EVALUATION OF INSECT GROWTH REGULATOR-FEEDING STIMULANT COMBINATIONS FOR MANAGEMENT OF FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

Application of RH-5992 2F, a neural agonist insect growth regulator, to foliage of corn (*Zea mays* [L.]) and southern pea (*Vigna unguiculata* [L.]), resulted in significant levels of fall armyworm (*Spodoptera frugiperda* [J. E. Smith]) larval control. The addition of a cottonseed flour-based feeding stimulant, Konsume, at 10% of total spray volume to the insect growth regulator reduced the length of time needed for larval mortality to occur compared to the insect growth regulator alone. Additionally, feeding damage and percentage of corn plants infested by fall armyworm was significantly reduced using RH-5992 2F + Konsume. Residual activity of RH-5992 remained high (> 84% larval mortality at the highest evaluated rate of RH-5992) on southern pea throughout the two-week test period.

Key Words: *Spodoptera frugiperda*, insect management, insecticide additives

RESUMEN

La aplicación de RH-5992 2F, un agonista neural regulador del crecimiento de los insectos, al follaje del maíz (*Zea mays* [L.]) y del guisante sureño (*Vigna unguiculata* [L.]), produjo niveles significativos de control larval del gusano trozador (*Spodoptera frugiperda* [J.E.Smith]). La adición al regulador de crecimiento de un estimulante de la alimentación a base de harina de algodón, Kosume, al 10% del volumen total de aspersión, redujo el tiempo requerido para matar las larvas en comparación con el regulador de crecimiento solo. Adicionalmente, el daño por alimentación de las larvas y el porcentaje de plantas de maíz infestadas por el gusano trozador fueron significativamente reducidos usando RH-5992 2F + Kosume. La actividad residual del RH-5992 permaneció alta (>84% de mortalidad larval en la concentración más alta de RH-5992) en el guisante sureño durante las dos semanas de prueba.

Use of phagostimulants to enhance activity of insect growth regulators against fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), in the laboratory has been reported (Chandler 1993). The mortality rate of FAW larvae increased significantly when they fed on leaves of southern pea, *Vigna unguiculata* (L.), that had been treated with either of two insect growth regulators (RH-5992 or diflubenzuron), in combination with Konsume[R], a cottonseed flour-based insect feeding stimulant. Larval mortality was increased 2 and 3 days after treatment when Konsume (10% of total solution) and RH-5992 were applied in combination (Chandler 1993). This increase in mortality was more notable than that observed with diflubenzuron/Konsume combinations. The increased mortality during the first three days following treatment with RH-5992 is important because it can reduce FAW related

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damage sooner following treatment, which may aid acceptance of this particular type of insect growth regulator by growers. RH-5992 interferes with the normal molting process of lepidopterous larvae by acting as an agonist of insect molting hormone (Rohm and Haas Co. 1989). It has been shown to have high (> 90%) levels of activity against FAW larvae at concentrations of 0.001 to 1.0% active ingredient [AI] (Chandler et al. 1992).

The studies reported here were designed to evaluate the use of RH-5992/Konsume combinations under simulated and actual field conditions for management of FAW. Studies were conducted to evaluate the residual effectiveness and control potential of RH-5992, with and without the addition of the feeding stimulant, and to compare the effectiveness of RH-5992 with thiodicarb, a standard chemical insecticide used for control of FAW larvae.

MATERIALS AND METHODS

Spray Table Study

RH-5992 2F (Rohm and Haas Co., Philadelphia, Pa.) was formulated in water at the rates of 11.0 and 22.0 gm AI/ha. Both of these formulations were sprayed on southern peas, with and without the addition of Konsume (Fermone Inc., Phoenix, AZ) (10% of total volume) to the mixture. In addition, peas were treated with a Konsume (10% of total volume)-water mixture and with water alone. The peas were planted in 25 x 61 x 5 cm rectangular plastic trays filled with potting media, and these were held in a greenhouse (24-30° C and 50-100% relative humidity [RH]). In the greenhouse the plants were allowed to reach the 2 leaf stage (approximately 2 weeks old) prior to treatment. On 17 May, 1993, 24 trays of peas per treatment (6 total treatments) were sprayed with the above mixtures. The trays were placed on a conveyor-driven spray table calibrated to apply 38.2 liter per ha at 59 kg/cm^2 with a single TX-6 cone nozzle fixed 46 cm above the crop. The table was set to convey the plants at a speed of 15.2 m per min, and the spray nozzle was powered by compressed air. Following treatment, the trays of peas were returned to the greenhouse.

Leaves were collected from the treated plants 2 h and 1, 3, 7, 10, and 14 days after treatment. Four trays of cowpeas were used on each collection date for each treatment. Each tray was designated as a separate replicate. Neonate FAW larvae were obtained from laboratory cultures at the Insect Biology and Population Management Research Laboratory in Tifton, GA. These larvae were reared as described by Perkins (1979). The larvae were held on pinto bean diet at 24 ± 1° C for 3 days before being exposed to treated leaf surfaces thus allowing all insects to reach a uniform age and size. On each leaf collection date, 30 leaves per replicate (4 replicates total per collection date) per treatment were placed in 30-ml plastic cups. Single 3-day-old larvae were placed on each leaf and the cup was capped. Cups containing larvae were held in environmental cabinets in the laboratory at 24 ± 1° C, a photoperiod of 12:12 (L:D), and 50 ± 5% RH. After 48 h, cups were opened and the number of living versus dead larvae was recorded. Surviving larvae were then placed in 30-ml cups containing 10 ml of bean diet and the number of living versus dead larvae recorded following an additional 3 days (120 h after application mortality). Larvae were then disposed of.

Field Study

Field corn (*Zea mays* [L.]) was planted in August 1993 at the USDA-ARS Belflower Farm in Tift Co., GA. Nine treatments, including an untreated control, were arranged

in a randomized block design with four replications. Plots were 3 rows (91 cm per row) wide by 7.6 m long. Treatments consisted of RH-5992 2F applied at rates of 22.0, 45.9 and 91.8 gm AI/ha with and without the addition of Konsume at 10% of the total volume. A 10% solution of Konsume alone and thiodicarb (Larvin 3.2) at 45.9 gm AI/ha were also evaluated. Three treatments were made to whorl stage corn beginning 23 August and continued every 10 days (final treatment on 13 September). Insecticide applications were made with a CO_2 backpack sprayer calibrated to apply 30.6 liter per ha at 79 kg per cm^2 using a TX-6 nozzle and traveling at 3.2 km/hr. Prior to and every 3-5 days after initial treatment through the test period, the number of damaged plants (15 plants examined per plot) were counted. Counts were terminated on 1 October. Damaged plants were defined as those where fresh larval feeding damage and frass were found. The number of plants damaged per plot were converted to percentages for data analysis. Additionally, damage ratings were taken beginning on the second count date following treatment. Ratings consisted of examining the entire plot for FAW feeding damage on a scale of 0-5, in which 0 = no damage, 1 = 1-20% damage, 2 = 21-40% damage, 3 = 41-60% damage, 4 = 61-80% damage, and 5 = 81-100% damage.

Data Analyses

Means and standard deviations were calculated for percent mortality, percentage of plants damaged, and damage ratings, both by date and as combined averages (after initial treatment) over the length of the experiments. Analyses of variance (PROC GLM, SAS 1985) were conducted for all data sets. For the spray table study, set least square means were used to compare all possible treatment combinations. Contrasts were made between individual rates of RH-5992 with and without Konsume, between RH-5992 treatments combined with and without Konsume, between the untreated control and Konsume only, and between the untreated control and all other treatments for 48 and 120 h mortality data. For the field study, orthogonal contrasts were made to determine whether the tested rates of RH-5992, with or without Konsume, resulted in either a linear or quadratic response in the number of damaged plants and damage ratings per treatment. Comparisons were also made between RH-5992 with and without the addition of Konsume, Konsume alone vs the untreated control, RH-5992 vs thiodicarb, and RH-5992 vs Konsume alone.

Results and Discussion

Spray Table Study

High levels of fall armyworm larval mortality were observed following application of RH-5992 2F with and without the addition of Konsume to the mix (Tables 1 and 2). Mortality ranged from 5.9 to 67.5 % and from 62.5 to 98.4 %, depending upon the date and rate of active ingredient, 48 and 120 hours after leaf collection of treated leaves, respectively. Over the entire 14-day leaf collection period, no trend in loss of RH-5992 residual activity could be discerned (Tables 1 and 2). Some mortality of fall armyworm larvae was noted following feeding on foliage treated with Konsume alone. However, the highest Konsume related mortality rates (17.5 %), compared to other-treatments, were not considered to be of great importance in inflicting death to the insect (Table 2).

TABLE 1. RESIDUAL MORTALITY OF FALL ARMYWORM LARVAE FOLLOWING APPLICATION OF RH-5992 WITH OR WITHOUT KONSUME (10% OF TOTAL VOLUME) TO COWPEA FOLIAGE; 48 HOUR MORTALITY (%) AFTER FOLIAGE COLLECTED ON INDICATED DATE.[1]

		$\bar{x}$ ± SD Mortality (%) at Indicated Leaf Collection Time after Treatment						
Treatment	gms AI/ha	2 Hour	1 Day	3 Days	7 Days	10 Days	14 Days	Study Average
RH-5992 2F	22.0	18.2 ± 9.9	44.2 ± 9.2	21.7 ± 4.3	41.7 ± 12.6	22.6 ± 10.2	17.5 ± 6.9	27.6 ± 13.9
RH-5992 2F	11.0	5.9 ± 1.7	25.0 ± 6.4	13.7 ± 6.4	44.2 ± 5.1	15.8 ± 5.7	21.7 ± 8.0	21.0 ± 13.3
RH-5992 2F + Konsume	22.0	36.1 ± 9.9	64.2 ± 5.0	24.2 ± 8.3	67.5 ± 5.7	25.0 ± 7.9	20.0 ± 2.7	39.5 ± 20.7
RH-5992 2F + Konsume	11.0	21.0 ± 5.2	48.0 ± 9.6	14.2 ± 8.3	40.0 ± 10.5	20.9 ± 9.6	15.9 ± 12.6	26.6 ± 15.5
Konsume	--	0.8 ± 1.7	3.3 ± 2.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	5.0 ± 5.8	1.5 ± 3.1
Untreated	--	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	5.0 ± 8.0	0.8 ± 3.5

[1]Application made on 17 May.

TABLE 2. RESIDUAL MORTALITY OF FALL ARMYWORM LARVAE FOLLOWING APPLICATION OF RH-5992 WITH OR WITHOUT KONSUME (10% OF TOTAL VOLUME) TO COWPEA FOLIAGE; 120 HOUR MORTALITY (%) AFTER FOLIAGE COLLECTED ON INDICATED DATE.[1]

		$\bar{x}$ ± SD Mortality (%) at Indicated Leaf Collection Time after Treatment						
Treatment	gms AI/ha	2 Hour	1 Day	3 Days	7 Days	10 Days	14 Days	Study Average
RH-5992 2F	22.0	86.5 ± 7.0	91.7 ± 4.3	86.7 ± 6.1	90.0 ± 2.7	89.1 ± 3.1	86.7 ± 6.1	88.4 ± 5.0
RH-5992 2F	11.0	65.0 ± 2.0	85.0 ± 8.0	74.7 ± 12.3	83.4 ± 6.1	80.8 ± 19.7	84.2 ± 1.7	78.8 ± 11.7
RH-5992 2F + Konsume	22.0	93.3 ± 4.7	98.4 ± 1.9	87.5 ± 9.6	95.0 ± 3.4	95.8 ± 3.2	84.2 ± 6.9	92.4 ± 7.1
RH-5992 2F + Konsume	11.0	84.1 ± 4.9	93.4 ± 6.7	79.2 ± 11.0	88.3 ± 5.8	92.5 ± 3.2	62.5 ± 14.2	83.3 ± 13.1
Konsume	--	0.8 ± 1.7	17.5 ± 10.0	9.2 ± 8.8	0.0 ± 0.0	2.5 ± 3.2	10.0 ± 7.2	6.7 ± 8.5
Untreated	--	0.0 ± 0.0	0.0 ± 0.0	1.7 ± 3.4	0.0 ± 0.0	5.0 ± 4.3	8.3 ± 6.4	2.5 ± 4.4

[1]Application made on 17 May.

Analysis of variance for 48 h after leaf collection mortality indicated a significant interaction between date and treatment (F = 7.74, df = 25, P = 0.0001). Similar results were obtained following analysis of variance for 120 hour after leaf collection mortality (F = 3.56, df = 25, P = 0.0001). These interactions indicated that treatments responded differently on each leaf collection date. Therefore, comparisons among treatments (least square means) were made on individual leaf collection dates. Contrasts were then conducted on seasonal average data to determine overall effects of the insect growth regulator/feeding stimulant mixture on fall armyworm mortality.

Least square means resulted in significant differences in treatment comparisons based on time of mortality observations and length of time after treatment (Tables 3 and 4). In most instances mortality from the untreated control and 10% Konsume alone treatments was significantly less than all other treatments for both 48 and 120 h mortality on each leaf collection date (Tables 3 and 4). Significant increases in mortality caused by RH-5992 + Konsume and RH-5992 alone treatments were most often noted within 7 days of treatment and primarily with 48 h mortality data. Data indicated that 48 h readings showed an increase in mortality within the first 7 days following treatment when Konsume was added to the insect growth regulator. Mortality observed after 120 h was similar among most insect growth regulator treatments. After 7 days, no increase in mortality could be attributed to Konsume in the formulations, but mortality rates remained high (Tables 3 and 4). RH-5992 (11.0 gms AI/ha) + Konsume resulted in significantly less mortality 14 days after application (120 h mortality) than was noted with other RH-5992 treatments.

Contrasts conducted for 48 and 120 h after leaf collection summary data indicated that increasing rates of RH-5992, with and without Konsume, significantly affected fall armyworm larval mortality. RH-5992 resulted in higher mortality at the 22.0 gm AI/ha rate than at the 11.0 gm AI/ha rate on both leaf mortality observation dates (Tables 5 and 6). Also, the addition of Konsume to RH-5992 resulted in higher levels of fall armyworm larval mortality, both 48 and 120 h after leaf collection, than that achieved with RH-5992 alone, regardless of insect growth regulator active ingredient rate (Tables 5 and 6). Konsume alone resulted in significantly higher levels of mortality than the untreated control, and the untreated control had significantly less larval mortality than all of the other treatments combined 48 and 120 h after leaf collection.

Field Study

Percentage of corn plants damaged by fall armyworm prior to initial insect growth regulator treatment (23 Aug.) ranged from 3 -22% per treatment (Table 7), but no significant differences in damaged plants were observed on this date although the data are quite variable. Damage increased in the untreated plots through 13 Sept. (Tables 7 and 8). Populations of fall armyworm then decreased as indicated by the reduced percentage of plants damaged. Damage again increased from 17 Sept. until 1 Oct. (Tables 7 and 8). Fewer plants were damaged in the plots treated with RH-5992 2F at 91.8 gm AI/ha mixed with 10% Konsume; percentage of plants damaged ranged from 2 to 32%.

There were no significant interactions between date and treatment for percentage of plants damaged and damage ratings (F=0.87, df=88, P = 0.7728 and F=0.52, df=72, P = 0.9994, respectively). All dates were combined for orthogonal contrasts.

Increasing rates of RH-5992, both with and without the addition of Konsume, resulted in a linear response for both reduction of percentage of plants damaged and plant damage ratings caused by fall armyworm larval feeding (Tables 9 and 10). A quadratic relationship was not indicated. The addition of Konsume to RH-5992 re-

TABLE 3. T VALUES FOR LEAST SQUARE MEANS COMPARISONS OF ALL POSSIBLE TREATMENT PAIRS 48 HOUR AFTER LEAF COLLECTED MORTALITY.

			t-Values at Leaf Collection Time after Treatment[1]					
Treatment	gms AI/ha	Treatment Pairs	2 Hour	1 Day	3 Days	7 Days	10 Days	14 Days
1. Untreated	--	1-2	-0.19	-0.67	0.00	0.00	0.00	0.00
2. Konsume	--	1-3	-1.36	-5.01*	-3.14*	-8.90*	-3.30*	-3.12*
3. RH-5992	11.0	1-4	-4.23*	-8.84*	-4.99*	-8.39*	-4.71*	-2.34
		1-5	-4.90*	-9.61*	-3.26*	-8.06*	-4.34*	-2.03
4. RH-5992	22.0	1-6	-8.43*	-12.86*	-5.56*	-13.60*	-5.21*	-2.81
		2-3	-1.17	-4.34*	-3.14*	-8.90*	-3.30*	-3.12*
5. RH-5992 + Konsume	11.0	2-4	-4.04*	-8.17*	-4.99*	-8.39*	-4.71*	-2.34
		2-5	-4.71*	-8.94*	-3.26*	-8.06*	-4.34*	-2.03
6. RH-5992 + Konsume	22.0	2-6	-8.23*	-12.19*	-5.56*	-13.60*	-5.21*	-2.81
		3-4	-2.87	-3.83*	-1.85	0.51	-1.42	0.79
		3-5	-3.53*	-4.60*	-0.12	0.84	-1.05	1.09
		3-6	-7.06*	-7.85*	-2.42	-4.70*	-1.91	0.31
		4-5	-0.66	-0.77	1.73	0.33	0.37	0.30
		4-6	-4.19*	-4.01*	-0.57	-5.21*	-0.49	-0.47
		5-6	-3.53*	-3.25*	-2.30	-5.53*	-0.86	-0.78

[1]*Indicates significant difference in treatment pairs, critical point for all comparisons is $|t| > 3.01$.

TABLE 4. T VALUES FOR LEAST SQUARE MEANS COMPARISONS OF ALL POSSIBLE TREATMENT PAIRS 120 HOUR AFTER LEAF COLLECTION MORTALITY.

			t-Values at Leaf Collection Time after Treatment[1]					
Treatment	gms AI/ha	Treatment Pairs	2 Hour	1 Day	3 Days	7 Days	10 Days	14 Days
1. Untreated	--	1-2	-0.29	-4.09*	-1.13	0.00	0.41	-0.32
2. Konsume	--	1-3	-22.50*	-19.88*	-10.96*	-34.64*	-12.55*	-14.60*
3. RH-5992	11.0	1-4	-29.93*	-21.44*	-12.76*	-37.40*	-13.92*	-15.08*
4. RH-5992	22.0	1-5	-29.11*	-21.83*	-11.63*	-36.71*	-14.48*	-10.42*
5. RH-5992 + Konsume	11.0	1-6	-32.31*	-23.00*	-12.88*	-39.49*	-15.03*	-14.60*
		2-3	-22.22*	-15.79*	-9.84*	-34.64*	-12.96*	-14.27*
6. RH-5992 + Konsume	22.0	2-4	-29.64*	-17.35*	-11.63*	-37.40*	-14.33*	-14.76*
		2-5	-28.83*	-17.74*	-10.51*	-36.71*	-14.89*	-10.10*
		2-6	-32.02*	-18.91*	-11.75*	-39.49*	-15.44*	-14.27*
		3-4	-7.43*	-1.56	-1.79	-2.76	-1.37	0.48
		3-5	-6.61*	-1.95	-0.67	-2.07	-1.93	4.17*
		3-6	-9.81*	-3.12*	-1.92	-4.85*	-2.48	0.00
		4-5	0.81	-0.39	1.12	0.70	-0.56	4.65*
		4-6	-2.38	-1.56	-0.12	-2.09	-1.11	-0.48
		5-6	-3.19*	-1.17	-1.25	-2.78	-0.55	-4.17*

[1]*Indicates significant difference in treatment pairs, critical point for all comparisons is $|t| > 3.01$.

TABLE 5. ANALYSIS OF VARIANCE TABLE FOR 48 HOUR AFTER LEAF COLLECTION FALL ARMYWORM LARVAE MORTALITY.

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	53	48757.842	919.959	19.94	0.0001
Error	90	4151.283	46.125		
Corrected Total	143	52909.125			

Type II

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Date	5	156.732	31.346	0.68	0.6400
Rep (Date)	18	845.290	46.961	1.02	0.4481
1) RH-5992 22.0 vs. 11.0 Gm Ai/Ha	1	521.401	521.401	11.30	0.0011
2) RH-5992 + Konsume 22.0 vs. 11.0 Gm Ai/Ha	1	1982.755	1982.755	42.99	0.0001
3) RH-5992 + Konsume vs. RH-5992	1	1834.876	1834.876	39.78	0.0001
4) Konsume vs. Untreated	1	14175.567	14175.567	307.33	0.0001
5) All Treatments vs. Untreated	1	24231.177	24231.177	525.33	0.0001
1) Interacted with Date	5	783.937	156.787	3.40	0.0074
2) Interacted with Date	5	779.919	155.984	3.38	0.0076
3) Interacted with Date	5	1658.931	331.786	7.19	0.0001
4) Interacted with Date	5	3269.530	693.906	14.18	0.0001
5) Interacted with Date	5	5690.151	1138.030	24.67	0.0001

sulted in significantly less feeding damage than when RH-5992 was used alone (Tables 9 and 10). No differences in percentages of plants damaged or damage ratings were observed comparing RH-5992 with thiodicarb (Larvin 3.2) (Tables 9 and 10). Differences were observed when comparing plants treated with all rates of RH-5992 and those treated with Konsume alone or with untreated plants. RH-5992 treated plants had significantly less damage than did plants treated with Konsume alone. Plants treated with Konsume resulted in a significant reduction in damage compared to the untreated control. However, plants treated with Konsume alone did not provide needed levels of economic fall armyworm control. These findings are similar to those observed with the spray table test.

In conclusion, use of RH-5992 2F resulted in significant levels of fall armyworm larval control on both southern pea and field corn. Addition of Konsume (at 10% of total volume) to the insect growth regulator provided significantly greater fall armyworm mortality in a shorter period of time and significantly reduced fall armyworm feeding damage compared to use of the insect growth regulator alone. These results further confirmed the laboratory findings of Chandler (1993) which indicated that the use of a cottonseed flour-based insect feeding stimulant enhanced the activity of RH-

TABLE 6. ANALYSIS OF VARIANCE TABLE FOR 120 HOUR AFTER LEAF COLLECTION FALL ARMYWORM LARVAE MORTALITY.

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	53	220142.655	4153.635	88.81	0.0001
Error	90	4209.078	46.768		
Corrected Total	143	224351.733			

Type II

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Date	5	625.084	125.017	2.67	0.0267
Rep (Date)	18	1000.820	55.601	1.19	0.2873
1) RH-5992 22.0 vs. 11.0 Gm Ai/Ha	1	1102.083	1102.083	23.57	0.0001
2) RH-5992 + Konsume 22.0 vs. 11.0 Gm Ai/Ha	1	980.117	980.117	20.96	0.0001
3) RH-5992 + Konsume vs. RH-5992	1	425.463	425.463	9.10	0.0033
4) Konsume vs. Untreated	1	120032.688	120032.688	2566.58	0.0001
5) All Treatments vs. Untreated	1	210735.730	210735.730	4506.03	0.0001
1) Interacted with Date	5	430.734	86.147	1.84	0.1126
2) Interacted with Date	5	429.367	85.873	1.84	0.1137
3) Interacted with Date	5	1526.069	305.214	6.53	0.0001
4) Interacted with Date	5	1039.311	207.862	5.30	0.0012
5) Interacted with Date	5	1239.215	247.843	5.30	0.0003

5992 and decreased time of larval mortality. Furthermore, spray table tests indicated that the residual activity of RH-5992 in a controlled environment remained relatively high throughout a two-week period. These positive results demonstrated the usefulness of insect growth regulator/feeding stimulant combinations for use in field settings. Further study is needed to refine insect growth regulator rates and to determine the economic feasibility of adding feeding stimulants to insect growth regulator mixtures.

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TABLE 7. PLANTS DAMAGED (%) BY FALL ARMYWORM LARVAE FOLLOWING APPLICATION OF RH-5992 2F WITH OR WITHOUT KONSUME (10% OF TOTAL VOLUME) TO WHORL STAGE CORN.[1]

		$\bar{x} \pm$ SD Damaged Plants (%)/Treatment												
Treatment	gm AI/ha	23 Aug Pre-treatment	26 Aug	30 Aug	2 Sept	6 Sept	9 Sept	13 Sept	17 Sept	21 Sept	23 Sept	28 Sept	1 Oct	Seasonal Average
RH-5992 2F	91.8	15 ± 11	38 ± 8	28 ± 6	53 ± 22	42 ± 16	31 ± 14	43 ± 20	23 ± 22	15 ± 13	13 ± 5	5 ± 6	30 ± 18	28 ± 19
RH-5992 2F	45.9	12 ± 16	22 ± 11	22 ± 11	52 ± 18	50 ± 7	42 ± 11	50 ± 13	32 ± 11	27 ± 5	15 ± 8	12 ± 15	32 ± 11	30 ± 18
RH-5992 2F	22.0	22 ± 13	58 ± 11	48 ± 18	55 ± 22	50 ± 28	40 ± 33	48 ± 29	32 ± 29	20 ± 8	22 ± 6	18 ± 6	47 ± 30	38 ± 24
RH-5992 2F + Konsume	91.8	3 ± 4	32 ± 11	27 ± 9	18 ± 6	25 ± 3	18 ± 16	17 ± 4	10 ± 7	12 ± 15	7 ± 5	2 ± 3	10 ± 13	15 ± 12
RH-5992 2F + Konsume	45.9	22 ± 17	28 ± 22	53 ± 20	45 ± 30	45 ± 22	25 ± 26	22 ± 21	23 ± 16	18 ± 15	17 ± 21	10 ± 9	27 ± 36	28 ± 23
RH-5992 2F + Konsume	22.0	20 ± 9	52 ± 6	48 ± 13	52 ± 19	48 ± 20	40 ± 9	35 ± 18	28 ± 14	22 ± 18	22 ± 18	15 ± 18	28 ± 13	34 ± 19
Konsume	--	10 ± 7	48 ± 40	48 ± 26	43 ± 21	45 ± 26	58 ± 15	55 ± 26	53 ± 32	27 ± 17	20 ± 12	15 ± 15	32 ± 46	38 ± 28
Larvin 3.2	45.9	22 ± 17	28 ± 14	30 ± 14	55 ± 20	45 ± 26	38 ± 30	47 ± 36	28 ± 20	30 ± 25	10 ± 9	13 ± 9	45 ± 30	33 ± 24
Untreated	--	15 ± 11	60 ± 31	47 ± 24	63 ± 18	63 ± 14	65 ± 31	65 ± 27	43 ± 21	28 ± 20	15 ± 6	13 ± 9	35 ± 35	43 ± 28

[1]Applications made 23 Aug, 3 and 13 Sept.

TABLE 8. DAMAGE RATINGS RESULTING FROM FEEDING BY FALL ARMYWORM LARVAE FOLLOWING APPLICATION OF RH-5992 2F WITH OR WITHOUT KONSUME (10% OF TOTAL VOLUME) TO WHORL STAGE CORN.[1]

		$\bar{x}$ ± SD Damage Rating/Treatment										
Treatment	gm AI/ha	30 Aug	2 Sept	6 Sept	9 Sept	13 Sept	17 Sept	21 Sept	23 Sept	28 Sept	1 Oct	Seasonal Average
RH-5992 2F	91.8	2.0 ± 0.0	3.3 ± 0.5	2.0 ± 0.8	2.3 ± 1.0	2.8 ± 1.0	2.0 ± 0.8	2.0 ± 0.8	2.3 ± 1.0	1.8 ± 1.0	1.3 ± 0.5	2.2 ± 0.9
RH-5992 2F	45.9	2.3 ± 0.5	3.0 ± 0.8	2.0 ± 0.0	2.3 ± 0.5	3.3 ± 0.5	2.8 ± 1.0	2.3 ± 0.5	1.5 ± 0.6	2.3 ± 1.3	1.8 ± 1.0	2.3 ± 0.8
RH-5992 2F	22.0	2.5 ± 0.6	3.3 ± 1.3	2.5 ± 1.3	2.3 ± 1.7	3.0 ± 1.4	3.0 ± 1.4	2.5 ± 1.0	2.5 ± 1.3	2.5 ± 0.6	2.3 ± 0.5	2.6 ± 1.1
RH-5992 2F + Konsume	91.8	2.0 ± 0.0	2.0 ± 0.0	1.5 ± 0.6	1.3 ± 0.5	1.5 ± 0.6	1.8 ± 1.0	2.0 ± 1.8	1.8 ± 1.5	1.3 ± 1.0	1.3 ± 1.0	1.6 ± 0.9
RH-5992 2F + Konsume	45.9	2.0 ± 0.0	2.8 ± 0.5	2.0 ± 1.2	1.5 ± 1.7	2.3 ± 1.3	2.8 ± 1.5	2.5 ± 1.3	2.5 ± 1.7	1.8 ± 1.0	1.8 ± 0.5	2.2 ± 1.1
RH-5992 2F + Konsume	22.0	2.3 ± 0.5	3.3 ± 0.5	2.3 ± 0.5	2.3 ± 0.5	2.8 ± 1.0	2.5 ± 1.0	2.5 ± 1.3	2.5 ± 1.3	1.8 ± 1.7	2.0 ± 0.8	2.4 ± 1.0
Konsume	--	2.5 ± 0.6	2.8 ± 1.0	2.3 ± 1.0	3.3 ± 1.0	3.0 ± 1.4	3.3 ± 1.5	2.8 ± 1.3	2.8 ± 1.3	2.5 ± 1.7	2.3 ± 1.0	2.7 ± 1.1
Larvin 3.2	45.9	2.0 ± 0.0	3.3 ± 1.0	2.0 ± 0.8	2.3 ± 1.0	3.0 ± 1.2	3.0 ± 0.8	2.3 ± 1.5	1.5 ± 1.0	2.5 ± 1.0	1.5 ± 0.6	2.4 ± 1.0
Untreated	--	2.5 ± 0.6	3.5 ± 0.6	2.5 ± 0.6	3.3 ± 1.1	3.8 ± 0.5	3.5 ± 0.6	3.3 ± 1.5	2.8 ± 0.5	2.5 ± 1.3	2.0 ± 0.0	3.0 ± 0.9

[1]Applications made 23 Aug, 3 and 13 Sept.

TABLE 9. ANALYSIS OF VARIANCE TABLE FOR PERCENTAGE OF PLANTS DAMAGED BY FALL ARMYWORM LARVAE, ORTHOGONAL CONTRASTS.

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	143	148613.169	1039.253	3.58	0.0001
Error	288	83671.605	290.526		
Corrected Total	431	232284.774			

	DF	Sum of Squares	Type II Mean Square	F Value	Pr > F
Date	11	65647.737	5967.976	20.54	0.0001
Rep (Date)	36	35683.951	991.221	3.41	0.0001
1) RH-5992-Linear	1	2467.130	2467.130	8.49	0.0038
2) RH-5992-Quad.	1	259.414	259.414	0.89	0.3455
3) RH-5992 + Konsume-Linear	1	8816.667	8816.667	30.35	0.0001
4) RH-5992 + Konsume-Quad.	1	326.543	326.543	1.12	0.2900
5) RH-5992 vs. RH-5992 + Konsume	1	3200.000	3200.000	11.01	0.0010
6) Konsume vs. Untreated	1	6373.663	6373.663	21.94	0.0001
7) RH-5992 vs. Larvin	1	28.408	28.408	0.10	0.7547
8) RH-5992 vs. Konsume	1	8779.020	8779.020	30.22	0.0001
1) Interacted with Date	11	793.981	72.180	0.25	0.9935
2) Interacted with Date	11	3101.698	281.973	0.97	0.4734
3) Interacted with Date	11	750.000	68.182	0.23	0.9949
4) Interacted with Date	11	1899.383	172.671	0.59	0.8331
5) Interacted with Date	11	4729.630	429.966	1.48	0.1381
6) Interacted with Date	11	4102.263	372.933	1.28	0.2331
7) Interacted with Date	11	2743.351	249.396	0.86	0.5818
8) Interacted with Date	11	6784.208	616.746	2.12	0.0189

TABLE 10. ANALYSIS OF VARIANCE TABLE FOR DAMAGE RATINGS RESULTING FROM FEEDING BY FALL ARMYWORM LARVAE, ORTHOGONAL CONTRASTS.

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	119	214.822	1.805	2.54	0.0001
Error	240	170.778	0.712		
Corrected Total	359	385.600			

TABLE 10. (CONTINUED) ANALYSIS OF VARIANCE TABLE FOR DAMAGE RATINGS RESULTING FROM FEEDING BY FALL ARMYWORM LARVAE, ORTHOGONAL CONTRASTS.

			Type II		
	DF	Sum of Squares	Mean Square	F Value	Pr > F
Date	9	45.656	5.073	7.13	0.0001
Rep (Date)	30	95.722	3.191	4.48	0.0001
1) RH-5992-Linear	1	4.513	4.513	6.34	0.0124
2) RH-5992-Quad.	1	0.104	0.104	0.15	0.7023
3) RH-5992 + Konsume-Linear	1	12.013	12.013	16.88	0.0001
4) RH-5992 + Konsume-Quad.	1	0.704	0.704	0.99	0.3208
5) RH-5992 vs. RH-5992 + Konsume	1	5.400	5.400	7.59	0.0063
6) Konsume vs. Untreated	1	15.313	15.313	21.52	0.0001
7) RH-5992 vs. Larvin	1	0.078	0.078	0.11	0.7407
8) RH-5992 vs. Konsume	1	22.802	22.802	32.04	0.0001
1) Interacted with Date	9	2.363	0.263	0.37	0.9490
2) Interacted with Date	9	2.854	0.317	0.45	0.9091
3) Interacted with Date	9	1.863	0.207	0.29	0.9768
4) Interacted with Date	9	1.421	0.158	0.22	0.9912
5) Interacted with Date	9	5.517	0.613	0.86	0.5605
6) Interacted with Date	9	3.007	0.334	0.47	0.8942
7) Interacted with Date	9	4.648	0.516	0.73	0.6851
8) Interacted with Date	9	5.375	0.597	0.84	0.5806

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