CARBINETM: FIELD PERFORMANCE AGAINST TARNISHED PLANT BUG AND APHID IN COTTON DURING 2007 Henry R. Mitchell FMC Corporation Louisville, MS Joseph Reed FMC Corporation

Joseph Reed FMC Corporation North Little Rock, AR Houston Joost FMC Corporation Philadelphia, PA

Abstract

Carbine TM , is a selective foliar-applied cotton insecticide for the control of *Lygus* species and aphids in cotton. The active ingredient, flonicamid, belongs to the pyridinecarboxamide class of chemistry. Carbine is a valuable tool for resistance management since it has not demonstrated any cross-resistance to existing classes of chemistry. Carbine is also soft on beneficial arthropods and fits well in IPM programs. Field-test during 2007 continue to demonstrate excellent activity against both nymph and adult plant bugs (*Lygus lineolaris* Palisot de Beavois and *L. hesperus* Knight) comparable to the neonicotinoid standards. Against cotton aphid (*Aphis gossypii* Glover), Carbine continues to exhibit excellent initial and extended residual activity generally superior to the older aphicides and equivalent to or better than the neonicotinoids. Further research has also demonstrated potential activity against tobacco thrips (*Frankliniella spp.*). Research continues across the cotton belt to further define insect spectrum and best use recommendations.

Introduction

Carbine, flonicamid, received US EPA registration in the fall of 2005 and was commercially introduced in cotton during the 2006 season. Carbine belongs to the class of chemistry, pyridinecarboxamide. It is highly specific for sucking pests with a novel mode of action and does not affect the target sites associated with any of the other known insecticide classes (Hancock, et. al. 2003; Hancock, 2004; Treacy, 2005). Carbine has also been shown to exhibit no cross-resistance with any existing chemistries thus making it an excellent choice for use in an insecticide resistance management program (Treacy, 2005). In addition, research has demonstrated that Carbine, at maximum field use rates, has minimal to no impact on beneficial arthropods (Treacy, 2005). Due to the minimal impact on beneficial arthropods, extreme selectivity to only pest species and lack of cross-resistance to other cotton pest management classes of chemistry, Carbine has tremendous potential to be utilized in an integrated pest management program.

FMC Corporation has conducted development activities with Carbine in cotton since 2001. Field trials have demonstrated excellent efficacy against cotton aphid (*Aphis gossypii* Glover) with results showing control at 5-7 days after treatment and, depending on rate, residual control up to 21 days (Hancock, et. al. 2003; Parks and Norman, 2003; Hancock, 2004; Long, et. al. 2005; Treacy and Mize, 2005, Mitchell, et. al. 2006; Heim, et. al. 2007). Tarnished plant bug (*Lugus lineolaris* Palisot de Beavois) and western plant bug (*L. hesperus* Knight) activity was also demonstrated in trials conducted in 2003-2006 (Greene and Caps, 2003; Hancock, 2004; Treacy and Mize, 2005; Mitchell, et. al. 2006; Heim, et. al. 2007). The key objective of the 2007 FMC research program was to further substantiate the activity of Carbine on the plant bug complex and aphid in cotton. These additional results will be presented here.

Materials and Methods

Field Trials – Aphids

Field trials have been conducted on cotton aphid from 2001 to 2007 at various rates up to 0.088 lb ai/A. Trials were located across the cotton belt with contract research, university and FMC internal researchers. Field trials were planted to both Bt and non-Bt varieties of cotton in minimum and conventional tillage systems. All trials utilized replicated experimental designs, typically a randomized complete block with a minimum of three replications. Application methods were generally those used in small plot research including CO^2 backpack and self-propelled

spray equipment. Either hollow-cone or flat fan type nozzles, usually two per row, were used. Application volume ranged primarily between 8 and 15 gallons per acre. The majority of the trials employed a single application of the various insecticide treatments. Plot size varied among trials but usually was 2 to 6 rows x 50 to 100 feet in length. Cotton aphid field trials were initiated at local threshold levels or later. Post treatment cotton aphid evaluations were taken at approximately 3, 7, and 15 days after application to determine initial and residual efficacy of Carbine in comparison to comparative standards. Untreated controls were utilized throughout. Assessments of insecticide efficacy were generally based on number of pest per unit area (square inch, leaf, terminal) and ranged for one to 10.

Field Trials – Plant Bugs

Field trials have been conducted on tarnished plant bug and cotton fleahopper from 2003 to 2007 at various rates up to 0.088 lb ai/A. Trials were located in key states across the cotton belt which demonstrated consistent and increasing yield and quality losses from this pest. Trials were conducted by either contract research or university researchers. Trials were planted to both Bt and non-Bt varieties of cotton in minimum and conventional tillage systems and typically conducted with a minimum of 4 replications in a randomized complete block design. Applications methods were generally those used in small plot research including backpack and self-propelled spray equipment using either hollow-cone or flat-fan nozzles that delivered an 8 to 15 gallon per acre spray volume. Plot size utilized standard small plot parameters, generally 4 to 6 rows x 50 to 100 feet in length. Trials were initiated at local threshold levels. Post treatment evaluations were taken approximately 3, 7, and 10 days after each application. Plant bug assessments were made with varying methods, but generally were conducted using beat cloth or sweep net sampling techniques. Untreated controls were utilized throughout.

Results and Discussion

Carbine efficacy trials continue to demonstrate the effectiveness against cotton aphid and various plant bug species. On cotton aphid, the research summary across the six years show that flonicamid at rates of 0.054 to 0.063 lb ai/a provide initial and residual control from 3 to 14 days after application that is comparable to the competitive standards thiamethoxam (0.047 lb ai/a) and acetamiprid (0.05 lb ai/a), and superior in performance when compared to imidicloprid (0.047 lb ai/a) (Table 1). Further studies in MS and TX during the 2007 season continue to support the excellent activity of Carbine against cotton aphid (Table 2 and 3).

Carbine research on plant bug efficacy in cotton continues to demonstrate its effectiveness. Results during 2007 continue to demonstrate effective levels of control at rates of 0.053 and 0.088 lb ai/a equal to that of thiamethoxam, acephate, imidacloprid, and acetamiprid (Table 4 and 5). Lower rates of Carbine (0.044 to 0.053 lb ai/a) continue to demonstrate effective control of cotton fleahopper as well (Table 6 and 7).

Further research indicates the potential for activity with Carbine against the tobacco thrips. Research conducted during 2006 and 2007 indicate potential activity at rates ranging from 0.031 to 0.044 lb ai/a (1.0 to 1.4 oz/a formulated) (Table 8, 9, 10, 11 and 12). Although there is currently on registration for the use of Carbine against tobacco thrips, future studies could support this as an area of label expansion.

Conclusions

Results presented here clearly demonstrate the significant potential Carbine will provide as an effective pest management tool for cotton plant bug, fleahopper and aphid control. Not only is flonicamid an effective pest management tool, it offers the additional benefits of exceptional safety and conservation of beneficial predators and parasites, minimal environmental and non-target impact, and an idea fit in an insecticide resistance management program due to the unique mode of action.

Acknowledgements

The author extends sincere appreciation to the university researchers participating in the Carbine (flonicamid) Cotton Field Development Program across the southern regions of the US.

References

Green, J.K. and C. Caps. 2003. Control options for tarnished plant bug, *Lygus lineolaris. in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, 1473-1475.

Hancock, H.G., M. de Lourdes Fustaino and M. Morita. 2003. Flonicamid (F1785, IKI220): Novel chemistry for cotton and other crops. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, Vol. II:83-88.

Hancock, H.G. 2004. Field performance of flonicamid (F1785) in cotton. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, 1629-1636.

Heim, C., H.R. Mitchell and Y. Ortega. 2007. CarbineTM: Results from 2006 grower demonstration program for control of plant bugs and aphids. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, 1643-1647.

Long, D.W., J.T. Bahr, P.E. Rensner and C.A. Staetz. 2005. Rainfastness and residual activity of flonicamid on cotton. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, 1544-1549.

Mitchell, H.R., J. Reed and C. Heim. 2006. CarbineTM: Field performance against tarnished plant bug and aphid in Mid-South cotton during 2005. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, 1562-1567.

Parker, R.D. and J.W. Norman. 2003. Evaluation of new insecticides for control of cotton aphid in the coastal bend and lower Rio Grande Valley of Texas. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, Vol. II 1448-1450.

Treacy, K.M. 2005. CarbineTM (flonicamid): Novel insecticide chemistry for cotton. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, 98-99.

Treacy, K.M. and T. Mize. 2005. CarbineTM – A new insecticide for foliar pest management in cotton. *in* Proceedings of the Beltwide Cotton Conference, Nation Cotton Council of America, 1709-1712.

Table 1. Efficacy of Carbine versus neonicotinoid insecticides against cotton aphid (Aphis gossypii) in cotton.^a

		Percent Control ^b							
Treatment ^d	lb ai/a	2-3 °	$(n)^{e}$	5-7	(n)	10-14	(n)		
Carbine	0.054	79	(32)	90	(31)	85	(27)		
Carbine	0.063	87	(23)	96	(28)	95	(31)		
Centric	0.047	76	(30)	85	(29)	74	(28)		
Intruder	0.05	87	(31)	90	(25)	92	(24)		
Trimax	0.047	70	(18)	71	(17)	66	(09)		

^a Data from replicated field trials conducted between 2002 and 2007 in North

America contract, university and FMC research.

^b Percent control based on untreated.

^c Days after application.

^d Treatments applied at local threshold.

^e Number of observations in mean.

		No. Ap			
Treatment ^b	oz/a	Upper Canopy	Lower Canopy	Total	
Carbine	1.5	3.0 b ^c	20.7 b	11.8 bc	
Intruder	0.75	0.7 b	17.0 b	8.8 c	
Centric	1.7	6.7 b	37.5 ab	22.1 bc	
Trimax	1.7	10.9 b	45.8 a	28.3 b	
Untreated		44.6 a	54.7 a	49.6 a	

Table 2. Efficacy of Carbine against cotton aphid (Aphis gossypii) in cotton. Dr. Kurns, TX, 2007

^a Days after treatment (dat).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (lsd p=0.05)

Table 3.	Efficacy	y of Carbine a	against co	otton aphid	(Aphis	gossypi	i) in cotton	. Dr. Catch	10t, MS,	2007
					_	_				

		No. Aphi		
Treatment ^b	oz/a	3dat ^a	6dat	
Intruder	0.75	22.8 b ^c	238.8 b	
Centric	1.7	187.8 b	309.0 b	
Trimax Pro	1.7	124.0 b	253.8 b	
Carbine	1.5	160.8 b	165.5 b	
Untreated		1127.8 a	745.5 a	

^a Days after treatment (dat).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (lsd p=0.10)

		No. 1PB nymphs Per 10 Row Ft.						
Treatment ^b	oz/a	4dat-A ^a	6dat-B					
Carbine	1.7	9.0 bc ^c	1.5 b					
Carbine	2.8	7.0 bc	1.8 b					
Trimax Pro	1.8	8.3 bc	6.5 b					
Vydate	12.8	7.3 bc	2.5 b					
Intruder	1.1	12.5 ab	1.5 b					
Centric	2.0	8.3 bc	4.8 b					
Orthene	16.0	3.8 c	6.3 b					
Untreated		18.8 a	15.8 a					

Table 4. Efficacy of Carbine against Tarnished Plant Bug (Lygus lineolaris) in cotton. Dr. Catchot, MS, 2007

^a Days after treatment (dat) A (first application) and B (second application). ^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (lsd p=0.10)

Table 5. Efficacy of Carbine against Tarnished Plant Bug (Lygus lineolaris) in cotton. Dr. Catchot, MS, 2007

	_	No. TPB nymphs Per 10 Row Ft.						
Treatment ^b	oz/a	5dat-A ^a	6dat-B					
Carbine	2.8	2.0 b ^c	1.3 b					
Trimax Pro	1.8	5.0 b	0.8 b					
Vydate	17.0	2.3 b	1.0b					
Bidrin	8.0	4.5 b	0.8 b					
Centric	2.5	1.8 b	0.8 b					
Orthene	16.0	1.3 b	1.0 b					
Untreated		10.8 a	12.8 a					

^a Days after treatment (dat) A (first application) and B (second application).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (lsd p=0.10)

		No	o. CFH Per 10 Sw	eeps	
Treatment ^b	oz/a	4dat ^a	7dat	13dat	% Sq. Retention 13dat
Carbine	1.4	0.3 °	0.4	0.6	93
Centric	2.5	0.5	0.3	1.0	87
Intruder	0.8	0.0	1.6	1.1	92
Trimax Pro	0.9	0.3	0.1	1.1	92
Untreated		12.1	10.5	5.8	72

Table 6. Efficacy of Carbine against Cotton Fleahopper (Pseudatomoscelis seriatus) in cotton. Dr. Banks, OK, 2006

^a Days after treatment (dat).

^b Treatments applied at local threshold.

^c Average of two replicated field trials.

Table 7. Efficacy of Carbine against Cotton Fleahopper (Pseudatomoscelis seriatus) in cotton. Dr. Kurns, TX, 2007

		No. CFH Per 10 Plants					
Treatment ^b	oz/a	3dat ^a	7dat				
Carbine	1.7	0.3 a ^c	1.0 b				
Trimax Pro	1.25	0.0 a	1.3 b				
Intruder	1.0	0.5 a	0.8 b				
Centric	1.5	0.3 a	0.3 b				
Orthene	4.0	0.0 a	1.0 b				
Untreated		0.8 a	3.5 a				

^a Days after treatment (dat).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (lsd p=0.10)

	No. Thrips Per 10 Plants								
Treatment ^b	oz/a	3dat ^a	7dat						
Carbine	0.8	11.0 b ^c	20.3 a						
Carbine	1.2	6.5 bc	9.0 bc						
Carbine	1.6	6.0 bc	12.3 b						
Centric	1.9	1.0 c	11.5 b						
Bidrin	3.2	1.0 c	1.8 c						
Untreated		28.8 a	23.5 a						

Table 8. Efficacy of Carbine against Thrips (*Frankliniella spp.*) in cotton. Dr. Leonard, LA, 2006

^a Days after treatment (dat).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (dmrt p=0.05)

Table 9. Efficacy of Carbine against Thrips (Frankliniella spp.) in cotton. Dr. Lorenz, AR, 2007

	No. Thrips Per 10 Plants						
oz/a	6dat-A ^a	3dat-B	7dat-B				
1.1	12 a ^c	6 b	21 b				
1.5	23 a	21 b	93 ab				
8.0	11 a	12 b	38 b				
4.0	12 a	7 b	71 ab				
4.4	16 a	13 b	17 b				
	15 a	67 a	126 a				
	oz/a 1.1 1.5 8.0 4.0 4.4	$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	No. Thrips Per 10 Pla oz/a 6dat-A ^a 3dat-B 1.1 12 a ^c 6 b 1.5 23 a 21 b 8.0 11 a 12 b 4.0 12 a 7 b 4.4 16 a 13 b 15 a 67 a	No. Thrips Per 10 Plants oz/a 6dat-A ^a 3dat-B 7dat-B 1.1 12 a ^c 6 b 21 b 1.5 23 a 21 b 93 ab 8.0 11 a 12 b 38 b 4.0 12 a 7 b 71 ab 4.4 16 a 13 b 17 b 15 a 67 a 126 a 126 a			

^a Days after treatment (dat) A (first application) and B (second application).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (snk p=0.10)

		No. Thrips Per 5 Plants					
Treatment ^b	oz/a	4dat-A ^a	3dat-B				
Carbine	1.0	15.0 bc ^c	7.0 c				
Orthene	3.5	10.8 c	9.0 bc				
Bidrin	2.5	19.0 ab	14.0 b				
Dimethoate	8.0	23.5 a	10.8 bc				
Untreated		23.5 a	20.8 a				

Table 10. Efficacy of Carbine against Thrips (Frankliniella spp.) in cotton. Dr. Stewart, TN, 2007

^a Days after treatment (dat) A (first application) and B (second application).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (lsd p=0.05)

Table 11.	Efficacy	y of	Carbine	against	Thrip	os ((Frankliniella s	sp	p.)) in cotton.	Dr.	Leonard,	LA,	2007
				-	-									

		No. Thrips Per 10 Plants			
Treatment ^b	oz/a	3dat-A ^a	7dat-A	7dat-B	
Carbine	1.4	40 b ^c	26 b	5 b	
Orthene	3.2	5 c	12 c	2 b	
Intruder	0.6	14 c	10 c	4 b	
Untreated		103 a	61 a	17 a	

^a Days after treatment (dat) A (first application) and B (second application). ^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (dmrt p=0.05)

Table 12. Efficacy of Carbine against Thrips (Frankliniella spp.) in cotton. Dr. Catchot, MS, 2007

	_	No. Thrips Per 5 Plants		
Treatment ^b	oz/a	2dat ^a	6dat	
Carbine	1.4	11.8 bc ^c	51.3 a	
Orthene	3.6	7.5 c	11.8 b	
Bidrin	3.2	13.8 bc	21.0 ab	
Untreated		23.3 a	44.0 a	

^a Days after treatment (dat).

^b Treatments applied at local threshold.

^c Means followed by the same letter do not significantly differ (lsd p=0.10)