Experimental Control of Bindweed in Established Blueberry Plantings

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Control of hedge bindweed (*Calystegia sepium*) is notoriously difficult (Kolmanič et al. 2020). This plant is an aggressive rhizomatous perennial in the Morningglory family (Convolvulaceae). Few herbicides provide good control of this weed (Besancon et al., 2022; Kolmanič et al., 2020; Sideman, 2024), partly due to its aggressive rhizomes; 50% of which are able to sprout from 20 cm deep within the soil profile (Willeke et al., 2015). This results in organic mulches being completely ineffective at control. Synthetic mulches prevent emergence where they cover the soil, but the mulch directs lateral shoot growth to the base of the crop. Repeated tillage can manage *C. sepium* growth over time, but 50% of fragments with just one bud are able to sprout, so inadequate tillage can increase an infestation by spreading these fragments (Willeke et al., 2015). In addition to direct competition with the crop for water, nutrients, and light; aboveground growth becomes intertwined within the crop and can impede crop management and harvest (Davison, 1976). Growers need new tactics to control this difficult perennial weed.

Quinclorac, a highly selective synthetic auxin that mimics an auxin overdose and causes an accumulation of abscisic acid in susceptible plants, may be an additional chemical weed control tool that growers could use to manage *C. sepium* (Enole et al., 1999; Grossmann, 1998). It had been labelled for use in lowbush blueberries and agronomic crops with a post-emergent application to control broadleaf perennials, primarily bindweeds (Moretti & Peachey, 2022). Research in highbush blueberries demonstrated that split pre-emergent and post-emergent applications of quinclorac could provide adequate control of field bindweed (*Convolvulus arvensis*) without damaging the crop on silt-loam soils in Oregon (Moretti & Peachey, 2022). This work led to a change in the label in 2018, allowing for both pre- and post-emergent applications of quinclorac in highbush blueberries. Since this change, little research has been done to test the efficacy of pre-emergent quinclorac use in highbush blueberries in the Northeast where soils are typically sandier, or on the efficacy of quinclorac on *C. sepium*, which is closely related to *C. arvensis*.

Another potential cultural weed control tool that may be useful in highbush blueberries would take advantage of their preference for the ammonium form of nitrogen (Claussen & Lenz, 1999; Osorio et al., 2020). Previous work has found that blueberry plant growth and yield can be higher in plants that are fertilized with only ammonium, compared to plants only fertilized with nitrate. However, in a field environment, soil microbial communities often quickly convert ammonium to nitrate (Coskun et al., 2017). Nitrification inhibitors chemically suppress the activity of soil nitrifiers, prolonging ammonium availability in field soil (Coskun et al., 2017; Lei et al., 2022). Many plants, including many weeds, prefer the nitrate form of nitrogen (Britto & Kronzucker, 2002). It is possible that keeping nitrogen in the ammonium form through the use of nitrification inhibitors will improve blueberry plant growth more than weed community growth. This could shift the competitive advantage away from the weed community and towards the blueberry plant.

This research tests both the efficacy of quinclorac on sandy soils to manage a heavy infestation of *C. sepium,* and then overlays a nitrification inhibitor treatment to potentially shift the competitive advantage away from the weed community and towards highbush blueberry growth.

Materials and Methods

Plots were laid out in an established highbush blueberry planting, located at Belchertown, MA. The blueberries were mixed varieties, organized with earlier ripening varieties located in the Northeast corner and later ripening varieties in the Southwest corner. Treatments were organized as a randomized complete block, with each row as one block. There were 7 treatments, each replicated 5 times, for a total of 35 plots. All plots were mulched with one inch (2.5 cm) of woodchips on March 25th. Treatments, shown in Table 1, included two rates of quinclorac (Quinstar 4L, Albaugh): high (12.6 oz/A) and low (6.3 oz/A), each applied pre-emergent and post-emergent with crop oil concentrate included at 2 pints per acre. Two controls were included, an untreated, mulch only control, and a grower standard control consisting of pre-emergent flumioxazin (Chateau EZ, Valent) at 12 oz/A followed by two applications of post-emergent glufosinate (Rely 280, BASF) at 56 oz/A. There was also a nitrification inhibitor treatment, with nitrification inhibitors (Instinct Nxtgen, Corteva) applied at 24 oz/A in the spring immediately after fertilizing (Ammonium sulfate) at 12 oz/bush. There were two additional treatments combining nitrification inhibitors and quinclorac applications at both high and low rates. All treatments were fertilized a second time at the same rate, on July 2nd, without an additional nitrification inhibitor treatment.

Weed emergence was monitored by counting bindweed emergence from the soil and measuring the height of 5 randomly selected shoots 7 and 9 Weeks After pre-emergence Treatment (WAT). After bindweed shoots began to wrap around aboveground vegetation weed growth was measured using photos of weed cover within a square foot, randomly placed within the plot once each week. Cover was estimated by uploading photos to Canapeo (Patrignani & Ochsner, 2015), which measures green and non-green pixels. Before harvest, a biomass clip of the weed community was done for each plot by clipping, identifying, counting, and then drying at 65°C all weeds within a randomly placed square.

Blueberry growth was monitored by harvesting fruit twice each week from June 27th until Sept. 16th. All fruit that was just beginning to ripen was harvested and weighed. Fruit was picked earlier than ideal because fruit left to ripen on the bush was eaten by birds. Leaves of blueberry bushes were harvested on Aug. 2nd and sent to Maine soil lab for tissue analysis. Plant nutrient levels were measured using acid digestion with a AIM600 Block Digestion System (SEAL Analytical, Kitchener, Ontario, Canada).

Data were analyzed in R 4.3.2 (R core team, 2024). General linear mixed models were used to test the effect of the treatments on the response variables. Treatments were the fixed effects, and block was the random effect. When necessary, response variables were square root transformed to fit assumptions of normality. An ANOVA was used to test for significance of fixed effects, and any significant effects were further explored with Tukey's HSD test post-hoc analyses to determine means separation.

Results

Emergence of bindweed shoots was slower in treatments including quinclorac, applied at both high and low rates early in the season, however, this effect was no longer significant 9 WAT (Fig. 1).

Weed canopy cover was significantly different over time (p-value = 0.001) and by treatment (p-value <

Table 1. Description of the seven treatments applied in a highbush blueberry planting in Belchertown, MA, designed to evaluate the effects of quinclorac and a nitrification inhibitor on hedge bindweed control. All plots were mulched (on March 25th) and fertilized uniformly with ammonium sulfate (on July 2nd).

Treatment Name	Herbicide and Fertilizer Applications
NI + Quinclorac (high rate)	March 25: Flumioxazin + Quinclorac (high rate); May 10: Nitrification inhibitor; May 24: Quinclorac; June 7: Glufosinate
NI + Quinclorac (low rate)	March 25: Flumioxazin + Quinclorac (low rate); May 10: Nitrification inhibitor; May 24: Quinclorac; June 7: Glufosinate
Quinclorac (high rate)	March 25: Flumioxazin + Quinclorac (high rate); May 10: Quinclorac; May 24: Glufosinate
Quinclorac (low rate)	March 25: Flumioxazin + Quinclorac (low rate); May 10: Quinclorac; May 24: Glufosinate
Nitrification Inhibitor (NI)	March 25: Flumioxazin; May 10: Nitrification inhibitor; May 24: Glufosinate
Current Practice	March 25: Flumioxazin; May 24: Glufosinate
Mulch Only (Control)	No herbicide applied

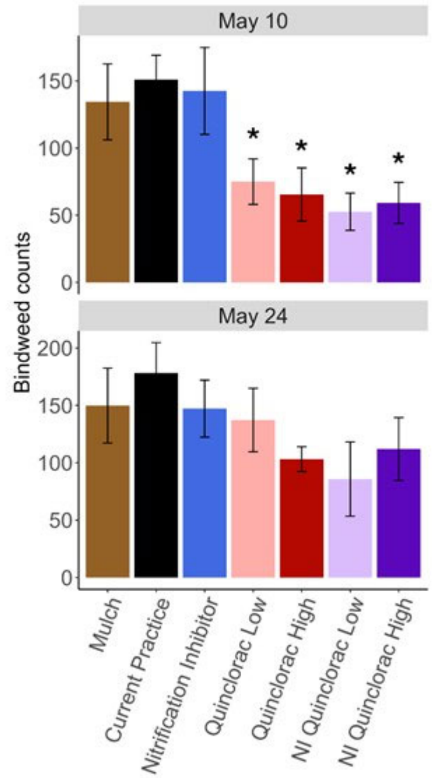

Figure 1. Bindweed shoot emergence 7 and 9 weeks after pre-emergent herbicide treatments. Bars labelled with a * had significantly lower counts than bars not labelled with a * at p< 0.05.

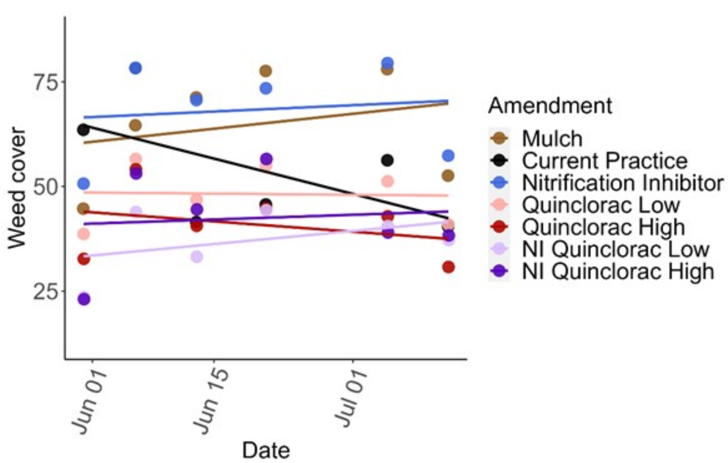

Figure 2. Weed canopy cover over time across 7 different herbicide and nutrient management treatments.

0.001), but not the interaction (p-value = 0.98) (Fig. 2).

The mulch only and nitrification inhibitor only treatments had higher weed canopy cover than all the treatments including quinclorac. However, average shoot height, bindweed biomass, and total weed biomass were not affected by treatments (Table 2),

Blueberry plant growth was similarly not affected by treatments, both yield and leaf tissue analysis were the same across all treatments (Table 3).

Discussion

Although pre-emergent treatments of quinclorac at first seemed promising for *C. sepium* weed control, effects of these treatments did not last long. Post-emergent applications of quinclorac did not lead to differences in bindweed control and all treatments resulted in unacceptable levels of control.

Despite disappointing levels of bindweed control, we hope to continue this experiment for another year. Systemic herbicides need to translocate through the plant to the site of action and are often slower to control weeds. According to the label, Quinstar 4L symptoms may not become evident for several weeks, up to 3-6 months. The pre-emergent application of quinclorac appeared more effective against bindweed growth than the post-emergent application because effects of treatment were only noticed during emergence and early in the growing season. Perhaps, since the infestation of bindweed was so extensive, multiple pre-emergent applications will be necessary before having a measurable effect on *C. sepium*.

Additionally, after looking at roots harvested from the no-quinclorac plots and the high-quinclorac plots, there are noticeable differences in root physiology (Fig. 3 and 4). Roots from the no-quinclorac plots had normal root hair development, but roots harvested from the high-quinclorac plots were lacking in root hair growth. This indicates that quinclorac is having an effect on *C. sepium* growth, even if it is not measurable aboveground within the first year of treatment. It would be interesting to see whether there is a delayed or cumulative effect over multiple years of treatment.

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Table 2. Mean *Calystegia sepium* growth metrics and total weed biomass per treatment. For each response variable, the p-values and f-statistics of an ANOVA run on a general linear mixed model are also given. Treatment was the fixed effect and block was the random effect. Treatments had no significant effect on any weed response variable.

Response variable	Average shoot height May 10th (cm)	Average shoot height May 24th (cm)	Bindweed biomass (g)	Total weed biomass (g)
P-value (F-statistic)	0.24 (1.42)	0.74 (0.58)	0.65 (0.69)	0.65 (0.71)
Mulch	16.4	90.3	12.0	22.1
Current Practice	17.0	89.6	7.9	14.3
Nitrification Inhibitor	15.2	72.0	17.2	27.1
Quinclorac low	13.2	82.6	9.8	14.6
Quinclorac high	11.3	72.7	6.2	19.7
NI and quinclorac low	14.2	74.2	8.2	23.6
NI and quinclorac high	11.2	73.4	17.0	27.5

Table 3. Mean blueberry fruit yield and leaf tissue nutrient level per treatment. For each response variable, the p-values and f-statistics of an ANOVA run on a general linear mixed model are also given. Treatment was the fixed effect and block was the random effect.

Response variable	P-value (F-statistic)	Mulch	Current Practice	Nitrification Inhibitor	Quinclorac low	Quinclorac high	NI and quinclorac low	NI and quinclorac high
Blueberry yield (g)	0.60 (0.78)	702	743	967	908	1,698	323	1,479
N (%)	0.41 (1.05)	1.9	1.9	2.0	2.0	2.1	1.9	2.1
Ca (%)	0.48 (0.95)	0.56	0.67	0.63	0.53	0.54	0.54	0.56
K (%)	0.76 (0.55)	0.45	0.47	0.49	0.50	0.53	0.48	0.51
Mg (%)	0.66 (0.69)	0.16	0.17	0.16	0.15	0.14	0.15	0.15
P (%)	0.11 (1.96)	0.12	0.12	0.13	0.13	0.15	0.13	0.15
Al (ppm)	0.26 (1.37)	64.3	70.8	78.3	67.0	52.9	47.0	49.9
B (ppm)	0.41 (1.05)	38.8	54.5	49.1	34.7	39.6	36.6	40.9
Cu (ppm)	0.34 (1.20)	3.6	3.8	3.3	3.0	2.9	2.8	3.2
Fe (ppm)	0.46 (0.98)	51.7	120.0	51	46.8	49.1	42.2	49.0
Mn (ppm)	0.93 (0.30)	166	175	168	185	155	121	135
Zn (ppm)	0.24 (1.42)	11.9	10.8	10.5	10.5	12.5	10.4	13.5

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Figure 3. *Calystegia sepium* root fragments excavated from plots without any quinclorac application.

Figure 4. *Calystegia sepium* root fragments excavated from plots sprayed with the high rate of quinclorac (12.6 oz/A Quinstar 4L).

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