Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

SUSTAINABLE CROP PROTECTION
Results from the Pesticide Risk Reduction Program

A New Biofungicide to Manage Fusarium Head Blight of Wheat

Background

Fusarium head blight (FHB) (**Figure 1**), caused by *Fusarium graminearum*, is the most serious disease of wheat in North America, causing losses in excess of $1 billion to wheat industries. The pathogen also seriously infects a number of other crops and plants in Canada including barley, oats, rye, corn, canary seed and forage grasses. Fusarium head blight in wheat has been occurring in Eastern Canada and in Canadian Prairie Provinces for many years, causing reductions in wheat grain yield quality. The pathogen produces deoxynivalenol (DON) and other mycotoxins that contaminate grains, resulting in reduced feed consumption and weight gain by livestock, degraded baking quality of flour, and food safety concerns.

To date, the application of chemical fungicides remains the major strategy for the control of FHB. Widespread use of pesticides in agricultural production has led to increasing public concerns about environmental contamination, food safety and human health, and has contributed to the pathogen's resistance to fungicides. There is, therefore, interest in developing a more sustainable strategy which would involve integrating multiple approaches including use of biopesticides for FHB management. Agriculture and Agri-Food Canada (AAFC) Science and Technology Branch scientists have been researching and developing sustainable, integrated management solutions to FHB in Canada for a number of years. In 2009, the Pesticide Risk Reduction Program (PRRP) of AAFC's Pest Management Centre (PMC) established a FHB working group and has subsequently supported several projects for the management of FHB using reduced-risk management approaches including decision support tools and refined crop management practices to reduce disease pressure. To enhance the toolbox of reduced-risk solutions for the FHB management, the FHB working group has also been supportive of the development of promising biopesticides that could be integrated into FHB management programs for conventional and organic farms.

A New Biopesticide: *Clonostachys rosea* strain ACM 941

Clonostachys rosea strain ACM 941, discovered by AAFC scientist Allen Xue, is a mycoparasite fungus isolated from field pea leaves in Manitoba. The fungal strain (**Figure 2 A-C**), provides protection against a number of plant pathogens including *F. graminearum*. It causes a series of physiological changes in plant fungal pathogens, including inhibition of pathogen growth by coiling

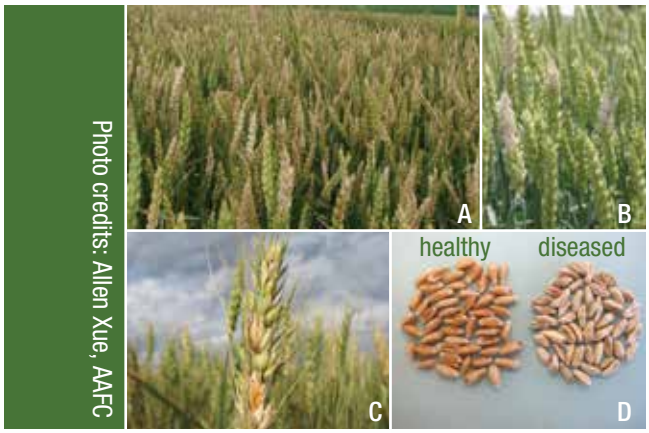

Figure 1. FHB symptoms: (**A** & **B**) bleaching of wheat spikelets in the field; (**C**) pathogen sporodochia (pink) on diseased glumes; (**D**) diseased seeds on the right appear shrunken and white when compared with healthy seeds.

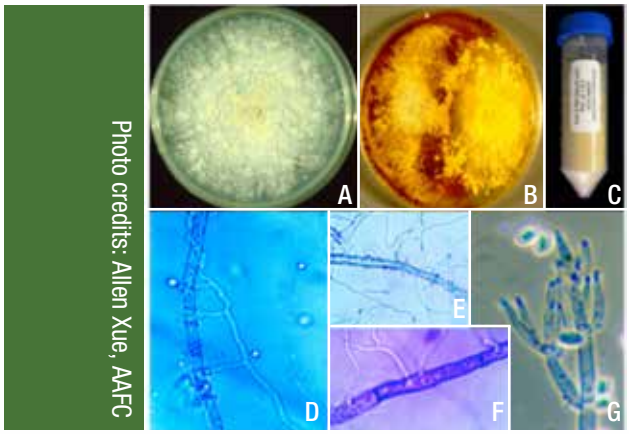

Figure 2. (A) Culture plate of *Clonostachys rosea* ACM 941; (**B**) dual-cultures of *Fusarium graminearum* (left) and ACM 941 (right); (**C**) ACM 941 product formulation; (**D-F**) ACM 941 is mycoparasite of many fungal pathogens; and (**G**) conidiophore with conidia of ACM 941.

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around and penetrating into pathogen mycelia (**Figure 2 D-F**). ACM 941 also effectively suppresses perithecial formation in the sexual stage (*Gibberella zeae*) of *F. graminearum* on wheat, corn and soybean residues, helping to reduce inoculum load for the following season.

Multi-stakeholder collaboration develops a promising discovery into a viable product

Since 2007, the PRRP has been working with Dr. Xue toward the registration and commercialization of this novel FHB control product. This work has involved close collaborations among AAFC's scientists and AAFC's Office of Intellectual Property and Commercialization, PRRP strategy and biopesticide coordinators, formulation developers at Cornell University, and contracted the product manufacturer, provincial experts and grower representatives, as well as pesticide regulators at Pest Management Regulatory Agency (PMRA) of Health Canada and the Environmental Protection Agency (EPA) in the United States.

A number of steps were taken in this collaborative process to establish ACM 941 as a viable biofungicide.

- The PRRP brought the discovery to the attention of industry stakeholders involved in the FHB working group through strategy consultations.
- ACM 941 formulation and product efficacy trials were conducted according to the guidance received from specialists at Health Canada's PMRA by teams involving AAFC scientists, Cornell University researchers and the contracted product manufacturer, with funding support from the PRRP.
- Five prototype formulations of ACM 941 were developed and tested through this collaboration and the most promising formulation was selected by Canadian growers and other stakeholders as the priority solution for the FHB management in wheat at the first annual Biopesticides Priority Setting Workshop in 2010.
- The PMC is facilitating efforts towards a joint regulatory submission of ACM 941 to the US-EPA and PMRA. In this process, PMRA and EPA have provided advice through the joint Canada/USA regulatory pre-submission consultation process. The PMC provides advice and assistance to the product registrant in developing the regulatory data package for the submission.

Field and greenhouse efficacy results

Efficacy and application rate range finding studies of ACM 941 (**Figure 3**) were conducted, as well as evaluations of the impact of different application approaches, and incorporation with other pest management techniques, including the use of wheat varieties resistant to FHB.

Key results from several trials indicate that:

- ACM 941 provided significant control of FHB, as indicated by one or more of the parameters measured;
- In general, efficacy was enhanced by increasing the ACM 941 concentration and the maximum concentration of 10^8 CFU/ml provided similar efficacy to commercial chemical fungicide Folicur (**Table 1**);
- The alternating application of ACM 941 and Folicur showed significantly better efficacy than two applications of ACM 941 alone, and was similar to the industry standard of two applications of Folicur, significantly reducing deoxynivalenol (DON) content (**Table 2**);
- ACM 941 was more effective in managing FHB in wheat cultivars which had a higher degree of resistance to the disease than in cultivars which are susceptible to the disease.

Figure 3. Efficacy and crop tolerance trials of *Clonostachys rosea* strain ACM 941 for the control of Fusarium head blight in wheat. (**A**) trials in greenhouse showing FHB suppression by ACM 941 (left row) compared with untreated (middle row) and Folicur treated (right row); (**B**) ACM 941 application in field trials; and (**C**) trial plots for evaluation of the disease control.

Details of these results are presented in Tables 1 & 2.

Table 1. Greenhouse and field evaluation of *Clonostachys rosea* strain ACM 941 efficacy for the control of Fusarium head blight in wheat†

Product	Treatment (CFU/ml)	AUDPC (% reduction)	FDK (% reduction)	Yield (% increase)	DON (% reduction)	
ACM 941	$1x10^4$	20.3	37.8	48.0	10.6	Greenhouse 2009
	$1 x10^5$	20.3	47.0	41.0	44.7	
	$1x10^7$	57.1	57.9	80.8	65.7	
	$1x10^8$	79.1	91.0	85.8	90.4	
Folicur (0.292 L/L)		67.2	90.0	84.7	94.2	
ACM 941	$1x10^5$	15.5	18.1	57.3	-	Greenhouse 2010
	$1x10^6$	27.1	40.8	68.4	-	
	$3x10^6$	34.0	33.6	68.4	8.8	
	$1x10^7$	73.8	74.4	86.7	78.5	
	$1x10^8$	83.2	91.6	88.1	95.1	
Folicur (0.292 L/L)		95.3	96.1	92.6	92.8	
ACM 941	$1x10^4$	16.2	30.9	1.7	26.5	Field 2009
	$1 x10^5$	20.5	19.8	-	26.9	
	$1x10^7$	31.2	28.6	-	34.7	
	$1x10^8$	43.3	43.2	7.0	28.7	
Folicur (0.292 L/L)		44.1	50.1	16.6	51.3	
ACM 941	$1x10^6$	27.9	25.0	-	24.8	Field 2010
	$3x10^7$	29.6	30.7	-	25.3	
	$1x10^8$	27.9	38.5	-	32.5	
Folicur (0.292 L/L)		40.3	39.8	-	21.4	

†AUDPC=area under the disease progress curve; FDK=Fusarium-damaged kernels; and DON=deoxynivalenol (a mycotoxin). Yield (% increase) indicates percent increase of yield compared to that of the untreated; and % reduction of AUDPC, FDK and DON indicates the percent reduction of these parameters compared with those of the untreated.

Table 2. Field efficacy evaluation of alternating application of fungicide Folicur with *Clonostachys rosea* strain ACM 941 for the control of Fusarium head blight in wheat†

Treatment	AUDPC (% reduction)	IS (% reduction)	FDK (% reduction)	DON (% reduction)
ACM 941 + ACM 941	26.1	28.3	41.0	4.4
ACM 941 + Folicur	67.0	91.6	62.6	64.8
Folicur + Folicur	70.5	92.6	59.0	56.0

†AUDPC = area under the disease progress curve; IS=percentage of infected spikelet; FDK=Fusarium-damaged kernels; and DON=deoxynivalenol. % reduction of AUDPC, IS, FDK and DON indicates percent reduction of these parameters compared with the untreated.

The results obtained through these various trials indicate a prominent role for ACM 941 in a disease management strategy which would integrate approaches including resistant cultivars, crop rotation for reduced inoculum build-up, and targeted use of chemical fungicides. The alternating application of ACM 941 with Folicur reduces the amount of chemical pesticide released into the environment by 50%, and can act as a strategy for managing the risk of development of pathogen resistance to Folicur. In addition, ACM 941 holds promise for organic growers since, as a biological fungicide, there is a likelihood that it will be determined to be acceptable for organic production systems.

Commercialization

ACM 941 was produced in a cost effective manner to exacting standards by means of a commercial production facility for agricultural microbial fermentation (**Figure 4**) and used for field and greenhouse trials.

Photo credits: Tobias Laengle, AAFC

Figure 4. Commercial production facility for agricultural microbial fermentation, where *Clonostachys rosea* strain ACM 941 was fermented in sufficient quantity for large scale field studies.

A number of companies are currently evaluating the technology and these potential commercial partners may submit proposals for licencing the technology from AAFC in 2013.

Next steps

The Pesticide Risk Reduction Program will continue to support projects to determine the best approach to use this product effectively in an on-farm setting.

A regulatory submission package will be prepared by a qualified registrant with assistance from PMC, for a joint review registration submission to Canadian and the United States regulatory authorities.

When the product becomes registered in Canada, on-farm demonstration trials and other outreach activities will be conducted to encourage uptake of this reduced-risk tool as part of an integrated, sustainable management approach by growers.

Thanks to the active participation of many stakeholders, the development of an AAFC discovery into an important and sustainable solution for FHB management is proceeding effectively, and is close to becoming a reality for Canadian growers.

For more details of ACM 941 research please contact Allen Xue, AAFC. For questions regarding product commercialization, please contact AAFC's Office of Intellectual Property and Commercialization (oipc-bpic@agr.gc.ca) or the Pesticide Risk Reduction Program of AAFC-PMC.

About the Pesticide Risk Reduction Program at Agriculture and Agri-Food Canada

The Pesticide Risk Reduction Program delivers viable solutions for Canadian growers to reduce pesticide risks in the agricultural and agri-food industry. In partnership with the Pest Management Regulatory Agency of Health Canada, the Program achieves this goal by coordinating and funding integrated pest management strategies developed through consultation with stakeholders and pest management experts.

The Pesticide Risk Reduction Program is actively pursuing the development and implementation of strategies which are key to reducing pesticide risks in the agricultural environment. To view the Program's current priorities and the issues being addressed, visit: www.agr.gc.ca/pmc. To consult other factsheets in this series, visit: www.agr.gc.ca/sustainable-crop-protection.

AAFC No. 12046E

Paru également en français sous le titre ***Nouveau biofongicide contre la fusariose de l'épi du blé***
For more information, reach us at www.agr.gc.ca or call us toll-free at 1-855-773-0241.