Agrotechnological Research Institute (ATO-DLO)
P.O. Box 17, 6700 AA Wageningen, The Netherlands

Instituut voor
Agrotechnologisch
Onderzoek
ATO-DLO
Bornsesteeg 59
Postbus 17
6700 AA Wageningen

A 220

Control of storage diseases with plant protection products

# Results of a storage experiment performed by ATO-DLO research institute, Wageningen (Holland) in the 1998/1999 storage season

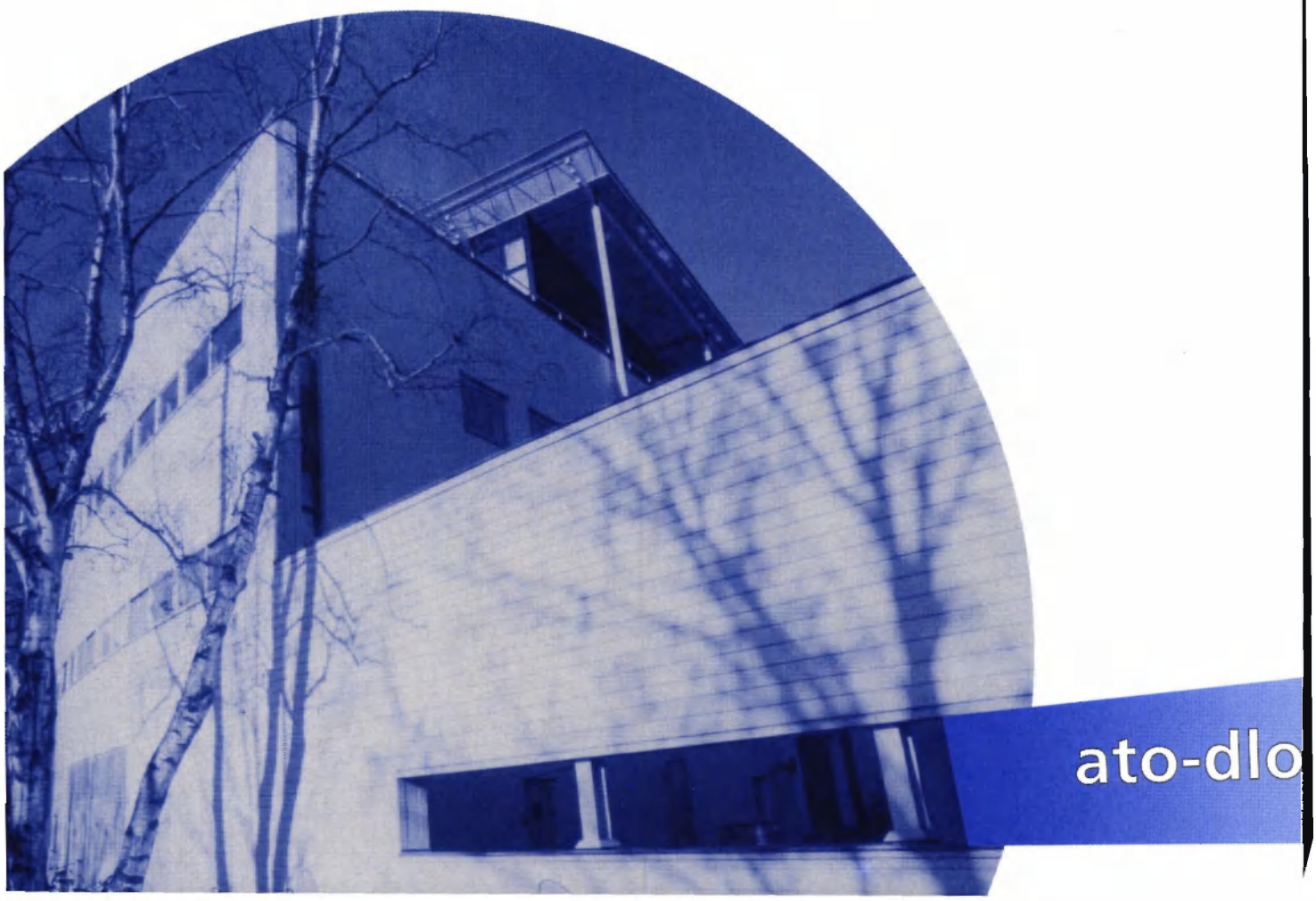
**(This investigation was performed by order of Rhône-Poulenc Agriculture Ltd., UK)**

Ing. P.S. Hak
assisted by

W. van Kleef
H. Sewtahal
J. Sinke
K. Groenewoud
G. Bunk

**Confidential**

**Report B402/ June 1999**



ato-dlo

# Control of storage diseases with plant protection products

**Results of a storage experiment performed by Agricultural Research Institute (ATO-DLO), Wageningen (Holland) in the 1998/1999 storage season**

**CONFIDENTIAL**

**(This investigation was performed by order of Rhône-Poulenc Agriculture Ltd., UK)**

**ATO-DLO Report B402 (June 1999)**

Ing. P.S. Hak

assisted by

W. van Kleef
H. Sewtahal
J. Sinke
K. Groenewoud
G. Bunk

## Content

# SUMMARY

Activity of the following products were evaluated during the 1998/1999 storage season:

- Fungazil[tm] 100 SL, containing 100 g imazalil/liter
  (applied in 10 and 15 g active ingredient imazalil per ton)

- Storite[tm] flowable, containing 450 g thiabendazol/liter
  (applied in 40.5 g active ingredient thiabendazol per ton)

against the following potato storage pathogens:

*Helminthosporium solani* (silver scurf)
*Fusarium solani var. coeruleum*
*Fusarium sulphureum*+ (resistant to thiabendazol)
*Fusarium sulphureum*- (not resistant to thiabendazol)
*Phoma exigua var. foveata*

Also control objects (not with fugicide treated potatoes) were concerned in this trial.

The trial was performed from November 5, 1998 to March 8, 1999.
To stimulate the fungal infections, potatoes were artificially inoculated and infected with spores (except for silver scurf). Infections with silver scurf (*Helminthosporium solani*) were obtained spontaneously during storage under warm and humid conditions.

The following results were obtained:

- Against *Helminthosporium solani* (silver scurf) all fungicides and doses gave a statistical significant effect.
  The activity of Fungazil[tm] 100 SL performed significantly better than Storite[tm] flowable. The dose of 150 ml/ton of Fungazil[tm] 100 SL was significantly the best of all.

- Also against *Fusarium solani var. coeruleum* all fungicides and doses gave a statistical significant effect.
  Against this pathogen, Fungazil[tm] 100 SL performed significantly better than Storite[tm] flowable. The dose of 150 ml/ton of Fungazil[tm] 100 SL was significantly the best of all.

- Against *Fusarium sulphureum+* only the two doses of Fungazil 100 SL gave a statistical significant effect.
  From Storite[tm] flowable non statistical significant effect against *Fusarium sulphureum+* was found. This is not surprising for this fungus type is resistant towards thiabendazol.

- Against *Fusarium sulphureum-* again all fungicides and doses gave a statistical significant effect.
  Also against this pathogen, Fungazil[tm] 100 SL performed significantly better than Storite[tm] flowable. The dose of 150 ml/ton of Fungazil[tm] 100 SL was significantly the best of all.

- Also against *Phoma exigua var. foveata* all fungicides and doses gave a statistical significant effect.
  The activity of Fungazil[tm] 100 SL in a dose of 150 ml/ton was clearly the best.

- Recapitulated against all 5 potato storage pathogens, the imazalil single product Fungazil[tm] 100 SL gave the best results, especially the dose of 150 ml/ton (15 g active ingredient imazalil per ton).

# 1. INTRODUCTION

Since in first instance silver scurf (*Helminthosporium solani)* and later on dry rot (*Fusarium sulphureum*) became resistant towards benzimidazoles (BCM's), research is focused on alternative products and combinations of products against storage diseases on potatoes.
Application of combination products (BCM + imazalil) after harvest gives in practice sufficient activity against resistant silver scurf strains and *Fusarium sulphureum.*

In this trial, the activity of a imazalil single formulation (in two doses) and a thiabendazol single formulation were tested against different storage pathogens, in comparison with untreated control.

# 2. PURPOSE

The purpose of this trial was to evaluate the activity of a imazalil single formulation (in 2 doses) and a thiabendazol single formulation, in comparison with untreated control, on the following pathogens:

- silver scurf (*Helminthosporium solani*);
- dry rot (*Fusarium solani var. coeruleum* and *Fusarium sulphureum*+ and -)*
- gangrene (*Phoma exigua var. foveata*)

* *Fusarium sulphureum*+ is resistant to thiabendazol
*Fusarium sulphureum*- is **not** resistant to thiabendazol

# 3. MATERIAL AND METHODS

## 3.1 Material

### 3.1.1 Potatoes

For this trial, ware potatoes were used (variety Bintje). These potatoes were grown on the ATO experimental farm "De Eest". The potatoes were harvested on September 10, 1998 and stored at ca. 10°C. On the end of September the potatoes were graded and per object ca. 400 kg (size 35-50 mm) was selected and stored in plastic boxes in a store room at 10°C till start of the trial, November 5, 1998.

### 3.1.2 Fungicides

In the trial the following chemicals were evaluated:

- Fungazil™ 100 SL, containing 100 g imazalil/l
- Storite™ flowable, containing 450 g thiabendazol/l

## 3.2 Methods

### 3.2.1 Artificial wounding and infection with fungi spores

Before the different *Fusarium* and *Phoma* fungi can be controlled, potatoes were inoculated with spores first. Two strains of *Fusarium sulphureum* were used:
*Fusarium sulphureum+* (resistant to thiabendazol) and *Fusarium sulphureum-* (**not** resistant to thiabendazol). The required spores were grown on agar in petri-dishes.
To distribute the spores over the potatoes, spores were set free from the agar medium with a spatula and some water and done in a defined quantity of water.
Before application/inoculation, the spore dilutions were well shaked to obtain a homogeneous liquid. For each spore suspension, a separate clean spatula was used.
The inoculation with *Fusarium solani var. coeruleum*, *Fusarium sulphureum* and *Phoma* spores was performed on November 5, 1998 at the ATO experimental farm "De Eest" in Nagele (The Netherlands).
Spore suspensions were sprayed by a spinning disc apparatus (type: Mafex 83-100) at a dose indicator level of the Mafex of 5.1, producing a fine mist over the potatoes at the dose of 1000 ml spore suspension per 1000 kg potatoes (or 1 ml spore suspension per kg potatoes).
Just before the artificial inoculation, the to be infected potatoes were wounded by passage over a rotating axis provided with pins of ca. 15 mm length. Wounding and inoculation were done in 1 line.
To obtain silver scurf, it was decided not to wound or inoculate in advance. The infection develops namely spontaneously during warm and humid storage conditions.

The following treatments (objects) were performed:

1. Wounded, inoculated but untreated potatoes

2. Wounded, inoculated and treated potatoes with Fungazil[tm] 100 SL at 100 ml/ton or 10 g active ingredient imazalil per ton

3. Wounded, inoculated and treated potatoes with Fungazil[tm] 100 SL at 150 ml/ton or 15 g active ingredient imazalil per ton

4. Wounded, inoculated and treated potatoes with Storite[tm] flowable at 90 ml/ton or 40.5 g active ingredient thiabendazol per ton

### 3.2.2 Application of fungicides

The application of fungicide products was performed one day (about 24 hours) after artificial wounding and infection (November 6, 1998). Also against silver scurf (for which the potatoes were not artificially wounded or inoculated) the treatment with chemicals was performed on November 6, 1998.
The chemicals were applied via a spinning disc apparatus (type: Mafex 83-100) fixed above a roller table. The chemicals were diluted with water to obtain a spray volume of 1 liter per ton of potatoes, or 1 ml/kg potatoes. The capacity of the roller table was fixed as 69 kg kg potatoes per minute so that 69 mm spray volume per minute must be applied.
Per chemical, 2 liters (2000 ml) spraying product (water + chemical) were prepared to have sufficient liquid to obtain the right spraying volume via the spinning disc to threat the potatoes and to control the exact spraying volume.
For the exact dosing of spraying volume for the different chemicals, the dose indicator of the Mafex varied between 4.5 to 4.6. During treatment, no problems were noted regarding passage of potatoes on the roller table (continious flow of potatoes in one layer) and the required doses (spray volume) of the chemicals was perfectly distributed on the rolling potatoes (passage of potatoes under a cone of "mist").

### 3.2.3 Storage (period and circumstances)

The potatoes for testing on attack of *Helminthosporium solani* (silver scurf), *Fusarium solani var. coeruleum*, *Fusarium sulphureum+*, *Fusarium sulphureum-* and *Phoma exigua var. foveata* were stored in separated storage rooms at the experimental farm "De Eest" and on ATO-DLO.
Per treatment/chemical and storage pathogen, 4 replicates were performed. Each replicate contained 22 to 24 kg potatoes and was stored in a plastic box. The boxes were statistically spread and stored in the different store rooms.
To stimulate the infections of *Helminthosporium solani* (silver scurf), *Fusarium solani var. coeruleum* and *Fusarium sulphureum+* and - a temperature of ca. 12°C was established during storage. For *Phoma exigua var. foveata*, it was decided to store at 8°C.
In the store room for silver scurf and in the store room for *Fusarium solani*, a relative humidity of > 90% was established as well.

## 3.3 Observations

### 3.3.1 Fungicidal activity against silver scurf

To evaluate the initial silver scurf infection, 6 samples (of 25 tubers each) were collected and evaluated at the start of the trial (November 5, 1998).
On January 6, 1999, 25 tubers of each replicate per treatment/chemical were collected to

perform an intermediate evaluation.
For the end-evaluation, samples were taken on March 8, 1999.
Always just before evaluation on silver scurf incidence, the tubers were washed.
Dependant of silver scurf incidence, tubers were classified.
The following classification system was used:

| | | | | | | |
|---|---|---|---|---|---|---|
| Class | I | | | 0 % | tuber surface infection - mean | 0 % |
| Class | II | 0 | - | 5 % | tuber surface infection - mean | 2.50 % |
| Class | III | 5 | - | 12.5% | tuber surface infection - mean | 8.75 % |
| Class | IV | 12.5 | - | 25 % | tuber surface infection - mean | 18.75 % |
| Class | V | 25 | - | 50 % | tuber surface infection - mean | 37.50 % |
| Class | VI | 50 | - | 75 % | tuber surface infection - mean | 62.50 % |
| Class | VII | 75 | - | 100 % | tuber surface infection - mean | 87.50 % |

To obtain a mean silver scurf percentage infection per sample, the following calculation was made:
Multiply number of tubers in the different classes by mean of infected tuber surface of the related class, add up these products and divide the total by the number of evaluated tubers (25). The silver scurf index can be 87.5 at a maximum (all the tubers of the sample in class VII).

### 3.3.2 Fungicidal activity against *Fusarium solani var. coeruleum*

The evaluation on *Fusarium solani var. coeruleum* was performed on February 25, 1999. For evaluation, total number of tubers and number of infected tubers were determined in all related objects (including replicates).

### 3.3.3 Fungicidal activity against *Fusarium sulphureum*+ and -

Evaluations were performed on February 26 and March 3, 1999. Also here, total number of tubers and number of infected tubers were determined in all related objects (including replicates).

### 3.3.4 Fungicidal activity against *Phoma exigua var. foveata*

Evaluations were performed on February 23, 1999. Also here, total number of tubers and number of infected tubers were determined in all related objects (including replicates).

### 3.4 Statistical analysis

To determine statistical differences between the used chemicals/doses and the untreated (regarding the disease incidence), a variance analysis was performed to obtain L.S.D. values (Least Significant Difference). The means of the chemicals/doses are significant different per disease, with a 95% confidence interval, in case a difference > L.S.D. value.

# 4. RESULTS

## 4.1 Storage

### 4.1.1 Ventilation, temperature and humidity

The used storage rooms were mechanically cooled. Temperature control and registration was all directed by computer.
The required storage temperatures are realised. Also the required high humidity in the store rooms for respectively silver scurf and *Fusarium solani* was well established.

## 4.2 Fungicidal activity

### 4.2.1. Silver scurf infection

In table 1 the results of intermediate evaluation are summarised.

Table 1: Infection by silver scurf on January 6, 1999

| Mean % silver scurf infected tuber surface | Object number | 3 | 2 | 4 | 1 |
|---|---|---|---|---|---|
| 20.9375 | 3 | | | | |
| 27.2250 | 2 | * | | | |
| 45.0500 | 4 | * | * | | |
| 50.4625 | 1 | * | * | * | |

L.S.D. = 1.5874 * significant differences

Initial infection with silver scurf, at start date of trial on November 5, 1998: 2.958 ± 0.210

From table 1, it can be concluded that after 2 months of storage time, all fungicide products/doses were significant active against silver scurf.
In between the fungicidal products, object 3 (Fungazil[tm] 100 SL, dose 150 ml/ton) gave the best effects.

The results of final evaluation on silver scurf are summarised in table 2.

Table 2: Silver scurf infection on March 6, 1999 (final evaluation)

| Mean % silver scurf infected tuber surface | Object number | 3 | 2 | 4 | 1 |
|---|---|---|---|---|---|
| 24.7625 | 3 | | | | |
| 30.5375 | 2 | * | | | |
| 49.5750 | 4 | * | * | | |
| 56.4000 | 1 | * | * | * | |

L.S.D. = 1.3511 * significant differences

Also at final evaluation, all fungicide products/doses gave a significant activity towards silver scurf.
In between the fungicidal products, object 3 (Fungazil[tm] 100 SL, dose 150 ml/ton) gave the best results against silver scurf. Also the dose of 100 ml of this product (object 2) gave a rather good result.

### 4.2.2 *Fusarium solani var. coeruleum* infection

Table 3 presents the results of *Fusarium solani var. coeruleum* infections.

Table 3: Infection *Fusarium solani var. coeruleum* on February 25, 1999

| Mean % *Fusarium solani* infected tubers | Object number | 3 | 2 | 4 | 1 |
|---|---|---|---|---|---|
| 3.5114 | 3 | | | | |
| 7.8004 | 2 | * | | | |
| 15.6402 | 4 | * | * | | |
| 27.6482 | 1 | * | * | * | |

L.S.D. = 0.5625 * significant differences

From the results in table 3, it is clear that all fungicide products/doses gave a significant activity towards *Fusarium solani var. coeruleum.*
In between the fungicidal products/doses, it was clear that Fungazil[tm] 100 SL gave the best results, especially the dose of 150 ml/ton.

### 4.2.3 *Fusarium sulphureum+* **infection** (resistant to thiabendazol)

In table 4, the results of *Fusarium sulphureum+* infections are presented.

Table 4: Infection by *Fusarium sulphureum+* on February 26, 1999

| Mean % *Fusarium sulphureum+* infected tubers | Object number | 3 | 2 | 4 | 1 |
|---|---|---|---|---|---|
| 2.6516 | 3 | | | | |
| 5.9628 | 2 | * | | | |
| 30.3357 | 4 | * | * | | |
| 30.5386 | 1 | * | * | | |

L.S.D. = 1.5171 * significant differences

From the results in table 4, it is clear that only the treatments of the product based on imazalil single (object 3 and 2) gave a significant activity towards *Fusarium sulphureum+*. In between the treatments, the dose of 150 ml/ton gave the best results.

### 4.2.4 *Fusarium sulphureum-* **infection** (non resistant to thiabendazol)

In table 5, results of *Fusarium sulphureum-* infections are presented.

Table 5: Infection by *Fusarium sulphureum-* on March 3, 1999

| Mean % *Fusarium sulphureum-* infected tubers | Object number | 3 | 2 | 4 | 1 |
|---|---|---|---|---|---|
| 2.6224 | 3 | | | | |
| 7.3082 | 2 | * | | | |
| 14.3386 | 4 | * | * | | |
| 22.7204 | 1 | * | * | * | |

L.S.D. = 0.5599 * significant differences

Against Fusarium sulphureum-, all fungicide treatments/doses again gave a significant activity. In between the fungicidal treatments/doses, those of Fungazil[tm] 100 SL, especially the dose of 150 ml/ton gave the best results.

### 4.2.5 *Phoma exigua var. foveata* infection

In table 6, results of *Phoma exigua var. foveata* infections are presented.

Table 6: Infection by *Phoma exigua var. foveata* on Februari 23, 1999

| Mean % *Phoma exigua var. foveata* infected tubers | Object number | 3 | 2 | 4 | 1 |
|---|---|---|---|---|---|
| 3.3936 | 3 | | | | |
| 9.2794 | 2 | * | | | |
| 14.7367 | 4 | * | * | | |
| 64.4263 | 1 | * | * | * | |

L.S.D. = 1.0870 * significant differences

Also against *Phoma exigua var. foveata*, all fungicide products/doses gave a significant activity.
In between the fungicidal treatments, it can be conclude that the activity from object 3 (Fungazil[tm] 100 SL was significantly higher compared to all other treatments.