(1) Final Report: EARI-09-002 – 4 year project
Evaluating Current and Innovative Weed Management Tools for New Brunswick Lowbush Blueberry Production
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(3) Summary

The wild blueberry industry is a vibrant and growing industry in New Brunswick. Weed issues, both in established production and new development, continue to be a significant limitation to wild blueberry production. Current industry priorities reflect a need to integrate new innovative weed management strategies within the existing weed control framework based on hexazinone use. This project consisted of multiple, 'stand-alone' herbicide research trials designed to evaluate control options for specific weed issues. Thirty-eight separate reports were compiled in response to the project objectives, including over five-hundred individual treatments evaluated. Weeds of interest included fescues, ticklegrass, poverty oatgrass, hawkweed, sheep sorrel, lambkill, rhodora and many other common weeds found within wild blueberry production in New Brunswick. Trials evaluated innovative products, application timings and sequences for the blueberry industry. The information helped to improve the production recommendations for New Brunswick wild blueberry producers and has been incorporated into multiple articles, presentations, fact sheets and the Wild Blueberry IPM Weed Management Guide. Trial data supported regulatory approval for many innovative herbicides and application patterns within wild blueberry, including mesotrione, sethoxydim, flumioxazin, glyphosate and foramsulfuron. In addition, trials evaluated the use of tank mixtures and repeated applications, ensuring sustainable herbicide use and protection against weed resistance. Using the information gained from this project, New Brunswick wild blueberry producers are able to manage weed issues in a more economical and environmentally sensitive manner.

(4) Introduction

The wild lowbush blueberry industry is a vibrant and growing industry in New Brunswick. Current production has increased to 28,000 acres across the province involving 300 producers producing 45 million pounds of fruit in 2012. An additional 5000 acres is currently under development. Weed issues, both in established production and new development, continue to be a significant limitation to lowbush blueberry production in New Brunswick. Weed populations cause yield reductions, hamper harvest, interfere with pollinators and act as alternative hosts for select diseases. Published reports suggest that weed density and diversity is increasing in lowbush blueberry fields. With the advent of mechanical harvesting and increased fertility, weed populations have shifted towards a greater proportion of grass weeds, including ticklegrass (*Agrostis scabra*) and Canada bluegrass (*Poa compressa*). Sheep sorrel (*Rumex acetosella*) is also becoming more problematic in fields and producers need more information on the proper management of this weed. Newly cleared land presents a unique weed spectrum. These fields are generally infested with lambkill (*Kalmia angustifolia*) and rhodora (*Rhododendron canadense*). These two perennial plant species are extremely difficult to manage. Typical herbicide practices, including the reliance on hexazinone, have been associated with potential environmental concerns and current industry prices require examination of more cost effective control methods. Current industry priorities reflect a need to integrate new innovative weed management strategies within the existing weed control framework based on hexazinone use. Additional products to supplement hexazinone need to be registered, so growers are not reliant on one herbicide option. Recent work with mesotrione has improved the situation, but additional products and timings need to be evaluated further. The availability of new products, combined with non-chemical approaches are essential in a resistance management strategy. The development of more integrated approaches to weed management will result in more effective weed management strategies which in turn enhance the competitiveness, sustainability and profitability of New Brunswick.

(5) Project Objective

Examine the use of conventional herbicide chemistries and timings within lowbush blueberry production in addition to innovative herbicide groups and timings to improve weed control and productivity of lowbush blueberry production in New Brunswick.

(6) Project Deliverables

Herbicide screening trials, application timings for hexazinone treatment in combination with fall herbicide application, evaluation of tank mix formulations for improved dicamba activity, integration of the use of sprout year herbicides for maximum sheep sorrel control, evaluation of flumioxazin for moss control, multiple trials exploring new graminicide registrations and exploring synergy and reduced rates for mesotrione and hexazinone combinations.

(7) Materials and Methods

This project consisted of multiple, 'stand-alone' herbicide research trials designed to evaluate control options for specific weed issues. This allows the examination of a broad range of issues while not compromising experiment quality. Multiple locations allowed for a broad examination of product performance, minimized localized site-effects and allowed testing across the production region. Each trial has a separate report, which outlines specific materials and methods used within that trial. A general description of materials and methods are outlined below.

Locations: Trials were located throughout the wild blueberry production regions of New Brunswick, including the Albert, Charlotte, Gloucester, Kent, Kings, Northumberland, Queens and Westmorland counties. Specific trial locations were dependant on grower interest, weed spectrum and crop stage.

Material & Methods: These experiments were mainly product screening trials targeted for specific, problematic weed issues within current production practices. Innovative herbicides to blueberry production and multiple application timings (fall, pre- and post-emergence) were examined through these experiments. Randomized complete block experiments with 2 x 6 m plots were used. Products were selected based on previous research and industry consultation.

Rating Schedule: For each trial location, there was an initial site evaluation to ensure that the area was suitable for research purposes followed by the determination of the specific plot areas. Treatment application occurred based on the protocol for the experiment (dependant on proper plant stage/timing). Plot areas were evaluated for visual crop injury and weed control ratings over at least four distinct rating timings (7-14 days after application [DAA], 21-35 DAA, 42-63 DAA and 63+ DAA) when warranted. These ratings were evaluated on a scale of 0-100 where 0 represented no injury or weed control and 100 represented complete control or complete crop loss. An analysis of variance was performed on all data and means separated using the least significant difference test (LSD $P<0.05$). Yield measurements, when warranted, were recorded by weight of hand harvested representative areas.

(8) Results and Discussion

Thirty-eight separate reports were compiled in response to the project objectives and over 500 individual treatments evaluated. Each detailed report is available from the author (refer to trial number given below), although a small synopsis of the results and discussion is presented.

2007-17: Evaluation of fall herbicide application for lambkill and rhodora control in wild blueberries followed by fall or spring pruning. This trial found that mowing timing had no effect on herbicide efficacy or crop injury from fall herbicide applications. Dicamba alone or with 2,4-D ester was the best choice for rhodora control.

2008-11: Evaluation of hexazinone, terbacil, mesotrione and tank mixes applied in the spring of the sprout year for grass and goldenrod control in wild blueberries. Hexazinone and terbacil both offered control of Canada bluegrass. Mesotrione suppressed goldenrod populations with no grass activity while terbacil was effective on grass species only. No significant benefit was shown by the addition of herbicide to hexazinone in the sprout year. Broadleaf control was improved in the terbacil/mesotrione treatments as compared to terbacil applied alone. Continued examination of the relationship of hexazinone, terbacil and mesotrione co-applications against additional weed species is warranted to ensure producers are able to achieve maximum utility from these herbicides.

2008-18: Evaluation of fall glyphosate application in combination with sprout year hexazinone timing for lambkill control. Minor crop injury was found after glyphosate application but plants recovered by harvest. All glyphosate treatments controlled lambkill in the sprout year, with no benefit to the addition of hexazinone. Glyphosate use doubled the crop yield as compared to untreated areas. This information supported a URMULE for fall glyphosate use.

2008-19: Evaluation of the rate effect of fall applications of dicamba, 2,4-D ester and tank mixes for lambkill and rhodora control. More crop injury was found from higher application rates of both dicamba and 2,4-D. Lambkill and rhodora control was improved at 2.2 and 3.4 kg ai/ha dicamba rates. There was no advantage to the addition of 2,4-D to higher dicamba use rates.

2008-110: Evaluation of fall applications of dicamba, glyphosate and tank mixes for lambkill and rhodora control. Glyphosate controlled lambkill, while the 2.2 kg ai/ha rate of dicamba is needed to control rhodora. As most producers currently use 2,4-D ester to improve dicamba control, the price difference between glyphosate and 2,4-D ester should be evaluated.

2009-11: Evaluation of graminicides for ticklegrass control in the sprout year. Both fluazifop and sethoxydim controlled ticklegrass, although a higher application rate was required. This is likely due to the advanced stage of the grass at application. Clethodim, foramsulfuron plus urea ammonium nitrate and potentially, nicosulfuron/rimsulfuron, could be utilized for ticklegrass control.

2009-12: Evaluation of post-emergent graminicides in tank mix combination with mesotrione in the sprout year. Fluazifop required a high application rate to provide control, while sethoxydim controlled the Canada bluegrass at both rates tested. Foramsulfuron and nicosulfuron/rimsulfuron have potential. None of the tank mixes with mesotrione decreased grass control, helping to broaden the control spectrum and decrease application costs for producers if they use a tank mix.

2009-13: Screening of herbicides for use in the spring following land clearing (two trials). The treatments evaluated were not effective against the weeds present. DPX-MAT rate and timing should be refined to determine its utility. Hexazinone alone was not effective and should be evaluated in combination with mesotrione to improve the weed control in land clearing.

2009-14: Evaluation of various spring applied, sprout-year herbicides in combination with fall propyzamide for sheep sorrel control. Early crop injury was shown for both sulfentrazone and nicosulfuron/rimsulfuron. Both hexazinone and sulfentrazone had a high level of control in the sprout year, while nicosulfuron/rimsulfuron had suppressed populations. The addition of propyzamide to any spring herbicide treatment increased control over the first two rating periods. Evaluating hexazinone rates for sheep sorrel control should occur to determine why producer use of hexazinone has not had satisfactory control.

2009-16: Evaluation of flumioxazin for hair-cap moss control in the sprout year. Moss control from flumioxazin showed a rate effect present over all rating dates. For season-long control, either 428 g ai/ha flumioxazin or 143 g ai/ha plus NIS would be required. The lower use rate with NIS would have a lower application cost and potentially improve crop safety. Control levels declined early in the crop year, indicating that multiple applications or different application timings may be required for moss control.

2009-17: Evaluation of mesotrione and nicosulfuron/rimsulfuron for black bulrush and hawkweed control. Highest bulrush control levels were found by using mesotrione applied early or else two applications at the registered rate. Nicosulfuron/rimsulfuron had a high level of control, with no improvement to weed control found in the sprout year by adding mesotrione. Hawkweed control was reduced, with suppression from two mesotrione applications at the registered rate or with a nicosulfuron/rimsulfuron treatment.

2009-18: Evaluation of the rate and tank-mix partner of dicamba to improve rhodora control. A high level of crop injury was found. This level is higher than what is typically found after application and may be due to the age of the blueberry crop at pruning. Rhodora control declined as the trial progressed for every herbicide treatment. Dicamba plus 2,4-D ester and dicamba alone at high rates suppressed populations while all other treatments were not effective in the sprout year. Further evaluation of the dicamba/glyphosate tank mix is warranted.

2010-11A: Evaluation of hexazinone rate and mesotrione timing for weed control following land clearing. Weed spectrum was highly variable in the field, contributing to the variability in control. The late mesotrione application had higher control due to late emerging bracken fern, which appears late in season. There was no advantage to adding mesotrione to any rate of hexazinone. This result may be dependant on weed species and weather conditions.

2010-11B: Evaluation of hexazinone rate and mesotrione timing for goldenrod control. A high rate of hexazinone controlled goldenrod, while the lowest evaluated rate suppressed goldenrod species. Mesotrione alone had limited suppression of goldenrod. There was no advantage to adding mesotrione to a high hexazinone rate within this trial, although mesotrione improved control from a lower hexazinone application rate. Hexazinone is relatively expensive for producers and it may be economically effective to apply low rates of hexazinone early and follow with mesotrione late in the season if the weed population is not controlled.

2010-12: Evaluation of herbicide options for rough cinquefoil control in the sprout year. Terbacil controlled cinquefoil over all rating periods. Hexazinone alone had limited suppression of cinquefoil, whereby improved control was shown by adding DPX-MAT or mesotrione. Two applications of mesotrione significantly improved control over one application. Tribenuronmethyl, mesotrione applied once, nicosulfuron/rimsulfuron and nicosulfuron/rimsulfuron plus mesotrione suppressed rough cinquefoil.

2010-13: Evaluation of foramsulfuron and other graminicides for perennial grass control in the sprout year. Fluazifop, and to a lesser extent sethoxydim, required a high rate for grass control. Nicosulfuron/rimsulfuron suppressed grass populations. Foramsulfuron-R had improved weed control as compared to foramsulfuron-O when applied without UAN, although the level of weed control would not be commercially acceptable. The addition of UAN improved weed control for both formulations, with no improvement from the higher use rates. Either formulation of foramsulfuron plus UAN is promising for weed control and should be examined further.

2010-14: Evaluation of mesotrione tank mix options and the effect on tufted vetch, cow wheat and bracken fern. Three trials were established in commercial wild blueberry fields in 2010 to evaluate mesotrione tank mixes with registered graminicides. Mesotrione applied alone had a negligible effect on the grass species and had control over the other species tested, including vetch, cow wheat and bracken fern. A tank mix of either fluazifop or sethoxydim and mesotrione, with or without Agral 90, did not significantly change crop injury or weed control when compared to the equivalent rate of either tank mix component alone.

2010-15: Evaluation of herbicide options for huckleberry control in the spring of the sprout year. The results for this trial were highly variable, showing the difficulty in controlling this weed species. No single treatment offered any level of suppression or control of this weed in any rating period. Additional control options, including the use of more potent herbicides in the fall following crop harvest, should be examined to evaluate all potential herbicide control options for this weed species.

2010-16: Evaluation of herbicide options for hawkweed control in the spring of the sprout year. As the trial progressed, clopyralid and terbacil (2000 g ai/ha) had suppressed hawkweed and hexazinone/DPX-MAT had controlled population. Two applications of mesotrione had significantly improved control over all rating periods as compared to one application. The use of combined treatments of terbacil, mesotrione, clopyralid and nicosulfuron/rimsulfuron should be evaluated further.

2010-18: Evaluation of flumioxazin applied in the fall or spring for hair-cap moss control in the sprout year. The use of both fall and spring applications were consistently the highest control levels, although control declined to suppression by the end of the sprout year. There were no consistent rate or surfactant differences within each timing evaluated.

2010-19: Evaluation of fall herbicide applications for improved lambkill and rhodora control. Some treatments delayed crop emergence. Dicamba at higher rates, triclopyr, metsulfuron/PDX-MAT and metsulfuron/aminopyralid controlled lambkill. Lower control was shown for rhodora populations. Lower rates of dicamba and triclopyr suppressed rhodora while the remaining treatments were not effective. There was no benefit to the addition of Agral 90.

2011-101: Evaluation of pre-emergent herbicide options for control of red fescue in the sprout year of wild blueberries in 2011. A low level of weed control was shown for all treatments. Fall mowing for pruning, species or application conditions may contribute to the lower control levels. Terbacil, propyzamide and dichlobenil all provided a level of suppression of red fescue. Foramsulfuron had limited suppression of red fescue.

2011-102: Evaluation of post-emergent herbicide options for control of fine-leaf sheep fescue in the sprout year of wild blueberries in 2011. The Group 1 herbicides had limited activity on fine-leaf sheep fescue. Nicosulfuron/rimsulfuron suppressed weed populations while foramsulfuron significantly improved control over the final two sprout year rating dates. Delaying foramsulfuron application significantly reduced fine-leaf sheep fescue control.

2011-103: Evaluation of Sinbar WDG and tank mixes for perennial grass and goldenrod control in the sprout year of wild blueberries in 2011. There was no difference in crop injury or weed control between the WP or WDG formulation of terbacil. Terbacil alone effectively controlled the perennial grass species present and there was no consistent grass control benefit to adding any tank mix partner. Terbacil alone was not able to control goldenrod. The addition of mesotrione, paraquat, nicosulfuron/rimsulfuron and low rates of hexazinone resulted in suppression of goldenrod species by the end of the sprout year. Terbacil plus the high rate of hexazinone controlled goldenrod.

2011-104: Evaluation of graminicide options for control of problem grasses in the sprout year of wild blueberries in 2011. Four trials evaluated registered and innovative grass control products for control of problematic grass species. Foramsulfuron performed similarly to commercial standards in most evaluations and registration of this product is warranted.

2011-105: Evaluation of mesotrione tank mixes and application timing within the crop year of wild blueberries in 2011. There was no significant crop injury found in any pre-bloom treatments. There were no significant yield effects for any treatment, although there was a general trend in both trials toward decreased yields within the mesotrione treatments applied mid-bloom. Including mesotrione within a sethoxydim or fluazifop treatment did not decrease poverty oatgrass, cow wheat or goldenrod control. There was no efficacy benefit to delaying the herbicide treatment to the mid-bloom timing, so producers should focus on a pre-bloom application for control on these weed species in the crop year. Repeated applications of mesotrione significantly increased goldenrod and poverty oatgrass control, although the increase shown for poverty oatgrass would not be commercially significant.

2011-106: Evaluation of innovative sprout year herbicides for sheep sorrel control in wild blueberries in 2011. Spring dichlobenil application caused significant crop injury in the sprout year. The low rate of hexazinone was not effective for sheep sorrel control while the high rate suppressed populations. Dichlobenil and pyroxsulam suppressed sheep sorrel on the final sprout year rating and should be evaluated further. Indaziflam plus glufosinate, sulfentrazone and oxyflurofen had promising control on early in the season, but declined as the trial progressed.

2011-107: Evaluation of registered sprout year herbicides for sheep sorrel control in wild blueberries in 2011. Sheep sorrel control was highly variable. Spring propyzamide application suppressed sheep sorrel. The high rate of hexazinone adequately controlled sheep sorrel, while the lower rate suppressed populations. The addition of nicosulfuron/rimsulfuron to a low rate of hexazinone significantly improved control. Nicosulfuron/rimsulfuron alone had limited suppression of sheep sorrel. The addition of mesotrione significantly improved control.

2011-108: Evaluation of mowing height and glyphosate formulation for fall control of lambkill in wild blueberries in 2011. There was no difference noted between the glyphosate formulations, where improved control was demonstrated by adding Agral 90 or Sylgard. LI700 did not improve control. This response should be verified in future trial work. Mowing as close to the ground as possible significantly improved weed control, irregardless of glyphosate treatment.

The specific reason for this improved control is not known and further examination of this phenomenon is warranted.

2011-109: Evaluation of fall herbicide options for hawkweed control in wild blueberries in 2011. As the trial area was over-sprayed, only early season evaluations were displayed. Terbacil had limited activity, while the lower rate of clopyralid and triclopyr had lower levels of control as compared to the more effective treatments. The plot areas will be monitored in 2013, in case treatment differences appear after the effects of the over-spray treatment are reduced.

2011-110: Evaluation of fall application of flumioxazin in combination with spring herbicide treatments for red fescue control in the sprout year of wild blueberries in 2012. Propyzamide was the best option for controlling red fescue. Nicosulfuron/rimsulfuron, foramsulfuron and terbacil all have potential for control, although they may have to be used in combination with other treatments. There was no advantage to layering any treatment with flumioxazin for red fescue control. Hexazinone and nicosulfuron/rimsulfuron had the highest ratings for sheep sorrel control. Flumioxazin offered moderate control while terbacil and foramsulfuron had low control levels.

2012-101: Evaluation of foramsulfuron application timing for red fescue control in wild blueberries in 2012. There was a reduction in control when foramsulfuron was applied at the typical hexazinone application timing (early May) or the typical fluazifop application timing (mid June). Growers may have to adjust application timings when applying foramsulfuron for fescue control. Adding foramsulfuron after a pre-emergent glufosinate treatment or multiple foramsulfuron applications improved fescue control.

2012-102: Evaluation of innovative herbicide options for fine-leaf sheep fescue control in wild blueberries in 2012. There was a high level of fine-leaf sheep fescue control following hexazinone treatment. Terbacil suppressed fine-leaf sheep fescue, with improved control when used in combination with nicosulfuron/rimsulfuron, glufosinate or hexazinone. Foramsulfuron also suppressed the grass and had significantly improved control when used following pre-emergent terbacil or glufosinate. Spring propyzamide and pyroxsulam had limited control. Hexazinone alone provided a high level of sheep sorrel control. Terbacil alone had limited activity on sheep sorrel, although activity was improved to control when combined with nicosulfuron/rimsulfuron and to suppression when combined with glufosinate. Pyroxsulam suppressed sheep sorrel while foramsulfuron and propyzamide were not effective.

2012-103: Evaluation of tank mix options for hexazinone and terbacil applied before wild blueberry emergence in 2012. Hexazinone suppressed the grass species present. Adding nicosulfuron/rimsulfuron, flumioxazin or terbacil increased grass control. Hexazinone alone had a high level of broadleaf weed control with no improvement shown by including any of the tested tank mix partners. Terbacil alone had good control and no tank mix partner significantly improved grass control. Terbacil alone had limited broadleaf activity and adding any of the tested tank mix partners improved broadleaf weed suppression.

2012-104: Evaluation of spring herbicide options for hawkweed control in wild blueberries in 2012. A high level of hawkweed control was shown from all clopyralid treatments, and there was no difference between clopyralid application rates of timings by the end of the sprout year. Terbacil suppressed hawkweed, where control was increased when combined with nicosulfuron/rimsulfuron, clopyralid or glufosinate. Foramsulfuron and pyroxsulam had limited suppression of hawkweed when applied alone.

2012-105: Evaluation of spring herbicide options for huckleberry control in wild blueberries in 2012. Aminopyralid and triclopyr caused significant blueberry injury following a post-emergent application. As these were the only treatments with acceptable weed control, other application timings and methods should be examined to improve crop tolerance.

2012-106: Evaluation of post-harvest and spring herbicides to control hawkweed in the sprout year of wild blueberries in 2013. Fall herbicides were applied in 2012 with no results available at this time.

2012-107: Evaluation of glyphosate rate and formulation on control of lambkill in wild blueberries in the fall of 2012. Fall herbicides were applied in 2012 with no results available at this time.

(9) Conclusion

Each individual trial helped to expand the knowledge base for specific weed species, herbicides and application timings. The information helped to improve the production recommendations for New Brunswick wild blueberry producers and has been incorporated into multiple articles, presentations, fact sheets and the Wild Blueberry IPM Weed Management Guide. Trial data supported regulatory approval for many innovative herbicides and application patterns within wild blueberry, including mesotrione, sethoxydim, flumioxazin, glyphosate and foramsulfuron. Trials also evaluated the use of tank mixtures and repeated applications, ensuring sustainable herbicide use and protection against weed resistance. Using the information gained from this project, New Brunswick wild blueberry producers are able to manage weed issues in a more economical and environmentally sensitive manner.

(10) Required Next Steps

Despite these efforts, weeds continue to be a significant issue for wild blueberry production in New Brunswick. Weed populations adapt to current control practises and environmental conditions, making on-going evaluations of new 'gap' weeds necessary. Continued support for trial evaluation for these weeds and screening of new herbicides to the wild blueberry market is required. Information gained from other areas and crops can be applied to this industry, but cannot replace local evaluation and knowledge gained within this very unique production system. Specific future needs within the New Brunswick wild blueberry industry include the evaluation of layered treatments and tank mixes, weed resistance management and continued product screening for new weed issues including hawkweeds, fescues and fern species.

(11) Communication

All final reports are available to the lowbush blueberry growers of New Brunswick from the author. Results are submitted for inclusion in the 2009-2012 Agricultural Research Abstracts from the NBDAAF. Trial information was included within the NBDAAF Crop Updates throughout the 2009-2012 growing seasons. An experiment was included as a tour stop during the 2009 Bleuets New Brunswick Blueberries Summer Field Day on July 18, 2009; during the 2010 BNBB Summer Field Day on July 17, 2010; during the NBSCIA Miramichi Farm of the Year Tour on July 27, 2010; and during the 2011 BNBB Summer Field Day on July 16, 2011, allowing growers to visualize the results of on-going experiments. Multiple small-scale plot tours occurred with local co-operators, extension personnel and the agri-chemical industry. Trial results were presented at the 2009 CWSS Meeting on November 25, 2009 in Charlottetown, PEI; at the BNBB Technical session on February 5, 2010 in Moncton; at the 2010 CWSS Meeting on

November 24, 2010 in Regina, SK; at the WildBREW session on October 21, 2010 in Quebec; the 2011 CWSS Meeting on November 24, 2011 in Niagara Falls, ON; at the WildBREW session on October 27, 2011 in Bangor, ME; and at the WildBREW session on October 26, 2012 in Fredericton, NB. Results were disseminated to multiple agro-chemical companies and were used at the AAFC-PMC 2010-2013 Minor Use Priority Setting Meetings to assist in determining priorities for herbicide registration in lowbush blueberry. Information was presented to growers in the BNBB Newsletter and education sessions. Experimental results were used in development of fact sheet revisions, including the Wild Blueberry IPM Weed Management Guide.