VIRGINIA SOYBEAN BOARD—2019 FINAL REPORT

TITLE: Reducing costs of managing insect pests in Virginia soybeans

PRINCIPLE INVESTIGATOR: Sally V. Taylor, Extension Entomologist

DURATION: 1 year (July 1, 2019 to June 30, 2020)

OBJECTIVES:

(1) Determine the effects of an IPM approach on plant injury (e.g., defoliation, seed injury), and grain yield in full-season and double-crop soybeans with different maturity groups (4.7-4.9 and 5.7-5.9). Measure densities of insect pests of soybean throughout the growing season including slugs, thrips, bean leaf beetles, corn earworms (aka soybean podworms), stink bugs, soybean loopers, and beneficial predators.

(2) Calculate the economic trade-offs between IPM and standard management plans.

(3) Make beat cloths, provide them to growers, and demonstrate how to scout for insect pests.

SUMMARY:

Objective 1

This objective investigated how location in Virginia, maturity group, and spray program would affect the insect pest complex in full-season and double-crop soybean. Experiments were conducted at the Virginia Tech Eastern Virginia Agricultural Research and Extension Center (EVAREC) in Warsaw and the Tidewater Agricultural Research and Extension Center (TAREC) in Suffolk. The varieties 'AG48X7 RR2X/SR' (maturity group 4.8) and 'AG56X8 RR2X' (maturity group 5.6) were planted full-season (May 17—conventional till at EVAREC, and May 24—no till following cotton at TAREC) and double-crop (June 21—conventional till at EVAREC, and July 9—no till following wheat at TAREC). Plot size at EVAREC was four rows (30-in row spacing) x 12-ft long and at TAREC was four rows (36-in row spacing) x 35-ft long. A split-plot experimental design was used with four replicates; main plots were maturity group and sub-plots consisted of one of five management programs:

1. Untreated control – all standard agronomic practices followed except that no insecticides were applied.
2. Tank mix standard approach (apply insecticide whenever you drive over the field) – pyrethroid insecticide (bifenthrin @ 6.4 oz/A) applied with pre-emergence herbicide application and at R3-R5 with fungicide application.
3. IPM approach (threshold-based sprays) – pyrethroid insecticides (bifenthrin @ 6.4 oz/A) applied only when established thresholds were met or exceeded.
4. IPM approach with premium insecticides (threshold-based sprays when price and infestation levels justify it) – same as #3 above except that a caterpillar-specific product (Prevathon @ 14 oz/A) was used when targeting corn earworm and soybean looper.
5. IPM approach with early termination – same as #4 above except that all scouting and insecticide sprays were stopped at R5.5

Specific application details and highlights for key pest species such as stink bugs, corn earworm, and soybean looper are provided by location and cropping system. Data were also collected on the following minor pest species and beneficial arthropods, but are not included in this report:

Japanese beetle	harlequin bug	ladybug
3-cornered alfalfa hopper	tarnished plant bug	bigeyed bug
green cloverworm	leafhopper	spiders
bean leaf beetle	grasshopper	lacewings
beet armyworm	flea hopper	nabid
fall armyworm	kudzu bug	hooded beetle
yellowstriped armyworm	click beetle	mantid
velvetbean caterpillar	southern corn rootworm	assassin bug
silverspotted skipper	burrower bug	minute pirate bug
blister beetle	dectes stem borer	

EVAREC, full-season

The first tank mix treatment (with pre-emergent herbicide) was on May 23. In maturity group 5 soybean, stink bugs never exceeded threshold numbers of 5 per 15 sweeps in any management program (Fig. 1). In maturity group 4 soybean, the tank mix treatment (applied on July 26 at R3-R4 soybean growth stage) was the only treatment over threshold three weeks later. There are little to no residual for stink bug products and eliminating beneficial predators before infestations begin can worsen problems. Corn earworm remained below threshold. Yields of maturity group 4 soybean averaged 50 bu/A, significantly higher than maturity group 5 (43 bu/A) (Table 1).

Fig. 1. EVAREC Full Season–Stink Bug

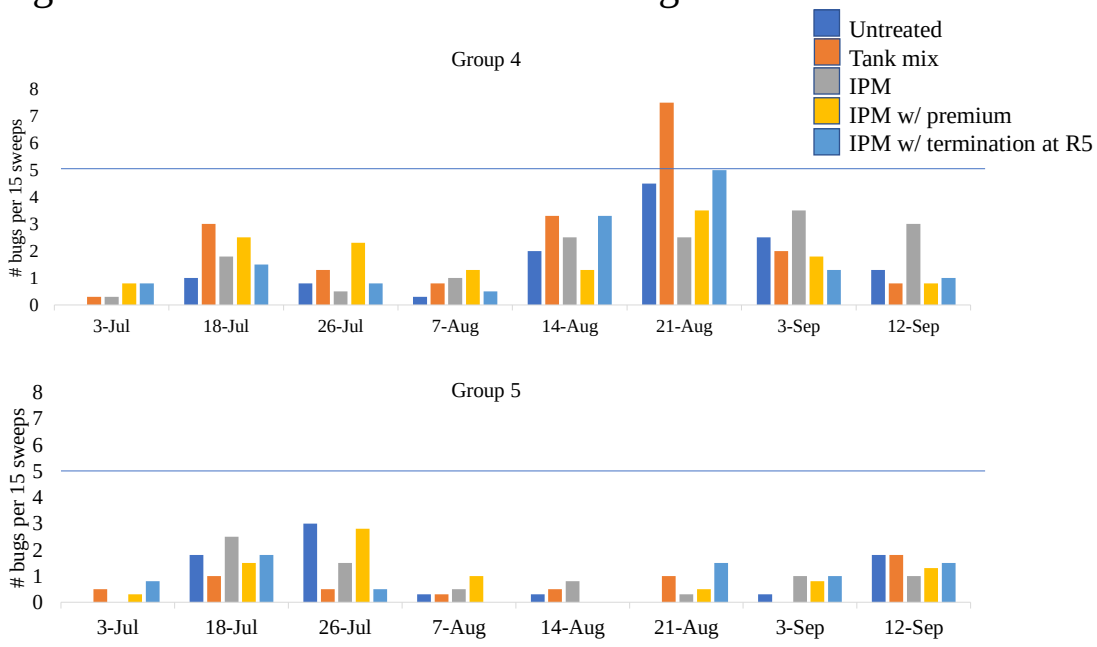


Table 1. Yield, EVAREC full-season experiment, 2019.

#	Materials	Yield (bu/acre)	
1	MG4 variety Untreated	49.8	ab
2	MG4 variety Tank mix	51.0	a
3	MG4 variety IPM threshold sprays	49.0	ab
4	MG4 variety Premium sprays	51.8	a
5	MG4 variety Terminate at R 5.5	48.8	ab
6	MG5 variety Untreated	43.8	bc
7	MG5 variety Tank mix	44.8	abc
8	MG5 variety IPM threshold sprays	39.8	c
9	MG5 variety Premium sprays	43.5	bc
10	MG5 variety Terminate at R 5.5	42.8	bc
	LSD (P=0.05) *P*(F)	7.03 0.02	

Means within a column followed by the same letter(s) are not significantly different (LSD, P=0.05).
[1]Yield based on weight of soybean with moisture content of 13%. Harvest date was October 10.

Split-plot analysis.

#	Maturity group	Yield
1	MG4 variety	50.1 a
2	MG5 variety	42.9 b
	LSD (P=0.05)	4.84

#	Management program	Yield
1	Untreated	46.8
2	Tank mix	47.9
3	IPM threshold sprays	44.4
4	Premium sprays	47.6
5	Terminate at R 5.5	45.8
	LSD (P=0.05)	4.97

Complete Factorial AOV Source	Yield P-value
Maturity group	0.0182
Management program	0.5905
Interaction (maturity group x management program)	0.9384

EVAREC, double-crop

The tank mix treatments (Bifenthrin @ 6.4 oz/A) were applied with pre-emergent herbicide on July 8 and with fungicide timing on August 21. The group 4 and 5 "premium spray" (Bifenthrin @ 6.4 oz/A) was applied on September 12 and 24, respectively. Stink bugs remained mostly below threshold (Fig. 2). The IPM treatment had higher numbers and did trigger a spray, but numbers were not significantly different from other treatments. Populations peaked in the group 5 plots one week following group 4 plots. Corn earworm remained below threshold (Fig. 3). In this double crop experiment, the group 4 plots were more attractive to moths. Yields were similar between maturity groups, averaging 35 and 34 bu/A for maturity groups 4 and 5 (Table 2).

Fig. 2. EVAREC Double Crop–Stink Bug

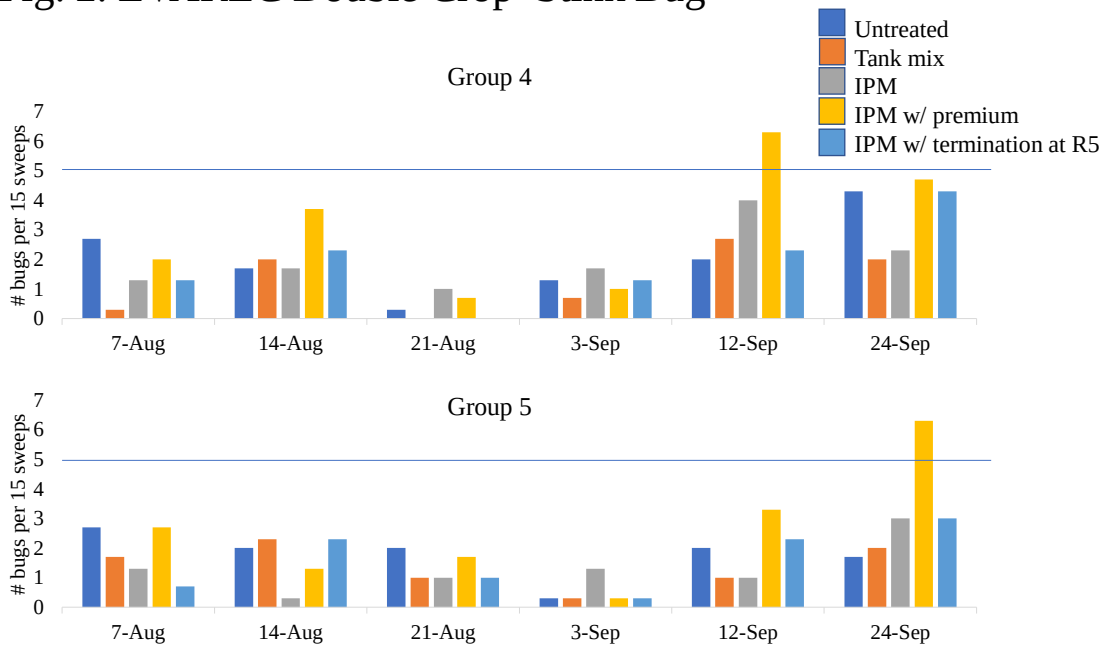


Fig. 3. EVAREC Double Crop–Corn Earworm

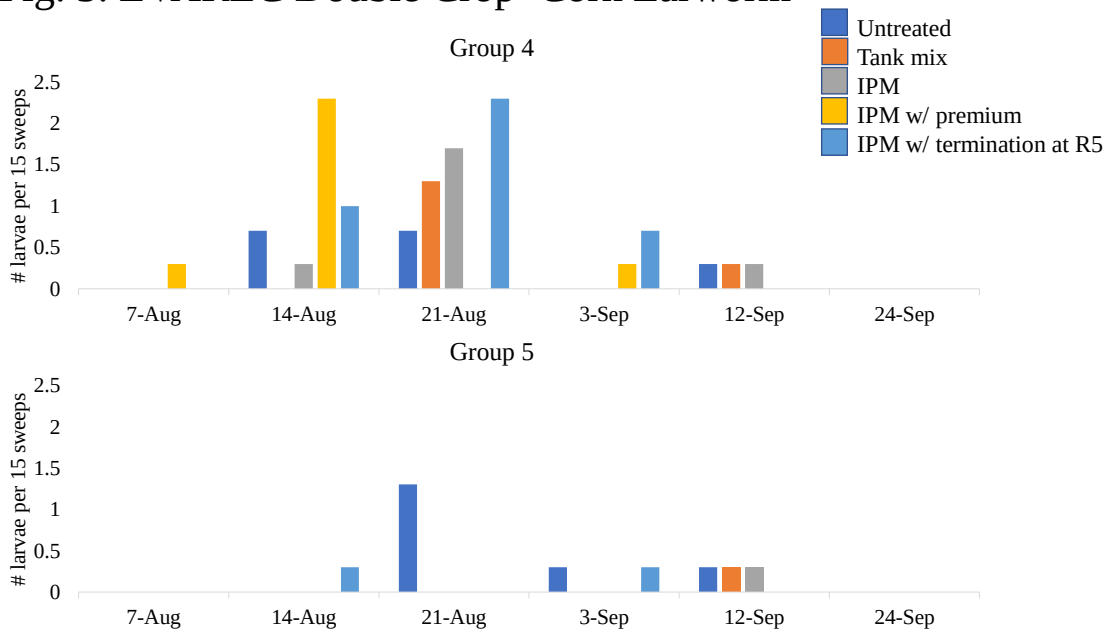


Table 2. Yield, EVAREC double-crop experiment, 2019.

#	Materials	Yield (bu/acre)
1	MG4 variety Untreated	37.2
2	MG4 variety Tank mix	35.4
3	MG4 variety IPM threshold sprays	31.2
4	MG4 variety Premium sprays	37.2
5	MG4 variety Terminate at R 5.5	35.1
6	MG5 variety Untreated	35.7
7	MG5 variety Tank mix	32.1
8	MG5 variety IPM threshold sprays	32.6
9	MG5 variety Premium sprays	33.8
10	MG5 variety Terminate at R 5.5	35.2
	LSD (P=0.05) *P*(F)	6.88 0.65

Means within a column followed by the same letter(s) are not significantly different (LSD, P=0.05).
[1]Yield based on weight of soybean with moisture content of 13%. Harvest date was October 10.

Split-plot analysis.

#	Maturity group	Yield
1	MG4 variety	35.2
2	MG5 variety	33.9
	LSD (P=0.05)	5.72

#	Management program	Yield
1	Untreated	36.5
2	Tank mix	33.8
3	IPM threshold sprays	31.9
4	Premium sprays	35.5
5	Terminate at R 5.5	35.1
	LSD (P=0.05)	4.76

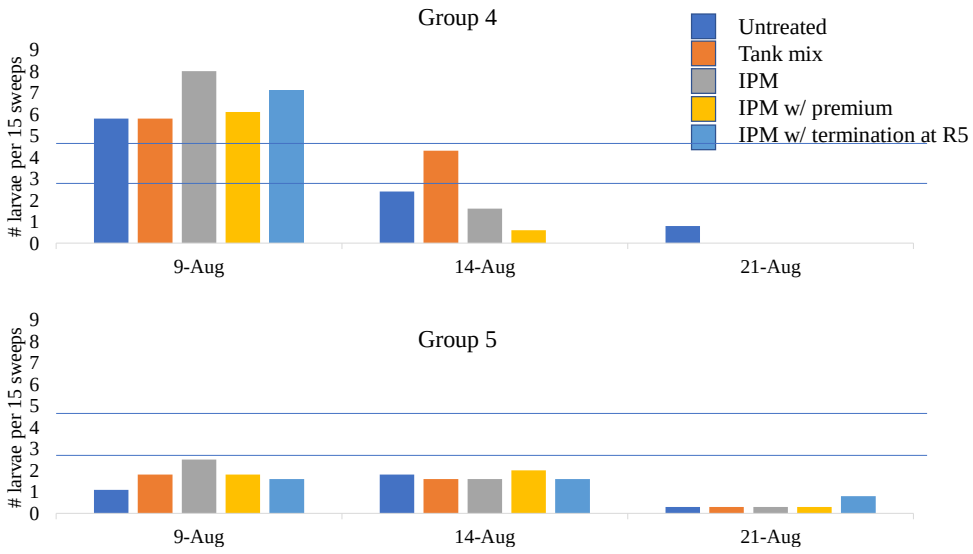
Complete Factorial AOV Source	Yield P-value
Maturity group	0.5149
Management program	0.3399
Interaction (maturity group x management program)	0.8026

TAREC, full-season

The tank mix treatments were applied with pre-emergent herbicide on May 28 and with fungicide timing on August 15 at R3/R4. On August 9, for maturity group 4, the "IPM treatment" was sprayed with Bifenthrin @ 6.4 oz/A, while treatments "IPM with premium" and "IPM with termination at R5" were sprayed with Prevathon @ 14 oz/A for corn earworm management. Sprays brought all treatments below threshold except for the tank mix application. Corn earworm was attracted primarily to maturity group 4 (Fig. 4).

Fig. 4. Suffolk Full-Season—Corn Earworm

The bottom line is the economic threshold for using a $10 application cost; the top line is using a $20 application cost. Thresholds were adjusted using the online corn earworm threshold calculator.



Both maturity groups were similarly attractive to stink bugs (Fig. 5). The tank mix spray (Bifenthrin @ 6.4 oz/A plus fungicide on August 15) remained below the stink bug threshold of 5 stink bugs per 15 sweeps. The IPM threshold (Bifenthrin @ 6.4 oz/A) and IPM with premium sprays (Orthene @ 16 oz/A) were applied on September 12. Maturity group 4 and 5 soybean averaged 54 and 58.5 bu/A, respectively (Table 3).

Fig. 5. Suffolk Full-Season—Stink Bug

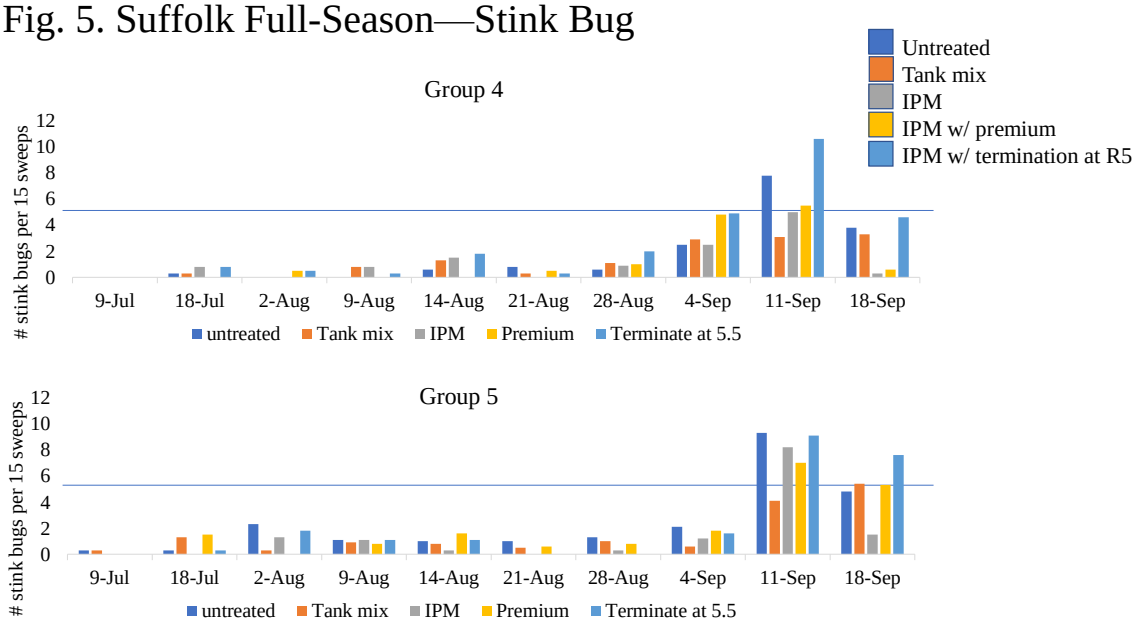


Table 3. Yield, TAREC full-season experiment, 2019.

#	Materials	Yield[1] (bu/acre)
1	MG4 variety Untreated	52.6 c
2	MG4 variety Tank mix	52.9 c
3	MG4 variety IPM threshold sprays	53.0 c
4	MG4 variety Premium sprays	56.6 abc
5	MG4 variety Terminate at R 5.5	55.6 bc
6	MG5 variety Untreated	59.6 ab
7	MG5 variety Tank mix	56.8 abc
8	MG5 variety IPM threshold sprays	60.4 a
9	MG5 variety Premium sprays	58.7 ab
10	MG5 variety Terminate at R 5.5	56.7 abc
	LSD (P=0.05) *P*(F)	4.51 0.008

Means within a column followed by the same letter(s) are not significantly different (LSD, P=0.05).
[1]Yield based on weight of soybean with moisture content of 13%. Harvest date was December 4.

Split-plot analysis for yield.

#	Maturity group	Bu/acre
1	MG4 variety	54.1
2	MG5 variety	58.5
	LSD (P=0.05)	4.45

#	Management program	Bu/acre
1	Untreated	56.1
2	Tank mix	54.8
3	IPM threshold sprays	56.7
4	Premium sprays	57.7
5	Terminate at R 5.5	56.1
	LSD (P=0.05)	2.99

Complete Factorial AOV Source	Bu/acre--P-value
Maturity group	0.0537
Management program	0.4185
Interaction (maturity group x management program)	0.1358

TAREC, double-crop

No corn earworm or stink bug populations of concern infested our double crop experiment, which was planted late (July 9). The only pesticide application was the pre-emergent tank mix of Bifenthrin @ 6.4 oz/A plus herbicide. Soybean looper infested in September in both maturities in high numbers (Fig. 6). Soybean looper management is based on percent defoliation thresholds and it typically does not cause issues unless soybean is planted late. Yields were statistically similar, averaging 24.5 and 22 bu/A for maturity groups 4 and 5 (Table 4).

Summary

Results of Objective 1 experiments indicate that insect pressure depends on location, planting date, soybean maturity group, and previous insecticide applications. A tank mix application can be hit or miss, and may cause pest problems. The best way to know what is in your field is to scout.

Fig. 6. Suffolk Double-Crop—Soybean Looper

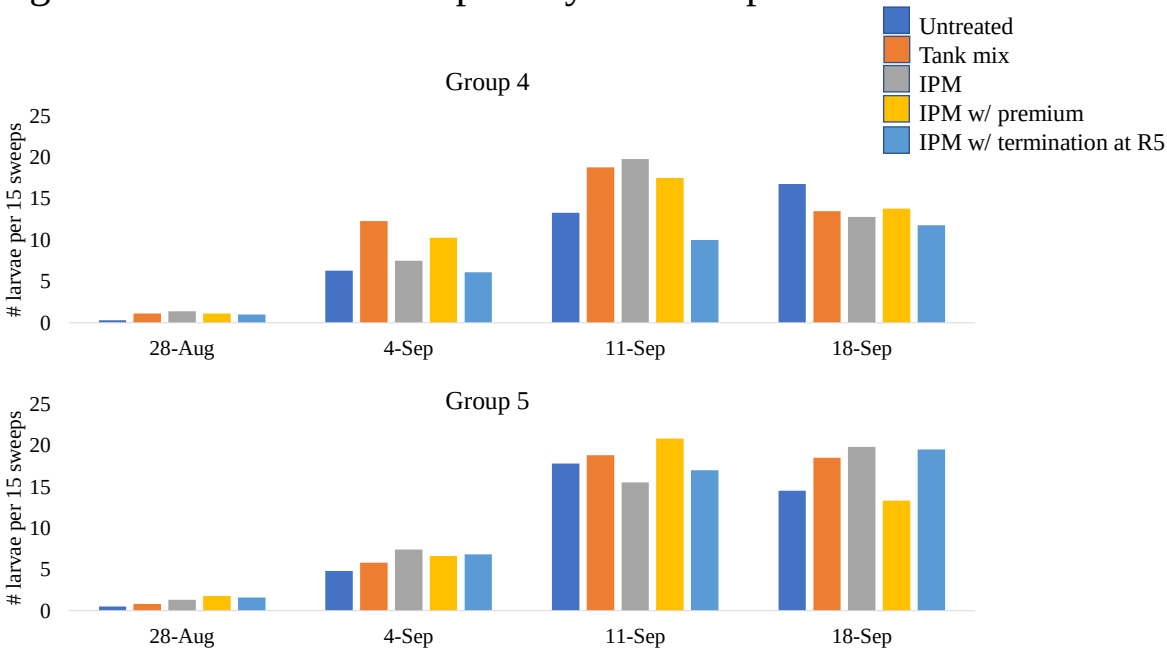


Table 4. Yield, TAREC double-crop experiment, 2019.

#	Materials	Yield[1] (bu/acre)
1	MG4 variety Untreated	27.2
2	MG4 variety Tank mix	24.0
3	MG4 variety IPM threshold sprays	22.8
4	MG4 variety Premium sprays	25.1
5	MG4 variety Terminate at R 5.5	22.7
6	MG5 variety Untreated	20.6
7	MG5 variety Tank mix	25.1
8	MG5 variety IPM threshold sprays	17.0
9	MG5 variety Premium sprays	21.2
10	MG5 variety Terminate at R 5.5	26.9
	LSD (P=0.05) *P*(F)	8.55 0.65

Means within a column followed by the same letter(s) are not significantly different (LSD, P=0.05).
[1]Yield based on weight of soybean with moisture content of 13%. Harvest date was December 4.

Split-plot analysis for yield.

#	Maturity group	Bu/acre
1	MG4 variety	24.5
2	MG5 variety	22.0
	LSD (P=0.05)	6.71

#	Management program	Bu/acre
1	Untreated	23.9
2	Tank mix	25.0
3	IPM threshold sprays	20.1
4	Premium sprays	23.1
5	Terminate at R 5.5	24.3
	LSD (P=0.05)	6.11

Complete Factorial AOV Source	Bu/acre P-value
Maturity group	0.3983
Management program	0.6374
Interaction (maturity group x management program)	0.4972

Objective 2
Economics of Objective 1's management programs were calculated using the following inputs:

Cost of insecticide:
bifenthrin @ 6.4 oz/A = $2.90/A
acephate @ 16 oz/A = $6.25/A
chlorantraniliprole @ 14 oz/A = $13.66/A

Sprayer application costs (per spray) = $7.50/A

Price of soybean = $9.00/bu

The cost of field visits were not included in the economic analysis.

For each experiment location and soybean maturity group, the economic difference between the untreated and each management program was calculated, with results provided in Table 5. It is important to note that some IPM treatments did not reach insect threshold levels and therefore did not get sprayed—these were considered to be the same as the untreated program. The "tank mix" program had automatic sprays.

In the EVAREC full-season and double-crop experiments, multiple IPM-based programs never reached treatable insect pest levels, and no management program had a net gain in value over the untreated. The number of field visits ranged from 10-12 in full-season and 7-9 in double-crop soybean.

Results of the TAREC full-season maturity group 5 and double-crop maturity group 4 experiments were similar to those at EVAREC, where no management programs had a net gain over the untreated. The TAREC full-season maturity group 4 had small gains over the untreated with the IPM with premium ($1/A) and the IPM with termination at R5 ($6/A) programs. The TAREC double-crop maturity group 5 soybean had a gain with the pre-emergent herbicide/insecticide tank mix application ($30/A). As mentioned in Objective 1, the effectiveness of tank mix applications can be hit or miss. The number of field visits ranged from 12-14 in full-season and 7-8 in double-crop soybean.

Table 5. Economic returns at two locations, full-season and double-crop soybean, two maturity groups, and five management programs in 2019.

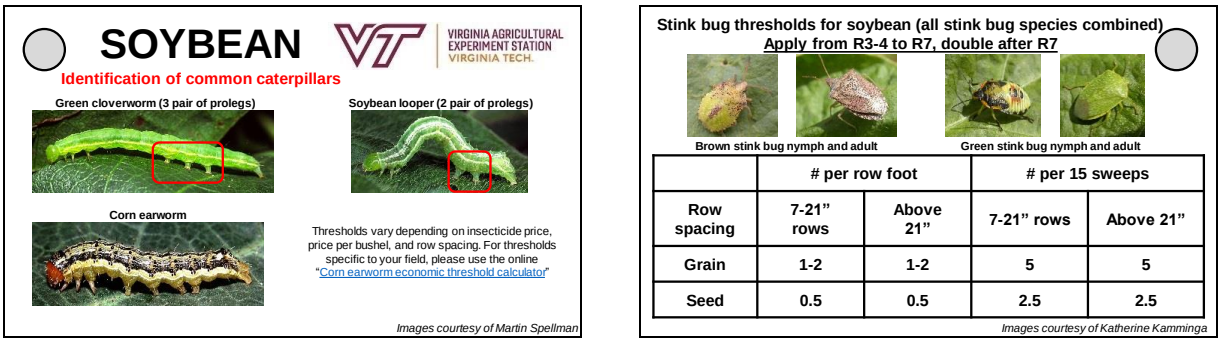
Virginia location	Cropping system	Maturity group	Management program	Insect Spray 1	Insect Spray 2	Total sprays	Field visits[1]	Cost of insecticide[2]	Insecticide + application cost/A[3]	Yield bu/A	Yield value/A - Ins + Appl cost[4]	Difference from Untreated ($/A)
EVAREC	Full-season	4	Untreated			0	10	0.00	0.00	49.8	448.20	0.00
		4	Tank mix	2.90	2.90	2	12	5.80	20.80	51.0	438.20	-10.00
		4	IPM			0	10	0.00	0.00	49.0	441.00	*
		4	IPM w/ premium			0	10	0.00	0.00	51.8	466.20	*
		4	IPM w/ termination at R5			0	10	0.00	0.00	48.8	439.20	*
		5	Untreated			0	10	0.00	0.00	43.8	394.20	0.00
		5	Tank mix	2.90	2.90	2	12	5.80	20.80	44.8	382.40	-11.80
		5	IPM			0	10	0.00	0.00	39.8	358.20	*
		5	IPM w/ premium			0	10	0.00	0.00	43.5	391.50	*
		5	IPM w/ termination at R5			0	10	0.00	0.00	42.8	385.20	*
EVAREC	Double-crop	4	Untreated			0	7	0.00	0.00	37.2	334.80	0.00
		4	Tank mix	2.90	2.90	2	9	5.80	20.80	35.4	297.80	-37.00
		4	IPM			0	7	0.00	0.00	31.2	280.80	*
		4	IPM w/ premium	2.90		1	8	2.90	10.40	37.2	324.40	-10.40
		4	IPM w/ termination at R5			0	7	0.00	0.00	35.1	315.90	*
		5	Untreated			0	7	0.00	0.00	35.7	321.30	0.00
		5	Tank mix	2.90	2.90	2	9	5.80	20.80	32.1	268.10	-53.20
		5	IPM			0	7	0.00	0.00	32.6	293.40	*
		5	IPM w/ premium	2.90		1	8	2.90	10.40	33.8	293.80	-27.50
		5	IPM w/ termination at R5			0	7	0.00	0.00	35.2	316.80	*
TAREC	Full-season	4	Untreated			0	12	0.00	0.00	52.6	473.40	0.00
		4	Tank mix	2.90	2.90	2	14	5.80	20.80	52.9	455.30	-18.10
		4	IPM	2.90	2.90	2	14	5.80	20.80	53	456.20	-17.20
		4	IPM w/ premium	13.66	6.25	2	14	19.91	34.91	56.6	474.49	1.09
		4	IPM w/ termination at R5	13.66		1	13	13.66	21.16	55.6	479.24	5.84
		5	Untreated			0	12	0.00	0.00	59.6	536.40	0.00
		5	Tank mix	2.90	2.90	2	14	5.80	20.80	56.8	490.40	-46.00
		5	IPM	2.90		1	13	2.90	10.40	60.4	533.20	-3.20
		5	IPM w/ premium	6.25		1	13	6.25	13.75	58.7	514.55	-21.85
		5	IPM w/ termination at R5			0	12	0.00	0.00	56.7	510.30	*
TAREC	Double-crop	4	Untreated			0	7	0.00	0.00	27.2	244.80	0.00
		4	Tank mix	2.90	**	1	8	2.90	10.40	24.0	205.60	-39.20
		4	IPM			0	7	0.00	0.00	22.8	205.20	*
		4	IPM w/ premium			0	7	0.00	0.00	25.1	225.90	*
		4	IPM w/ termination at R5			0	7	0.00	0.00	22.7	204.30	*
		5	Untreated			0	7	0.00	0.00	20.6	185.40	0.00
		5	Tank mix	2.90	**	1	8	2.90	10.40	25.1	215.50	30.10
		5	IPM			0	7	0.00	0.00	17.0	153.00	*
		5	IPM w/ premium			0	7	0.00	0.00	21.2	190.80	*
		5	IPM w/ termination at R5			0	7	0.00	0.00	26.9	242.10	*

[1]Field visits based on the number of sprays applied, insect sampling and related data collection, and harvest.
[2]Calculated using the following insecticide costs: bifenthrin @ 6.4 oz/A = $2.90/A; acephate @ 16 oz/A = $6.25/A; chlorantraniliprole @ 14 oz/A = $13.66/A.
[3]Calculated using a sprayer application cost of $7.50/A (per spray).
[4]Calculated using soybean valued at $9.00/bu.
*When there were no costs associated with the management program (i.e., when insect populations were below thresholds and therefore the program had no insecticide application), the treatment was considered to be the same as the untreated program.
**There was no fungicide/bifenthrin tank mix application in the late-planted TAREC double-crop experiment (a pre-emergent herbicide/bifenthrin tank mix was applied on July 9).

Objective 3

To facilitate and encourage scouting, we made and distributed beat cloths to soybean producers and agribusiness personnel at Extension-sponsored field days and meetings, and provided training on proper sampling technique, insect identification, and management recommendations (Figs. 7-9). Beat cloths were made from 15-oz cotton canvas duck and 0.5-inch-diameter wooden dowel rods. Virginia Cooperative Extension Agents assisted with beat cloth distribution within their counties.

Fig. 7. Beat cloth and accompanying insect threshold card produced by the Taylor laboratory.



	# per row foot		# per 15 sweeps	
Row spacing	7-21" rows	Above 21"	7-21" rows	Above 21"
Grain	1-2	1-2	5	5
Seed	0.5	0.5	2.5	2.5

Fig. 8. Insect identification/threshold card, front and back.

● **Brown, green, brown marmorated stink bug** 10 beat sheet samples per field, or 12 - 15 sweep samples Small nymph groups (<1/2 inch) should be counted as 1 adult. Large nymphs (>1/2 inch) should be counted with adults.	**Thresholds –** Seed and edible: 0.5 per row ft. (3 per 36" beat sheet sample); 2.5/15 sweeps Grain: 1 per row ft. (6 per 36" beat sheet sample); 5/15 sweeps	**Critical stages and considerations**: R4 most sensitive stage, followed by R5 Damage can occur at R6, but likely requires larger populations (~4 per row ft) Damage can occur at R7, but likely requires very high populations (>8 per row ft)
Corn earworm 3 samples per field + 1 sample for every 3 acres in fields over 6 acres 1 beat sheet or 15 sweeps at each location Each sweep should cover 5, 3, or 2 rows of 7 inch, 14 inch, or 21 inch rows, respectively	**Thresholds –** Use https://www.ces.ncsu.edu/wp-content/uploads/2017/08/CEW-calculator-v0.006.html Example using $9/bushel $10-22 costs: 1-2 per beat sheet sample or 2-4/15 sweeps	**Critical stages and considerations**: Rarely control in flowering beans; not attractive to moths past flowering and early-podding.Yield losses occur when seed are almost full size. Do not spray below threshold populations.
Defoliators + soybean looper Estimate the percentage defoliation at 3 - 10 locations per field Take 1 beat sheet or 15 sweeps at each location if threshold or near threshold defoliation is observed.	**Thresholds –** 30% foliage loss up to two weeks prior to blooming; 15% foliage loss from two weeks prior to flowering – pod fill; 50-60% full seed + 12 or more loopers per 15 sweeps	**Critical stages and considerations**: Use judgement and restraint when making treatment decisions. Do not spray beans nearing maturity. A leaf area index of 3.5 or more is ideal in double-crop beans. Do not confuse loopers with other caterpillars.

Insecticide name	Rate	Stink bug	Corn earworm	Soybean looper	Other thoughts
Acephate (Orthene 97)	.49 - .47 lb ai/A .5 – 1 lb product/A	Yes	No	No	Secondary pest outbreaks
Pyrethroids (Brigade, Baythroid, Warrior II, generics)	Use max. labeled rate for brown stink bug and corn earworm	Yes (less effective against brown)	Maybe (expect <100% efficacy)	No (will make worse)	Secondary pest outbreaks
Prevathon	14-20 oz product/A	No	Yes	Maybe	14-21 d residual
Besiege	5-8 oz product/A	Yes (less effective against browns)	Yes	Maybe (may make worse)	14-21 d residual
Intrepid Edge	4-6.4 oz product/A	No	Yes	Yes	Ensure coverage, no residual
Steward EC	5-11 oz product/A	No	Yes	Yes	Ensure coverage, no residual
Radiant	2-4 oz product/A	No	Yes	Yes	Ensure coverage, no residual
Blackhawk	1.7-2.2 product/A	No	Yes	Yes	Ensure coverage, no residual

Trade names are included to aid in the identification of the specific active ingredient of a pesticide known to be effective. No discrimination against a similar product is intended or implied by omission. Mention of a commercial product does not constitute an endorsement by the authors or by their respective Extension Services. Consult the pesticide label for any changes in rate, timing, handling, or registration

Fig. 9. Handout with insect thresholds and insecticide recommendations.

ACKNOWLEDGMENTS: We would like to acknowledge the Virginia Soybean Board for their support of our entomology program. Appreciation is extended to Dr. Joseph Oakes and staff at the EVAREC for their assistance with Objective 1, and to Virginia Cooperative Extension ANR Agents for help distributing beat cloths to soybean producers in their counties.