THE DEVELOPMENT OF SEED TREATMENT PRODUCTS BASED ON THE NEW FUNGICIDE IPCONAZOLE

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RESUMÉ

Ipconazole est un nouveau fongicide à large spectre appartenant au groupe des fongicides à base de triazole SBI. Il est actif contre les champignons pathogènes dans les grands groupes de Zygomycetes, Ascomycètes, Basidiomycètes et Deuteromycetes, et est actif en tant que traitement des semences contre majeur des pathogènes rencontrer sur grain et dans le sol. Ipconazole 15 ME a été développé sur des petites céréales en Europe, et les résultats présentés illustrent son activité élevée contre le charbon nu (*Ustilago nuda*) dans l'orge, la carie du blé (*Tilletia caries*) dans le blé, la rayure des feuilles (*Pyrenophora graminea*) dans l'orge et la fonte des semis (*Fusarium spp / Microdochium nivale*) dans le blé. Ipconazole 15 ME démontre également un très haut niveau de sélectivité des cultures.

Mots-clés : ipconazole, traitement de semences, cereales, seléctivité, maladie tranmise par les semences.

SUMMARY

Ipconazole is a new broad spectrum fungicide belonging to the triazole group of SBI fungicides. It has activity against pathogenic fungi in the major groups of Zygomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes, and is active as a seed treatment against major seed-borne and early soil-borne pathogens. Ipconazole 15 ME has been developed on small grain cereals in Europe. It is highly active against loose smut (*Ustilago nuda*) in barley, bunt (*Tilletia caries*) in wheat, leaf stripe (*Pyrenophora graminea*) in barley and seedling blights (*Fusarium spp/Microdochium nivale*) in wheat. Ipconazole 15 ME also demonstrates a very high level of crop selectivity.

Key words: ipconazole, seed treatment, cereal, seed-borne disease, selectivity

INTRODUCTION

Seed treatment continues to increase in importance as a first step in sustainable crop protection in global agriculture. Whilst this market is in many ways driven by the use of insecticides, there is also a need for the development of new and effective fungicides to partner the seed treatment insecticides on a wide range of crops. It is against this background that the fungicide ipconazole was discovered and developed. Ipconazole was first patented by Kureha Chemical Corporation, and the seed treatment uses have since been licensed for global development to Chemtura Corporation. It is one of the more recent additions to the triazole group of fungicides, with an SBI demethylation (DMI) mode of action at the cytochrome P450 site. Ipconazole controls target pathogens by both protectant and curative activity as it is both a contact and systemic fungicide. It has a broad spectrum of activity relative to some earlier triazoles and controls fungal pathogens in all classes except Oomycetes. Ipconazole is very selective, being safe to seed of both monocot and dicot crops. The selectivity and efficacy profiles of ipconazole fit it for use as a seed treatment on a wide range of crops; it is already registered in Japan, Latin America and USA, and has recently received provisional or full approval in several European countries, with the UK being the RMS for the EU.

This paper describes the development of the 15 ME (microemulsion) formulation of ipconazole on wheat and barley in Europe and illustrates its activity against the major seed-borne pathogens of wheat and barley.

METHODS AND MATERIALS

Ipconazole (1RS,2SR,5RS;1RS,2SR,5SR)-2-(4-chlorobenzyl)-5-isopropyl-1-(1*H*-1,2,4-triazol-=1-ylmethyl) cyclopentanol (IUPAC) was discovered and developed as a rice and wheat seed treatment in Japan by Kureha Chemical Corporation (Tateishi et al, 1998). Chemtura Corporation have since undertaken extensive formulation evaluation work in USA and Europe, culminating in the development of a range of stable commercial products, one of which is ipconazole 15g/l ME (microemulsion). This product is being targeted at the cereal seed treatment market in Europe. The ME technology gives a very low viscosity product which can be easily and accurately delivered to seed through existing commercial treatment equipment. (CLAPPERTON & LITTLEWOOD, 2009). Ipconazole 15 ME has a favourable toxicology profile, and is not classified.

The ipconazole ME product was applied to seed using a laboratory-scale batch treater such as the Rotogard R300, mostly pre-diluted with water. In most of the trials described, the rate of use was the label rate: 100ml/100kg on wheat (delivering 1.5g a.s.) and 133ml/100kg on barley (delivering 2g a.s.). Commercial seed treatment formulations of standard fungicides were applied in the same equipment for use as references in the trials.
Efficacy evaluations were done in small plot field trials, mostly with a plot size of 1.4-2 x 6-12 m and 4 replications, using seed infected with the relevant pathogen. All carried natural infections except for common bunt, where spores of *Tilletia caries* were mixed with the wheat seed (2g/kg seed) prior to chemical treatment. Control of soil-borne common bunt was assessed in trials where the plots were inoculated with a spore/sand mix prior to sowing the wheat seed. Efficacy against *Fusarium* spp and *M. nivale* was assessed soon after emergence (crop stage BBCH 12-13) by counting numbers of emerged plants per square meter to give a measure of seedling blight damage. Loose smut symptoms were assessed in barley by counting infected ears at BBCH 60-69. Bunt symptoms were assessed by sampling mature ears of wheat (BBCH 73-92) and counting the number of healthy and infected ears to calculate the percent infection.

Selectivity and seed safety was evaluated in field trials and in laboratory tests using healthy seed. Speed of emergence was assessed visually at BBCH 10, and then final plant emergence was assessed by counting seedlings in pairs of 0.5 or 1.0m row lengths at 5 locations per plot at BBCH 12-13. Laboratory tests were conducted according to ISTA Rules in rolled paper towels, with germination being assessed after 4 and 7 days incubation at 20℃ with an 8h photoperiod. This period was preceded by a pre-chill incubation at 5℃ to break dormancy in winter cereals.

RESULTS

Control of bunt of wheat

a) Seed-borne bunt

Trials were conducted over several seasons in Europe against soil-borne bunt, and data from six trials in the UK are shown in Table I. Ipconazole 15 ME at the UK label rate gave 99.9-100% control and was comparable to the prothioconazole standards, and this robust level of control has been repeated across the EU.

Table I –Efficacité d'ipconazole sur le carie transmisé par la semence.
Control of seed-borne bunt by seed treatment with ipconazole

Treatment	Rate g a.s. per 100kg	E06/ 13-3	EC06-SAC	XAC 1475	E06/ 33-1	E06/ 33-2	E06/ 33-3
Untreated % infection	-	17.6	12.4	16.8	3.3	10.1	16.7
Ipconazole	1.5	99.9	100	100	100	100	99.6
Prothioconazole	10	99.0	100	100	-	-	-
Prothioconazole + fluoxastrobin	5.625/ 5.625	-	-	-	100	99.4	100

b) Soil-borne bunt

Infection from soil-borne spores of common bunt can be relatively important in dry autumns in France and the eastern part of the UK, and a summary of five trials carried out with ipconazole in these countries in 2005 and 2006 is given in table II. Infection was very successful, with symptom expression ranging from 13.3 to 61%. Ipconazole at 2g a.s. per 100kg seed gave excellent control of this disease: control ranged from 99.4 to 100%, and was equivalent to prothioconazole and fludioxonil/difenoconazole standards and more effective in one trial than tebuconazole/triazoxide/imidacloprid.

Table II: Efficacité d'ipconazole sur le carie transmisé par le sol.
Control of soil-borne bunt by seed treatment with ipconazole

Treatment	Rate g a.s. per 100kg	UK 06/1	UK 06/2	France 05/1	France 05/2	France 05/3
Untreated % infection	-	26.6	15.2	61.0	49.7	13.3
Ipconazole	2	99.4	99.9	99.7	99.8	100
Prothioconazole	10	99.2	99.5	-	-	-
Product A	5/5/50	-	-	100	100	-
Product B	3/2/70	-	-	-	-	88.6

Product A = Fludioxonil + difenoconazole + anthraquinone
Product B = Tebuconazole + triazoxide + imidacloprid

c) Control of seedling blight of wheat

The effect of *Fusarium* spp and *M. nivale* on wheat plants and suppression of attack by seed treatments is a complex subject. The trials reported here are limited to the effects of seed-borne inocula on seedling emergence, and to the improvement in that emergence by the use of seed treatments.

Trials were conducted in the UK in 2006, 2007 and 2008 with a range of seed stocks infected with either pure *M. nivale* or a mixed infection of several species of *Fusarium* plus *M. nivale* as shown in Table III. Ipconazole at 1.5g gave good improvements in numbers of emerged plants, but its effect was less uniform than that of the best standard carboxin/thiram. There is some evidence that the activity of ipconazole is stronger against seed-borne *Fusarium* spp than against *M. nivale*, and this is borne out by the use of ipconazole on maize where its activity against *F. moniliforme* is very good.

Table III: Efficacité sur *M.nivale/Fusarium roseum.* Plantes levées (m/rang)
Field plot emergence counts (plants per m row) for *Fusarium* infected (*M. nivale* and *Fusarium* spp) winter wheat

Treatment	Rate g a.s. per 100kg	E06/ 05 -3R	E07/ 15 -2H	E07/ 25 -2R	E08/ 27-2	E08/ 28-2
% seed infection: M. nivale	-	39	25	21.5	31	76
% seed infection: Fusarium spp	-	0	65.1	70.5	24	0
Untreated	-	8.8	7.6	6.8	9.5	2.6
Ipconazole	1.5	14.9	11.1	9.5	13.8	8.1
Carboxin/thiram	60/60	19.6	-	-	15.6	10.8
Prothioconazole + fluoxastrobin	5.63/ 5.63	-	12.9	11.3	-	-
LSD (P=0.05)	-	-	1.38	1.48	1.88	1.88

d) Control of loose smut of barley

Many trials have been carried out to prove the efficacy of ipconazole against loose smut, and data from five trials from the UK and France in 2005 and 2006 are summarised in Table IV.

Table IV: Efficacité d'ipconazole sur le charbon nu de l'orge.
Control of loose smut in barley with ipconazole

Treatment	Rate g a.s. per 100kg	E05/ 18 -3 UK	XAC 1475 UK	A10193 /CT 2 UK	AF/8396 /CT2 FR	D27 ITS BS FR
Untreated infection	-	2.4%	20.8/ m^2	2.6%	2.9%	8.5%
Ipconazole	2	100	99.8	98.6	100	100
Tebuconazole	3	100	-	-	-	-
Carboxin/thiram	60/60	-	93.1	91.6	-	-
Prothioconazole	10	-	97.7	95.8	-	-
Fludioxonil Tebuconazole cyproconazole Anthraquinone	2.5/ 3/ 5/ 50	-	-	-	100	100

Ipconazole at 2g a.s. per 100kg seed gave a very high and uniform level of control of this important disease, which requires systemic activity to limit the growth of mycelium from the inoculum carried inside the embryo of the seed. Ipconazole was equal to the fludioxonil/tebuconazole/cyproconazole standard and superior to prothioconazole and carboxin/thiram.

f) Seed safety and crop selectivity

These parameters are vital when considering the development of any new seed treatment, and are particularly important for a triazole fungicide as this class of chemistry can also have plant growth regulation effects on emerging seedlings, particularly under adverse field conditions.

Ipconazole 15 ME has shown excellent crop safety on a range of cultivars of winter wheat and winter barley, and evaluation of this new fungicide at the label rate and twice the label rate in many field trials with healthy as well as infected seed has not indicated any reduction in speed of emergence nor final stand. Those field trials have included late drilling in difficult seed beds, and it seems that is evident that ipconazole has good crop safety under a wide range of conditions.

The excellent selectivity of ipconazole has been confirmed in laboratory seed safety tests, and typical data from rolled paper towel tests is presented in Table V. This shows that the germination of seed treated at 2N rates and stored for up to 12 months was not adversely affected by ipconazole: the germination of untreated seed had decreased slightly over this period, as is usual, but the germination of seed treated with ipconazole is often higher than that of the untreated.

Table V: Germes normaux (%) sur blé et orge d'hiver avant et après le stockage de les semences traité. Etude en laboratoire papier, moyenne de 12 lots.
Percent of normal germination of winter wheat and barley at the final assessment in paper towel tests before and after storage of seed, mean of 12 tests

Treatment	Wheat			Barley		
Storage period	0 days	180 days	360 days	0 days	180 days	360 days
Untreated	95.8	90.4	89.8	91.2	85.2	84.0
Ipconazole label rate	96.0	91.4	93.8	91.2	84.8	86.8
Ipconazole 2N label	95.2	91.8	94.2	90.6	83.8	87.6

DISCUSSION

The broad spectrum, systemic fungicidal activity of ipconazole linked to its excellent seed safety which were evident in early-stage evaluations have proved to be key benefits of the products developed in Europe for cereal seed treatment.

Ipconazole 15 ME is the first in a range of products being developed by Chemtura based on ipconazole, and is being registered and introduced across Europe as Rancona®. Dose-response trials defined the use rate on wheat to be 1.5g a.s. per 100kg seed, and the data presented in this paper demonstrate the full control of seed-borne common bunt given by ipconazole 15 ME at this rate. This rate, equivalent to 100ml of formulated product per 100kg seed, has also been shown to improve crop establishment of winter wheat by giving protection against seedling blight caused by seed-borne *Fusarium spp* and *M. nivale*. The same product but at the slightly higher rate of 2g a.s. (133ml of formulated product) also gives full control of soil-borne common bunt, even at high infection levels.

The use rate of ipconazole at 2g a.s. on winter barley has given complete or almost complete control of loose smut.

The ipconazole 15 ME product has been shown to be very safe to wheat and barley seed even at high rates and after storage of treated seed, and it is very selective on crops in the field.

CONCLUSION

Ipconazole 15 ME will therefore be a valuable addition to the range of seed treatment fungicides for small grain cereals in Europe.
This will be followed by the further introductions of other solo formulations and mixtures of ipconazole with other active ingredients for seed treatment use on cereals and other crops.
Other solo ipconazole products are registered in USA, Canada and Latin America. Mixtures with co-fungicides, including metalaxyl, which expand the spectrum of ipconazole to suit crops such as maize, peanuts and soybeans, are now registered in the USA and Argentina.

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