An observational investigation of potential cow wheat (Melampyrum lineare Desr.) interference with wild blueberry (Vaccinium angustifolium Ait)

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Short Communication

An observational investigation of potential cow wheat (*Melampyrum lineare* Desr.) interference with wild blueberry (*Vaccinium angustifolium* Ait)

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Abstract

Wild blueberry stem density, length, diameter, biomass, and berries per stem were 28%, 30%, 26%, 61%, and 55% lower in quadrats containing wild blueberry and cow wheat relative to quadrats containing only wild blueberry. Cow wheat may reduce wild blueberry growth and controlled studies to explore this interference are warranted.

Key words: hemiparasite, *Melampyrum lineare*, lowbush blueberry, parasitic weed, *Vaccinium angustifolium*, wild blueberry

Résumé

La densité, la longueur, le diamètre, la biomasse et le nombre de baies des tiges de bleuet sauvage étaient respectivement de 28, 30, 26, 61 et 55 % plus faibles dans les quadrats où poussaient du bleuet sauvage et du mélampyre linéaire que dans ceux où ne poussait que du bleuet sauvage. Le mélampyre linéaire pourrait réduire le rendement du bleuet sauvage, ce qui justifie la tenue d'études contrôlées qui approfondiront ces interférences. [Traduit par la Rédaction]

Mots-clés : hémiparasite, *Melampyrum lineare*, bleuet nain, adventice parasite, *Vaccinium angustifolium*, bleuet sauvage

Introduction

The wild blueberry (*Vaccinium angustifolium* Ait.) is an economically important fruit crop in Quebec and the Atlantic provinces of Canada and the state of Maine in the United States (Anonymous 2019). Commercial fields are developed from native stands that are managed using a 2 year production cycle in which plants are pruned to ground level by flail mowing or burning in the first year, or nonbearing year, and flowering and fruit production occur in the second year, or bearing year (Penney and McRae 2000). Crop rotation and tillage are currently not possible in this production system and weeds are therefore a major limiting factor in wild blueberry production (Eaton 1994). The weed flora consists largely of native and non-native woody and herbaceous perennial plants (Jensen and Kimball 1985), though shorter-lived annual plants are increasingly common (Lyu et al. 2021).

Cow wheat (*Melampyrum lineare* Desr.) is a root hemiparasitic annual plant (Piehl 1962) that occurred in 44% of wild blueberry fields surveyed from 2017 to 2019 (Lyu et al. 2021). Plants of the genus *Melampyrum* form haustorial connections with multiple host species (Piehl 1962; Matthies 2017), including *V. angustifolium* (Cantlon et al. 1963), and reduce biomass of parasitized hosts (Matthies 2017). Wild blueberry growers routinely report anecdotal observations of yield loss in fields infested with cow wheat, but no studies on cow wheat interference with wild blueberry have been conducted.

The objective of this research was to conduct an initial observational field study to determine if the presence or absence of cow wheat affects wild blueberry growth and fruit production. It was hypothesized that wild blueberry stem density, stem length, stem diameter, stem biomass, and berry number per stem would be lower for blueberry plants growing with cow wheat relative to blueberry plants growing in the absence of cow wheat.

Material and methods

Study fields and data collection

Twenty bearing year wild blueberry fields (Fig. 1) were utilized in this study and were chosen based on the presence of adequate cow wheat populations interspersed among relatively weed-free patches of wild blueberry. Data collection consisted of cow wheat density and aboveground biomass, wild blueberry stem density and aboveground biomass, and wild blueberry stem length, stem diameter, and berry number per stem in ten 0.5 m × 0.5 m quadrats containing weed-free wild blueberry plants and ten 0.5 m × 0.5 m quadrats containing cow wheat and wild blueberry plants. Quadrat lo-

Fig. 1. Distribution of bearing year wild blueberry (*Vaccinium angustifolium*) fields used to conduct an initial observational field study to determine if the presence or absence of cow wheat (*Melampyrum lineare*) affects wild blueberry growth and fruit production in Nova Scotia, Canada. Map data: Google, © 2022. Landsat/Copernicus Data SIO, NOAA, U.S. Navy, NGA, GEBCO.

cations within a given field were chosen based on the presence or absence of cow wheat and were not placed in areas containing other weed species. Areas containing obvious sources of confounding effects on blueberry growth, such as tractor tire tracks, low spots, field edges, etc., were also avoided.

Cow wheat density and aboveground biomass, as well as wild blueberry stem density, were determined on a whole-plot basis. Cow wheat plants were clipped at ground level, placed in paper bags in the field, brought back to the lab, and dried in an oven for 48 h at 50 °C for biomass determinations. Wild blueberry biomass, stem length, stem diameter, and berries per stem were determined on 20 stems per plot selected using a line transect method. Berries per stem were determined directly in the field. Stems were clipped to ground level following berry counts, placed in paper bags in the field, and brought back to the lab for length and diameter measurements. Stem length was determined to the nearest cm and stem diameter was determined to the nearest mm using a digital caliper (General Ultra Tech No. 1433). Stems were then dried at 50 °C for 48 h and weighed to determine biomass. Cow wheat density and biomass were expressed as plants/m^2 and g/m^2, respectively, for analysis. Wild blueberry stem density and biomass were expressed as stems/m^2 and g/stem, respectively, for analysis.

Statistical analysis

The effect of the presence or absence of cow wheat on wild blueberry stem density, stem length, stem diameter, berries per stem, and biomass was determined using ANOVA in PROC MIXED in SAS (Statistical Analysis System, version 9.4, SAS Institute, Cary, NC). The presence or absence of cow wheat was modelled as a fixed effect and site was modelled as a random effect in the analysis. Assumptions of normality and constant variance for all analyses were assessed using PROC UNIVARIATE in SAS, and data were LOG(Y + 1) or SQRT(Y + 1) transformed where necessary to achieve normality and constant variance. Means separation, where necessary, was conducted using a t test in PROC MIXED at $\alpha = 0.05$.

Results and discussion

Mean cow wheat density and biomass across study sites were 680 ± 30 plants/m^2 and 87 ± 3 g/m^2 (mean ± SE), respectively, with minimum and maximum density of 52 and 2448 plants/m^2, respectively, and minimum and maximum biomass of 14 and 213 g/m^2, respectively. Cow wheat density in natural populations ranges from 11 to 21 plants/m^2 (Gibson 1993), indicating that density in wild blueberry fields is higher than that observed in other natural populations. Future research should therefore focus on identification of variables that promote cow wheat seedling establishment and survival in wild blueberry fields.

There was a significant effect of the presence or absence of cow wheat on all wild blueberry response variables ($P < 0.0001$). Mean wild blueberry stem density was 28% lower in quadrats containing cow wheat relative to those that did not (Table 1). Reduced wild blueberry stem density is a common outcome of weed interference (Jensen and Kimball 1985) and cow wheat interference may also reduce stem density. Wild blueberry stem density, however, is largely the result of nonbearing year stem emergence from rhizomes. As such, lower stem density may be an artefact of other factors that affected stem density in the previous nonbearing year. Controlled studies across both the nonbearing and bearing years should therefore be conducted before concluding that cow wheat consistently reduces wild blueberry stem density.

Table 1. Effect of the presence or absence of cow wheat on wild blueberry stem density, stem length, stem diameter, biomass, and berries per stem in 20 bearing year wild blueberry fields sampled in Nova Scotia, Canada during 2020 and 2021.

	Stem density (stems/m^2)*	Stem length (cm)	Stem diameter (mm)	Biomass (g/stem)†	Berries per stem (#/stem)*
Wild blueberry	448a	16.4 ± 0.44a	1.9 ± 0.03a	1.3a	11a
Wild blueberry + cow wheat	321b	11.4 ± 0.44b	1.4 ± 0.03b	0.5b	5b

Note: Means within columns followed by different letters are significantly different according to a *t* test conducted in PROC MIXED in SAS at a significance level of $\alpha = 0.05$. Values represent the mean ± SE unless otherwise indicated.
*Data were SQRT(Y + 1) transformed prior to analysis to meet the assumptions of constant variance and normality for the ANOVA. Geometric means determined using PROC MEANS in SAS are presented.
†Data were LOG(Y + 1) transformed prior to analysis to meet the assumptions of constant variance and normality for the ANOVA. Geometric means determined using PROC MEANS in SAS are presented.

Wild blueberry stem length was 30% lower in the presence of cow wheat relative to the absence of cow wheat (Table 1). Wild blueberry stem length in managed fields ranges from 13 to 25 cm in the absence of weed competition (Eaton 1994) and stem length observed in the absence of cow wheat (Table 1) is typical of high-yielding stems (Jordan and Eaton 1995). Stem length in the presence of cow wheat, however, was <13 cm, which is typical of lower yielding stems such as those growing with weeds (Eaton 1994). Cow wheat removed radio-labelled phosphorous from *Pinus banksiana* (Cantlon et al. 1963) and may therefore limit availability of phosphorous or other nutrients needed to support increases in stem length during the bearing year (Jordan and Eaton 1995).

Wild blueberry stem diameter was 26% lower in the presence of cow wheat relative to the absence of cow wheat (Table 1). We are unable to find reports of typical wild blueberry stem diameters in managed fields, but wild blueberry is a woody species that increases stem diameter through production of secondary xylem and phloem via activity of a vascular cambium (Lens et al. 2004). Lower stem diameter in the presence of cow wheat therefore suggests that interference from this weed species may reduce activity of the vascular cambium, thus reducing the amount or thickness of secondary tissues produced by stems.

Stem biomass was 61% lower in quadrats with cow wheat relative to quadrats without cow wheat (Table 1), likely due to a combination of lower stem length and diameter in the presence of cow wheat. *Melampyrum arvense* reduced aboveground biomass of *Medicago sativa* by up to 53% (Matthies 1995). Matthies (1995) also indicated that host plant biomass was reduced by 2.4 g for every gram of parasite biomass produced. Stem biomass of healthy wild blueberry plants ranges from 0.7 to 1.03 g/stem (Percival et al. 2003), which is very similar to what we found in quadrats where cow wheat was absent (Table 1), further suggesting that cow wheat may reduce overall growth of wild blueberry stems.

Berries per stem in quadrats with cow wheat were 55% lower relative to quadrats without cow wheat (Table 1). Although variable, up to 20 berries/stem is common in productive stands of wild blueberry (Percival et al. 2003), suggesting that the presence of cow wheat may reduce yield through reductions in berry number per stem. Lower berry number per stem may be a function of the lower length, diameter, and biomass of stems in patches with cow wheat (Table 1), or other unknown mechanisms. For example, cow wheat removed phosphorous and radio-labelled carbon from host plants (Cantlon et al. 1963; Nave et al. 2017). Availability of phosphorous can increase wild blueberry yield (Penney and McRae 2000) and carbohydrate content of wild blueberry fruit increases steadily during fruit ripening (Kaur et al. 2012). Reduction of these resources by cow wheat could therefore affect berry number and should be considered in future research.

A final implication of our results is the potential effect of cow wheat on the use of a 3 year wild blueberry production cycle consisting of a nonbearing year followed by two bearing years. Blueberry stems during the second bearing year must be taller and more branched than those of the first bearing year to produce adequate yields (Jordan and Eaton 1995). Our results suggest that possible reductions in stem length, diameter, and biomass by cow wheat during the first bearing year may inhibit the implementation of a 3 year cropping cycle in infested fields.

In conclusion, results of our study suggest that wild blueberry stem density, stem length, stem diameter, stem biomass, and berries per stem are lower when wild blueberry grows with cow wheat relative to when it does not. Future research utilizing controlled laboratory and field experiments spanning both the nonbearing and bearing years is therefore warranted to confirm these effects, as well as to confirm the presence or absence of haustorial connections between cow wheat and wild blueberry.

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