereals are part of it in Spain. Indeed, it is a national business organization with more than 40 years of experience. In this organization, there are 190 associates representing almost all the autonomous communities.

Here are some objectives and functions of this organization:

- To promote links between organizations in general, and also at regional, provincial and national level.
- To allow its members to be a channel in consultative and decision-making bodies at national level an in economic matters.
- To promote and protect the organizations that can be created within the association.

Cereales Teruel is recognized as an *Agricultural Producers Association* since 1991 and can product 70 000 ha of cultivation. There are 2 500 cooperative members grouped in 10 sections located in municipalities of Alto Teruel (Albónica, Alto Jiloca, Bañón, Campo de Bello, Campo de Visiedo, Cereales del Huerva, La Val, Sierras del Jiloca, Sierras del Pobo y La Hoya de Teruel).

Garlan was created in 1986. Today there are 9 first-degree cooperative companies, 46 holders of agricultural holdings which makes a social base of 600 farmers.
The objective of the company since its creation has been and is still to improve and optimize the marketing structures of agricultural products and supplies in order to access increasingly globalized and competitive markets.

c) Volume of stored grains cereals

This data is unavailable to get.

d) Volume of treated stored grains

This data is unavailable and difficult to get because depending on different parameters.

e) Storage sites + How are stored the grains (on-farm, off-farm, export shipments) [6,7]

- **Storage sites**

According to the website *Agrodigital* [6], Spain has increased its storage sites in 10 years (+7,4 Mt). Its capacity of storage is equal to 29.91 Mt between 2005 and 2015. In comparison, France and Germany are considered as the main players in the storage domain in UE.

According to FEGA[7], the first storage site in Spain was constructed in 1949 *(the Silo of Alcalá de Henares)* by the National Silos network. This storage site was created in accordance with the existing lines of railway and other kind of transport connections. They started constructing other storages in Spain between 1945 and 1986. Between this dates, 663 silos and 275 barns were constructed with a global capacity of 2 684 947 tons.

Here below the main objectives of the National Silos Network:

- Being able to buy all the wheat harvest to farmers
- Being able to keep a national reservation of the consumption of cereals
- Being able to allow the good reception of the importation and exportation
- Being able to treat the grains and select it

Today, the current public storage in Spain is composed of 142 silos and barns with a global capacity of **980 070 tons.**

The Figure 29 below describes the storage situation in Spain. It is possible to have further information in the FEGA website. Indeed, there is a link for each autonomous community. Each link gives information about the location of silos, the location of the barns, their capacities for each, the tons for each community …

COMUNIDAD AUTÓNOMA	Macros		Silos		Macro + Silo		Graneros		Total	
	t	nº	t	nº	t	nº	t	nº	t	nº
Andalucía	165.000	6	24.250	6	189.250	12	14.000	2	203.250	14
Aragón	35.000	2	139.350	35	174.350	37	6.100	5	180.450	42
Castilla-La Mancha	86.000	4	7.000	1	93.000	5	0	0	93.000	5
Castilla y León	186.000	10	140.200	40	326.200	50	3.950	4	330.150	54
Cataluña	12.000	1	7.500	1	19.500	2	0	0	19.500	2
Extremadura	45.500	3	54.520	12	100.020	15	1.050	2	101.070	17
La Rioja	0	0	11.550	3	11.550	3	0	0	11.550	3
Madrid	10.000	1	0	0	10.000	1	0	0	10.000	1
C. Foral de Navarra	15.000	1	16.100	3	31.100	4	0	0	31.100	4
TOTAL	**554.500**	**28**	**400.470**	**101**	**954.970**	**129**	**25.100**	**13**	**980.070**	**142**

Figure 29 : Current basic network – distribution by autonomous community

- **How are stored the grains (on-farm, off-farm, export shipments)** [8]

According to Table 43, the storage capacity of Spain is around **29 985 000 t** in 2015. We can presume that the storage capacity has increased as the production is more important in 2020 than in 2005. The following map (Figure 31) illustrates the distribution of storage capacity by size classes, and its allocation among the different stages of the supply chain.

Table 43 : Available storage capacity at Member State level vs. storage needs (minimum/maximum)

Member states	2005 mapped storage capacities (t)	2015 mapped storage capacities (t)	Minimum needed storage capacity (t)	Maximum needed storage capacity (t)
Spain	22 464 548	29 905 814	23 858 000	29 985 000

Capacity of storage in Spain (2014-2015 data):
Between 20 and 40 million tons => around 30 millions of tons, probably more nowadays.

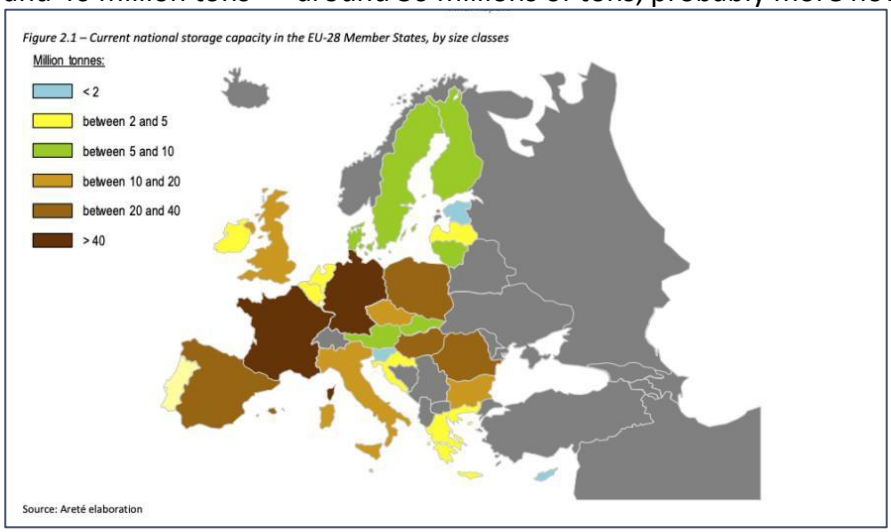


Figure 30 : Current national storage capacity in the EU- 28 Member States, by size classes

The storage is divided in 3 types of storage:

- Storage on-farm
- Storage off-farm: cooperatives & traders
- Storage off-farm: export shipments (harbors)

The Table 44 proposes an overview of the storage repartition according to different types of storage.

Table 44 : Repartition of the total share in Spain according to different types of storage

Type of storage (2015 data)	Share in total storage (%)	Estimation of storage capacity
Individual farms = on-farm	23%	6.9 million tons
Farming cooperatives = off-farm	25%	7.5 million tons
Processing industries = off-farm	6%	1.8 million tons
Wholesale/trade = off farm	23%	6.9 million tons
Transportation hub *(including ports)*	23%	6.9 million tons
Storage capacity	**100%**	**30 million tons**

To summarize, farming cooperatives represents the highest share in the overall storage even if a certain heterogeneity can be highlighted.

2) Focus on specific stored grains cereals: wheat, barley, oat, maize, rice

a) Estimated volumes of each stored grains variety

This part is listed in the part 1)a.

b) Treatment used for each stored grain variety [9,10]

Before storing the grains, some research showed that it is very important to dry the grains in order to eliminate the humidity. Indeed, if there is too much humidity during the storage phase, grains can be damaged, softened and we can observe the apparition of mushrooms. Fundamentally, the storage grains used to be located in silos associated to drying units. These units are used to decrease the humidity until some limits judged as sufficient for its conservation.

Another alternative of storage is called the "silo bags". Indeed, this alternative can protect the grains from the air contact when the grains need to be stored for a long time and to keep its humidity low. According to Luis Márquez and Oscar Pozzolo (El almacenamiento y la conservación de los granos, 2012), the process of conservation of the grains isn't the same in function of the grain's characteristics.

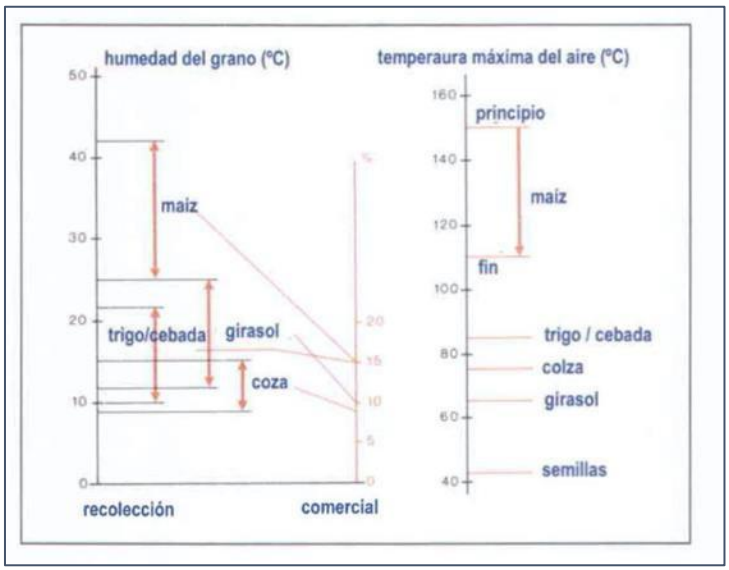


Figure 31 : Storage and preservation of grains – limitations for drying grains (2012)
**Maiz (corn) / trigo(wheat), cebada (barley) / girasol (sunflower) / coza / semillas (seeds)*

There are few kinds of drying machine: static drying grains, static drying grains with circulation, continuous drying grains.

Other information about the general grains treatment is available in part 6) *"control means available"*. Unfortunately, we couldn't find further information about the treatment used for each variety of stored grains in Spain. These data are not really available and difficult to find.

c) Speed of grain rolling (incoming, stored, outgoing) [12]

- **Spain Import – outside UE**

Table 45 : List of non-EU countries where Spain imports cereals (t)

IMPORT	Common wheat	Durum Wheat	Barley	Maize	Oats	Rice
2017/2018	Ukraine: 1.12M Russia: 117.65k UK: 62.03k Moldova: 45.43k Serbia: 19.61k	Canada: 28.44k India: 252.09 Japan: 218.56 USA: 153.13 China: 83.3	Ukraine:164.3k Moldova: 12.9 k Colombia: 2.86 Peru: 1.22 China.: 1.15	Brazil: 3.08M Ukraine: 1.76M USA: 1.02M Canada: 238.44k South Africa: 105.3k	Chile: 3	Not found
Total	**1.4M**	**29.2k**	**177.2k**	**6.2M**	**3**	
2018/2019	Ukraine: 311.8k Canada: 219.03k Russia: 91.5k Serbia: 77.58k USA: 65.09k	USA: 9.31k India: 273.41 Japan: 242.3 China: 99.5 Morocco: 69.5k	Serbia: 48 Peru: 2.74 Colombia: 1.1 Switzerland: 0.82 Norway. 0.03	Ukraine: 4M Brazil: 2.28M Canada: 375.09k USA: 249.36k Argentina: 115.98k	USA:0.36 Switzerland:9m Colombia: 4m	Not found
Total	**770.2k**	**10.0k**	**52,71**	**7.13M**	**0.36k**	
2019/2020	Ukraine: 315.9k Turkey: 30,9 k UK: 30.81k Russia: 18.28k India: 241.47	Canada: 48.46k UK: 10.64k USA: 4.45k India: 388.83 Morocco:136.5	Ukraine: 371.91k U.K: 36.97k Moldova: 19.48k Peru: 1.67 Oman: 0.6	Ukraine: 3.76M Brazil: 2.92M Serbia: 149.4k Canada: 92.68k Argentina: 21.66k	UK: 14.04k Chile: 10 New Zealand: 2m Australia: 1m	Not found
Total	**396.2k**	**64.2k**	**428.3k**	**6.9M**	**14.0k**	
2020/2021	Ukraine : 346.8k Serbia : 36.81k USA : 21.16k Russia : 13.98k Canada : 13.6k	Canada :126.76k USA : 9.49k Morocco:237.46 India : 187.73 UK : 29.02	U.K : 31.05k Ukraine : 24.2 Peru : 3.53 Bolivia : 0.3 UK : 0.09	Brazil : 2.46M Ukraine : 1.43M Serbia : 338,79k Canada : 136.2k Argentina: 34.9k	UK : 3.9k Ukraine : 16 Japan : 3,91k India : 1m	Not found
Total	**441.4k**	**136.7k**	**31.08k**	**4.4M**	**3.91K**	
Top countries	**Ukraine Canada Russia**	**Canada UK India**	**Ukraine UK**	**Brazil Ukraine Serbia**	**UK**	**X**

- **Spain exports – outside UE** [12]

Table 46 : List of non-EU countries where Spain exports cereals (t)

EXPORT	Common wheat	Durum Wheat	Barley	Maize	Oats	Rice
2017/2018	Syrian Arab Republic: 27.6k Melilla : 4.83k Dominican Republic:3.24k Venezuela : 3.2k Ceuta : 3.04k	Tunisia : 96.14k Mali : 33.63k Saudi Arabia:18.37k Libya : 16.97k Mauritania:161.15k	Djibouti : 5.03k Angola : 1.45k Ethiopia : 755.65 Vietnam : 508 Morocco : 383.28	Cameroon:17.9k Turkey : 7.26k Ivory Coast:6.62k Gabon : 4.46k Angola : 4.4k	Algeria : 4.79k Morocco : 566 Cuba : 300 United Arab Emirates : 292.66 Egypt : 70	Not found
Total	**51.7k**	**224.4k**	**9.3k**	**65.8k**	**6.1k**	
2018/2019	Syrian Arab Republic : 13.32k Dominican Republic : 6.01k Melilla : 4.67k Ceuta : 2.83k Andorra : 2.02k	Tunisia : 211.2k Mauritania : 32.66k Mali : 16.17k Turkey : 11k Senegal : 10.11k	Algeria : 55.36k Libya : 34.22k Tunisia : 28.46k Turkey : 22.03k Morocco : 15.25k	Cameroon:20.34k Ivory Coast : 11.14k Turkey : 10.08k Gabon : 8.41k Hong Kong : 3.93k	Norway : 4.33K Cuba : 503.5 Algeria : 427.28 Morocco : 29.05 Israel : 23.4	Not found
Total	**32.4k**	**312.5k**	**171.4k**	**81.5k**	**5.3k**	
2019/2020	Turkey : 6.88k Syrian Arab Republic : 5.67k Melilla : 4.73k Ceuta : 3.52k Dominican Republic : 2.22k	Tunisia : 251.39k Turkey : 117.68k Senegal : 24.59k Morocco : 21.79k Mali : 21.18k	Morocco : 16.68k Tunisia : 7.67k Cuba : 1.94k Vietnam : 1.27k Equatorial Guinea : 452.62	Cameroon : 19.87k Turkey : 18.05k Ivory Coast : 5.28k Hong Kong : .4,63k Burkina Faso : 4.35k	Algeria : 521.4m Dominican Republic : 68.16m Qatar : 57.21m Israel : 26.31m Andorra : 18.16m	Not found
Total	**28.0k**	**514.4k**	**29.5k**	**85.1k**	**716.0**	
2020/2021	Melilla : 3.83k Ceuta : 2.86k Andorra : 903.89 Morocco : 462.61 Iraq : 312	Mali : 18.54k Senegal : 15.62k Ivory Coast : 13.82k Libya : 7.14k Egypt : 5.8k	Algeria : 94,75k Morocco : 30.34k Libiya 14,7k Tunisia : 13.35k South Africa : 6.36k	Cameroon : 15.09k Turkey : 13,9k Ivory Coast : 7.14k Gabon : 5.37k Angola : 3.37k	Algeria : 15.48k Morocco : 394.53 Cuba : 200 Andorra : 15,59 Israel : 12.03	Not found
Total	**10.1k**	**79.23k**	**165.27k**	**61.7k**	**16.11k**	X
Top countries	Syrian Arab Republic Turkey	Tunisia Turkey Mali	Algeria Morocco	Cameroon Turkey Ivory Coast	Algeria Norway	X

According to the study on storage capacities and logistical infrastructure for EU agricultural commodities trade, Spain was the leader COP importer between 2005 and 2015. We can see that in 2019/2020 Spain has imported from the EU more maize (6.96M) than the other kind of cereals whereas it has exported at the same period more durum wheat (514.46k).

Unfortunately, we couldn't find some data on the import/export made by Spain inside the EU.

3) Stored grains cereals invasive species

a) Occurrence & Percentage of damages [13,14]

We made a focus on the more frequent insect species present in the grains stored.
We couldn't find some information about the % of presence in Spain per species.

- **Primary insects**

Table 47 : Primary insects found in Spain

Sitophilus Oryzae	*Sitophilus Granaries*	*Sitophilus Zemais*	*Rhyzoperta Dominica*	*Oryzaephilus Surinamensis*	*Indian Meal Moth (Plodia Interpunctella)*	*Sitotroga cerealella*
X	X	X	X	X		X

- **Secondary insects**

Table 48 : Secondary insects found in Spain

Tribolium Castaneum	*Tribolium Confusum*	*Sitophilus Zemais*
X	X	X

Here are the other species that we can find in Spain which can damaged the grains.

- *Cryptoleptes pusillus*
- *Trogoderma granarium*
- *Acanthoscelides obtectus*
- *Callosobruchus naaculatus*
- *Lasioderma serricorne*
- *Ephestia kuehniella*
- *Plodia interpunctell*
- *Sitotroga cereczlella*
- *Blatta orientalis*
- *Blatella germanica*
- *Periplaneta americana*

- **Mites like :** *Acarus siro*

4) Storage on bigger scales

a) Types of storage facilities [11,15,16]

We can notice two kinds of storage facilities in Spain according to the Ministry of Agriculture, Fisheries and Food.

- The first one is **the storage in controlled atmosphere**.
  The atmosphere of the place where the grain is stored has been modified to reduce the amount of oxygen present in the air. This reduction in oxygen prevents the proliferation and development of mushrooms and the appearance of insects that can be detrimental to an optimal conservation of the grain and prevents its oxidation and deterioration. The bulk bag grains represent a way to conserve the grain in a controlled atmosphere.

Figure 32 : Battery of silos bags

- The second kind of the storage occurred in **normal atmosphere** (sheet metal silos, storage cells, sheds or wire mesh silos).
  It is characterized by the fact that in this type of storage, the air surrounding the grains has a composition similar to the atmospheric air. It is important to keep the grains dry to avoid its deterioration.

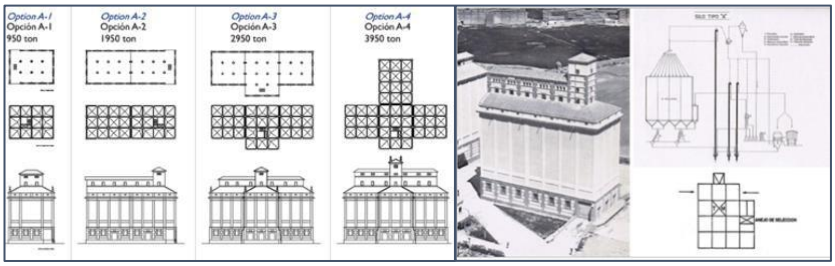
We will focus on different types of storage facilities in this part. Thanks to the website Silosygraneros.es[16], it is possible to have an overview of the different types of silos but it does not take into consideration the metallic silos. We will discover in the part right after some manufacturers of metallic silos.

Silosygraneros.es is a private research group that promotes the enhancement of the historic National Network of Silos and Granaries of Spain through actions for its documentation, valorization, conservation, and dissemination.

- **Reception silos** [16]

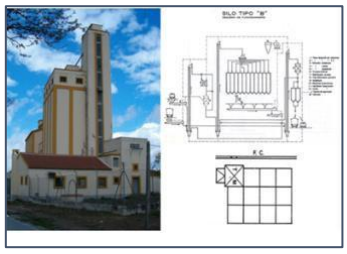
1. Type A

These silos are intended exclusively for reception. They are used to facilitate the delivery of cereals by farmers and its conservation until its transfer to other silos or withdrawn by flour producers and farmers.



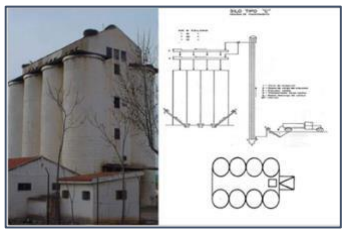
2. **Type B**

Silos that perform the same functions as Type A differing only in the location of the elevator, which in this case is located in one of its corners and is higher. This allows the distribution of the grain through the upper gallery that occupies the entire surface of the silo and is externally recognizable by the presence of holes, something not usual in other types.



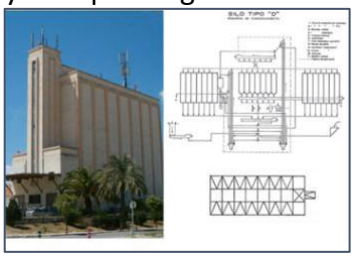
3. **Type C**

These reception silos arise in order to achieve “cells” whose walls work with continuous pressure laws, as well as with the aim of reducing machinery by taking the cells to the support plane of the building, which normally used to be one and a half meters above the ground. They present a smaller number of cells arranged in only two rows, but on the other hand they have a much larger section.



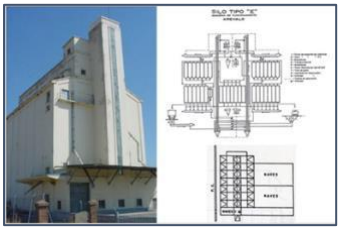
4. **Type D**

They are reception silos that emerged as an evolution of types A and B, but with high formal similarity. Sometimes several silos of this type can even be seen together, as it was a cheaper option compared to the possibility of expanding the A and B.



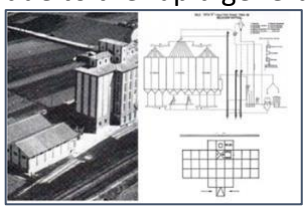
5. **Type E**

Reception silos with a capacity much higher than all the previous ones. It arises as an addition of two D-type elevators joined by a row of outer cells and eliminating one of them. It was used in areas where it was necessary to store a greater quantity of grain without having to build two storage units, although later it was observed that in many municipalities it was necessary to expand the units or the construction of other surrounding areas to support the increasing flow of stored grain.



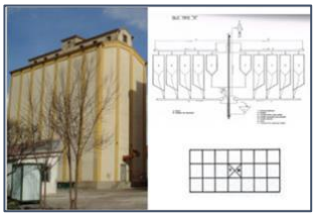
6. **Type F**

Large capacity reception silos achieved through an arrangement of concentric cells from the elevator (forming a cross) that arise as a variant of type A silos. They did not have much diffusion in the Spanish territory, perhaps due to the large amount of machinery they required in relation to with its ability and also due to the rapid generalization of type D.



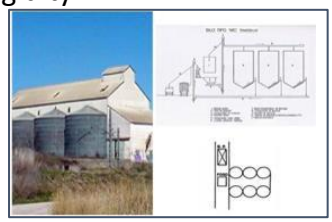
7. **Type H**

Reception silos that conceptually come from the frontal union of two type D silos, that is, through the elevator. After this union, two cells are placed on the sides of the elevator and consequently it remains in the center of the building so that only the upper part can be seen on roofs.



8. **Type MC**

Silos of reception of metallic cell and circular section, of prefabricated construction with corrugations that give it greater rigidity.



9. **Type X**

They are acquired silos of exclusive or predominant reception with diverse characteristics that do not allow it to be included in any of the previous multiple. Only 2 units have been registered, Alicante and Manresa.

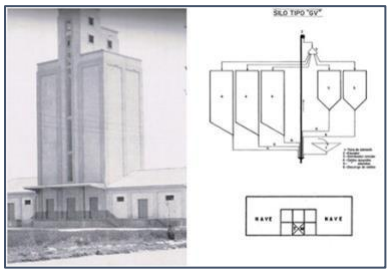
- **<u>Type of storage facilities: barns reception</u>**

10. **Type G and GA**

They are exclusively or predominantly factory-built barns with a sloping gabled roof. The walls are resistant to the horizontal thrusts it receives. Those with a larger volume had portable machinery for moving and weighing the grain.

11. Type GV

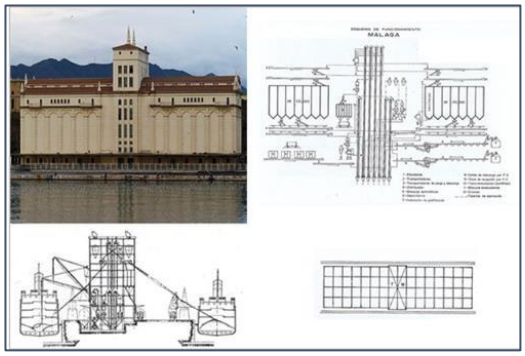
They are silos known as "vertical barns" due to the predominance of horizontal warehouses on the ground floor compared to the verticality of the cells and the elevator. As a consequence, their capacity is reduced but they are very useful for areas where the capacity of a barn falls short, and the construction of a silo would be excessive.



- **<u>Types of storage facilities: transit silos (port silos)</u>**

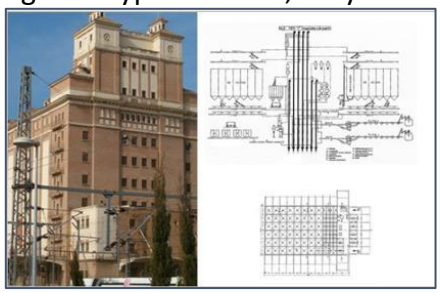
12. Type P

They are transit silos located in the port area. They were screened in many coastal cities of the peninsula (La Coruña, Malaga, Santander, Valencia, ...) but finally only the units in Tenerife and Malaga were built. The peculiarity of its location in the port and its ability to unload grain from the vessels give it a unique formalization on the Internet.



13. Special type T

Transit silos, that is, capable of simultaneously carrying out loading, unloading, cleaning and seed selection operations thanks to significant mechanical installations. Their greater capacity and strategic location compensate for the needs of the remaining silos, becoming the backbone of the Network. Along with types A and B, they were the first to be built.



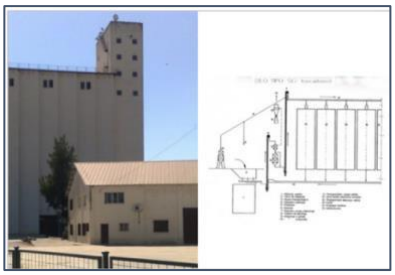
- **<u>Type of storage facilities: seed selection</u>**

14. Type SA

They are seed selection silos, that is, those where seed selection predominates over storage capacity. Only one unit was built that is located in Briviesca (Burgos).

15. Type SG

They are silos or granaries for the drying of grain. In 1970, up to 15 units were dated, although by 1978 only 2 remained within the Network.



16. Type SH

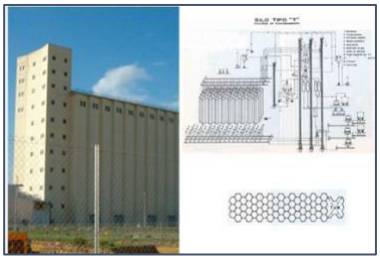
They are granaries for the selection of seeds built with a factory. Only two units were built, with an average capacity of 1600 tons.

17. Type SV

They are predominant seed selection silos, that is, those where seed selection predominates over storage capacity.

- **Type of storage facilities: type T and macro silos**

In the decade of the 70s year, international agrarian policy changed towards large capacity silos, developing the well-known “macrosilos”, whose functions are identical to the original type T, but whose constructive characteristics differ radically. Macrosilos continue to function today and are part of what we know as the “core network”.



- **Type of storage facilities: type Z**

Undoubtedly, it is the most unique type of all those used by the SNT (one of the different classification tables made for silos), being old castles and unique buildings restored and conditioned for storage.
They are of exclusive or predominant reception, since their machinery is scarce and specific. There are few units throughout the Spanish territory because their rehabilitation and conditioning were expensive and slow.

Here below : some Spanish silos manufacturers

We decided to focus on some silos manufacturers that might be of high interest. In this part, we can focus on some metallic silos.

HERPASA [17]

This company has 43 years of experience in the manufacture of stainless-steel tanks and projects for the food and chemical industries. They are specialized in the storage of liquid and solid products. They are localized in Barcelona (Spain).
It is not possible to see on the website the different kinds of silos proposed by the company.

SILOS CORDOBA [18]

Silos Cordoba is specialized in manufacturing metallic silos for grain storage. They have a multidisciplinary team of specialized engineers to study the needs of their clients in a personalized way and direct the conception and material execution of projects.

We can see on their website different kinds of silos manufactured by the company.
There is more technical information available on their website for each kind of metallic silos.

- **Flat bottom silos**

Their silos, either flat or hopper bottom, are used for extended storage of large quantities of grain, seeds and granulate products. Their range of concrete base silos cover capacities ranging from 83 m^3 to 45 055 m^3 and with diameters from 4.58 m to 41.25 m**.**

- **Hopper silos**

Hopper silos are designed to store grains, seeds, legumes, pellets and other products that require special storage conditions. The stored product stays off the ground to prevent moisture and lower the possibility of breakage. This type of silo not only brings economic savings, as no sweeping machine is necessary, but also simplifies the foundation work which considerably reduces the building costs and streamlines assembly work.
Their range of hopper silos covers capacities ranging from 43 m^3 to 2 016 m^3 with diameters from 3.82 meters to 10.70 meters.

- **Truck load silos**

Structure-based truck load silos are designed for the storage and later dispatch of bulk products such as granulates, flour, etc. For agricultural facilities, feed plants or flour plants, the silos available range from 2.55 m in diameter to 4.58 m with capacities ranging from 11 m^3 to 200 m^3. For industrial facilities with silos for truck or rail dispatch, we recommend silos with a diameter of at least 4.58 m and capacities ranging from 80 m^3 to 400 m^3, upon request.

- **Farm silos**

Farm silos are used for the storage of animal feed in livestock, poultry and pig farms.
Their wide variety of high-quality steel farm silos (farm bins) are protected by an innovative coating up to 10 times more resistant to environmental corrosion than traditional galvanisation.

Their modular design with no welding or paint utilizes steel sheeting with a shallow corrugation in order to manage product stored with a tendency to stick on the wall sheets.

They have green pre-lacquered silos available, which comply with the regulations on environmental impact that are in force in some areas.

SYMAGA SILOS [19]

This Spanish company is specialized in designing, manufacturing, and marketing silos. These silos are made for all grain and seeds type storage but also for different industries such as breweries, animal feed, port facilities, flourmill, ethanol, drying, and storage of raw materials for the plastic industry and biofuels.

The company manufactures different kind of silos: flat bottom silos, hopper silos, delivery silos, indoor silos, mass discharge silos, feed silos. There are videos and technical information on their website.

b) Biggest site of storage for the exported cereals

c) Several non-EUcountries from where cereals come from (= import) [20]

b) and c) are in the same part of the document.

Tarragona's port is a very interesting place because there are equipment and storage facilities for handling agri-bulk for import and export. The port of Tarragona maintains an indisputable leadership in the movement of agri-food products, both in Spain and the Mediterranean. Indeed, the infrastructures allowed the movement of agri-food products. It has historically been the leader in the movements of cereals and floors, and feed and fodder in Spain. The sector contributes 5.8% of the national economy's Gross Value Added (GVA) in 2017.

According to the website *Port Tarragona,* the port has 260 000 sq. meters of covered floor-space, a figure only comparable to the capabilities of our Port for storing bulk liquids. The movement of agri-food products is one of the foremost activities in the Port of Tarragona, both in terms of its volume and for the important facilities and economic impact in the hinterland (catalonia + Aragon + Navarre + Castile).

Some information about Tarragona's port:

- 4 terminals
- A capacity of storage of 1.3 million tones
- A docking line of 2 500 meters
- An annual traffic of 5 million tones in 2017
- Wheat, canola, sunflower, soybean flours, maize, rye and other cereals products

The high degree of specialization in agri-food traffic helps the Port of Tarragona to work with a wide variety of agri-food products and by-products (over 60), which is why our Port is situated in a very prominent position compared to other European ports.

If we focus on the import, the reception of agri-food products comes from the major producer countries such as the Ukraine, Romania, Argentina and the United States. The products are imported via the Port of Tarragona, and from there are transported to areas where the food for animal feeding is manufactured, such as the factories of Lleida, Saragossa, Girona and, to a lesser extent, in industries in Soria and Huesca.

The Port of Tarragona has an important presence in the European agri-food sector. It participates in the most outstanding international events such as the European cereal exchanges. It also organizes a biennial international congress that brings together all the most important actors from the sector.

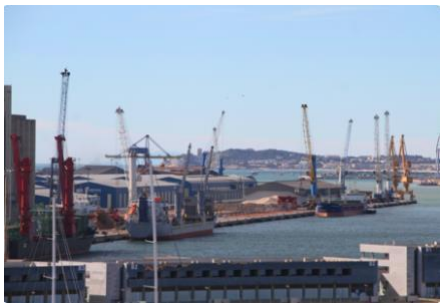


Figure 33 : Port of Tarragona

d) Industry mapping in grain storage [8,21,22]

The website *silosygraneros.es* is very interesting because it gives a lot of information about the silos in Spain. Some datas are not very recent but can give a good overview of the silos' situation in Spain. On the website it is possible to have a look at the map below. We can zoom and see more in details this map.

It is also possible to see the Silos and granaries location table by provinces (Silos y graneros → Mapa de silos y graneros en Espana → Ver table → Tabla ubicación silos y graneros por provincias). Unfortunately, we cannot know the date of this map.

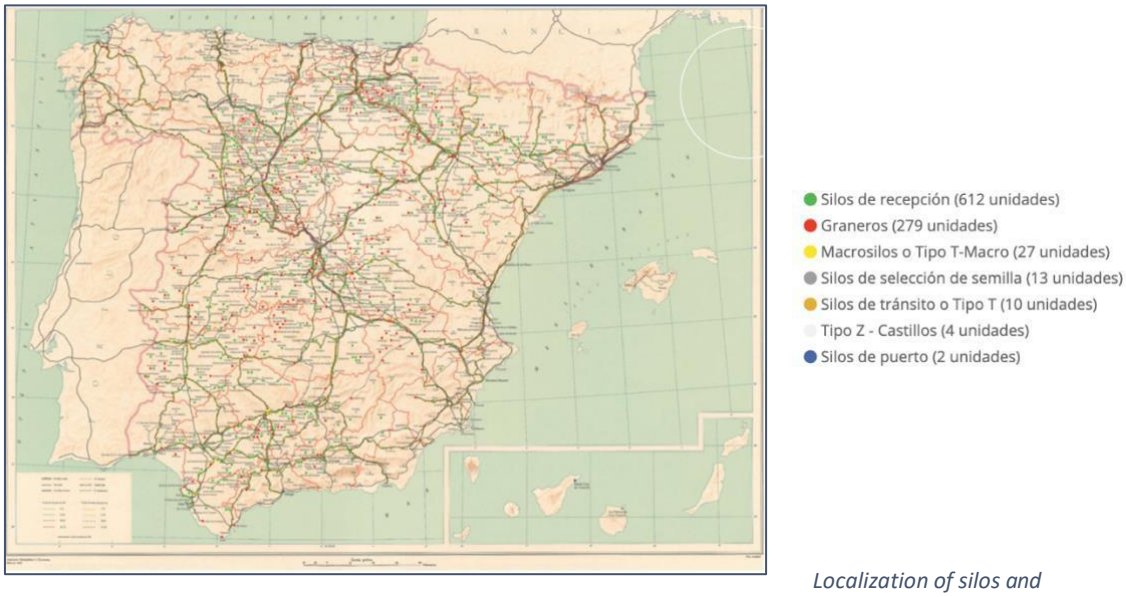


Figure 34 : Localization of silos and barns in Spain

- **Seaports and container terminal :**

In the map below, we can the seaports and container terminal.
The biggest seaports in Spain are:

- The port of Algeciras (Cadiz – Andalucia): it is the largest port in Spain and the ninth largest port in Europe in terms of trade. The port is an important center for the tobacco, oil, fishing, and agriculture industries, and around 70 million tons of cargo pass through it per year.

- The port of Valencia: Now it is the first and last port of call for the shipping route between the Western Mediterranean and the Atlantic. Its economic importance stems from the fact that around 50% of the country's GDP is generated within a 350-km radius of the port, as is half of the country's employment.
- The port of Barcelona: it also plays a significant role in cargo shipping, managing 63 million tons of cargo each year. Barcelona has the largest port in the region of Catalonia, which produces 18% of the country's GDP.

The Figure 35 shows a list of the seaports and container terminals in Spain in 2021.

- 40 seaports and 20 container terminals

Figure 35 : Sea ports and container terminal in Spain

- **Spain road transportation**

If we look at the map below, we can see in red the top 100 national road transportation flows of agricultural goods in 2015 in Spain. **4 roads in Spain are recorded in the top 100.**

Table 49 : Top 100 national road transportation flows of agricultural goods in 2015 (Spain focus)

N°	Origin	Region	Destination	Region	Quantity in tonnes (2015)
25	ES42	Castilla-La Mancha	ES30	Comunidad de Madrid	1 199 873
28	ES24	Aragón	ES51	Cataluña	1 126 245
30	ES62	Región de Murcia	ES52	Comunidad Valenciana	1 092 425
65	ES41	Castilla y León	ES30	Comunidad de Madrid	807 292

Figure 36 : Top 100 national road transportation flows of agricultural goods in 2015 (Spain focus)

- **Railway network in Spain**

The plan below puts on the light the core railway network in Spain.

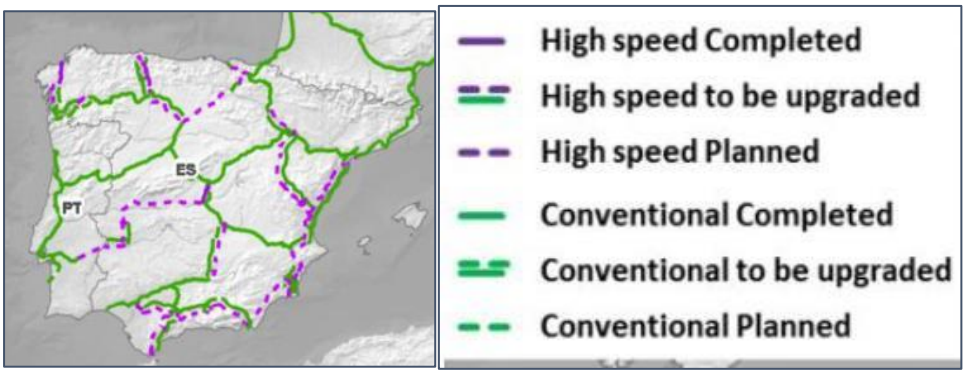


Figure 37 : European core railway network (Spain focus)

- **Spain national rail transportation flows of agricultural goods in 2015**
-

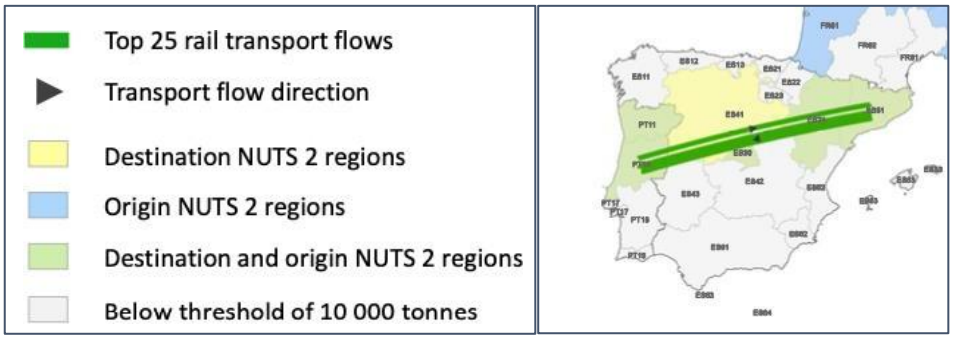


Figure 38 : Spain national rail transportation flows of agricultural goods in 2015

Table 50 : Spain national rail transportation flows of agricultural goods in 2015

N°	Origin	Region	Destination	Region	Quantity in tonnes (2015)
4	**ES51**	**Cataluña**	**PT16**	**Centro (P)**	**506 330**
9	**PT16**	**Centro (P)**	**ES51**	**Cataluña**	**226 591**

5) Potential users of the new solution [23]

- Agricultural cooperatives in Spain (2019): 3 669 companies and 1 165 595 members
- Number of agricultural cooperatives specialized in cereals : data not found
- List of Spanish distributors in the grain stored domain : data not found

6) Control means available (+ boundary conditions)

It was really difficult to find some information in this part as we couldn't find a phyto platform for Spain where all the active substances are registered.

a) Focus on insecticides used within the market for indoor, post-harvest grain treatment) [24] [25]

The Table 51 presents the authorized insecticides in Spain which are used to treat the store grains. These products are used with pulverization or nebulization system.
It appears that the 2 types of active substance authorized are:

- Deltamethrin
- Cypermethrin

Table 51 : Some insecticides used in Spain for the grain treatment

Product	Manufacturer	Active substance	Concentration
Talisma Super	UPL	CYPERMETRIN 2% p/v. UL Piperonyl butoxide 5.7%	0,084 L/Tm
Talisma X	**Not found**	**Not found**	**Not found**
Talisma EC	UPL	CYPERMETRIN 8% p/v. EC	0,02 L/Tm
K-Obiol (EC-25)	Bayer	Deltametrin Piperonyl butoxide	25 g/L 225g / L

**: p/V : per volume / UL: Ultra low volume / EC : Emulsionnable concentrate*

b) Fumigation and powder formulation [25,26]

The Table 52 refers to the authorized insecticides in Spain used to treat the stored grains and the premises of storage. It appears that one type of active substance is authorized :

- Phosphide: Magnesium or Aluminium

Table 52 : Some products used in Spain for fumigation and powder formulation

Product	Manufacturer	Active substance	Concentration
Phosphotoxin bag	UPL	ALUMINIUM PHOSPHIDE 57%. GE	5-10 g/m3
Phosphotoxin Pellet	DETIA DEGESCH GROUP	ALUMINIUM PHOSPHIDE 56-57%	0.2 g phosphine gas
Phosphotoxin Tablet	DETIA DEGESCH GROUP	ALUMINIUM PHOSPHIDE 56-57%	1 g phosphine gas
Gastoxin B	DETIA DEGESCH GROUP	ALUMINIUM PHOSPHIDE 56%	5 - 10 g/m3
Gastoxin S	*Data not found*		
Quickphos T	UPL	ALUMINIUM PHOSPHIDE 56% (3 g / tablet). GE	3-5 tabl/m3
Quickphos Pellets	UPL	ALUMINIUM PHOSPHIDE 56% (0,6 g/tablet). GE	15-25 tabl/m3

c) Alternative methods and possible solutions in the future

- Spinosad (SA)
- Diatomaceous earth (SA)

d) Boundary conditions = Specific limitations & restrictions [27]

Here below a table with the active substances authorized in spain for grains storage treatment.

Table 53 : Some substances authorized in Spain in the grain store domain

Molecule	Product
Aluminum phosphide 56%	Phosphotoxin bag
Aluminum phosphide 56%	Phosphotoxin Pellet
Aluminum phosphide 56%	Phosphotoxin Tablet
Aluminum phosphide 56%	Gastoxin B
Aluminum phosphide 56%	Gastoxin S
Aluminium phosphide 56%	Quickphos T
Aluminium phosphide 56%	Quickphos Pellets
Aluminium phosphide 56%	Not found
Cypermethrin 56%	Talisma SUPER
Cypermethrin 56%	Talisma X
Cypermethrin 56%	Talisma EC
Deltamethrin 56%	K-OBIOL

Unfortunately,we don’t get the ban of active substance in Spain.

ITALY

ITALY

Introduction

The slight growth in the period 2019/2020 is driving record levels in the cereal production. Today, consumption and uncertainty over production in 2021 push up prices. The global estimations shows that the estimate of consumption growth over the two-year period 2020-2021 is drawing, with growth prospects close to 2% per year.

1) Stored grains cereals general data

a) Volume of cereals produced [1]

Table 54 : Italy gross production by selected crops for the last 5 marketing years (thousand tonnes) - Eurostat

Cereals / Year (th T)	2017/18	2018/19	2019/20	2020/21	2021/22
Type	*	*	*Estimate*	*Forecast*	*Projection*
Soft wheat	2 754	2 788	2 727	2 669	2 611
Durum Wheat	4 213	4 145	3 849	3 885	4 221
Barley	984	1 010	1 072	1 091	988
Oat	229	243	238	243	238
Maize Grain	6 049	6 179	6 259	6 771	6 752
Triticale	77	60	59	59	74
Rye	*11*	*11*	*13*	*11*	*12*
Sorghum	*241*	*294*	*312*	*362*	*307*
Other cereals	*96*	*105*	*103*	*107*	*71*
Total cereals IT	14 653	14 835	14 633	15 197	15 273
Total cereals EU-28	**307 959**	**292 357**	**322 532**	**n.a**	**n.a**
Total cereals EU-27	**284 960**	**271 272**	**297 015**	**280 365**	**295 108**
% IT / EU-27 prod	5.1%	5.5%	5.0%	5.4%	5.1%

**For all cereals : marketing year from 1st July N to 30th June N+1*
Other cereals: millet, buckwheat, canary seed, maslin, mixed grains, other

According to the Table 54, the production in 2019/2020 was a little bit more important than in 2018/2019. Italy produces more maize than the other kind of cereals (6 259 tonnes).
The biggest production in Italy in 2020/2021 are: grain maize (6 771), durum wheat (3 885) and soft wheat (2 669). The prevision for 2021 is also very encouraging, an increase of production is planned.

Between 2010 and 2020 the general decrease in the relative weight of cereal areas characterizes almost all geographic areas in Italy.

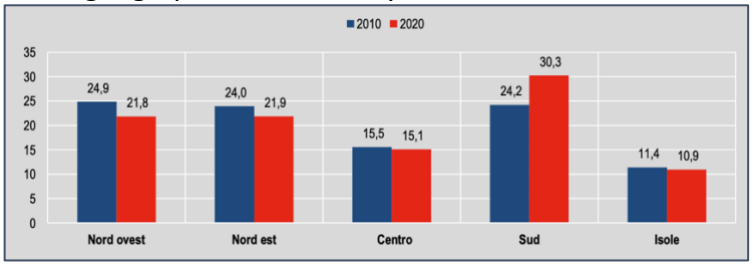


Figure 39 - Relative weight of cereal surfaces by geographic distribution (2010 and 2020, % valor) – Istat

The regions which, in 2020, have the highest shares of cereal area are Puglia and Piedmont, respectively 13.8% and 11.4% of the national total. In particular, in Puglia more than 83% of the cereal area is invested in durum wheat (344 300 hectares, 28% of the total national), in Piedmont, 40.1% of cereal areas are invested in maize (137 422 hectares, which represent 22.8% of the national total).

Piedmont is the region with the largest area planted with rice (more than 50% of the national total).

In comparison between 2010 and 2020, decisive changes appear among the varieties of cereals, especially in the cultivation of durum wheat *(frumento duro)* and corn *(mais).* Durum wheat, in fact, increases its impact on the complex of cereal surfaces when it passes from 36.9% in 2010 to 40.3% in 2020. The cultivation of corn, on the contrary, affects less and less the total cereals: increased from 26.7% to 20.1%.

A moderate increase also characterizes soft wheat *(frumento tenero)* (from 15.8% in 2010 to 16.7% in 2020) and barley *(orzo)* (7.8% to 8.8%). On the other hand, there are no significant variations for the remaining cereals.

Puglia is the region where the invest surface in durum wheat *(frumento duro)* is equal to 344 300 hectares in 2020. It was equal to 283 870 hectares in 2010.

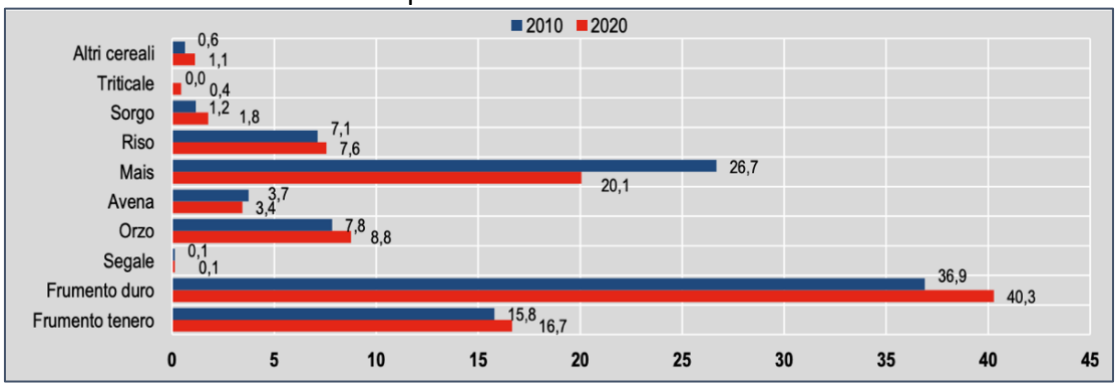


Figure 40 - Different cereal varieties in Italy between 2020 and 2021

**Altri cereal : other cereal / Triticale /Sorgo : sorghum/ Riso : rice / Mais : corn / Avena : oats / Orzo : barley / Segale : rye / Frumento duro : durum wheat / Frumento tenero : common wheat*

b) One big cereals producer [2–4]

Some big companies are producing cereals in Italy. Among these companies, many are specialized in producing cereals for breakfast.

CAPACOLOGNA

The Cooperative, founded in 1970, supports and protects the agricultural activities of over 1 300 members in the Po Delta area with qualified agronomic technical assistance and the supply of useful products for the cultivation of soft wheat, durum wheat, corn, barley, soy, paddy, etc.

The structure covers an area of 100,000 square meters, owned and equipped with 4 advanced drying systems, capable of processing over 4 800 tons of cereals per day. The quality of the product is guaranteed right from the campaign thanks to the valuable work of agronomist technicians who provide periodic assistance to the members' crops.

The founding members created this cooperative, driven by the needs of the agricultural producers in the area to have a structure on site that would allow the collection, drying, storage and marketing of the products.

Agricola Piovese process about 700 000 quintals of grains a year.
Following are the main services carried out by the Piovese Agricultural Cooperative:

- Storage: operation mainly of an organizational and logistic nature
- Drying: natural process, dedicated to the Storage, Preservation and Quality of the Agricultural Product
- Roasting and Splitting: Corn and Soybean processing process, intended to increase the Quality and Safety of Animal Nutrition

The Confederation of Agricultural Producers-Copagri is a professional agricultural organization with a general vocation that has over 650 thousand members and is present throughout the national territory, with a national headquarters, 20 regional offices, 77 provincial offices, 261 municipal offices.
The cooperative company "Op Italia Cereals" was officially established, promoted by Copagri Basilicata, which includes a cooperative located in the north of the Region, a consortium of Matera that produces organic cereals, a recently established consortium that groups together cereal growers of Basilicata and Puglia, and numerous farms, very different from each other both from the organizational and production point of view and from the trade union point of view.

c) Volume of stored grains cereals

Data not found

d) Volume of treated stored grains cereals

Data not found

e) Storage sites + how are stored the grains (on-farm, off-farm, export shipments) [5] [6]

According to a study performed in Italy in 2019 [5], there are 1 460 storage sites in 2019.
The 52 pages of the full report are available online. These storage sites pertain to 1 103 companies. It seems that there is a main concentration of storage sites in the south of Italy and in the isles (362 companies).

The total storage capacity declared by the 1 225 responding storage centers (out of 1 460 surveyed) amounts to approximately 9 million tons distributed for 37% in the South and Islands, for 31% in the North East, 17% in the North West and 16% in the Center.

By analyzing the legal form of companies owning storage centers, it appears that only 16% are represented by individual companies, with a very limited role in terms of storage capacity (2% of the total).

Table 55 - Distribution of companies and storage centers in Italy in 2019

Geographic area	Companies	Incidence of the companies on the global amount	Number of Centers	Centers incidence on the total
North West	269	24%	336	23%
Northeast	269	24%	356	24%
Center	203	18%	349	24%
South West	362	33%	419	29%
Total	1 103	100%	1.460	100%

If we focus deeper on the localization of storage site in Italy:

- The North West regions represent 23% of the number of centers. In this geographical sub-area, Lombardy and Piedmont prevail.

- In the North East, 24% of the storage centers are located in this area. 13.2% of the total centers surveyed are located in Emilia Romagna and 7.9% in Veneto.

- In Central Italy, there are 24% of the centers surveyed and 16% of the declared storage capacity; the central regions are characterized by an average size of storage per single center significantly lower than the national average. In territorial detail, Marche and Tuscany prevail, which jointly represent 16% of the total centers and 12% of the storage capacity.

- 29% of the total centers are located in the South and Islands and the largest number is attributable to Puglia and Sicily, which represent 6.8% and 8.6% respectively; in terms of capacity Puglia prevails while the largest average storage size (both at the geographical area level and at the national level) falls in the region of Sardinia.

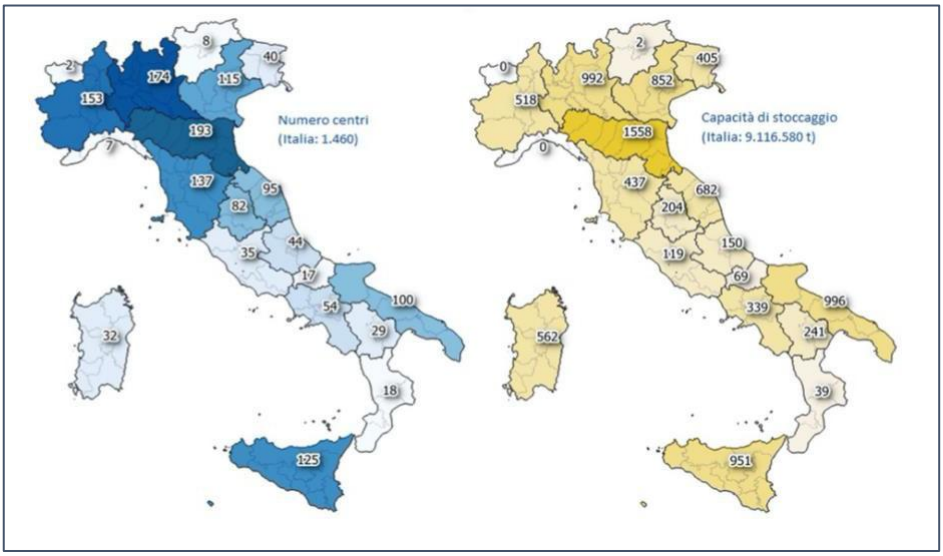


Figure 41 - Repartition of the capacity of storage in Italy (.000 t) - Ismea

Table 56 - Distribution of centers and storage capacity by region - Ismea

Region	Number of centers	Incidence of the centers on the global amount	Storage capacity (t.)	Incidence of storage capacity on the total	Average storage size (t.)
Liguria	7	0.5%	316	0.0%	105
Lombardia	174	11.9%	992.157	10.9%	7.190
Piemonte	153	10.5%	518.248	5.7%	3.897
Valle d'Aosta	2	0.1%	10	0.0%	10
Nord-Ovest	**336**	**23.0%**	**1.510.731**	**16.6%**	**5.494**
E. Romagna	193	13.2%	1.557.662	17.1%	9.272
Friuli V.G.	40	2.7%	404.964	4.4%	11.249
Trentino A.A	8	0.5%	1.510	0.0%	503
Veneto	115	7.9%	852.126	9.3%	9.683
Nord-Est	**356**	**24.4%**	**2.816.262**	**30.9%**	**9.547**
Marche	95	6.5%	682.243	7.5%	8.220
Lazio	35	2.4%	119.127	1.3%	3.723
Toscana	35	2.4%	119.127	1.3%	3.723
Umbria	82	5.6%	204.173	2.2%	3.347
Centro	**349**	**23.9%**	**1.442.977**	**15.8%**	**4.731**
Abruzzo	44	3.0%	150.387	1.6%	4.423
Basilicata	29	2.0%	240.641	2.6%	9.255
Calabria	18	1.2%	38.641	0.4%	2.415
Campania	54	3.7%	338.956	3.7%	7.532
Molisa	17	1.2%	69.492	0.8%	4.343
Puglia	100	6.8%	995.747	10.9%	12.447
Sardegna	32	2.2%	995.747	10.9%	12.447
Sicilia	125	8.6%	950.838	10.4%	9.143
Sud e Isole	**419**	**28.7%**	**3.346.610**	**36.7%**	**9.562**
Total	**1.460**	**100.0%**	**9.116.580**	**100.0%**	**7.442**

- If we look at the kind of structures present in the storage centers, the survey shows that in Italy about 57% of the storage capacity is attributable to the silos and 40% to warehouses.
- In territorial detail, silos are represented with a higher share than the national average in the Center (65%) and in the South (55%).
- Storage through warehouses *("maggazino")* prevails in the South and Islands with a share of the territorial total equal to 43%, and followed by the North-East with just under 42%.
- From the analysis of the geographical distribution of the centers that use silo bags, it emerges that these are mainly used in the North East (2.8% of the storage capacity of the geographical area) and in particular in Emilia Romagna, for a total of 67 thousand tons of storage capacity, and in Veneto with 10 thousand tons.

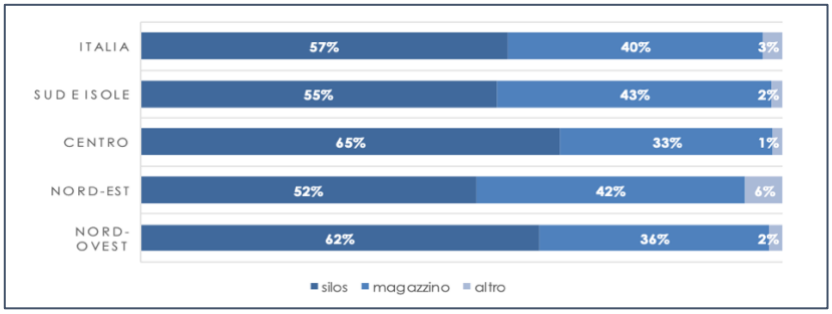


Figure 42 - Storage in silos and warehouses by geographic area

Capacity of storage in Italy (2014-2015 data) : Between 10 and 20 million tons => we do not have more precise data.

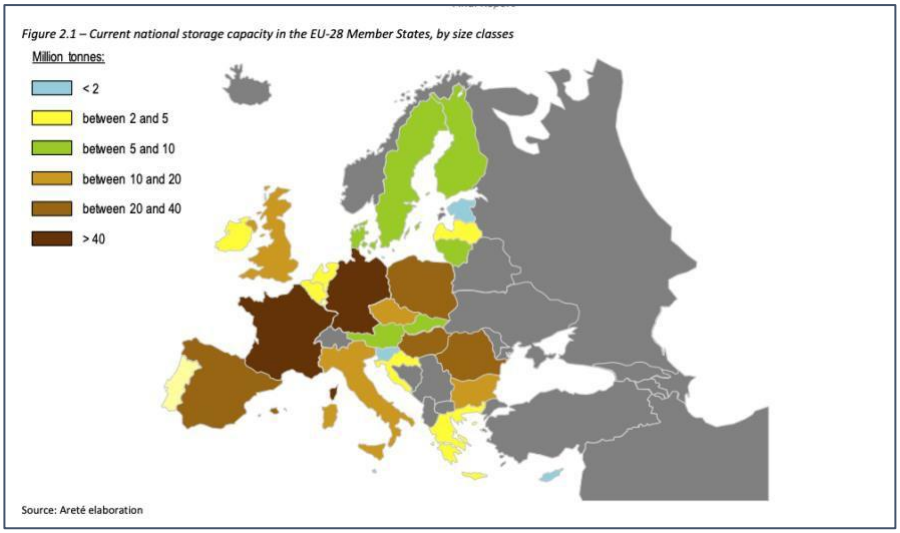


Figure 43 - Current national storage capacity in the EU- 28 Member States, by size classes

According to some information founded in the report made by the European Commission in 2017 [6] , we can organize the storage within 3 categories:

- Storage on-farm
- Storage off-farm: cooperatives & traders
- Storage off-farm: export shipments: harbors (*we don't have more precise data)*

Table 57 : Repartition of the total share in Italy according to different types of storage

Type of storage (2015 data)	Share in total storage (%)	Estimation of storage capacity
Individual farms = on-farm	4%	Between 0.4 & 1.8 millions
Farming cooperatives = off-farm	28%	Between 2.8 & 5.6 millions
Processing industries = off-farm	17%	Between 1.7 & 3.4 millions
Wholesale/trade = off farm	32%	Between 3.2 & 6.4 millions
Transportation hub ***(including ports)***	19%	Between 1.9 & 3.8 millions
Storage capacity	**100%**	**Between 10 & 20 millions**

To summarize, wholesale/trade and farming cooperatives represents the highest share in the overall storage.

2) Focus on specific stored grains cereals: wheat, barley, oat, maize, rice

a) Estimated volumes of each stored grains variety

Data not found

b) Treatment used for each stored grain variety [7]

The information below was found in the report made by the Emilia Romagna Region and the EU Agricultural Fund for Rural Development: Europe invests in rural areas[7]. This report made a focus on the area of Emilia Romagna between 2014 and 2020. This area is very relevant in the grain domain in Italy. The information below can be extended to the other regions of Italia.

After its cultivation, the grains need to be carried out in a suitable place and with suitable methods in order to allow the organoleptic characteristics of the cereals. Once the grains are cultivated, the products are transported to storage centers in order to be treated. During the entire storage phase, it is also important to protect the traceability of the product.

In addition to the checks relating to the presence of the chemical-physical requirements referred to in the special section, before starting a batch for storage, it is essential to ensure that the cereal or the warehouses and silos that can be used for this purpose are not already infested with parasites.
It is known that the sources of contamination of the kernels or of the silo are numerous and of varied origin: the infestation can in fact comes from residual grains in the maintenance and transport circuit (dead spots) or from the outside for opportunistic species that reach the stocks walking or flying. Contaminations from warehouse to warehouse are the most frequent and derive from the same grain that can host species perfectly adapted to life inside.

- **Cereals coming directly from the field:**

- As regards the characteristics of the transport vehicle, the degree of cleanliness of the bins must be assessed (that these are not soiled with foreign and / or harmful materials, etc.)

- **Cereals coming from other storage:**

- An entomological check must be carried out in addition to the mention specified for the cereals coming directly from the field.

Table 58 - Pest control programs for cereals in warehouses and silos

Phytophagous	Action thresholds *	Active substance	Limitations of Use and Notes
Group 1 – Primary phytophagous			
Sitophilus granarius ***Sitophilus oryzae*** ***Sitophilus zeamais***	**1 insect / trap / week 1 insect / 5 kg**	**Phosphine**	**Only one treatment is allowed**
Rhyzopertha dominica	**1 insect / trap / week 1 insect / 5 kg**	**Phosphine**	
Trogoderma granarium	**1 insect / trap / week 1 insect / 5 kg**	**Phosphine**	**Sample the mass at least monthly to determine the degree of infestation**
Group 2 – Secondary phytophagous			
Cryptolestes ferrugineus	**2 insect / trap / week 2 insect / 5 kg**	**Phosphine**	**At the first catches in the traps, sample the mass to determine the degree of infestation.**
Liposcelis spp.	**15 insects / kg**	**Phosphine**	
Oryzaephilus mercator ***Oryzaephilus surinamensis***	**2 insect / trap / week 2 insect / 5 kg**	**Phosphine**	
Tenebrio molitor	**2 insect / trap / week 2 insect / 5 kg**	**Phosphine**	
Ephestia spp ***Plodia interpunctella***	**2 insect / trap / week 2 insect / 5 kg**	**Deltamethrin Cypermethrin Pyrimiphos-methyl Pyrethrins**	
Tribolium castaneum ***Tribolium confusum***	**2 insect / trap / week 2 insect / 5 kg**	**Phosphine Azadirachtin**	**Only intervene with surface treatments.**

(*) Survey frequency: at least twice a week for the traps and monthly for the mass in storage.

When even a single individual belonging to group 1 of the next table, it is necessary to intervene with a fumigation with phosphine. With reference to the monitoring methods of pests, the provisions and indications of the General Regulations must be observed.

When a sensitive infestation of insects belonging to group 2 is detected (at least 2 insects per week), intervene with a fumigation with phosphine or with the active ingredients indicated in the table.

Remember that refrigeration and the controlled atmosphere used for the conservation of the grain have an induced effect on insect control.

- The pest control program is the same for the rice treatment.

- For the Maize treatment, the primary phytophagous insects are treated with the active substance called Phosphine. We can add to this category the *Prostephanus truncates*. This species is no present at the moment in Italy but need to be report to the phytosanitary service due to its potential danger. If we refer to the secondary phytophagous insects, the active substance used is only phosphine.

c) Speed of grain rolling (incoming, stored, outgoing) [8] [9]

Table 59 - Italian imports (outside of EU)

IMPORT	Common wheat	Durum Wheat	Barley	Maize	Oats	Rice
2017/2018	Ukraine:361.52k Moldova :319.17k USA : 247.17k Canada : 129.96k Russia : 36.01k	Canada : 370.4k Kazakhstan: 277.39k Australia : 269.27k USA : 169.96k Russia : 67.43k	Ukraine: 24.34k Moldova : 8.4k Ecuador : 36 China : 8.81 Tunisia : 4.9	Ukraine : 1.65M Brazil : 240.1k Moldova : 212.13k Russia : 15.04k Argentina : 3.13k	Uruguay:201.6 Ukraine:128.48 Canada : 52.43 USA : 0.11	Data not found
Total	**1.13M**	**1.21M**	**32.78k**	**2.13M**	**382.63**	
2018/2019	Moldova : 263.09k USA : 262.59k Ukraine : 243.29K Canada : 177.23k Russia : 43.84k	Canada :563.11k USA : 252.88k Kazakhstan:207.58k Russia : 66.74k Australia : 25.75k	Moldova : 6.6k Ecuador : 36 China : 8.05	Ukraine: 1.66M South Africa:184.52k Moldova:130.26k Canada : 113.66k Serbia : 76.12k	Ukraine:366.45 Argentina : 15	Data not found
Total	**1.02M**	**1.13M**	**6.64k**	**2.2M**	**381.45**	
2019/2020	USA : 239.33K Moldova: 215.45k Canada : 144.05k Ukraine : 121.46k Russia : 47.79k	Canada : 1.07M USA : 729.93k Kazakhstan:153.51k Turkey : 37.5k Mexico : 35.27k	Ukraine : 9.51k Moldova : 6.18k UK : 205.28 Ecuador : 36 China : 5.28 Sri Lanka : 0.5	Ukraine : 993.94k Brazil :341.94k Serbia : 188.68k Moldova : 124.44k South Africa : 5.14k	Ukraine:287.18 Uruguay:273.75 Argentina : 122 Canada : 39.02 Serbia : 23.94	Data not found
Total	**787.76k**	**2.06M**	**15.94k**	**1.66M**	**748.75**	
2020/2021	Canada : 124.5k Ukraine : 118.68k USA : 109.11k Russia : 40.58k UK : 1.29k	Canada : 1.09M USA : 311.25k Russia : 42.67k Turkey : 35.65k Kazakhstan : 34.22k	UK : 7.55k Ukraine: 1.95k Ecuador : 36 China : 6.92 Switz : 6.64	Ukraine:401.81k Brazil : 335.49k Serbia : 80.55k South Africa:48.32k Moldova : 8.61k	Ukraine : 317 Uruguay : 97 Canada : 26	Data not found
Total	**394.38k**	**1.54M**	**9.57k**	**878.78k**	**440**	
Top countries	**Ukraine, USA**	**Canada, USA**	**Ukraine, Moldova**	**Ukraine, Brazil**	**Uruguay, Ukraine**	

Table 60 - Italian exports (outside of EU)

EXPORT	Common wheat	Durum Wheat	Barley	Maize	Oats	Rice
2017/2018	USA : 34.48k Libya : 21.31k Switzerland : 9.84k Australia : 7.65k Canada : 5.23k	Tunisia : 222.63k Mali : 5.96k Senegal : 5.81k Egypt : 4.59k Serbia : 3.3k	Libya : 23.71k Vietnam : 195.01 Switzerland : 82.03 Turkey : 32.59 Bahrain : 27.05	Israel : 13.99k USA : 5.71k Switzerland :5.66k Qatar : 3.87k Kuwait : 1.69k	Algeria : 2.3k Libya : 104.4 Albania : 85.05 Lebanon : 62.54	Data not found
Total	**118.01k**	**266.13k**	**24.14k**	**41.56k**	**2.55k**	
2018/2019	USA : 37.13k Switzerland : 9.71k Australia : 6.44k Libya : 4.32k Canada : 4.3k	Tunisia : 18.89k Libya : 11.44k Saudi Arabia : 5.4k USA : 4.47k Switzerland : 3.94k	Switzerland : 121.32 Saudi Arabia : 70.44 Philippines : 20.33 Israel : 20 Canada : 16.02	Israel : 14.04k USA : 5.05k Switzerland : 3.7k Kuwait : 1.56k Taiwan : 1.5k	Serbia : 84.32 Albania : 35 Lebanon : 25 Hong Kong : 23 Switzerland : 3.23	Data not found
Total	**103.9k**	**76.03k**	**269.56**	**35.28k**	**170.54**	
2019/2020	USA : 30.01k UK : 13.13k Australia : 7.15k Switzerland : 5.8k Albania : 5.15k	SaudiArabia :24.65k USA : 8.42k Switzerland : 4.52k Australia : 4k Israel : 3.59k	Israel : 39 Lebanon : 30 Turkey : 27.54 UK : 25.35 New Zealand : 8.15	Israel : 17.2k USA : 10.37k Switzerland : 3.4k UK : 2.16k Korea : 1.94k	Albania : 269.98 Libya : 73.2 Lebanon : 49.62 Serbia : 48.95 UK : 12	Data not found
Total	**105.43k**	**69.66k**	**157.44**	**48.42k**	**453.75**	
2020/2021	USA : 21.6k UK : 17.63k Australia : 5.85k Russia 3.8k Albania : 3.69k	Tunisia : 27.5k SaudiArabia :27.37k Libya : 5.99k Switzerland : 4.25k Mali : 3.98k	Lebanon : 8.91k Morocco : 6.59k Libya : 4k UK : 191.34 Turkey : 22.88	Israel : 10.95k USA : 6.23k Switzerland : 2.38k Turkey : 2.18k Korea : 2.11k	Albania : 340.35 Lebanon : 70.99 UK : 42	Data not found
Total	**87k**	**97.06k**	**19.76k**	**33.89k**	**453.25**	**X**
Top countries	**USA, Switz**	**Tunisia, SaudiArabia**	**Switz, Lebanon**	**Israel, USA**	**Albania, Libya**	**X**

According to the Table 59, in 2019/2020 Italy has imported in the EU more durum wheat than the other cereals (2.06M). At the same period, Italy has exported in the EU more Common wheat (105.43k) than the other cereals.

Unfortunately, we couldn't find some datas on the import and export made by Italy inside the EU.

Output components (constant prices)	2017	2018	2019		
	Million EUR		Million EUR	% of total	% of EU27_2020
Cereals:	**3 225**	**3 339**	**3 368**	**7.9%**	**8.1%**
Wheat and spelt	1 587	1 604	1 591	4%	8.0%
Rye and meslin	1	1	2	0%	0.1%
Barley	147	169	176	0%	2.3%
Oats and summer cereal mixtures	34	41	42	0%	3.6%
Grain maize	1 045	1 069	1 049	2%	11.2%
Rice	246	261	305	1%	41.6%
Other cereals	164	193	205	0%	11.4%
Industrial crops:	**765**	**753**	**732**	**1.7%**	**4.6%**
Oil seeds and oleaginous fruits	351	352	299	1%	3.5%
Protein crops	141	148	160	0%	14.8%
Raw tobacco	155	153	181	0%	41.1%
Sugar beet	96	78	70	0%	2.8%
Other industrial crops	22	22	22	0%	0.6%
Forage plants	**1 357**	**1 740**	**1 649**	**3.9%**	**7.8%**
Vegetables and horticultural products	**8 478**	**8 305**	**9 143**	**21.5%**	**17.5%**
Potatoes	**593**	**533**	**613**	**1.4%**	**4.9%**
Fruits	**4 161**	**4 496**	**3 992**	**9.4%**	**16.5%**
Wine	**6 325**	**8 244**	**6 767**	**16%**	**32.8%**
Olive oil	**2004**	**1135**	**1469**	**3%**	**29.4%**
Other crop products	**349**	**331**	**331**	**1%**	**15.0%**
Crop output	**27 258**	**28 876**	**28 066**	**66.0%**	**14.3%**
Animals:	**9 257**	**8 673**	**8 545**	**20.1%**	**10.0%**
Cattle	2 752	2 728	2 650	6.2%	10.5%
Pigs	3 144	2 780	2 738	6.4%	7.6%
Equines	86	89	90	0.2%	10.2%
Sheep and goats	151	149	149	0.4%	4.1%
Poultry	2 396	2 292	2 290	5.4%	12.9%
Other animals	728	635	627	1.5%	29.4%
Animal products:	**5 697**	**5 734**	**5 913**	**13.9%**	**10.0%**
Milk	4 508	4 454	4 623	10.9%	9.5%
Eggs	1133	1214	1225	2.9%	15.1%
Other animal products	56	66	65	0.2%	2.7%
Animal output	**14 954**	**14 408**	**14 457**	**34.0%**	**10.0%**
Agricultural goods output	**42 212**	**43 284**	**42 523**	**100.0%**	**12.5%**

Figure 44 - Some agricultural output in Italy

The Figure 44 puts on the light the fact that Italian Cereals generates 8.1% of the overall output components in the EU. In 2019, it generates around 3 368 million of euros.

Input components	2017	2018	2019	2018/2017	2019/2018
	Million EUR			% Change	
Seeds and planting stock	1 246.8	1 261.2	1 316.2	1.2%	4.4%
Energy	2 725.2	2 893.3	3 004.3	6.2%	3.8%
Fertilisers and soil improvers	1 358.0	1 361.0	1 383.2	0.2%	1.6%
Plant protection products	875.4	891.3	930.3	1.8%	4.4%
Veterinary expenses	692.6	699.6	722.5	1.0%	3.3%
Feedingstuffs	7 141.3	7 662.7	7 458.3	7.3%	-2.7%
Maintenance of materials	742.0	748.0	758.8	0.8%	1.4%
Maintenance of buildings	316.3	317.4	319.7	0.3%	0.7%
Agricultural services	2 592.7	2 601.1	2 654.1	0.3%	2.0%
Other goods and services	3 622.8	3 611.3	3 710.2	-0.3%	2.7%
Total intermediate consumption	**21 623.1**	**22 309.7**	**22 529.3**	**3.2%**	**1.0%**
Fixed capital consumption	**10 924.8**	**10 817.0**	**10 777.2**	**-1.0%**	**-0.4%**

Figure 45 - Some agricultural input in Italy

Values at basic prices	2017	2018	2019	2018/2017	2019/2018
	Million EUR			% Change	
Output of the agricultural "industry":	**51 046.0**	**52 112.3**	**51 465.8**	**2.1%**	**-1.2%**
Crop output	27 257.5	28 876.4	28 065.5	5.9%	-2.8%
Animal output:	14 954.2	14 407.7	14 457.4	-3.7%	0.3%
Animals	9 257.1	8 673.4	8 544.6	-6.3%	-1.5%
Animal products	5 697.2	5 734.4	5 912.8	0.7%	3.1%
Agricultural services	4 609.7	4 582.0	4 657.2	-0.6%	1.6%
Secondary activities	4 224.6	4 246.2	4 285.6	0.5%	0.9%
- Intermediate consumption	**21 623.1**	**22 309.7**	**22 529.3**	**3.2%**	**1.0%**
= Gross value added at basic prices	**29 422.9**	**29 802.6**	**28 936.5**	**1.3%**	**-2.9%**
- Consumption of fixed capital	10 924.8	10 817.0	10 777.2	-1.0%	-0.4%
- Taxes	536.2	558.9	579.2	4.2%	3.6%
+ Subsidies	3 885.4	4 430.3	4 573.0	14.0%	3.2%
= Factor income	**21 847.3**	**22 857.0**	**22 153.2**	**4.6%**	**-3.1%**
Agricultural income* (2010=100)	**131.3**	**136.8**	**132.8**	**4.2%**	**-2.9%**

Figure 46 - Some agricultural income in Italy

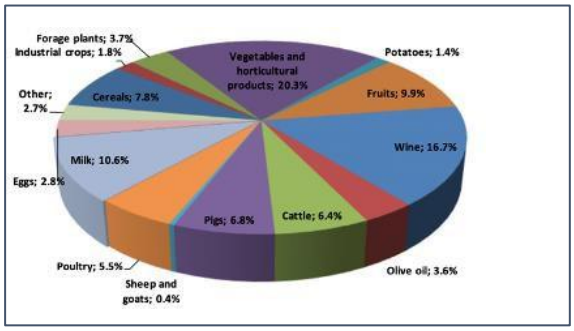


Figure 47 - output components (2017-2019 average)

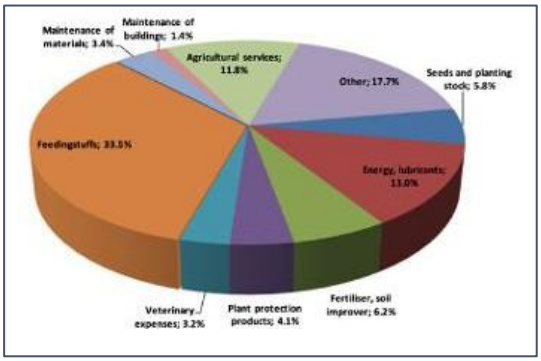


Figure 48 - Intermediate consumption (2017-2019 average)

By category of product	Total trade	Trade with EU countries		Trade with non-EU countries	
	Million EUR	Million EUR	% change 2019/2018	Million EUR	% change 2019/2018
Exports					
Commodities	2 899.1	1 993.8	1.5%	905.2	8.10%
Other primary products	6 593.8	5 266.8	-4.5%	1 326.2	15.84%
Processed products	18 221.8	10 924.7	2.0%	7 294.4	5.69%
Food preparations	10 702.7	6 837.5	5.9%	3 864.7	10.09%
Beverages	2 614.9	1 524.0	15.2%	1 089.3	17.78%
Non edible	3 724.1	1 741.8	7.5%	1 863.2	54.30%
Total agricultural products	**44 756.5**	**28 288.7**	**2.5%**	**16 343.1**	**12.50%**
as % of total exports	9.4%	10.7%		7.8%	
Imports					
Commodities	10 893.3	5 230.2	-1.0%	5 663.1	6.5%
Other primary products	12 868.7	10 051.6	6.5%	2 817.0	4.4%
Processed products	5 516.9	5 045.6	-1.3%	470.9	-7.0%
Food preparations	4 259.2	3 876.8	1.8%	382.3	9.0%
Beverages	1 479.9	1 132.6	-1.9%	347.3	37.3%
Non edible	5 295.7	4 103.4	-6.2%	1 192.2	-2.1%
Total agricultural products	**40 313.6**	**29 440.3**	**0.9%**	**10 872.7**	**5.12%**
as % of total imports	9.5%	11.8%		6.3%	
Balance					
Commodities	-7 994.2	-3 236.4		-4 757.9	
Other primary products	-6 275.0	-4 784.8		-1 490.8	
Processed products	12 705.0	5 879.1		6 823.6	
Food preparations	6 443.6	2 960.6		3 482.5	
Beverages	1 135.1	391.5		742.0	
Non edible	-1 571.6	-2 361.7		671.0	
Total agricultural products	**4 442.9**	**-1 151.7**		**5 470.4**	

Source: Directorate General for Agriculture and Rural Development, based on COMEXT data — Updated: June 2020

Figure 49 - Agricultural trade in 2019

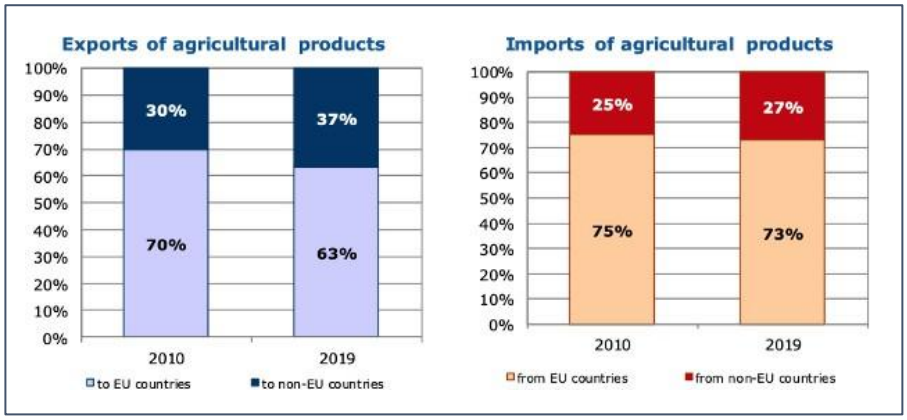


Figure 50 - Exports and imports of agricultural products (2010 and 2019)

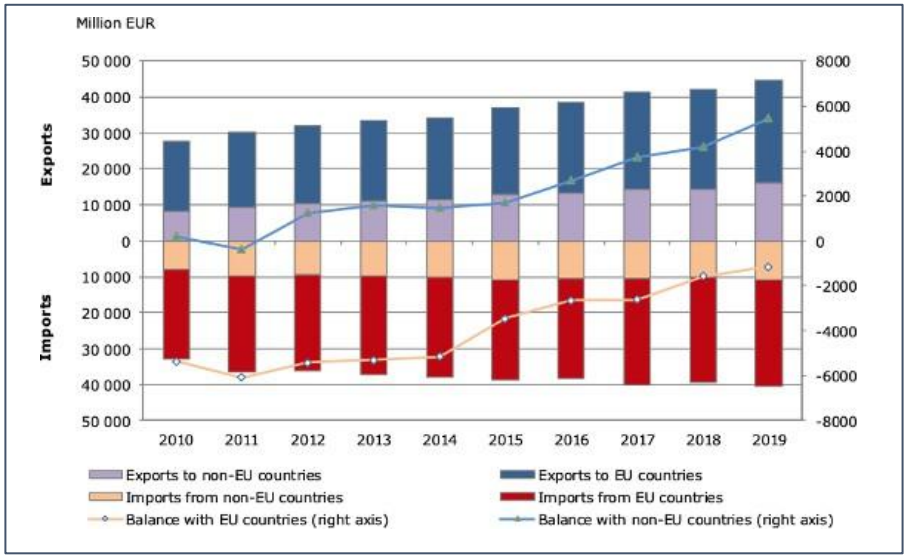


Figure 51 - Evolution of agricultural trade with EU and non-EU countries

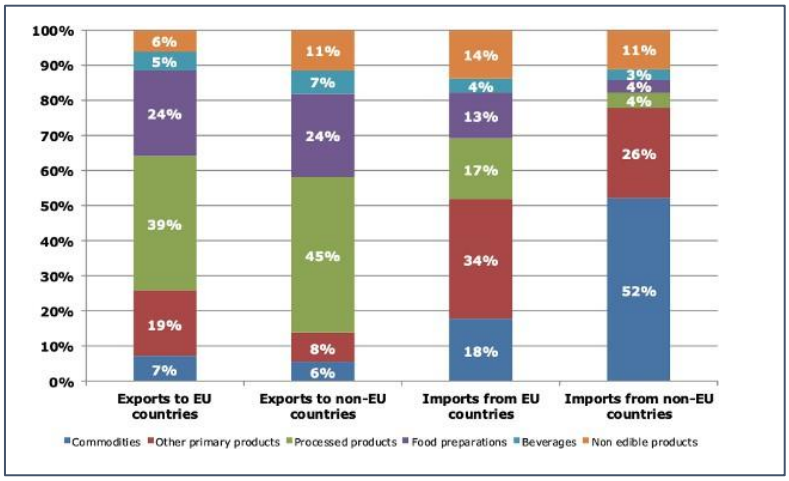


Figure 52 - Structure of agricultural exports and imports

3) Stored grains cereals invasive insect species [10]

a) Occurrence & Percentage of damages

According to a private source localized in Italy, the main pests in the BIO domain are: *Sitophilus Granarius, Rhizoperta Domenica, Sitotraga cerealella.*

- **Other beetle :**

- *Trogoderma granarium*
- *Gryptolestes ferrigineus*
- *Tenebroides mauritanicus*
- *Tribolium castaneum*

- **Other Lepidoptersa**

- *Ephestia kuehniella*
- *Plodia interpunctella*

We highlight the fact that it is very difficult to find some recent information according to the main pest grain species in Italy. Nonetheless, we found a study made in 2006 focusing on the pests localized in central southern Italy (Molise, Apulia and Basilicata regions).

Surveys were conducted by analyzing samples of stored wheat taken from both traditional warehouses of small farms and from different types of commercial storage facilities, such as flat structures, concrete silos and metal bins.

The results obtained showed various levels of infestation with differences in insect species and populations. A total of about 25 species of insect pests representing five orders were found, predominantly Coleoptera. **Cryptolestes ferrugineus** (Steph.), **Oryzaephilus surinamensis** (L.), **Plodia interpunctella** (Hb.), **Rhyzopertha dominica** (F.), **Sitophilus oryzae** (L.) and **Tribolium castaneum** (Herbst) were the most frequently detected species. In this paper, these results are discussed in view of the commercial importance of hard wheat in the crop areas under study and the various insect pest management techniques adopted in the storage facilities of central southern Italy.
In Figure 53, the insects recorded were found in traditional and commercial hard wheat warehouses. The majority of species collected were primary and secondary phytophagous pests typically associated with stored products. In Figure 54, the insect species were found in metal bins whereas in Figure 55 there were found in silos and flat warehouse.

Order	Species	Traditional Warehouse	Commercial Warehouse
Psocoptera	*Trogium* spp.	**	**
Rhynchota	*Aelia rostrata* Boheman	*	
	Eurygaster austriaca (Schrank)	*	
Lepidoptera	*Ephestia elutella* (Hb.)	*	
	Ephestia kuehniella (Z.)	*	
	Plodia interpunctella (Hb.)	*	**
	Sitotroga cerealella (Olivier)	*	
Coleoptera	*Alphitobius diaperinus* (Panzer)		*
	Carcinops pumilio (Erichson)	*	
	Cryptolestes ferrugineus (Steph.)	**	****
	Latheticus oryzae Waterhouse	**	*
	Oryzaephilus surinamensis (L.)	***	****
	Rhyzopertha dominica (F.)	**	***
	Sitophilus granarius (L.)	***	*
	Sitophilus oryzae (L.)	**	***
	Sitophilus zeamais Motschulsky	*	
	Stegobium paniceum (L.)	*	
	Tenebroides mauritanicus (L.)	*	
	Tribolium castaneum (Herbst)	***	****
	Tribolium confusum du Val	*	*
	Trogoderma granarium Everts	*	
	Typhaea stercorea (L.)	*	
	Carabidae	*	
	Staphilinidae	*	
Hymenoptera	Calcidoidea	*	

= 10 % of samples; * 11-25 % of samples; *** 26-50 % of samples; **** > 50 % of samples.

Figure 53 - Insect species found in hard wheat warehouses of the Molise, Apulia and Basilicata regions

Species	Metal bin															
Sample	Ma	Mb	Mc	Md	Aa	Ab	Ac	Ad	Ae	Af	Ag	Ah	Ai	Ba	Bb	Bc
Alphitobius diaperinus						x										
Cryptolestes ferrugineus	xo				xo	xo	xo	xo	xo	xo	xo			xo		
Latheticus oryzae								x								
Oryzaephilus surinamensis		x	x	x	o	xo	o		o	o	o	o	xo	xo		xo
Plodia interpunctella					o	o	o									
Rhyzopertha dominica		x			x	x	x	x			x	x	x	x	x	x
Sitophilus oryzae										o		xo		xo	x	
Tribolium castaneum			x	x	o	xo	xo	xo	o	xo	xo					xo
Tribolium confusum					x										x	
Trogium spp.	xo				xo	xo	xo	o	xo	xo	xo					

Ma - Md: samples from Molise; Aa - Ai: samples from Apulia; Ba - Bc: samples from Basilicata

x = found in the first analysis; o = found in the second analysis

Figure 54 - Insect species found in the commercial storage facilities of the Molise, Apulia and Basilicata regions (metal bins)

Species	Concrete Silo				Flat Warehouse														
Sample	Aj	Ak	Al	Am	Me	Mf	Mg	Mh	Mi	Mj	An	Ao	Ap	Aq	Ar	As	Bd	Be	Bf
Alphitobius diaperinus									o								x		
Cryptolestes ferrugineus	xo	o				x	xo	xo		xo	xo	xo	xo		x	x	xo		
Latheticus oryzae																			
Oryzaephilus surinamensis	xo	xo	xo		o	o	xo	xo	xo	xo		o	xo	xo	xo	xo	xo	xo	x
Plodia interpunctella							x	x	x						x				
Rhyzopertha dominica		x			xo	xo				o	xo	xo					xo		
Sitophilus granarius							o			xo			o		x				
Sitophilus oryzae		x	x				xo			xo	x	x	xo			x			xo
Tribolium castaneum		xo	xo	x	xo	o	xo	xo		xo	xo		xo	xo	xo	x	xo	xo	
Tribolium confusum																	xo		
Trogium spp.		xo								xo					x				

Me - Mj: samples from Molise; Aj - As: samples from Apulia; Bd - Bf: samples from Basilicata.

x = found in the first analysis; o = found in the second analysis.

Figure 55 - Insect species found in the commercial storage facilities of the Molise, Apulia and Basilicata regions (concrete silos and flat warehouses)

4) Storage on bigger scales

a) Types of storage facilities [11]

By grain silo we mean a structure or a warehouse or a room outside or inside a separate and closed building, in which the products of the agri-food industry are stored. They are mainly dedicated to the storage of cereals (corn, wheat, rice, legumes and similar).

- The steel silos are the most widely used and guarantee long shelf life over time, they are waterproof and resistant to atmospheric agents. Very hygienic with a high degree of conservation of the raw material.

- The concrete silos are mainly used in port areas as they are of great height and large containment capacity. They are more permeable than steel ones. Concrete storage warehouses, on the other hand, have the advantage of being large and can be open space or divided into cells as if they were silos.

- While fiberglass silos are those that have the greatest thermal resistance, high mechanical strength and good thermal insulation, usually built with a circular section they do not require. particular maintenance and are used a lot for animal feed.

Some manufacturers of silos in Italy [12,13]

Zanin F.lli designs and manufactures machines and systems such as cleaners, dryers, conveyors and storage systems for the agro-food industry and for industry in general. This company proposes metallic silos for the grain stored domain.

Mulmix was founded in 1962 as a small company for the production of silos, mills and mixing augers. With its experience of more than 40 years and its young team full of ideas, Mulmix collaborates with its customers to find the most suitable and favorable solutions for their business.

The widespread presence in the territories, however, is the element that distinguishes the company and is giving important satisfaction; commercial offices and organizations in different countries create the necessary physical contact that customers today demand more and more.

b) Biggest site of storage for the exported cereals [14]

If we focus on the biggest seaports in term of goods flow (*expression in thousands of tons per year*) in 2019 and updated on 2/04/2020 by Assoporti (Association of Italian Ports), we can see that there are 15 seaports ranking in term of goods flow. It is a good unity to measure and classify commercial ports.

- Trieste: 61.997.445 / Genova : 52.759.195
- Livorno: 36.715.346 / Cagliari-Sarroch : 34.701.792
- Gioia Tauro: 29.122.760 / Ravenna : 26.256.248
- Venezia: 24.917.830 / Messina-Milazzo : 24.295.221
- Augusta: 21.422.613 / Napoli : 18.550.424
- Taranto: 18.125.171 / La Spezia : 15.881.905
- Savona-Vado: 14.392.738 / Salerno : 14.326.847
- Citavecchia: 9.571.791

c) Industry mapping in grains storage [15]

- **Commercial seaports**

In this map, we can see the seaports and containers terminals in Italy. The seaports and containers terminals can be a good information about the flow of grains coming from the import and export.

It is possible to have further information about each seaport and container terminal online: https://www.searates.com/fr/maritime/italy.html

We can notice 102 localizations where the grains can be stored. There are more seaports than container terminals.

Figure 56 - Seaports and container terminals in Italy

- **National road transportation – agricultural goods**

If we look at the map below, we can see in red the "top 100 national road transportation flows of agricultural goods" in 2015 in Spain.

Figure 57- Italy road transportation core network

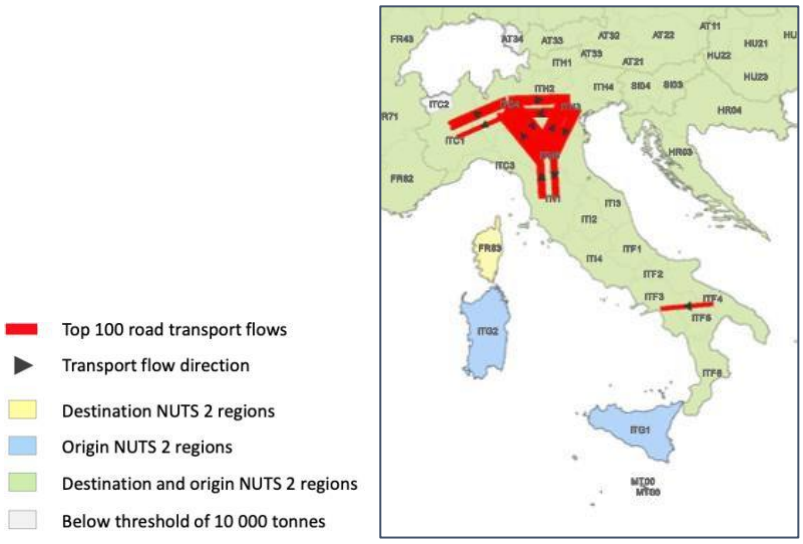


Figure 58 : Italy road transportation core network (next)

Table 61 : Top 100 national roads transportation flows of agricultural goods in 2015 in Italy

N°	Origin	Region	Destination	Region	Quantity in tonnes (2015)
1	ITH5	Emilia-Romagna	ITC4	Lombardia	3 004 700
2	ITH5	Emilia-Romagna	ITH3	Veneto	2 996 699
3	FI1D	Pohjois	FI1C	Etelä-Suomi	2 528 814
4	ITC4	Lombardia	ITH5	Emilia-Romagna	2 093 240
5	ITH3	Veneto	ITH5	Emilia-Romagna	2 038 697
6	ITC4	Lombardia	ITH3	Veneto	1 931 158
7	ITC1	Piemonte	ITC4	Lombardia	1 930 635
8	ITH3	Veneto	ITC4	Lombardia	1 871 884
13	ITI1	Toscana	ITH5	Emilia-Romagna	1 436 178
14	ITH5	Emilia-Romagna	ITH5	Emilia-Romagna	1 412 139
50	ITF4	Puglia	ITF3	Campania	888 343

Figure 59 - Italy core railway network

Name of the main infrastructure owner: RFI
Total line km:18 011
Share of multiple tracks lines: 47%
Share of electrified lines: 73%

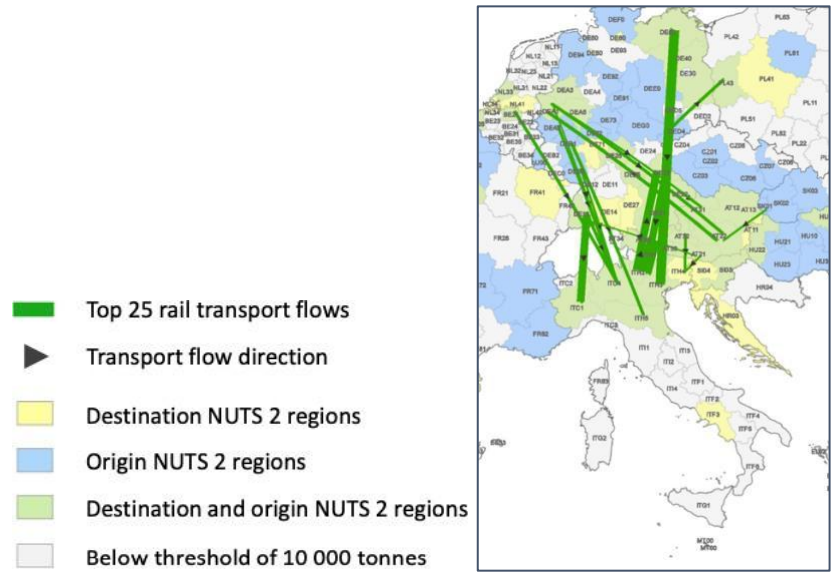


Figure 60 : Italian national rail transportation flows of agricultural goods in 2015 in Italy

Table 62 : Italian national rail transportation flows of agricultural goods in 2015 in Italy

N°	Origin	Region	Destination	Region	Quantity in tonnes (2015)
2	AT33	Tirol	ITH2	Trento	677 982
3	DE80	Mecklenburg-Vorpommern	ITH3	Veneto	524 328
5	DE13	Freiburg	ITC1	Piemonte	424 190
7	DE23	Oberpfalz	ITH2	Trento	390 142
10	DE13	Freiburg	ITC4	Lombardia	196872
14	DEB1	Koblenz	ITH5	Emilia-Romagna	172 946
16	BE21	Prov. Antwerpen	ITC4	Lombardia	162 610
17	AT32	Salzburg	ITH4	Friuli-Venezia Giulia	158 173
18	DEA2	Köln	ITC4	Lombardia	150808
20	AT21	Kärten	ITH4	Friuli-Venezia Giulia	131 251
21	DEB3	Rheinhessen-Pfalz	ITC4	Lombardia	124 527
25	DEA1	Düsseldorf	ITC4	Lombardia	90 744

5) Potential users of the new solution

a) List of companies buying the product (appliers, users)

- Number of agricultural cooperatives specializing in cereals :*difficult to find these data*
- List of Italian distributors in the grain stored domain : *data not found*

6) Control means available (+ boundary conditions) [16]

a) Focus on the insecticides used within the market for indoor, post-harvest grain treatment

Pre-storage conventional

In this part, we decided to focus on some products sold by Newpharm in Italy. Indeed, the document "Catalogo stoccaggio cereal 2020" is very interesting because there are a lot of information and details in it. This document gives a good overview of some kinds of products sold and used in Italy.

- **Treatment to insect control the stored grains**

(1) Treatment to insect control the stored grains cereals treatment production harvest / pest of stored products

- **Treatments to insect control the premises where are stored the grains**

(2) General treatments, insect control, premises structure, equipments (POV)

→Fumigants

Table 63 : Fumigants used in storage treatment in Italy

Product	Manufacturer	Target	Active substance	Concentration	Formulation type	Dosage
Dobol® Fumigante	Newpharm	Flying : moths, paralipsa, false wheat moth, true moth Crawling: miller darkness, tribbles, yearning, dermestids, trogoderma of cereals, anobio, cryptolestes	Pure Cifenotrin	7.2%	Hydro-reactive diffuser	**(2)** 100 g : 700-1.250 20 g: 150-350
Actellic® Smoke Generator	Newpharm	Weevils or calenders (Sitophilus spp.), Tribbles (Tribolium spp.), Silvani (Oryzaephilus spp.), Cereal capuchin (Rhyzopertha dominica), trogoderma (Trogoderma spp.) And other food beetles; True wheat moth (Sitotroga cerealella), gray moth (Ephestia kuehniella), fasciata moth (Plodia interpunctella) and other arthropods that infest foodstuffs	Pyrimiphos-methyl	22.5%	Smoke can	**(2)** 90 g: 570

→ **Concentrated liquid**

- ULV nebulizers on the environment

Table 64 : Concentrated liquids used in storage treatment in Italy

Product	Manufacturer	Target	Active substance	Concentration	Formulation type	Dosage
Actellic® 50	**Newpharm**	Weevils or calenders (Sitophilus spp.), Tribbles (Tribolium spp.), Silvani (Oryzaephilus spp.), Cereal capuchin (Rhyzopertha dominica), trogoderma (Trogoderma spp.) And other food beetles; True wheat moth (Sitotroga cerealella), gray moth (Ephestia kuehniella), fasciata moth (Plodia interpunctella) and other arthropods that infest foodstuffs.	Pure pyrimiphos-methyl 49.02%	500 g / L	Emulsifiable concentrate	**(2)** 1L
K-Obiol® Ec 25	**Newpharm**	Weevils or calenders (Sitophilus spp.), Tribbles (Tribolium spp.), Silvani (Oryzaephilus spp.), Capuchin (Rhyzopertha dominica), trogoderma (Trogoderma spp.) And other food beetles; true wheat moth (Sitotroga cerealella), gray moth (Ephestia kuehniella), fasciata moth (Plodia interpunctella) and other arthropods that infest warehouses.	Deltametrin pure 2.66 % PBO 23.96 %	25 g/L 225 g/L	Emulsifiable concentrate	1L
Water						98L
Direct treatment on cereals :* disperse 8mL of Actellic 50 newpharm in 1 L of water, then apply on a ton of cereal** ***Environmental treatment (2) : environmental treatment: disperse in 1% water (1 L of ACTELLIC® 50 NEWPHARM in 100 L of water) then use 100 mL of the dispersion per m2 of surface. Dilute appropriately with BIOSOL® NEW for interventions on the environme nt with suitable ULV equipment. ***Treatment aimed at bags of cereal: disperse 1.2-2.8 L of ACTELLIC® 50 NEWPHARM in 100 L of water, then apply 50 mL of the dispersion every m2 of surface of the bag or other container.*** ***With manual sprayers on mL / m2 surfaces : 100***						

Product	Manufacturer	Target	Active substance	Concentration	Formulation type	Dosage
Actellic® 50 Newpharm	**Newpharm**	Weevils or calenders (Sitophilus spp.), Tribbles (Tribolium spp.), Silvani (Oryzaephilus spp.), Cereal capuchin (Rhyzopertha dominica), trogoderma (Trogoderma spp.) And other food beetles; True wheat moth (Sitotroga cerealella), gray moth (Ephestia kuehniella), fasciata moth (Plodia interpunctella) and other arthropods that infest foodstuffs.	Pure pyrimiphos-methyl 49.02%	500 g / L	Emulsifiable concentrate	**(2)** 1L
Nuvacid® 50	**Newpharm**	Flying: moths, paralipsa, false wheat moth, true moth. Crawling: miller darkness, tribbles, yearning, dermestides, trogoderma of cereals, anobio, cryptoleste.	Tetramethrin 2.85 g PBO 13.86 g	24 g/L 116.4 g/L	Liquid concentrate	1L
Water						98L
With manual sprayers on mL / m2 surfaces : 100						

Product	Manufacturer	Target	Active substance	Concentration	Formulation type	Dosage
K-Obiol® Ec 25	**Newpharm**	Weevils or calenders (Sitophilus spp.), Tribbles (Tribolium spp.), Silvani (Oryzaephilus spp.), Capuchin (Rhyzopertha dominica), trogoderma (Trogoderma spp.) And other food beetles; true wheat moth (Sitotroga cerealella), gray moth (Ephestia kuehniella), fasciata moth (Plodia interpunctella) and other arthropods that infest warehouses.	Deltametrin pure 2.66 % PBO 23.96 %	25 g/L 225 g/L	Emulsifiable concentrate	1L
Nuvacid® 50	**Newpharm**	Flying: moths, paralipsa, false wheat moth, true moth. Crawling: miller darkness, tribbles, yearning, dermestides, trogoderma of cereals, anobio, cryptoleste.	Tetramethrin pure 2.85 g PBO 13.86 g	24 g/L 116.4 g/L	Liquid concentrate	IL
Water						98L
With manual sprayers on mL / m2 surfaces : 50						

Product	Manufacturer	Target	Active substance	Concentration	Formulation type	Dosage
Talisma®	**Newpharm**	Weevils or calenders (Sitophilus spp.), Tribbles (Tribolium spp.), Silvani (Oryzaephilus spp.), Cereal capuchin (Rhyzopertha dominica), trogoderma (Trogoderma spp.) And other food beetles; True wheat moth (Sitotroga cerealella), gray moth (Ephestia kuehniella), fasciata moth (Plodia interpunctella) and other arthropods that infest foodstuffs.	Cypermethrin 7.89 % PBO 22.49 %	80 g/L 228 g/L	Liquid concentrate	1L
Nuvacid® 50	**Newpharm**	Flying: moths, paralipsa, false wheat moth, true moth. Crawling: miller darkness, tribbles, yearning, dermestides, trogoderma of cereals, anobio, cryptoleste.	Tetramethrin 2.85 g PBO 13.86 g	24 g/L 116,4 g/L	Liquid concentrate	IL
Water						
With manual sprayers on mL / m2 surfaces : 50						

Table 65 : List of ready to use formulations & concentrated liquids for the grains treatment

	Ready to use formulations	Concentrated liquids
Wheat	Actellic® 5 Newpharm K-obiol® ULV 6 Talisma® UL Actellic® 2/P Newpharm K-Obiol® DP2	Actellic® 50 Newpharm K-obiol® EC 25 Talisma® EC Actellic® 5 Newpharm
Spelled	K-obiol® ULV 6 Talisma® UL K-Obiol® DP2	K-obiol® EC 25 Talisma® EC Actellic® 5 Newpharm
Oats	Actellic® 5 Newpharm K-obiol® ULV 6 Talisma® UL Actellic® 2/P Newpharm K-Obiol® DP2	Actellic® 50 Newpharm K-obiol® EC 25 Talisma® EC Actellic® 5 Newpharm
Rye	K-obiol® ULV 6 Talisma® UL K-Obiol® DP2	K-obiol® EC 25 Talisma® EC Actellic® 5 Newpharm
Barley	Actellic® 5 Newpharm K-obiol® ULV 6 Talisma® UL Actellic® 2/P Newpharm K-Obiol® DP2	Actellic® 50 Newpharm K-obiol® EC 25 Talisma® EC Actellic® 5 Newpharm
Triticale	Actellic® 5 Newpharm K-obiol® ULV 6 Talisma® UL Actellic® 2/P Newpharm K-Obiol® DP2	Actellic® 50 Newpharm K-obiol® EC 25Newpharm Talisma® EC Actellic® 5 Newpharm
Corn	K-obiol® ULV 6	K-obiol® EC 25 Actellic® 5 Newpharm
Paddy rice	K-obiol® ULV 6	Actellic® 5 Newpharm

Direct grain treatment

Treatment to desinsectize the stored grains Cereals treatment production harvest / pest of stored products

- **Ready to use**

Short – 0 – 4 months

Table 66 : Ready to use formulations used in the direct grain treatment – 0 to 4 months

	Product	%	mL/ton	deficiency interval (days)	Cereals
1	K-Obiol® Ulv6	60	80-100	2	All kind of cereals
	Pygrain®	10			
	Phytorob®	30			
2	Actellic® 5 50 Newpharm	50	80-100	2	All kind of cereas except corn, rice and spelled
	K-Obiol® Ulv6	40			
	Pygrain®	10			
3	Actellic® Newpharm	50	80 -100	2	All kind of cereas except corn, rice
	K-Obiol® Ulv6	40			
	Pygrain®	10			
4	Talisma® Ul	90	80-120	2	All kind of cereas except corn, rice
	Pygrain®	10			

Medium 0 – 9 months

Table 67 : Ready to use formulations used in the direct grain treatment – 0 to 9 months

	Product	%	mL/ton	deficiency interval (days)	Cereals
5	K-Obiol® Ulv6	90	100 – 120	2	All kind of cereals
	Pygrain®	10			
6	Actellic® 5 Newpharm	60	120 – 150	0	All kind of cereas except corn, rice and spelled
	Talisma® Ul	40			
7	K-Obiol® Ulv6	50	???	0	All kind of cereas except corn, rice and spelled
	K-Obiol® Ulv6	50			

Long 0 – 12 months

Table 68 : Ready to use formulations used in the direct grain treatment – 0 to 12 months

	Product	%	mL/ton	deficiency interval (days)	Cereals
8	Actellic® 5 Newpharm	50	120-150	0	All kind of cereas except corn, rice and spelled
	K-Obiol® Ulv6	50			
9	Actellic® 5 Newpharm	40	120-150	0	All kind of cereas except corn, rice and spelled
	K-Obiol® Ulv6	60			
10	Actellic® 5 Newpharm	25	150 –180	0	All kind of cereas except corn, rice and spelled
	K-Obiol® Ulv6	50			
	Talisma® UI	25			
11	K-Obiol® Ulv6	60	120 -150	2	All kind of cereals
	Pygrain®	10			
	Phytorob®	30			

- **With concentrated liquids**

Short - 0 – 4 months

Table 69 : concentrated liquid formulations used in the direct grain treatment – 0 to 4 months

	Product	%	mL/ton	Deficiency interval (days)	Cereals
1	K-Obiol® Ec 25	1	1	2	All kind of cereas except corn and rice
	Pygrain®	1			
2	Talisma® Ec	2	1	2	All kind of cereals except corn and rice
	Pygrain®	1			

Medium 0 – 9 months

Table 70 : concentrated liquid formulations used in the direct grain treatment – 0 to 9 months

	Product	%	mL/ton	Deficiency interval (days)	Cereals
3	K-Obiol® Ec 25	1	1	2	All kind of cereals except corn and rice
	Talisma® Ec	2			
4	Actellic® 50 Newpharm	1	1	2	All kind of cereals except corn and rice
	Talisma® Ec	2			

Long 0 – 12 months

Table 71 : Concentrated liquid formulations used in the direct grain treatment – 0 to 12 months

	Product	%	mL/ton	Deficiency interval (days)	Cereals
5	Actellic® 50 Newpharm	1	1	0	All kind of cereals except corn and rice
	K-Obiol® Ec 25	1			
6	Actellic® 50 Newpharm	1	1	2	All kind of cereals except corn and rice
	® Ec K-Obiol 25	1			
	Talisma® Ec	2			

b) Focus on fumigation and powder formulations

Data not found

c) Alternative methods and possible solutions in the future

Data not found

d) Special focus on Biological Agriculture and solutions

In this part, we will focus on the possible application of the environments intended to accommodate organic food. Once again, we will focus on the document *"Catalogo stoccaggio cereal 2020 - Newpharm".*

Several products are available and alternative to chemical insecticides: Pygrain®, Nuvex® EC, Phytorob® Bio, Biosol® new, PROCrop® Solido (powders), Silicosec®.

e) Boundary conditions = Specific limitations & restrictions

Data not found

HUNGARY

HUNGARY

Introduction

Located in the Carpathian Basin, Hungary is made of rolling plains and flat land for one part. For another part, the country counts, next to the Slovak borders, hills, and low mountains. The climate is favourable for the multiplication of seed of many species and several foreign seed companies use Hungary for that purpose.[1]

Arable lands and permanent crops cover nearly 5 million ha, of which 210 000 ha is under irrigation, with 1.1 million ha of permanent pastures and 1.7 million ha of forest. Over most of the country the soil is rich and suitable for agricultural production. The main crops include wheat, maize, vegetables, fruits, medicinal and aromatic plants.[1]

Table 72 : Hungary's relevant indicators concerning agriculture[2]

Indicator	Amount
Share of Agriculture in the GDP	3,70%
Share of Agriculture in the investments	6,10%
Share of Agriculture in the employment	4,60%
Trade balance of Agriculture	(+) 3B€
Used Agricultural Land	5,3 Mha
Arable Land	4,4 Mha

Hungary is one of the main protectors of the CAP (Common Agricultural Policy). During the last one concerning 2014-2020, Hungary defended the regulatory market mechanisms and the budget destinated to agricultural products. This statement, seen as a conservative one, is due to the dependence of the Hungarian Agricultural sector to the common fund. In fact, during this period, the amount of the CAP subsidies is approaching 1 764 M€ each year. (1 274 M of direct subsidies and 490 M€ for rural development).

1) Stored grains cereals general data

a) Volume of cereals produced

The following table presents the production of COP in Hungary since 2017.

Table 73 : Cereals production in Hungary for the last 5 marketing years

Cereals / Year (th T)	2017/18	2018/19	2019/20	2020/21	2021/22
Type	*	*	Estimate	Forecast	Projection
Soft wheat	5 087	5 049	5 215	4 893	5 568
Durum wheat	159	209	162	117	117
Barley	1 416	1 146	1 383	1 434	1 543
Oat	95	59	70	69	84
Grain maize	6 739	7 977	8 278	8 382	8 742
Triticale	374	329	338	299	349
Rye	87	88	91	82	104
Sorghum	25	43	126	136	108
Other cereals	24	18	23	17	23
Total cereals HU	14 006	14 918	15 687	15 429	16 638
Total cereals EU-28	**307 959**	**292 357**	**322 532**	**n.a.**	**n.a.**
Total cereals EU-27	**284 960**	**271 272**	**297 015**	**280 365**	**295 108**
% HU / EU-27 prod	**4.9%**	**5.4%**	**5.3%**	**5.5%**	**5.6%**

**For all cereals: marketing year from 1st July N to 30th June N+1, Eurostat[3]*

The grain sector is taking a huge part of the country agricultural production. For instance, in 2014, the grain crops represented 68% of the national crops. Moreover, in 2020, Hungary grain production reaches 15 440 Kt.

b) One big cereals producer

In Hungary, the multiplication of certified seed is carried out on approximately 170 000 ha and involves harvesting of some 360 000 tons of seed. About 25% of this quantity is exported, mostly to EU markets. Foreign seed companies use Hungary for seed production, particularly for maize, vegetables, sunflower, rape, mustard seed, alfalfa, grasses, and peas.[1]

This high production regarding the utilized Agricultural Land is mainly due to several actors. First, the **Grain Producer's Association of Hungary** (GPAH) regroups all the producers. Then, the **Hungarian Grain and Feed Association** (HGFA) regroups all the processors and traders of the country. Finally, the **Association Interprofessional Organization and Marketing Board** (AIOMB) regroups the actors of the seed sector. [4].

Also, under the MEM (Ministry of Agriculture and food Industry), the Grain Trust (GT), a state enterprise, is responsible for procurement, storage and marketing of grains entering the market to meet domestic demand including those for maintaining national reserve stocks and export purposes.[5].

c) Volume of stored grains cereals

Over the last 30 years, the refurbished and newly built grain storage capacity has created a stable background not only for grain, but also for oily and protein plants, the so-called COP plants. Hungary made huge investment in the global storage system. According to the world Bank: "The main […] aim was to increase the exportable surplus of cereals, of which 80 percent is sold for convertible foreign currency. Other objectives included improved farm management decision-making at the enterprise level, a price policy study to provide decision-makers with the analytical tools for pricing policies to ensure optimal production and efficiency levels, and preparation of other investment projects." [6].

That is why, the production is combined with a great storage service. Indeed, in Hungary, the storage capacity is 20 000 Kt whereas in 2020, 11506 kt were stored. This difference really represents the country's goal to improve its agricultural sector, and so its stored and trade system.

d) Volume of treated stored grains cereals

Grain control is necessary to prevent storage from insects or diseases. First, the Seed Inspection Division of the National Institute for Agricultural Quality Control, following standard rules for testing and field inspection, inspects and controls seeds on land. For instance, in 1999, the Seed Inspection Division inspected for seed production: 43 572 ha of winter wheat, 25 912 ha of maize, 1 649 ha of potato, 3 782 ha of sunflower, 6 271 ha of pulses; and 9 546 ha of lawn and fodder grasses.

Hungary is the largest producer of good quality wheat in Europe. The quality of wheat is determined by three main factors - geographic location, agronomic practices and the biological bases, which in turn are influenced by milling and baking practices. Hungary has agricultural exports of 2.5-3.0 billion euros, of which grain, fodder and milling products comprise of 20%. [7]

If we now consider the volume of stored grains, the amount is too difficult to reach for now, according to the Hungarian ministry of Agriculture. But the institution also remarks the global interest about agricultural and grain stored question. More than structure investment, Hungary is working on easy-access information.

e) Storage sites + How are stored the grains (on-farm, off-farm, export shipments)

Hungary is part of EU and takes place in the middle of Eastern Europe. Close to sea, but never counting a coastline, the country is somehow strongly made of agriculture in small farms.

The International Grains Council (IGC) forecasts Hungary's total grains crop in 2018-19 at 13.9 million tons, unchanged from 2017-18. Wheat production in 2017-18 is forecast at 4.9 million tons, down from 5.2 million tons in the previous year.[8]. In 2017, Hungary reaches the 6th place, better than UK. In fact, storage has gain 5000kt in 12 years, and so amplified its capacity by a third. The trend of a growing capacity is re-enforced by the Hungarian government want to increase the country's agricultural sector.

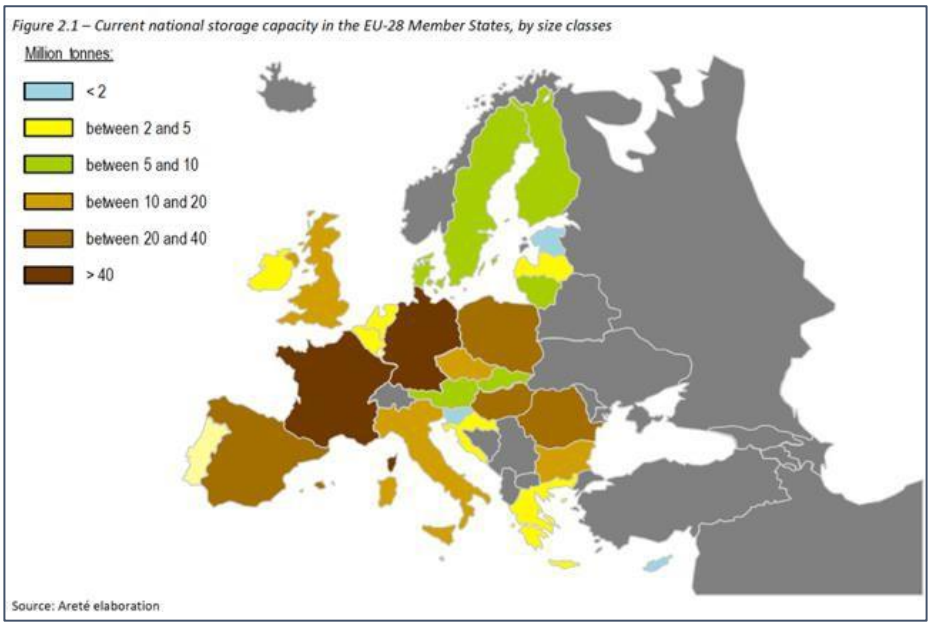


Figure 61 : Current national storage capacity in the EU-28 Member states, by size classes

As shown on the Figure 61, Hungary is part of the top country with great storage capacity. Moreover, Hungary is reaching a 30%-40% percentage of increase of the storage department.

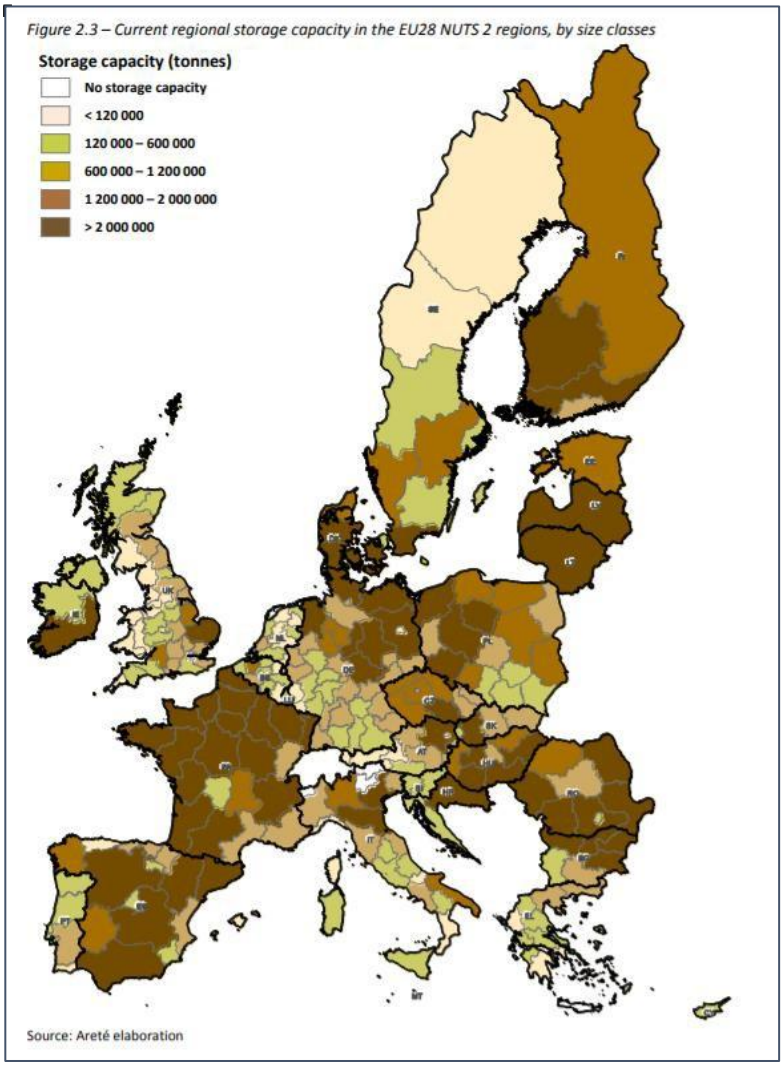


Figure 62 : Current regional storage capacity in the EU-28 NUTS2 region, by size classes[4]

According to the European report, 4 regions (NUTS2) stored a minimum of 2 M, 2 regions stored between 1.2M and 2M and 1 region stored between 600K and 1.2 M. To sum up, Hungary stores at least 10,8 M tons of grains in 2015 [4]. Nowadays, the storage capacity is even bigger and known as 20 M tons.

The storage system is divided in 3 categories as we saw for the other countries. However, Hungary is mostly made of several small farms. Therefore, on table 3 we can remark that most of the storage is on farm.

Table 74 : Distribution of the total share in Hungary according to different types of storage

Type of storage (2015 data)	Share in total storage (%)	Estimation of storage capacity
Individual farms = on-farm	42%	8.4 million tons
Farming cooperatives = off-farm	10%	2 million tons
Processing industries = off-farm	6%	1.2 million tons
Wholesale/trade = off farm	37%	7.4 million tons
Transportation hub (including ports)	5%	1 million tons
Storage capacity	**100%**	***20 million tons***

2) Focus on specific stored grains cereals: wheat, barley, oat, maize, rice

a) Estimated volumes of each stored grains variety.

Table 75 : -Estimation of the stored grain quantity in Hungary

Wheat	3 597.0
Maize	8011.0
Barley	396.0
Rice	8.0
Oat	60.3

Hungary stored 5 types of different grains: wheat, maize, barley, rice, oat.

- Maize is currently the first by far, ahead from wheat or barley.
- Rice and oat are tiny storage slots. We may now consider what are the flows of each grain in the country process. The estimation is realized according to the average production of the last years and the average stored grain amount of the last years.

b) Treatment used for each stored grains variety.

This part is related to the *part 6) "Control means available".*

c) Speed of grain rolling (incoming, stored, outgoing)

Due to the natural givens of Hungary, it is possible to produce a volume that far exceeds national needs.
Indeed, the exports of wheat and maize gather a huge excess (Figure 63 & Figure 64).

Years	Area (harvested thousand acre)	Grain (thousand tonnes)	Export		Import	
			Amount (thousand tonnes)	Its value (thousand USD)	Amount (thousand tonnes)	Its value (thousand USD)
2003	1 114	2 941	1 142	157 183	1	229
2004	1 174	6 007	962	131 978	37	6 995
2005	1 131	5 088	1 592	195 741	16	2 306
2006	1 078	4 379	2 039	289 266	14	1 887

Figure 63 : Main market data for Maize between 2003 and 2006

Years	Area (harvested thousand acre)	Grain (thousand tonnes)	Export		Import	
			Amount (thousand tonnes)	Its value (thousand USD)	Amount (thousand tonnes)	Its value (thousand USD
2003	1 145	4 532	1 270	157 512	3	530
2004	1 190	8 332	1 288	207 132	13	3 598
2005	1 198	9 050	1 851	233 966	2	760
2006	1 229	8 441	2 259	300 499	16	2 914

Figure 64 : Main market datas for Maize between 2003 and 2006 - part 2

The Table 76 regroups all the flows concerning the grain sector in Hungary. Excepting rice, the different grains are ranked in the same way. Moreover, it seems that a small amount of rice is stored in the Hungarian infrastructure each year. It might be cause by a difficulty to store this type of grain in Hungary. Even the quantities are low, the rice sems to be a market opportunity. [9]

Table 76 : Flows for each type of grain in Hungary

Type of Grain	Incoming (kt)	Stored (kt)	Outgoing (kt)
Wheat	5492	3597	5102
Maize	7833	8011	7758
Barley	1335	396	1385
Rice	62	8	63
Oat	76	60.3	86.6

3) Stored grains cereals invasive species

a) Occurrence & Percentage of damages

The species of interest are *Sitophilus oryzae, Sitophilus granarius, Sitophilus zeamais, Rhyzopertha dominica, Oryzaephilus surinamensis, Plodia interpunctella = Indian meal moth*
Unfortunately, we don't have the occurrence of species.

As Hungary datas are difficult to find, the Table 77 describes the statement concerning the occurrence of each species in the country. We settle our table with two sources.
As we can see, lots of occurrence are expected but difficult to prove by a scientific report. Nonetheless, Sitophilus granarius was record in the collection of the natural History Museum of London, UK. The specimen was directly related to Hungary.

Table 77 : Occurrence of each species in Hungary according to internal knowledge and CABI

Species	Internal knowledge	CABI
Sitophilus oryzae	YES	N/A
Tribolium castaneum	YES	N/A
Cryptolestes spp.	YES	N/A
Oryzaephilus surinamensis	YES	N/A
Rhyzopertha dominica	YES	N/A
Sitophilus granarius	YES	NHM, Undated a. Specimen record from the collection in the Natural History Museum (London, UK)., London, UK: Natural History Museum (London).
Mycetophages, Typhaea stercorea (hairy fungus beetle)	N/A	N/A
Tribolium confusum	N/A	N/A
Indian meal moth	YES	N/A

4) Storage on bigger scales

a) Types of storage facilities

As explained before, there are several types of storage facilities, but Hungary is concerned only by a small variety of those. After introducing the distribution of all storage structures on the *1)e*), whether on-farm or off-farm, we will focus now on the type of storages in Hungary.

Even if the datas were difficult to find, many world Bank projects reports are available to see the distribution of each type of storage in Hungary. First of all, the storage component is well defined by the projects, as we can see in Figure 65.

The strategy of the storage component is to:

(a) provide flexible new storage capacity, particularly off-farm, to meet peak demands for wheat procurement;

(b) increase the effective capacity of existing facilities by modernization and improved grain handling equipment;

(c) provide new and upgraded storage capacity for new demands imposed by imported feed components; and

(d) replace deteriorating grain storage facilities, especially temporary storage, as rapidly as possible.

Figure 65 : Strategy of the storage component according to the World Bank[5]

On the other hand, the projects were proposed in the 1980's. At that time, the storage capacity was only reaching 10 011 ktons. In less than 40 years, the capacity has double and now reached 20 000 ktons.

Table 9: Repartition of the total share in Hungary according different types of storage

Table 2.7: HUNGARY - GRAIN STORAGE BALANCE 1981 and 1985

SUPPLY	Form of Storage			
Year	Silos	Flat	Temporary	Total
	Installed Capacity ('000 tons)			
1981	2,079	5,491	1,470	9,040
1982	2,248	6,630	1,481	10,359
1985				
Without project /a	2,079	5,351	1,170	8,600
With project /b	2,289	6,154	1,668	10,011
	Effective Capacity ('000 tons) /c			
1981	4,158	3,844	1,470	9,472
1982	4,496	4,641	1,481	10,618
1985				
Without Project	4,158	3,746	1,170	9,074
With Project	5,723	8,000	1,668	15,390

DEMAND	Production ('000 tons) /d			
Year	Small Grains	Maize	Oilseeds /e	
1981	5,772	6,825	1,935(774)	14,532
1982	6,899	7,730	1,818(727)	16,447
1985	7,602	6,800	2,500(1,000)	16,902

Figure 66 : repartition of the total share[5]

Even if those capacity are not actual, they represent a clue to estimate actual distribution of storage capacity between the 3 possible kinds of storages asked in this report. We can manage to get a realistic estimation of low and high limits.

Table 78 : Estimation of the distribution for each type of storage facilities in Hungary[5]

Year		Silos		Flat		Temporary		Total	
1985	Without Project	4158	45.82%	3746	41.28%	1170	12.89%	9074	100%
	With Project	5723	37.19%	8000	51.98%	1668	10.84%	15390	100%
2020	Low limit	9165	45.82%	8257	41.28%	2579	12.89%	20000	100%
	High limit	7437	37.19%	10396	51.98%	2168	10.84%	20000	100%

- **Transport and logistics in Hungary**

Before discussing about flows such as exportations and importations, we need to detail the grain travel from production to transformation and so the trading network. The following figures records all the steps of the process. We can note that farming and harvesting is just the beginning of the path. Even if farming and harvesting are sources of potential losses, we are here really concern about the storage, which is spread to all the other's steps.

Moreover, each single storage implied a reception process to prevent the storage from contamination and also implied a departure process to guarantee a high level of quality.

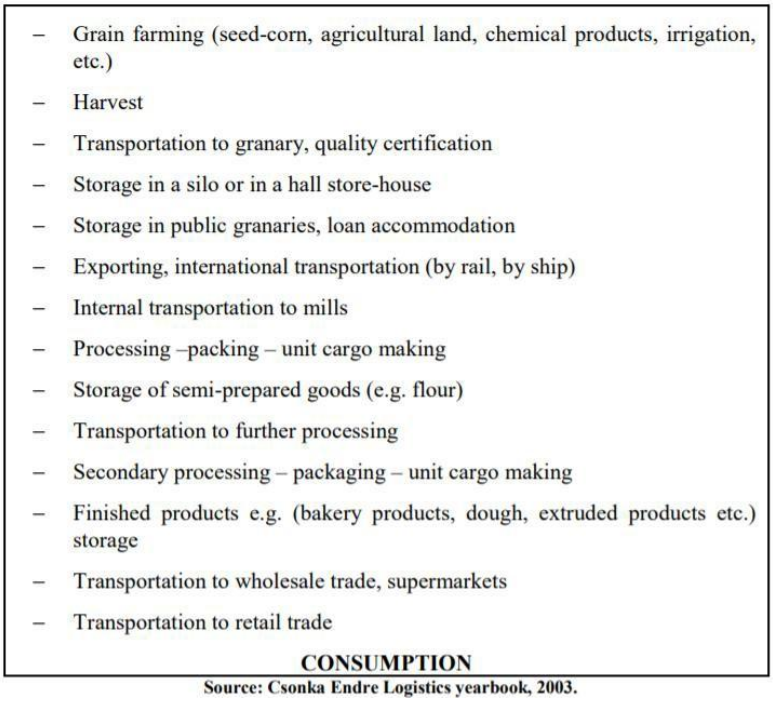


Figure 67 : the process of grain market in Hungary[10]

Therefore, logistics service centres help to use railways and inland water ways rather than roads for transportation.

Figure 68 : transport and logistic system in Hungary[11]

Hungary is a good example of stored grain industry development and progress [4].
The country is divided into storage sectors and non-storage sectors, or let us say less-storage sector. However, the lands are all used to propose a total transport and logistic coverage. Even some bottlenecks on the road network and the waterway network, companies can use the Danube in order to carry goods from intern Europe to Mediterranean Sea. Moreover, motorway, road, highspeed and conventional rail are planned or being upgraded. Hungary is at a crossroad of Europe and the Mediterranean Sea from North to South, and of the Europe and western countries (Mediterranean West) and the Eastern countries (Mediterranean East and the black sea).

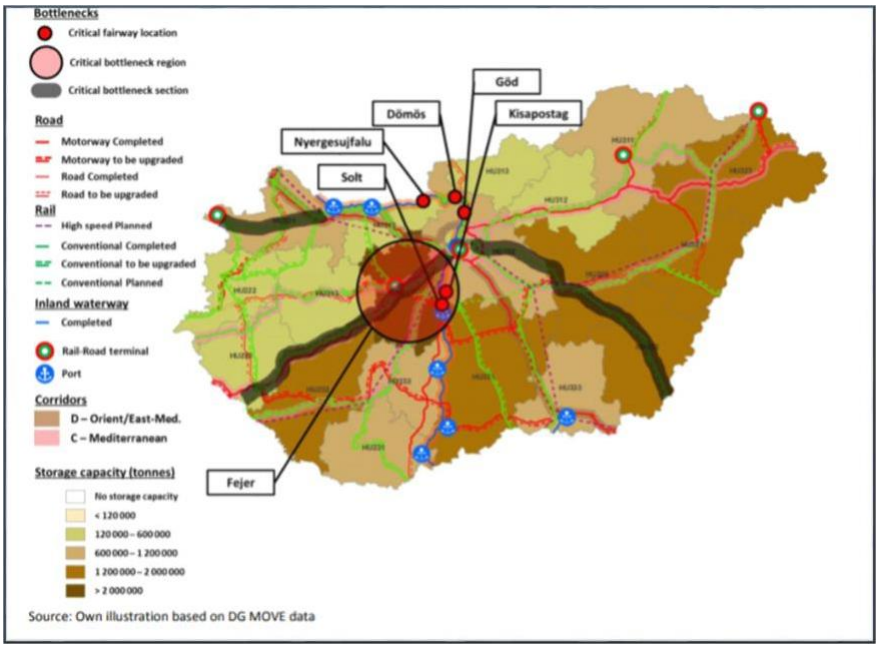


Figure 69 : Situation of transport and logistics in Hungary regarding bottlenecks in transport system [4]

Despite those new investments in the end of 2010's, the transport and logistic situation as always be in Hungary. Due to a regular increase of the exports, the system has been severely tested every single year since the 2000's. [10.]

On the Figure 70 and Figure 71, the development of internal logistic and transport is well represented on two different periods.

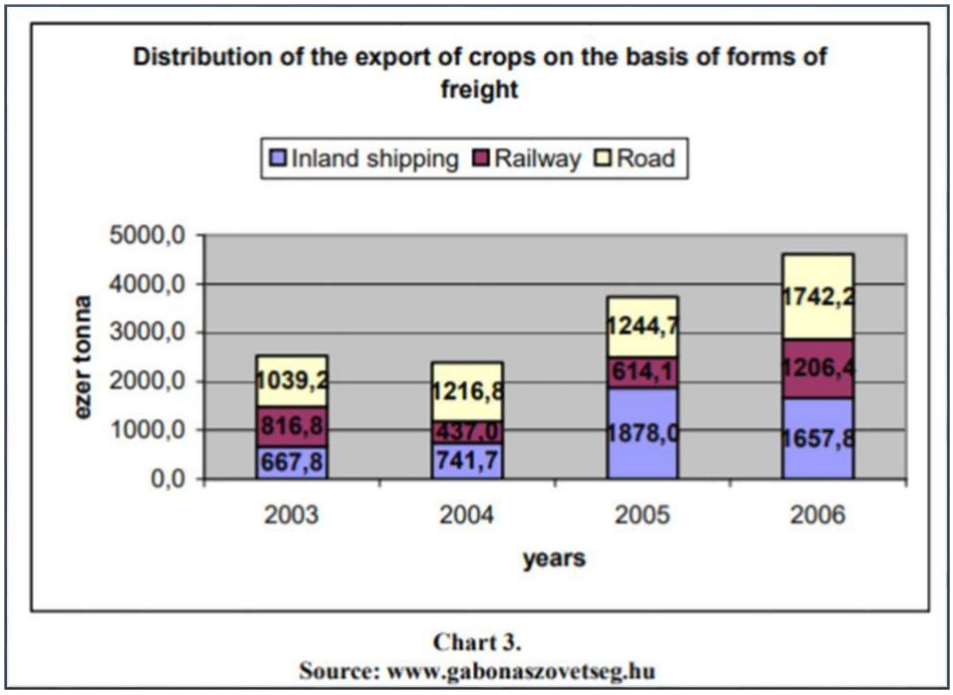


Figure 70 : distribution of the export of crops in Hungary on the basis of forms of freight (between 2003 and 2006)

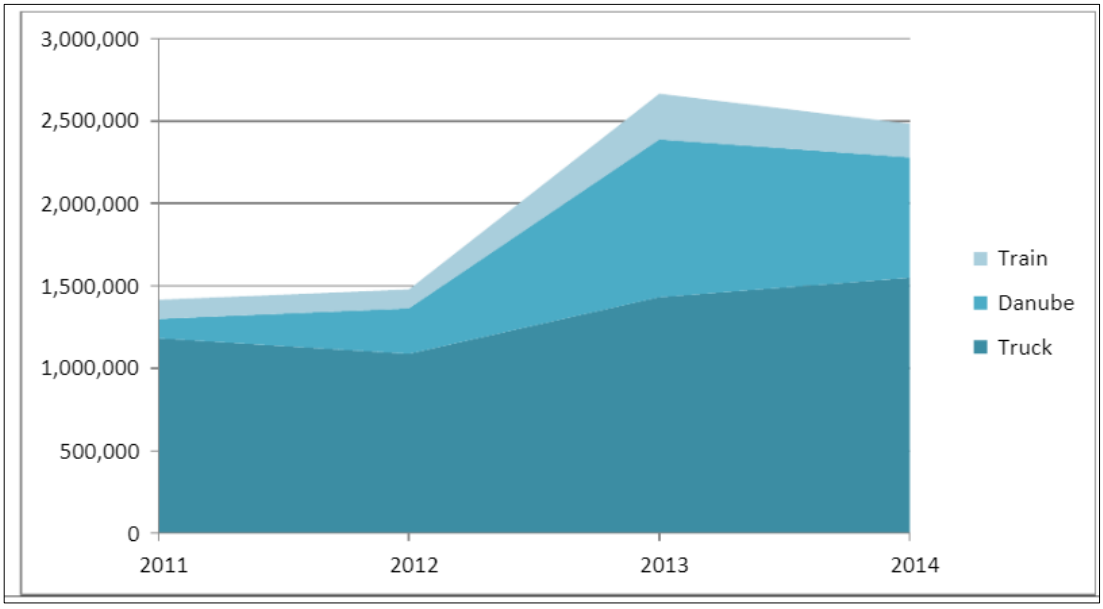


Figure 71 : wheat export by freight types between 2011-2014 in Hungary[12]

As the 2016 report suggested, the Danube has been taking more and more flows of goods, including the grains such as wheat. [12]

b) Biggest site of storage for the exported cereals

In this part we will show the details of the exports by the end of the 2010's (2017).
The study concerns Hungarian exports for wheat, oats, maize, barley whereas rice has been a missing data.

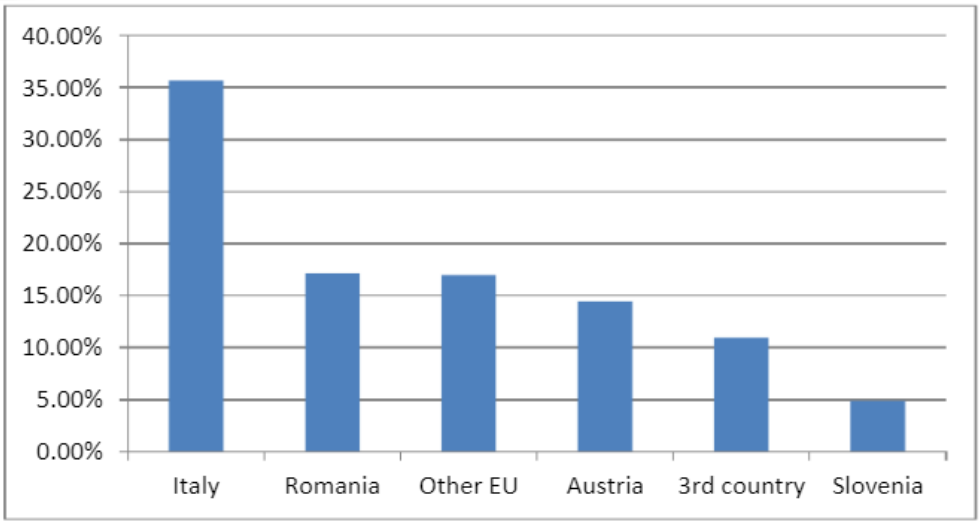


Figure 72 :Hungarian wheat export by countries in 2015[12]

The Hungarian agriculture has gone through important and fast changes during the last decades of the previous century. Hungary joined EU in 2004 and benefit from internal EU export. Indeed, almost 90% of the total production was exported to EU member state in 2015. From a long time, Italy remains the most dominant export direction for wheat for instance due to its huge processing sector. Other dominant countries were neighbors such as Romania, Austria and also Slovenia. [12]

Table 79 : Hungarian exports (outside EU)[13] (in t)

EXPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice
2017/2018	BOSNIA : 145.84K	UKRAINE : 1.23K	BOSNIA : 8.55K	RUSSIA : 17.41K	BOSNIA : 426.26	Data unavailable
	SWITZERLAND : 5.53K	SERBIA : 783.51	AZERBAIJAN: 341.12	UKRAINE : 16.42K	SERBIA : 298.2	
	KOSOVO :5.39K	MOLDOVA:114.94	UKRAINE : 153.16	CONGO : 5.88K	SWITZERLAND : 171.2	
	NORTHMACEDONIA: 3.84K	KOSOVO :72	SERBIA : 44	BOSNIA : 3.74K	KOSOVO : 46.16	
	CHINA 1.93k	SWITZER: 52.66	GEORGIA : 12.54	SERBIA : 3.23K	TURKEY : 1.2	
Total	**164.12K**	**2.29K**	**9.11K**	**56.21K**	**943.02**	
2018/2019	BOSNIA : 166.55K	UKRAINE : 1.14K	BOSNIA : 432.29	RUSSIA : 16.86K	BOSNIA : 1.06K	
	KOSOVO : 24.52K	KOSOVO : 828	AZERBAIJAN: 260.79	UKRAINE : 14.92K	SERBIA : 149.56	
	NORTH MACEDONIA: 3.6K	SERBIA : 568.99	SERBIA : 145.18	CONGO : 7.31K	X	
	SERBIA : 2.07K	ALBANIA : 7.5	SWITZER: 104.17	SERBIA : 2.69K	X	
	SWITZERLAND : 985.2	SWITZER : 6.85m	UKRAINE : 80.83	BELARUS : 1.32K	X	
Total	**198.38K**	**2.54K**	**1.04K**	**51.74K**	**1.2K**	
2019/2020	BOSNIA : 210.29K	UKRAINE : 1.77K	BOSNIA : 3.65K	SWITZER: 35.9K	SERBIA : 854.01	
	KOSOVO : 26.76K	SERBIA : 1.24K	SWITZER: 257.07	RUSSIA : 16.17K	BOSNIA : 302.12	
	NORTHMACEDONIA:10.2K	KOSOVO:142.56	AZERBAIJAN: 175.01	UKRAINE : 13.24K	KOSOVO : 24	
	SWITZERLAND : 2.52K	UK : 13.35	SERBIA : 94.01	CONGO : 3.04K	NORTHMACEDONIA : 0.1	
	SERBIA : 1.7K	MOLDOVA: 8.56	BELARUS : 60	CAMEROON: 2.57K	X	
Total	**253.8K**	**3.17K**	**4.42K**	**81.21K**	**1.18K**	
2020/2021	BOSNIA : 122.13K	UKRAINE : 1.32K	SWITZER: 1.44K	RUSSIA : 14.8K	SERBIA : 201.4	
	KOSOVO : 5.32K	SERBIA : 601.84	BOSNIA : 658.07	SWITZER: 14.5K	MONTENEGRO: 76.6	
	NORTHMACEDONIA: 3.28K	UK : 16.06	AZERBAIJAN: 201.93	UKRAINE : 7.16K	BOSNIA : 47.34	
	ALBANIA : 1.83K	MOLDOVA: 14.4	SERBIA : 123.53	SERBIA : 2.69K	KOSOVO : 24	
	SERBIA : 1.15K	x	UKRAINE : 111.6	CONGO : 1.52K	X	
Total	**134.68K**	**1.95K**	**2.64K**	**49.65K**	**349.34**	
Top countries EXPORT	BOSNIA KOSOVO NORTH MACEDONIA	UKRAINE SERBIA KOSOVO	BOSNIA AZERBAIJAN SWITZERLAND	RUSSIA UKRAINE CONGO	BOSNIA SERBIA KOSOVO	

Moreover, the country can count on a huge maize export in the EU or outside the EU. This sector is, with the wheat one, taking advantage of all the grain market in the country. The production,

the storage or even the transport is a central problematic, constantly optimized by all the actors, public or private.[14]

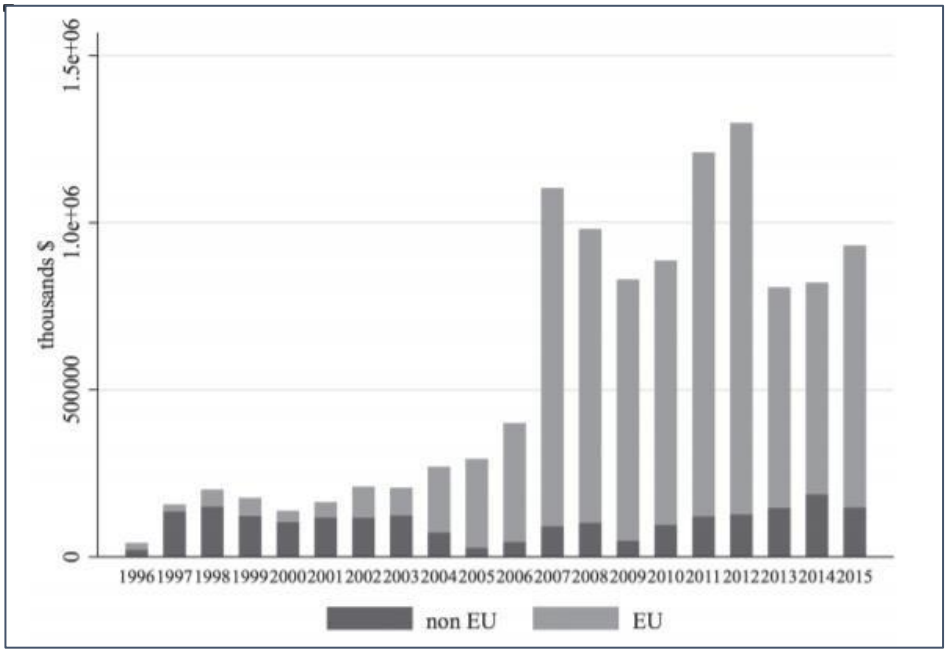


Figure 73 : Hungarian Maize exports by main markets segments (1996-2015)[14]

c) Several non-EU countries from where cereals come from (=import)[15]

In this part we will show the details of the imports by the end of the 2010's (2017). The study is related to Hungarian exports for wheat, oats, maize, barley whereas rice has been a missing data.

Table 80 : Hungarian exports (inside EU)[13]

IMPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice
2017/2018	UKRAINE : 1.45K	SWITZERLAND :13.46	SERBIA : 6.46K	UKRAINE:33.97K	UKRAINE : 19.19	Data unavailable
	SERBIA : 11.49	EGYPT : 0.38	USA : 0.03	SERBIA :4.87K	X	
	SWITZERLAND : 10.11	SERBIA : 0.07	X	USA : 210.8	X	
	USA : 2.21	X	X	TURKAY : 137.1	X	
	CHINA : 0.69	X	X	RUSSIA : 57.91	X	
Total	**1.57K**	**13.92**	**6.46K**	**39.3K**	**19.19**	
2018/2019	UKRAINE : 384.97	SERBIA : 11.92	SERBIA : 9.12K	SERBIA : 24.86K	SERBIA : 50.8	
	SERBIA : 34	CHINA : 0.01	UKRAINE : 177.16	UKRAINE:21.22K	UKRAINE : 29.78	
	BOSNIA : 30.22	X	RUSSIA : 0.05	TURKEY : 583.86	CHINA : 1	
	SWITZERLAND : 19.99	X	X	USA : 208.53	X	
	USA : 0.69	X	X	BELARUS : 19.62	X	
Total	**470.87K**	**11.93**	**9.3K**	**46.93K**	**81.58**	
2019/2020	SERBIA : 83.1	UK : 38.8	SERBIA : 989.54	SERBIA : 16.29K	SERBIA : 556.66	
	SWITZERLAND : 19.11	X	X	UKRAINE : 15.3K	UKRAINE : 550	
	RUSSIA : 10.5	X	X	TURKEY 925.44	X	
	USA : 1.45	X	X	USA : 175.8	X	
	UK : 0.16	X	X	RUSSIA : 91.41	X	
Total	**114.33**	**38.8**	**989.54**	**32.83K**	**1.11K**	
2020/2021	SERBIA : 23.6	SERBIA : 35.1	SERBIA : 50.22	SERBIA : 19.56K	UKRAINE : 638	
	SWITZERLAND : 14.23	UK : 23.86	X	UKRAINE:19.14K	SERBIA : 356.65	
	RUSSIA : 0.56	INDIA : 0.08	X	TURKEY : 1.58K	X	
	UK : 0.16	KOREA : 0.03	X	USA : 224.18	X	
			X	MEXICO : 5.18	X	
Total	**38.5**	**59.07**	**50.22**	**40.51**	**994. 65**	
Top countries IMPORT	**UKRAINE SERBIA SWITZERLAND**	**SWITZERLAND SERBIA UK**	**SERBIA UKRAINE RUSSIA**	**SERBIA UKRAINE TURKEY**	**UKRAINE SERBIA CHINA**	

Approximatively 93% of farm imports comes from EU member states. Hungary has many important trading partners: Germany (20.4%), Poland (12.8%), Slovakia (9.2%), Austria (7.5%), the Netherlands (6.9%), the Czech Republic (5.9%), and Italy (5.6%) in the EU member state.

But for the Non-EU import partners, it includes Ukraine, Serbia, the United States, Turkey, Indonesia, and China in the plant product dominated markets.[16]

d) Industry mapping in grains storage

The Hungarian storage industry mapping is a difficult data to find. As we have seen before, on the transport and logistic maps, many storage points are along the Danube. Moreover, the country is manly composed of agricultural lands. The following figure is approaching the truth of the storage mapping by showing all the grain dryers in Hungary and surrounding countries.

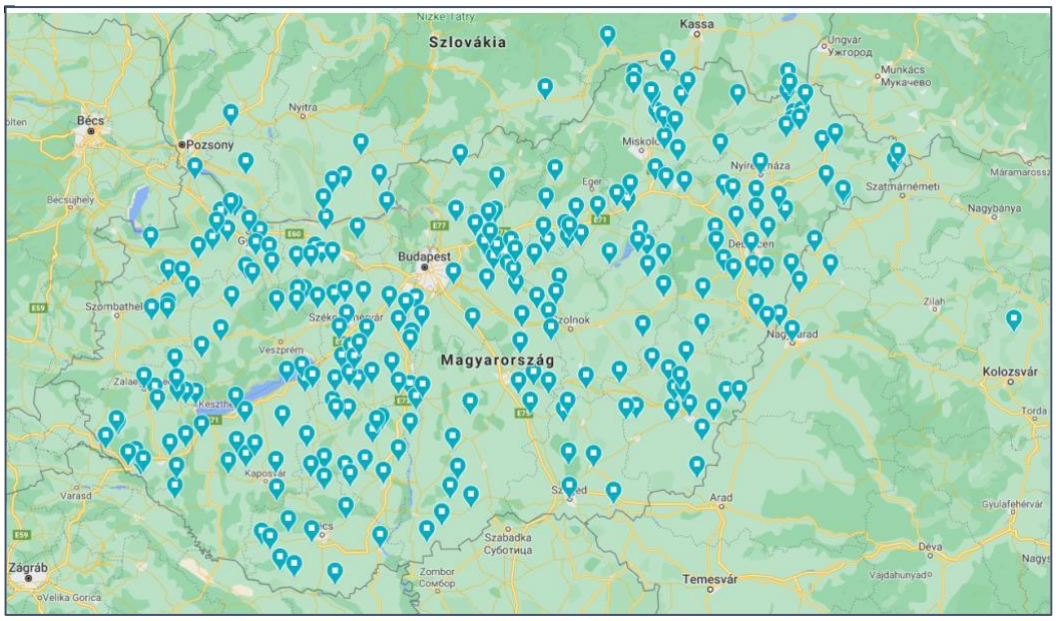


Figure 74 : listing os some grains storage in Hungary[17]

The next figure is performed by the same website that we used for other countries, “searates”. As we can see, this port data is not interesting and relevant for our report about Hungary.

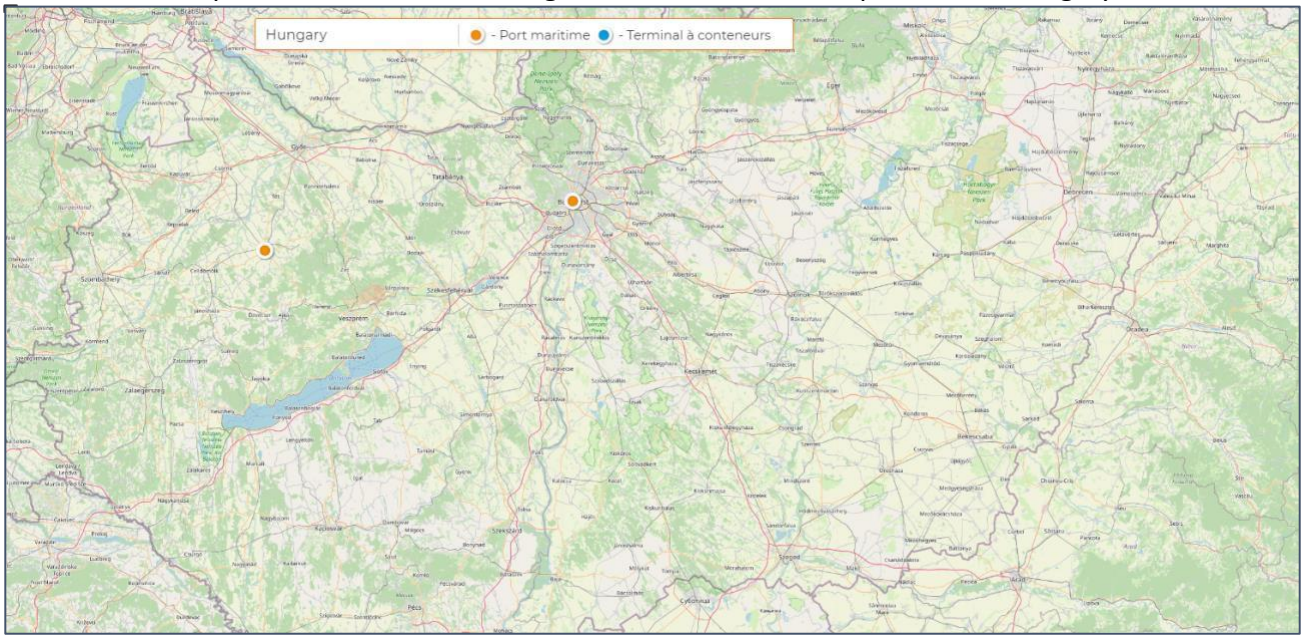


Figure 75 : List of Hungarian ports[18]

5) Potential users of the new solution

a) List of companies buying the product (appliers, users)

The potential users for new solutions are likely the same as the actors we described in the first place upper in this report.
However, a few sites, grain dryers, flat storages and silos are put up for sale in Hungary, with a market value of USD 400,000 to 25 million— depending on geographical location and capacities. The project with the value of 25 million US dollars is a port on the Danube with a capacity of 500,000 tons, fit for loading grain or other commodities to barges and rendering them navigable at the Constanta seaport. [19] So we may wonder if those investors could be somehow interested into actual solution but also new solutions.

6) Control means available (+ Boundary conditions)

a) Focus on insecticides used within the market for indoor, post-harvest grain treatment

Here, we put the active substances approved in Hungary according to EU data Base. These actives substances can be either used with pulverization or fumigation. The next table sums up all the active substances available in Hungary.

Table 81 : List of active substance used in grain stored protection in Europe

Active substance	Date of approval	End of approval
Deltamethrin (IN)	01/11/03	31/10/21
Cypermethrin (AC, IN)	01/03/06	31/10/21
Pirimiphos-methyl (IN)	01/10/07	31/07/22
Pyrethrins (IN)	01/09/09	31/08/22
Aluminium phosphide (IN)	01/09/09	31/08/22
Magnesium phosphide (IN)	01/09/09	31/08/22
Spinosad (IN)	01/02/07	30/04/22

We can notice that sulfuryl fluoride or diatomaceous earth are not authorized in the country compared with France for example.

b) Fumigation and powder formulation

The Table 82 below contains all the insecticide solutions that could be used in a curative way in Hungary by fumigation. This list is available on the Ministry website.

Table 82 : List of insecticides (« synthetic chemistry ») authorized in Hungary to treat stored grains and the premises of storage – used with fumigation system

Actellic 50 EC	Pirimifosz-metil	alapengedély	rovarölő szer	2024.09.30	✓
Degesch Magtoxin	Magnézium foszfid	alapengedély	rovarölő szer, atk…	2022.12.31	✓
Degesch Phostoxin tabletta, …	Aluminium-foszfid	alapengedély	rovarölő szer, atk…	2022.12.31	✓
Degesch Plates, strip gázosí…	Magnézium foszfid	alapengedély	rovarölő szer, atk…	2022.12.31	✓
Detia Gas Ex-B	Aluminium-foszfid	alapengedély	rovarölő szer, atk…	2022.12.31	✓
Quickphos	Aluminium-foszfid	párhuzamos	atkaölő szer, gáz…	2022.12.31	✓
Quickphos	Aluminium-foszfid	alapengedély	gázosító szer, ro…	2022.12.31	✓

c) Alternative methods and possible solutions in the future [20]

The following table presents a short list (listed in the Table 83 below) with a product based on Spinosad. We don't have a lot of data about this part.

Table 83 : List of « alternative methods » authorized in Hungary to treat stored grains and the premises of storage

Product	Manufacturer	Active substance	Concentration	Formulation type	*(1)*	*(2)*
Topgrain = Orgrain	Corteva Agriscience France SAS	**Spinosad**	24 g/L	Suspension concentrate (insecticide)	41.6 mL/t – 1 appli	X

**1: is referred to the same legend than for France*

In terms of alternative methods (not based on chemical ingredients), there are a few ideas which needs to be improved to fit with the logistics field : GRAIN AERATION, REFRIGERATED STORAGE, MODIFIED ATMOSPHERE TECHNOLOGY, HERMETIC STORAGE, for example.

d) Boundary conditions = specific limitations & restrictions [20]

The Table 84 presents all the various banned substances in Hungary for the treatment of stored grains. Some have already been disapproved, others are to be currently re-examined due to hazardous toxicology.

Table 84 : List of insecticides banned in Hungary to treat stored grains and the premises of storage

Emperor	Klórpirifosz-metil	származtatott	rovarölő szer	2019.01.31	
GrainPrevent	Deltametrin	származtatott	rovarölő szer	2023.10.31	
Granprotec	Deltametrin	alapengedély	rovarölő szer	2023.10.31	
K-Obiol	Deltametrin	alapengedély	rovarölő szer	2022.10.31	
Magnaphos	Magnézium foszfid	alapengedély	rovarölő szer, atk…	2010.03.31	
Megatox 22 EC	Klórpirifosz-metil	származtatott	rovarölő szer	2019.01.31	
Megatox 40 EC	Klórpirifosz-metil	származtatott	rovarölő szer	2011.12.31	
Pyrinex M22	Klórpirifosz-metil	származtatott	rovarölő szer	2019.01.31	
Reldan 22 EC	Klórpirifosz-metil	alapengedély	rovarölő szer	2023.01.31	
Reldan 40 EC	Klórpirifosz-metil	alapengedély	rovarölő szer	2007.05.28	
Reldan 40 EC	Klórpirifosz-metil	alapengedély	rovarölő szer	2011.12.31	

Products based on diatomaceous earth are not authorized.

ROMANIA

ROMANIA

Introduction

Romania takes 9% of European planted area and 5% of the harvested production [21].

Since 1889, cooperatives are settled in Romania and take place as a member of the International Alliance of Cooperatives. The country is very thankful to its cooperative structures because the agriculture economic evolution reached the upper limit determined before 1989.
After the revolution, the cooperatives were not maintained by local investments. The economy was not meant to prevent agriculture from this time of trouble. The change came in 2004 with Law 566. That is why the Romanian cooperatives are very young in comparison to the other European cooperatives, which have been settled in the same process for decades.

To sum up, during the last 10 years, everything was made from scratch, and step by step, new principles were made to rebuild the system. To reach a new gold age of agriculture in Romania, impulsing actors of public and private services are necessary. [22]

Table 85 :Romania's relevant indicators concerning agriculture[23]

Indicators	Number
Share of Agriculture in the GDP	5%
CAP subsidies 2014/2020	18,9 Billions EUR (+38 %)
Share of Agriculture in the employment	25.6 %
Trade balance of Agriculture	(+) 3B€
Used Agricultural Land	12.5 Mha
Arable Land	7.8 Mha

Romania is ranking 6th country in Europe considering its Utilised Agricultural Land with approximately 13 billion ha. The cereal production represents 40% of those lands. Moreover, 80% of this cereal production remains wheat and maize. The cultivated lands in wheat, barley, maize stays at the same level since 2010. In the other hand, rapeseed is slowly taking lands years after years, reaching 0,6 billion ha in 2017.[24]

The Table 86 contains all the basic data concerning Romania in 2019.
The document was made by the French government to compare both countries.

Table 86 : comparison of indicators between France and Romania[25]

Main data	Romania	France
Surface (km^2 – 2017)	238 390	549 087
People (Mhab 2017 & evolution 2017/16)	19.6 (-0.6%)	67.1 (+0.4%)
Human development index (2016)	0.802 (50th place in the world)	0.897 (21th place in the world)
PIB (MdEuros – 2017)	187	2 285
GDP growth rate (% annually -2017/16)	7.3	1.8
GDP / habitant (euros – 2017)	9 570	34 050
share of agriculture in PIB (% - 2017)	4.4	1.5
Arable land (Mha – 2015)	8.8	18.5
Forest land (Mha – 2015)	6.9	17.0
Trade balance all sectors (MdEuros -2017)	-4.1	-25
Agrifood trade balance (MdEuros -2017)	Exports: 6.4 Imports: 7.3 Balance: -0.9	Exports: 61.1 Imports: 55.4 Balance: +5.7
Agrifood exports (MdEuros – 2017)	Romania to France: 213	France to Romania:247

On the other hand, in Romania, farms benefits of an access to the transport infrastructure for raw materials: Constanta port at the East, Danube in the South and railways to EU [24]

1) Stored grains cereals general data

a) Volume of cereals produced

In the country, plains cover around 36% of the overall Romanian surface, whereas hills and plateau occupied 33%, and mountains, 31%.

"According to Koeppen's classification, Romania's climate is mostly cold type, with temperate climate in the south of the country and dry climate in the southeast. Winters are generally cold and cloudy, and summers are warm with frequent showers."

9.9 million ha is covered by arable land and permanent crops, permanent pasture is taking 4.9 million ha and forests is at 6.7 million ha. The main crops include maize, wheat, rye, barley, vegetables, sunflower, potatoes, sugar beet, soybeans, and fruit.[26]

The following table presents the production of each grain since 2017 in Romania. Moreover, the table presents the share of Romania in European agriculture.

Table 87: Cereals production in Romania for the last 5 marketing years

Cereals/Year (mT)	2017 /18	2018/19	2019/20	2020/21	2021/22
Type	*	*	*Estimate*	*Forecast*	*Projection*
Soft wheat	10 014	10 123	10 281	6 390	9 454
Durum wheat	21	21	17	20	23
Grain maize	14 326	18 664	17 432	10 844	16 191
Barley	1 907	1 871	1 880	1 121	1 841
Triticale	332	337	314	263	256
Oat	408	384	362	199	382
Rye	28	29	26	28	27
Sorghum	54	76	60	66	69
Other cereals	6	5	1	5	6
Total cereals	27 096	31 510	30 372	18 937	28 250
Total cereals EU-28	**307 959**	**292 357**	**322 532**	**n.a.**	**n.a.**
Total cereals EU-27	**284 960**	**271 272**	**297 015**	**280 365**	**295 108**
% RO / EU-27 prod	**9.5%**	**11.6%**	**10.2%**	**6.7%**	**9.6%**

**For all cereals: marketing year 1st July - 30th June, Eurostat* [3]

b) One big cereals producer

In 2018, Romania ranked third, after France and Germany, with a production of over 31 million tons, according to *Eurostat data*. Although, we can remark that Romania's production has nearly doubled for the last decade. It is one of the best improvements with France results. However, Romania harvested this year the greatest amount of corn and sunflower. The country ranked fourth for the harvest of wheat. Indeed, the wheat production reaches 10 million tons, and was increased by 1.3% in a year. All the production information is closely looked by the *National Institute of Statistics*. [27]

The Table 88 presents the main companies in the agricultural market, ranked by performance.

Table 88 - ranking of the largest certified agricultural producers[27]

Rank	Company (group)	CA 2018 (≈MEuros)	CA 2017 (≈MEuros)	Net profit 2018 (≈MEuros)	Net profit 2017 (≈MEuros)	Number of employees 2018	Number of employees 2017	General manager	Shar
1.	**AGRO-CHIRNOGI** www.agrochirnogi.ro	**N/A**	**880**	**N/A**	**4.7**	**N/A**	**548**	Dumitru Radut	Mar (Le
2.	**CEREALCOM DOLJ** www.cerealcom.com	**677**	**737**	**5.8**	**10.6**	**319**	**319**	Mihai Anghel	Mih (Rc
3.	**AGRICOST** www.agricost.ro	**375**	**359**	**80.3**	**73.3**	**791**	**834**	Lucian Buzdugan	AL (Uni Em
4.	**COMCEREAL Vrancea**	**142**	**144**	**4.6**	**4.7**	**226**	**231**	Gelu Scutaru	Gelu (Rc

As we explained before, Romania is a country with a lot of cooperatives who are concerned by the grains stored market. Thanks to the link below, it's possible to find a list of all of the cooperatives available on the national ministry website: *https://www.madr.ro/docs/agricultura/2020/cooperative/registrul-national-cooperativelor-agricole.xls*

But more specifically, some organizations related to the agricultural market take place inside the country. For instance, the OIPCOPD *(Interprofessional organization of cereal, oil, other products)* or the LAPAR *(Romanian organization of agricultural producer's league)*. Moreover, we should underline the presence of the UNPAR *(National Union of Romanian agricultural producers)* and the AFAR *(organization of the Romanian farmers)* [28].

To conclude this part, the cereal market is made of 7 000 companies and 40 000 employed persons. The main companies in this sector are property of external capital and are really into trading. More recently, the French government did a review of all the trading cooperatives. Those companies are also the place of storage.

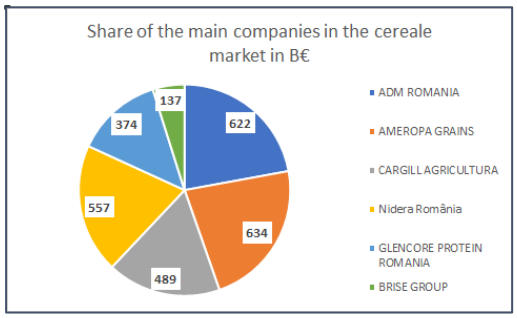
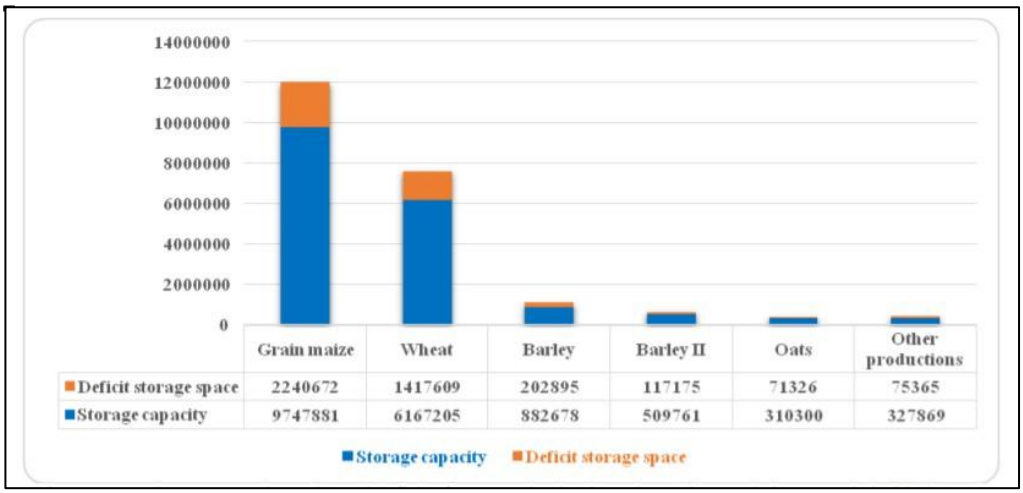


Figure 76 : Distribution of the main companies in the Romanian cereal market in B€ [24]

c) Volume of stored grains cereals

The storage capacity is essential in order to hold the role of a major player in the market. Holders of deposits impose a price. Indeed, they impose a purchase price of products from small and medium agricultural producers, and later they transact at higher prices. [29]



	Grain maize	Wheat	Barley	Barley II	Oats	Other productions
Deficit storage space	2240672	1417609	202895	117175	71326	75365
Storage capacity	9747881	6167205	882678	509761	310300	327869

Figure 77 : The storage capacity and the deficit of storage in 2014 for each type of grain in Romania [29]

That is why, the production is combined with a great storage service. Indeed, in Romania, the storage capacity is over 23 000 Mt whereas in 2020, 14 365 Mt were stored. This difference really represents the country's goal to improve its agricultural sector, and so its stored and trade system.[4]

d) Volume of treated stored grains cereals

Unfortunately, this data is missing because depending on different parameters.

e) Storage sites + How are stored the grains (on-farm, off-farm, export shipments)

Romania has got a strong advantage in comparison with all its surrounding neighbors: the Constanta Port. This port is the main gate for not only grains and oilseeds originated in Romania, but also in Bulgaria, Hungary, and Serbia. Moreover, storage capacity in Constanta Port is continuously expanding. The current grain storage capacity is estimated at 1– 1.5 MT, but in the context of positive prospects for agricultural commodities in Romania and the region, several international grain players plan to develop new capacities or upgrade existing ones.[30]

The Figure 78 present the storage capacity of each European countries (already seen in the report).

As we seen, Romania is sharing the best places with its 23 Mt of capacity. It remained with the countries between 20 and 40 Mt such as Hungary, Poland or Spain for instance.

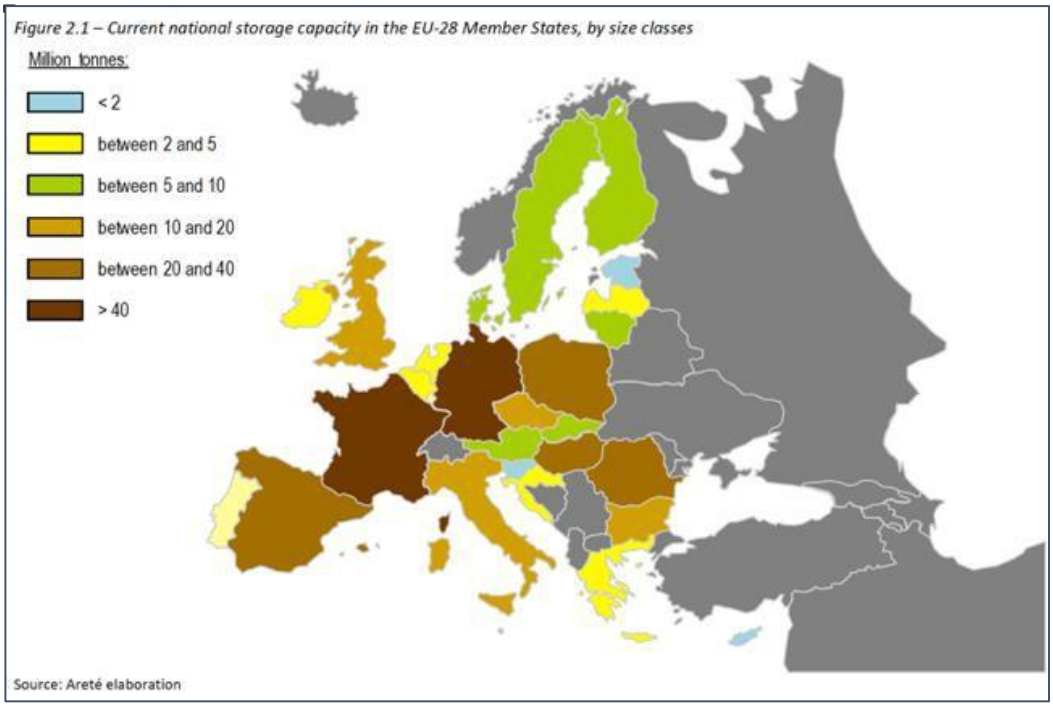


Figure 78 : Current national storage capacity in the EU-28 Member States, by size classes[4]

Romania is part of the top country with great storage capacity. In this group, we also find Spain and Estonia or even Hungary. The best countries in terms of storage capacity are Greece, Bulgaria, Romania, Poland, Latvia, and Sweden.

According to the European report, 5 regions (NUTS2) stored a minimum of 2M, 1 region stored between 1.2M and 2M and 1 region stored between 600K and 1.2M. To sum up, Hungary stores at least 11.8M tons of grains in 2017 [4]. Nowadays, the storage capacity is even bigger and known as 23M.

The storage system is divided in 3 categories as we saw for the other countries. However, Hungary is mostly made of several small farms. Therefore, on the table below, we can remark that most of the storage is on-farm.

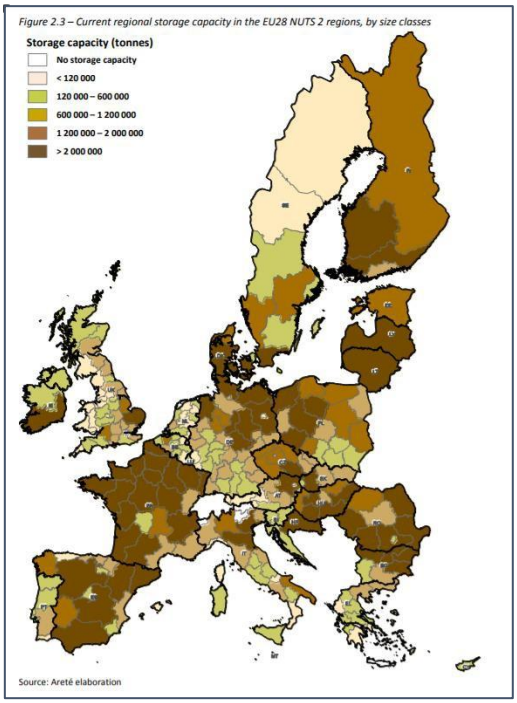


Figure 79 : Current regional storage capacity in the EU-28 NUTS2 region, by size classes[4]

Table 89 : Distribution of the total share in Romania according to different types of storage

Type of storage (2015 data)	Share in total storage (%)	Estimation of storage capacity
Individual farms = on-farm	40%	9.2 million tons
Farming cooperatives = off-farm	0%	0 million tons
Processing industries = off-farm	10%	2.3 million tons
Wholesale/trade = off farm	41%	9.43 million tons
Transportation hub (including ports)	9%	2.07 million tons
Storage capacity	**100%**	***23 million tons***

2) Focus on specific stored grains cereals: wheat, barley, oat, maize, rice

a) Estimated volumes of each stored grains variety

Romania stored 5 types of different grains: wheat, maize, barley, rice, oat.

- Maize is currently the first by far, ahead from wheat or barley.
- Rice and oat are tiny storage slots.

We may now consider what are the flows of each grain in the country process.

The estimation in the Table 90 is realized according to the average production of the last years and the average stored grain amount of the last years.

Table 90 : Estimation of the stored grain quantity in Romania

Type of Grain	Estimated Stored Quantity (kt)
Wheat	8228
Maize	13614
Barley	396,00
Rice	34
Oat	1526

b) Treatment used for each stored grain variety

This part is related to the 6) "Control means available".

c) Speed of grain rolling (incoming, stored, outgoing)

Due to its important agricultural land and farms, Romania has been a net surplus country in terms of COP production. That is to say the country is a massive exporter of COP. This point is well improved by Constanta port, a unique platform to embrace global market level.
Indeed, for instance the wheat market has been closely looked between 2007 and 2015.

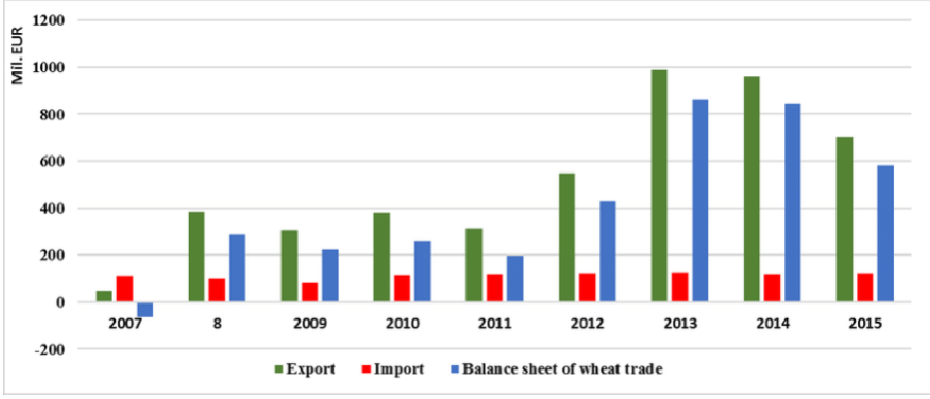


Figure 80 : Main market datas for wheat in Romania between 2007 and 2015[31]

If we take a look to all the market datas (even for Barley, Maize, and Wheat), Romania is clearly a net exporter for the COP considered. The Figure 81 presents all the data and focuses on the 2017 year.

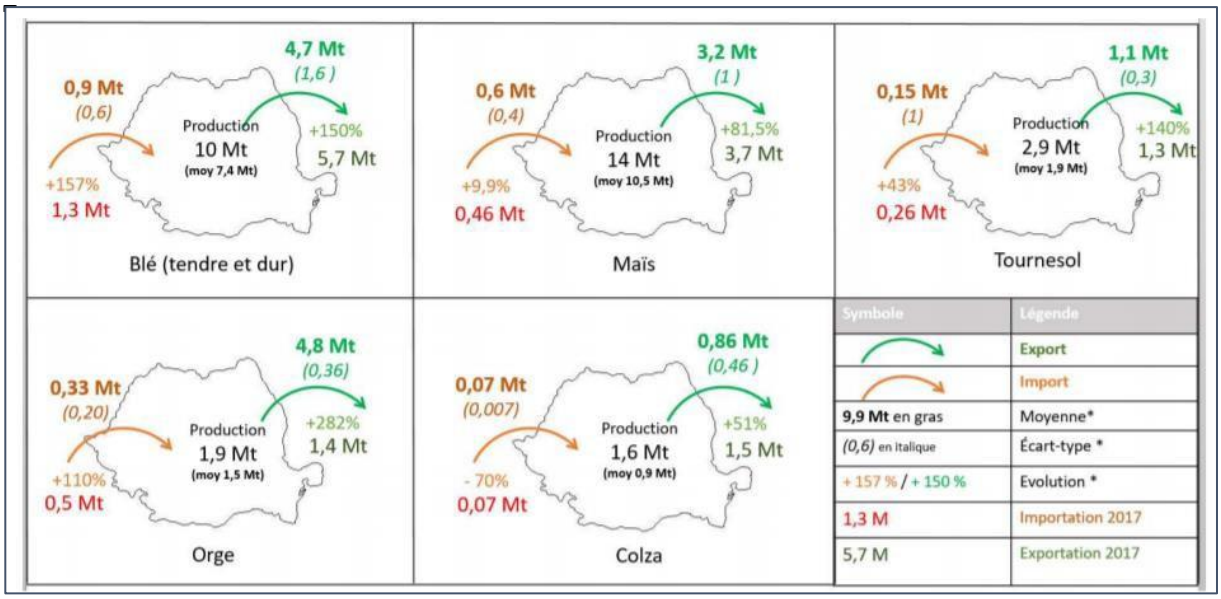


Figure 81 : Main market datas for COP in Romania between 2010 and 2017[24]

**Presentation of exportations & importations of 3 cereals & 2 oilseeds on the 2010-17 period. The production data is only for 2017*
**Calculation done between 2012 & 2017 for wheat, barley & calculation done between 2010 & 2017 for rapeseed, sunflower, corn*

The Table 91 regroups all of the flows concerning the grain sector in Romania. Excepting rice, the different grains are ranked in the same way that the storage ranking. Moreover, the country manages to only leave small amount of rice in the stored infrastructure each year. It might be cause by a difficulty to store this type of grain in Romania. Even the quantities are low, the rice seems to be a market opportunity.[32]

Table 91 : Flows for each type of grain in Romania[32]

Type of Grain	Incoming (kt)	Stored(kt)	Outgoing(kt)
Wheat	**10837**	**8228**	**3190**
Maize	**18313**	**13614**	**3511**
Barley	**2950**	**1030**	**1560**
Rice	**102**	**34**	**17**
Oat	**2272**	**1526**	**781**

3) Stored grains cereals invasive species

a) Occurrence & Percentage of damages

The species of interest are :

- *Sitophilus oryzae*
- *Sitophilus granaries*
- *Sitophilus zeamais*
- *Rhyzopertha dominica*
- *Oryzaephilus surinamensis*
- *Plodia interpunctella = Indian meal moth*

As Hungary datas are difficult to find, the Table 92 presents the statement concerning the occurrence of each species in the country. We settle our table with two sources.

As we can see, lots of occurrence are expected but difficult to prove by a scientific report. Nonetheless, *Sitophilus granarius* was record in the collection of the natural History Museum of London, UK. The specimen was directly related to Hungary.

Table 92 : Occurrence of each species in Romania according to internal knowledge and CABI (https://www.cabi.org/)

Species	Internal knowledge	CABI
Sitophilus oryzae	YES	N/A
Tribolium castaneum	YES	N/A
Cryptolestes spp.	YES	N/A
Oryzaephilus surinamensis	YES	Champ B R, Dyte C E, 1976. Report of the FAO global survey of pesticide susceptibility of stored grain pests. Rome, Italy: FAO. 308 pp.
Rhyzopertha dominica	YES	N/A
Sitophilus granarius	YES	NHM, 1950. Specimen record from the collection in the Natural History Museum (London, UK)., London, UK: Natural History Museum (London).
Mycetophages, Typhaea stercorea (hairy fungus beetle)	N/A	N/A
Tribolium confusum	N/A	N/A
Indian meal mooth	YES	CABI Data Mining, 2001. CAB Abstracts Data Mining.,

4) Storage on bigger scales

a) Types of storage facilities

There are several types of storage facilities, but Romania is concerned only by a small variety of those.

After introducing the distribution of all storage structures on the part 1)e), whether on-farm or off-farm, let's now focus on the type of storage in Romania.

Even if the data is quite difficult to find. We can now observe that the storage is distributed between storehouse and silos. The Figure 82 presents this kind of data but also this distribution regarding all the different storage region of Romania.

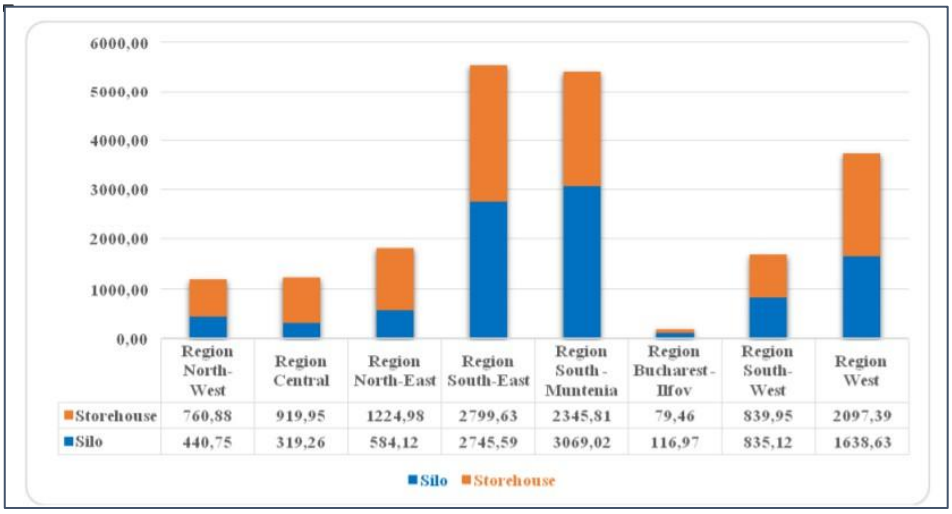


Figure 82 : Distribution of storage in the various region of Romania[29]

- **Transport and logistics in Romania**

Romania benefits from a market access with the Black Sea and so the Constanta Port. This port has seen its traffic increase by 15.4% between 2012 and 2017, ranking ahead from Calais or Dunkerque in terms of good exchanges. The Black Sea basin, mainly dominated by Russia or Ukraine, gives also access to the Mediterranean Sea or the Middle East market. Besides, the Ministry of Transport of Romania has been developing several projects to modernise infrastructures of internal transport (such as waterways, railways or roads) using the EU funds and national funds. Although, the Danube remains the biggest waterway axis and its investment and its accessibility will stay as number one in investments.[24]

The Figure 83 presents all the transport and logistic system of Romania.

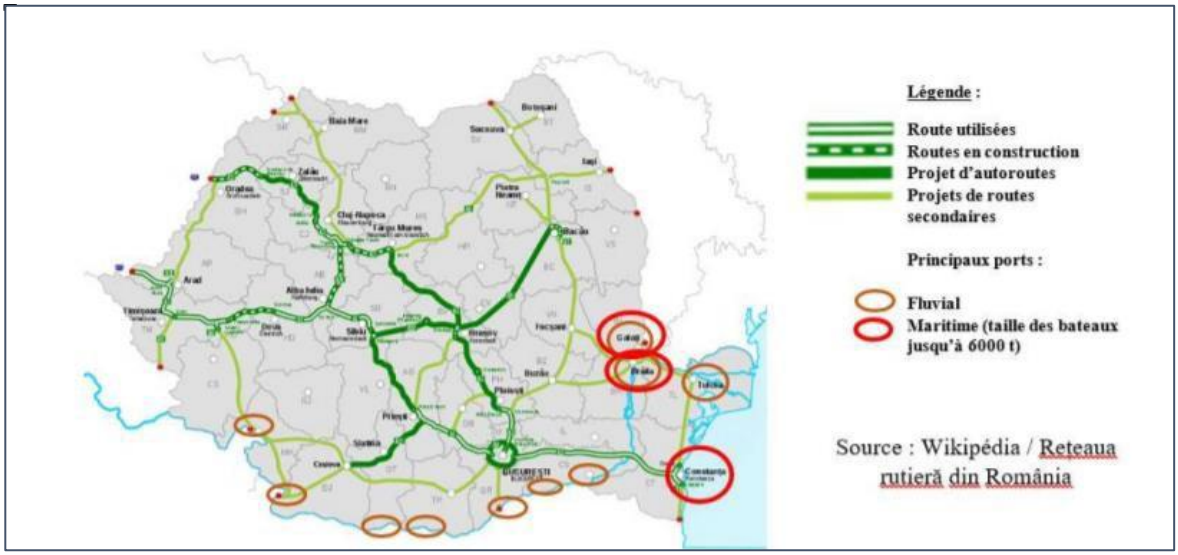


Figure 83 : Transport and logistic system in Hungary [11]

Romania is a waterway transport country. Danube is the internal way whereas ports are here to export or receive goods and raw materials. The country must propose a good logistic based on the water transport possibility. Moreover, because Romania is receiving all the neighbors' countries export and so the quality has to be at each step of the transport.

The Figure 84 sums up the different big numbers about waterway use in Romania.

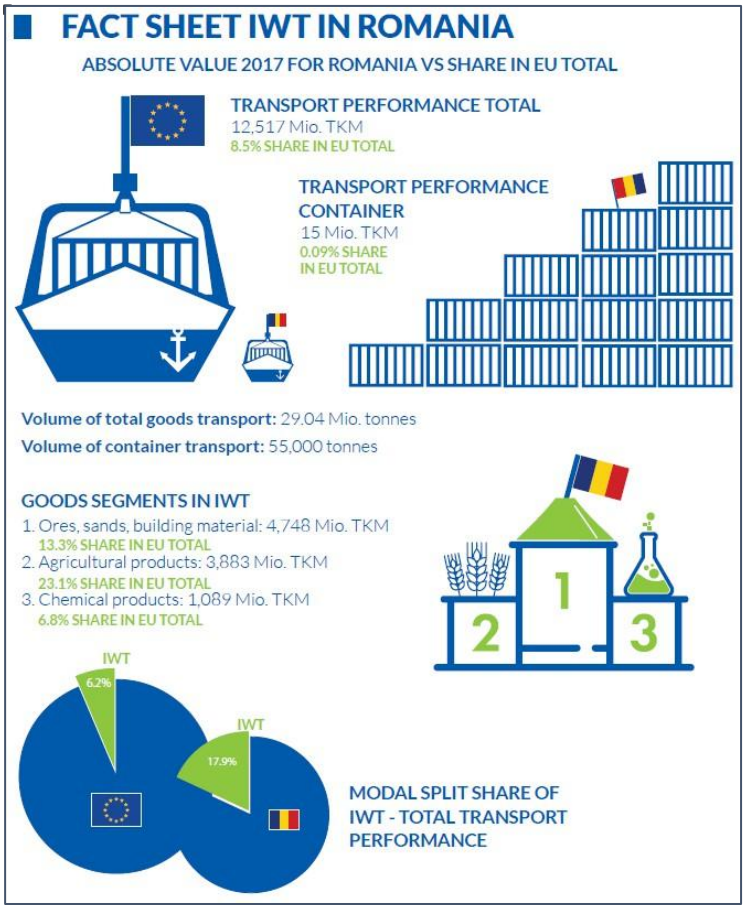


Figure 84 : Big numbers of the different use of waterways and ports in Romania[33]

We presented Constanta port as a unique transport hub system, designed to organize all the Eastern part of Europe. The Figure 86 explains how Constanta port maintained a constant increase of its exchanges and flows (traffic in million tons)

The port of Galati in comparison is presented in the Figure 85. Galati is the second port in Romania to export grain. (traffic in million tons)

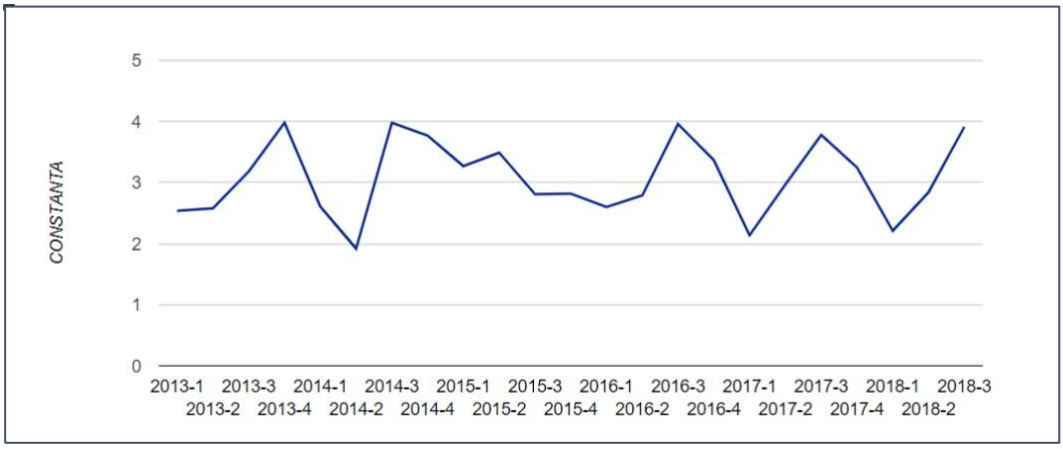


Figure 85 : Inland waterway traffic in the port of Constanta[33]

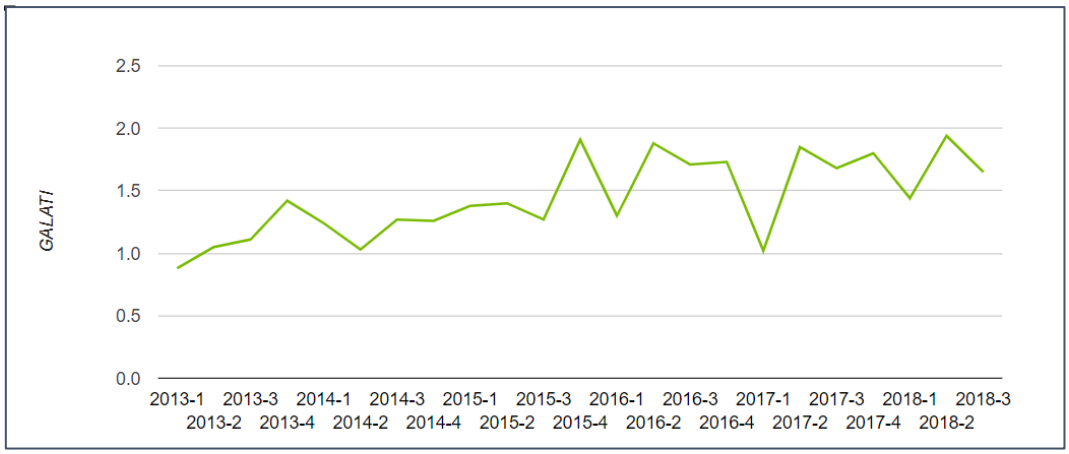


Figure 86 : Inland waterway traffic in the ports of Galati[33]

b) Biggest site of storage for the exported cereals

In this part we will show the details of the exports by the end of the 2010's. The study is on Romanian exports for wheat, oats, maize, barley whereas rice has been a missing data.

For instance, the Table 93 concerns wheat and contains all the number of exports by country from 2014 to 2016.

Table 93 : Romanian Wheat export by countries 2014-2016[30]

Romania Export Statistics - Wheat

Commodity: 1001, Wheat And Meslin

Year Ending June: 2014 - 2016, Year To Date: 07/15 - 11/15 & 07/16 - 11/16

Partner Country	Unit	Year			Year To Date		
		2014	2015	2016	07/15 - 11/15	07/16 - 11/16	%Change
World, of which	**T**	**5,005,970**	**4,875,842**	**4,719,757**	**1,810,815**	**3,832,909**	**111.67**
Egypt	T	1,947,958	1,489,812	1,258,183	540,562	411,431	-23.89
Jordan	T	140,596	654,708	771,969	276,042	285,144	3.3
Ethiopia	T	46,686	98,163	433,081	-	114,143	n/a
Spain	T	161,498	337,787	391,225	332,057	273,328	-17.69
Libya	T	409,289	247,605	258,852	11,000	180,593	1541.75
Djibouti	T	-	181,841	198,306	44,000	136,893	211.12
Italy	T	194,291	202,384	166,948	120,048	179,580	49.59
Sudan	T	-	195,750	157,083	-	136,873	n/a
Israel	T	88,115	163,027	152,387	8,972	37,858	321.96
Tunisia	T	240,244	174,675	113,996	62,566	81,673	30.54
Greece	T	110,358	87,943	110,148	62,349	92,387	48.18
Vietnam	T	49,437	105,488	62,613	62,613	838,201	1,239
Syria	T	209,224	27,500	57,934	-	-	n/a
Yemen	T	-	-	56,365	-	5,219	n/a
Thailand	T	-	-	55,650	46,060	-	(100)
Indonesia	T	-	54,497	55,000	-	70,655	n/a
France	T	22,212	28,602	46,413	33,189	87,629	164
Nigeria	T	22,000	27,403	45,469	-	44	n/a
United Kingdom	T	30,267	22,089	44,904	37,607	5,029	(87)
Netherlands	T	22,312	55,302	39,316	39,105	92,521	137
United Arab Emirates	T	-	-	35,772	35,772	175,726	391
Algeria	T	-	-	31,500	31,500	-	(100)
Korea, South	T	607,910	80,533	26,250	-	73,251	n/a
Others	T	703,577	640,734	150,393	67,373	554,735	723

Romania is climbing in the hierarchy of EU wheat exporters. The export pace after the harvesting was very brisk, stimulated by the gap left in the market by the traditional EU wheat exporters, such as France, which harvested a drastically lower wheat quantity [30]

Table 94 : Romanian exports (outside of the EU). [13]

EXPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice
2017/2018	EGYPT :1.06M	LYBIA : 21.3K	SAUDIARABIA:788.4K	TURKEY : 413.4 K	TURKEY : 413.4K	Data unavailable
	JORDAN: 761.9k	MOLDOVA : 127.0	IRAN : 186.4	LEBANON : 257.9K	LEBANON : 257.9K	
	LYBIA : 321.9k	USA : 2.9	LYBIA :88.2K	IRAN: 231.8K	IRAN : 232.8K	
	SUDAN: 290.6k	NORWAY : 0.48	JORDAN : 51K	NEW ZEALAND: 102.6K	NEWZEALAND : 102.6K	
	ETHIOPIA:278.6k	CANADA : 0.44	TURKEY : 36.3K	LYBIA : 31.2K	LYBIA : 31.2K	
Total	**3.93M**	**21.46K**	**1.23M**	**1.14M**	**1.14M**	
2018/2019	EGYPT :1.3M	LEBANON:10.9K	SAUDIARABIA : 718.3K	TURKEY:883.2K	TURKEY : 883.2K	
	JORDAN: 641.5k	TURKEY : 5.4K	TUNISIA:101.5K	LEBANON:380.4K	LEBANON: 380.4K	
	ISRAEL: 290.4K	MOLDOVA:297.2	LYBIA : 63.8K	EGYPT : 296.9K	EGYPT : 296.9K	
	SUDAN: 317.2k	SERBIA : 85.4	KUWAIT : 37.3K	IRAN : 203.7K	LYBIA : 187.5K	
	ETHIOPIA : 314.6k	JORDAN: 79.4	LEBANON : 22.0K	LYBIA : 187.5K	IRAN : 203.7K	
Total	**3.68M**	**16.82K**	**973.87K**	**2.67M**	**2.67M**	
2019/2020	EGYPT :1.25M	TURKEY : 9.88k	SAUDI ARABIA: 509.5K	TURKEY : 995.72K	TURKEY : 995.72K	
	JORDAN:682.69k	UK: 157.18	LYBIA :200.24K	EGYPT : 837.22K	EGYPT : 837.22K	
	PHILIPPINES:623.7K	MOLDOVA:109.3	TUNISIA:134.0K	KOREA : 387.8K	KOREA : 387.8K	
	SUDAN: 317.19k	USA : 5.92	TURKEY : 82.05K	ISRAEL : 294.4K	ISREAL : 294.4K	
	THAILAND : 427.1k	CANADA : 5.7	JAPAN 75.5K	LEBANON:236.4K	LEBANON :236.43K	
Total	**5.39M**	**10.16K**	**1.21M**	**3.68M**	**3.68M**	
2020/2021	EGYPT : 252K	UK: 115.57	SAUDIARABIA : 504.8K	IRAN : 312.6K	IRAN : 312K	
	JORDAN: 605.63k	MOLDOVA: 83.4	TUNISIA :149.86	LEBANON: 188.4K	LEBANON:188.45K	
	ISRAEL : 241.7K	CANADA : 6.7	JORDAN : 129.5K	TURKEY : 159.6K	TURKEY:159.6K	
	LEBANON: 217.8k	USA : 6.3	LYBIA : 57.3K	KOREA : 111.2K	KOREA:111.2K	
	SUDAN : 165.66k	TANZANIA: 0.07	MOROCCO:36.6K	UK : 96.9K	UK : 96.9K	
Total	**2.12M**	**212**	**937.25K**	**1.49M**	**1.49M**	
Top countries	**EGYPT JORDAN ISRAEL**	**TURKEY MOLDOVA LYBIA**	**SAUDI ARABIA TUNISIA LYBIA**	**TURKEY LEBANON IRAN**	**TURKEY LEBANON IRAN**	

c) Several non-EU countries from where cereals come from(=import) [15]

In this part we will show the details of the imports by the end of the 2010's.

Table 95 : Romanian imports (outside of the EU). [13]

IMPORT	Common wheat	Durum wheat	Barley	Maize	Oat	Rice
2017/2018	MOLDOVA : 45.9K	MOLDOVA :0.14	UKRAINE : 16.8K	MOLDOVA : 36.17K	MOLDOVA : 2	Data unavailable
	SERBIA :1.02K	TURKEY : 9m	MOLDOVA :6.17K	SERBIA : 2.71K	X	
	TURKEY : 0.48	X	SERBIA : 3.94K	ARGENTINA : 624.92	X	
	JAPAN : 6.85m	X	X	UKRAINE : 489.47	X	
	X	X	X	USA : 311.85	X	
Total	**46.92K**	**0.15**	**26.9K**	**40.66K**	**2**	
2018/2019	MOLDOVA : 39.9K	TURKEY : 1.5	UKRAINE : 5.9K	MOLDOVA : 39.7K	X	
	SERBIA 17.8k	X	SERBIA : 3.6K	SERBIA : 4.1K	X	
	UKRAINE 258.0	X	MOLDOVA : 243.8	LIBYA : 2.7K	X	
	TURKEY : 4.1	X	X	TURKEY : 975.7	X	
	JAPAN: 4.11m	X	X	USA : 499.6	X	
Total	**58.01K**	**1.5**	**9.79K**	**48.68K**	**X**	
2019/2020	MOLDOVA : 18.1K	KAZAKHSTAN:28.1	UKRAINE : 20.6K	SERBIA : 64.7K	X	
	RUSSIA :3.3K	SAN MARINO:0.14	MOLDOVA : 2.6K	MOLDOVA : 36.8K	X	
	SERBIA : 372.1	SERBIA : 0.1	SERBIA : 1.7K	TURKEY : 900.0	X	
	UKRAINE 56.8	UK : 0.01	UK : 3.02	UKRAINE : 536.8	X	
	UK : 19.0	X	X	ARGENTINA : 465.9	X	
Total	**21.87K**	**28.33**	**24.99K**	**104.2K**	**X**	
2020/2021	SERBIA : 15.45K	X	SERBIA : 14.11K	SERBIA : 58.14K	X	
	MOLDOVA : 7.69K	X	UKRAINE : 3.02K	MOLDOVA : 2.65K	X	
	UK : 11.28	X	MOLDOVA : 1.77K	TURKEY : 1.36K	X	
	UKRAINE : 0.43	X	UK : 15.61	CHILE : 610.63	X	
	LEBANON : 0.34	X	X	ARGENTINA : 256.94	X	
Total	**23.15**	**X**	**18.92K**	**63.34K**	**X**	
Top countries	**MOLDOVA SERBIA UKRAINE**	**MOLDOVA TURKEY KAZAKHSTAN**	**UKRAINE MOLDOVA SERBIA**	**MOLDOVA SERBIA TURKEY**	**MOLDOVA**	

d) Industry mapping in grains storage

The Romanian storage industry mapping is a really difficult data to find.

The following figures presents the different waterways storage structures.

Figure 87 : waterways storage in Romania[33]

The Figure 88Figure 88 : List of storage deposit on waterways (searates) is taken out from the same website we used for other countries, “searates”. As we can see, this port data well deserves the waterway traffic situation we described.

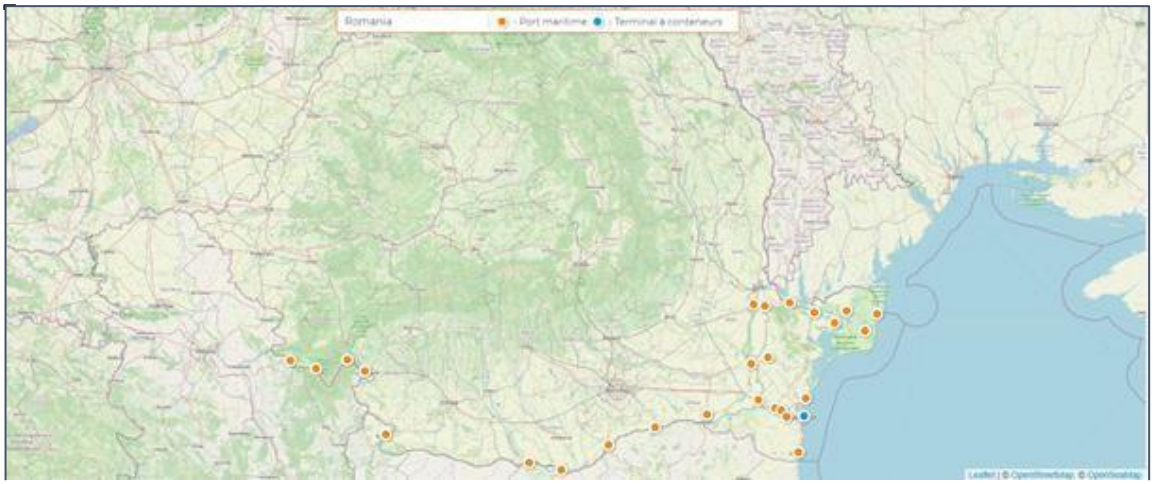


Figure 88 : List of storage deposit on waterways (searates)

Even if the storage sites data is not currently available, the number of cooperative systems (made of farmers) for each region is available in the Figure 89.

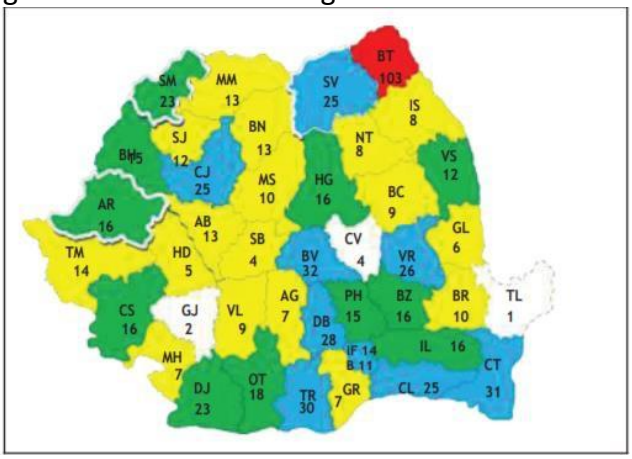


Figure 89 : Distribution of cooperatives in Romania (number by region) [22]

5) Potential users of the new solution

The list of the Romanian actors was detailed in the first map with the list of all the cooperatives of the country (Figure 76)

6) Control means available (+ Boundary conditions)

a) Focus on insecticides used within the market for indoor, post-harvest grain treatment

The active substances approved in Romania according to EU data Base are presented below.

Table 96: List of active substances used in grains stored protection in Romania

Active substance	*Date of approval*	*End of approval*
Deltamethrin (IN)	01/11/03	31/10/21
Cypermethrin (AC, IN)	01/03/06	31/10/21
Pirimiphos-methyl (IN)	01/10/07	31/07/22
Pyrethrins (IN)	01/09/09	31/08/22
Aluminium phosphide (IN)	01/09/09	31/08/22
Magnesium phosphide (IN)	01/09/09	31/08/22
Spinosad (IN)	01/02/07	30/04/22

We can notice that sulfuryl fluoride or diatomaceous earth are not authorized in the country compared with France.

b) Focus on fumigation and powder formulation

There is no existing public basis for Romanian fumigation products to use to treat the grain. Only one report of the recent reunion for approval can be found. But two points have to be noticed. First the government recommends a first preventive treatment of the deposit.

Table 97 : Some products used for fumigation in Romania

Products
ACTELLIC 50 EC-1% (50-100 ml sol./mp)
K'OBIOL 25 EC - 50 ml / 5 l of water for 100 m2 of storage space
K'OBIOL 25 EC –100ml / 99 l of water for 100 t of cereals
RELDAN 22 EC - 22 ml / t (in 0,75-1,5 l of water / t).

This treatment is used to prevent the contamination of the second arrival grain lot. It is a way to prepare and to secure each grain which pass through Romania.

Secondly, Romania has the same banned substances than Hungary, we may say that Romanian storers can use the same products to fumigate the grain than Hungarian storers.

c) Alternative methods and possible solutions in the future

The following table presents a short list (listed in the Table 98 below) with a product based on Spinosad. We don't have a lot of data about this part.

Table 98 : List of "alternative methods" authorized in Romania to treat stored grains and the premises of storage

Product	Manufacturer	Active substance	Concentration	Formulation type	*(1)*	*(2)*
Topgrain = Orgrain	Corteva Agriscience France SAS	**Spinosad**	24 g/L	Suspension concentrate (insecticide)	41.6 mL/t – 1 appli	X

**1: is referred to the same legend than for France*

Many alternative methods are considered in this developing country, but the efficiency regarding all the field factors is not confirmed: GRAIN AERATION, REFRIGERATED STORAGE, MODIFIED ATMOSPHERE TECHNOLOGY, HERMETIC STORAGE

d) Boundary conditions = specific limitations & restrictions

Products based on diatomaceous earth are not authorized.

Updates 2024

1° Storage analysis

In this topic it's important to understand also that the type of storage could have an impact on the insect's infestation.

Wheat (Triticum aestivum) is the most essential cereal crop grown all over the world, which is also an important source of human nutrition. Grain moisture, humidity and temperature are the major factors affecting the ecosystem of the stored wheat (Sorour and Uchino, 2004). These factors affect the quality of the stored wheat by inducing the growth of the microbes, insects and molds (Nithya et al., 2011). Insect infestation causes severe damage in the form of cracks and holes in grains, which can cause half of wheat loss during storage period (Fornal et al., 2007). The general estimate of loss is around 30 % of harvested grains.

Insect-infestation: Mean squares showed significant differences in insect-infestation under the effect of storage methods, storage durations and interaction of storage methods × storage duration (Table 1). Insect infestation indicated an increasing trend throughout the experiment, whereas the highest value with 18.2% was noted at the end of storage period (Table 2). The highest insect-infestation (12.4%) was observed with the grains, kept in stored room, followed by metallic bin (8.6%), earthen bin (6.6%) and then concrete block bin (5.4%) as shown in Table 2. The highest insect-infestation percentage in room storage may be because of high temperature and moisture conditions.

Not many new data are available on storage types, their age and condition and their uses. Novel storage types appear (for example boxing), still one can assume that the majority of the current storages, silos have been built after WW2 and are still in use. Very least data are available on empty silo, storage treatment.

2° Update of the storage capacity for the targeted countries

Note EU commission Study on storage capacities and logistical infrastructure for EU agricultural commodities trade (with a special focus on cereals, the oilseed complex and protein crops (COP)) - Publications Office of the EU (europa.eu)

The study provides an overview and mapping of the storage capacity and logistical infrastructure for cereals, the oilseed complex and protein crops (COP) in the EU, identifies the related bottlenecks, and analyses their evolution since 2005.

The current storage capacity for COP in the EU28 amounts to 359 million tonnes, up 20% from 2005. EU COP production increased by 11% in the same period. Structural shortage of COP storage capacity currently affects a limited number of Member States. Storage capacity has increased in all 28 MS, with substantial growth especially in Eastern EU Member States. Some key factors behind this evolution are specific to the COP supply chain, such as growth in yields, production and exports, and increased price volatility. The switch to just-in-time inventory management models by processors also played a role, especially in the United Kingdom and Germany.

Inland waterways and railways handle almost all long-distance COP tonnage (60-70% for inland waterways, 30-40% for railways) along the four main COP transportation corridors (Baltic-Adriatic, North Sea-Baltic, Rhine-Alpine and Rhine-Danube); truck transportation prevails in short-distance moves.

Even with deep research we didn't find any update of the storage capacities but detailed production for some of the targeted countries

Member states	*TOTAL GRAIN PRODUCTION (IGC)*	*FOR YEAR*	*PREVIOUS YEAR*	
FRANCE	*57,6 M tonnes*	*2020-21*	*71 M tonnes*	*Focus on France | World Grain (world-grain.com)*
GERMANY	*45,7 M tonnes*	*2019-20*	*37,9 M tonnes*	*Focus on Germany | World Grain (world-grain.com)*
ITALY	*14,5 M tonnes*	*2021-22*	*14,9 M tonnes*	*Focus on Italy | World Grain (world-grain.com)*
ROMANIA	*20,2 M tonnes*	*2022-23*	*27,2 M tonnes*	*Focus on Romania | World Grain (world-grain.com)*

3° Competitor analysis

Before the competitor analysis, it's interesting to check all the solutions which are tested as potential alternative products. The here below table contains a number of AI it could be interesting to follow and analyse as potential competitor in the future.

Table 1 Information on terpenoids with insecticidal activity.

Molecular name	Source of natural plants	Insect-resistant species and activity	Pharmacological potential	References
Linalool	*Cinnamomum camphora*, *Zanthoxylum planispinum*	The LC_{50} value for *Tribolium castaneum* (Herbst) is 2.5×10^4 ppm; The LC_{50} values for each species were: *Zabrotes subfasciatus*-429.3 ug/cm^2; *Acanthoscelides obtectus*-412.1 ug/cm^2; *Rhyzopertha dominica*-430.2 ug/cm^2; Sitophilus oryzae – 426.7 ug/cm^2	anti-inflammatory, anticancer, antihyperlipidemic, antimicrobial, etc.	(Pereira et al., 2018, Wang et al., 2019)
L-carvone	*Anethum graveolens* L.	It completely suppressed egg hatching at the concentration of 7.72 mg/cm^2 and above.	Antitumor, anesthetic	(Du et al., 2011, Patel and Thakkar 2014, Brosnan et al., 2022)
D-limonene	*Citrus reticulata Blanco*, *Amomum tsaoko*, *Zanthoxylum armatum*	It exhibited contact toxicity against *S. zeamais* and *T. castaneum* adults, with LD_{50} (lethal dose, 50 %) values of 29.86 μg/adult and 20.14 μg/adult, and showed fumigant toxicity with LD_{50} values of 33.71 mg/L and 21.24 mg/L	Anticancer, antioxidant, antidiabetic, anti-inflammatory, cardioprotective, etc	(Du et al., 2011, Anandakumar et al., 2021, Chebet et al., 2021)
Ascaridole	*Chenopodium ambrosioides L.*	It showed strong fumigant toxicity against *S. zeamais* adults with the LC_{50} values of 0.84 mg/L air and exhibited contact toxicity with the LD_{50} values of 0.86 μg g – 1 body weight	Sedative hypnotic effect	(Chu et al., 2011, Dougnon and Ito 2021)
Sabinene	*Zingiber purpureum*	It exhibited contact toxicity against L. serricorne with LD_{50} values of 15.7 μg per adult and showed fumigant toxicity against *T. castaneum* with LD_{50} values of 18.2 mg/liter of air	Flavorings, flavor additives, fine chemicals, and advanced biofuels	(Wang et al., 2015, Cao et al., 2018)
Terpinen-4-ol	*Melaleuca alternifolia*, *Zanthoxylum planispinum*	It showed the strongest contact toxicity against *T. castaneum* and *L. serricorne* (LD_{50} = 19.7 and 5.4 μg per adult, respectively) and also the strongest fumigant toxicity against *T. castaneum* and *L. serricorne* (LC_{50} = 3.7 and 1.3 mg/liter of air, respectively)	Antimicrobial, anti-arthritic, anti-cancer	(Wang et al., 2019, Liao et al., 2020, Aslam et al., 2022)
Piperitone	*Zanthoxylum armatum*, *Clinopodium chinense*	It gave 90 % mortality against *C. maculatus* after 24 h at a concentration of 6.7 μL/L and had LC_{50} values of 311.12 ug/liter against booklice	modulate cholesterol metabolism	(Li et al., 2015, Wang et al., 2015, Sut et al., 2021)
Trans-p-Mentha-1 (7),8-dien-2-ol	*Illicium pachyphyllum*	It exhibited contact toxicity against *S. zeamais* and *T. castaneum* adults, with LD_{50} values of 8.66 μg/adult and 13.66 μg/adult, and showed fumigant toxicity with LD_{50} values of 6.01 mg/L and 8.14 mg/L	_-	(Liu et al., 2012)
1,8-cineole	*Artemisia annua* L., *Morinda lucida*, *Zanthoxylum armatum*	It gave 100 % mortality in closed cups but no mortality in open ones	hypnotic-sedative and antipsychotic-like effects	(Tripathi et al., 2003, Owolabi et al., 2014, Sobreira Dantas Nóbrega de Figuèiredo et al., 2019)
α-pinene	*Callistemon citrinus*, *Artemisia mongolica*	It showed fumigant toxicity with LD_{50} values of 1.402 ppm and exhibited contact toxicity with LD_{50} values of 4.133 ppm	Antibacterial, antifungal, anti-leishmania, neuroprotective	(Geng et al., 2011, Allenspach and Steuer 2021)
β-caryophyllene	*Plectranthus zeylanicus*, *Clinopodium chinense*	It exhibited contact toxicity against *L. bostrychophila* with an LC_{50} value of 275.00 μg/cm^2	Anti-inflammatory and anti-metabolic disease	(S et al., 2017, Mantzoukas et al., 2020, Franco-Arroyo et al., 2022)
Fraxinellone	*Dictamnus dasycarpus*, *Fagaropsis glabra*, *Melia azedarach*	It possessed feeding deterrent activity against adults and larvae of *T. castaneum* as well as *S. zeamais* adults with EC_{50} values of 36.4, 29.1, and 71.2 ppm, respectively.	Alleviate kidney fibrosis and secondary brain damage.	(Liu et al., 2002, Guo et al., 2019, Lu et al., 2021, Zheng et al., 2021)

Table 1 (*continued*)

Molecular name	Source of natural plants	Insect-resistant species and activity	Pharmacological potential	References
Geraniol	*Cinnamomum tenuipilum, Valeriana officinalis*	The LD_{50} value for *C. maculatusis* is 0.7140 μL	neuroprotective effects as well as ameliorating influence in memory impairment; anti-diabetic	(Reis et al., 2016, Lei et al., 2019, El Azab and Mostafa 2022, Liu et al., 2022)
Citronellal	*Cymbopogon nardus*	The LD_{50} value for *C. maculatusis* is 2.261 μL	Antifungal; inhibit Staphylococcus aureus growth and enterotoxin production	(Reis et al., 2016, Zhang et al., 2022)
Eugenol	*Syringa oblata Lindl.*	The LD_{50} value for *C. maculatusis* is 0.9473 μL	antioxidant, anti-inflammatory, and antibacterial effects	(Reis et al., 2016, Zhao et al., 2022)
Bornyl acetate	*Clinopodium chinense*	It exhibited acute toxicity against *Liposcelis bostrychophila* with LC_{50} values of 321.42 μg/cm^2	anti-inflammatory, antioxidant activities	(Chen et al., 2014, Li et al., 2015)
Tagalsin A	*Ceriops tagal*	It exhibited strong feeding deterrent activity against *T. castaneum* adults with EC_{50} (50 % effective concentration) values of 375.3 ppm	_	(Lei et al., 2019)
Tagalsin B	*Ceriops tagal*	It exhibited strong feeding deterrent activity against *T. castaneum* adults with EC_{50} values of 277.3 ppm	_	(Lei et al., 2019)
Tagalsin H	*Ceriops tagal*	It exhibited strong feeding deterrent activity against *T. castaneum* adults with EC_{50} values of 285.45 ppm	_	(Lei et al., 2019)
17-hydroxyjolkinolide A	*Euphorbia fischeriana*	It exhibited feeding deterrent activity with EC_{50} values of 631.9 ppm for *S. zeamais* and 656.5 ppm for *T. castaneum adults.*	_	(Geng et al., 2011)
17-hydroxyjolkinolide B	*Euphorbia fischeriana*	It possessed strong feeding deterrent activities against *S. zeamais* and *T. castaneum* adults with EC_{50} of 543.9 and 551.5 ppm, respectively	Anticancer	(Wang et al., 2009, Geng et al., 2011)
Jolkinolide B	*Euphorbia fischeriana*	It possessed strong feeding deterrent activities against *S. zeamais* and *T. castaneum* adults with EC_{50} of 342.1 and 361.4 ppm, respectively	Anticancer, reduce renal fibrosis	(Geng et al., 2011, Li et al., 2022, Wang et al., 2022)
12-deoxyphorbol 13-(9*Z*)-octadecenoate 20-acetate	*Euphorbia fischeriana*	It exhibited feeding deterrent activity against the two-grain storage insects with EC_{50} values of 884.3 ppm for *S. zeamais* and 1058.4 ppm for *T. castaneum adults.*	_-	(Geng et al., 2011)
Azadirachtin	*Azadirachta indica A. Juss.*	The longer the treatment time, the lower the lethal concentration of azadirachtin to *Corcyra cephalonica*, and the difference between them was significant	antimalarial, and anticancer	(Tripathi et al., 2002, Zandi-Sohani et al., 2013, Fernandes et al., 2019)

Table 2 Information on alkaloids with insecticidal activity.

Molecular name	Source of natural plants	Insect-resistant species and activity	Pharmacological potential	References
Matrine	*Sophora flavescens*	The LD_{50} value for *Acyrthosiphon pisum* is 68.88 ng/aphid	anti-oxidative stress, anti-inflammation, and anti-apoptosis	(Ma et al., 2020, Yuan et al., 2022)
Dictamnine	*Dictamnus dasycarpus*	It had feeding deterrent activity against adults and larvae of *T. castaneum* as well as *S. zeamais* adults with EC_{50} values of 57.6, 47.9, and 91.7 ppm, respectively	anti-bacterial, anti-fungal, anti-cancer, and hepatoxicity	(Liu et al., 2002, Lin et al., 2021)
Schinifoline	*Zanthoxylum schinifolium*	Schinifoline has feeding deterrent activity against *T. castaneum* and *S. zeamais* adults with EC_{50} values of 47.8 and 85.6 ppm respectively	tubulin polymerization inhibitors, heterogeneous enzyme inhibitors, and antiplatelet agents	(Liu et al., 2009, Wang et al., 2014)
Skimmianine	*Zanthoxylum schinifolium*	Skimmianine possesses feeding deterrent activity against *T. castaneum* and *S. zeamais* adults with EC_{50} values of 75.7 and 129.7 ppm respectively	Antitumor, anti-inflammatory	(Liu et al., 2009, Ratheesh et al., 2013)
Erysopine	*Erythrina variegata*	It possessed antifeedant activity against *S. zeamais* adults with EC_{50} values of 108.5 ppm.	_	(Liu et al., 2012)
Erysovine	*Erythrina variegata*	It possessed antifeedant activity against *S. zeamais* adults with EC_{50} values of 89.7 ppm.	_	(Liu et al., 2012)
Sophocarpine	*Sophora alopecuroides*	the LD_{50} value for *Acyrthosiphon pisum* is 83.44 ng/aphid	anti-oxidation, anti-inflammation, anti-tumor, antivirus, and immune regulation	(Ma et al., 2020, Yang et al., 2021)
Chasmanine	*Aconitum episcopale*	It exhibited feeding deterrent activity against *T. castaneum* adults with EC_{50} values of 297.0 ppm	activating blood circulation and removing blood stasis.	(Liu et al., 2011, Yang et al., 2019)
Talatisamine	*Aconitum episcopale*	It exhibited feeding deterrent activity against *T. castaneum* adults, with EC_{50} values of 342.8 ppm	Antitumor; neuroprotection.	(Liu et al., 2011, Wang et al., 2012)
Karacoline	*Aconitum episcopale*	It exhibited feeding deterrent activity against *T. castaneum* adults with EC_{50} values of 395.3 ppm	analgesic effect	(Liu et al., 2011, Zhou et al., 2020)
Sachaconitine	*Aconitum episcopale*	It exhibited feeding deterrent activity against *T. castaneum* adults with EC_{50} values of 427.8 ppm	_	(Liu et al., 2011)
Crassicauline A	*Aconitum episcopale*	It possessed feeding deterrent activity against *T. castaneum* adults with EC_{50} values of 1134.5 ppm	_	(Liu et al., 2011)
Yunaconitine	*Aconitum episcopale*	It possessed feeding deterrent activity against *T. castaneum* adults, with EC_{50} values of 653.4 respectively.	Anti-inflammatory, analgesic, sedative, antipyretic, and antineoplastic effection	(Liu et al., 2011, Zhang et al., 2020)

Table 3 Information on organic acids with insecticidal activity.

Moleculer	Source of natural plants	Insect-resistant species and activity	Pharmacological potential	References
Lauric acid	*Cocos nucifera* L.; *Litsea cubeba*	It showed a mortality rate of 4.32 % against *Sitophilus granarius*	Antibacterial	(Abay et al., 2013, Zhang et al., 2017)
Myristic acid	*Myristica fragrans*	Myristic acid showed a mortality rate of 53.34 % against *Sitophilus granarius*	reduces skin inflammation and nociception; antibacterial	(Abay et al., 2013, Alonso-Castro et al., 2022)
Palmitic acids	*Trachycarpus fortunei*	It showed a mortality rate of 17.75 % against *Sitophilus granarius*	Anti-Inflammatory	(Abay et al., 2013, de Souza et al., 2018)
α- costic acid	*Dittrichia viscosa* (L.)	The calculated dose of α-costic acid was 3.40 μg/adult in contact toxicity assay	Acaricidal activity	(Rotundo et al., 2019)
γ- costic acid	*Dittrichia viscosa* (L.)	The calculated dose ofγ- costic acid was 9.57 μg/adult in the contact toxicity assay	_	(Rotundo et al., 2019)

Table 4 Leading compounds of natural products with anti-insect activity and their derivatives.

The name of the natural compound	The structural formula of new insect-resistant compounds	Structure-activity relationship	Characteristics and mechanism of insect resistance	references
Fraxinellone	Fraxinellone-1 Fraxinellone-2	when R was alkyl groups, the long length of the alkyl chain could decrease the growth inhibitory activity	They affected the development, ecdysis, and emergence of pests	(Guo et al., 2019)
	Fraxinellone-3 Fraxinellone-4 Fraxinellone-5 Fraxinellone-6	Derivatives obtained by introducing the C-4 carbonyl or oxime substituent are more effective than those bearing a C-10	They showed growth inhibitory activity against pests and affected the insect molting hormone	(Li et al., 2016)
Podophyllotoxin	Podophyllotoxin −1 Podophyllotoxin-2 Podophyllotoxin-3	The introduction of the chlorine atom at the C-2′ or C-2′,6′ position on the E-ring of picropodophyllotoxin and oxime sulfonate derivatives of picropodophyllotoxin was essential for the insecticidal activity.	The podophyllotoxin derivatives showed insecticidal activity equal to, or higher than, that of the positive control toosendanin and exhibited the anti-molting hormone effect	(Wang et al., 2015)
Piperine	Piperine-1 Piperine-2 Piperine-3	The introduction of the substituents at the C-2 position on the phenyl ring of the hydrazone derivatives afforded the potent compounds.	They exhibited the anti-molting hormone effect	(Qu et al., 2013)
Eugenol	Eugenol-1 Eugenol-2	—	Trigger a process of programmed cell death	(Fernandes et al., 2020)
Mimosine	Mimosine-1 Mimosine-2	The length of the alkyl groups and the functional substituents at the C-5 position of phosphoramidothionates derived from mimosinol are important for their insecticidal activities	Acetylcholinesterase inhibitory activity	(Nguyen et al., 2015)
Osthole	Osthole-1 Osthole-2 Osthole-3 Osthole-4	The conversion of the carbonyl group into a thiocarbonyl group does not improve its insecticidal activity, and the introduction of electron-withdrawing groups on the phenyl ring of intermediate afford more potent derivatives.	Growth inhibitory activity	(Guo et al., 2020)

Next to these potentials the most common AI and their potential pressure of renewal at EU level.

ACTIVE INGREDIENT	SOME TRADE NAMES	EU Durability	COMMENTS	REF infos
Deltamethrin	Deltagrain	OK		Deltagrain CE 25 PB | Envu France
Deltamethrin	Kobiol	OK		https://www.fr.envu.com/grains-stockes/produits/k-obiol-ce-25-pb
AlPH3	Quickphos	OK		https://www.upl-ltd.com/ma/produit-d%C3%A9tails/quickphos
MgPH3	Degesh	OK		https://www.upl-ltd.com/ma/produit-d%C3%A9tails/quickphos
Sulfuryldifluoride	Profume	Difficult	effect on the ozone layer Effluents need to be treated	https://profume.com/
Pirimyphos-methyl	Actellic	??		Actellic® 50 EC - Produit professionnel | Syngenta
Spinosad	Topgrain	OK		https://www.agrodistribution.fr/actualites/article/814506/topgrain-nou
Na2CO3	Procrop	OK		https://edialux.fr/solutions-anti-insectes-professionnelles/9729-6402-p
NAT Pyrethrum	Nebulous Turbo	OK		
NAT Pyrethrum	Dedevap green	OK		https://www.be.envu.com/plaagdierbeheersing/produits/dedevap-plus
Cypermethrin	Talisma	OK		https://www.upl-ltd.com/uk/product-details/talisma-ec

Since 2018 there has been a net loss of 53 active substances, notwithstanding 30 approvals, equates to a real loss of 95 active substances in the last 4 years and 118 since 2011. The main reduction of active substances is not only due to a falling-off of chemicals (95) but also a significant decay of BCA (19) impacting crop protection with an important reduction of the herbicides and a small increase of fungicides with a high replacement rate, with all crops being impacted, while the residue situation has greatly improved.

BCA the abbreviation of Biocontrol agents in the EU S-methoprene is not considered as falling within the biocontrol agent category, while for example in the USA, it does.

Although the number of AS has decreased since 2011, however the number of BCAs have increased.

For us the importance lies with post harvest grain protectors, where however no significant change has occurred. Most of the used ASs should be under review and re-approved, but due to the overload of authorities the Commission has postponed the re approval procedure. Today it is very hard to tell or even forecast which AS or gas might fail under the procedure.

There is no doubt that the market leaders of post-harvest grain protection are:

- Fumigants
    - Phosphine
- Chemicals
    - Deltamethrin
    - Pyrimiphos methyl

The use of fumigant or/and chemical is rather a cultural question and strongly differs country-by-country. The common in these protectants is that all have developed resistance.

Other protectants in use:

- Spinosad – a relatively novel, a fermented AS. Rarely used in the EU, has price issues
- Chlopyrifos-methyl – falling out of use
- Cypermethrin – remaining is strongly questionable
- Zeta-cypermethrin – probably not renewed
- Pyrethrins – less commonly used
- Kieselguhr – probably remains, not a chemical, but physical harm to insects

The physical approaches, like ventilation, aeration, heating-cooling, CO2, N2 etc. are valid solutions, however the fluctuated oil and energy prices make their future use more pending.

For commercial farmers and grain traders the most common option is fumigation or by less, but chemical use.

S-methoprene has long been used in Australia, USA and Canada for grain protection. These countries are huge grain producers and traders. Beside Hungary S-methoprene sources are the USA and China. Due to the relatively late introduction of S-methoprene to these markets, resistance is much less than to other AS and formulations. In case of mid and heavy infestation, S-methoprene formulations are in favor, however precise market share of S-methoprene based formulations in these countries are not shared and are not available.

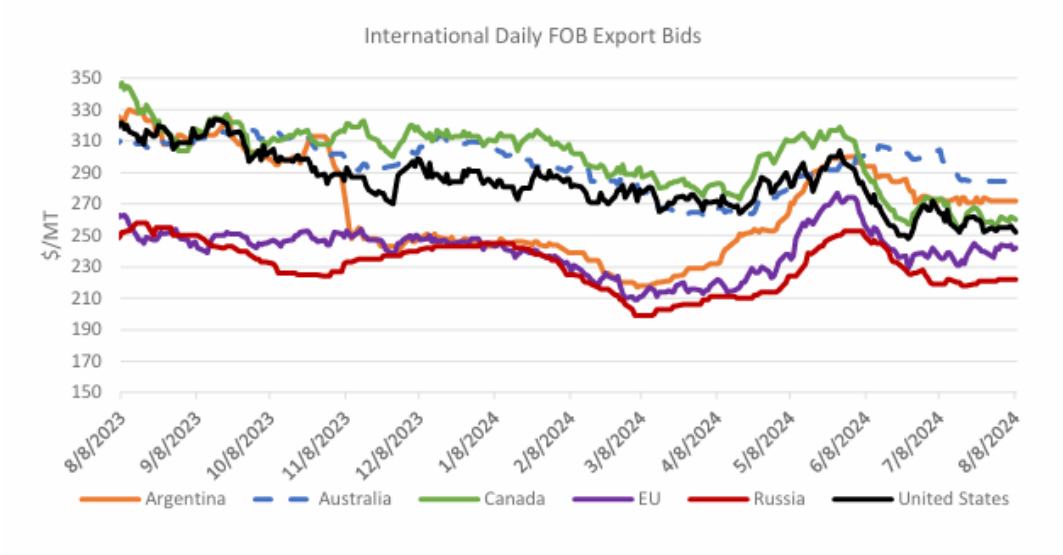
The past decades' enormous changes – like the generation and use of electricity, rapidly replacing coal and oil, the novel imaging technologies of the health and other industries, the AI etc. – will have an impact on agriculture and grain treatment as well. The currently available chemicals and fumigants have been in use for many decades, their re-evaluation and approval are pending, therefore novel insecticides and technologies of protection is a need and a must. Among the current alternatives S-methoprene is a highly placed candidate.

4° Impact of UKRAINE/RUSSIAN war, shipping lane hardships and market evolution

The latest update of the worldwide market and trade regarding grain situation.

Argentina	Australia	Canada	EU	Russia	United States
$272	$282	$260	$242	$222	$252

Note: Data as of August 9, 2024

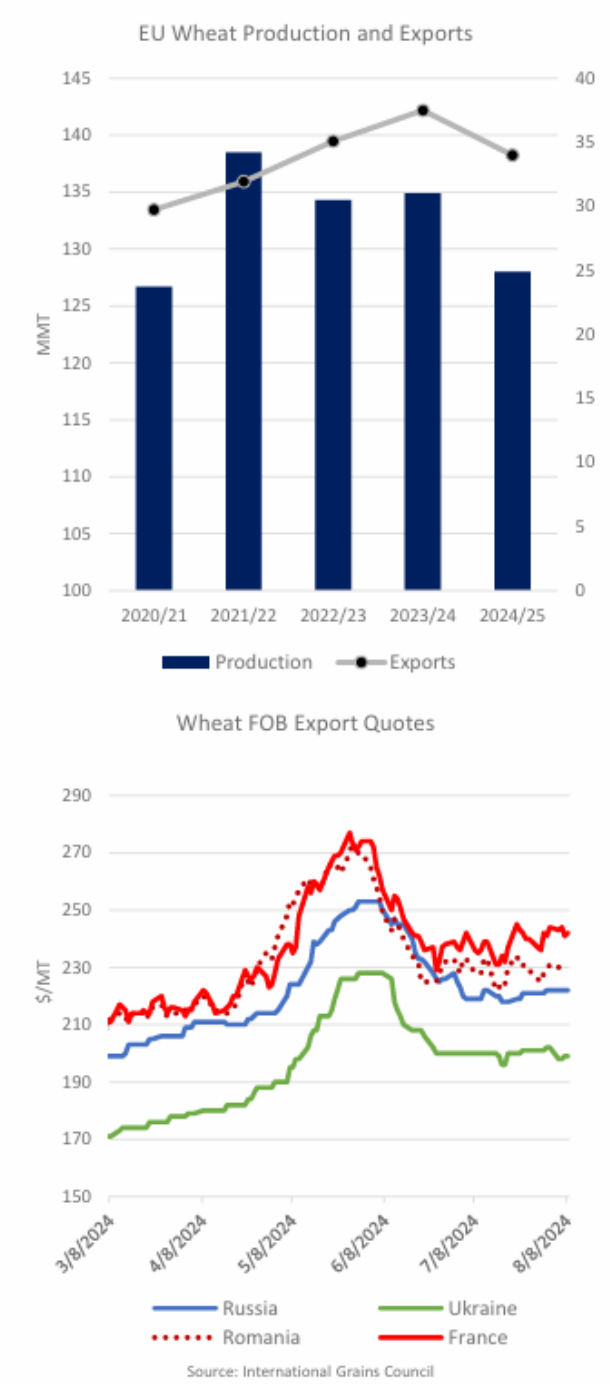


Source: International Grains Council

*Note on FOB prices: Argentina- 12.0%, up river; Australia- average of APW; Kwinana, Newcastle, and Port Adelaide; Russia - Black Sea- milling; EU- France grade 1, Rouen; US- HRW 11.5% Gulf; Canada- CWRS (13.5%), Vancouver

It is worthwhile to note that these per ton prices should be comparable to insecticide/fumigant prices and costs of treatment. Although we have had no intention of going into the complicated and highly variable pricing it is worthwhile to note. We are confident that material and treatment cost is a very small fragment of the above indicated FOB prices

EU Wheat Exports to Tumble in 2024/25



EU wheat exports in 2024/25 are forecast at the lowest level in 3 years. As the second largest global wheat exporter, key importing markets will need to turn to alternative suppliers. The primary driver is a smaller wheat crop, which is down 5 percent from the prior year on smaller harvested area[1]. Notably, in key exporter France, wheat production is anticipated to be down 20 percent from the prior year to the lowest level in almost 4 decades. Exportable supplies are further tightened given the lower carryin stocks in the region.

Prolonged weather-related issues in France have also reduced grain quality, reducing the amount of milling wheat available. With greater availability of feed-quality wheat and a smaller corn crop, the demand for wheat feed use within the EU is expected to remain strong. EU feed and residual use is forecast up 1.5 million tons this month to 46.0 million.

The reduced harvest prospects for EU grains have resulted in higher wheat export quotes from France over the past month, with quotes currently about 10 percent higher relative to key competitor Russia and continuing to rise. The EU, Russia, and Ukraine have traditionally had lower priced exports and shipped to price-conscious importers in the Middle East, Africa, and Asia. Despite smaller crops in Russia and Ukraine, exports from these origins are expected to remain strong as prices are competitive compared to EU quotes. The EU will likely lose market share in some of its top markets, including Morocco, Algeria, Nigeria, and Egypt. Furthermore, with favorable crop prospects in Canada and United States, the EU will face additional competition in top market China.

Not only the climate change but the rather hectic oil and energy prices have had their influence. For the EU, the Russian attack of Ukraine has resulted as a “wake-up call” and most of the Member States have with great efforts broke away from Russian energy sources. The take-away lesson of this, is that in case of grave danger there is always a solution from where one is able to better perform, than before. There must be pressure and will to do so.

Transport wise more and more sensitive and dangerous sea routes cover the World. To note a few:

- Red Sea (Huti and Somali rebels and pirates)
- Suez Canal (not designed for the large ships of nowadays, stucking)
- Malacca strait (piratering)

- Panama strait (uncertain political formations)
- Northern arctic routes (Russian, Chinese involvements)
- Black Sea (Russian and Ukrainian dominance war)
- Yellow Sea (strong Chinese presence and threats)

According to the French speaking association in Belgium (CEFAWAL), the circulation speed is chosen by the regional negociant according on the market prices.

It could happen that the stock is quickly sold about 6 months but the main duration of the stock in silo's is 1 year.

Our understanding is that this information is strictly handled in relative secrecy. The prior knowledge of silo emptying and transport may have an impact and influence on the stock price. Removal of stored grain is mostly a matter of price on the stock market, or urgent need, or favourable sales conditions. Most of the insecticides used have a residuality of 6 - 9 – 12 months.

Sales are also influenced by the buyers' national (if foreign) regulations and conditions, for example existence of the used AS approval, the formulation and the MRL meets the expected national level.

Circulation speed is also influenced by the mode of transport. If transported via sea, one should also calculate with the delivery duration (that can be months), hence the last grain treatment takes place either in port or the out of the port (most commonly fumigation).

TRADE CHANGES IN 2024/25 (1,000 MT)

Country	Attribute	Previous	Current	Change	Reason
Algeria	Imports	**8,500**	**9,000**	**500**	Continued growth in FSI consumption
Chile	Imports	**1,300**	**1,100**	**-200**	Lower imports and FSI trends
European Union	Imports	**10,000**	**11,000**	**1,000**	Smaller corn and wheat crops with larger exports from key supplier Ukraine
Iran	Imports	**2,500**	**1,800**	**-700**	Lower expected consumption
Kazakhstan	Imports	**2,000**	**1,000**	**-1,000**	Larger crop and ban on wheat imports via all modes of transport
Nigeria	Imports	**4,800**	**5,200**	**400**	Suspension of import duty
Pakistan	Imports	**300**	**100**	**-200**	Import ban implemented
Thailand	Imports	**3,000**	**3,300**	**300**	Continued growth in FSI consumption
United Kingdom	Imports	**3,000**	**3,200**	**200**	Smaller crop
Australia	Exports	**22,000**	**23,000**	**1,000**	Larger crop
Egypt	Exports	**1,300**	**1,500**	**200**	Strong demand for flour from several African countries
European Union	Exports	**34,500**	**34,000**	**-500**	Smaller crop and less milling wheat supplies
Ukraine	Exports	**13,000**	**14,000**	**1,000**	Larger crop

TRADE CHANGES IN 2023/24 (1,000 MT) – based on trade data

Country	Attribute	Previous	Current	Change
Algeria	Imports	9,000	9,200	200
China	Imports	14,000	13,635	-365
European Union	Imports	12,500	13,000	500
Indonesia	Imports	12,600	13,015	415
Iran	Imports	2,500	2,000	-500
Jordan	Imports	900	1,100	200
Nigeria	Imports	4,800	5,000	200
Thailand	Imports	3,100	3,316	216
Turkey	Imports	9,500	8,922	-578
United Kingdom	Imports	2,800	3,000	200
Uzbekistan	Imports	4,000	3,800	-200
Australia	Exports	23,200	22,515	-685
European Union	Exports	37,000	37,500	500
Kazakhstan	Exports	9,000	8,500	-500
Ukraine	Exports	18,100	18,400	300

World Wheat, Flour, and Products Trade

July/June Year, Thousand Metric Tons

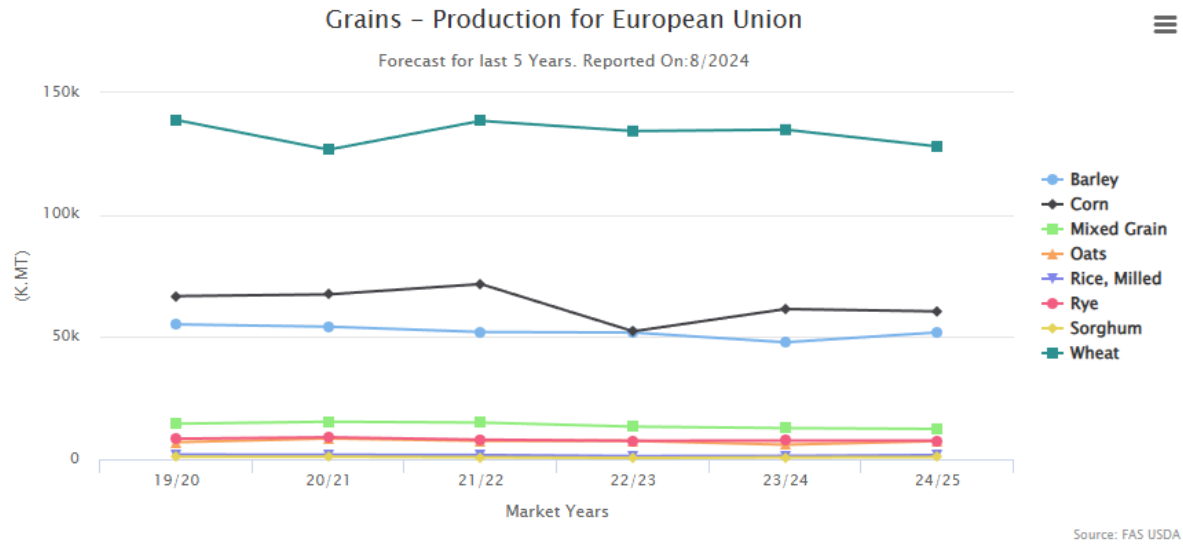
	2020/21	2021/22	2022/23	2023/24	2024/25 Jul	2024/25 Aug
TY Exports						
Russia	39,100	33,000	49,000	55,500	48,000	48,000
European Union	29,736	31,927	35,079	37,500	34,500	34,000
Canada	27,722	15,010	25,334	25,664	25,000	25,000
Australia	19,720	25,958	32,329	22,515	22,000	23,000
Ukraine	16,851	18,844	17,122	18,400	13,000	14,000
Argentina	9,597	17,651	4,681	7,282	11,500	11,500
Kazakhstan	8,128	8,455	9,862	8,500	10,500	10,500
Turkey	6,571	6,646	6,953	9,991	8,500	8,500
Brazil	911	3,105	2,689	2,812	3,000	3,000
Uzbekistan	974	1,394	1,119	1,700	1,800	1,800
Others	13,672	21,848	13,234	14,242	12,587	13,052
Subtotal	172,982	183,838	197,402	204,106	190,387	192,352
United States	26,636	21,347	20,279	19,594	22,500	22,500
World Total	199,618	205,185	217,681	223,700	212,887	214,852
TY Imports						
China	10,618	9,568	13,282	13,635	12,000	12,000
Egypt	12,149	11,256	11,221	12,000	12,000	12,000
Indonesia	9,995	11,271	9,446	13,015	12,000	12,000
European Union	5,390	4,631	12,193	13,000	10,000	11,000
Algeria	7,680	8,500	8,700	9,200	8,500	9,000
Turkey	8,051	9,555	12,500	8,922	8,000	8,000
Morocco	5,191	4,726	5,770	6,000	7,500	7,500
Bangladesh	7,200	6,340	5,120	6,500	6,500	6,500
Philippines	6,105	6,886	5,743	6,500	6,000	6,000
Brazil	6,359	6,582	4,985	5,921	5,600	5,600
Mexico	4,724	5,326	5,232	5,288	5,600	5,600
Japan	5,493	5,605	5,452	5,346	5,300	5,300
Nigeria	6,586	6,187	4,732	5,000	4,800	5,200
Afghanistan	3,700	4,000	4,350	4,400	4,500	4,500
Vietnam	3,900	4,517	4,317	5,000	4,500	4,500
Korea, South	3,889	5,099	4,533	4,990	4,400	4,400
Uzbekistan	3,546	3,318	4,269	3,800	4,300	4,300
Yemen	4,058	3,442	4,157	4,000	3,900	3,900
Saudi Arabia	2,773	3,052	5,260	4,100	3,600	3,600
Thailand	3,306	2,351	3,163	3,316	3,000	3,300
United Kingdom	3,033	2,635	2,016	3,000	3,000	3,200
Kenya	2,092	2,042	2,300	2,600	2,600	2,600
Iraq	2,175	2,576	3,986	2,750	2,400	2,400
Sudan	2,064	2,381	2,276	2,300	2,400	2,400
Colombia	1,906	2,057	2,036	1,950	2,000	2,100
Others	59,937	65,291	61,766	63,033	59,545	58,740
Subtotal	191,920	199,194	208,805	215,566	203,945	205,640
Unaccounted	5,012	3,260	5,607	4,355	5,942	6,212
United States	2,686	2,731	3,269	3,779	3,000	3,000
World Total	199,618	205,185	217,681	223,700	212,887	214,852

World Wheat Production, Consumption, and Stocks

Local Marketing Years, Thousand Metric Tons

	2020/21	2021/22	2022/23	2023/24	2024/25 Jul	2024/25 Aug
Production						
China	134,250	136,946	137,723	136,590	140,000	140,000
European Union	126,684	138,479	134,293	134,865	130,000	128,000
India	107,860	109,586	104,000	110,554	114,000	114,000
Russia	85,352	75,158	92,000	91,500	83,000	83,000
Canada	35,437	22,422	34,335	31,954	35,000	35,000
Pakistan	25,248	27,464	26,209	28,161	31,400	31,400
Australia	31,923	36,237	40,545	26,000	29,000	30,000
Ukraine	25,420	33,007	21,500	23,000	19,500	21,600
Turkey	18,250	16,000	17,250	21,000	19,000	19,000
Argentina	17,640	22,150	12,550	15,850	18,000	18,000
Kazakhstan	14,256	11,814	16,404	12,111	14,500	16,000
Iran	15,000	12,000	13,200	14,000	14,500	14,500
United Kingdom	9,658	13,988	15,540	13,980	10,850	10,850
Brazil	6,235	7,679	10,554	8,100	9,500	9,500
Egypt	9,102	9,842	9,500	8,870	9,200	9,200
Others	60,867	62,828	58,513	63,820	64,078	64,298
Subtotal	723,182	735,600	744,116	740,355	741,528	744,348
United States	49,523	44,804	44,898	49,314	54,659	53,930
World Total	772,705	780,404	789,014	789,669	796,187	798,278
Total Consumption						
China	155,000	148,000	148,000	153,500	151,000	151,000
India	102,217	109,882	108,676	112,356	113,000	113,000
European Union	104,750	108,250	109,000	111,000	109,250	110,250
Russia	42,500	41,750	41,000	40,500	38,750	38,750
Pakistan	26,300	27,700	29,000	30,200	31,200	31,200
Turkey	20,600	20,100	20,200	19,800	20,200	20,200
Egypt	20,500	20,500	20,550	20,500	20,300	20,100
Iran	17,400	18,200	18,100	17,300	17,300	17,100
United Kingdom	13,240	15,324	15,000	15,300	14,000	14,000
Algeria	11,150	11,370	11,570	11,750	11,650	11,950
Brazil	11,800	11,750	11,850	12,000	11,900	11,900
Indonesia	10,100	10,500	9,800	11,300	11,400	11,600
Morocco	10,300	10,500	10,000	10,000	10,100	10,100
Afghanistan	8,200	8,250	8,500	9,100	9,600	9,600
Canada	9,100	10,148	9,447	9,200	9,300	9,300
Others	183,826	186,161	180,801	184,289	183,941	186,591
Subtotal	755,936	760,939	760,256	768,525	769,078	773,098
United States	30,185	30,411	30,331	30,227	30,862	30,917
World Total	786,121	791,350	790,587	798,752	799,940	804,015
Ending Stocks						
China	139,120	136,759	138,818	134,503	134,508	134,503
European Union	10,698	13,631	16,038	15,403	10,938	10,153
India	27,800	19,500	9,500	7,500	8,500	8,500
Russia	11,380	12,088	14,388	10,188	6,738	6,738
Algeria	4,724	4,351	5,081	5,226	5,171	5,271
Pakistan	3,056	4,530	3,919	4,967	4,667	4,467
Saudi Arabia	2,429	2,002	3,504	4,204	4,304	4,354
Others	61,753	61,799	64,693	61,261	59,102	60,111
Subtotal	260,960	254,660	255,941	243,252	233,928	234,097
United States	23,001	18,355	15,501	19,107	23,309	22,525
World Total	283,961	273,015	271,442	262,359	257,237	256,622

We also used the USDA database by region: [PSD Online (usda.gov)]

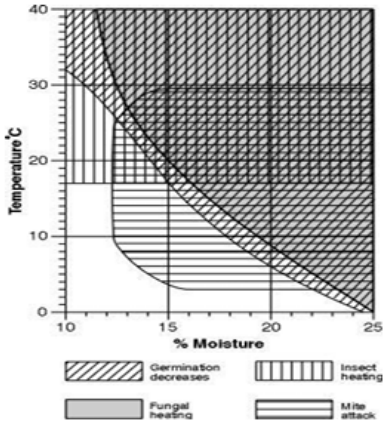


5° To be considered

Some ventilators are used to maintain the temperature as low as possible.

The climate change will have a big impact on the energy consumption for such methods.

Coupled with the instability of the grains' market price, the costs to maintain stock without insects will be crucial for the coming years.



As insects cannot control their body temperature, they are inactive at low temperatures (below 8 °C for insects and 3 °C for mites). Moisture content of grain below 13% stops the growth of most moulds and mites. Moisture content below 10% limits the development of most stored grain insects and pests. In addition to actual moisture content of the grain, the volume of stored grain also affects the rate of cooling. Practical storage conditions are summarized in Figure 1.

Figure 1: *Practical storage conditions.* Adapted *from Appert, 1987.*

6° Pesticide's resistance

Storage insecticides and fumigants are used extensively in the grain industry. Resistance to organophosphates, fenitrothion, pirimiphos-methyl and chlorpyrifos-methyl is widespread. In addition, resistance to one or more of these products has occurred in most major pest species. Since there is no single compound that will control all species attacking stored products, a combination of

two products must be applied. Resistance to phosphine had been detected in China, India, the Dominican Republic and Australia (Collins, 2001). Heavy reliance on phosphine for insect control, however, means that there is enormous selection pressure for insects to evolve resistance. Besides, options for managing resistance to phosphine are limited because at present, there are few ready alternatives.

The novIGRain testing has been conducted on pest samples arriving from the field or (if samples contained immatures) as species and strains were multiplied to number sufficient for testing.

Two interesting conclusions of these test are the following:

- Resistance has been found more frequently for phosphine (PH3) than for deltamethrin and pirimiphos-methyl
- Not a single population of Sitophilus granarius pests has been found resistant to deltamethrin, and only one population has shown resistance to pirimiphos-methyl. This is an interesting result concerning the use of S-methoprene, as previous studies indicated reduced effectiveness against this species.

8° Analyse of LMR on stored grains

Substance	Approval holder	Oilseeds		Cereals		Inclusion 91-414-EC Annex 1	EFSA opinion
		EU MRL mg/kg	CODEX MRL mg/kg	EU MRL mg/kg	CODEX MRL mg/kg		
Pirimiphos-methyl (F)	Syngenta	0.05*	-	5	7	IN Link: Decision 2007/52/EC Regulation (EU) No 540/2011	Link to the opinion
Chlorpyrifos-methyl	Dow AgroSciences Ltd	0.05 *	-	3	10 Wheat 0.1Rice	IN Link : Dir. 2005/72/EC Regulation (EU) No 540/2011	
Deltamethrin cis-Deltamethrin	Bayer	0.1 Rape, 0.05 Others 1 Olives for oil crushing	0.05 Sunflower	2	2	IN Link : Dir 2003/5/EC Regulation (EU) No 540/2011	Link to the opinion 9 Jan 2009
Zeta-Cypermethrin	FMC	0.2* linseed, sesame, poppy, sunflower, cotton, rape seeds 0.05 soya bean	0.1	2 barley, oats, rice rye, wheat. 0.03 maize, millet, sorghum	0.3 cereal grains 2 barley, oats, rice rye and wheat	IN Link: Dir 2009/37/EC	
Cypermethrin	FMC					IN Link: Decision 2005/53/EC	
Pyrethrins 1 and 2	generic 11 applicants	3 all oilseeds	-	3 cereal grains	0.3 cereal grains	IN Link: Decision 2008/127/EC	AS of no concerns. EFSA will deliver an assessment later.
Kieselguhr (diatomaceous earth, *TSS, diatomite, silica)*	generic 5 applicants	No MRL required		No MRL required		IN Link: Decision 2008/127/EC Regulation (EU) No 540/2011	

Spinosad (F) sum of SA and SD, expressed as S	Dow AgroSciences Ltd	0.02*	0.01* Cotton seeds	1	1 cereal grains	IN Link: Decision 2007/6/EC	
Malathion	Cheminova A/S (DK)	0.02*	20 cotton seeds	8	10 wheat 3 sorghum 0.05 maize	IN Link: Commission Directive 2010/17/EC	Link to the review report
Sulfuryl fluoride	Dow AgroSciences Ltd	0.01 (Fluoride ion = 2)		0.05 (Fluoride ion = 2)	0.05	IN Link: Commission Directive 2010/38/EU	
Bifenthrin	FMC Chemical s.p.r.l	0.5 cotton seed 0.1 other oilseeds	0.05 rape seed 0.5 cotton seeds	0.5 wheat, barley, oats, 0.05 *other cereals	0.5 Wheat 0.05 barley, maize	IN Link: Regulation (EU) No 582/2012	Link to the opinion
Dichlorvos	Denka International (NL)	0.01*	-	0.01*	5	OUT Link : Decision 2007/387/EC	Link to the opinion
Fenitrothion	Sumitomo Chemical Agro Europe initial applicant But AS fell into the public domain	0.02*	-	0.05*	6	OUT Link: Decision 2007/379/EC	Link to the opinion
Endosulfan	Bayer Crop Science	0.5 Soybean 0.3 cotton seed 0.1* other oilseeds	1 soybean dry 2 soybean crude oil	0.05*		OUT Link: Decision 2005/864/EC	Link to the opinion
Piperonyl butoxide		Not applicable	-	Not applicable	30 in cereal grains (accommodates post-harvest treatment)	Not applicable	

	Groups and examples of individual products to which the MRLs apply (a)	CEREALS	NOTE
Pirimiphos-methyl (F) Reg. (EU) No 2016/53 (Tab A)	**Applicable**		(F) Fat soluble
Chlorpyrifos-methyl (R) (F) Reg. (EU) 2020/1085 (Tab B)	**Applicable**	0.01*	(R) Chlorpyrifos-methyl - code 500000: sum of chlorpyrifos-methyl and desmethyl chlorpyrifos-methyl (F) Fat soluble
Deltamethrin (cis-deltamethrin) (F) Reg. (EU) 2018/832 (Tab C)	**Applicable**		Footnote 1: The European Food Safety Authority identified some information on analytical methods, storage conditions of samples and residue trials as unavailable. When re-viewing the MRL, the Commission will take into account the information referred to in the first sentence, if it is submitted by 18 October 2018, or, if that information is not submitted by that date, the lack of it.
Pyrethrins Reg. (EC) No 149/2008 (Tab D)	**Applicable**	3	
Kieselguhr (aka diatomaceous earth) (++) Reg. (EC) No 839/2008 (Tab E)	**Applicable**	No MRL required	(++) Substances temporarily included in Annex IV, pending finalisation of their evaluation under Directive. 91/414/EEC and pending submission of EFSA's reasoned opinion in accordance with Article 12(1)
Sulfuryl fluoride Reg. (EU) 2022/1321 (Tab A)	**Applicable**	0.01*	
Spinosad (spinosad, sum of spinosyn A and spinosyn D) (F) Reg. (EU) 2022/1406 (Tab B)	**Applicable**	2	Footnote 1: The European Food Safety Authority identified some information on the nature of residues in processed commodities as unavailable. When re-viewing the MRL, the Commission will take into account the information referred to in the first sentence, if it is submitted by 17 April 2017, or, if that information is not submitted by that date, the lack of it.
Methoprene Reg. (EU) No 899/2012 (Tab C)	**Applicable**	5	
Calcium carbonate Reg. (EU) 2022/1435 (Tab D)	**Applicable**	No MRL required	(++) Substances temporarily included in Annex IV, pending finalisation of their evaluation under Directive. 91/414/EEC and pending submission of EFSA's reasoned opinion in accordance with Article 12(1)

Appendixes

Appendix 1: SWOT of the market study

Strengths	Weaknesses
-Availability of scientific, technical & business intern experts -> Entomologist, toxicologist, -> Experiences 10-30 years in stored grains market -> Excellent quality of given data -Very good knowledge of influencers, buyers, users, applicators -Training center for users & applicators -Technical trials center of biocidal & plant production products -Very good knowledge of stored grains market -Complete availability of a project manager dedicated to the market study	-Low availability of figures in the literature -Low update of data sources in the literature -Non exhaustivity of data -Data sources are kept confidential, approach difficult
Opportunities	**Threats**
-Identification of 2/3 potential "First clients" for the product -Identification of potential sales volumes for the product in EU -Identification of European competitors, gaps in the market -Identification of ways to accelerate market penetration	-Incorrect figures in the literature or based on experiences -Data not found in the literature -Small competitors not detected due to lack of available data -Change of the market trend during the product development period time -Climate change impact

NovIGRain project

Market study conducted by IZInovation (SWOT, Benefits // Barriers) for Babolna

Achieving a market study by IZInovation is a guarantee of success, quality and efficiency:

- IZInovation has qualified and experienced scientific, technical & business experts in the area of stored grains.
- IZInovation has a network of field users in the area of stored grains thanks to its training activity.
- IZInovation has the knowledge of the products used in the area of stored grains thanks to its activity of efficiency tests.

Performing a market study by IZInovation will allow to identify the potential customers of the future NovIGRain solution, the potential sales volumes, the prescribers, the societal trends but also the competitors of the solution.

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