



FINISH®, a Physiological Approach to Cotton Boll Opening and Defoliation

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ABSTRACT

Dehiscence processes (boll opening, leaf shedding) in the cotton plant is mediated through a delicate balance of plant hormones. Ethylene promotes dehiscence primarily by stimulating the enzymes involved in the hydrolysis of insoluble pectates and cellulose that ensure the adherence of cells in the abscission zones. The growth promoting plant hormones auxin (IAA) and gibberelins antagonize this process. By associating ethephon (2-chloroethyl phosphonic acid) that releases ethylene directly into the plant tissues with cyclanilid, (1-[2,4-dichloro phenylaminocarbonyl] cyclopropane carboxylic acid) an auxin polar transport and gibberelic acid synthesis inhibitor in the Finish® product, superior boll opening and defoliation could be achieved. Finish® has been tested in numerous critical replicated trials and commercial applications during the past several years in most cotton growing countries worldwide. Mode of action is discussed and typical results presented.

Introduction

In cotton (*Gossypium spp.*) and other plant species, the dehiscence processes such as square, boll, leaf shedding (abscission) and boll opening (the splitting of carpels) is mediated by the balance between the plant hormones ethylene, gibberelins and auxin (IAA). Dehiscence is stimulated by a relatively high ethylene and low auxin and gibberelin concentrations in the organs or tissues involved. Ethylene inhibits auxin transport to some extent from its site of synthesis in the meristematic tissues and stimulates its break down by boosting the activity of IAA-oxidase and IAA-decarboxylase enzymes. More importantly, it also stimulates the activity of cellulase and pectinase enzymes (probably by increasing their transfer through the plasma membrane to the cell walls) that catalyze the hydrolysis of insoluble pectates and cellulose compounds in the abscission zones.

Dehiscence can be induced by exogenous ethylene application either in the form of gas (difficult in the field) or as liquid ethephon that is quickly absorbed by the plant tissues and broken down to release ethylene. This promotes the dehiscence process on its own and stimulates "in vivo" ethylene biosynthesis.

When roughly 50-60% of total boll load is open, the opening of remaining bolls is protracted because the ethylene concentration in the plants decreases. Ethephon (PREP®) application's maintain ethylene concentration in the plant at appropriate levels to promote the opening of all physiologically mature bolls.

The leaf abscission (defoliation) response to ethephon, while not negligible, is generally moderate compared to boll opening because in actively photosynthesizing leaves, relatively large amounts of so called "juvenile"

plant hormones (i.e. auxin, gibberelin) are synthesized and oppose the action of ethylene. Cyclanilide also boosts the defoliation effect of ethephon by inhibiting the synthesis and transport of auxin and reducing gibberelic acid synthesis.

Through combination of these two active compounds into a single formulation the Rhône Poulenc product FINISH™ was developed that stimulates both boll opening and defoliation.

Materials and Methods

FINISH® (60 g cyclanilide + 480 g ethephon ai's per liter) has been tested for the promotion of earlier, concentrated boll opening and defoliation over the past nine years in all major cotton growing countries. More than three hundred trials were laid out in a broad variety of conditions. In this paper, typical results of only critical trials are reported.

Trials were laid out in 3-6 replicates of locally important commercial varieties. Plot size was generally four rows by 10-15 m. Only the two inner rows in each plot were used for efficacy assessments. Defoliation and boll opening counts were made either along the entire length of rows or on 20 labeled plants in each plot. FINISH® was applied at various rates from 1.5 lt/ha up to 4.5 lt/ha usually in 0.5 lt/ha increments. Other treatments were PREP® and locally used standard defoliant products alone and/or in tank mixture. The spray volume was usually 150-300 lt/ha. The results were analyzed for statistical significance as appropriate.

Results and Discussion

The results obtained show that FINISH®, at equivalent active ingredient. Rates, ensured as good or often better boll opening than PREP® and as good or often better defoliation than the best defoliant (Tribufos,

Thidiazuron) whether these were used alone or in tank mixture with Prep®. FINISH® also provided a good inhibition of juvenile regrowth and its boll opening/defoliant efficacy was only slightly decreased at lower temperatures. Available space and time would not allow the reporting of all trials results. Typical examples are shown here.

In two European countries, Greece and Spain, a total of roughly 600 K hectares of well-managed cotton is grown. Varieties in which the FINISH® trials were conducted included Zeta 2, Crema 111, Coker 310, Korina, Nata and Corona (Tables 2, 3 and 4). Ethephon promotes boll opening on its own right in Australia so the investigation was primarily the defoliation efficacy of FINISH®. Application rates in Australia are probably relatively higher than elsewhere because of reduced efficacy of harvest aid products under arid conditions (Table 5).

The development of FINISH® product actually started in the United States in 1989 and it appeared interesting to include the results of an early trial (Table 6, 7). These encouraging early results have been confirmed by subsequent trials. Out of more than three hundred trials roughly half were conducted in the USA, setting up an important data base.

The effect of FINISH® on juvenile regrowth has also been investigated in several countries and the example from Brazil (Table 8) shows that it is practically as effective as Thidiazuron used in tank mixture with PREP®.

Conclusion and Recommendations

These examples clearly show that the results obtained with FINISH® in various cotton growing areas of the world are consistent with those generated in the USA during the same period. Hence, in countries where the registration approval process is somewhat quicker such as Argentina, it was launched commercially with great success in 1995. In the USA the EU was obtained in 1996 and the full commercial introduction took place in 1997. Currently, FINISH® is registered in all important cotton growing countries of the world, including Australia, Turkey and Spain.

In a number of instances during the course of the technical development work, the performance of FINISH® was less dependent on optimum temperature conditions than that of some other harvest aid products. This was confirmed through “controlled temperature” studies. Nevertheless both whole cotton metabolism and the response to FINISH® is, to some extent, temperature dependent. Current (international) rate recommendations, therefore, are based on the temperature at the time of treatment and forecasts for the following few days. The higher indicated rates are aimed at rank crops and generally difficult harvest conditions. In most situations the lower rate is appropriate.

Acknowledgment

The Rhône Poulenc Product development Teams across all cotton growing countries conducted the trial work and generated the considerable data base from which these examples were taken. Their work is acknowledged with appreciation.

Table 1. Boll opening and defoliation 7 DAT's with FINISH® and PREP® -Brazil 1994.

Treatments	Rates (g ai/ha)	% Boll opening	% Defoliation
UTC	----	33.3	36.2
FINISH	720+90	57.3	98.1
FINISH	960+120	62.1	98.0
FINISH	120+150	69.4	97.0
PREP	960	50.0	74.9
PREP	1200	57.0	87.8

Table 2. Cotton boll opening and defoliation with FINISH® 7 DAT's, Greece 1994.

Treatments	Rates (g ai/ha)	% Boll opening ₁	% Defoliation ₁
FINISH	960+120	81.7 ab	70.0 ab
FINISH	1200+150	80.0 ab	76.7 ab
FINISH	1440+180	86.7 a	83.3 a
Ethephon	1440	80 ab	53.3 b
Tribufos	1790	73.3 bc	76.7 ab
Ethephon+	1200+	66.7 c	85.0 a
Merphos	1430		
Ethephon +	1200+	78.3 ab	60.0 ab
Thidiazuron	125		
UTC	----	70.00 c	10.0 c

Table 3. Cotton boll opening and defoliation with FINISH® 14 DAT's, Greece 1995.

Treatments	Rates (g ai/ha)	% Boll opening ₁	% Defoliation ₁
FINISH	960+120	91.70 b	88.30 b
FINISH	1200+150	95.00 ab	91.67 ab
FINISH	1440+180	98.33 a	95.00 a
Ethephon	1440	93.33 b	78.33 c
Tribufos	1790	85.00 c	93.33 ab
Ethephon	1200+	93.33 b	95.00 a
Tribufos	1430		
Ethephon +	1200+	93.33 b	80.00 c
Thidiazuron	125		
UTC	----	83.33 c	20.00 d

Table 4. Cotton boll opening and defoliation with FINISH® 7 DAT's, Spain 1995.

Treatments	Rates	% Boll opening	% Defoliation
UTC	----	56.25	11.25
FINISH	2.5 l/ha	74.00	81.25
FINISH	3.0 l/ha	82.25	93.75
Merphos	2145 g/ha	60.00	96.25
Thidiazuron	175 g/ha	59.75	73.75

Table 5. Cotton var. CS 189+ defoliation with FINISH®, Australia 1995.

Treatments	Rates	% Defoliation ₁	
		7 DAT's	10 DAT's
UTC	---	20.3 ef	25.3 c
FINISH	3.0 l/ha	78.0 a	91.9 ab
FINISH	3.75 l/ha	81.0 a	94.6 a
FINISH	4.5 l/ha	87.0 a	95.2 a
PREP-720	2.0 l/ha	58.0 bc	82.8 ab
PREP-720	2.5 l/ha	61.7 b	84.7 ab
Thiadiazuron	0.125 kg/ha	37.8 de	77.2 b
Prep-720+	0.51 +	42.3 cd	80.4 b
Thiadiazuron	0.125 kg/ha		

Table 6. Cotton boll opening and defoliation with FINISH® -14DAT's, Alabama, USA 1989.

Treatments	Rates (g ai/ha)	% boll opening ₁	% defoliation ₁
Ethephon	1000	94.7 a	83.3 d
FINISH	1000 + 125	96.7 a	95.0 a
Ethephon+	1000 +	90.0 ab	90.0 ac
Tribufos	1680		
Ethephon+	1000 +	93.0 a	93.3 a
Thiadiazuron	110		
Thiadiazuron	110	84.0 ab	81.7 cd
Tribufos	1680	88.0 ab	93.3 a
UTC	-	76.3 b	55.0 e

Table 7. Boll opening and defoliation with FINISH® -7 DAT's, Louisiana, 1994.

Treatments	Rates	% boll opening	% defoliation
UTC		23	24
Ethrel	2.33 l/ha	72	78
Ethrel	3.5 l/ha	78	79
FINISH	2.33 l/ha	90	93
FINISH	3.5 l/ha	92	94
Ethrel+	2.33 l +	78	81
Thiadiazuron	70 g/ha		
Ethrel+	2.33 l +	73	79
Terbufos	560 g/ha		

Table 8. Cotton regrowth 18 DAT's with various harvest aid products, Brazil 1991.

Treatments	Rates 1, kg/ha	% regrowth:	
		Top	Bottom
UTC	---	8.33	3.67
PREP	1.39 l/ha	8.67	4.33
FINISH	2.08 l/ha	0.67	3.00
PREP+	1.39 l +		
Tribufos	075 kg/ha	2.67	2.33
Prep +	1.39 l +		
Thiadiazuron	0.10 kg/ha	0.00	3.33

Table 9. FINISH® rate recommendations.

Temperature °C	Finish rate l/ha
Above 35	1.5-2.0
35-31	2.0-2.5
30-26	2.5-3.0
25-21	3.0-3.5
20-17	3.5-4.0
Below 17: Wait for warmer weather!!	

1 Numbers followed by the same letter are not significantly different ($P \geq 0,05\%$)