SUMMARY: Herbicide and Integrated Soybean Weed Management 2019

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Can I just plant wheat or do I need cereal rye? Do I need to roll to cover crop or can I leave it standing? How much good is the cover crop doing for weed suppression? Results from objective 1 indicate that maximizing cover crop biomass is most important for weed suppression. When sufficient biomass is achieved (~7,500 lbs/a) similar weed suppression is achieved whether cover crop residues are rolled or left standing. Standing residue is recommended for common ragweed. It resulted in greater control than rolled residue in most cases, despite allowing more light penetration to the soil surface.

Common ragweed and Palmer amaranth survival and seed production was evaluated from various postemergence herbicides (objective 2) and herbicide programs (preemergence followed by postemergence; objective 3). Palmer amaranth and common ragweed control decreased as size increased for all herbicides. Palmer amaranth control was best and seed production least from glufosinate, dicamba + fomesafen, 2,4-D + fomesafen, and glufosinate + fomesafen. Dicamba, 2,4-D, and glufosinate with or without fomesafen and mesotrione + fomesafen resulted in the greatest biomass reduction. Farmers should continue to target Palmer amaranth and common ragweed at small sizes (2 to 4 inches in height) for best outcomes. Herbicide program research results reinforce the utility of PPO PREs when used as part of a program with multiple, effective sites of action. Preemergence applications of flumioxazin, fomesafen, and sulfentrazone provide effective control and reductions of Palmer amaranth density. Dicamba, 2,4-D, and glufosinate on Palmer amaranth are effective on escapes from PPO-containing PRE herbicides. Further research is necessary before recommending targeting taller Palmer amaranth and common ragweed for reducing seed production, but results are promising.

The information gleaned from this research will be incorporated into Extension activities including web-based information, presentations, and field day demonstrations. Producers may then implement weed management changes/recommendations as they see fit.

VIRGINIA SOYBEAN BOARD

PROJECT REPORT – 2019

Title: **Herbicide and Integrated Soybean Weed Management 2019**

Justification and Background:

Herbicide resistance is increasing in Virginia and current herbicide practices (i.e. not consistently using multiple, effective herbicide sites-of-action) are unsustainable. Research and adoption of integrated weed management techniques is essential for the long-term sustainability of Virginia crop production.

One integrated weed management technique that hold tremendous promise in Virginia is the use of high residue cover crops for summer annual weed suppression. Previous research efforts in Virginia indicate that summer annual weeds can be controlled 60 to 70% for 4 weeks after planting (6 weeks after cover crop termination) with cereal rye and cereal rye + legume (crimson clover or hairy vetch) without any adverse effects to soybeans. Research conducted by Flessner et al. in Virginia indicates that high residue cover crops reduce horseweed/marestail populations by 88 to 97% at preplant burndown timing. However, horseweed control remains elusive for some soybean growers and herbicide options after soybean has emerged are extremely limited. Therefore, herbicide evaluation is still necessary in the presence of other weed control methods.

While new, integrated weed management techniques are essential moving forward, it is also imperative to properly steward existing herbicide options in order to prevent and mitigate herbicide resistance. In that regard, new soybean genetic traits have been or soon will be released that allow new herbicide options in soybeans. These include Xtend, LibertyLink GT27, and Enlist, which allow the use of dicamba, isoxaflutole, and 2,4-D, respectively. Of course, these varieties variously include glyphosate and glufosinate resistance traits. These traits, properly used, can help combat group 14 (PPO-inhibiting) herbicide resistance that is present in Palmer amaranth throughout the mid-south, the Midwest, and in North Carolina. Additionally, group 14 resistant common ragweed has been reported in North Carolina and Delaware. To date, PPO resistance has not been found in Virginia. Therefore, Virginia soybean producers have the unique opportunity to utilize new herbicide resistant technologies to proactively manage herbicide resistance. But, research efforts are needed to ensure best recommendations to producers.

Objective 1: Cover crops for common ragweed and Palmer amaranth management.

Methods. A 2 by 2 by 4 factorial evaluated cereal rye versus wheat residue; rolled residue versus left standing; and no, low, medium, or high residue levels for effect on Palmer amaranth and common ragweed germination and establishment. Two locations were established in 2017 with these treatments (Table 1). The cover crop (wheat and cereal rye) was terminated with Roundup Powermax at 1 qt/a approximately 1 week prior to soybean planting, although no soybean crop was planted. Cover crop rolling took place in appropriate plots at this time with a tractor mounted roller/crimper. At the time of termination, Palmer amaranth and common ragweed were seeded into micro-plots within the larger cover crop plots. Data collected included light penetration (photosynthetically active radiation at the soil surface) through time, germination counts through time, cover crop biomass at termination, and biomass of each weed 4 to 5 weeks after cover crop termination.

Table 1. Treatments for Objective 1: Cover crop planting dates, seeding rates, and residue treatment.

	Cover crop species	Biomass rate	Planting date	Seeding rate (lbs/a)	Type of cover
1	---	---	---	---	---
2	cereal rye	low	Nov. 15	50	standing
3	cereal rye	med	Oct. 15	75	standing
4	cereal rye	high	Sept. 15	100	standing
5	cereal rye	low	Nov. 15	50	rolled
6	cereal rye	med	Oct. 15	75	rolled
7	cereal rye	high	Sept. 15	100	rolled
8	wheat	low	Nov. 15	50	standing
9	wheat	med	Oct. 15	85	standing
10	wheat	high	Sept. 15	120	standing
11	wheat	low	Nov. 15	50	rolled
12	wheat	med	Oct. 15	85	rolled
13	wheat	high	Sept. 15	120	rolled

Results:

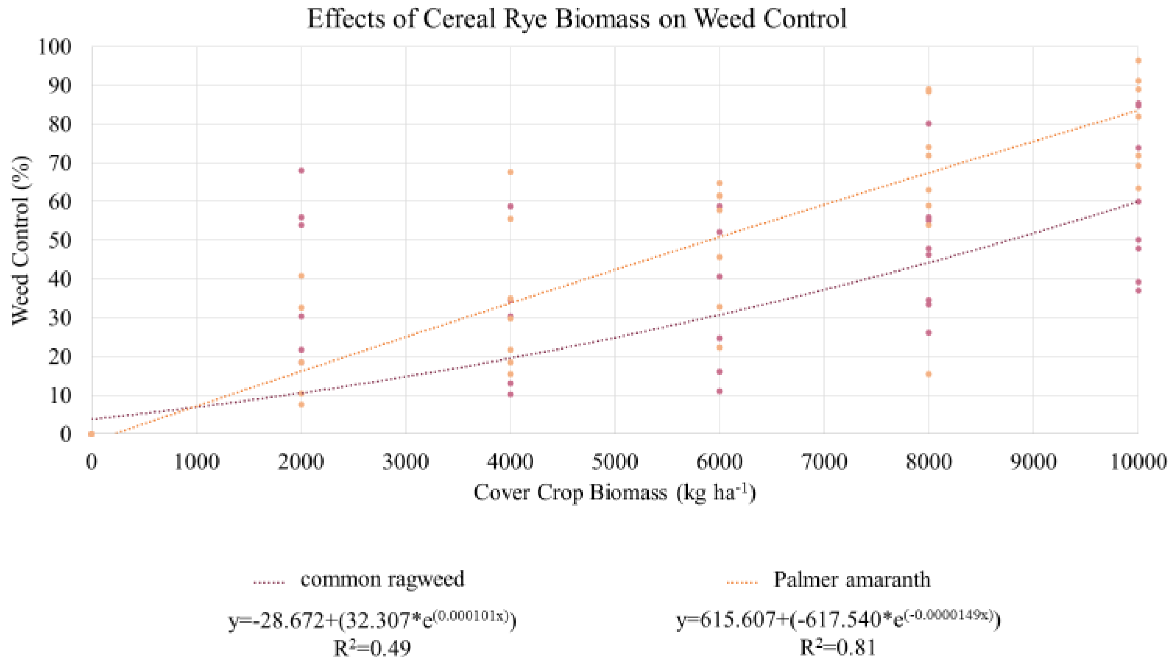

Figure 1. Effects of cereal rye biomass on common ragweed and Palmer amaranth control 4 weeks after initiation from twice-replicated greenhouse studies in Blacksburg, VA in 2018-2019.

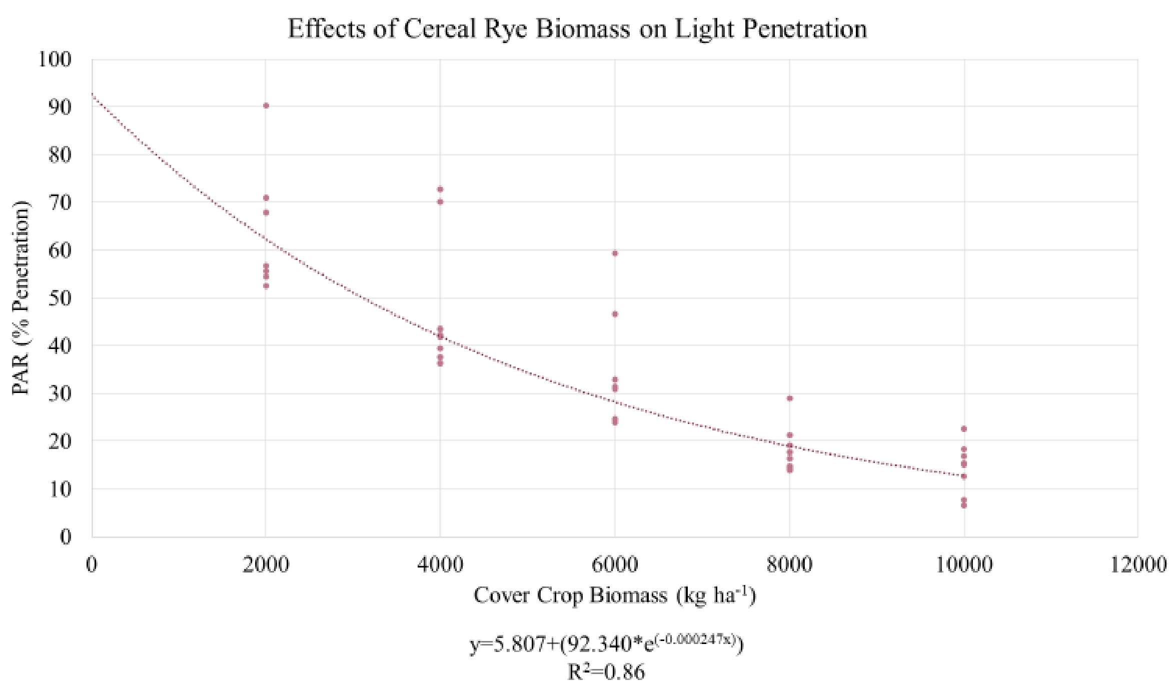

Figure 2. Effect of increasing cereal rye biomass on cumulative photosynthetically active radiation (PAR) 4 weeks after initiation from twice-replicated greenhouse studies in Blacksburg, VA in 2018-2019.

No data are presented from field experiments on Palmer amaranth because it was not present in sufficient densities to result in quality data.

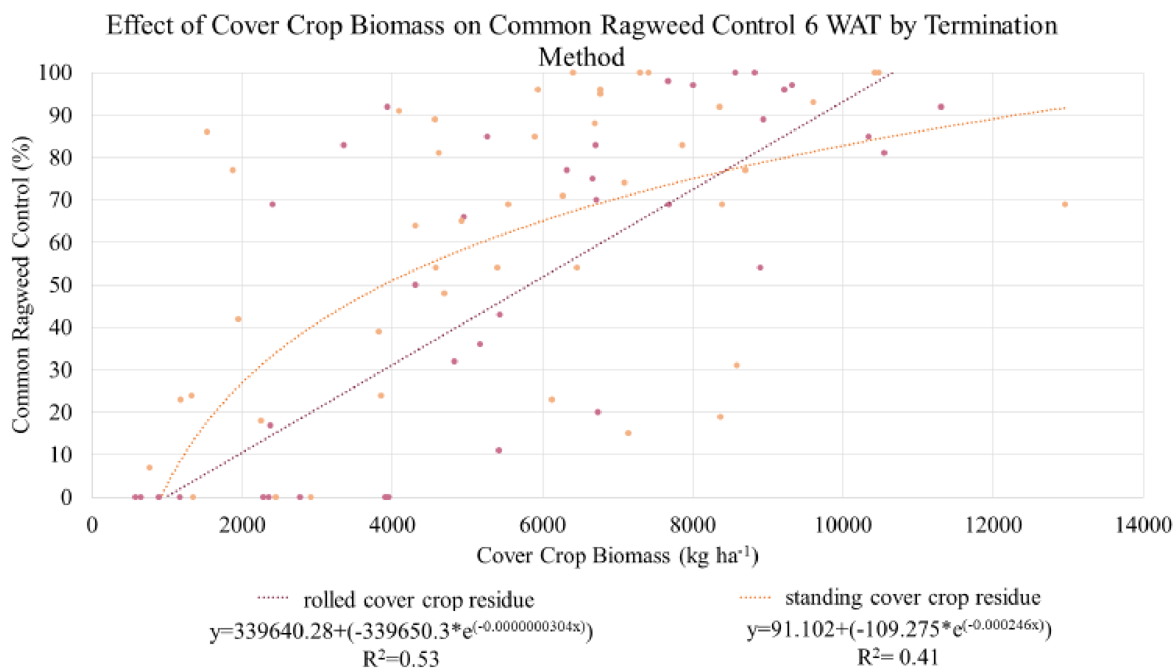

Figure 3. Effects of cereal rye and wheat biomass on common ragweed control 6 weeks after cover crop termination from 2 site-years in Virginia.

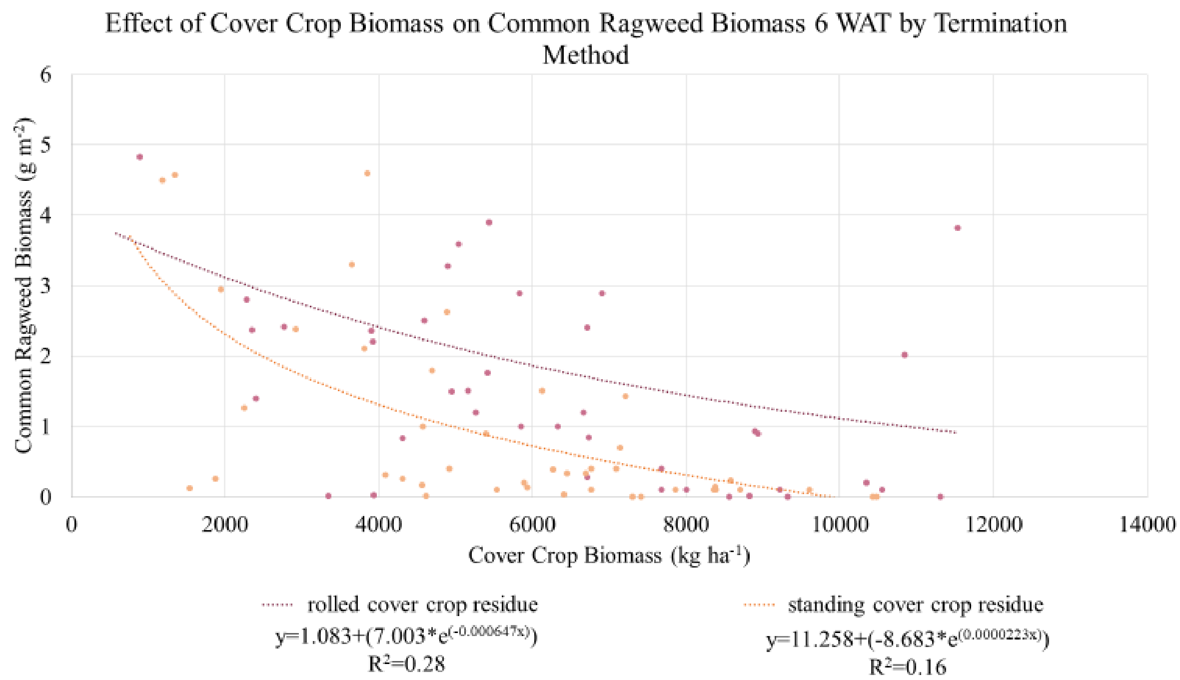

Figure 4. Effects of cereal rye and wheat biomass on common ragweed biomass 6 weeks after cover crop termination from 2 site-years in Virginia.

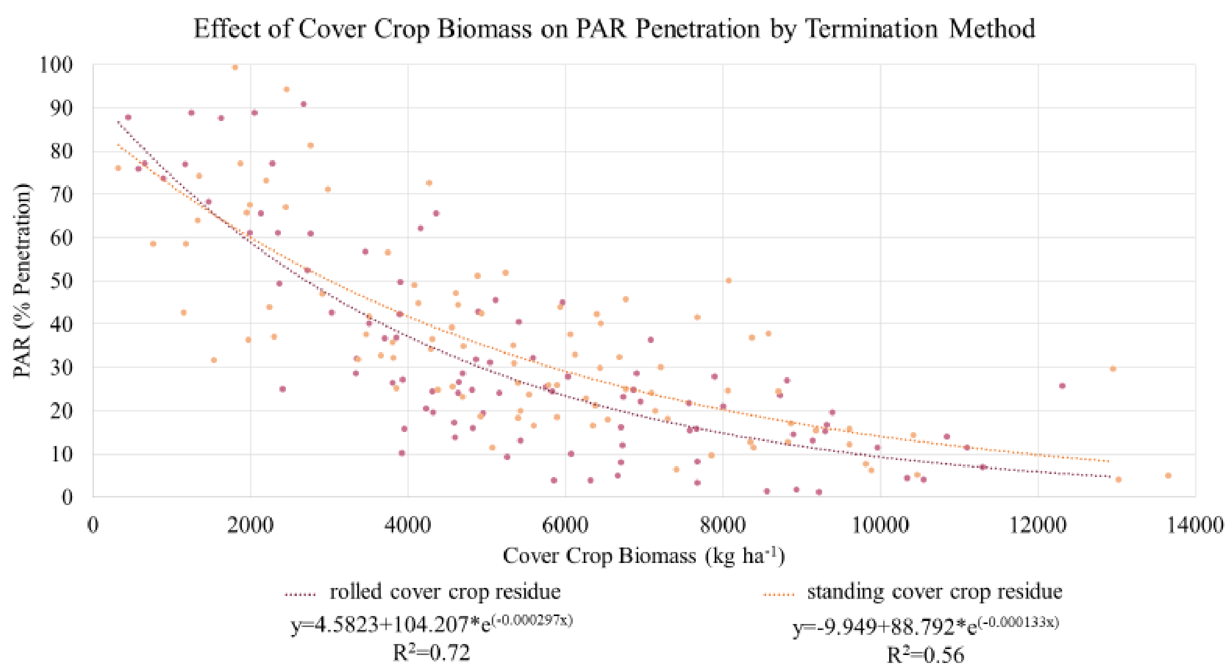

Figure 5. Effects of cereal rye and wheat biomass on cumulative photosynthetically active radiation (PAR) from cover crop termination to 6 weeks after cover crop termination from 2 site-years in Virginia.

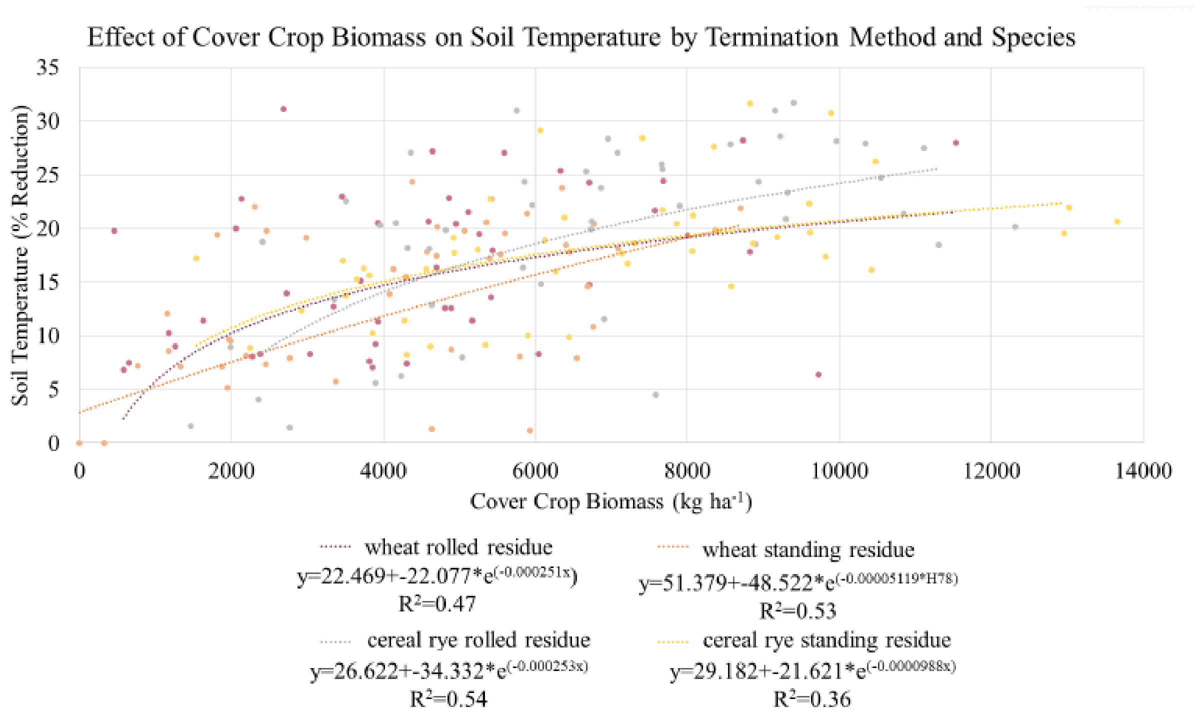

Figure 6. Effect of cover crop biomass on reduction in average soil temperature reduction relative to the no-cover check from cover crop termination to 6 weeks after by termination method (rolled versus standing) and cover crop species (cereal rye or wheat).

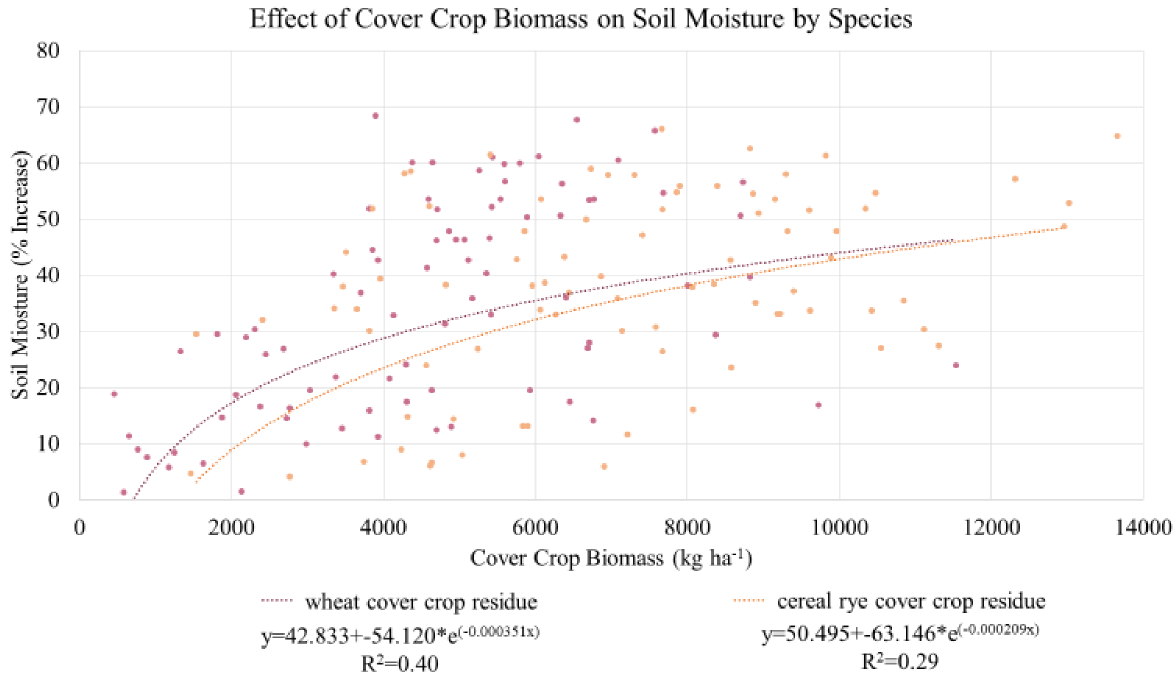

Figure 7. Effect of cover crop biomass on average soil moisture increase relative to the no-cover check from cover crop termination to 6 weeks after by cover crop species (cereal rye or wheat).

Discussion:

As cover crop biomass increased, weed control increased, light penetration decreased, soil moisture increased, and soil temperature decreased. Standing residue provided greater common ragweed control than rolled residue until ~8200 kg ha_{-1} of cover crop biomass. Standing residue resulted in lower common ragweed biomass than rolled residue. Rolled residue resulted in lower light penetration. Wheat residue increased soil moisture more than cereal rye.

Moyer et al. (1999) saw different results: greater weed suppression from a roller crimper terminated cover crop, but this was in a different cropping system and examined different weeds. Davis et al. (2010) also observed less PAR penetrating rolled compared to standing residue. Teasdale and Mohler (1993) also observed increased soil moisture and decreased soil temperature under cover crop residue.

Conclusions and recommendations:

Maximizing cover crop biomass is most important for weed suppression. When sufficient biomass is achieved (~7,500 lbs/a) similar weed suppression is achieved whether cover crop residues are rolled or left standing. Standing residue is recommended for common ragweed. It resulted in greater control than rolled residue in most cases, despite allowing more light penetration to the soil surface.

Literature Cited:

Davis AS (2010) Cover-crop roller-crimper contributions to weed management in no-till soybean. Weed Sci 58: 300-309

Moyer JR, Blackshaw RE, Smith EG, McGinn SM (1999) Cereal cover crops for weed suppression in a summer fallow-wheat cropping sequence. Can J Plant Sci 80:441-449

Teasdale JR, Mohler CL (1993) Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. Agron J 85:673-680

Objective 2: Assess herbicide-resistant Palmer amaranth and common ragweed control with alternatives to glyphosate and ALS herbicides.

Methods. Survival and seed production of both weeds was determined from postemergence applied treatments. Seed production is an important part of determining risk of future herbicide-resistance development. The experiment was conducted at two locations in a non-crop setting. Prior to treatment application, common ragweed or Palmer amaranth of various height classes (2 to 4”, 4 to 8”, 8 to 12”) were marked with different color flags. The goal was to flag four of each height class per plot, and if four of the respective weeds were not present, then all that were present were flagged. After plants were treated, they were allowed to grow until mature.

Data collected included visible control as described below within each height class as well as overall. Additionally, the number of plants surviving at harvest time and their biomass was collected within each height class. After drying and weighing to determine biomass, samples were threshed to determine the number of seeds produced per plant, using average weight of seed per plant.

Table 2: Treatments

1	Nontreated check
2	Mesotrione
3	Dicamba
4	2,4-D
5	Glufosinate
6	Fomesafen
7	Lactofen
8	Glyphosate (TTI11002)
9	Glyphosate (11002XR)
10	Mesotrione + fomesafen
11	Dicamba + fomesafen
12	2,4-D + fomesafen
13	Glufosinate + fomesafen
14	Glyphosate + fomesafen

Table 3: Herbicides and Rates

Common Name and Rate		**Trade Name and Product Rate**	
Mesotrione	105 g ai/ha	Callisto	3 fl oz/a
Dicamba	560 g ai/ha	Xtendimax	22 fl oz/a
2,4-D Choline	1060 g ai/ha	Freelexx	2.0 pt/a
Glufosinate	656 g ai/ha	Liberty	32 fl oz/a
Fomesafen	420 g ai/ha	Reflex	1.5 pt/a
Lactofen	219 g ai/ha	Cobra	12.5 fl oz/a

Glyphosate	1260 g ai/ha	Roundup Powermax	32 fl oz/a

Results:

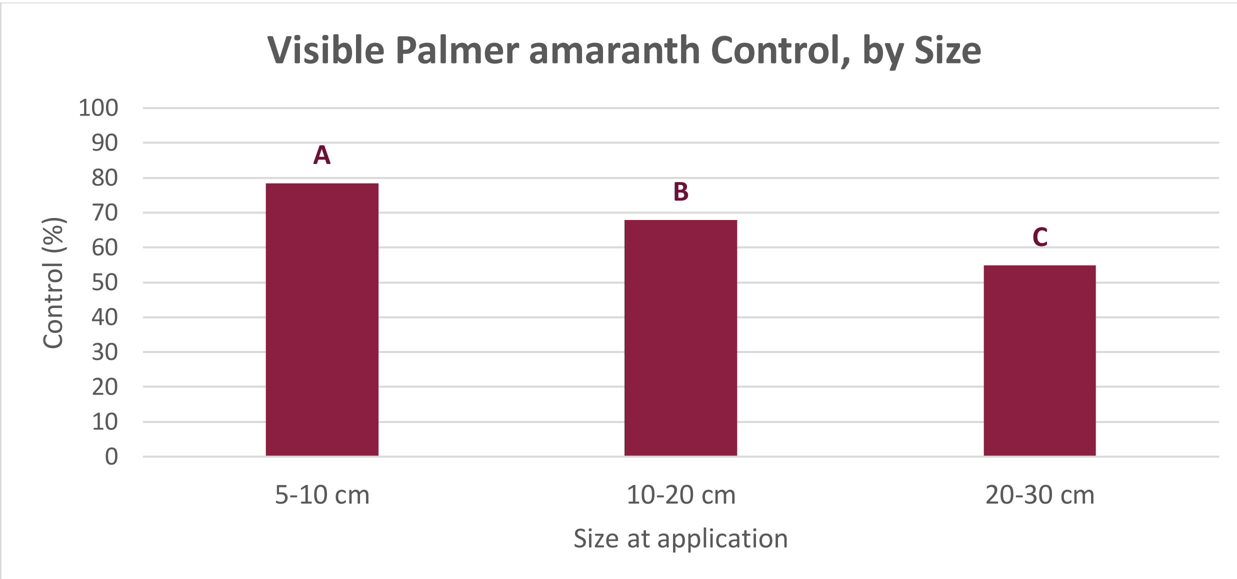

Figure 8. Palmer amaranth control 4 weeks after treatment by size class from three site years in Virginia. Data were pooled across herbicides as an herbicide by size class interaction was not detected.

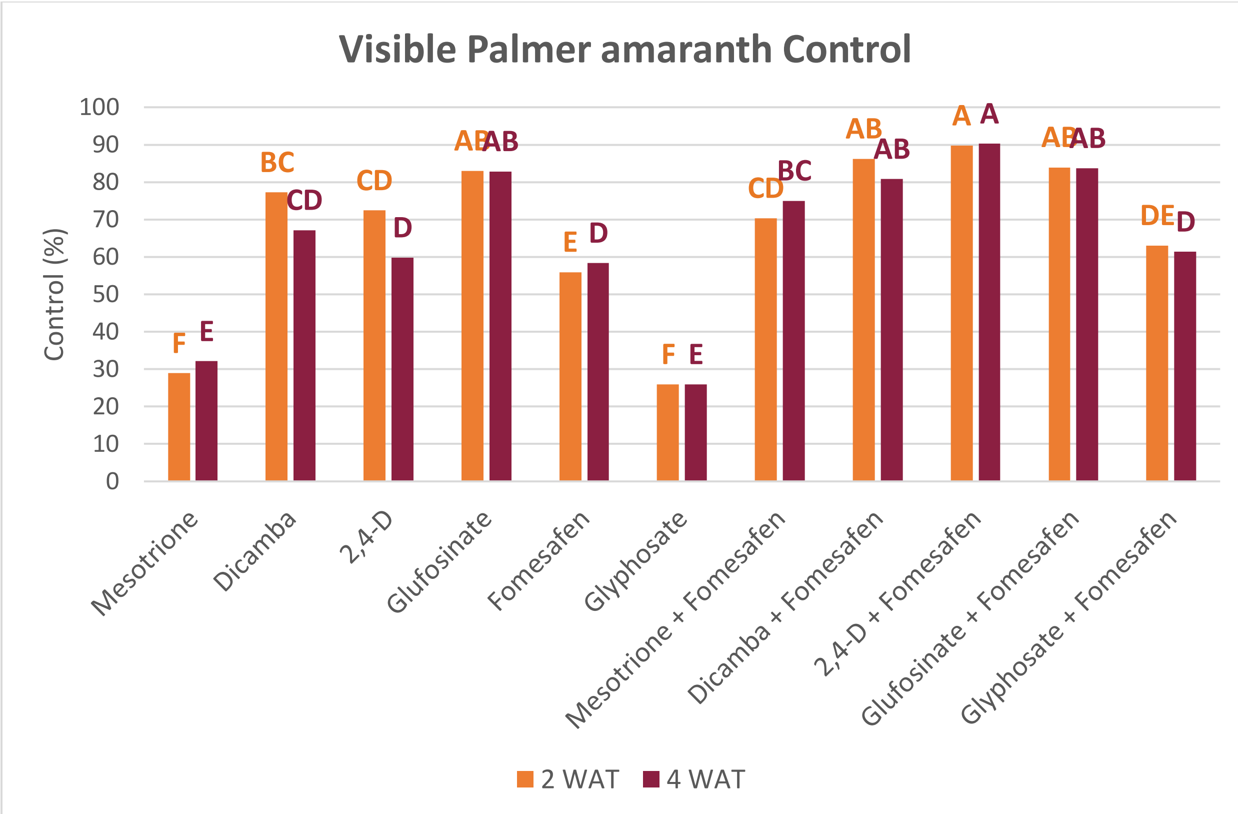

Figure 9. Palmer amaranth control 2 and 4 weeks after treatment (WAT) by herbicide(s). Data were pooled across size class because an herbicide by size class interaction was not detected.

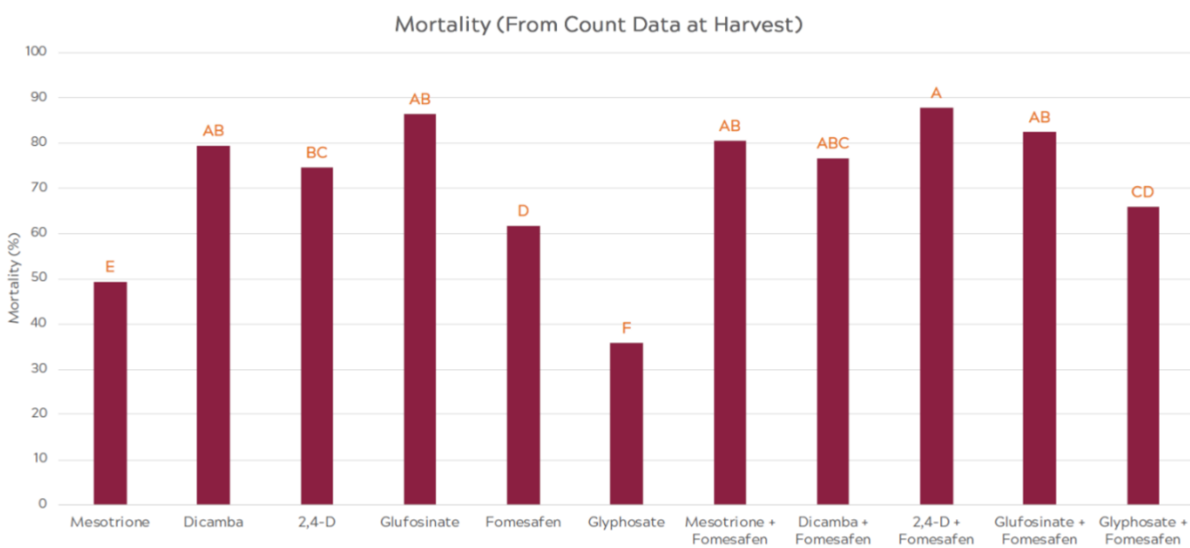

Figure 10. Palmer amaranth mortality at harvest from field experiments at 3 site-years in Virginia.

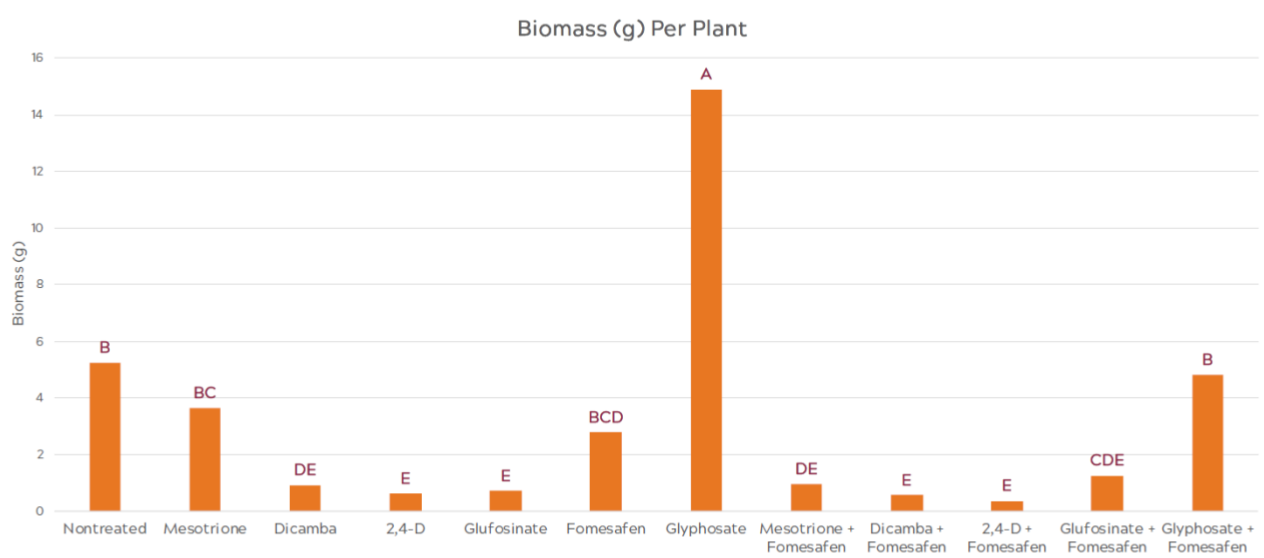

Figure 11. Palmer amaranth biomass at harvest from field experiments at 3 site-years in Virginia. Treatment by size interaction was not significant so data were pooled across size class. Data were cube transformed to improve normality and back transformed data reported.

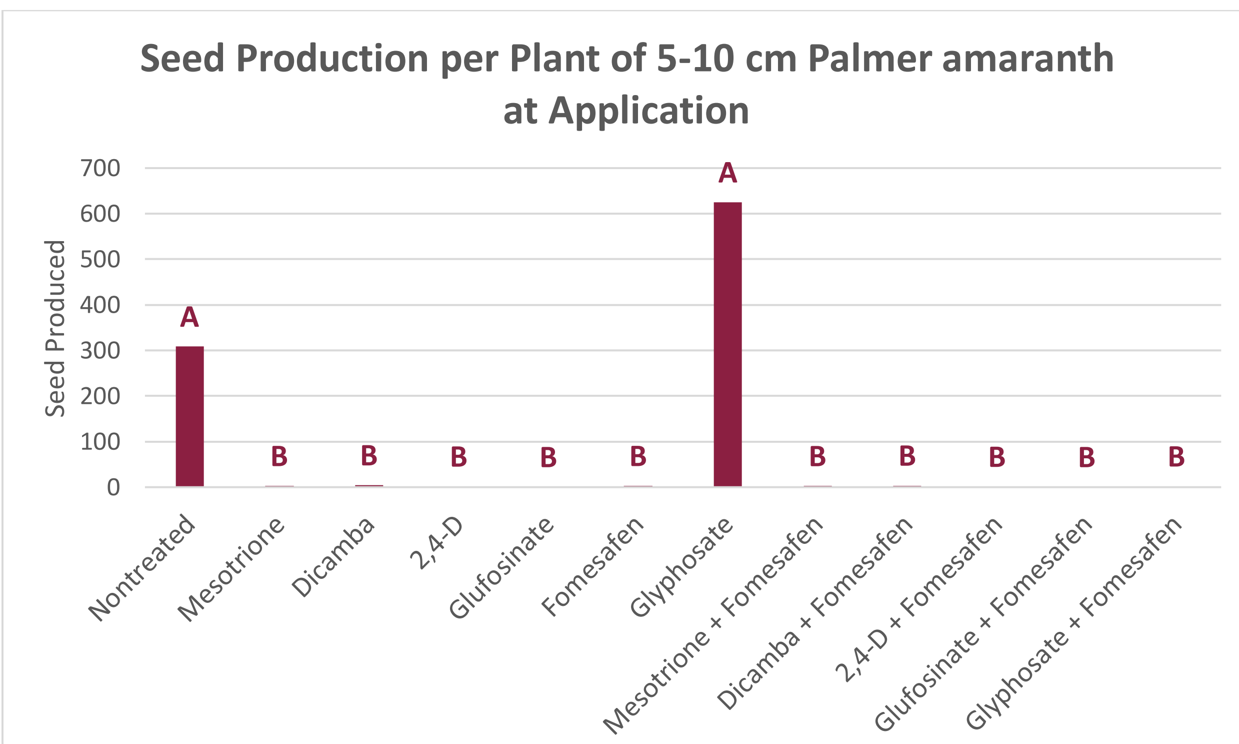

Figure 12. Palmer amaranth seed production from 2 to 4 inch tall plants at herbicide application. Data were inverse hyperbolic sine transformed to improve normality and back transformed data reported.

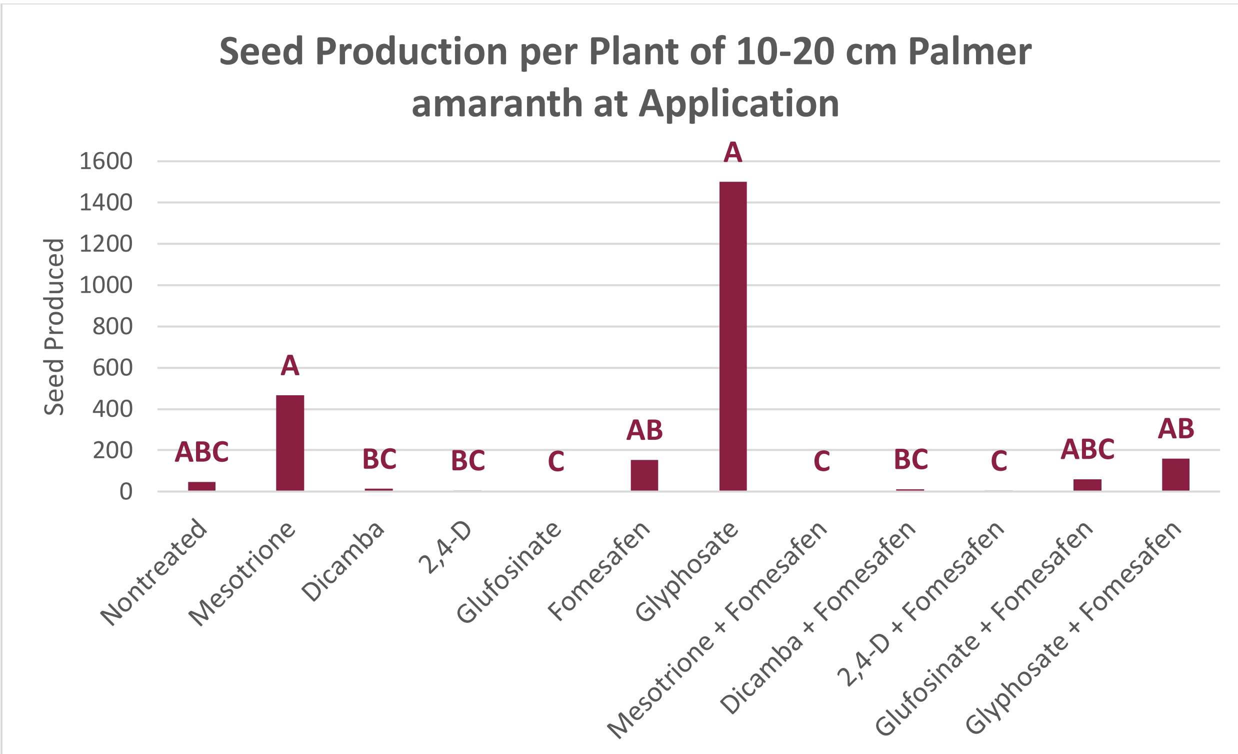

Figure 13. Palmer amaranth seed production from 4 to 8 inch tall plants at herbicide application. Data were inverse hyperbolic sine transformed to improve normality and back transformed data reported.

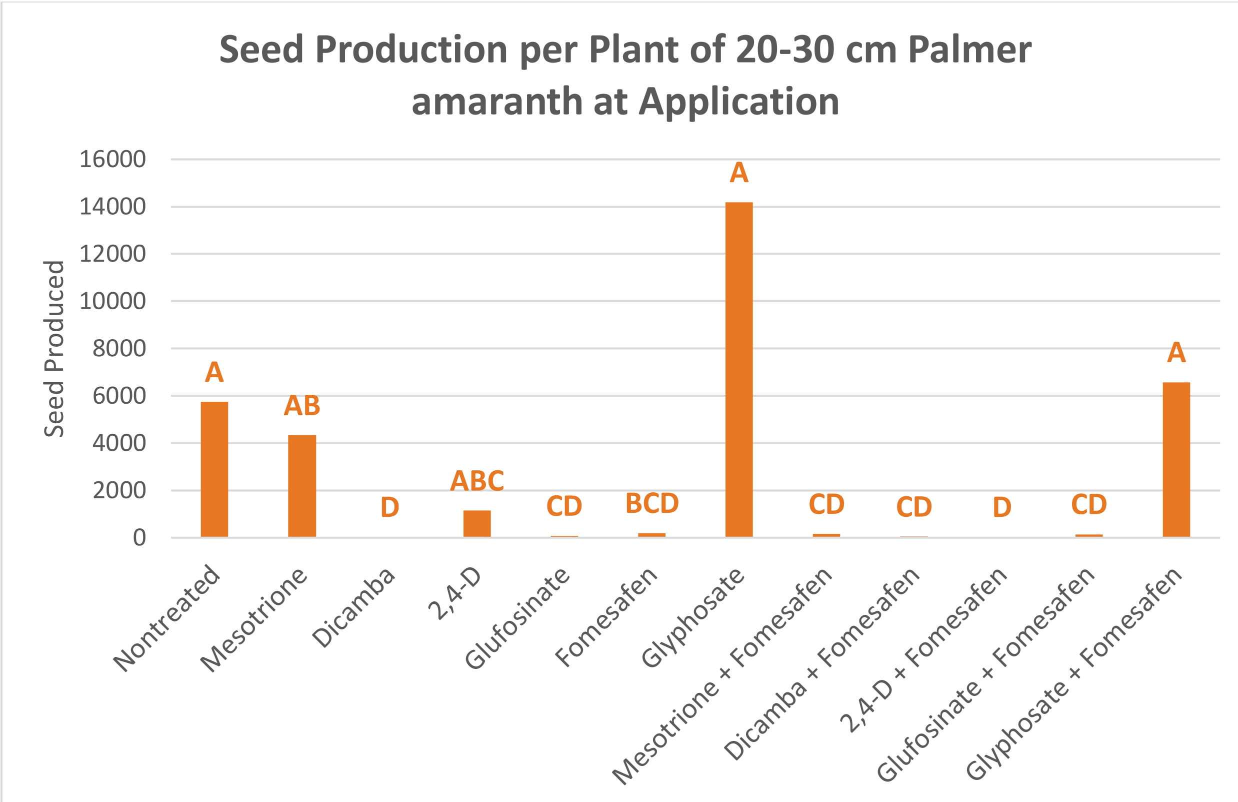

Figure 14. Palmer amaranth seed production from 8 to 12 inch tall plants at herbicide application. Data were inverse hyperbolic sine transformed to improve normality and back transformed data reported.

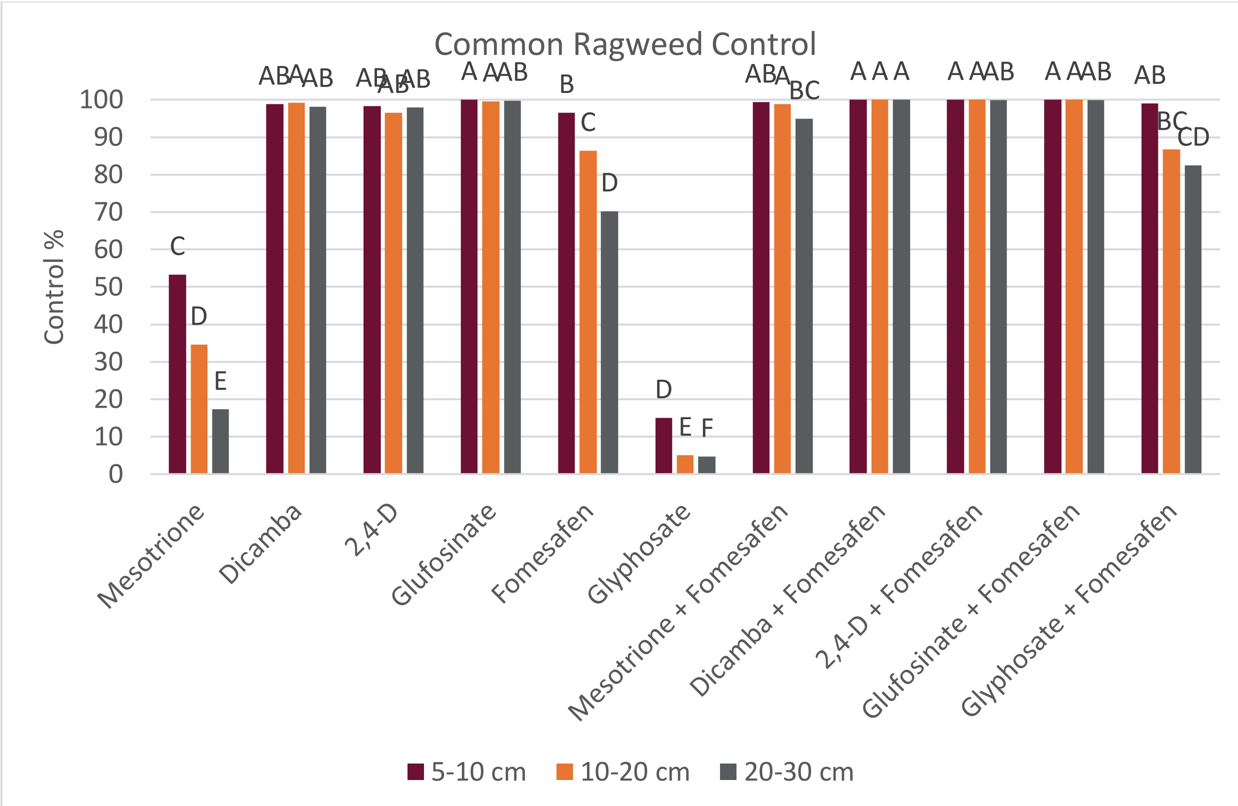

Figure 15. Common ragweed visible control 4 weeks after treatment (WAT) by size class from two field experiments in Virginia. Herbicide by size interaction p = 0.07.

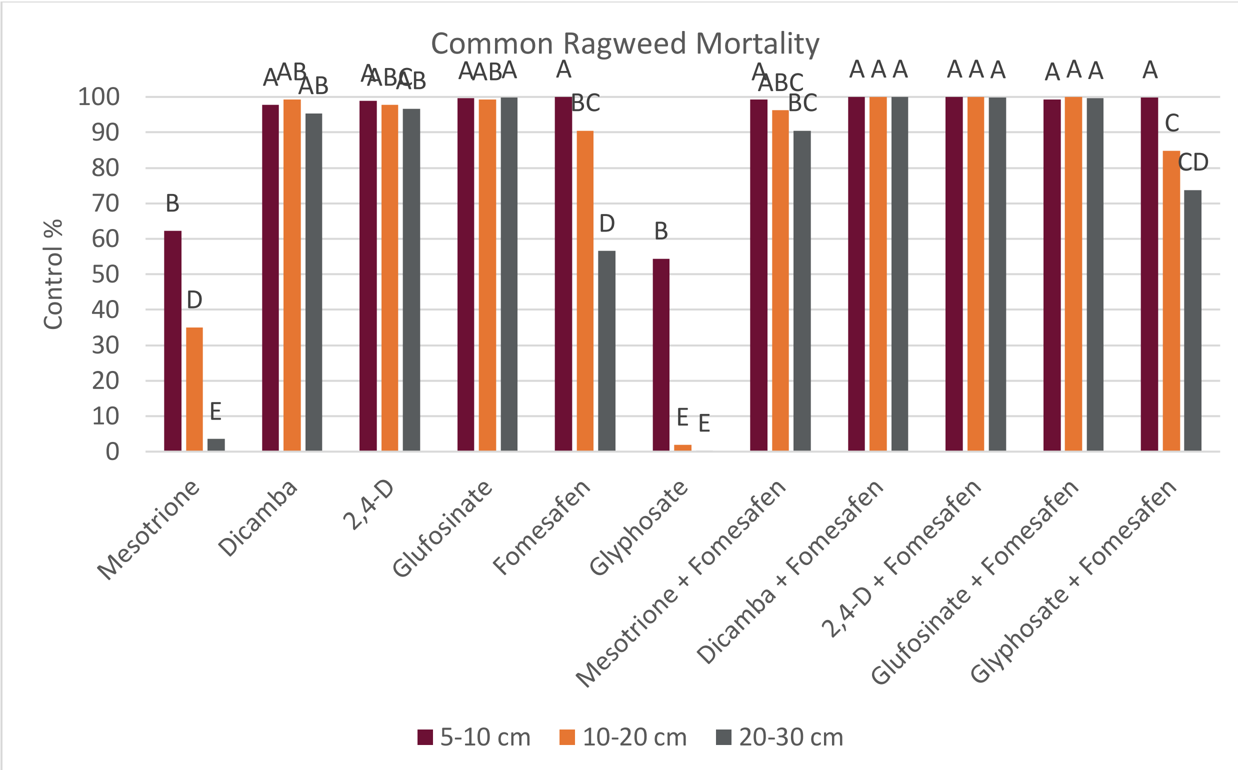

Figure 16. Common ragweed mortality at harvest from two field experiments in Virginia.

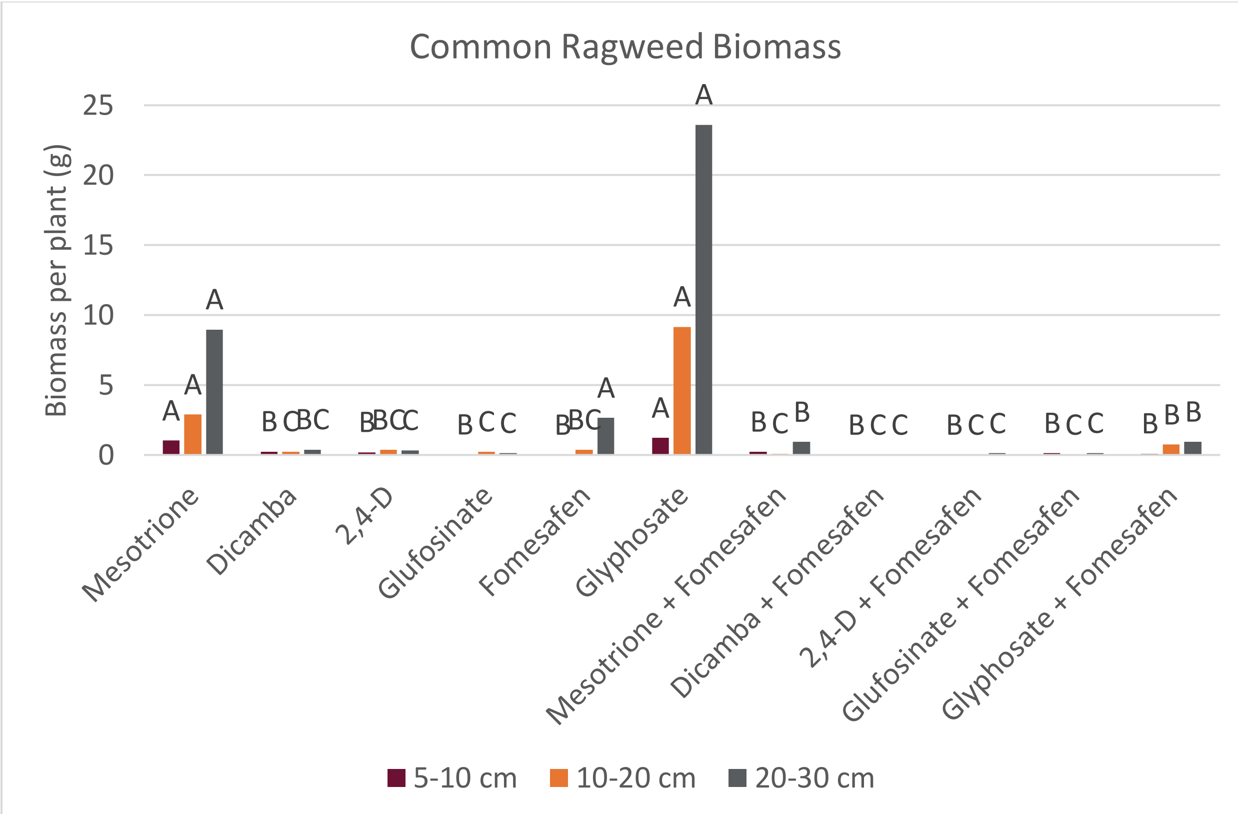

Figure 17. Common ragweed biomass per plant from two field experiments in Virginia. Data were arctangent transformed to improve normality and back transformed data are presented.

No data are presented for common ragweed seed production. These samples are currently being processed and will be included in the 2020 Virginia Soybean Project report.

Discussion:

Palmer amaranth and common ragweed control decreased as size increased for all herbicides. Palmer amaranth control was best from glufosinate, dicamba + fomesafen, 2,4-D + fomesafen, and glufosinate + fomesafen. Dicamba, 2,4-D, glufosinate with or without fomesafen and mesotrione + fomesafen resulted in the greatest biomass reduction. These treatments also resulted in the greatest reduction in seed production. Common ragweed control was best from 2,4-D, dicamba, glufosinate, and all herbicides tested when tank-mixed with fomesafen.

Conclusions and recommendations:

Farmers should continue to target Palmer amaranth and common ragweed at small sizes (2 to 4 inches in height) for best outcomes. Further research is necessary before recommending targeting taller Palmer amaranth and common ragweed for reducing seed production, but results are promising.

Objective 3: Herbicide program approaches for mitigation of PPO resistant common ragweed and Palmer amaranth.

Methods. Common ragweed and Palmer amaranth survival and fecundity were evaluated from PPO-containing soybean herbicide programs. Prior to application of PRE-herbicide treatments, a preplant burndown herbicide application (Roundup Powermax 1 qt/A + Liberty 1 qt/A) was made followed by light tillage (disking) to manage uneven residue from previous crops. Prior to treatment application, 20 common ragweed or Palmer amaranth were flagged per plot. If 20 of the respective weeds were not present, then all that were present were flagged. Following treatment applications, broadcast graminicide applications were conducted as needed to control annual grass species. PRE-herbicide treatments were applied around typical soybean planting time (mid-May) and POST-herbicide treatments were applied around 4 weeks after the PRE, when 4-6" weeds were present. All applications were made with a CO_2 backpack sprayer using a 6-nozzle, 10' boom, with TTI11002 nozzles for auxin-based treatments and TeeJet 11002XR nozzles for all other treatments. After plants were treated they were allowed to grow until plants were mature. Treatments are presented in Table 5 and associated rates in Table 4.

Table 4: Herbicides and Rates

Common Name and Rate		**Trade Name and Rate**	
Flumioxazin	89 g ai/ha	Valor	2.5 oz/a
Sulfentrazone	280 g ai/ha	Spartan 4F	8 fl oz/a

Fomesafen	420 g ai/ha	Reflex	1.5 pt/a
Glyphosate	1260 g ai/ha	Roundup Powermax	32 fl oz/a
Mesotrione	105 g ai/ha	Callisto	3 fl oz/a
Dicamba	560 g ai/ha	Xtendimax	22 fl oz/a
2,4-D choline	1060 g ai/ha	Freelexx	2.0 pt/a
Glufosinate	656 g ai/ha	Liberty	32 fl oz/a

Table 5: Treatments

	PRE	**POST**
1	Nontreated check	Nontreated check
2	--	Glyphosate
3	Flumioxazin	--
4	Sulfentrazone	--
5	Fomesafen	--
6	Flumioxazin	Mesotrione + glyphosate
7	Sulfentrazone	Mesotrione + glyphosate
8	Fomesafen	Mesotrione + glyphosate
9	Flumioxazin	Dicamba + glyphosate
10	Sulfentrazone	Dicamba + glyphosate
11	Fomesafen	Dicamba + glyphosate
12	Flumioxazin	2,4-D choline + glyphosate
13	Sulfentrazone	2,4-D choline + glyphosate
14	Fomesafen	2,4-D choline + glyphosate
15	Flumioxazin	Glufosinate + glyphosate

16	Sulfentrazone	Glufosinate + glyphosate
17	Fomesafen	Glufosinate + glyphosate
18	Flumioxazin	Fomesafen + glyphosate
19	Sulfentrazone	Fomesafen + glyphosate
20	Fomesafen	Fomesafen + glyphosate

Data collected included visible weed control at the POST application, 2 and 4 weeks after POST, and at "soybean harvest" by whole plots and only flagged plants. Additionally, the number of flagged plants surviving at harvest time and their biomass were collected (indicating they were present at harvest). After drying and weighing to determine biomass, samples were threshed to determine the number of seeds produced per plant, using average weight of seed per plant.

Results:

No data are presented for common ragweed. Common ragweed experiments were initiated at two locations (Blacksburg and Blackstone, VA), and both locations received supplemental common ragweed seed in December 2018. Unfortunately, neither location had sufficient weed density to result in reliable data.

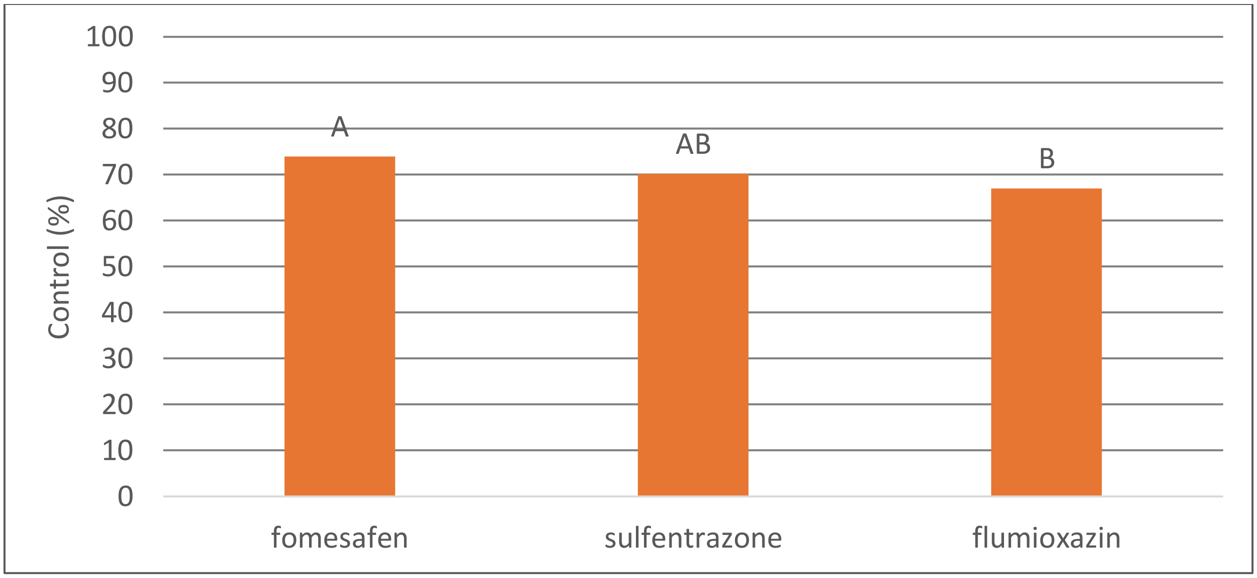

Figure 15. Palmer amaranth visible control at POST application from preemergent herbicides from field experiments in Virginia.

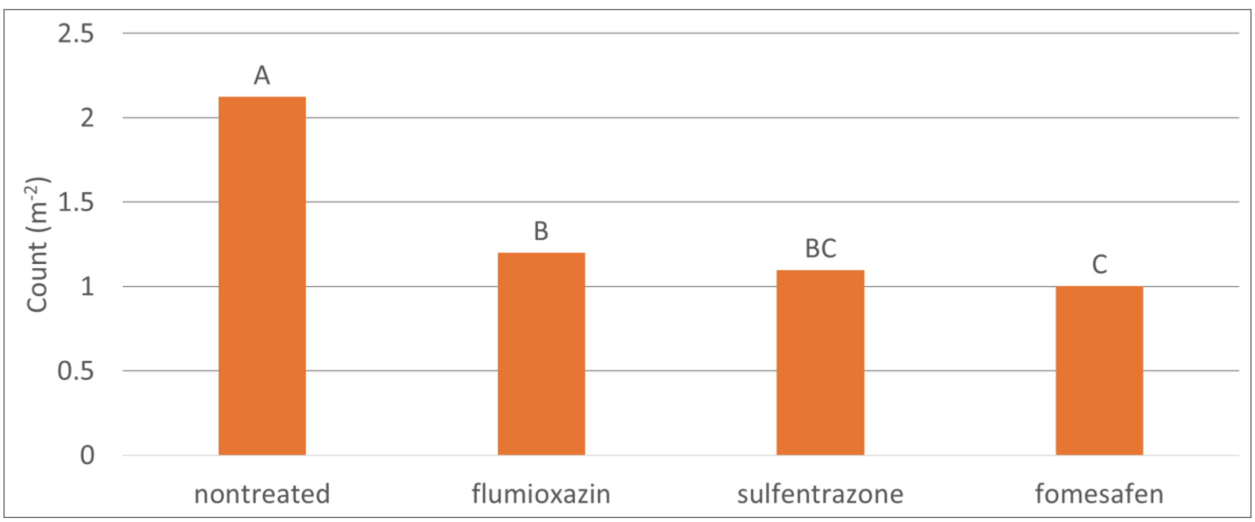

Figure 16. Palmer amaranth counts at POST application from preemergent herbicides from field experiments in Virginia.

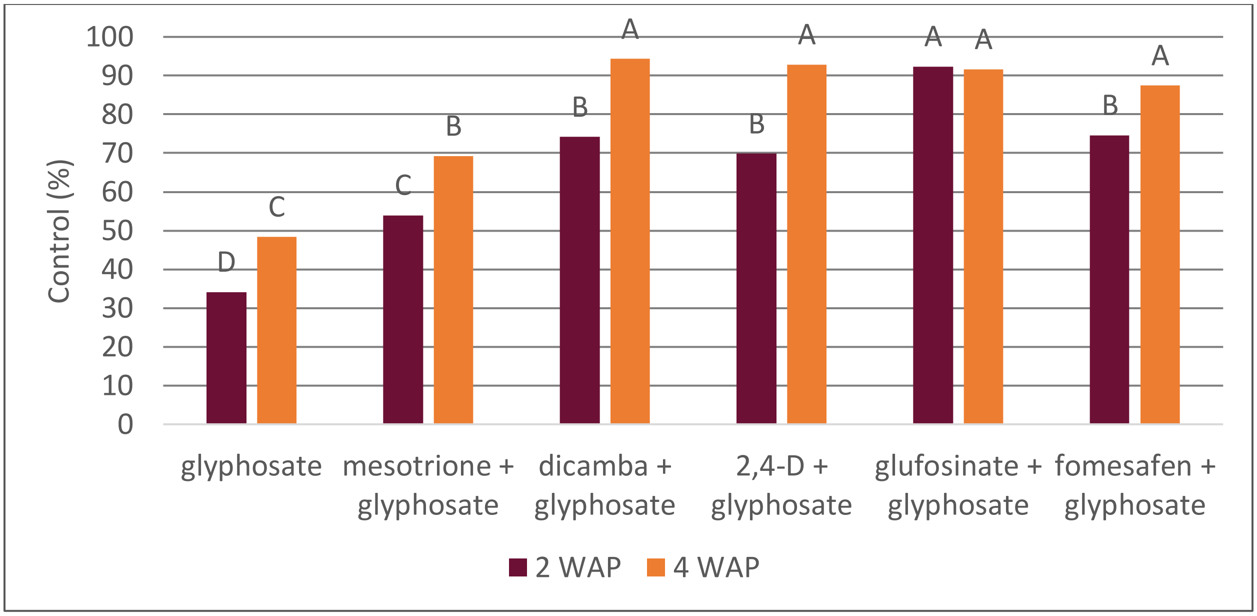

Figure 17. Emerged Palmer amaranth control, 2 and 4 weeks after post (WAP) from field experiments in Virginia.

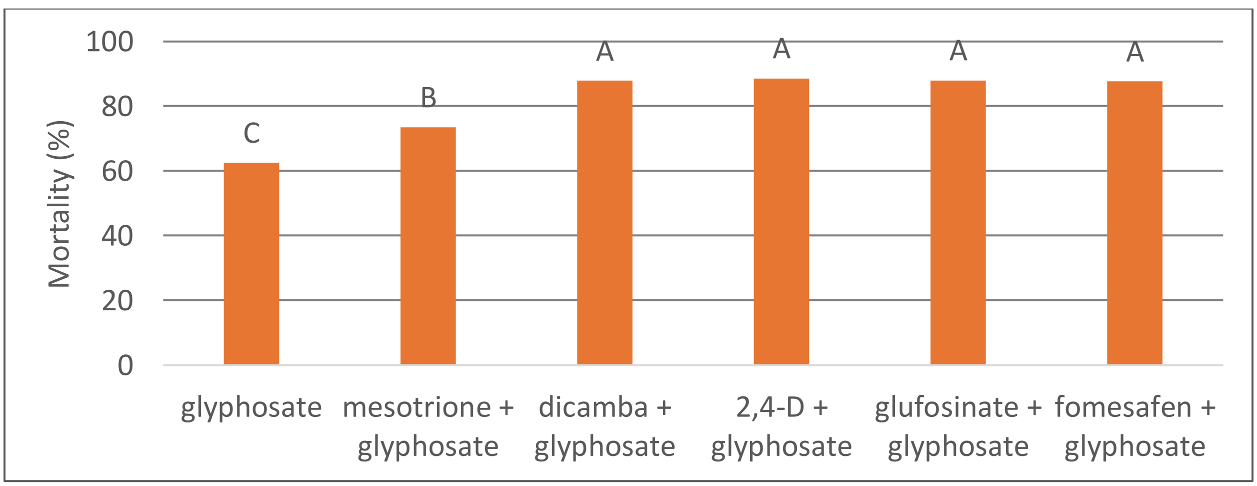

Figure 18. Emerged Palmer amaranth control at harvest (calculated from count of plants surviving at harvest / number of plants flagged prior to POST application) from field experiments in Virginia.

Discussion:

Flumioxazin, sulfentrazone, and fomesafen reduced Palmer amaranth density 43-53% compared to the nontreated (Figure 15). Fomesafen resulted in lower density (1 plant m^{-2}) and greater control (74%)

than flumioxazin (1.2 plant m^{-2}, 67% control) (Figures 15 and 16). Dicamba, 2,4-D, glufosinate, and fomesafen all tank-mixed with glyphosate resulted in 87-94% control (Figure 16). Dicamba + glyphosate, 2,4-D + glyphosate, fomesafen + glyphosate all resulted in ~88% mortality (Figure 17). These results reinforce the utility of PPO PREs when used as part of a program with multiple, effective sites of action.

Conclusions and recommendations:

Preemergence applications of flumioxazin, fomesafen, and sulfentrazone provide effective control and reductions of Palmer amaranth density. Dicamba, 2,4-D, and glufosinate on Palmer amaranth are effective on escapes from PPO-containing PRE herbicides.

Methods for all studies, unless indicated otherwise:

Treatments were applied at 15 GPA (unless stated otherwise) at 3 MPH. Appropriate adjuvants were included in all herbicide treatments, as indicated by the product label. A randomized complete block design with 3 to 4 replications per treatment was utilized. Nontreated and treated checks were included where appropriate. Digital images were collected to document treatment effects. Data were subjected to ANOVA and means separated using Fisher’s protected LSD or other appropriate statistical analysis.

Submitted by:

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