Effective Use of a Debris Cleaning Brush for Mechanical Wild Blueberry Harvesting

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Abstract. *Wild blueberries are an important horticultural crop native to northeastern North America. Management of wild blueberry fields has improved over the past decade causing increased plant density and leaf foliage. The majority of wild blueberry fields are picked mechanically using tractor mounted harvesters with 16 rotating rakes that gently comb through the plants. The extra foliage has made it more difficult for the cleaning brush to remove unwanted debris (leaf, stems, weeds, etc.) from the picker bars while harvesting. Currently, there is no protocol for adjustment of the brush into the picking teeth for maximum debris cleaning performance while minimizing wear. Research is required to determine the cleaning brush's acceptable wear limit to allow harvester operators to make better management decisions.*

A wild blueberry field was selected in central Nova Scotia to benchmark the performance of different wear levels of debris cleaning brushes. Two-hundred-meter-long test strips were setup and four different brush wear levels were replicated in quadruplicate to study the blueberry yield and harvest time required. Results suggested that the harvesting time was increased by 27.8% when using a brush with a bristle length of 120 mm as compared to a brush with an 87 mm bristle length. The shorter bristle length caused excess buildup of debris in the picker teeth resulting in the operator continually stopping for manual debris removal. Ten-meter long test strips in the same field were replicated in quadruplicate and used to evaluate the amount of debris lodged in the picker teeth using the four different brush wear levels. This experiment was completed in both weedy and non-weedy conditions. Results suggested that both brush wear and weeds in the field increase the amount of debris lodged in the picker teeth. Results from this study were used to develop an optimum brush performance protocol and adjustment guide that operators can use throughout the harvesting season.

Keywords. *Field efficiency, time savings, economics, optimization.*

Introduction

Wild blueberries (Vaccinium angustifolium Ait.) thrive in the acidic soils of northeastern North America, to which they are native too. A crop that was historically a wild occurring commodity, has since been commercialized. The management practices surrounding this crop have significantly increased over the past decade leading to an increase in the yield and vegetation produced by this crop, with record high yield production in 2016 (Yarborough 2013). During harvesting this additional vegetation causes issues in berry quality and slows down processing times once the berries arrive at the processing plant (Eaton 1988). The wild blueberry processing facilities have indicated the need to decrease debris in the bins to reduce processing time and increase fruit quality (M. Wood Personal Communication 2018). To address this industry concern, further evaluation of the debris management systems on wild blueberry harvesters is required. The hypothesis proposed in this study is that a protocol for proper cleaning brush adjustments and effective lifespan will decrease the amount of debris collected in the harvested bins during the harvesting process.

Wild Blueberries are an important crop to the northeastern North American economical landscape, with over 93,000 ha under management leading to approximately 117 million kg of berries, which are worth 491 million dollars per year (Yarborough 2013). Wild blueberries grow on a two-year cycle, with the first year being vegetative growth and the second year producing fruit yield (Zaman et al. 2008). Stem heights of wild blueberry range from 50 to 300 mm and blueberry fruit ranges from 4.8 mm to 12.7 mm in diameter (Hayden and Soule 1969).

Traditional manual hand raking of wild blueberries has yield losses that vary depending on the workers, but range from 15% to 40% (Kinsman 1993). Hand raking of wild blueberries requires huge labor forces and has since been replaced by mechanical harvesters (Hall et al. 1983). Mechanical harvesting is significantly faster than hand raking but can cause damages to the berries and losses to the yield (Soule and Gray 1972). These damages can consist of bruising and cracking of the berries (Soule and Gray 1972). Damage to the wild blueberry fruit lessens the quality and increases the risk of decay during the storage process (Dale et al. 1994; Mehra et al. 2013). The major manufacturer of commercial mechanical wild blueberry harvesters is Doug Bragg Enterprises Limited (DBE), located in Collingwood, Nova Scotia. DBE blueberry harvesters obtain a 88% to 92% picking efficiency (Farooque et al. 2014).

The modern single head wild blueberry harvester consists of a picking head mechanism with its height and speed hydraulically controlled by the operator from the cabin of the tractor (Fig. 1). The head consists of a circular picking reel with 16 teeth bars, each with 65 curved teeth spaced equally apart (Farooque et al. 2014). The picker teeth of the head travel in the opposite direction of the direction of the tractor to which it is attached (Farooque et al. 2012). A cleaning brush with 120 mm long nylon bristles is fixed above the picker teeth and used for debris removal during the harvesting process (Fig. 1). Street sweeping vehicles commonly use a circular brush for cleaning of road ways (Vanegas-Useche et al. 2015). The bristles on the sweeping brush attachment can vary in material from steel wires to polypropylene bristles which have similar characteristics to the nylon that is used in the production of brushes for wild blueberry harvesters (Rosca and Butsch 2016).

The blueberries are picked with the rotating reel travelling at 19 rpm then dropped onto a conveyer belt with a blower fan system that removes the remaining debris (stems, leaves and soil). The blueberries are then transported by the conveyer into bins (1.2 by 1.2 m and 0.3 m deep) loaded on the tractor that carry 136 kg of fruit (Fig. 1). The limitation is the inability to properly remove debris lodged in the picker teeth in wet and weedy field conditions because of wore or miss-adjusted cleaning brushes (Farooque et al. 2014).

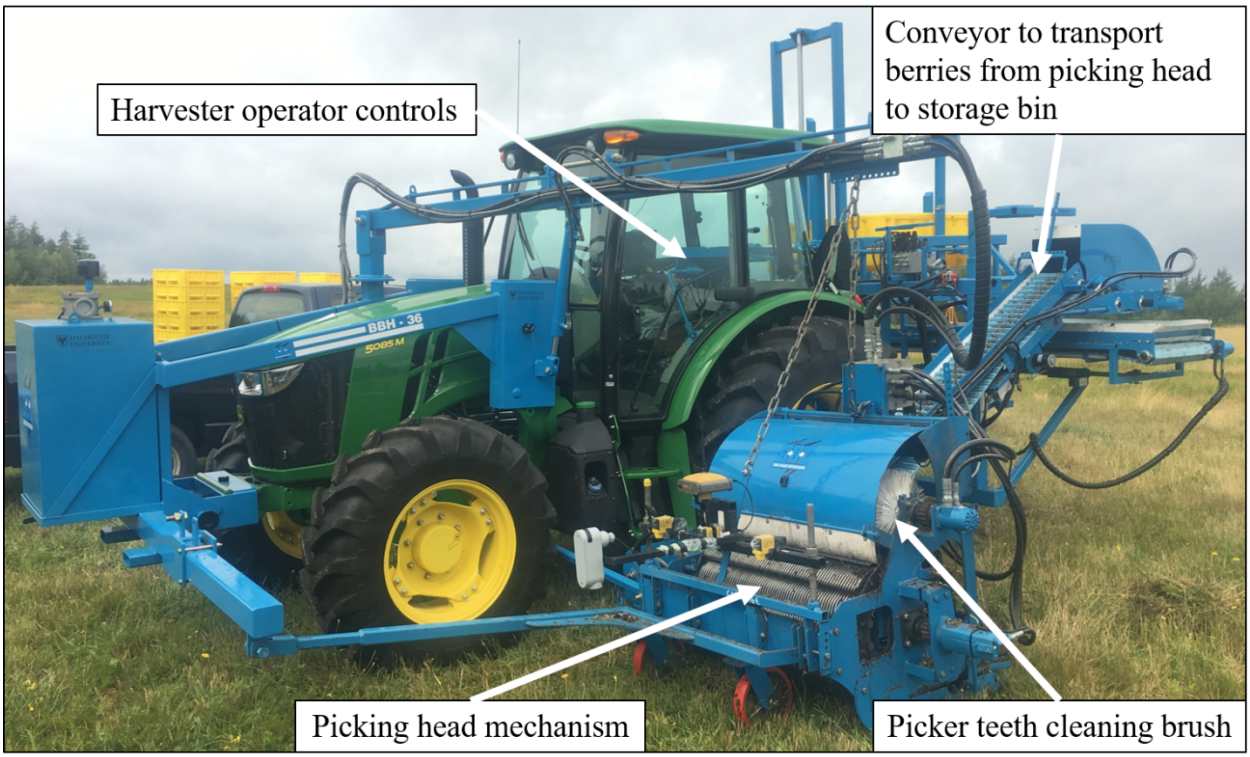

Fig. 1 Doug Bragg Enterprises Limited wild blueberry mechanical harvester.

Objective

The objective of this study was to field evaluate different wear levels of the cleaning brush on a mechanical wild blueberry harvester to determine the optimal debris removal setting and develop a recommended replacement protocol to optimize effective harvesting.

Materials and Methods

A commercial wild blueberry field was selected in Eastmines, Nova Scotia (45.427182°N, -63.481906°W; 3.76 ha) for testing purposes during this experiment. The selected field was in cropping year during experimentation in August 2017. The field received conventional fertilizer, weed, and disease management practices along with biennial pruning by mowing for the past decade. A commercial DBE harvester with 16 bars each with 65 equally spaced picker teeth was mounted on a 63.4 kW John Deere 5085M tractor and used for debris cleaning brush benchmark testing.

Four different wear conditions of brush were tested; B1= 120 mm, B2 = 115 mm, B3 = 106 mm, B4 = 87 mm (Fig. 2). Brush wear condition was tested in combination with both low moisture and high moisture field conditions. Eight combinations of; (B1 x LW1; B1 x LW2; B2 x LW1; B2 x LW2; B3 x LW1; B3 x LW2; B4 x LW1 & B4 x LW2) were tested in both weedy non-weedy field conditions. Each combination was replicated in quadruplicate.

Fig. 2 Debris cleaning brushes with different wear levels used for field experimentation.

Ten-meter long plots the same width as the harvester head (0.91 m) were arranged randomly throughout the field using a measuring tape and marker flags. Wild blueberry stem density and stem height was measured in three randomly selected sample areas inside the plot using 150 by 150 mm quadrates prior to harvest.

The harvester operator raised the picking head just prior to entering each plot and removed all debris from the picker teeth by rotating the reel in reverse. Any remaining debris lodged in the picker teeth was manually removed prior to plot harvest. The harvester was operated at a speed of 1.1 km h-1 and while in motion, debris removed from the picker teeth and flung behind the harvester by the cleaning brush was manually collected using a large collection bin (Fig. 3). The harvested yield was also collected from each plot. At the end of each harvested plot the operator stopped the picking reel and any remaining debris left in the teeth was manually collected and transferred to a clear bag for further analysis. Debris and yield samples from each plot were weighed using an electronic scale (TP-1502, Denver Instruments Inc., Bohemia, N.Y.).

Fig. 3 Manual collection of debris removed by cleaning brush from picker teeth and flung clear of harvester head.

In the same field, a ProMark3 mobile mapper DGPS (Thales Navigation, Santa Clara, Ca.) was used to mark 200 m long test plots the same width as the harvester picking width (0.91 m). The harvester was tested with four brushes with bristle lengths; B1= 120 mm, B2 = 115 mm, B3 = 106 mm, B4 = 87 mm. Each brush was tested in triplicate changing the brush at the beginning of each new test plot to ensure randomization of the experiment.

A timer was used to record the start of the plot harvest when the head was first lowered into the plot. The harvester proceeded through the test plot unless the picker teeth were clogged by debris. Teeth clogging required the operator to stop the forward motion of the harvester and raise the head to reverse the hydraulic motor allowing the brush to dislodge the debris from the teeth. If the brush successfully cleaned the picker teeth the harvester picking reel was lowered back into the plants and the plot harvest continued. However, if the brush was unable to successfully remove the debris, the operator was required to stop the picking reel rotation and exit the cab to manually remove the debris from the teeth. The total time to harvest the 200 m plot and all the individual stop times were recorded. Yield was collected in commercial totes during harvest of each plot and individually weighed using an electronic floor scale (M1, Western Scale Co. Ltd., Port Coquitlam, B.C.).

Results and Discussion

Results from the 10 m non-weedy test plots revealed that the amount of debris remaining in the picker bar teeth was significantly greater when using a cleaning brush with a bristle length of 106 mm or less (Fig. 4). Both the 120 and 115 mm bristle length brushes performed equally well to remove a significant portion of the debris from the teeth and leaving only 18.0 and 32.3 g of debris respectively.

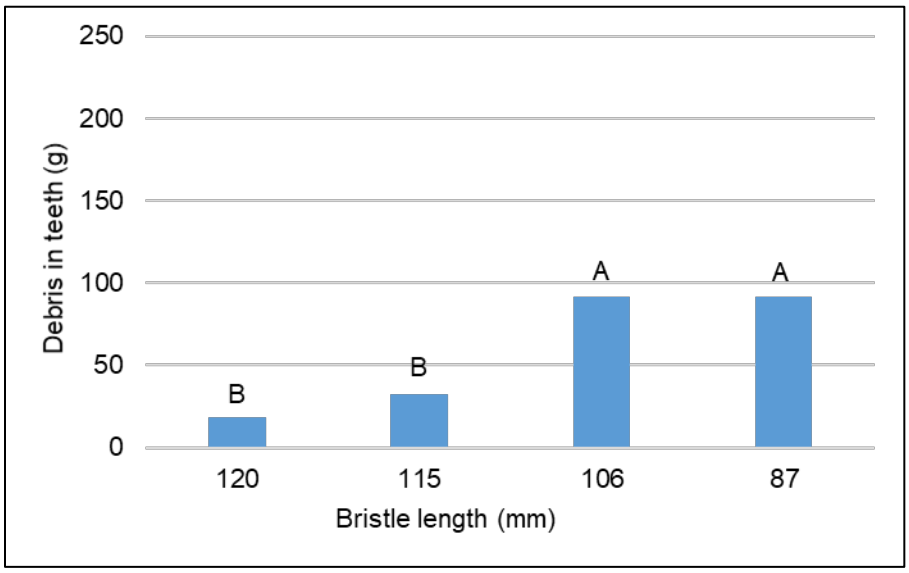

Fig. 4 Debris remaining in picker bar teeth in non-weedy field conditions

As expected, results from the 10 m test plots concluded that more debris remained in the teeth after harvesting weedy plots as compared to non-weedy. Debris remaining in the picker bar teeth in weedy plots was significantly less when using a cleaning brush with a bristle length of 115 or 120 mm (Fig. 5). Both the 106 and 87 mm bristle length brushes performed poorly in the weedy plots leaving 290.0 and 235.3 g of debris in the picker teeth respectively.

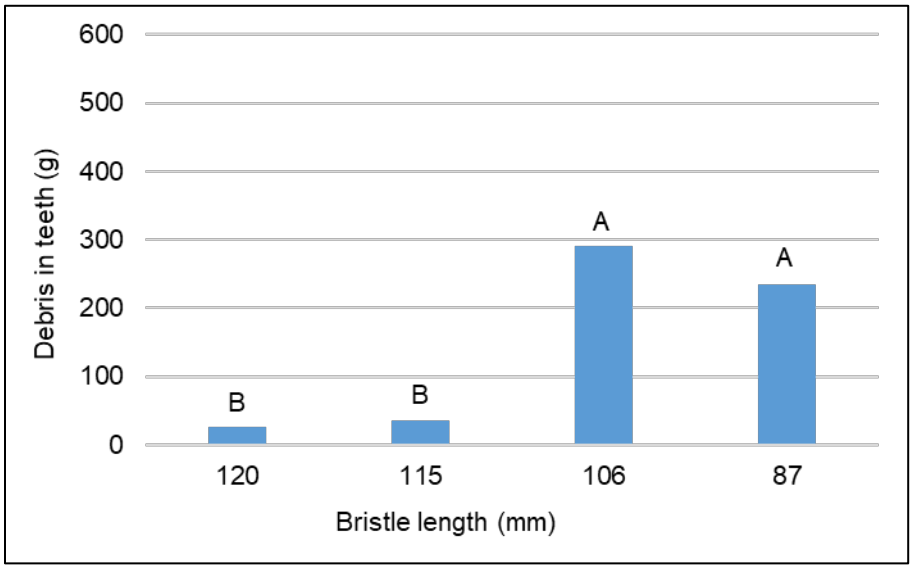

Fig. 5 Debris remaining in picker bar teeth in weedy field conditions

It was found that a cleaning brush with a bristle length of 87 mm increased the harvesting time by 27.8% as compared to a brush with bristle length of 120 mm (Fig. 6). Similar to the 10 m long test plots, results from the 200 m plots revealed a non-significant difference in the amount of time required to harvest using a brush with a bristle length of 120 and 115 mm. Harvesting using a cleaning brush with a bristle length of 87 mm required a significantly longer amount of time (162 s) as compared to the other three brush bristle lengths. Visual observation showed that debris continually built up in the picker teeth with a brush with bristle length of 87 mm causing the operator to frequently stop the tractor.

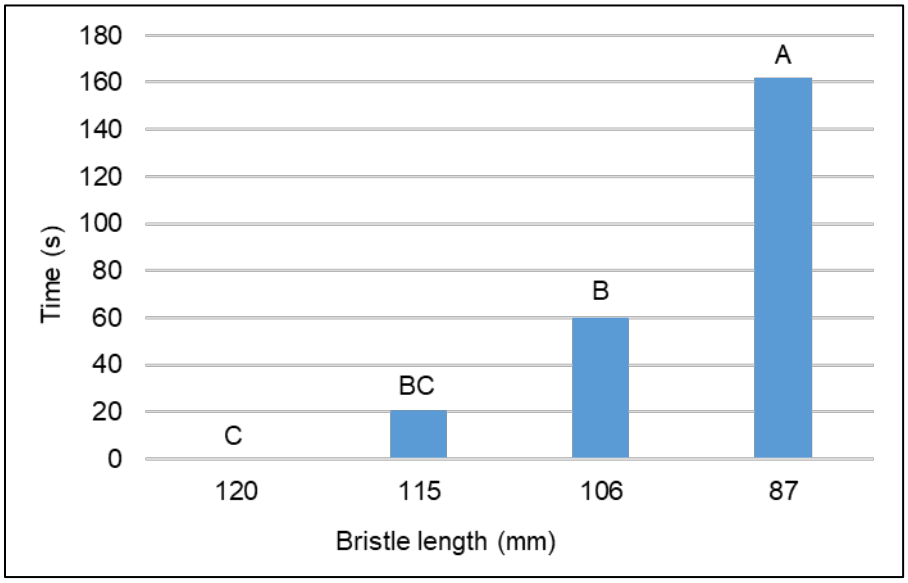

Fig. 6 Amount of time harvester was required to stop during 200 m trials

During field experimentation visual observation revealed the picker teeth stayed relatively clear of debris when operating with a brush bristle length of 115 and 120 mm. When harvesting with a brush bristle length of 106 mm or less it was visually apparent that a significant amount of debris was remaining in the picker teeth especially in weedy field conditions. Similarly, visual observation showed that a bristle length of 106 mm or less caused excessive debris buildup on the rear of the harvester head requiring the operator to stop the harvest and manually dislodge it. This was likely caused by the shorter brush bristles not having enough tip velocity to allow the debris to be thrown far enough behind the harvester head to clear the rear crossmember. Results from both the 10 and 200 m long test plots concluded that a harvester operating with a cleaning brush with a bristle length of 120 or 115 mm performed better than the brushes with shorter bristle lengths.

Conclusion

After extensive data collection it was found that brush bristle length and adjustment is essential for operational performance of the mechanical wild blueberry harvester. The use of a brush with a bristle length of 106 or 87 mm significantly increases the amount of debris stuck in the teeth. A cleaning brush with a bristle length of 87 mm increased the harvesting time by 27.8% as compared to a brush with bristle length of 120 mm. After analysis of the data it is recommended that the brush be replaced before the bristle length is reduced to 106 mm to ensure high field efficiency and effective debris removal from the picking reel of the mechanical wild blueberry harvester. The results from this study can help operators make better decisions to replace the cleaning brush at the most economical time.

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