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SCREENING COVER CROP SPECIES FOR IN-ROW AND INTER-ROW IN CANADIAN ORGANIC VINEYARDS

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Abstract: Grape growers are increasingly interested in cover cropping to enhance long-term productivity while improving the ecosystem health. A wide range of cover crop species for in-row and inter-row use in vineyards were evaluated in two provinces of Canada in 2019. Superior species were selected based on characteristics such as seeds availability and cost, establishment, dry biomass, growth rate, canopy cover, weed suppression, height, host for pest and diseases, maturity date, drought tolerance, traffic tolerance, and risk of being invasive. Among tested species for British Columbia superior species were Ladino white clover and spring lentil for in-row, and ryegrass, fescue, cereal rye, tillage radish, vetch and berseem clover for inter-row. In Ontario, superior inter-row species were crimson clover, pearl millet and yellow clover. Field studies are planned to assess the effect of the superior cover crop species on soil ecology, yield, and fruit quality/composition in the next three years.

Introduction: Canada is a major player in wine market, exporting over $36.9 million in wine to 40 countries in 2011. Organic wines have seen a significant increase in popularity and growing areas d from 2002 to 2013, representing 4.6% of the total grape production worldwide [1]. Canadian grape growers are increasingly interested in adoption of cover crops in the vineyards to reduce the environmental footprint and benefit from provided ecosystem services. Cover crops (CC) in vineyards help provide essential services such as water infiltration [2], carbon sequestration, nutrient supply and retention, weed suppression, biological control agents, microbial activity and diversity [3], and reduction of soil erosion [4]. Positive effects of cover crops on grape yield and/or sensory attributes and soil function are reported [5-8]. Results on cover crops attributes in vineyards however are inconsistent, variable among years, and under influence of grape varieties, growth stages, CC species and management, climate, and soil resource availability and properties [9]. While everyone agrees on the important positive effect of cover crops, Small effects on yield in short-term has been found [10]. Grape growers are nevertheless reluctant to use cover crops, due to concerns about water and nutrient competition between cover crops and grapevines. In order to encourage a wider adoption of CC in vineyards, research must introduce suitable CC species for each region and develop management practices that address trade-offs between provided services and competition for

resources need. With climate change and the need to adapt to climate uncertainties (e.g. droughts, heavy rainfall), cover crops can represent a great opportunity to buffer against these uncertainties.

The successful adoption of CC in vineyards for each region highly depends on selection of appropriate cover crop species and using management strategies that minimize competition. In selecting a vineyard CC, factors such as vineyard management, local environmental and climatic conditions, and the grower's goals, such as reduction of pests and production costs and ease of mechanization need to be taken into account [8]. There is need for a comprehensive study on intra-row and in-row cover crops species suitable for vineyards in each grape growing region of Canada and for strategies to boost the benefits of cover crops through minimizing the competition between vine and cover crops. This project will first screen cover crop species and mixtures for each region (semi-arid and cool-humid climate). A short list of suitable options will be tested under field conditions. We hypothesized that some of the tested cover crop species will establish well, suppress weeds, and provide a great groundcover all without being in competition with the vines.
Material and methods: Experiment was conducted in two organic vineyards in Okanagan Valley, British Columbia (BC), and one vineyard (initially two but due to heavy rainfall and flooding until July, the second was not available) in Niagara Region, Ontario (ON), Canada in 2019. The BC region is characterized by cool winters, warm summers, and low annual precipitation of 326 mm year^{-1} while the ON climate is characterized by cool-humid winters, warm summers, and high annual precipitation of 880 mm year^{-1}. Vineyard 1 in BC was a 13 years old Merlot grape block at Covert Farm Family Estate, BC (N 49^{o}14'39.8"; W 119^{o}32'42.7") with loamy sand soil texture. Vineyard 2 in BC was a 10 years old Zwiegeld grape block at Kalala Organic Estate Winery, BC (N 49^{o}50'31.2"; W 119^{o}38'42") with silty loam soil texture. In-row and inter-row spacing was 1.2 x 2.7m. Vineyard 1 in ON was a 15 year old Merlot grape block at Southbrook Vineyards, ON (N 43^{o}11'28.1'. W 79^{o}9'42.8") growing on red shale with high silt and clay content soil. Experimental design was a randomized complete block design (RCBD) with 5 replications. In each site, up to 9 cover crop species were tested in the vine row (in-row) and up to 15 cover crop species were tested in alleyways (inter-row). Cover crop species for each region were selected according to regional studies [5-7], literature [2,11,12,13], their function within the agro-ecological landscape, and in consultation with experts. Each in-row plot consisted of 5-7 vines between two panels with a guard vine at each end of the plot and each inter-row plot consisted of the alleyway between the 2 panels. Dual irrigation system consisting of a drip irrigation system for vine row and an overhead sprinkler system for alleyways were used in each vineyard in BC and the ON vineyard was drip-irrigated. Regional standard fertility and diseases/pest management practices were used.

In BC, in-row CC were seeded in late May, 2019 while inter-row CC were seeded in early June, 2019. In ON, seeding of both in- and inter-row CC occurred in early June, 2019. Cover crops were sampled at three-time intervals in BC and five times in ON. In BC and ON, cover crops were mowed according to needs. For BC cover crops and weeds canopy coverage at each sampling date were recorded in two randomly placed 0.25 m^2 quadrats per plot using the method described by Daubenmire (1959) [14], then all vegetation inside each quadrat was cut from an inch above the ground and separated into cover crop and weeds. In ON, in addition of this method, cover crops and weeds coverage at each sampling date were recorded using three 5 m^2 areas centrally located within each plot. For all three sites, the cover crop and weed samples were dried in an oven at 60°C for 48 h or until dry weight stabilized and the dry weight was recorded and calculated based on kg ha^{-1} unit.

Results: In BC, among 9 species tested in-row Credcendo Ladino clover (*Trifolium repens* cv. Ladino) provided the best establishment, canopy coverage, regrow after mowing, and least completion with vine; however, it slowly established and is not drought tolerant. Spring lentil (*Lens culinaris*), turnip (*Brassica rapa subsp. Rapa*) and phacelia (*Phacelia tanacetifolia*) were also performed well under vine. In BC, among 15 species tested inter-row perennial ryegrass+tillage radish (*Lolium perenne*+*Raphanus sativus*), fescue mixture (*Festuca arundinacea*+*Festuca rubra*+*Festuca ovina*), hairy vetch or field pea+winter rye (*Vicia villosa* or *Pisum sativum* +*Secale cereal*), and berseem clover (*Trifolium alexandrinum*) established fast and well, supressed weeds, regrow after mowing, less sensitive to drought and required no supplemental fertilization.

In ON, the preliminary results of the first year suggest that for between rows, crimson clover (*T. incarnatum*), pearl millet (*Pennisetum glaucum*), yellow clover (*Melilotus officinalis*) were significantly performing better than the other cover crops. They were followed by alfalfa (*Medicago sativa*), berseem clover (*T. alexandrinum*), red clover (*T. pretense*), and perennial ryegrass (*Lolium perenne*). While buckwheat (*Fagopyrum tataricum*) also performed well, it had to be mowed relatively in the season due to its aggressive growth and capacity to seed. Green lentil (*Lens culinaris*) and white clover (*Trifolium repens*) did not perform well. Due to the high level of rain and delayed season none of the alyssum and lentil under the vines grew.

Discussion: In BC, Okanagan Valley a level of drought tolerance is desirable for cover crops dues to light soil textures and semi-arid climate. Perennial cover crops are preferred in the vineyards due to lower soil disturbance and cost. Cover crops that regrow after mowing usually provide greater biomass and level of weed control through the growing season. Perennial ryegrass established slowly under forage radish and toward end of the season provided a great groundcover. Perennial ryegrass and fescue mix were the only two cover crops that show resistant to tractor traffic. Some cover crops harboured pests and diseases such as wire worms on root crops or aphid and insects on Winfred brassica (*Brassica napus* cv. Winfred).

In the case of ON, it was clear that the 2019 extreme spring delayed sowing and affected the performance of cover crops. Some species such as crimson clover, and pearl millet, showed more promising results under humid conditions. Climate uncertainties over the years are increasing and grape growers must deal with changing conditions that affect production. Cover crops may have many benefits to vineyards, but climatic variability must be integrated into the management plan. Irrigation and rainfall may significantly affect their performance, which can also influence the soil microbiome [15]. Cover crops in vineyards have great potential to enhance the capacity of this agroecosystem to mitigate and adapt in the face of climate change as the plants increase carbon sequestration and reduce erosion during heavy rain [16]. In ON this is particularly important considering that spring are becoming wetter and it is a season that can be highly vulnerable to erosion. Field studies are planned to assess the effect of superior cover crop species on soil ecology, yield, and fruit quality and composition in the next three years.

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