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Cranberry Research Report 2018: Defining new approaches to weed management in cranberry.

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<u>Cranberry Research Report</u>
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Title: **Defining new approaches to weed management in cranberry.**

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RESEARCH OBJECTIVES

1. <u>Screening novel herbicides</u>
   A. Assess crop safety of screened herbicides in field trial
   B. Preemergence (PRE) greenhouse germination tests to evaluate control by novel herbicides of:
      - dodder seeds
      - Perennial grass seeds: broomsedge (BS), deer-tongue grass (DTG), and little bluestem (LBS)
   C. Postemergence (POST) greenhouse tests to evaluate control by novel herbicides of perennial grasses (BS, DTG, and LBS)
   D. Postemergence field tests with novel herbicides to evaluate control of dodder

2. <u>Establish use patterns for Kerb SC</u>
   - Test various rates of Kerb SC (a.i. pronamide) at different cranberry growth stages to evaluate crop injury
   - Screen Kerb for activity against grasses (PRE and early POST)

3. <u>Investigate QuinStar mechanism of delayed efficacy against dodder (Year 3).</u>

Table 1. Novel Herbicides Screened in 2017.

Herbicide Name	AI	Maker	Used	HRAC / WSSA Group	Rate
Method	aminocyclopyrachlor	DuPont	PRE + POST	4	4 oz/A
Reflex	fomesafen	Syngenta	PRE + POST	E / 14	1.25 pt/A
Sandea	halosulfuron	Gowan	PRE + POST	B / 2	0.75 oz/A
Zeus	sulfentrazone	FMC	PRE	E / 14	12 oz/A
Zidua	pyroxasulfone	BASF	PRE	K3 / 15	2.75 oz/A
Untreated	N/A (not applicable)	N/A	N/A	N/A	N/A

SUMMARY OF ACCOMPLISHMENTS:

Crop Safety – screening novel herbicides

A crop safety study was conducted on State Bog ('Howes') to assess the impact of novel herbicides on cranberry plants. Herbicides were applied preemergence (May 1, 2017, at bud swell / cabbage head) or postemergence (July 18, 2017) based on their labeled use patterns (Table 1). Plots 1-m^2 were established in the field and treatments were applied by CO_2-powered backpack sprayer. Herbicides were delivered in the equivalent of 400 gallons of water per acre to simulate application by chemigation. Postemergence applications of Method, Reflex, and Sandea included 0.25% v:v nonionic surfactant as recommended by label.

Cranberry fruit were collected from a 1-ft^2 area in each plot on September 18, 2017. Berries were sorted, then counted and weighed to determine the number and weight of sellable cranberry fruit. All postemergence applied herbicides and Method PRE significantly decreased the number of fruit compared to the untreated control (Figure 1). Cranberry vines treated with Method PRE showed cupping of the leaves after budbreak and abnormal growth. Method POST and Reflex POST showed visual signs of injury to the cranberry vines one week after treatment and the injury was still apparent two months later at harvest.

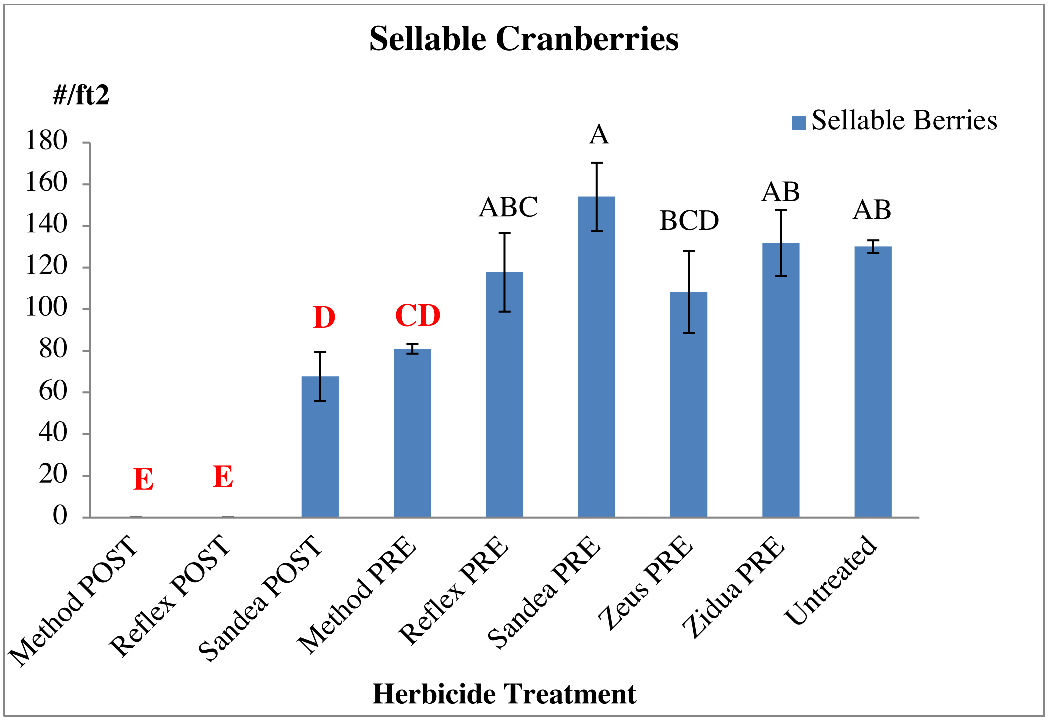

Figure 1. Average number of sellable cranberry fruit per ft[2] (±SE, N=4) from field plots treated with different herbicides. Means with similar letters are not statistically different (Duncan Multiple Range Test, $P \leq 0.05$).

Dodder germination test - screening novel preemergence herbicides

A study testing preemergence herbicides for dodder control was conducted twice in the greenhouse (Run 1 treated 6/15/2017 and Run 2 was treated 6/20/2017). Sets of dodder seeds (100 per treatment) had dormancy broken by mechanical scarification (Ghantous and Sandler 2012). After scarification, a set of seeds was sprinkled onto the surface of a 4-in pot filled with a 25% peat:75% sand mix, and covered with a dusting of sand. Each pot received a single preemergence herbicide treatment (Table 1) and treatments were replicated four times per run. Treatments were applied by CO_2-powered backpack sprayer, and herbicides were delivered in the equivalent of 400 gallons of water per acre to simulate application by chemigation. Pots were taken outside of the greenhouse to be sprayed, and returned to the greenhouse after treatment. Pots were evaluated every other day for 4 weeks after treatment, and emerged seedlings were counted and removed from pots.

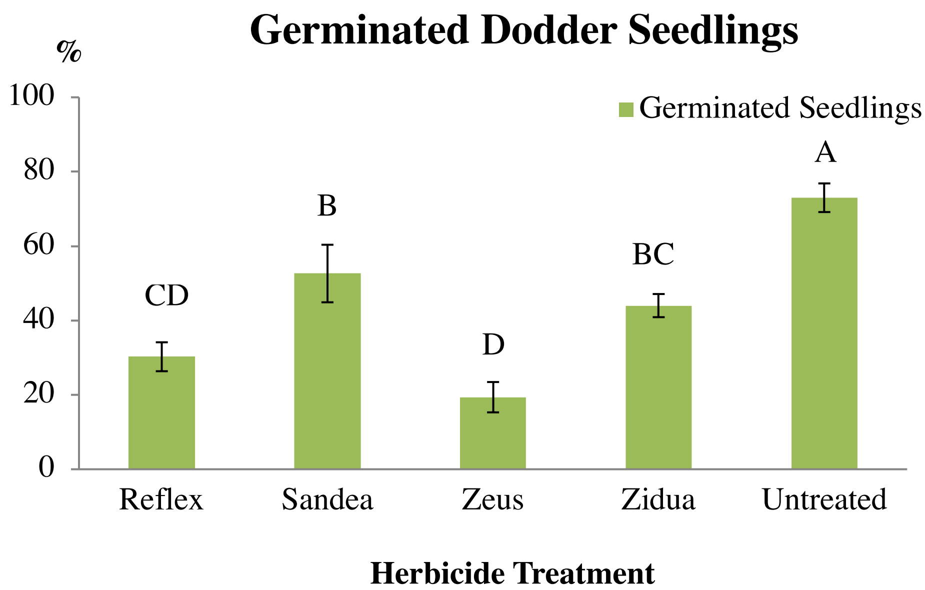

Figure 2. Average percentage of dodder seedlings that germinated after preemergence herbicide treatments in a potted greenhouse study. Means are averaged across both runs of the study (N=8, ± SE). Means with similar letters are not statistically different (Duncan Multiple Range Test, $P \leq 0.05$).

Results for dodder treated with Method differed by Run. Method did not significantly reduce dodder germination in Run1, while it did in Run 2. This may be due to an error made during herbicide mixing or application. Based on the discrepancy between runs, it is difficult to draw a conclusion about the efficacy of Method. However, Method was injurious to cranberry vines and negative impacted fruit yield, rendering it a poor choice for further testing.

Zeus, Reflex, Zidua, and Sandea applied preemergence significantly reduced the percentage of dodder seedlings that germinated compared to the untreated (Figure 2). Zeus was the most effective, followed by Reflex, Zidua, and Sandea.

Perennial grasses germination test - screening novel preemergence herbicides

A study testing preemergence herbicides for perennial grass control was conducted twice in the greenhouse (Run 1 treated 6/15/2017 and Run 2 was treated 6/20/2017). Grass species tested were broomsedge (BS; *Andropogon virginicus*), deer-tongue grass (DTG; *Dichanthelium clandestinum*), and little bluestem (LBS; *Schizachyrium scoparium*). A set of LBS (0.5 g;

approx. 300 seeds), BS (0.10g; approx. 300 seeds), or DTG (100 counted) seeds was sprinkled onto the surface of a 4-in pot filled with a 25% peat:75% sand mix, and covered with a thin layer of the potting mixture. According to package instructions, DTG seeds were cold stratified for 6 weeks prior to planting. Each pot received a single preemergence herbicide treatment (Table 1) and treatments were replicated four times. Treatments were applied by CO_2-powered backpack sprayer, and herbicides were delivered in the equivalent of 400 gallons of water per acre to simulate application by chemigation as described above. Grasses were visually evaluated for 5 weeks; seedlings were counted, dried, and weighed. Run 1 was harvested 7/19/17, and Run 2 was harvested 7/26/17.

Zidua was effective at reducing the germination of seedlings for BS (Run 1) and DTG (both runs) (see Table 2). Zidua also reduced the biomass of BS (Run 1), DTG (both runs), and BS (Run 1) which indicates that it cannot only reduces the amount of seed that germinated but can also impact the vigor of the seedlings that do germinate. Zeus did not significantly reduce the number of seedlings that germinated, but did reduce the biomass of DTG (both runs) and LBS (Run 1). Results for other herbicides were inconsistent. Method showed some control of DTG and LBS, but only in one run and had poor crop safety. Reflex reduced DTG and LBS biomass in one run only. Sandea was not effective at reducing germination or biomass of any grass species.

Table 2. Mean number of seedlings ± SE (g) of grasses 4 weeks after seeds were treated with preemergence herbicides, reported by grass species and study run (N=4). Bolded numbers highlighted in grey are statistically different from the untreated control within each column (Dunnett's Test, P ≤ 0.05).

	BS		DTG		LBS	
	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2
Untreated	96.8 ± 6.1	34.5 ± 3.9	85.0 ± 2.6	82.8 ± 3.7	36.0 ± 0.9	19.0 ± 3.6
Method	98.0 ± 16.2	44.3 ± 10.5	**49.0 ± 9.8**	81.8 ± 1.8	21.3 ± 3.2	17.0 ± 1.4
Reflex	116.8 ± 14.1	67.8 ± 17.4	78.0 ± 3.3	77.5 ± 7.2	20.5 ± 2.0	16.3 ± 2.6
Sandea	119 ± 14.0	42.8 ± 5.7	90.8 ± 3.6	79.3 ± 1.4	28.3 ± 3.8	20.0 ± 3.2
Zeus	111.3 ± 14.3	48.5 ± 9.4	70.0 ± 6.3	65.3 ± 7.6	24.0 ± 4.7	12.5 ± 2.5
Zidua	**42.5 ± 6.4**	9.0 ± 2.3	**43.8 ± 3.4**	**61.8 ± 3.6**	18.0 ± 2.2	16.0 ± 3.1

Table 3. Mean biomass ± SE (g) of grasses 4 weeks after seeds were treated with preemergence herbicides reported by grass species and study run (N=4). Bolded numbers highlighted in grey are statistically different from the untreated control within each column (Dunnett's Test, $P \leq 0.05$).

	BS		DTG		LBS	
	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2
Untreated	0.21 ± 0.02	0.08 ± 0.02	0.63 ± 0.01	0.46 ± 0.02	0.29 ± 0.02	0.15 ± 0.03
Method	0.11 ± 0.04	0.08 ± 0.02	**0.34 ± 0.07**	0.46 ± 0.02	**0.15 ± 0.02**	0.14 ± 0.02
Reflex	0.14 ± 0.01	0.14 ± 0.04	**0.46 ± 0.01**	0.36 ± 0.03	**0.12 ± 0.01**	0.16 ± 0.03
Sandea	0.19 ± 0.02	0.09 ± 0.01	0.58 ± 0.03	0.48 ± 0.03	0.20 ± 0.03	0.21 ± 0.03
Zeus	0.26 ± 0.05	0.08 ± 0.02	**0.36 ± 0.03**	**0.32 ± 0.05**	**0.14 ± 0.03**	0.10 ± 0.02
Zidua	**0.05 ± 0.02**	0.02 ± 0.01	**0.14 ± 0.02**	**0.20 ± 0.01**	**0.10 ± 0.02**	0.14 ± 0.03

Postemergence grass study - screening novel herbicides

A set of LBS (0.5 g, approx. 300 seeds), BS (0.10 g, approx. 300 seeds), or DTG (50 counted) seeds was sprinkled onto the surface of a pot filled with a peat/sand mix, and covered with a thin layer of the potting mixture. DTG seeds were cold stratified for 6 weeks prior to planting. Grasses were grown to a height of 4+ inches before treatments. Each pot received a single postemergence herbicide treatment (Table 1) and treatments were replicated four times. Treatments were applied by CO_2-powered backpack sprayer. Herbicides were delivered in the equivalent of 400 gallons of water per acre to simulate application by chemigation, and included 0.25% v:v nonionic surfactant as recommended by label. Grasses were visually evaluated for 8 weeks after treatment (Run 1) and 6 weeks after treatment (Run 2). The biomass was harvested from each pot, then dried and weighed. The entire study was conducted twice. Run 1 was treated 7/19/17 and Run 2 was treated 8/3/17. Both runs were harvested 9/15/17.

Results were variable between species and runs (Table 4). Grasses treated with Method had significant reductions in biomass for BS (Run 1), DTG (both runs), and LBS (only one run was done for this species). However, Method was very injurious to cranberry plants and resulted in no sellable fruit in test plots from the crop safety study (see Fig. 1). Reflex reduced BS (Run 1), DTG (Run 2), and LBS (Run 1), but was also very injurious to cranberry plants in the crop safety study. Sandea was not effective at reducing biomass of any grass species except BS (Run 1), and was also shown to significantly reduce cranberry yield in test plots. Based on crop safety trials, none of these herbicides are a good choice for postemergence application in cranberry, regardless of potential weed control.

Table 4. Mean biomass ± SE (g) of grasses 4 weeks after plants were treated with postemergence herbicides, reported by grass species and study run (N=4). Bolded numbers highlighted in grey are statistically different from the untreated control within each column (Dunnett's Test, $P \leq 0.05$).

	BS		DTG		LBS	
	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2
Untreated	6.47 ± 0.33	4.37 ± 0.59	3.83 ± 0.24	4.17 ± 0.13	3.27 ± 0.49	4.44 ± 0.82
Method	**1.53 ± 0.09**	2.26 ± 0.45	**1.44 ± 0.11**	**3.01 ± 0.06**	.	**1.46 ± 0.61**
Reflex	**4.38 ± 0.51**	1.77 ± 0.58	3.66 ± 0.23	**2.68 ± 0.20**	**1.65 ± 0.34**	3.99 ± 0.63
Sandea	**2.52 ± 0.25**	5.92 ± 1.43	3.28 ± 0.26	3.86 ± 0.40	3.56 ± 0.41	3.71 ± 0.40

Postemergence dodder test

Plots 0.25-m^2 were established on a commercial cranberry farm (Carver, MA) with a dodder infestation. Plots were treated on 7/18/17 (Method, Reflex, Sandea, or untreated), and treatment were replicated four times. Due to the extensive damage seen from applications of these postemergence herbicides in the crop safety study, adjuvants were not used for the dodder POST study to minimize damage to the grower's bog (although inclusion is recommended on the product labels). Visual symptoms of injury were less severe than seen on plots with the inclusion of adjuvants, however cranberry yields were still reduced in all treated plots even without the use of adjuvants (See Fig 5).

Dodder seeds from this study are currently being sorted, counted, and weighted. Preliminary results suggest that plot treated with Method produced no viable dodder seeds, while plots treated with Reflex and Sandea did not differ from untreated plots. Although Method was effective at controlling dodder seed production, it was very injurious to cranberry and significantly reduced cranberry yield, making it a poor choice for further testing. We will include the final dodder seed data in the updated report (along with QuinStar data).

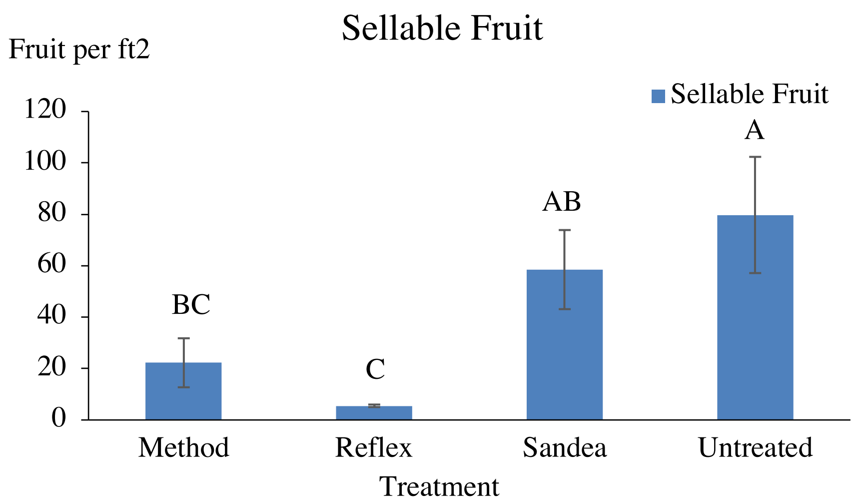

Figure 5. Average number of sellable cranberry fruit produced per ft^2 from plots treated with different postemergence herbicides without adjuvants included in the spray mixtures (n=4, ± SE) in an area infested with dodder. Means with similar letters are not statistically different (Duncan Multiple Range Test, $P \leq 0.05$).

Conclusions from screening projects

- Zeus and Zidua
    - Potential for PRE control of both dodder and perennial grasses
    - Good crop safety PRE
    - Best candidates for further testing and potential for use in cranberry
- Sandea
    - Marginal PRE control of dodder and no control of perennial grasses
    - Good crop safety PRE, poor crop safety POST
    - Ground water concerns may make it a poor candidate for cranberry
- Reflex
    - Potential for PRE control of dodder
    - Good crop safety PRE, poor crop safety POST
    - Ground water concerns may make it a poor candidate for cranberry
- Method
    - Poor crop safety PRE and POST
    - Poor candidate for cranberry

Kerb SC

1. Crop safety. This study took place on State Bog on a set of 0.25-m^2 plots on 'Howes'. Treatments were applied by CO_2-powered backpack sprayer. Herbicides were delivered in the equivalent of 400 gallons of water per acre to simulate application by chemigation. Each plot received a single treatment (see Table 5). Treatments were replicated five times. Cranberry plants were visually evaluated for injury periodically (5/30, 6/15, 6/26, and 7/19). No symptoms were visually apparent at any observation between treatment and harvest. Cranberry fruit were collected from a 1-ft² area in each plot on September 18, 2017. Berries were sorted, then counted and weighed to determine the number and weight of sellable cranberry fruit.

Table 5. Kerb SC treatments and treatment dates for crop safety field study.

Treatment	Date
Untreated	n/a
1 app, 5 pt/a (spring dormant)	5/1/2017
1 app, 5 pt/A (after budbreak)	5/30/2017
2 apps, 2.5 pt/A (sd + 21 days later)	5/1 and 5/30/17
2 apps, 2.5 pt/A (after bb + 21 days later)	5/30 and 6/26/17

Kerb had excellent crop safety. No treatment differed from the untreated for number or weight of sellable fruit, even the treatment with an application in late June when cranberry was actively growing.

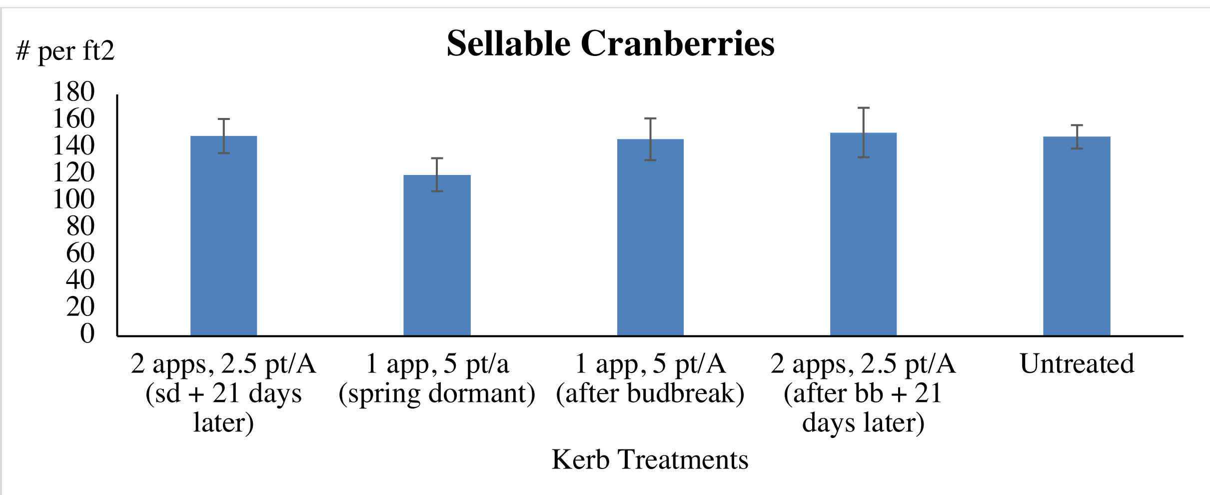

Figure 3. Average number of sellable cranberry fruit per ft² (±SE, N = 5) from field plots treated with different Kerb applications. Means do not differ statistically ($p > 0.05$).

2. *Efficacy*. Kerb is labeled for use against a wide range of grasses. An early postemergence treatment against small, recently germinated seedlings of each grass species was included. Kerb was screened for activity against broomsedge (BS; *Andropogon virginicus*), deer-tongue grass (DTG; *Dichanthelium clandestinum*), and little bluestem (LBS; *Schizachyrium scoparium*) in greenhouse trials at the same rates and similar treatment intervals at the crop safety trials

described above. A set of LBS (0.5 g; approx. 300 seeds), BS (0.10g; approx. 300 seeds), or DTG (100 counted) seeds was sprinkled onto the surface of a 4-in pot filled with a 25% peat:75% sand mix, and covered with a thin layer of the potting mixture. According to package instructions, DTG seeds were cold stratified for 6 weeks prior to planting. Each pot received a single preemergence herbicide treatment (Table 6) and treatments were replicated four times. Treatments were applied by CO_2-powered backpack sprayer, and herbicides were delivered in the equivalent of 400 gallons of water per acre to simulate application by chemigation as described above. Grasses were visually evaluated for 10 weeks; seedlings were counted, dried, and weighed 8/3/2017.

Table 6. Kerb SC treatments and treatment dates for GH efficacy study.

Treatment	Date
Untreated	n/a
1 app, 5 pt/a (Preemergence)	5/25/2017
2 apps, 2.5 pt/A (Preemergence + 21 days later)	5/25 and 6/15/17
1 app, 5 pt/A (Early Postemergence)	6/15/17

Overall, Kerb was effective for controlling the three species of grass tested. For BS and LBS, preemergence application of Kerb significantly reduced grass biomass 10 weeks after application compared to the untreated control ($p \leq 0.05$). There was no difference between a single application made at 5 pt/A and two sequential applications of 2.5 pt/A (see Figure 4). A single 5 pt/A application made early postemergence significantly reduced biomass of these species compared to the untreated control, but was not as effective as preemergence applications. For DTG, both preemergence treatments were very effective, but the early postemergence application did not reduce DTG biomass compared to the untreated control (see Figure 4).

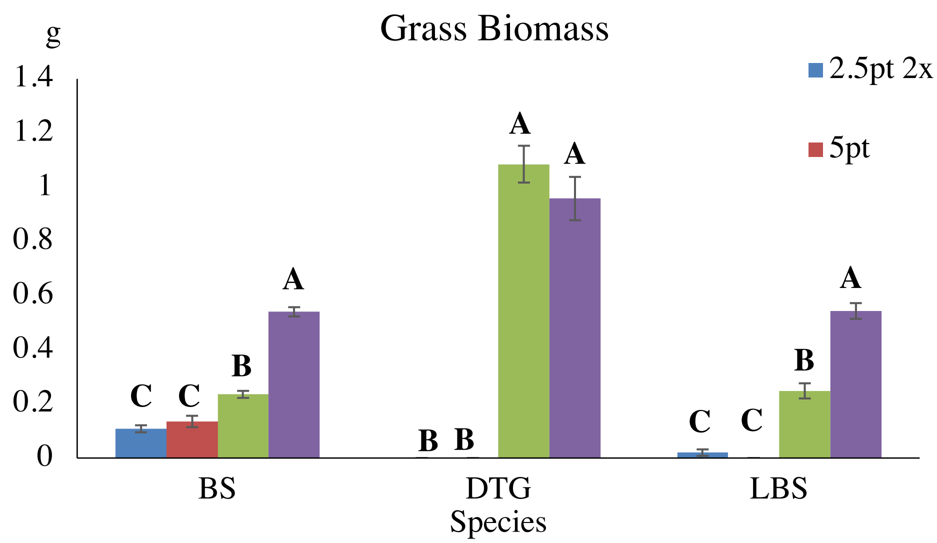

Figure 4. Average biomass (g) of BS, DTG, and LBS after preemergence and an early post emergence Kerb treatments (n=4, ±SE). Means with similar letters are not statistically different (Duncan Multiple Range Test, P ≤ 0.05) within each grass species.

QuinStar mechanism of delayed efficacy against dodder (Year 3)

The final application year of a field study (initiated in 2015) looking at QuinStar interaction with cranberry over time was completed. The study plots were re-treated in 2017 at the maximum label rate (8.4 oz/A, applied twice). Treatments were replicated four times, and were:

- Untreated,
- Treated in Year 1 only (treated 2015 only),
- Treated in Years 1 and 2 only (treated 2015 and 2016),
- Treated in Years 1, 2, and 3 (treated 2015, 2016, and 2017).

Plots were treated 6/7/17 and 7/11/17. Fruit were collected from a 1-ft^2 area of each plot on 9/13/16. Cranberry tissue was collected from a 0.25-m^2 area of each plot, separated by stem type, leave were then separated from stems, and frozen. Frozen tissue was processed by Ocean Spray Cranberries (OSC) in 2015 prior to herbicide extraction. The milling equipment is no longer available for use at OSC, so we found a collaborating lab on UMass Amherst campus to assist with grinding the tissue samples. Samples collected in 2016 are now ground, and we anticipate OSC will be able to analyze them for residues in the near future. We have processed the samples collected in 2017, and will bring them to campus to be ground in preparation for residue analysis, performed by OSC. We will share the results of the tissue residue analysis with CCCGA, CI, and OSC once completed and statistically analyzed.