Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Crop Protection 23 (2004) 1011–1014
Crop Protection
www.elsevier.com/locate/cropro

Short communication

Control of *Phytophthora cryptogea* (Pethyb.and Laff.) of witloof chicory (*Cichorium intybus* L.) with azoxystrobin applied before the forcing period

M. Benigni[a,*], G. Bompeix[b]

[a] *FNPE, Station Expérimentale de l'Endive, 2 Rue des Fleurs, 62 000 Arras, France*
[b] *Laboratoire de biochimie et pathologie végétales, Université Paris VI, C155, 4 Place Jussieu, 75230 Paris Cedex 05, France*

Abstract

Azoxystrobin at 0.25 g/m^2 applied by spraying roots achieved very good control of *Phytophthora cryptogea* an important pathogen of witloof chicory. Its efficacy was better than propamocarb-HCl at 7.22 g/m^2, with a reduction of 50–90% in the root infection rate at the end of the forcing period. In one trial, the efficacy of azoxystrobin was better than that obtained with fosetyl-Al at 12 g/m^2 .

Keywords: Chicory; Forcing period; *Phytophthora cryptogea*; Azoxystrobin

1. Introduction

Witloof chicory (*Cichorium intybus* L.) is a biannual plant that can produce a tuberized root during its first growth period (also called the vegetative period), from spring to fall. At the end of this period, the roots are harvested, stored in a cold room and forced in the dark in a hydroponic system. This is called the forcing period. Under these conditions, a white salad (etiolated bud) called the ‘‘chicon’’ grows in 21 days.

The Oomycete, *Phytophthora cryptogea* (Pethybridge and Lafferty) found in many stem or collar diseases in trees, shrubs and ornamental flowers (Smith et al., 1988) is also a major pathogen of witloof chicory. Primary infection occurs during the vegetative period in the field, generally without symptoms (Mestdagh, 1998). Necrosis on the roots appears in most cases during the forcing period when temperature (16–22°C at root level) and humidity are favourable for the formation and spreading of spores. The development of the disease is very quick, especially when hydroponic systems are used.

1.1. Disease control on witloof chicory

Preventive fungicide treatments are applied :

- when harvesting before root storage (root dipping, drenching or spraying), and
- when planting roots, before the forcing period (root-collar spraying).

Azoxystrobin is active on *Phytophthora* spp, essentially in terms of suppressing sporangium formation and reducing zoospore mobility (Matheron and Porchas, 2000). So, a formulation with 250 g of active ingredient per liter was tested at the *Station Expérimentale de l'Endive* in order to evaluate the efficacy of using azoxystrobin for the protection of witloof chicory.

2. Material and methods

2.1. Efficacy trials

Trials were carried out in randomized blocks with four replicates. A block consisted of a ‘‘layer’’ or ‘‘level’’ in the piles of small forcing boxes that were stacked up upon each other during the forcing period. The hybrid used during all trials was BEA (INRA/Ctifl). Each box contained 70–80 roots.

*Corresponding author. Tel.: +33-3-21-60-54-50; fax: +33-3-21-60-54-54.
E-mail addresses: benigni.fnpe@wanadoo.fr (M. Benigni), faivre@moka.ccr.jussieu.fr (G. Bompeix).

0261-2194/$ - see front matter
doi:10.1016/j.cropro.2004.03.006

Contamination: Regular and homogeneous contamination by *P. cryptogea* was obtained as follows (Benigni et al., 2000): infected roots were disposed among healthy roots at the beginning of the forcing period (2–3% infected roots compared to healthy roots). Infected roots had previously been contaminated using a sporangia suspension (about 5000 sp/ml) and subjected to forcing before being set among healthy roots.

Developmental conditions of the disease were identical to those encountered by growers in their own installations. The temperature of the nutritive solution, maintained at 21°C in order to foster the development of *P. cryptogea* (Erwin and Ribeiro, 1996), was also compatible with chicon development. Each watering circuit was independent from the others to avoid mixing of fungicides in a nutritive solution.

Studied fungicides modalities: Fungicides were sprayed on plant collars using 5 l of water per square meter (Table 2). In an initial approximation, the azoxystrobin usage rate for witloof chicory was derived from the trial results concerning other vegetables (Dacol et al., 1998). Azoxystrobin showed a good response between 200 and 250 g active ingredient/ha. One hectare of chicory represents approximately 35 tons of roots which can be planted over 350 m^2 before the forcing period. The highest usage rate at 0.5 g active ingredient per square meter (corresponding approximately to 100 kg of roots) was chosen to limit the risk of finding residues in the chicons.

Five trials were carried out at the *Station Expérimentale de l'Endive* using roots harvested in several plots in northern France. Azoxystrobin was compared with two fungicides registered to control *P. cryptogea* on witloof chicory : fosetyl-Al and propamocarb-HCl. Untreated roots were also used as a control.

Disease assessment: At the end of the forcing period, roots were halved longitudinally to record necrosis (Fig. 1), and chicons were harvested in order to assess the influence of contamination on the yield.

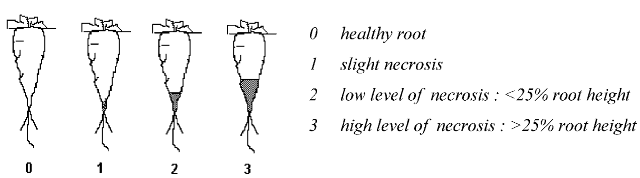

Fig. 1. Symptoms scale used to evaluate the intensity of contamination.

Table 1
Trial in Roye, 1998. results of contamination

	Healthy	High level necrosis
Azoxystrobin 0.20 g/m^2	94 a[a]	3
Fosetyl-Al 12 g/m^2	95 a	1
Untreated control	59 b	6

[a] Homogeneous group with 5% Newman–Keuls test (arcsin$\sqrt{p}$).

3. Results

3.1. Efficacy

In 1998, 41% of the untreated roots were infected (Table 1), but a low percentage of high-level necrosis was recorded. Azoxystrobin usage at 0.20 g/m^2 significantly reduced the rate of infected roots : only 6% of the plants were contaminated. This efficacy appears to be equivalent to that obtained with fosetyl-Al (5% of roots with necrosis).

In 1999, in two trials under conditions of high infection level—88% of untreated roots contaminated in January, and 100% in April (Table 2)—azoxystrobin achieved a significant improvement in root protection with less than 10% infected plants. In the January trial, the percentage of class 3, high necrosis roots, was reduced from 76% in the untreated batch down to 5–8% in the batches treated with azoxystrobin at 0.25 and 0.5 g active ingredient/m^2. Increasing the dosage to 0.5 g a.i/m^2 did not improve root protection (8% of roots in class 3). In this trial, azoxystrobin showed the same efficacy as the fosetyl-Al used as reference. In April, only 1% of the roots treated with azoxystrobin at 0.25 g/m^2 showed a high level of necrosis (class 3). Ninety nine percent of the roots were healthy. The protection was better than that obtained with fosetyl-Al (85% of roots without necrosis).

Table 2
Trials in Arras 1999, results of contamination

	January 1999		April 1999	
	Healthy	High-level necrosis	Healthy	High level necrosis
Azoxystrobin 0.25 g/m^2	95 a[a]	5 b	99 a	1 b
Azoxystrobin 0.50 g/m^2	92 a	8 b	not tested in this trial	
Fosetyl-Al 12 g/m^2	97 a	2 b	85 b	1 b
Untreated control	12 b	76 a	0 c	100 a

[a] Homogeneous group with 5% Newman–Keuls test (arcsin$\sqrt{p}$).

Table 3
Trials 2001, results of contamination

	Gruny		Arras	
	healthy	High-level necrosis	Healthy	High-level necrosis
Azoxystrobin 0.25 g/m^2	63 b[a]	2 c	92 a	1 c
Fosetyl-Al 12 g/m^2	not tested		92 a	1 c
Propamocarb-HCl 7.22 g/m^2	35 c	8 b	11 b	17 b
Contaminated control	0 d	99 a	0 c	96 a
Uncontaminated control	100 a	0 c	100 a	0 c

[a] Homogeneous group with 5% Newman–Keuls test (arcsin$\sqrt{p}$).

In 2001, azoxystrobin at 0.25 g/m^2 again caused a significant reduction in contamination. In Gruny, 37% of the plants treated with azoxystrobin were infected and only 2% showed high level of necrosis (Table 3). Under the same conditions, all control plants had developed the disease (99% with a high level of necrosis). Azoxystrobin provided a better control of *P.cryptogea* than Propamocarb-HCl (65% of the roots became contaminated). In Arras, the results confirmed that azoxystrobin provides a good control of *P.cryptogea* infection. Only 8% of the roots treated with 0.25 g/m^2 were contaminated when compared with 100% of untreated plants. This efficacy compares with the level obtained with fosetyl-Al but is better than that of propamocarb-HCl (89% of the roots contaminated).

Table 4
Roye 1998, chicon yield

	Chicon yield (kg/100 chicons)	
	Biomass	Marketable
Azoxystrobin 0.20 g/m^2	17.7 a[a]	13.6 a
Fosetyl-Al 12 g/m^2	17.3 a	13.4 a
Untreated control	16.4 b	12.8 b

[a] Homogeneous group with 5% Newman–Keuls test.

Table 5
Arras 1999, chicon yield

	Chicon yield (kg/100 chicons)			
	January 1999		April 1999	
	Biomass	Marketable	Biomass	Marketable
Azoxystrobin 0.25 g/m^2	19.7 a[a]	12.2 a	15.2 a	12.0 a
Azoxystrobin 0.50 g/m^2	20.7 a	13.7 a	Not tested	
Fosetyl-Al 12 g/m^2	20.4 a	13.4 a	13.8 b	10.7 b
Untreated control	14.1 b	8.6 b	5.0 c	1.8 c

[a] Homogeneous group with 5% Newman–Keuls test.

3.2. Chicon yield

In 1998, azoxystrobin treatment resulted in a 7% increase in biomass and a 5% increase in marketable categories when compared with untreated roots (Table 4).

In 1999, the protection achieved by azoxystrobin resulted in a significant improvement of the biomass (+43% in January, +300% in April compared with untreated roots). Roots treated with azoxystrobin achieved a chicon yield equivalent (January) or better (April) than that of roots treated with fosetyl-Al (Table 5). In the April trial we recorded a 10% increase in biomass and 12% in marketable categories.

In 2001 (Table 6), contamination by *P.cryptogea* caused an important loss in production. The difference in produced biomass between uncontaminated and contaminated control roots was 70% in Gruny and 35% in Arras. Under these conditions, azoxystrobin treatment resulted in chicon yield at the same level as that of uncontaminated plants (no significant difference).

Table 6
2001 trials, chicon yield

	Chicon yield (kg/100 chicons)			
	Gruny		Arras	
	Biomass	Marketable	Biomass	Marketable
Azoxystrobin 0.25 g/m^2	19.3 a[a]	15.1 a	18.2 a	14.9 a
Fosetyl-Al 12 g/m^2	not tested		17.0 a	14.0 a
Propamocarb-HCl 7.22 g/m^2	21.0 a	16.6 a	15.3 a	12.9 a
Untreated control	5.6 b	2.0 b	10.6 b	8.7 b
Untreated and uncontaminated control	18.8 a	14.8 a	16.4 a	13.3 a

[a] Homogeneous group with 5% Newman–Keuls test.

4. Conclusion

Five trials were carried out to test the protection of witloof chicory against *Phytophthora cryptogea* by azoxystrobin. These tests have shown that azoxystrobin provides a very good control of the disease. Sprayed on the roots at 0.20, 0.25 or 0.50 g/m^2 before the forcing period, azoxystrobin consistently and significantly reduced the percentage of infected roots. In treated batches of plants, the rate at which roots showed necrosis was between 35% and 99% less than that seen in untreated control batches. Even in trials with high disease development (100% of untreated roots contaminated), we counted less than 10% of infected roots.

Under these conditions, the protection supplied by azoxystrobin at 0.25 g/m^2 was equivalent (4 trials) or better (1 trial) than that obtained with fosetyl-Al at 12 g/m^2 (1% infected roots with azoxystrobin and 15% with fosetyl-Al).

Chicon yield was preserved and maintained at the same level as uncontaminated, untreated roots in plants contaminated by *P. cryptogea* and treated by azoxystrobin.

The use of azoxystrobin at 0.25 g/m^2 against *P. cryptogea* on chicory roots before the forcing period was officially authorized in France in March 2002.

References

Benigni, M., Laville, J., Bompeix, G., 2000. Control of *Phytophthora cryptogea* (Pethyb and Laff.) of witloof chicory (*Cichorium intybus* L.). Study of fluazinam efficacy applied before forcing period. Med. Fac. Landbouww University Gent, 65/2b, pp. 761–769.

Dacol, L., Gibbard, M., Hodson, M.O, Knight, S., 1998. Azoxystrobin—development on horticultural crops in Europe. Pests. Dis. 3, 843–848.

Erwin, D.C., Ribeiro, O.K., 1996. *Phytophthora cryptogea* Pethybridge and Lafferty (1919). *Phytophthora* Diseases Worldwide. APS Press, The American Phytopathological Society, St Paul, Minnesota, pp. 301–309.

Matheron, M.E., Porchas, M., 2000. Impact of azoxystrobin, dimethomorph, fluazinam, fosetyl-Al and metalaxyl on growth, sporulation and zoospore cyst germination of three *Phytophthora* spp. Plant Dis. 84 (4), 454–458.

Mestdagh, S., 1998. Détection de *Phytophthora cryptogea* en culture de Witloof. Mémoire de fin d'études ingénieur agronome défense des végétaux. Faculté universitaire des sciences agronomiques de Gembloux, p. 90.

Smith, I.M., Dunez, J., Lellot, R.A., Phillips, D.H., Archer, S.A., 1988. European Handbook of Plant Diseases(EMPPO Editions). Blackwell Scientific Publications, Oxford.