

SPOT- APPLICATION OF PRE-EMERGENCE HERBICIDE USING A VARIABLE RATE SPRAYER IN WILD BLUEBERRY

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ABSTRACT

Wild blueberry producers apply herbicides uniformly to control grasses and weeds without considering the significant weed density variability and bare spots within fields. The repeated and excessive use of herbicides in significant bare spots has resulted in an increased cost of production and environmental contamination. The objective of this study was to examine the impact of spot-application (SA) of herbicide using a prototype variable rate (VR) sprayer to control weeds and grasses in a wild blueberry field. The 6.1 m VR sprayer was mounted on all-terrain vehicle (ATV). The machine vision sensing and control system of the VR sprayer consisted of μ Eye digital color cameras mounted on a separate boom in front of the ATV, fast ruggedized computer, custom image processing software, VR controller, Land Manager II, flow valve, solenoid valves and a Pocket PC. Nine 6.1 m wide test plots were selected in a wild blueberry field and the bare spot, grass and weed areas were mapped using RTK-DGPS. Three different techniques (uniform application (UA), SA in blueberry plant areas only and SA in weed areas only) were applied in nine selected plots (each application in three randomly selected plots). Weed density was measured at 20 randomly selected data points in plant areas of each plot after approximately 2, and 10 weeks of herbicide application. Weed density data was examined to determine the impact of SA of herbicide in plant areas of the wild blueberry field as compared to a traditional UA. The chemical saved with SA in plant areas ranged from 14.17 to 31.92 % depending on the size of bare patches.

Keywords: digital color camera, RTK-GPS, plant detection, real-time sensing system, VR controller

INTRODUCTION

Wild blueberry producers apply agrochemicals to minimize weed, grass and disease pressures within fields to maintain high yielding crops (Percival and Dawson, 2009, Yarborough and Jemison, 1997). Perennial weeds that have a life cycle of greater than two years are the most difficult to control in wild blueberry fields (Wild Blueberry Factsheet, 1997). Fields developed from woodland, often have to be treated with herbicides to control tree seedlings, perennial bushes and shrubs. However, fields developed from abandoned hayfields or pastures typically have to be treated for control of grasses and perennial weeds (Wild blueberry factsheet, 1997).

Hexazinone (velpar®) has been used heavily in wild blueberry production since 1983 to suppress competing weed cover (Yarborough and Jemison, 1997). As a result, velpar® increases blueberry stem density, length, and number of buds maximizing yields up to threefold (Yarborough and Bhowmik, 1989, Yarborough and Jemison, 1997). Eaton (1993) found that wild blueberries react slowly to herbicide and fertilizer applications, and that much of the yield increases are from the effect of herbicides rather than from fertilizers. Velpar® is known for leaching into ground water from wild blueberry fields because of the mostly sandy loam soils and the herbicide's chemical composition (Yarborough and Jemison, 1997). As a result, velpar® has been applied at a reduced rate resulting in an increased weed pressures within wild blueberry fields (Yarborough and Marra, 1997). Pre-emergent application of herbicide is one of the most effective methods in controlling weeds, while later post-emergent applications are effective but can cause serious foliar damage to the crop (Jensen, 1985). The Nova Scotia wild blueberry network information centre suggests farmers to follow a list of best management practices for wild blueberry production including when, where and how to apply agrochemicals. Producers need to scout their fields and spray only when and where necessary (Wild Blueberry Factsheet, 1997). Yarborough and Marra, (1997) found it does not pay to control common weeds found in wild blueberry fields until one-fourth to one-half of the field is infested with the weeds. If spot-application (SA) technologies were to be used it would allow for growers to apply herbicides to fields with any given percentage of weed coverage without worry of wastage of chemical that would increase production cost and pollute the environment.

Prior to the registration of pre-emergent herbicides, cutting and hand-wiping or herbicide rollers were used to control the growth of taller weeds (Yarborough, 2006). However, cutting is not effective and wiping could result in injury to the blueberry plant. Both cutting and wiping methods are laborious and time consuming. Newer post-emergent innovations such as the wick master wiper, sideswipe hockey stick wiper, sproutless weeder and clean cut applicator are readily available, effective and cause less damage to the plant however, these methods are also laborious and time consuming (Yarborough, 2006).

Precision agriculture brings technologies together to make agriculture more economically and environmentally efficient (Al-Gaadi et al, 1999; Castro et al, 2011; GopalaPillai et al, 1999). One of the newest innovations in precision agriculture is the real-time variable rate (VR) sprayer. Motivation for the development of this type of VR sprayer is increased field performance and lower

chemical use and costs (Mooney et al, 2009; Zaman et al., 2011; Esau, 2012). This type of VR sprayer does not use prescription maps, but relies on sensors or cameras to provide real-time weed and bare spot detection information to the controller for spraying the correct targets. Zaman et al., (2011) and Esau, (2012) developed and evaluated a prototype variable rate sprayer for SA of agrochemicals in wild blueberry fields using ultrasonic sensors for tall weed detection and spraying. Chang et al. (2012) developed color co-occurrence matrix based machine vision algorithms for wild blueberry fields. The developed algorithms were designed to identify bare spots, wild blueberry plants and weeds in wild blueberry cropping fields. Chang et al. (2012) used four color cameras to take images in real-time and transfer via USB link to a ruggedized laptop with custom-written programs coded in Microsoft Visual® C++. The textural features of each image were extracted using MATLAB® Image Processing Toolbox Version 7.8.0 (Math Works, Natick, MA, USA) and later analyzed with SAS® (SAS Institute, Cary, NC). The accuracy levels of developed algorithms for detecting weeds, blueberry plants and bare spots ranged from 91.4 to 94.9 % with processing time of 27 to 55 ms which allows for a maximum vehicle travel speed of 6.3 to 3.1 km hr⁻¹, respectively.

Although research programs throughout North America have concentrated on the development of VR technologies for different crops to date, little attention has been put towards wild blueberry production systems. In this study, the performance of the VR sprayer was tested for SA of pre-emergence herbicide using digital color cameras and custom image processing software to only target and spray blueberry plant areas in the field.

MATERIALS AND METHODS

A wild blueberry field was selected in Debert, Nova Scotia (45.441649°N, 63.449205°W) to test the performance accuracy of the VR sprayer for spot-application (SA) of pre-emergence herbicide during the spring of 2011. Detailed design and operation of the VR sprayer can be seen in Zaman et al., (2011) and Esau (2012) (Fig. 1).

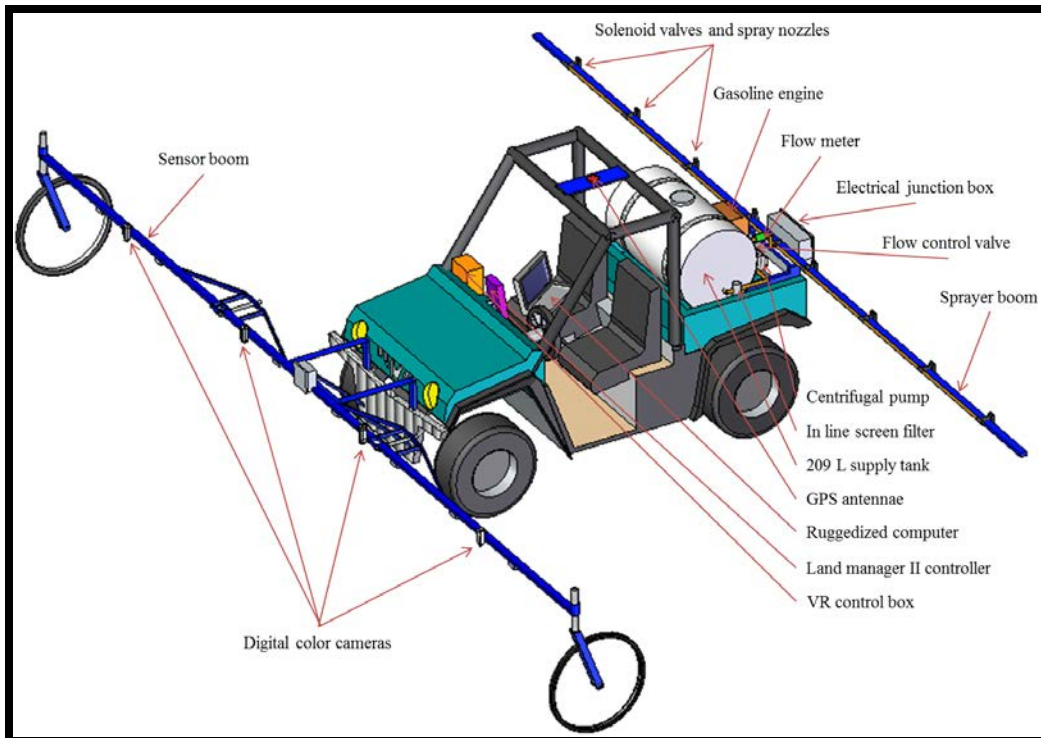


Fig. 1. Schematic diagram of an automated variable rate sprayer using cost-effective µEye cameras.

The selected field was in the vegetative sprout year of the biennial crop production cycle. The predominant weed species, in rivalry with the wild blueberry were *Scirpus atrovirens* Willd. (black bulrush), *Solidago* sp. (goldenrod), *Rumex acetosella* (sheep sorrel) and a variety of other broad leaf weeds in the Debert Field. The blueberry plants were pruned using a gang mower (Doug Bragg Enterprises Ltd, Collingwood, Nova Scotia) the previous fall of 2010. The Debert Field was broken into nine test tracks (100 x 6.1 m wide) that were marked to investigate the accuracy of the VR sprayer for detecting and spraying herbicide at the correct targets (Fig 2). The boundaries of selected tracks were mapped with a real time kinematics-global positioning system (RTK-GPS). On May 17, the developed VR sprayer was used to apply a tank mix of velpar® and terbicil (sinbar®) pre-emergence herbicide at a rate of 2 and 1.5 kg/ha to selected tracks in the Debert Field respectively. Three tracks were selected at random and applied with a uniform application (UA) of pre-emergent herbicide, three tracks were applied with a spot-application (SA) on green weeds only and the remaining three tracks were applied with a SA on blueberry plants areas only (Fig 2). Visual observations revealed large weed patches were mostly in bare spots. SA was applied to blueberry plant areas because the pre-emergence herbicide reduces growth of weeds that compete with the blueberries for nutrients, water and sunlight. Some producers want to keep weeds growing in areas where blueberry plants are not growing to reduce soil erosion. Pre-emergence herbicide was applied to weed patches only to see the effect of weed pressures within blueberry plant areas without the herbicide spray. Meteorological conditions were the same for herbicide applications in each track during the field experiment. Due

to space constraints results of herbicide application in plant areas only were presented and discussed in this paper.

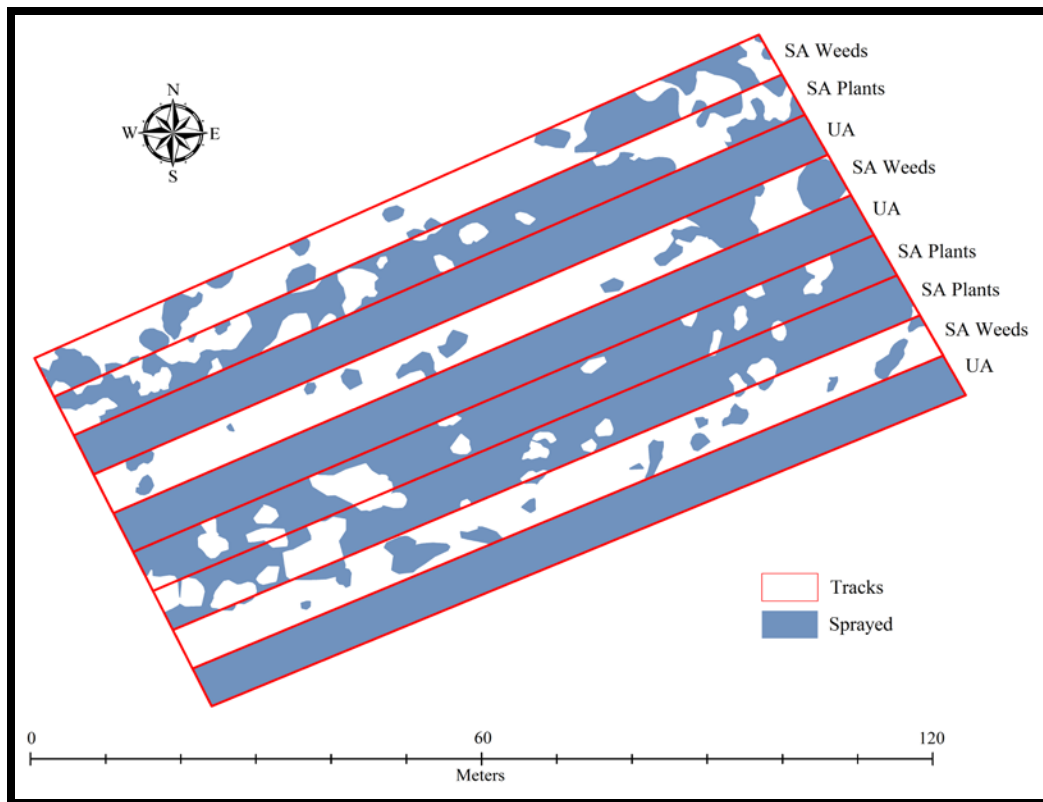


Fig. 2. Map showing experiment layout for pre-emergence herbicide applications in selected tracks (UA, SA on plants and SA on weeds) in Debert Field.

An RTK-GPS was used to record the position of 20 randomly selected points in blueberry plant areas in each of the tracks. A one meter square quadrat was placed at each of the points and the weed density was recorded on a percentage bases during the summer after herbicide application on June 1st, and July 25th. The percentage of weed coverage versus date of data collection was plotted using a bar chart in Microsoft Excel software (Microsoft, WA, USA). The weed coverage was compared using the paired t-test and a 95 % confidence interval with Minitab 15 statistical software (Minitab Inc., NY, USA) to examine whether the weed coverage with SA was any different from the weed coverage with UA of pre-emergence herbicide.

RESULTS AND DISCUSSION

On a conventional chemical broadcast application sprayer, the vehicle speed is required to remain constant for maintaining a proper application rate. Visual observation when applying SA of pre-emergence herbicide revealed that the flow controller automatically compensated for the changes in nozzle flow rate caused

by variation in ground speed during operation by monitoring the flow valve position.

The percentage of weed coverage showed similar decreasing trends for both the SA and UA technique (Fig. 2). Both SA and UA of pre-emergence herbicide seemed to be equally effective by the end of July with less than 5 % weed coverage left in the plot areas (Fig. 2).

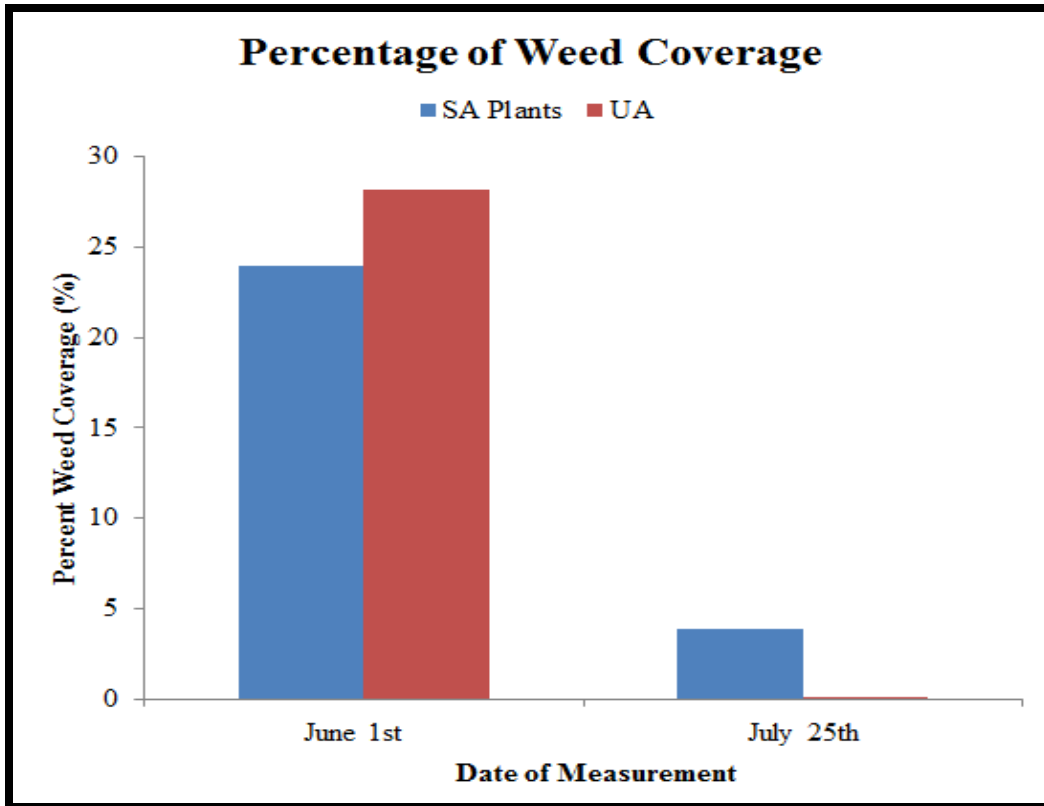


Fig. 2. Percent weed coverage versus date of measurement for spot-application versus uniform application technique after pre-emergence application.

The paired t-test for SA in plant areas versus UA weed coverage measurements indicated that there was no significant bias (P-value = 0.587) two weeks after application of pre-emergence herbicide (Table 1). Approximately 10 weeks after the herbicide application weed density measurements on July 25th showed no significant difference in percentage of weed coverage. (P-value = 0.188) (Table 1). Overall, results suggest that SA of pre-emergence herbicide on blueberry plant areas in wild blueberry fields is an effective method of applying pre-emergent herbicide to reduce weed coverage and a reduced agrochemical use.

Table 1. Summary statistics and student t-test comparison of percent of weed coverage (%) for determining the precision of SA technique relative to the UA with the prototype VR sprayer applying pre-emergence herbicide.

Application date	Plant yield parameter (n)	Min (%)	Max (%)	Mean (%)	S.D.	P - value
June 1 st	SA (20)	0.00	98.00	23.95	29.69	0.587
	UA (20)	0.00	50.00	28.18	12.36	
July 25th	SA (20)	0.00	48.00	3.89	12.23	0.188
	UA (20)	0.00	1.00	0.053	0.23	

Chemical savings from applying pre-emergence herbicide to only blueberry plant areas in the Debert Field ranged from 14.17 to 31.92 % depending on bare spot areas within the track (Table 2). Track 3 had the most chemical herbicide savings because it had the lowest percentage of blueberry plants growing within the track boundary. A newly developing field with significant bare spots (30-50 % of the total field area; Zaman et al., 2008) would have a significant amount of chemical savings using the SA technique. Esau (2012) saved herbicides and fungicides up to 90 % and 40 % respectively in wild blueberry fields. Therefore, SA with a VR sprayer could save significant amount of agrochemicals and reduce environmental risks.

Table 2. Chemical savings with spot-application compared to uniform application using prototype VR sprayer.

Track (#)	Total area (m ²)	Sprayed Area (m ²)	Chemical Savings (%)
1	703.81	579.84	17.61
2	700.74	601.48	14.17
3	691.10	470.50	31.92

SUMMARY AND CONCLUSIONS

Weeds and grasses remain a serious threat for the growth of wild blueberry as well as for smooth mechanical harvesting causing fruit losses. Results of this study indicated that automated identification of blueberry plants in real-time and SA of pre-emergence herbicide with VR sprayer using digital color cameras and fast VR controllers help to lower chemical input while effectively lowering weed coverage. Weed density results indicated similar results with both SA and UA tracks after pre-emergence herbicide application.

This VR sprayer could be used for a variety of precision farming applications including site-specific liquid fertilization in plant areas and fungicide/ insecticide spraying on foliage only in wild blueberry cropping systems. Further research and

experimentation is needed to determine the optimal chemical input amount for different weed control with the VR sprayer.

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