



## Cotton Insect Pest Control with Indoxacarb: A Novel Insecticide

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### ABSTRACT

The cotton insect pest spectrum is dominated by the orders *Lepidoptera* and *Homoptera*. The status of different pests and control measures on cotton is dynamic and varies with geography and pest complex. Indoxacarb, a new broad-spectrum *Lepidoptera* control agent with some activity against *Homoptera* (e.g. *Empoasca* spp.), has a unique mode of action. Active at low use rates, indoxacarb provides effective control of major lepidopteran pests (*Helicoverpa armigera*, *Spodoptera exigua*, *S. littoralis*, *Earias* spp. and *Pectinophora gossypiella*) that attack cotton at all growth stages. Indoxacarb controls pests via stomach and contact activity. Laboratory and field results show consistent efficacy against larval stages of all target *Lepidoptera* species with additional ovicidal action on some species. Crop protection of 10-14 days is common and the product has a positive temperature correlation. Rapid feeding inhibition and consequent pest death (1-2 days) results in very high levels of crop protection. Indoxacarb is safety to beneficial insects and mites, favouring its inclusion in IPM systems.

### Introduction

Indoxacarb is a novel insect control agent in global development from DuPont de Nemours (Harder *et al.*, 1996). The insecticide exhibits a unique mode of action in blocking sodium channels in nerve cells and is active by both stomach and contact routes. Indoxacarb also exhibits a favourable positive temperature/toxicity correlation. Indoxacarb has a good environmental and toxicological profile. The insecticidal activity is predominantly against *Lepidoptera*, although insects of some other orders are also controlled. The purpose of this paper is to highlight the role of indoxacarb in the effective control of cotton pests while preserving beneficial insect (Mead-Briggs *et al.*, 1996) and mite populations for integrated control.

Cotton is often intensely treated with insecticides to maximize yields. This reflects the heavy infestation pressure throughout the crop's growth and development (Matthews, 1989). This use pattern has resulted in resistance to insecticides in many cases (Reynolds *et al.*, 1982). *Heliothis virescens* from the US and *Helicoverpa armigera* from Turkey, Israel, Australia, China, India, Pakistan, Thailand and South and West Africa, have all shown resistance to pyrethroid insecticides. Indoxacarb is not cross-resisted in any of these strains.

### Indoxacarb Activity Spectra in Different Countries

Indoxacarb exhibits broad-spectrum efficacy against a wide range of cotton pests. An important observation is the equivalent activity of indoxacarb against pest lepidopteran larvae of all instars. This is advantageous in cotton, allowing efficacious treatment against both young and established infestations.

The following tables cover the activity of indoxacarb on selected important cotton pests, including bollworms, leafworms, armyworms and jassids and its place in cotton in specific countries or regions. Knowledge of indoxacarb on cotton is based on more than 5 years of global testing on this crop. The formulation used in all these studies is the 150g/l SC (Avaunt®). In view of the diverse and dynamic nature of the cotton pest complex from various countries, mixtures of indoxacarb with other active ingredients are also being considered.

### Discussion

The data presented show the excellent efficacy of indoxacarb against cotton pests. As well as controlling major lepidopteran pests including *Heliothis*, *Spodoptera* and *Diparopsis*, this compound is also effective in the control of some sucking pests such as jassids, *Empoasca* spp. Its activity extends to all larval instars of lepidopteran pests, contributing to a flexible approach to integrated management systems. The novel mode of action confers a rapid cessation of feeding, normally within 2-6 hours, minimizing crop damage and manifested by increased yields. Numerous studies have shown that the important beneficial insects, namely chrysomelid, chrysopid and syrphid larvae are unaffected. Parasitic wasps, predatory mites and spiders are also less affected compared with other commonly used insecticides. The lack of effect on beneficial insects and mites is important in the control of residual populations of lepidoptera, as well as in the control of other pest species not controlled by indoxacarb (aphids, mites) whose populations may be contained by these beneficial insects.

The unique mode of action of indoxacarb makes it an ideal tool for resistance management providing and

effective and environmentally benign alternative to other materials already affected by resistance.

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**Table 1. Indoxacarb performance against larvae of the American bollworm, *Helicoverpa armigera*(Hübner) in Uzbekistan (3 different trial sites).**

Treatment	Rate (g ai/ha)	Site	% efficacy larvae		Mean control	
			7DAT	14DAT	7DAT	14DAT
Indoxacarb	37.5	A	72.7	63.5	73	71
		B	78.6	76.3		
		C	67.7	73.4		
	45	A	89.5	90.6	89.4	90.2
		B	89.2	95.7		
		C	89.5	84.3		
	52.5	A	81.2	100	87.2	93.4
		B	92.4	98.3		
		C	88.1	81.8		
Deltamethrin	17.5	A	80.3	58.5	82.4	68.7
		B	78.2	67.4		
		C	88.9	80.1		
Control (average number of larvae)	-	A	19.9	13.8	-	-
		B	22.7	18	-	-
		C	16.3	12.3	-	-

**Table 2. Indoxacarb performance (% efficacy) against larvae of the American bollworm, *Helicoverpa armigera*(Hübner) in Sudan.**

Treatment	Rate (g ai/ha)	2 DAT	7 DAT
Indoxacarb	25	100	100
	37.5	100	100
	50	100	100
Profenofos + Endosulfan	1.66+1.78*	95	99
Control**	-	42.5	51.4

\* l/ha \*\*average number of larvae per 100 plants. (Coccinellids and Chrysopids unaffected by indoxacarb treatment)

**Table 3. Indoxacarb performance against larvae of the American bollworm, *Helicoverpa armigera*(Hübner) in Iran.**

Treatment	Rate(g ai/ha)	% efficacy (DAT)			% damage (DAT)		
		2	5	8	2	5	8
Indoxacarb	25	65	80	93	3.8	3.5	1.5
	40	80	91	100	2.9	3	2
	50	83	94	100	1.9	1.9	0.8
Thiodicarb + Formothion	800+250	55	71	87	4.5	3.8	2.6
Control *	-	6.25	5.25	3.75	8.6	9.2	3.9

\*number of larvae/10plants/plot. Low effect on beneficial coccinellids and braconid wasps

**Table 4. Indoxacarb performance (% efficacy) against larvae of the American bollworm, *Helicoverpa armigera*(Hübner) in Israel.**

Treatment	Rate (g ai/ha)	3DAT	6DAT
Indoxacarb	45	51	72
	67.5	69	96
	90	93	100

Endosulfan	1225	85	81
Control (number of larvae per 1m row)	-	8.7	7.0

**Table 5. Indoxacarb performance against larvae of the cotton leafworm, *Spodoptera littoralis* (Boisduval) in Turkey.**

Treatment	Rate (g ai/ha)	% efficacy (larvae)			% damage		
		2DAT	4DAT	7DAT	2DAT	4DAT	7DAT
Indoxacarb	45	2.6	10.7	47.6	8.3	15	20
	52.5	20.5	57.3	78.4	5.3	7.7	8.3
	60	30.8	70.9	94.7	3.3	5.7	5.7
Chlorfluazuron	37.5	61.5	92.3	97.4	16	16.7	16.7
Control	-	13*	13*	13*	26.7**	55**	86.7**

\* number of larvae

\*\* % damage

**Table 6. Indoxacarb performance against larvae of the Beet armyworm, *Spodoptera exigua*(Hübner) in Turkey.**

Treatment	Rate (g ai/ha)	% efficacy			% damage		
		2DAT	3DAT	5DAT	2 DAT	3DAT	5DAT
Indoxacarb	45	96.3	100	100	2	2	2
	52.5	92.6	100	100	1.7	1.7	1.7
	60	88.9	100	100	1.3	1.3	1.3
Endosulfan	720	14.8	18.5	22.7	18.3	21.7	26.7
Control	-	10*	9*	9*	26.7**	31.7**	35**

\* number of larvae

\*\* % damage

**Table 7. Cotton protection in RSA .**

Treatment	Rate (g ai/ha)	<i>Helicoverpa</i>			<i>Diparopsis</i>			<i>Earias</i>		
		DAT (treatment #)			DAT (treatment #)			DAT (treatment #)		
		6(1)	6(2)	12(2)	6 (1)	6 (2)	12 (2)	6 (1)	6 (2)	12 (2)
Indoxacarb	25	4	4	2	0	3	3	2	0	3
	37.5	2	1	2	0	2	1	1	0	2
	50	3	1	2	1	1	2	1	1	3
Tralomethrin	9	1	2	1	1	1	4	0	0	1
Control*	-	10	14	6	0	11	6	1	6	7

\* number of larvae. No effects against adults and larvae of *Coccinellidae*, *Cheilomenes* spp., adults of *Chrysopidae*, larvae of *Syrphida*. There was a marked reduction in numbers of the orthopteran *Zonocerus elegans*.

**Table 8. Cotton protection in Sudan against jassids (*Empoasca* spp.).**

Treatment	Rate (g ai/ha)	Precount	2 DAT	7 DAT	14 DAT
Indoxacarb	25	6.8	0	5.4	12

	37.5	10.4	0.4	0	0
	50	7.2	0	4.6	3.5
Standard*	1.66 +1.78	1.2	0	7	5.8
Control	-	9	13	16.8	20.2

\*profenofos + endosulfan

No effect on Coccinellids or Chrysopids

**Table 9. Cotton protection in Benin against lepidopteran larvae.**

Treatment	Rate (gai/ha)	Earias insulana (# of larvae)	Sylepta derogata*				Yield (kg/ha)
			30.8	8.9	10.9	1.10	
Indoxacarb	15	21	0.3	1.4	3.0	1.2	822
	25	16	0	0.5	0.7	0.6	813
	40	13	0	0.1	0	0.1	1103
	60	5	0	0	0	0.3	1294
Carbosulfan	250	21	3.4	5.4	9.4	20.8	752
Triazophos	150	9	0.6	0	0	0	495
Deltamethrin	10	19	2.6	2.4	7.6	16.8	991
Control	-	60	8.1	12.6	18.4	47.2	431

\* % plant infestation