

2. WHAT ARE DITHIOCARBAMATES?

To understand what dithiocarbamates are, we need to consider one of agriculture's oldest challenges: protecting plants against disease.

A cultivated plant has to contend with more than insects, drought and nutrient deficiencies. There is a whole world of microscopic organisms capable of attacking its leaves, stems, roots and fruit. Some cause spots and deformities, others impair growth, and in the most severe cases they can destroy entire harvests.

Among the diseases most feared by farmers are downy mildews, which can affect important crops such as grapevines, potatoes and tomatoes.

It was to combat diseases of this kind that numerous fungicidal products were developed during the twentieth century, including dithiocarbamates.



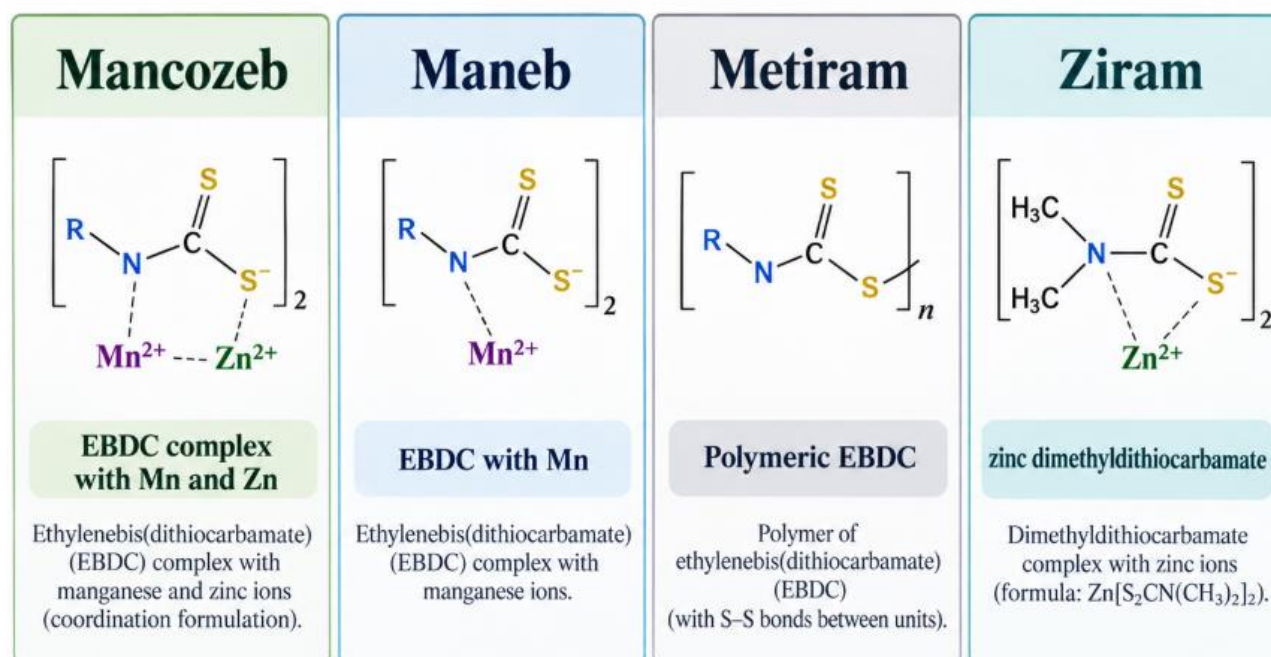
A FAMILY OF SUBSTANCES, NOT A SINGLE PRODUCT

The term dithiocarbamates does not refer to a single chemical substance, but to a family of compounds that share certain structural characteristics.

Their distinguishing feature is the presence of sulphur-containing chemical groups, which play an important role in their biological activity.

Many dithiocarbamates used in agriculture are compounds associated with metals such as manganese or zinc.

The Dithiocarbamate Family



Same chemical family, but different substances in structure, behaviour and toxicological profile.

Figure: The dithiocarbamate family — Mancozeb: manganese–zinc ethylenebis(dithiocarbamate) (EBDC) complex; Maneb: manganese EBDC; Metiram: polymeric EBDC; Ziram: zinc dimethyldithiocarbamate. Compounds in the same family may differ in structure, behaviour and toxicological profile.

Among the best known are:

- Mancozeb: for decades one of the most widely used fungicides worldwide, particularly for protecting grapevines, potatoes and tomatoes.
- Maneb: a manganese-containing compound historically used against various fungal diseases.
- Metiram: used to protect numerous crops, particularly against leaf diseases.
- Ziram: a zinc-containing compound belonging to a different chemical subgroup from the preceding substances.
- Propineb: another fungicide in the family, historically used on a range of crops.
- Thiram: also known for its use as a seed treatment to protect seeds against fungal infections.

Although they belong to the same broad family, these substances are not identical. They can differ in their environmental behaviour, degradation products and toxicological effects.

This distinction matters: belonging to the same chemical family does not necessarily mean having the same effects on health.

HOW THEY ACT AGAINST FUNGI

Imagine a fungal spore reaching the surface of a leaf.

If moisture and temperature conditions are favourable, it may germinate and initiate an infection.

Many dithiocarbamates were developed specifically to hinder this process.

They are predominantly contact fungicides: they are applied to the plant surface and act primarily as a protective barrier before infection has a chance to develop.

But how can they stop a microscopic organism?

The answer lies in how cells function.

To survive, grow and reproduce, a fungus relies on numerous chemical reactions controlled by specialised proteins called enzymes.

We can think of enzymes as small working tools, each performing a task essential to the functioning of the cell.

Dithiocarbamates can interfere with several of these processes, disrupting the activity of enzymes and other cellular components.

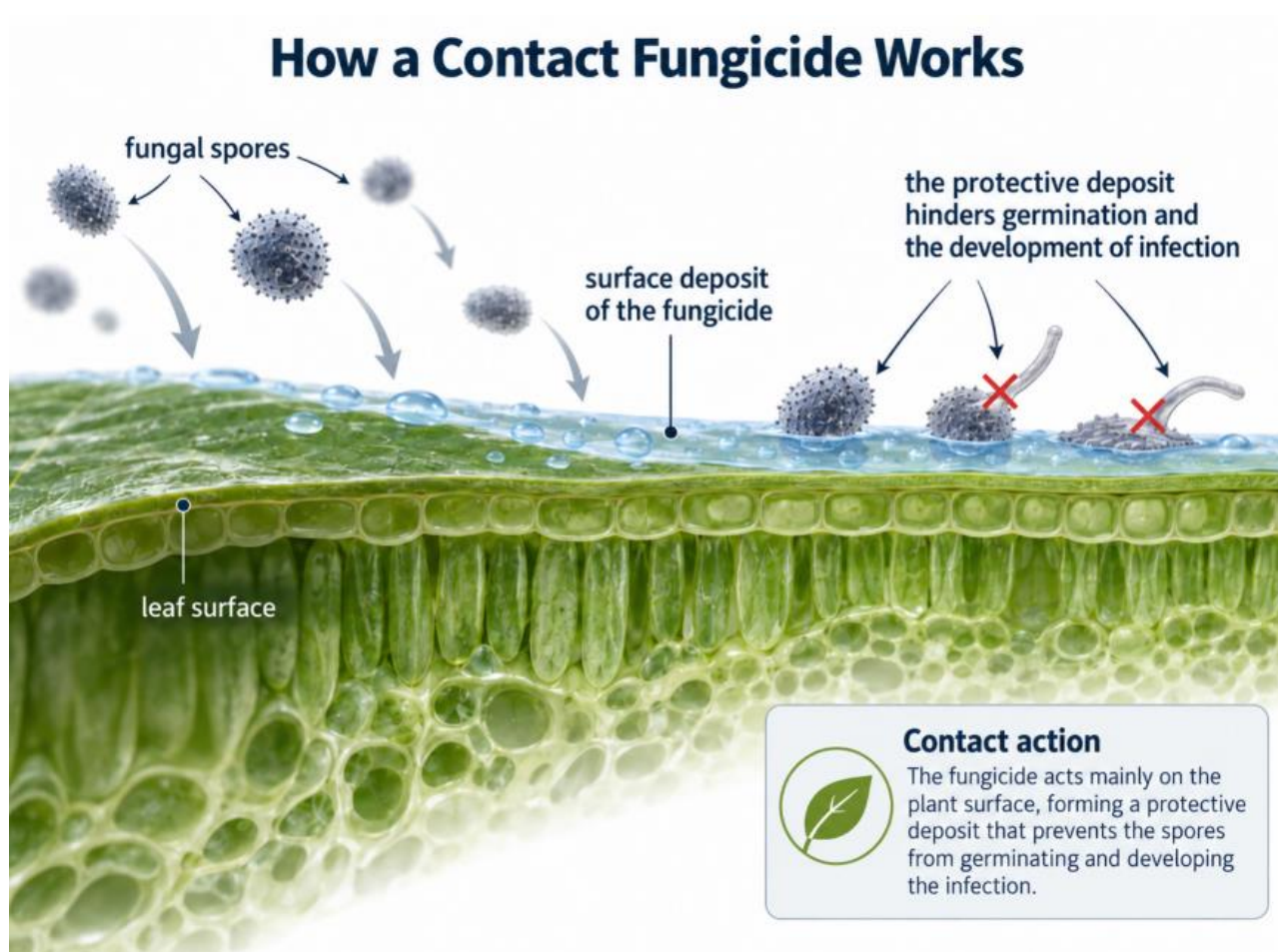


Figure: How a contact fungicide works — Fungal spores encounter a protective fungicide deposit on the leaf surface. This surface treatment hinders spore germination and infection development.

As a result, the fungus has greater difficulty germinating and developing.

This is described as a multisite mode of action because it does not depend on inhibiting a single biological target.

This is an important feature: when a fungicide acts on only one target, a mutation may sometimes allow a fungus to develop resistance. When several cellular processes are affected simultaneously, developing effective resistance is generally more difficult.

This helped make dithiocarbamates widely used in twentieth-century agriculture.

WHY THEY WERE SO WIDELY USED

For many years, these fungicides were an important tool in crop protection.

There were three main reasons for their success: activity against a wide range of diseases, good preventive efficacy and relatively low cost.

Their multisite action also made them useful in crop-protection programmes that alternated fungicides with different modes of action.

However, their agronomic effectiveness is not the whole story.

A substance capable of interfering with biological processes that are essential to fungi may, under certain exposure conditions, also have undesirable effects on other organisms.

This does not mean that all dithiocarbamates present the same hazards. Rather, it explains why their toxicological properties need to be assessed individually.

Over time, advances in scientific knowledge have led to a reassessment of the use of several active substances in this family.

FROM WIDESPREAD USE TO RESTRICTIONS

The history of dithiocarbamates also illustrates how the regulation of chemical substances can change as scientific knowledge evolves.

In the European Union, several active substances in this family are no longer approved for use in plant protection products.

For example, EU approval of mancozeb was not renewed in 2020, following assessments that identified significant toxicological concerns.

Metiram was likewise subject to non-renewal of approval in 2023, followed by the withdrawal of authorisations for products containing it.

These decisions do not mean that every food previously treated with these substances was necessarily dangerous. Rather, they indicate that, in light of the available assessments, the conditions required to maintain approval in the European Union were not met.

It is also important to distinguish between authorisation to use an active substance in agriculture and the residue limits applicable to foods, including foods imported from outside the Union. These are related but distinct regulatory issues.

A PROBLEM THAT DOES NOT DISAPPEAR WITH A BAN

At this point, a question may arise: if several dithiocarbamates are no longer approved in the European Union, why do we continue to test foods for them?

There are several reasons.

First, some may still be used in countries with different rules. Agricultural products, however, move through international markets and may reach consumers far from where they were grown.

Testing may also be needed to verify compliance with residue limits and identify any unauthorised uses.

But there is another complication, one that is particularly interesting from a scientific perspective.

As we noted in the introduction, the analytical methods traditionally used to test for this family of fungicides may measure carbon disulphide without being able to identify with certainty which substance produced it.

Moreover, in certain vegetables, some of the carbon disulphide measured may originate from compounds naturally present in the plant.

This means that monitoring dithiocarbamates is not simply a matter of looking for a substance: it also requires an understanding of what the analytical result actually represents.

We will explore this issue in the following chapters, after examining how these compounds can reach food, undergo transformations in the environment and give rise to other substances.

Scientific references for Chapter 2

1. EFSA (2023). Review of the existing maximum residue levels for dithiocarbamates according to Article 12 of Regulation (EC) No 396/2005. EFSA Journal, 21(5), 7987. [Read the EFSA scientific publication](#)
2. European Commission (2023). Commission Implementing Regulation (EU) 2023/2455 of 7 November 2023 concerning the non-renewal of the approval of the active substance metiram. [Read the official text on EUR-Lex \(Italian\)](#)
3. European Commission (2020). Commission Implementing Regulation (EU) 2020/2087 of 14 December 2020 concerning the non-renewal of the approval of the active substance mancozeb. [Read the official text on EUR-Lex \(Italian\)](#)