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The Impacts of Fertilizer and Hexazinone on Sheep Sorrel (*Rumex acetosella*) Growth Patterns in Lowbush Blueberry Fields

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Sheep sorrel is an invasive, creeping perennial weed of lowbush blueberry fields that decreases yields and hinders harvest. Much of the basic phenology of sheep sorrel in blueberry fields is unknown and not documented in peer-reviewed journals. Three levels of fertilizer (0, 20, and 40 kg N ha^{-1}) and two levels of hexazinone (0 and 1.92 kg ai ha^{-1}) were applied to three vegetative-year blueberry fields to determine their effects on root and shoot growth, biomass allocation, and seed production of sheep sorrel plants. Hexazinone efficacy varied widely between sites, but suppressed shoot biomass, achene number and weight, and reproductive biomass, as well as the reproductive : shoot biomass ratio. Fertilizer tended to increase achene number and increased sheep sorrel shoot biomass in the absence of hexazinone, but had no effect on achene weight, root biomass, or reproductive biomass. When fertilizer was applied, sheep sorrel allocated resources to sexual reproduction at the expense of vegetative growth.

Nomenclature: Hexazinone; Velpar; sheep sorrel, *Rumex acetosella* L.; lowbush blueberry, *Vaccinium angustifolium* Ait. and *Vaccinium myrtilloides* Michx.

Key words: Broadleaf, perennials, biomass allocation, phenology, reproductive biomass, seed production, Velpar, weed management.

Lowbush blueberries are the most important fruit crop in Nova Scotia, Canada, with respect to export sales, total acreage, and provincial wealth (McIssac 1997). Weeds are a major problem in lowbush blueberry fields in eastern Canada because they inhibit harvesting operations, decrease berry quality, and reduce yields (Kennedy 2009, Kennedy et al. 2010). Sheep sorrel (*Rumex acetosella* L.) is one of the most common weeds present in eastern Canadian blueberry fields and is drastically reducing yields (Kennedy 2009; Kennedy et al. 2010) partially because its physiology in blueberry fields is not well understood or documented.

Commercial lowbush blueberry production occurs on a 2-yr production cycle. In the first year, fields are pruned (vegetative or prune year) by burning or flail mowing to stimulate vegetative growth; flowering, fruit development, and harvest occurs in the second year (fruiting or crop year) (Barker et al. 1964). Unlike many other agricultural crops, the perennial lowbush blueberry is managed rather than planted; the crop cannot be rotated nor the fields cultivated. This results in limited control options for troublesome weeds and thus farmers tend to rely on herbicides for weed control due to lack of alternatives. The herbicide hexazinone is the most common herbicide applied in the spring of the sprout year to control broadleaf weeds including sheep sorrel (McCully et al. 2005). In commercial blueberry production, it is applied PRE to blueberry bud break after fields have been flail mowed or burned. It is a photosynthesis inhibitor that is absorbed by plant roots and translocated to the foliage (Ross and Lembi 1999). Hexazinone controls sheep sorrel populations, but efficacy varies between sites and years (Kennedy 2009, Kennedy et al. 2010). Hexazinone also can be applied POST at a rate of 1.0 kg ai ha^{-1} in the spring of the crop year if susceptible weeds pose a problem to crop yields (Jensen and Specht 2002). Applications must be conducted no later than the early bloom stage (DuPont 2009; Jensen and Specht 2002) as applications after this date will cause serious foliar damage to the blueberry plant resulting in significant crop damage and yield loss (Jensen 1985; Jensen and Specht 2002). During the 2-yr production cycle, blueberry farmers also add fertilizers to improve blueberry yields and promote growth (Jeliazkova and Percival 2003). Fertility combined with inadequate weed control results in larger, taller weeds that compete with the blueberry and reduce yield (Kennedy et al. 2010).

Sheep sorrel is an invasive, dioecious, perennial weed that is commonly found in pastures (Putwain et al. 1968), roadsides, and eastern Canadian blueberry fields (Sampson et al. 1990). It tends to occur in areas with acidic soils, poor drainage, low soil nitrogen levels, and little competition from other plants (Uva et al. 1997). Sheep sorrel reproduces sexually via seed (Putwain et al. 1968) and vegetatively from adventitious shoots (ramets) that emerge from creeping roots (Escarré et al. 1994; Putwain et al. 1968). It can either flower and set seed in its seedling year or it can produce adventitious shoots (Harris 1970). Its seeds are 1 to 1.5 mm in length and are enclosed within a triangular achene (Uva et al. 1997).

Literature and field guides often misinterpret sheep sorrel as a rhizomatous perennial (Thieret et al. 2001; Uva et al. 1997; Walters 1991). Rhizomatous perennials contain horizontal underground stems with nodes from which roots and shoots originate. Gleason and Cronquist (1991) identified sheep sorrel as a creeping perennial with underground roots from which buds are capable of generating new shoots at random intervals along its length (Ross and Lembi 1999). Creeping perennials typically have vegetative reproductive structures, which contain large food reserves and numerous buds that are capable of generating new shoots (Ross and Lembi 1999). Repeated control attempts are required to exhaust the buds and stored food reserves of these weeds (Ross and Lembi 1999).

Creeping perennials such as sheep sorrel are phenotypically plastic and can alter their growth patterns depending on the environment they are invading. In competitive situations, particularly late-successional communities, microsites for effective perennial seed germination are limited (Kupferschmid et al. 2000); plants tend to persist by increasing their size through vegetative growth (Putwain et al. 1968). Jongejans et al. (2006) found that perennial weed biomass

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increased with fertility and under simulated succession (achieved by adding nutrients), broadleaf perennials transitioned from allocating energy to vegetative biomass to sexual biomass. Increased seed production was achieved by increasing plant size or by allocating resources to sexual reproduction; differences tended to be species-dependent. Fertility inputs can increase perennial broadleaf ramet density (Kennedy et al. 2010), height (Fan and Harris 1999; Schippers and Olff 2000), and biomass (Carlson and Hill 1986; Schippers and Olff 2000), whereas herbicide applications tend to decrease density (Kennedy et al. 2010; Zewdie and Suwanketnikom 2005).

The biology and phenology of sheep sorrel in lowbush blueberry fields has not been adequately documented. The majority of studies conducted on sheep sorrel have been done within pastures (Putwain et al. 1968; Putwain and Harper 1970) or greenhouses (Harris 1972; Putwain and Harper 1972). It is imperative to understand how sheep sorrel behaves in an agricultural setting, because as Korpelainen (1993) documented, the vegetative growth patterns of sheep sorrel differs greatly in natural and experimental conditions. It is crucial to understand how resources are allocated to its vegetative and reproductive structures, and also how management alters this allocation. This information can aid in the effective control of sheep sorrel. Putwain et al. (1968), Putwain and Harper (1970), and Escarré et al. (1994) have documented the seed production and seedling survival of sheep sorrel in pastures, but no information has been published on the physiology of sheep sorrel within blueberry fields. It is unknown if achenes that produce seedlings survive to contribute to the population or if seedlings play any role in this weed problem. It is important to determine this information as achenes can be transferred within and between blueberry fields on field equipment (Boyd and White 2009), potentially creating a larger weed infestation. We do not know the area that the root system can cover or the size of a sheep sorrel plant, of if seedlings contribute to the weed population.

The objectives of this study were to determine the effects of hexazinone and fertilizer on sheep sorrel root length, the number of ramets per centimeter of root, shoot biomass, root biomass, biomass of reproductive structures, the biomass ratio of roots to shoots, the biomass ratio of reproductive structures to shoots, achene number per ramet, and achene weight.

Materials and Methods

Study Sites. Field experiments were conducted in vegetative year blueberry fields at Kemptown, Nova Scotia, Canada (45°29′N, 63°10′W), and Sackville, New Brunswick, Canada (45°54′N, 64°14′W) on May 1, 2007. In 2008, the experiment was repeated in another vegetative year field at Mt. Pleasant, Nova Scotia (45°46′N, 63°50′W). In 2007, an adjacent field at Mt. Pleasant was used to assess achene production. The 2007 and 2008 Mt. Pleasant sites will be referred to as Mt. Pleasant07 and Mt. Pleasant08, respectively. Sites with relatively consistent blueberry and sheep sorrel cover were selected for the experiment.

Soil at Kemptown is of the Queens type composed of 10 to 30 cm of silt to clay loam on top of 30 to 50 cm of firm, silt to clay loam over compacted loam to clay loam derived from shale and sandstone (Webb et al. 1991). It contains 6.5% organic matter and has a pH of 4.6. Soil pH and organic matter content were determined by obtaining soil samples within each site and were sent to a lab[1] for analysis. Soil at Sackville is a sandy loam of the Aulac type (Aalund and Wicklund 1953) with 4.7% organic matter and a pH of 4.5. Soil at Mt. Pleasant is a sandy loam over a gravely sandy loam of the Hansford type (Nowland and MacDougall 1973) with a pH of 4.7 and an organic matter content of 4.1 and 4.3% for Mt. Pleasant07 and Mt. Pleasant08 respectively.

Experimental Design. The experimental design consisted of a two by three factorial design in four blocks. Treatments consisted of the addition of hexazinone[2] at two levels (0 or 1.92 kg ai ha^{-1}) in conjunction with the addition of a 14–18–10 synthetic fertilizer[3] with applications based on nitrogen content (0, 20, or 40 kg N ha^{-1}). Nitrogen was present in the mix as ammonium sulphate. Hexazinone was sprayed with a hand-held, CO_2-pressurized sprayer[4] fitted with TeeJet 8002VS nozzles[5] at a rate of 1.92 kg ai ha^{-1} in a water volume of 200 L ha^{-1} to control existing sheep sorrel and to prevent seedling germination from the seed bank. Agrochemical application was conducted at the beginning of the vegetative year before blueberry bud break. Plots were 4 by 6 m in size with a 1-m buffer between rows of treatments.

Data Collection. *Underground Structures.* Cross-sections of underground structures and aboveground stems of sheep sorrel were prepared, stained with methyl blue, and observed under a compound microscope to document stellar patterns to verify if the underground structures of sheep sorrel were rhizomes or roots. This procedure was conducted an hour after harvest.

Whole Plant Harvest. A whole plant harvest was conducted at three sites. Two sheep sorrel plants per plot were harvested at Sackville and Kemptown, for a total of 48 plants per site. At Mt. Pleasant08, three plants per plot were harvested for a total of 72 plants to obtain more subsamples in an attempt to increase precision. Sheep sorrel plants were harvested by hand and with an asparagus knife to expose roots for removal. Roots were followed to their ends. If the main (primary) root was broken at the beginning of the whole plant harvest, a new plant was chosen for collection. The closest plant to the center of the plot was chosen as the first sheep sorrel plant to be harvested, and the second plant was selected haphazardly by throwing a pointed stake. Chosen plants were in the flowering stage of development, but male and female plants were not differentiated.

Sheep sorrel plants were then taken back to the laboratory to determine total root length, the number of ramets per centimeter of root, and the distance between ramets on the root. The plants were then separated into roots, shoots, and sexual reproductive structures. Plants were cut at the base of the plant to separate shoots from roots; the shoots were cut again above the last true leaf to obtain the reproductive structures, which consisted of panicles and flowers. The roots, shoots, and reproductive structures were dried in an oven at 50 C for 48 h and then weighed to determine biomass.

Achene Production. Ten sheep sorrel ramets per plot were collected at each site. The ramets were randomly selected, but only ramets with green achenes (not fully mature) were collected, to reduce the probability of seed loss due to

Table 1. Mean shoot biomass, root length, and number of ramets per centimeter of root of sheep sorrel affected by fertilizer in vegetative-year blueberry fields at Kemptown, Nova Scotia; Sackville, New Brunswick; and Mt. Pleasant, Nova Scotia.

	Site		
Fertilizer[a]	Kemptown	Sackville	Mt. Pleasant08
(kg N ha^{-1})	Shoot biomass (g plant^{-1})		
0	0.33	0.11	0.14
20	0.59	0.25	0.12
40	1.08	0.34	0.24
Linear	0.005[b]	0.02	0.24
	Total root length (cm plant^{-1})		
0	77.1	82.5	58.0
20	80.3	88.3	30.5
40	73.9	49.5	34.5
Linear	0.88	0.02	0.08
Quadratic	0.80	0.04	0.16
	Ramets (no. cm^{-1} root)		
0	0.09	0.07	0.05
20	0.07	0.07	0.04
40	0.04	0.07	0.05
Linear	0.02	0.68	0.56

[a] 14–18–10 fertilizer was applied with rates based on kg N ha^{-1}.

[b] P-values obtained from polynomial contrast of fertilizer rates.

shattering. Achenes from all 10 ramets per plot were weighed together to determine (1) average achene number per ramet and (2) impact of herbicide and fertilizer applications on achene weight and number. Bulk samples of 100 achenes from each 4 by 6–m plot were counted and weighed with a balance calibrated to 10^{-4} g due to the extremely small size of the achenes. The weight of 100 achenes was used to estimate the total achene number per ramet.

Statistical Analysis. The data were first analyzed as a nested design using PROC MIXED in SAS,[6] with blocks nested within sites. A nested design was used because treatments were randomized within blocks but not across sites and because sites differed in field age, management history, sheep sorrel susceptibility to hexazinone, and organic matter content (Shen 1995). Sites were then analyzed separately because of the known differences between sites that were of interest and because blocks nested within sites was significant ($P < 0.0001$). Data were transformed where necessary to achieve normality and constant variance, but data were back-transformed for interpretation and figure creation. Back-transformed means are presented. Polynomial contrasts were used to determine the impact of incremental levels of fertility on shoot biomass, total root length, and ramet number per centimeter of root. All other means were compared using a *t*-test with a probability level of $P \leq 0.05$ unless otherwise noted.

Results and Discussion

General Growth Dynamics. Literature and field guides often misinterpret sheep sorrel as a rhizomatous perennial (Thieret et al. 2001; Uva et al. 1997; Walters 1991). Gleason and Cronquist (1991) correctly identified sheep sorrel as a creeping perennial with ramets emerging from buds along its horizontally growing roots. Cross-sections from our study confirmed that sheep sorrel does not have rhizomes; the horizontal roots had a protostele stellar pattern, typical of roots, whereas stems had a eustele stellar pattern with xylem and phloem present within vascular bundles forming a ring pattern around the pith. Roots were yellow in color and were observed to grow just below the soil surface above blueberry rhizomes, which tended to be deeper in the soil. Sheep sorrel roots were small in appearance, with an approximate diameter of 0.1 cm. Few root hairs were observed and roots were intertwined extensively around each other and around blueberry rhizomes. Sheep sorrel emergence was first observed from the end of April to early May at all sites, but continued to emerge throughout the summer. Flowering commenced during the first 2 wk of July, and at this time sheep sorrel flowers were red and open for pollination. Seed set, indicated by mature red achenes, was observed during the second to last week of July, and dying or dead sheep sorrel shoots, indicated by a brown color and skeleton-like appearance, were observed in early August.

Fertility Effects on Sheep Sorrel Morphology. *Biomass.* Shoot biomass increased linearly with fertilizer rates at Kemptown and Sackville, but fertilizer had no effect at Mt. Pleasant08 (Table 1). Fertilizer levels of 40 kg N ha^{-1} increased shoot biomass by as much as 227% at Kemptown and 209% at Sackville when compared to 0 kg N ha^{-1}. Fertilizer application did not affect the root and reproductive biomass (weight of panicles and flowers), as well as the root : shoot and reproductive : shoot biomass ratios at all three sites (data not shown). Sheep sorrel was most likely using these nutrients to increase its aboveground biomass to produce leaves with larger surface areas to compete with the blueberry.

Root Length and Ramet Number. The effect of fertilizer on root length differed between sites. Fertilizer did not significantly affect root length at Kemptown or Mt. Pleasant08, but did decrease root length by 40% at Sackville (Table 1). At Sackville total root length decreased quadratically with fertilizer inputs; root length increased from 0 to 20 kg N ha^{-1} and decreased from 20 to 40 kg N ha^{-1}. This contradicts the findings of Klimeš and Klimešová (1999) who reported that sheep sorrel root length increases with the addition of nutrients. However, if nutrients are added to an area within a field that is deficient in nutrients, plant roots will grow toward the concentrated nutrients and increase their lengths (Sattelmacher et al. 1990; Wang et al. 2002). This may explain why sheep sorrel roots in the control plots had longer roots than those in the plots treated with 40 kg N ha^{-1}.

At Kemptown the number of ramets per centimeter of root decreased linearly with increasing fertilizer levels, but fertilizer had no effect at Sackville or Mt. Pleasant08 (Table 1). This was not expected to occur as it has been shown that bud dormancy can be broken by soil resource pulses (Hsiao and McIntyre 1984; McIntyre 1979), or an increased nutrient supply (Petersen 1975). It is possible that the decrease in shoot number per centimeter of root is due to a transition from vegetative to sexual reproduction (see below).

Achene Number and Weight. Fertilizer did not have a significant effect on achene number at Kemptown, Sackville, and Mt. Pleasant07, ($P = 0.14$, $P = 0.67$, $P = 0.58$, respectively). Achene numbers tended to increase with fertility where hexazinone was not applied, though this trend was not

Table 2. Mean shoot biomass, total root length, and number of ramets per centimeter of root of sheep sorrel affected by hexazinone in vegetative-year blueberry fields at Kemptown, Nova Scotia; Sackville, New Brunswick; and Mt. Pleasant, Nova Scotia.

	Site		
Hexazinone	Kemptown	Sackville	Mt. Pleasant08
(kg ai ha^{-1})	Shoot biomass (g plant^{-1})		
0	0.66[a]	0.33	0.29
1.92	0.68	0.15	0.04
P-value	0.93	0.03	0.001
	Total root length (cm plant^{-1})		
0	72.7	75.0	73.6
1.92	71.3	67.1	0.9
P-value	0.93	0.56	< 0.0001
	Ramets (no. cm^{-1} root^{-1})		
0	0.05	0.06	0.07
1.92	0.08	0.08	0.02
P-value	0.13	0.17	< 0.0001
	Achenes (no. ramet^{-1})		
0	270	240	177[b]
1.92	311	192	0
P-value	0.44	0.48	< 0.0001

[a] Means within a column and individual factors were compared using a *t*-test.

[b] There was a significant herbicide by fertilizer interaction at this site whereby 0 seeds ramet^{-1} were produced where hexazinone was added, but where hexazinone was not applied 168, 121, and 231 seeds ramet^{-1} were produced by the 0, 20, and 40 kg N ha^{-1} treatment, respectively. Seed production at the highest fertility rate was significantly higher than the remaining two treatments ($P \leq 0.05$).

significant (data not shown). The interaction between hexazinone and fertilizer was significant at Mt. Pleasant08 ($P = 0.01$); the number of achenes per ramet significantly increased when 40 kg N ha^{-1} was applied in comparison to the control (Table 2 footnote), but regardless of fertilizer level, where hexazinone was applied, the number of achenes present per ramet was always zero (Table 2 footnote).

Fertilizer did not affect achene weight (Kemptown, $P = 0.59$; Sackville, $P = 0.83$; Mt. Pleasant07, $P = 0.29$; Mt. Pleasant08, $P = 0.28$); it did, however, increase the number of achenes produced per ramet at Mt. Pleasant08 (Table 2 footnote). Therefore we conclude that sheep sorrel, like other perennials, invests its energy into producing larger numbers of seeds rather than bigger, heaver seeds (Fortunel et al. 2009). In theory, this allows sheep sorrel to effectively disperse seeds away from the mother plant (Howe and Smallwood 1982).

It is likely that changes in management caused a transition from vegetative to sexual reproduction. Plants at Kemptown were in a highly competitive environment (i.e., had the highest ramet density of all sites), whereas plants at Sackville and Mt. Pleasant08 were in a less competitive environment. At Kemptown, sheep sorrel plants did not alter their root length with fertility, but reduced the number of ramets per root length and increased shoot biomass with fertility inputs (Table 1). This resulted in fewer, larger, ramets with increased achene number per panicle, spaced farther apart on the roots. As fertility levels increased at Sackville, sheep sorrel decreased root length, did not alter ramet frequency on the roots, and increased shoot biomass (Table 1). Thus, there were fewer plants present, with fewer ramets per plant, which resulted in smaller sheep sorrel plants with larger ramets. As fertility levels increased at Mt. Pleasant08, sheep sorrel decreased root length, but did not alter ramet frequency, total biomass, or shoot biomass. The plants allocated resources toward greater sexual reproduction, as achene number significantly increased with fertilizer addition (Table 2). This may have significant implications for management, as fertility inputs may lead to a larger seed bank and potentially a more persistent weed issue.

Effect of Hexazinone on Sheep Sorrel Morphology. *Biomass.* Shoot biomass was unaffected by hexazinone at Kemptown ($P = 0.93$), but hexazinone significantly decreased shoot biomass at Sackville ($P = 0.03$) and Mt. Pleasant08 ($P = 0.001$) (Table 2). Lower efficacy at Kemptown may be partially explained by the fact that hexazinone binds tightly with soil organic matter (Kalouskova 1989), which was higher at this site. Soil organic matter increases the sorption and decreases the bioavailability of *s*-triazine herbicides (Brouwer et al. 1990; Laird et al. 1994; Stevenson 1972). Organic matter is directly related to the behavior of herbicides, because it adsorbs herbicides when soil pH is between 4 and 8 (Stevenson 1972). Triazine herbicides have the greatest adsorption affinity for soil organic matter of all soil constituents (Brouwer et al. 1990; Laird et al. 1994); the lateral or vertical movement of hexazinone in soil is slowed by high organic matter content (Neary et al. 1983).

Hexazinone affected sheep sorrel root and reproductive biomass parameters, but the effects varied by site. Hexazinone decreased the reproductive : shoot biomass ratio at all sites by as much as 96% (Table 3). At Mt. Pleasant08, hexazinone reduced root and reproductive biomass as well as the root : shoot biomass ratio. At Sackville hexazinone reduced reproductive biomass; at Kemptown hexazinone had no effect on root or reproductive biomass, or on the root : shoot biomass ratio. Although nearly 100% control was observed at Mt. Pleasant08 for all parameters mentioned above, hexazinone has the ability to decrease sexual reproductive biomass at some locations.

Table 3. Mean biomass of sheep sorrel roots, reproductive structures, root : shoot biomass ratio, and reproductive : shoot biomass ratio affected by hexazinone in vegetative-year blueberry fields at Kemptown, Nova Scotia; Sackville, New Brunswick; and Mt. Pleasant, Nova Scotia.

Site	Hexazinone	Root biomass	Sexual reproductive biomass	Root : shoot biomass	Reproductive : shoot biomass
	(kg ai ha^{-1})	g plant^{-1}		No.	
Kemptown	0	0.32	0.31	0.30	0.27
	1.92	0.36	0.18	0.36	0.13
P-value		0.69[a]	0.18	0.62	0.04
Sackville	0	0.60	0.35	0.80	0.38
	1.92	0.61	0.08	0.87	0.09
P-value		0.98	0.01	0.78	0.002
Mt. Pleasant08	0	0.22	0.33	0.29	4.06
	1.92	0.002	0.01	0.04	0.15
P-value		0.001	< 0.001	< 0.001	< 0.001

[a] Means within a column and site were compared using a *t*-test.

Hexazinone also decreased the reproductive : shoot biomass ratio at all sites, indicating that this herbicide can decrease the number of sheep sorrel flowers present per panicle in an individual ramet, thereby limiting reproductive capability.

Root Length and Ramet Number. The effect of hexazinone on root length differed between sites. Hexazinone had no effect on root length at Kemptown ($P = 0.93$) and Sackville ($P = 0.56$), but substantially decreased root length at Mt. Pleasant08 ($P < 0.001$) (Table 2).

Hexazinone had no significant effect on the number of ramets per centimeter of root at Kemptown ($P = 0.13$), or Sackville ($P = 0.17$), but significantly decreased the distance between ramets at Mt. Pleasant ($P < 0.001$) (Table 2). Though root length and ramet number were only affected by hexazinone at one out of three sites, hexazinone may have the ability to manage sheep sorrel vegetative growth, and ramet density is unlikely to increase where hexazinone is applied (Kennedy et al. 2010).

Achene Number. The main effect of hexazinone did not have a significant effect on the number of achenes per ramet at Kemptown ($P = 0.44$), Sackville ($P = 0.48$), or Mt.Pleasant07 ($P = 0.24$). At Mt. Pleasant08 however, the interaction was significant ($P < 0.0001$); achene number increased with increasing fertility where hexazinone was not applied, but where hexazinone was applied seed production was inhibited (Table 2 footnote).

Achene Weight. Hexazinone decreased achene weight at Kemptown ($P = 0.02$), Mt. Pleasant07 ($P = 0.06$), and had a marginal significant effect at Sackville ($P = 0.08$). The weight of 100 achenes at Kemptown decreased from 0.0364 to 0.0310 g with the addition of hexazinone. At Mt. Pleasant07 achene weight decreased from 0.0455 to 0.0323 g when treated with hexazinone, and achene weight at Sackville was 0.0254 and 0.0218 g without and with hexazinone, respectively. Achene weight at Mt. Pleasant08 in the control plot was 0.0390 g, but the weight of achenes in the hexazinone-treated plots could not be assessed because where hexazinone was applied, no achenes were produced.

The weight and number of achenes found within this experiment coincide with results found by Stevens (1932) whom documented that the approximate weight of 100 achenes was 0.0525 g, and this value doubled for a large plant. Stevens (1932) presented a table comparing his results for the weight of 100 achenes to three other publications, which ranged from 0.0300 to 0.0500 g. The weight of 100 achenes obtained from this study falls within these ranges. Stevens (1932) also documented that 250 seeds were present on a sheep sorrel ramet, which is similar to our findings (Table 2).

Sheep sorrel is a phenotypically plastic, creeping perennial that can alter its growth patterns to transition to sexual reproduction under high fertility situations. Putwain et al. (1968) and Putwain and Harper (1970) reported that vegetative reproduction is the primary form of reproduction for sheep sorrel and that seedling contribution to the population size is insignificant. Under high-competition environments, seedlings do not survive (Putwain and Harper 1970) and as a result do not contribute to the population. These seeds have little probability of surviving within blueberry clones (Kennedy 2009), but may contribute to the population if they land and colonize within disturbed or bare areas (Harris 1972), which can lead to increased weed density.

Hexazinone efficacy on sheep sorrel varied widely between sites probably due to differences in organic matter content, moisture, and past agrochemical applications at each field. Hexazinone effectively reduced shoot biomass at two of the three sites even where fertilizer was applied. Hexazinone did not have a significant effect on root length and biomass, but significantly reduced achene weight, shoot and reproductive biomass, and the reproductive : shoot biomass ratio. A decline in root length translates to less root length present for possible adventitious shoot propagation. A decline in shoot biomass, reproductive biomass, and the reproductive : shoot biomass ratio results in fewer flowers and panicles producing flowers able to contribute to sexual reproduction, resulting in a lower achene production. Because shoot production was inhibited, photosynthesis was reduced and thus the reproductive production was hindered, which resulted in the observed smaller, lighter seeds. Hexazinone can control both the vegetative and sexual reproductive capabilities of sheep sorrel.

Sources of Material

[1] The Nova Scotia's Department of Agriculture's Quality Evaluation Lab, 176 College Road, Harlow Institute (NSAC campus), Truro, Nova Scotia, Canada, B2N 2P3.

[2] Hexazinone, Velpar 75DF, E.I. DuPont Canada Company, P.O. Box 2300, Streetsville Mississauga, Ontario, Canada, L5M 2J4.

[3] 14-18-10 Fertilizer, Cavendish Agri Services, 100 Midland Drive, Dieppe, New Brunswick, Canada, E1A 6X4.

[4] R&D CO_2-pressurized sprayer, 419 Hwy 104, Opelousas, LA 70570.

[5] TeeJet 8002VS nozzle, Rittenhouse, 1402 Fourth Ave., St. Catharines, Ontario, Canada, L2R 6P9.

[6] SAS, SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513.

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