2023 SOYBEAN RESEARCH REPORT

Grain and Forage Center of Excellence
Martin-Gatton College of Agriculture, Food and Environment

Contents

INCIDENCE OF FROGEYE LEAF SPOT AND TARGET SPOT AMONG SOYBEAN VARIETIES IN KENTUCKY

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INTRODUCTION / OBJECTIVE

Frogeye leaf spot (caused by *Cercospora sojina*) is a common fungal disease that primarily affects the foliage of soybean, causing round to misshapen tan to gray spots on leaves. The spots are up to 1/4-inch in diameter and surrounded by a thin dark reddish-purple margin. Target spot (caused by *Corynespora cassiicola*) is a less common fungal disease in Kentucky that primarily affects the foliage of soybean, causing round to irregular-shaped spots with a zonate pattern that resembles a target.

Symptoms of frogeye leaf spot generally are not observed until the late vegetative stages or until after flowering, while symptoms of target spot can be observed on leaves in the lower to mid-canopy during vegetative and reproductive stages of soybean development. Infections by both pathogens are favored by warm, wet and humid weather. Planting resistant varieties is a sustainable and effective way to manage both diseases. Crop rotation may help reduce inoculum levels in field and if warranted, foliar fungicides with multiple modes of action can be effective in protecting leaves against infection.

The objective of this study was to evaluate the severity and incidence of frogeye leaf spot and target spot, respectively, among soybean varieties in Kentucky.

MATERIALS AND METHODS

One hundred thirty-five soybean varieties were planted at Princeton, KY on 4/19/2023 and at Murray, KY on 5/1/2023. The trials were set up in a randomized complete block design with three replications. Collection of disease data occurred at approximately growth stage R6-R7. There were no fungicides applied to these trials. Frogeye leaf spot (FLS) was rated as severity (%) and target spot (TS) was listed as susceptible (having >20% incidence) or moderately susceptible (<20% incidence). The results summary presented in Table 1 show the average rating values from a combined analysis across the two locations. There were no other diseases besides FLS and TS with adequate symptoms to rate in 2023.

RESULTS AND DISCUSSION

Frogeye leaf spot severity ratings ranged from 0 to 10.3% with 60 of the 135 varieties showing no symptoms, and a majority of the others having minimal symptoms (Table 1). Only 14 oF the 135 varieties had an FLS severity rating > 5%. There was no relationship between FLS severity and maturity group (correlation coefficient = 0.2) [data not shown]. Likewise, there was no difference in FLS severity among GMO traits, such as Xtend (Dicamba tolerant), Enlist (2-4D tolerant) or non-GMO (data not shown). Only 10 of the 135 varieties had target spot symptoms, and in half those cases, the disease incidence was < 20%.

The amount of disease pressure for any pathogen varies by year and location based on environmental conditions and presence of pathogen inoculum. These data indicate that for the level of target spot and frogeye leaf spot pressure in 2023, the vast majority of varieties appear to have high levels of genetic resistance, and fungicide applications may only be warranted if planting TS or FLS susceptible varieties.

ACKNOWLEDGEMENTS

This research was funded in part by the Kentucky Soybean Promotion Board. Additional thanks to Dalton Mertz and Philip Shine (UK, Research Analysists) for their efforts with this project.

Table 1. Soybean variety differences in Frogeye Leaf Spot and Target Spot incidence.

Variety	FLS	TS	Variety	FLS	TS	Variety	FLS	TS
AGRIGOLD G3957E3	0.0		HS 32E30	0.0		PIONEER P40A23E	5.0	
AGRIGOLD G4051E3	0.0		HS 35E10	0.0		PIONEER P42A84E	0.5	
AGRIGOLD G4094XF	4.0		HS 38F20	0.2		PIONEER P45A79E	0.0	
AGRIGOLD G4393E3	10.3		HS 39F30	0.5		PIONEER P46A09E	0.0	
ARMOR 39-F73	1.0	MS	HS 40E30	0.0		PIONEER P48A14E	0.2	
ARMOR 43-E70	0.0		HS 41E20	0.0		Revere 3908XFS	0.0	
ARMOR 45-E73	0.5		HS 42E10	0.0		Revere 4237XFS	3.0	
ARMOR 45-F65	1.8		HS 44F30	0.5		Revere 4299XS	0.3	
ARMOR 49-E72	0.2		HS 47E30	0.8		Revere 4526XFS	8.2	
ASGROW AG27XF3	0.0		HS 48E10	0.0		Revere 4795XS	1.0	
ASGROW AG30XF2	0.5		HS 48F30	2.3		Revere 4826XF	2.7	
ASGROW AG30XF4	0.0		Innotech 3750E3S	0.8		Revere 5029XF	1.2	
ASGROW AG33XF3	0.0		Innotech 3961E3S	0.0		STEWART 3843XF	0.3	MS
ASGROW AG35XF1	1.3	S	Innotech 4233E3S	3.7		STEWART 3954XF	0.0	
ASGROW AG38XF3	1.7	MS	Innotech 4545E3S	0.0		STEWART 4053XF	0.0	
ASGROW AG40XF1	0.0		Innotech 4983E3S	6.2		STEWART 4353XF	2.5	
ASGROW AG40XF4	1.7		Innotech 5143E3	0.0		STEWART 4533XF	2.3	
ASGROW AG42XF4	3.0		Innvictis A3992XF	4.8		STEWART 4834XF	0.0	
ASGROW AG43XF2	5.8		Innvictis A4103XF	1.3		STINE 38EF32	0.0	
ASGROW AG44XF4	0.3		Innvictis A4503XF	0.0		STINE 39EC22	0.0	
ASGROW AG45XF3	7.5		Innvictis A4862XF	0.0		STINE 39EF32	0.2	MS
ASGROW AG46XF3	7.8		Innvictis A5003XF	0.0		STINE 40FB23	2.8	
ASGROW AG48XF3	4.2		Innvictis B4603E	0.0		STINE 41EB32	0.0	
ASGROW AG49XF3	4.8		MO S17-17644C	0.0		STINE 41EE62	0.0	
ASGROW AG49XF4	0.0		MO S18-6328C	0.0		STINE 44EE20	0.8	
CHANNEL 3823RXF	0.8	MS	MO S19-10701C	0.0		STINE 46EE20	0.8	
CHANNEL 3924RXF	0.5		NuTech 33N04E	0.0		STINE 46EG92	0.0	
CHANNEL 4023RXF	0.8		NuTech 34N02E	0.0		STINE 46FD29	1.7	
Dyna-Gro S38XF22S	0.8	S	NuTech 36N04E	0.0		STINE 47EE02	1.0	
Dyna-Gro S40EN54	0.0		NuTech 37N03E	0.8		STINE 48EE20	0.8	
Dyna-Gro S41EN72	0.0		NuTech 39N07E	0.0		STINE 49EE21	0.0	
Dyna-Gro S45XF02	0.0		NuTech 42N05E	0.0		STINE 50EE12	9.0	
Dyna-Gro S47XF23S	2.7		NuTech 45N09E	0.0		USG 7392XFS	0.2	S
Dyna-Gro S48EN73	1.3		NuTech 47N04E	0.0		USG 7434XF	0.8	
Dyna-Gro S49XF43S	0.0		P38MOO23	0.2		USG 7461XFS	0.0	
ESSEX (check)	2.0		P41ILO21	0.2		USG 7463XF	4.3	
GDM V4921S	0.3		P41IMO21	0.8		USG 7474XFS	3.7	
Golden Harvest GH3994E3	0.0		P45XP421	0.0		Xitavo XO 3803E	0.0	S
Golden Harvest GH4093E3	0.0		P48MO21	0.0		Xitavo XO 3922E	0.0	
Golden Harvest GH4214E3S	0.5		PB 3323 E3 S	0.2		Xitavo XO 4084E	0.0	
Golden Harvest GH4222XF	9.5		PB 3923 E3 S	0.0	S	Xitavo XO 4132E	0.0	
Golden Harvest GH4433E3S	0.0		PB 4124 E3 S	0.0		Xitavo XO 4364E	5.3	
Golden Harvest GH4663XFS	6.3		PB 4424 E3 S	8.7		Xitavo XO 4522E	0.5	
Great Heart GT-4320ES	6.7		PENNYRILE (check)	0.0		Xitavo XO 4653E	0.3	
Great Heart GT-4366XFS	1.0		PIONEER P37A18E	0.2		Xitavo XO 4894E	5.8	

FLS = Frogeye Leaf Spot severity (%)

TS=Target Spot: MS = moderately susceptible; S = susceptible.

EVALUATION OF FOLIAR FUNGICIDES ON SOYBEAN IN PRINCETON, KY, 2023

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INTRODUCION AND OBJECTIVE

The objective of this research was to evaluate different fungicide products for management of frogeye leaf spot and their impact on soybean yield.

METHODS & MATERIALS

A field trial was conducted at the University of Kentucky Research and Education Center (UKREC) in Princeton, KY in 2023. Soybean cultivar 'NK43-Y9XFS' was planted on May 22, 2023, at 135,000 seeds/A. Plots were no-till planted into soybean stubble from the previous crop. Plots were 4 rows wide (on 30 inch row spacings) and 21 ft long. Each treatment was replicated four times in a randomized complete block design. Foliar fungicide treatments were applied to plots at the R3 soybean development stage (beginning pod stage) using a backpack sprayer calibrated to deliver 20 gal/A on August 1, 2023. Severity of frogeye leaf spot (caused by *Cercospora sojina*) was rated multiple times starting 2 weeks after treatment application, and then every two weeks after that. Disease severity was rated by evaluating leaves in the upper canopy and estimating the percentage of leaf area affected by frogeye leaf spot. Final disease ratings collected on September 18, 2023, are reported below. Plots were harvested with a small plot combine equipped with an H3 GrainGage (Harvest Master, Logan, UT), which collected total plot weight and seed moisture and concentrations of protein and oil in the seed. Yields were calculated and standardized to bushels per acre at 13% moisture. Data were statistically analyzed using SAS software (version 9.4). When treatments were found to be statistically significant ($P \leq 0.05$), means were compared for differences using Fisher's least significant difference (LSD) test with an alpha = 0.05. University of Kentucky Cooperative Extension recommendations were followed for nutrient and weed management.

RESULTS AND DISCUSSION

Final disease severity in the nontreated check was relatively high (41.7%) (Table 1). All treatments significantly reduced frogeye leaf spot severity compared to the non-treated check. Lucento treated plots had the lowest frogeye leaf spot severity, but were not statistically different than Revytek, Veltyma, Topguard EQ, Delaro Complete, Initate 720 + Monsoon + Topsin 4.5 FL, Miravis Neo, Trivapro, or Topsin 4.5 FL. No statistically significant differences among treatments occurred for yields or protein and oil concentrations.

Widespread resistance to quinone outside inhibitor (QoI) fungicides in the frogeye leaf spot pathogen (*C. sojina*) are present in Kentucky and other states. These research results show that alternative chemistry classes can be used to manage frogeye leaf spot. Although the only QoI single active ingredient product evaluated in this trial (Quadris) did significantly reduce frogeye leaf spot severity relative to the non-treated check, all other products evaluated performed better than Quadris. When considering foliar fungicide products, it is important to utilize products that contain fungicide active ingredients from classes other than QoIs for the best efficacy.

ACKNOWLEDGEMENTS

This research was funded by a Multi-Regional Soybean Checkoff grant distributed by the North Central Soybean Research Program.

TABLES

Table 1. Effect of different fungicide treatments applied at the R3 developmental stage to soybean on frogeye leaf spot (FLS) severity, yield, oil, and protein at Princeton, KY in 2023.

Treatment	**Rate (fl oz/A)**	**FLS severity (%)**	**Yield (bu/A)**	**Oil (%)**	**Protein (%)**
Non-treated check	.	41.7	76.1	20.3	34.4
Topguard EQ	5	16.7	83.9	20.0	34.9
Lucento	5	13.7	79.5	20.0	34.7
Trivapro	13.7	19.2	81.1	20.1	34.9
Quadris	6	35.8	76.0	20.2	34.6
Veltyma	7	16.3	84.5	20.1	34.8
Revytek	8	16.2	85.0	20.0	34.9
Initiate 720 + Monsoon + Topsin 4.5 FL	36 + 4 + 20	17.5	82.2	20.1	34.7
Delaro Complete	8	17.5	81.1	20.1	34.7
Miravis Neo	13.7	19.2	81.6	20.1	34.4
Topsin 4.5 FL	20	20.0	78.6	20.1	34.9
Miravis Top	13.7	23.7	83.6	20.2	34.6
Aproach Prima	6.8	28.7	78.3	20.1	34.8
	P > F	**0.0001**	**0.0660**	**0.6629**	**0.3308**
	LSD 0.05	**5.4**	**NS**	**NS**	**NS**

DETERRENT FEEDING EFFECT OF GROUND TOBACCO ON MOLLUSKS

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INTRODUCTION AND OBJECTIVE

Snails and slugs are well known pests of horticultural crops that cause substantial economic losses. Nowadays, they are emergent pest of field crops particularly soybean and corn. Chemical control using metaldehyde pellets is the more common approach, this chemical however can cause toxicity to nontarget organisms: birds and mammals. Integrated pest strategies provide alternatives for snail control with less negative impact on the environment. Among plant products tobacco dust showed molluscicidal effects against juvenile and adult pond snails (*Cerithedea congulata* Gmelin), the efficacy, however, depends on the nicotine concentration (Borlongan et al., 198).

This report presents a series of laboratory studies that were performed to evaluate ground air and fire-cured tobacco leaves, stems, and stalks as feeding deterrents to slugs and juvenile and adult land snails.

METHODS & MATERIALS

Mollusks: Adult slugs (*Deroceras invadens)* were collected at a Kentucky soybean field in the summer of 2022. In 2023, a snail (*Mesodon clausus*) colony was initiated with adult animals gathered from a heavily infested soybean field. Immature snails (1-5 weeks old) were obtained from a colony reared in a growth chamber at 25°C, 20% RH, photo- period of 12:12 (L:D).

Choice and no choice test for slugs: Ground dark air-cured tobacco leaves and stems were used for slugs in 2022. Ground dark-air-cured (DACT) and dark-fire-cured tobacco (DFCT) stalks were used for snails in 2023. Miracle-Gro® potting mix, field soils from the UKREC (Princeton, KY) (Crider silt loam and sandy loam soils) were evaluated as alternative substrates to ground tobacco for choice test studies. Arenas were built with Petri dishes (100x20 mm or 150x20 mm). Each plate was divided into halves to test two substrates at a time (Figure 1). Arenas were similar for slugs and snails.

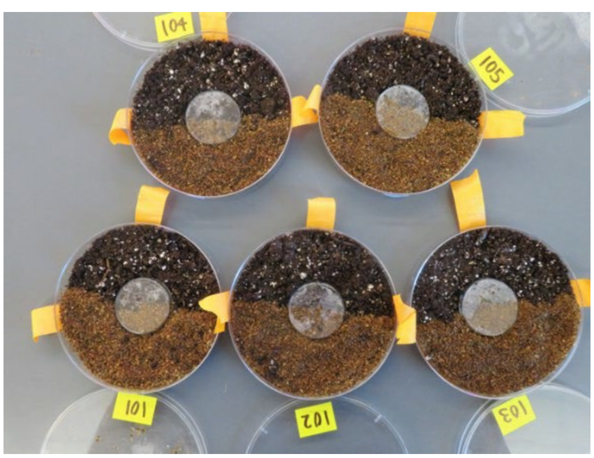

Figure 1. Petri dish used for choice test for slug studies using ground dark air-cured tobacco, ground tobacco leaves, or potting mix substrates.

Deterrence of tobacco band to snail in soybeans: Adult snails were handpicked from a corn field in 2023. A 3-cm layer of Crider silt loam soil was set in a plastic shoe box (35.6 x 20.3 x 12.4 cm) and then planted with 5 pre-germinated soybean seeds. Once the seedlings reached the VE (vegetative emergence) and VC (vegetative cotyle- don) stages, 10 g DFCT was spread as a band on each seedling row (6x30cm). Six snails were set per box, three on each side of the band. The arenas were enclosed using a white nylon tulle fabric held up with a wire piece (Figure 2). Boxes with no tobacco were included as control. Each treatment was repeated four times.

Figure 2. Arenas used to test the deterrent effect of ground tobacco against snails. Snails reach the soybean foliage using the walls of the shoe box and the nylon fabric.

RESULTS AND DISCUSSION

The use of plant extracts or secondary metabolites as antifeedant or deterrent substances has been reported to manage mollusks. This approach plays an important role in organic crop systems and very sensitive environments such as freshwater reservoirs. In this study, slugs, on two-tobacco-substrate (leaves and stems) choice test (Figure 3A), stayed on the centerpiece, and died 3 h after the beginning of the experiment. The potting mix as a choice attracted most slugs, only one slug chose to stay on the tobacco stalk and died after 3 hours (Figure 3B). It took a few more hours for slugs to reach potting mix when the tobacco leaf substrate was the alternative. All snails that reached the potting mix side of the Petri dish stayed alive for the duration of the experiment (Figure 3B and 3C).

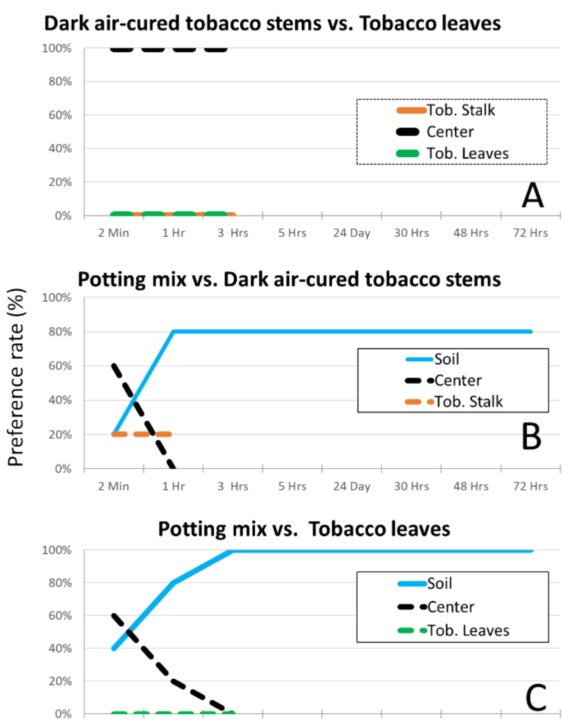

Figure 3. Substrate preference rates of adult slugs in choice tests.

Antifeedant activity of tobacco substrates was observed on juvenile and adult snails. When food was provided on potting mix substrate, immature snails were active and mainly moved to eat carrots. On DFCT tobacco, most immature snails stayed very close together making a "ball" at the center of the plate. Later, a few moved to carrots or somewhere else but remained inactive afterwards. Similar behavior was observed in DACT, but a few more snails were attracted to carrots for a short time. After three days, juvenile snails were transferred to soilless mix with food to determine mortality, about 58% became active after 24 hours.

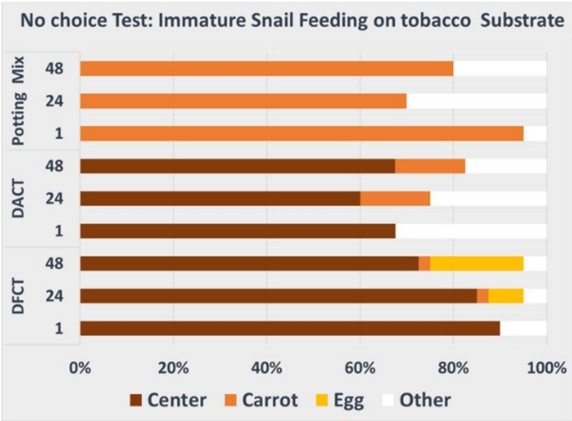

Figure 4. Immature snail feeding on tobacco or potting mix substrates.

Snails voraciously chew the soybean fleshy cotyledon destroying the protected apical meristem; thus, the seedlings die at an early stage. Snails were somehow active on the soil sides when a band of tobacco was spread on the seedling row. However, they did not attack the VE soybeans for at least three days, whereas high percentages of seedlings were attacked when no tobacco was present. A low number of VC soybeans were attacked in presence of tobacco strip, perhaps they climbed to higher points in the plants where they were far from the tobacco volatiles (Figure 5). Ground tobacco might deteriorate with frequent watering, it would be interesting to evaluate the nicotine concentration in the tobacco sources and its stability over time.

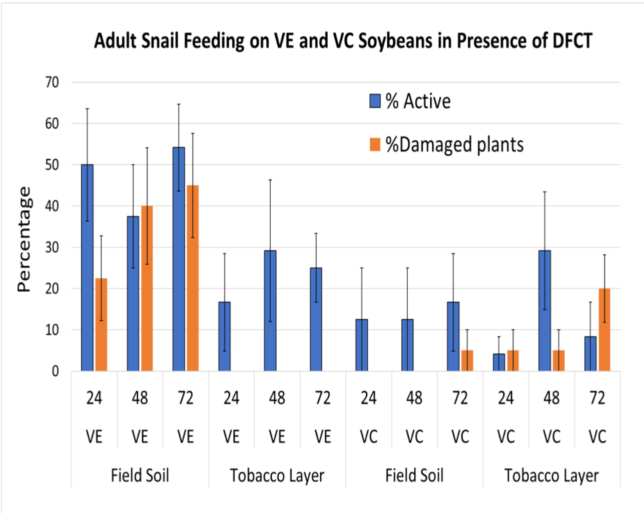

Figure 5. Effect of a DFCT band placement on deterring adult snails from attacking soybean seedlings.

CONCLUSION

Ground tobacco was very toxic to slugs, they died after being exposed to air or dark tobacco in no choice test. Only one snail oozed and died after eating tobacco, all the rest survived. Snails and slugs avoided tobacco substrates. Tobacco showed a strong antifeedant effect on juvenile snails and was not as strong in adult individuals. Adult snails became inactive when tobacco was the substrate in no-choice tests, they buried themselves in soil when food was not provided in the choice tests. A ground tobacco band deterred adult snails from feeding on the VE soybeans for at least 3 days.

ACKNOWLEDGEMENTS

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REFERENCES

Borlongan, I.G., R.M. Coloso, E.F. Mosura, F.D. Sagisi and A.T. Mosura. 1998. Molluscicidal activity of tobacco dust against brackishwater pond snails (Cerithidea cingulata Gmelin). Crop Protection. 17(5): 401-404. https://doi.org/10.1016/S0261-2194(98)00032-5

Kuhn, D.D., S.A. Smith, M.E. Mainous, D.P. Taylor. 2014. Toxicity of tobacco dust to freshwater snails (Planorbella trivolvis) and channel catfish (Ictalurus punctatus). Aquacultural Engineering. 60:14-19. https://doi.org/10.1016/j.aquaeng.2014.03.002

DIVERSITY OF GROUND BEETLES IN CORN-SOYBEAN ROTATION SYSTEMS OF KENTUCKY

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INTRODUCTION AND OBJECTIVE

Carabids are an important ecological component in agroecosystems (i.e., predators, seed consumers, and prey). In Kentucky corn and soybeans are the top crop commodities managed in rotation systems ($1.45 and $1.39 billion USD in 2022, respectively). However, the diversity of carabids remains overlooked in such systems, thus hampering our understanding of ecological functionality on field crops. Intensive agricultural practices such as soil tillage and pesticide application are common in these crops, which in turn can disrupt the populations of beneficial insects (e.g., Carabidae). Moreover, many Kentucky farmers are concerned about the increasing damage on soybeans and corn seedlings caused by snail and slugs every year. In some cases replantating was completed at least four times. Several carabid species play an important role as mollusk predators. In this study, we aimed to provide an overview of the carabid species found in corn-soybean rotation systems in western Kentucky.

METHODS & MATERIALS

During the summer of 2018-2023, adult ground beetles were collected from soybean-corn rotation fields in western Kentucky. Carabids were collected from pitfall traps in 2018 and after that year collections were done while conducting scout in corn and soybean fields. All these specimens were sorted, and identifications were conducted in the labora- tory. Specimens are deposited at the UR-REC, Princeton, KY. Occurrence records were obtained from Global Biodi- versity Information Facility (GBIF).

RESULTS AND DISCUSSION

Despite corn-soybean rotation fields are ecologically simplified habitats (recurrent disturbance caused by tillage, fertilization, pesticide application and harvesting), there is a complex community of ground beetles associated with these agricultural systems. Apparently, *H. pensylvanicus, C. sodalis, and Amara* spp., are highly adapted to agricultural landscapes of KY. These species have a great potential as predators in corn-soybean systems. The species richness and composition are similar to a previous study of carabids on alfalfa fields in KY [i.e., Barney and Pass (1986) reported 40 carabid species].

Species	Count	%
Cicindela sexguttata*	729	13.41
Stenolophus ochropezus*	553	10.17
Stenolophus lecontei	323	5.94
*Scarites subterraneus**	247	4.54
Stenolophus comma	170	3.13
Cicindela repanda	145	2.67
*Harpalus pensylvanicus**	142	2.61
*Galerita janus**	133	2.45
*Tetracha virginica**	127	2.34
Cicindela punctulata	118	2.17
Clivina bipustulata	118	2.17

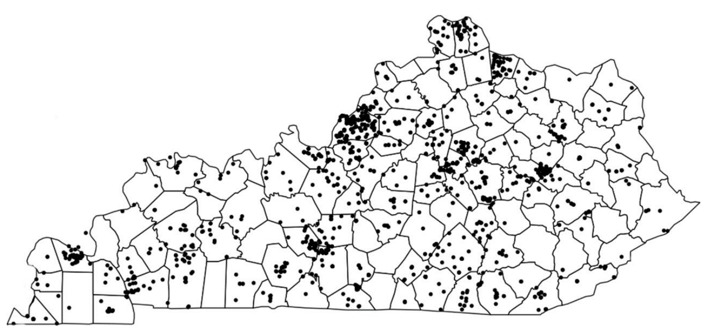

Figure 1. Common carabid species in Kentucky representing 50% of occurrence from Global Biodiversity Information Facility records. (*) represent the species of carabids found in corn-soybean fields in this work.

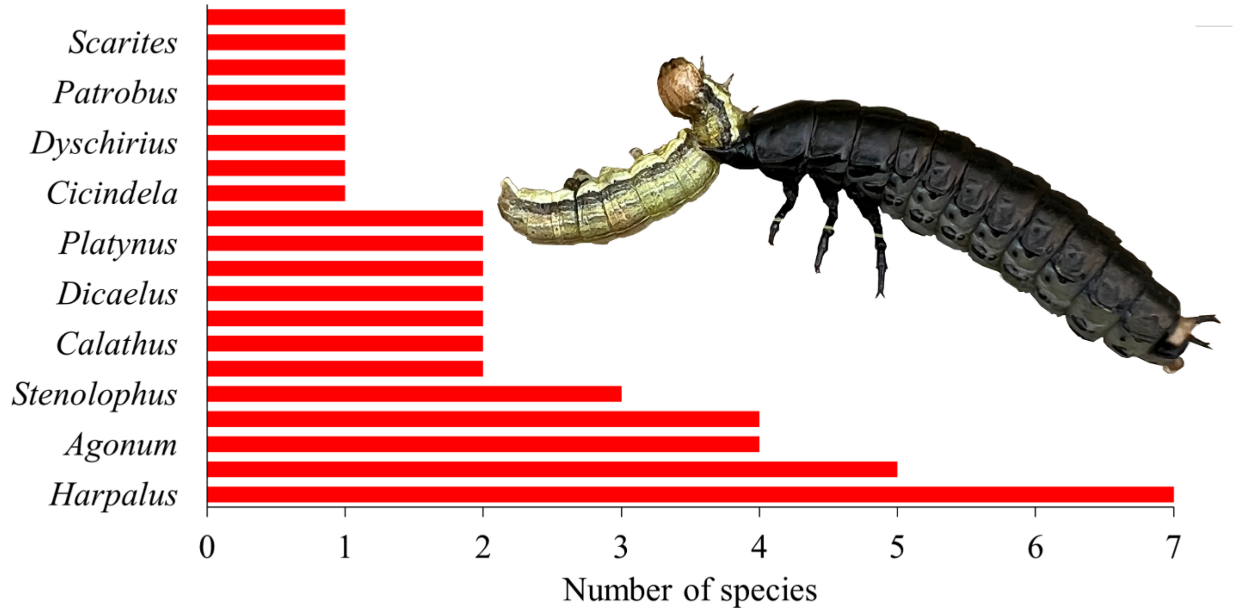

Figure 2. In total, **45 carabid species** of 20 genera were found in corn-soybean rotation systems in western Kentucky.

CONCLUSION

Attention should be paid to the ecological service (i.e., predation) provided by ground beetles on corn-soybean rotation systems. It is recommended to evaluate the impact of ground beetle communities on pest populations in field crops, especially upon snails and slugs, which are causing important damage to early stages of soybeans and corn plants in western Kentucky.

ACKNOWLEDGEMENTS

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REFERENCES

Barney, R.J. and Pass, B.C., 1986. Ground beetle (Coleoptera: Carabidae) populations in Kentucky alfalfa and influence of tillage. *Journal of Economic Entomology*, *79*(2): 511-517.

INTERACTIONS OF COCKLEBUR WEEVIL WITH DECTES IN SOYBEAN-SUNFLOWER SYSTEMS

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INTRODUCTION AND OBJECTIVE

The soybean stem borer *Dectes texanus* (Coleoptera: Cerambycidae) is a native long horned beetle that feeds on soybeans. This species can cause losses to soybean production across North America. The feeding larvae debilitate the plant causing lodging. Previous works proposed the use of sunflower as a trap crop to reduce the attacks of Dectes (Michaud et al. 2007). However, this interaction can be disrupted if another insect arrives first at the host plant: the red cocklebur weevil (RCW) *Rhodobaenus quinquepunctatus* (Coleoptera: Curculionidae) (Villanueva and Falcon-Brindis 2022).

Here, we evaluated the feasibility of using sunflower as a trap crop in soybeans in KY considering the interaction with the RCW within the same host plant.

METHODS & MATERIALS

During three consecutive years (2021, 2022, and 2023), the attack incidence of *D. texanus* on soybean and sunflower was evaluated in Lyon County and Caldwell County, in western Kentucky.

A 10 m by 20 m (width and length) area of sunflower were planted, contiguous to a soybean area 10 m by 100 (width and length). In these plots, sampling was conducted every 2 weeks from August to September. Ten plants were randomly removed from a sunflower plot, while soybeans were randomly chosen from sites 0, 5, 10, 20, 50, and 100 m away from the sunflowers border. Both sunflower and soybean plants were taken to the laboratory for further inspection. Then the larvae of Dectes and RCW were recorded from each host plant Figures 1A and 1B, respectively.

RESULTS AND DISCUSSION

Overall, the highest numbers of Dectes were found in 2021 and 2023 (Fig. 2A and 2C). Also, high numbers of this beetle were found in soybean plants 0.5 and 20 m away from the sunflowers (Fig. 2A, B and C). In 2021 and 2023, the number of Dectes significantly decreased as the distance to sunflower increased, but in 2022 (Fig. 2B), Dectes larvae were concentrated at one single distance: 20 m. The lowest incidence of Dectes in soybean stalks was found 100 m away from the sunflowers for the three years the study took place. The highest proportion of soybean plants infested with Dectes were found at 10 and 20 m (Fig. 3A, B and C).

The red cocklebur weevil was only found feeding on sunflower stalks (n = 191). We observed the RCW larva colonized sunflowers earlier than Dectes (i.e., early August). Adults of RCW were observed since mid-April. The RCW was found in larger proportions (96%) than Dectes on sunflower plants. The galleries of RCW were found mainly in the lower half of the sunflowers. Pupation occurred at the root and then adults chewed their way out of the plants.

Figure 1. Larva of **(A)** *D. texanus* in soybean a soybean stem and **(B)** R. *quinquepunctatus* in a sunflower stalk. Photos: A. Falcon-Brindis.

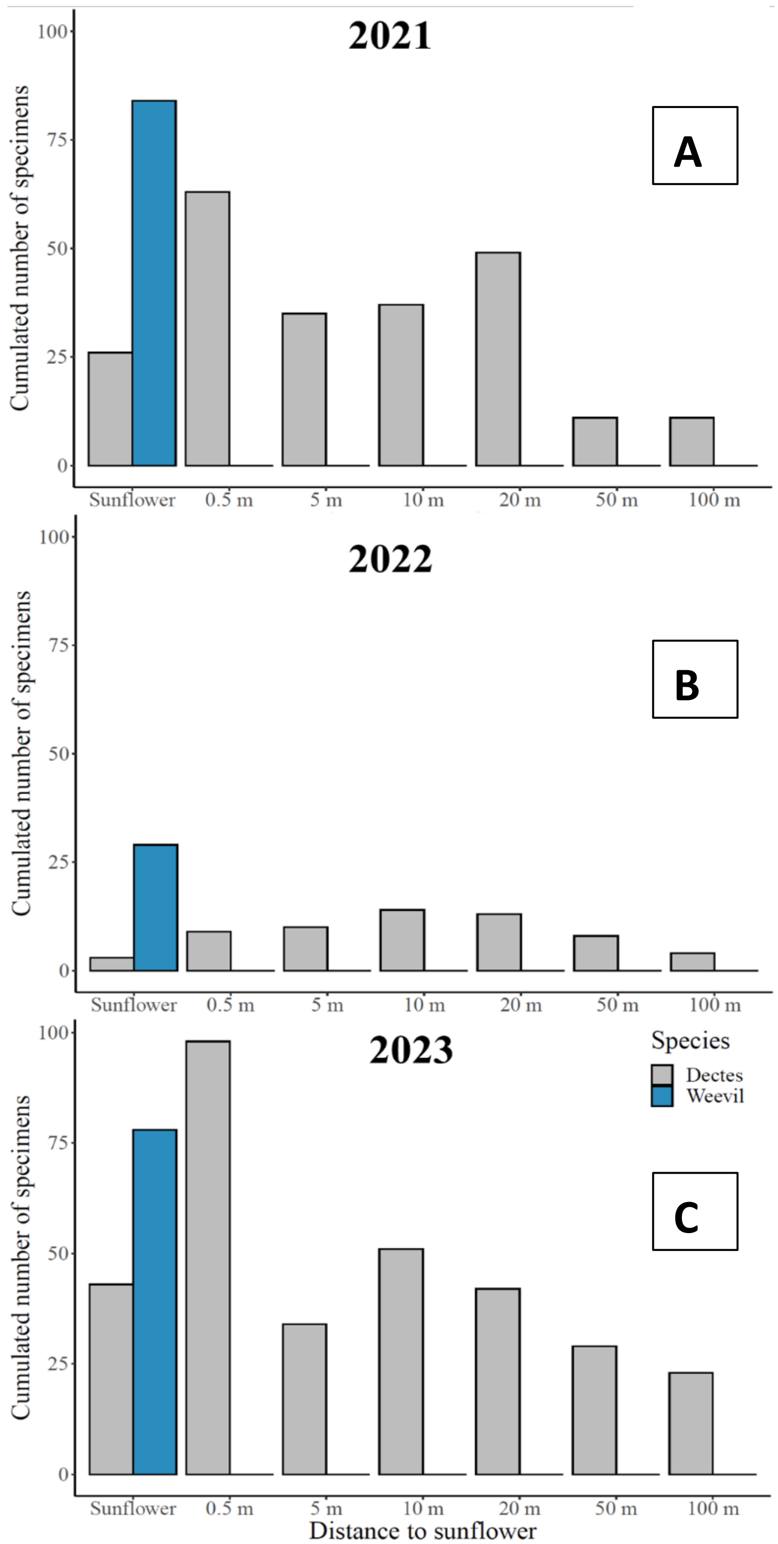

Figure 2. Accumulated numbers of Dectes and red cocklebur weevil (RCW) per host plant across different distance categories in 2021, 2022, and 2023.

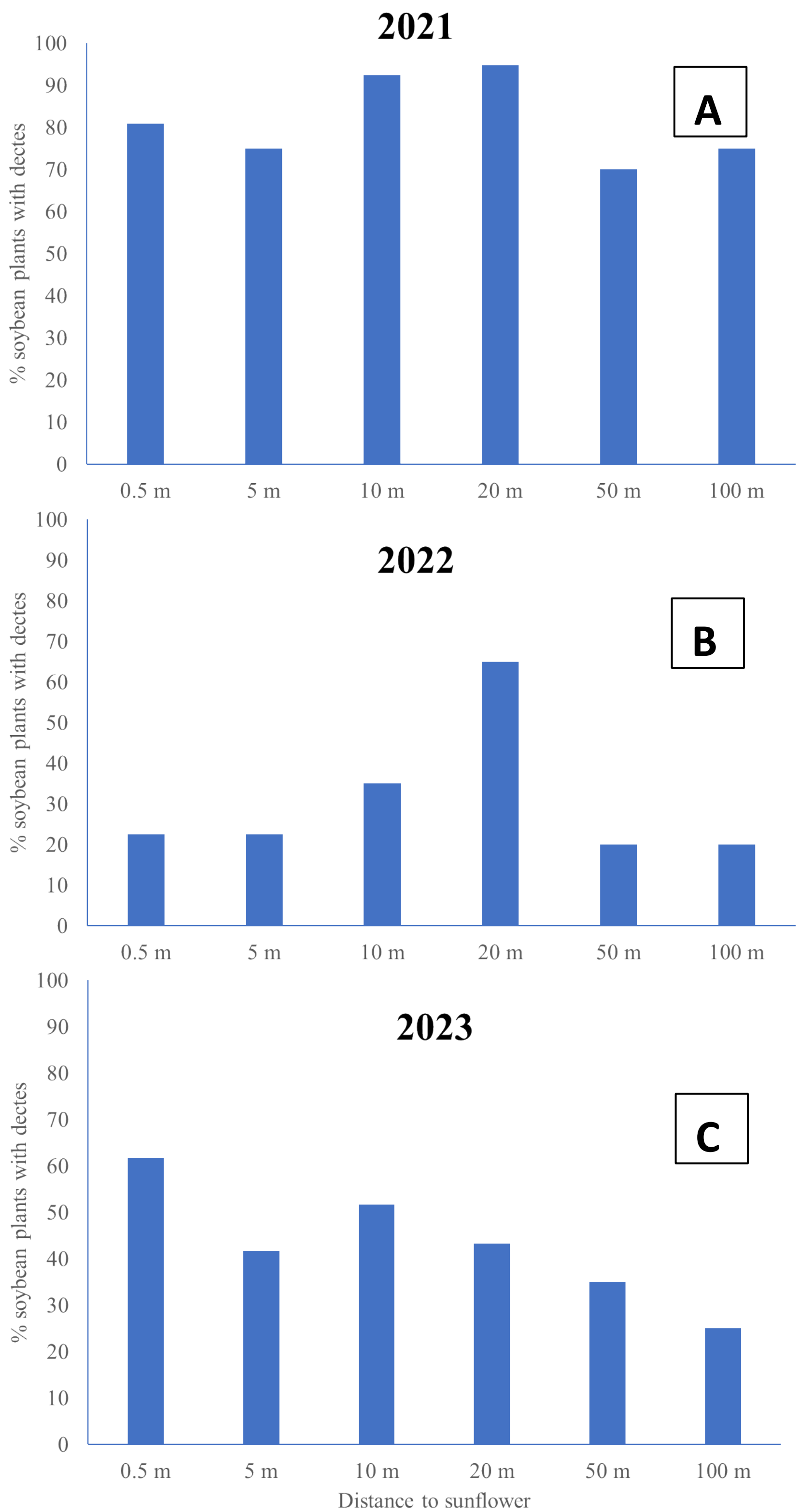

Figure 3. Percentages of soybean plants infested with Dectes at different distances from sunflower in 2021 to 2023.

CONCLUSION

The interaction between Dectes and RCW was previously unknown and is apparently restricting the success of Dectes larva in sunflowers. Therefore, the use of sunflower as a trap crop may be disrupted by this competitive relationship in KY. This relation was not described by Michaud and Grant (2005) and Michaud et al. (2007), although the RCW was previously recorded in Kansas.

Even though sunflower is an attractive host for Dectes, the cocklebur weevil infested these plants earlier than Dectes, thus restraining Dectes to complete its life cycle and might be causing mortalities that were not recorded in this study. The low Dectes and RCW populations in 2022 were related to a severe drought that occurred in western KY. More research needs to be done to understand the interaction between the RCW and Dectes in soybean systems using sunflowers as trap crops.

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REFERENCES

Michaud, J. P., Grant, A. K. 2005. The biology and behavior of the longhorned beetle, *Dectes texanus* on sunflower and soybean. Journal of Insect Science, 5(25):1-15.

Michaud, J. P., Qureshi, J. A., Grant, A. K. 2007. Sunflowers as a trap crop for reducing soybean losses to the stalk borer *Dectes texanus* (Coleoptera: Cerambycidae). Pest Management Science, 63:903-909.

Villanueva, R.T. and A. Falcon-Brindis. 2022. ENTFACT-159: Red Cocklebur Weevil | University of Kentucky.

Evaluation of Postemergence Residual Herbicide Application Timing for Control of Waterhemp in Early Planted Soybean

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INTRODUCTION AND OBJECTIVE

Soybean farmers in Kentucky continue to experiment with earlier planting dates with some pushing soybean planting dates up to as early as March. This trend of pushing soybean planting date earlier into the growing season will likely continue to increase in Kentucky with more and more farmers trying it each year.

As with all changes in our production systems, with change comes new challenges and that does not exclude weed control. One of the principles of cultural weed control is adjusting cropping growing cycles to be outside of peak problematic weed emergence, although this trend is pushing the soybean season further into some of our peak weed emergence events. This creates the question of how to maximize the efficiency of our weed control products as we continue to see soybean planting dates move earlier into the growing season.

Research conducted in 2021 and 2022 evaluating herbicide programs for control of waterhemp in early planted soybean indicated that residuals applied at a March or April planting date may decreased suppression of waterhemp emergence as compared to residual applied at a May planting date. This is likely due to the March and April applied residuals dissipating prior to the bulk of waterhemp emergence in May.

The objective of this research was to evaluate the use of a overlapping residual applications in early planted soybean in comparison to sequential residual applications.

METHODS & MATERIALS

Field trials were conducted in 2022 and 2023 at the University of Kentucky Research and Education Center in Princeton Kentucky. Trials were placed on fields with a known population of glyphosate-resistant common waterhemp. The trials were targeted for planting in the first week of April, although weather conditions delayed planting in 2022. The trials were planted on April 29, 2022 and April 11, 2023. Enlist E3 soybean were planted in both years at a density of 140,000 seeds per acre at a depth of 1.5 inches.

Five soil residual herbicide products were applied at planting along with a burndown herbicide to control all existing vegetation in the no-till plots. The five products evaluated were Canopy, Dimetric Charge, Tendovo, Fierce EZ, and Fierce MTZ. Following each residual herbicide, a postemergence application of Enlist Duo plus Prefix was applied at either 21 days after planting or when waterhemp in the plot reached 2 to 4 inches in height. The two postemergence times represent two different approaches: an overlapping residual herbicide application (21 days after planting) and a sequential herbicide application (2 to 4 inch waterhemp). The majority of farmers currently practice the use of a sequential residual herbicide application where the initial residual herbicide is allowed to dissipate or "break" and weeds that emerge are allowed to reach 2 to 4 inches prior to being controlled with an application of a foliar and residual herbicide mix. In contrast the overlapping residual application is applied 21 days after planting to create and overlap of the two residuals on the field. Based on past experience with early planted soybean we predicted that an overlapping residual would be more beneficial than the traditional sequential herbicide application in early planted soybean. A complete list of herbicides applied and dates of the overlapping and sequential herbicide applications are listed in Table 1.

No further herbicide applications were applied following the postemergence residual herbicide application. Visual control ratings were taken 21 days after the postemergence applications as well as at crop canopy and harvest. Waterhemp density per square meter was collected at crop canopy and just prior to soybean harvest.

All data was analyzed using PROC GLIMMIX in SAS 9.4. When necessary, means separation was conducted using Tukey HSD with an alpha of 0.05.

RESULTS AND DISCUSSION

The first hypothesis of this research was that the sequential postemergence herbicide application (allowing at planting residual to "break" and waterhemp to reach 2 to 4 inches in height) would be applied significantly later in the growing season and have higher waterhemp densities than an overlapping postemergence residual application (21 days after planting). This hypothesis was false in 2022, but true in 2023 and this is due to the differences in planting date in the two years. In 2022, wet weather conditions in April did not allow for planting of soybean until April 29, which would not be considered an early soybean planting date in respect of this research's objective. Whereas in 2023 soybean were planted on April 11, which would be considered an early planted soybean date. In 2022 the difference in date of the overlapping residual application and sequential residual application within an at planting residual herbicide was only 3 to 10 days (Table 1). Whereas the difference in 2023 supported our hypothesis with a difference of 19 to 33 days between the two postemergence application timings within an at planting residual herbicide (Table 1). Additionally, we predicted that there would be more waterhemp plants at the time of postemergence application in the treatments receiving a sequential residual application as compared to an overlapping application. In 2022 this prediction was false as plots receiving the sequential residual application had 154 plants per square meter at the time of that application and was similar to plots receiving an overlapping residual application that had 186 plants per square meter at the time of application (Table 2). In 2023, again the year when soybean planting did occur in the early planting window, this prediction was true with a significantly less waterhemp plants in each treatment at the overlapping timing as compared to the sequential timing when making direct comparisons of timing within an at planting residual herbicide (i.e. Canopy followed by an overlapping residual = 89 plants per m^2 as compared to Canopy followed by a sequential application = 1910 plants per m2) (Table 2).

The 2023 data would suggest that in an early planted soybean the use of a sequential postemergence residual application created significantly more herbicide resistance selection pressure on the postemergence herbicide than the overlapping residual application due to the higher waterhemp densities at that sequential timing as compared to densities at the overlapping timing.

Analysis of waterhemp control at crop canopy and waterhemp density at crop harvest both indicated greater overall control was achieved with a sequential postemergence residual application as compared to the overlapping residual application in both years. In 2022, waterhemp control at crop canopy was 62 percent in the overlapping residual application treatments as compared to the sequential residual application treatments at 83 percent (Table 3). Similarly in 2023, waterhemp control at crop canopy was significantly lower in the overlapping residual treatments at 32 percent as compared to the sequential treatments at 93 percent control (Table 3). At the end of the season these trends held true when assessing waterhemp density per square meter. Treatments receiving an overlapping residual had a density of 5 and 2 plants per square meter in 2022 and 2023 respectively; as compared to the significantly lower density of 2 and 0 plants per square meter in the sequential residual application treatments in 2022 and 2023, respectively (Table 4). The analysis of waterhemp control at crop canopy and waterhemp density at soybean harvest would suggest that in both years that waiting for the initial at planting residual to "break" and waterhemp plants to get to 2 to 4" was a better weed control strategy than using an overlapping residual application at 21 days after planting. This is due to the sequential herbicide application being made closer to crop canopy than the overlapping application and achieving control up to and through the critical stage of soybean canopy closure. It should be noted that no further herbicide applications were applied following the sequential or overlapping residual application, whereas in a farmer field scenario a likely second postemergence application would have occurred in the overlapping residual plots, especially in 2023, to achieve full control of the waterhemp population.

CONCLUSION

While the goal of this research was to understand the value of an overlapping residual herbicide application in early planted soybean over two years, the study ultimately indicates the different approaches that may be needed in an early planted soybean as compared to the traditional soybean planting date. Based on this research and past research we would recommend the following practices for waterhemp control depending on soybean planting date:

Typical Soybean Planting Window (Late April through May) – Apply a robust multiple site of action residual herbicide at soybean planting. Allow the initial residual to dissipate or "break" and apply a postemergence foliar herbicide to control emerged waterhemp and include a residual herbicide to provide additional control up to crop canopy. Always scout fields following applications to determine if additional control may be needed or if resistance selection may be occurring.

Ealy Soybean Planting Window (Late March to Mid April) - Apply a robust multiple site of action residual herbicide at soybean planting. Make a planned overlapping residual herbicide application 21 to 30 days after planting (Late April to Early May). Scout fields and plan to apply a foliar postemergence application when weeds reach 2 to 4" in height.
While the 2023 data suggest that a two-pass program with an at planting residual followed by sequential post with residual herbicide is effective in early planted soybean, the data also suggest that we are placing significant herbicide resistance selection pressure on the postemergence herbicide with this practice. This recommendation is based on balancing the agronomic benefits of early planted soybean, complete weed control within the season, and mitigation of herbicide resistance selection pressure.

Further research is planned to compare the 2 pass sequential residual system to a 3 pass overlapping residual system in early planted soybean to further support this recommendation.

ACKNOWLEDGEMENTS

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TABLES

Table 1. Residual Herbicides applied at soybean planting and dates of postemergence residual applications in 2022 and 2023.

At Planting Residual Herbicide		Postemergence Residual Timing and Date (Prefix – 2.25 pt/a + Enlist Duo – 4.75 pt/a)		
		Application Timing[a]	2022	2023
Dimetric Charged – 15 fl oz/a	metribuzin (5) + flumioxazin (14)	Overlapping Residual	May 21	May 3
		Sequential Residual	May 24	May 31
Tendovo – 2.1 qt/a	S-metolachlor (15) + metribuzin (5) + Cloransulam-methyl (2)	Overlapping Residual	May 21	May 3
		Sequential Residual	May 31	May 31
Fierce EZ – 9 fl oz/a	flumioxazin (14) + pyroxasulfone (15)	Overlapping Residual	May 21	May 3
		Sequential Residual	May 31	June 5
Fierce MTZ – 1.25 pt/a	flumioxazin (14) + pyroxasulfone (15) + metribuzin (5)	Overlapping Residual	May 21	May 3
		Sequential Residual	May 31	June 5
Canopy – 8 oz/a	chlorimuron (2) + metribuzin (5)	Overlapping Residual	May 21	May 3
		Sequential Residual	May 24	May 22

[a] Overlapping Residual – Application at 21 days after soybean planting; Sequential Residual – Application based on when waterhemp reaches 2 to 4 inches in height in each treatment.

Table 2. Waterhemp density at time of postemergence residual herbicide application as influenced by at planting soil residual herbicide and timing of postemergence application.

	2022 (Planting Date – April 29)			**2023 (Planting Date – April 11)[a]**		
	21 Day Overlap	**2 to 4" Waterhemp**	***All Timings[b]***	**21 Day Overlap**	**2 to 4" Waterhemp**	***All Timings***
Canopy	460	320	***391 a***	89 CD	1910 A	**-**
Dimetric Charge	178	173	***175 b***	12 CD	413 B	**-**
Tendovo	59	116	***88 b***	0 D	362 B	**-**
Fierce EZ	145	87	***110 b***	0 D	172 BC	**-**
Fierce MTZ	85	87	***86 b***	0 D	183 BC	**-**
All Preemergence Residuals[c]	***186 A***	***154 A***		**-**	**-**	

[a] Means followed by a different letter are significantly different. Tukey HSD α= 0.05. Data transformed using Square Root Transformations to meet ANOVA assumptions.

[b] Means within the column followed by a different letter are significantly different. Tukey HSD α= 0.05.

[c] Means within the row followed by a different letter are significantly different. Tukey HSD α= 0.05.

Table 3. Visual waterhemp control at soybean canopy as influenced by soil residual herbicide applied at soybean planting and postemergence residual herbicide application timing.

	2022 (Planting Date – April 29)			2023 (Planting Date – April 11)		
	21 Day Overlap	**2 to 4" Waterhemp**	***All Timings***[a]	**21 Day Overlap**	**2 to 4" Waterhemp**	***All Timings***[a]
Canopy	71	79	***75 ab***	6	74	***40 b***
Dimetric Charge	44	63	***53 b***	56	98	***77 a***
Tendovo	50	91	***71 ab***	28	99	***64 ab***
Fierce EZ	76	92	***84 a***	25	99	***62 ab***
Fierce MTZ	66	91	***78 ab***	44	94	***69 ab***
All Preemergence Residuals[b]	***62 B***	***83 A***		***32 B***	***93 A***	

[a] Means within the column within a Year followed by a different letter are significantly different. Tukey HSD α= 0.05.

[b] Means within the row within a Year followed by a different letter are significantly different. Tukey HSD α= 0.05.

Table 4. Waterhemp density per square meter at soybean harvest as influenced by soil residual herbicide applied at soybean planting and postemergence residual herbicide application timing.

	2022 (Planting Date – April 29)			**2023 (Planting Date – April 11)**		
	21 Day Overlap	**2 to 4" Waterhemp**	***All Timings***[a]	**21 Day Overlap**	**2 to 4" Waterhemp**	***All Timings***[a]
Canopy	5	4	***5 a***	5	0	***2 a***
Dimetric Charge	5	3	***4 a***	1	0	***1 a***
Tendovo	6	0	***3 a***	1	0	***1 a***
Fierce EZ	4	2	***3 a***	2	0	***1 a***
Fierce MTZ	3	1	***2 a***	0	0	***0 a***
All Preemergence Residuals[b]	***5 A***	***2 B***		***2 A***	***0 B***	

[a] Means within the column within a Year followed by a different letter are significantly different. Tukey HSD α= 0.05.

[b] Means within the row within a Year followed by a different letter are significantly different. Tukey HSD α= 0.05.