

## Importance of methiram in the control of Brown Spot of Pear in Portugal

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Technical Management APES

Pear crop in Portugal occupies an area of about 12.000 ha. More than 90% of pear growing area are concentrated in a relatively small region in the central west coast of the country (so called Oeste region).

From a climatic point of view Oeste region, due the strong influence of Atlantic Ocean could be characterized by a temperate climate with rain (average temperatures during warmer months inferior to 22 C°) and high relative humidity (average 80%).

Among growing cultivars, Rocha, a native pear variety, it is by far the most important, with a production area of 11.000 ha, distributed through 5000 growers. Fruits from this cultivar, under the brand "Rocha do Oeste", are recognized by the European Union as a quality agricultural product belonging to the Portuguese Cultural Heritage. More than 60% of the annual production is exported mainly to European and South American Countries which reflect this crop significant economic impact our agricultural economics.

Brown Spot of Pear is a fungal disease caused by *Stemphylium vesicarium* (Wallr.) E. Simmons economically important in pear-production areas in Europe. Although bibliographic references refer that has been reported in Portugal in 1996, there were a previous reference from 1972 to a dry rot in pears, developing before harvesting due to *Stemphylium botryosum* Wallroth. Pear Brown Spot start appears initially in irregular way but, disease importance increased significantly during the last 15 years, being nowadays considered the most important fungal disease on pear, superior to the traditional scab, and a menace to the crop sustainable production. Depending on location and year damages could reach up 80 to 90% of affected fruits.

The combination of climatic conditions favorable to pathogen overwintering and disease development, together with a pear orchard based on the same cultivar – Rocha – considered medium susceptible to the disease, growing in a geographic limited area, makes easy the disease dispersal. In addition, despite the absence of specific studies about the eventual evolution / adaptation of the pathogen to the local conditions, some recent unpublished research results have identified the presence of very aggressive strains side by side with relatively benign ones. This fact together with the occurrence of very high disease attacks in particular locations, suggests an eventual pathogen evolution/adaptation to the local conditions.

*Stemphyllium vesicarium* contamination and infection development could occur since the flowering up to the harvest period. Ascospore and conidia are released during all growing period (Fig. 1 and 2).

Figure 1: Evolution of average number of ascospores / week / cm<sup>2</sup> in 5 orchards - 2018

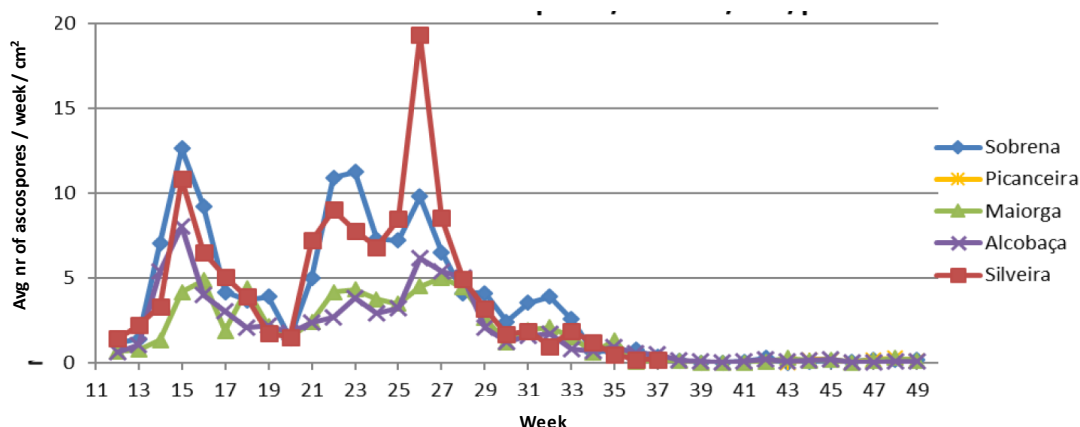
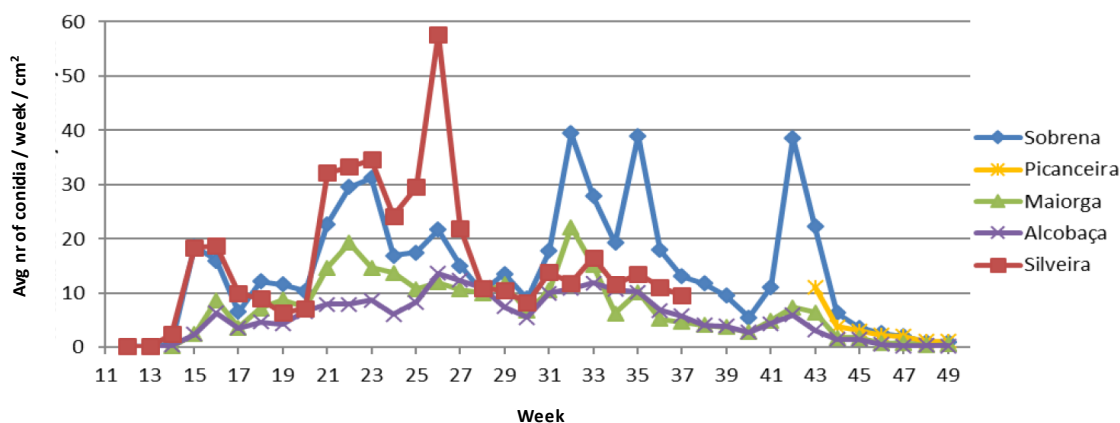


Figure 2: Evolution of average number of conidia / week / cm<sup>2</sup> in 5 orchards - 2018



Consequently, under favorable climatic conditions (rain / high relative humidity periods) pear crop is subjected to a sequence of infection during the growing period. Usually visual symptoms on leaves appear during flowering period. On fruits which are susceptible to contamination during all growing cycle, symptoms start to be perceptible after BBCH 75 but, strongly increase in frequency and intensity during the maturity period (approx 45 days before harvest). In the recent years we have seen an increase of symptoms in fruit calyx area as a result of contaminations of floral structures (flower style, decaying petals or sepals) under conditions of prolonged wetting periods that remain latent close to harvest. The change in the type of fungicides used by farmers in the beginning of 1990 decade could also have had a positive impact on disease spread and intensity. The use of broad spectrum Dithiocarbamates, main compounds used for scab control – those days the most important disease – were, due to the successful implementation of IPM principles, replaced in an appreciable extension by compounds like dithianon less effective on *Stemphylium vesicarium*.

From disease control point of view, the recommended agronomic measures to manage Pear Brown Spot are not easy to implement/adopt by our farmers. Biological control agents are not introduced. Some trials are ongoing but is not clear its impact in the reduction of disease intensity. Removal of fallen leaves and fruits is difficult to be followed by majority of the farmers. Elimination of weeds is a difficult practice once farmers must keep a vegetable mulch covering the soil during growing season. Some attempts to change the composition of vegetal mulching through the introduction of species less susceptible to *Stemphylium vesicarium* have had no success. Replacement of Rocha cultivar by less susceptible cultivars is, for economic reasons, out of question. Therefore, the desired integrated approach to Brown Spot of Pear control using all available agronomic measures together with chemical treatments is limited to the application of chemical fungicides.

In front of a disease with a short incubation period, several cycles of infection covering the entire growing season, and a crop susceptible up to the harvest, farmers must do from 15 to 20 treatments per season in order to achieve an acceptable level of disease control. Regarding the problematic of the number of treatments farmers are also facing two additional limitations. From one side the absence of efficient curative activity against the disease. Once the spore germination took place toxin responsible for the symptoms have already been released and spot will appear. On the other hand disease forecast model – BSPcast – seemed that have never been properly adjusted to the distinct micro climatic conditions / different disease development dynamics. Therefore, is not a very useful tool to rationalize the use of fungicides.

Regarding fungicides, [REDACTED] and combination of [REDACTED] with [REDACTED], were the fungicides recognized by farmers as the most effective for *Stemphylium vesicarium*. Recently [REDACTED], all belonging to [REDACTED] group, were introduced in the Portuguese market. In 2018 [REDACTED] and the combination [REDACTED] got the approval for Brown Spot of Pear control. In the meantime, some combinations of [REDACTED] were also registered for the same purpose.

Having in mind [REDACTED]  
[REDACTED] the available actives  
for [REDACTED] are indicated in Fig. 3.

Figure 3: Active ingredients registered [REDACTED] maximum number of applications allowed, modes of action and risk of resistance

A.I.	Max nr applic	Mode of Action Code (FRAC)	Risk of resistance (FRAC)
[REDACTED]	3	[REDACTED]	Medium-high+high
[REDACTED]	2	[REDACTED]	Medium+medium
[REDACTED]	3	[REDACTED]	High
[REDACTED]	1	[REDACTED]	High+medium
[REDACTED]	2	[REDACTED]	Medium-high
[REDACTED]	3	[REDACTED]	Low (multi-site)
[REDACTED]	3	[REDACTED]	Medium-high
[REDACTED]	3	[REDACTED]	Medium-high
[REDACTED]	3	[REDACTED]	High
[REDACTED]	3	[REDACTED]	High

From above table seems clear that, [REDACTED]  
[REDACTED]  
[REDACTED] to control Brown Spot. From these four groups, only fluazinam is a multi-site active. In addition, all groups are limited to a maximum of 2 a 3 applications per season.

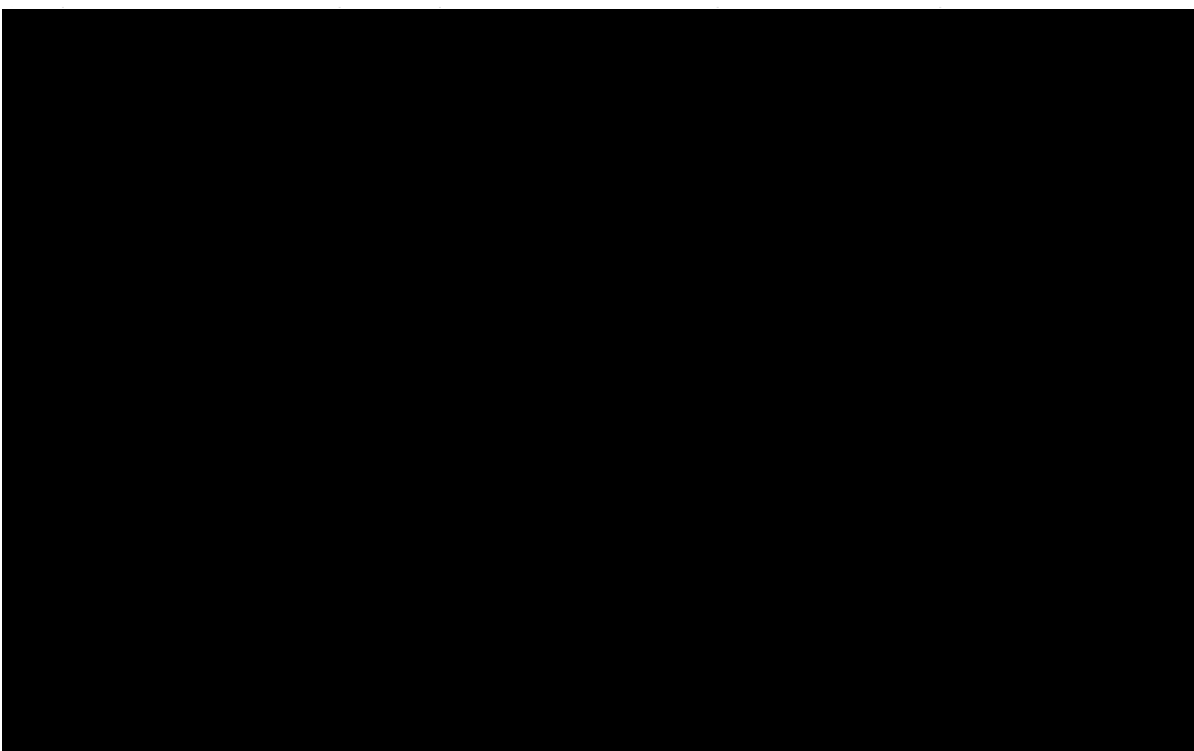
Having in mind the high number of treatments needed to cover all pear growing season, number and type of available modes of action and its risk of resistance, the adoption of anti-resistance fungicide strategies (alternation of modes of action, limitation of the number of treatments with risk fungicides, tank mixtures of risk with multi-site modes of action) oriented to the preservation of existing fungicide efficacy overtime will be much more difficult if not impossible.

In addition, we should consider also that, due to the farmers intensive use of the most efficient compounds, the efficacy of QoI group is already affected by the development of *Stemphylium vesicarium* resistant biotypes. These biotypes are spreading over time through all pear growing area. For SDHI too, a shift on efficacy under field conditions have already started to be perceived. On the opposite way broad spectrum contact fungicides like dithiocarbamates (thiram, methiram...) maintained up to know a consistent level of efficacy.

## Resistance status of brown spot in pear in Portugal

Launched on pear in the first decade of the century, the new group of [REDACTED] compounds [REDACTED] characterized by high efficacy and a specific mode of action have been intensively used either alone, or in blocks of several consecutive treatments, or even in attempts of curative / eradicating treatments against *Stemphylium vesicarium*.

In 2017 and 2018, taking advantage from BASF Italia Spa collaboration with [REDACTED] [REDACTED] there were the opportunity to include Portuguese *Stemphylium vesicarium* samples in their extensive resistance monitoring that covers several European pear growing countries. Monitoring was focused on [REDACTED] mode of action. In 2018 [REDACTED] were also included. Results (Fig. 4) showed that [REDACTED] fungicides, are under serious threat of field resistance due to the development of resistant biotypes. This result is in accordance with recent FRAC (FRAC ,2018) indication of *Stemphylium vesicarium* resistance in Portugal.



Development of *Stemphylium vesicarium* biotypes resistant to [REDACTED] on pear is not new in Europe. As a matter of fact, resistance against this group of fungicides was firstly described in Italy, by Alberoni *et al.* (2010), who found the first resistant strains in 2006 and concluded that by then the fungicidal activity against the fungus at issue was already insufficient. Consequently, the use of these actives in mixture and/or in alternation with multi-site products is highly recommended in order to preserve their efficacy and/or limit the spread of resistance.

## Fungicide resistance management

The experience from other crops together with FRAC recommendations, strongly suggest the need to implementation measures to prevent and/or minimize the development and / or spread of biotypes resistant to fungicides with specific mode of action.

Actually, FRAC classifies *Stemphylium vesicarium* as a high resistance risk pathogen in general, at the same level than *Venturia inaequalis*. Currently we know that this disease is very aggressive, and the development of resistant strains have already occurred and was detected in several orchards. Nevertheless, as referred by Brent and Hollomon, in 1998, the inclusion of dithiocarbamates in spray programs, due to its multi-site mode of action, reduces the combined pathogen-fungicide risk of resistance development.

Faced to this situation it is assumed that chemical control of *Stemphylium vesicarium* must rely in an integrated approach that covers the following main aspects:

- Use of all agronomic measures that reduce disease incidence
- Build up fungicide spray programs based on the alternation of fungicides with different modes of action.
- Multisite fungicides like methiram must be included in alternation programs.
- Tank mix single site fungicides with multi-site compounds like methiram.
- Avoid consecutive applications of fungicide with the same mode of action
- Avoid always curative and/or eradivative applications.
- Follow dose rates indicated in the labels. Do not use lower rates.
- Spray interval should be adjusted to the evolution of conditions (rain events, high relative humidity) favorable to disease contamination. Do not overextend the spray interval.
- Target specific products to appropriate crop growth stages.

In this resistance management strategy multi-site fungicides play a crucial role. Regarding these aspects, FRAC published in 2018 a document emphasizing the high Importance of multisite fungicides in managing pathogen resistance. The use of multi-site fungicides in spray programs in crops with multiple treatments such as fruits, vegetables or potatoes is really important. Due to their mode of action, multi-site fungicides are considered as a low resistance risk group. Consequently, they can be used as mixing partners or in alternation with medium to high resistance risk fungicides. Moreover, after decades of intensive use, no cases of field resistance against multi-site fungicides have been reported. (FRAC, 2018).

In brief the benefits in recommend multisite fungicides in spray programs are as follows:

- Multisite fungicides have a low risk to develop resistance and are effective mixing/alternating partners for medium to high risk fungicides.
- Beyond protecting and prolonging the lifespan of highly effective medium/high resistance risk fungicides, multi-site fungicides provide added efficacy levels and activity spectrum. As a consequence, they can support the single site modes of action to be even more efficient.
- Multisite fungicides are considered as a valuable tool to manage resistance by preventing or delaying its development regarding many pathogens in many crops.

Therefore, the use restriction of multisite fungicides in important crops could result in faster development of resistance to fungicides with single site mode of action. Due to the risk of resistance development these restrictions could lead to epidemic disease development, serious crop losses and finally loss of highly effective fungicides for a sustainable disease management.

## **Situation in Portugal about the role of multisite fungicides in controlling Brown Spot of Pear**

Nowadays in Portugal there are several products based on fungicides with different modes of action registered for *Stemphylium vesicarium* control. Fluazinam and methiram are the unique actives with multi-site activity and both are limited to 3 applications per season. Basic relevant biological characteristics are as follows:

- Still maintain good efficacy
- Preventative activity
- Broad spectrum (*Venturia* spp, *Alternaria* spp...)
- Compatible with other fungicides

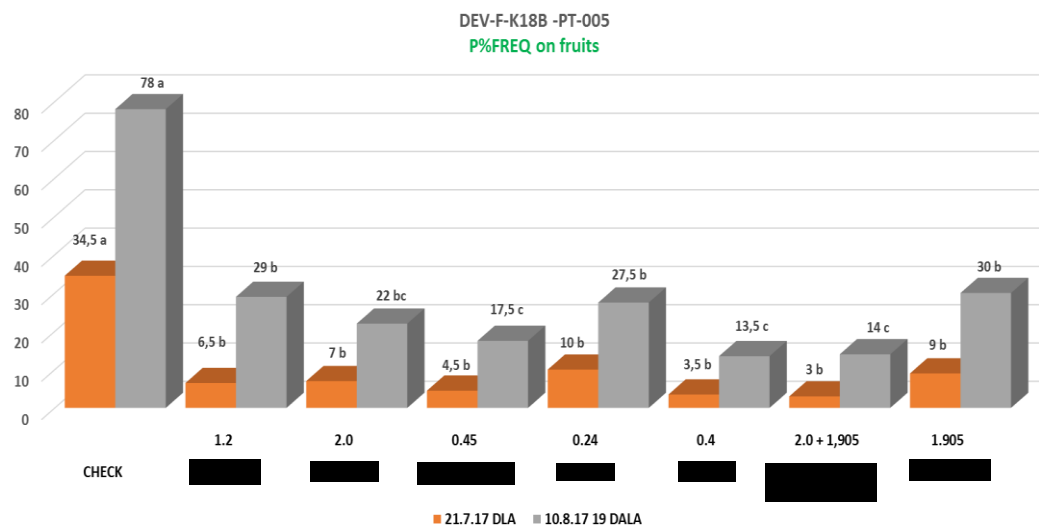
Methiram, belonging to the Dithiocarbamates group is as referred below one of the few multi-site compounds still present in the market. Like the other few compounds belonging to this group they are under pressure. Thiram is no more available in Portuguese market since April 2019. [REDACTED] phase out is also considered as possible. Chlorotalonil, a fungicide that got this year an exceptional use approval for 120 days has already been object of non-inclusion decision by UE.

In this way, the segment multi-site fungicides, essential, due to its broad spectrum of activity, to prevent the development of resistance of pathogens to fungicides with specific mode of action (risk fungicides) is now under risk of be banned or have its use limited in European market, generating this way additional difficulties for a sustainable pear protection / production.

Methiram (Polyram DF) efficacy alone and as a partner of other BASF compounds against *Stemphylium vesicarium*, was confirmed in a field trial carried out in Portugal in 2017 in an orchard of Rocha cultivar (applications started preventatively at flowering and continue at 15 days before harvest at 7 to 10 days interval).



Figure 1 - Comparison of different fungicides in controlling *Stemphylium vesicarium* on pear.  
Trial DEV F 2017-K18B-0.01-PT-PTD-005



Carried out under conditions of high disease pressure trial results clearly confirm:

- 1) Methiram (Polyram DF) alone, at the registered rate of 2.0 kg/ha still maintain good efficacy against Brown Spot of Pear.
- 2) Capacity of methiram to improve the efficacy of other fungicides, this case [redacted] in tank mixtures

As a conclusion, the multisite active ingredients still maintain a good level of fungicidal efficacy, with the advantage of contributing for an efficient resistance management when applied alone in alternation or in tank mixture with risk compounds. This way multi-site compounds strongly contribute to preserve the future efficacy of the single-site modes of action.

After the phase out of thiram, methiram becomes the main multisite fungicide in pear fungicide market to control *Stemphylium vesicarium*. Having in mind the already decided future phase out of chlorotalonil, other multisite compound with potential in this crop, pear growers will face additional difficulties to control Brown Spot of Pear. Having in mind this situation a positive decision on the re-registration of methiram will allow farmers to keep a fundamental tool to manage, in a sustainable way *Stemphylium vesicarium*, key disease in Portuguese pear orchards.

Benefiting also from the implementation of resistance management strategies is also scab. (*Venturia pyrina*), is an endemic pathogen in pear which, is considered by FRAC as a moderate risk pathogen from resistance development point of view. All the compounds used to control Brown Spot of Pear also control scab. Therefore, the risk of developing scab biotypes resistant to [redacted] and or [redacted] is not negligible. Considering the good efficacy of dithiocarbamates against scab, all the arguments used to defend the maintenance of this mode of action available to control Brown Spot of Pear in a sustainable way, are also valid for pear scab.

## Summary & conclusions

Multi-site fungicides and specifically methiram are very important in pear disease management due to the following reasons:

- Effective control of Brown Spot of Pear and scab, the two most important and destructive pear diseases in Portugal.
- Brown Spot of Pear is very aggressive and entails a high risk of developing resistance to many currently registered fungicides.
- An effective resistance management to control this disease is absolutely needed
- For the time being fungicides are the main tool to control this disease and those with multisite mode of action are the key group in order to reduce the risk of resistance and prolong the efficacy of the other very specific modes of action in the future.
- From practical point of view methiram together with fluazinam are the only effective multisite fungicides currently available against pear BrownSpot of Pear.
- Methiram could soon suffer significant use restrictions or even be out of the market.

As a final conclusion, if dithiocarbamates based compounds would be out of market, and considering that [REDACTED] is also under risk, in the next future only four modes of action, with a limited number of applications allowed, will be likely available in the portuguese market to effectively control *Stemphylium vesicarium*. With an exception for [REDACTED] all the remaining actives like [REDACTED] and [REDACTED] are risk compounds due to its specific mode of action. For all this reasons Metihram is a very important tool for Portuguese pear growers to control in a sustainable way Brown Spot of Pear maintaining the profitability of the crop.

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