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RAINFASTNESS AND RESIDUAL ACTIVITY OF FLONICAMID ON COTTON

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Abstract

Flonicamid has been in co-development in the Americas since late 2001 by FMC Corporation and Ishihara Sangyo Kaisha, Ltd. for the control of aphids and other piercing/sucking insects. Results of a small plot field trial revealed that simulated rain events occurring at 5 hours after application, or later, do not reduce flonicamid's control of cotton aphids, *Aphis gossypii.* Results of a second rainfastness field-to-laboratory trial employing over-head irrigation from a lateral irrigation unit demonstrated that flonicamid is rainfast within 2 hours of application or less. Results of two laboratory bioassays suggest that flonicamid enters the plant and is available for translaminar activity very rapidly and wash-off of remaining leaf surface flonicamid residue has no impact on residual aphid control. Results of two field-to-laboratory bioassays using a laboratory strain of cotton aphid showed that flonicamid provides a good level of residual control of 14 days or greater. The residual control achieved with flonicamid was greater than Provado® 1.6F, Centric® 25WP, or Assail® 70WP. These results suggest that the residual control of a natural population of cotton aphids with flonicamid (average 90% residual control from 0.062 lb ai/A rate out to 18-22 days) is a combination of active ingredient residual activity and slow pest population resurgence. The excellent initial activity and apparent long residual efficacy of flonicamid on cotton aphid could potentially reduce the number of needed aphicide applications. These attributes, along with others such as safety to beneficials and novel mode of action, make flonicamid a sound choice for inclusion in a cotton pest management program.

Introduction

Flonicamid has been in co-development in the Americas since late 2001 by FMC Corporation and Ishihara Sangyo Kaisha, Ltd. for the control of aphids and other piercing/sucking insects. Flonicamid, a pyridinecarboximide, is highly specific for sucking pests and possesses a novel mode of action distinct from the neonicotinoids (Morita et al. 2000; Hancock et al. 2003). Since acquiring the development and marketing rights to flonicamid, FMC has conducted extensive field research trials to determine its level and extent of insecticidal activity among various pest species. An overall analysis across three years of research (35 North American field trials) provided a robust comparison with neonicotinoids, organophosphate and carbamate insecticides (Table 1). These results defined flonicamid as a highly effective and long-lasting cotton aphicide that was generally superior to the standards used in these trials.

One objective of the following research trials was to determine the impact of rainfall upon the performance of flonicamid on cotton aphids. A second objective was to further define the apparent lengthy residual control of cotton aphids on cotton.

Materials and Methods

Rainfastness

Trial one: A small plot field efficacy trial was conducted to evaluate time of exposure prior to a rain event on efficacy of flonicamid on cotton aphid. Cotton, Delta Pine 5690RR, was planted on April 30, 2003 into a sandy loam soil at FMC's Southeast Research Station near Tifton, Georgia. The treatments were replicated four times in a RCB design and consisted of 8 rows 50 feet long on three foot row spacing with 10 buffer rows between plots. Flonicamid 50WG was applied at a rate of 0.054 lb ai/A at 40 psi in 10 gallons of water per acre using a high-clearance sprayer equipped with two TX-6 hollow cone nozzles per row. The treatments were applied on 24 June to

cotton, with an average of thirty aphids per 5th-node leaf. The respective plots received 1.0 inch of overhead irrigation at 5, 24, and 72 hours after treatment. At 96 hours after treatment, 0.40 inches of natural rainfall occurred over all plots. On 01, 08, 15, 22 and 29 July, ten 5th-node leaves were randomly selected from each plot and placed into a one-quart ball jar containing a mixture of water, soap and sodium hypochlorite solution. In the laboratory, contents of the jar were dumped into a 100-mesh sieve and subjected to filtering process. A dissecting scope was used to count all live aphids. The treatment data was subjected to analysis of variance and the means were separated using Student-Newman-Keuls Test (P=0.05).

Trial two: A laboratory bioassay was conducted to evaluate effect of time of wash off on the translaminar activity of flonicamid. Cotton plants were grown to the four-leaf stage. All treatments were applied to a single leaf, usually the largest available leaf, and typically the second true leaf from the bottom of the plant. Flonicamid 50SG was applied at 100, 300 and 1000 ppm using an artist's paintbrush. Artificial "rainfall" was applied using an automatic watering system to apply one inch of "rainfall". There were five wash-off timings (15, 30 & 60 minutes and 4 & 24 hours) and a non-wash control. Approximately 20-40 aphids were placed on the lower surface of the treated leaf once the application had dried or wash-off treatment had been made. A barrier of petroleum jelly was placed at the perimeter of the upper leaf surface to prevent the aphids from directly contacting the applied flonicamid. Aphid mortality was assessed at 96 hours after infestation and was based on the number of live aphids on the infested leaf at infestation and the number of live aphids on the leaf at 96 hours after infestation.

Trial three: A laboratory bioassay was conducted to evaluate effect of wash-off on the residual duration of translaminar activity of flonicamid. Flonicamid 50SG was applied at 100, 300 and 1000 ppm using an artist's paintbrush. There were five bioassay intervals (1, 2, 5, 8 and 11 days) and a non-wash control for each interval. All other procedures were the same as described for the laboratory bioassay above.

Residual bioassays

Field to laboratory bioassays: In general, treatments were replicated four times in a randomized complete block design and consisted of 1 row by 30 feet. Treatments were applied using a CO_2 backpack sprayer calibrated with water to deliver 13 GPA. At each evaluation interval, one terminal per plot was removed and placed into a 15-ml centrifuge tube containing distilled water. Cotton plants were then transported to the laboratory. A piece of cotton with approximately 25 completely susceptible cotton aphids was removed from a colony maintained at FMC's Southeast Research Station and placed onto each leaf. The number of aphids was recorded for each terminal. An eight-inch tall by 4-inch diameter clear plastic cylinder was placed over each terminal to confine the aphids. The top of each cylinder was removed and a piece of mesh cloth was put over each to allow for ventilation. Ninety-six hours after aphids were challenged, the number of live aphids on each leaf was counted and recorded. Percent control of the aphids was calculated using the Henderson-Tilton formula. The treatment means were subjected to an analysis of variance and the means were separated using the Student-Newman-Keuls Test (P=0.05).

Results and Discussion

Rainfastness

Trial 1: At 7 days after treatment (DAT), all treatments significantly reduced numbers of aphids present by greater than 90% (Table 2.). There were no a statistical differences between times of exposure prior to irrigation. At 14 DAT, all treatments significantly reduced numbers of aphids present by 79-93%. There were no statistical differences between times of exposure prior to irrigation. The number of aphids in the untreated check plots dropped from an average of 189 per 10 leaves to only 34 per ten leaves. At 21 DAT, all treatments significantly reduced numbers of aphids present by 63-89%. There were no statistical differences between times of exposure prior to irrigation. The number of aphids in the untreated check declined from an average of 34 per10 leaves to 23.5 per ten leaves. At 28 DAT, all treatments significantly reduced numbers of aphids present by 80-95%. There were no statistical differences between times of exposure prior to irrigation. At 35 DAT, all treatments significantly reduced numbers of aphids present by 61-73%. There were no statistical differences between times of exposure prior to irrigation. It appears that simulated, and actual, rain events occurring at 5 hours or later will not reduce the control of cotton aphid populations. It appears that control started to drop sometime between the 4 and 5 weeks sampling intervals.

Trial 2: Plants that did not receive the surface wash application resulted in 92-94% control at all rates tested (Table 3). A reduction in aphid control at the 100 ppm rate of flonicamid was observed for all wash-off timings except for the 15 and 60 minute wash-off periods. At the 300 and 1000 ppm rates, there appeared to be little loss in activity due to wash-off, although there was some variability in the aphid control observed. The high level of control observed, even at the low rate, suggests that flonicamid enters the plant and is available to provide translaminar activity very rapidly.

Trial 3: At the 1 DAT sampling interval, the average percent control was 98% for all rates of flonicamid, which had a wash-off application and an average of 95-97% for all rates, which did not receive the wash-off application (Table 4). At the 2 DAT sampling interval, the average percent control was 93-97% for all rates of flonicamid, which had a wash-off application, and an average of 99-100% for all rates which did not receive the wash-off application. At the 5 DAT sampling interval, the average percent control was 92-94% for all rates of flonicamid, which had a wash-off application, and an average of 91-100% for all rates which did not receive the wash-off application. At the 8 DAT sampling interval, the average percent control was 88-100% for all rates of flonicamid, which had a wash-off application, and an average of 89-97% for all rates which did not receive the wash-off application. At the 11 DAT sampling interval, the average percent control was 42% for the 100 ppm rate of flonicamid, which had a wash-off application, and an average of 53% for the corresponding rate which did not receive the wash-off application. The average percent control was 77% for the 300 ppm rate of flonicamid, which had a wash-off application, and an average of 96% for the corresponding rate which did not receive the wash-off application. The average percent control was 65% for the 1000 ppm rate of flonicamid, which had a wash-off application, and an average of 74% for the corresponding rate which did not receive the wash-off application. These data suggest that wash-off of remaining leaf surface flonicamid has no impact on residual translaminar aphid control except for a slight effect at 8 and 11 days after application. Translaminar aphid control remained high, with and without wash-off, until 11 days after treatment.

Residual Activity

Trial one: The rate response and residual activity for all rates of flonicamid between 0.036 and 0.088 lb ai/A were similar (Table 5). There was a general decline of approximately 9 to 22% by 3 DAT, 33 to 65% by 6 DAT, and 40 to 67% by 10 DAT. The residual activity of Centric® (thiamethoxam) declined 53% by 3 DAT and 100% by 6 DAT. The residual activity of Assail® (acetamiprid) declined 15% by 10 DAT.

Trial two: Control achieved from terminals sampled for all treatments one hour after application was 100% (Table 6). Between the 1 HAT and 4 DAT sampling, 2.35 inches of heavy rainfall were received. Samples taken 4 DAT, revealed a comparable level of control (82-83%) for flonicamid and Assail® while Provado® (imidacloprid) and Centric® achieved only 29 and 9% control respectively. Samples taken 7 DAT, revealed a comparable level of control (75-76%) for flonicamid and Assail® while Provado® and Centric® produced only 14 and 20% control respectively. An additional 1.35-inch of rainfall was received between 7 and 14 DAT. At 14 DAT, flonicamid achieved a level of control (29%) comparable to that of Assail® (39%). These data clearly demonstrate that the residual performance of flonicamid and Assail® is not adversely impacted by significant rain events.

Conclusions

Flonicamid is rainfast at least two hours after application and the residual control is equivalent to (or better at recommended rates) Assail 70WP® and greater than Centric 25WP® or Provado 1.6F®. These results suggest that the residual control of a natural population of cotton aphids with flonicamid (average 90% residual control from 0.062 lb ai/A rate out to 18-22 days) is a combination of active ingredient residual activity and slow pest population resurgence. The excellent initial activity and apparent long residual efficacy of flonicamid on cotton aphid could potentially reduce the number of needed aphicide applications. These attributes, along with others such as safety to beneficials and novel mode of action, make flonicamid a sound choice for inclusion in a cotton pest management program.

References

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Table 1. Comparative efficacy of Flonicamid on cotton aphid (*Aphis gossypii*), 2001-2003.[a]

		PERCENT APHID CONTROL[b]							
Treatment	lb ai/A	1-3[c]	(n)[d]	6-10	(n)	11-15	(n)	18-22	(n)
Flonicamid	0.044	86	(21)	89	(22)	90	(14)	77	(4)
	0.054	77	(31)	83	(26)	79	(18)	67	(9)
	0.062	88	(16)	96	(24)	93	(12)	90	(4)
Imidacloprid	0.047	60	(12)	65	(10)	46	(4)	29	(2)
Thiamethoxam	0.050	81	(26)	85	(25)	68	(17)	62	(7)
Acetamiprid	0.050	87	(22)	92	(18)	90	(9)	65	(4)
Dicrotofos	0.25	68	(4)	28	(6)	31	(5)	32	(2)
Carbofuran	0.25	96	(5)	89	(8)	53	(6)	49	(4)
Untreated[e]		53	(40)	49	(41)	40	(23)	25	(9)

[a] Overall analysis of 35 North American field trials.
[b] Percent control based on untreated.
[c] Days after application
[d] Number of observations in mean.
[e] Number of pests per 10 leaves or terminals.

Table 2. Effect of time of exposure prior to a rain event on efficacy of Flonicamid on cotton aphid (*Aphis gossypii*).

	Time of	No. Aphids per 10 leaves				
Treatment	irrigation	7 DAT	14 DAT	21 DAT	28 DAT	35 DAT
Untreated		189.0 a	34.0 a	23.5 a	39.0 a	46.0 a
Flonicamid 50WG	5 hours	17.8 b (91)[1]	7.3 b (79)	8.8 b (63)	7.3 b (81)	15.5 b (66)
0.053 lb ai/A	24 hours	16.0 b (92)	5.0 b (85)	4.3 b (82)	7.8 b (80)	18.0 b (61)
	72 hours	15.0 b (92)	4.5 b (87)	3.3 b (86)	2.0 b (95)	12.3 b (73)
	96 hours	15.0 b (92)	2.5 b (93)	2.5 b (89)	2.5 b (94)	17.0 b (63)

Means in the column followed by a different letter are significantly different (P=0.05; Student -Newman-Keuls)
[1] Percent control compared to untreated check

Table 3. Translaminar control of cotton aphids (*Aphis gossypii*) on cotton: effect of washing off surface flonicamid at various intervals after application.

	Rate	SAMPLING INTERVAL[1]						
Treatment	ppm	None	15 Min	30 Min	60 Min	2 Hour	4 Hour	24 Hour
Flonicamid	1000	92[1]	84	98	71	91	92	96
50SG	300	92	86	72	80	81	96	86

100	94	94	63	86	67	68	80

[1] Percent mortality 96 hours post-challenge.

Table 4. Impact of timing of wash-off of surface Flonicamid on translaminar activity on cotton aphids (*Aphis gossypii*) on cotton.

Treatment	Rate ppm	PERCENT APHID MORTALITY 1 DAT[1]	2DAT	5 DAT	8 DAT	11 DAT
Flonicamid 50SG	1000	98 [97][2]	96 [99]	94 [100]	100 [89]	65 [74]
	300	98 [97]	97 [100]	92 [98]	88 [97]	77 [96]
	100	98 [95]	93 [99]	94 [91]	88 [96]	42 [53]

[1] Timing of wash-off
[2] Mortality with no wash-off

Table 5. Field to lab bioassay evaluation of rate response and residual activity of Flonicamid on cotton aphid (*Aphis gossypii*) in cotton, 2002.

Treatment	Rate lb ai/A	PERCENT APHID CONTROL[1] 0 DAT	3 DAT	6 DAT	10 DAT
Flonicamid 50WG	0.036	99 a	81 ab	35 bc	33 ab
	0.044	100 a	78 ab	45 ab	60 ab
	0.070	99 a	85 ab	48 ab	50 ab
	0.079	100 a	84 ab	67 ab	59 ab
	0.088	100 a	91 ab	62 ab	55 ab
Centric® 25WP	0.047	100 a	47 b	0 d	0 b
Assail® 70 WP	0.050	99 a	100 a	86 a	85 a

Means in the column followed by a different letter are significantly different (P=0.05; Student -Newman-Keuls)
[1] Percent control 96 hours post challenged calculated using Henderson-Tilton formula.

Table 6. Field to lab bioassay evaluation of residual activity of Flonicamid and competitive insecticides on cotton aphid (*Aphis gossypii*) in cotton, 2004.

Treatment	Rate g ai/ha	PERCENT APHID CONTROL[1] 1 Hour	4 DAT	7 DAT	14 DAT
Flonicamid 50WG	0.062	100 a	83 a	75 a	29 ab
Assail® 70WP	0.050	100 a	82 a	76 a	39 a
Provado® 1.6F	0.050	100 a	29 b	14 b	…..
Centric® 25WP	0.050	100 a	9 c	20 b	…..
			↑ 2.35" Rain		↑ 1.35" Rain

Means in the column followed by a different letter are significantly different (P=0.05; Student -Newman-Keuls)
[1] Percent control 96 hours post challenged calculated using Henderson-Tilton formula.