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Under-trellis cover crop and planting density to achieve vine balance in a humid climate

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ABSTRACT

The goal of our study was to improve Tannat *Vitis vinifera L.* grape and wine composition, by achieving vine balance in a humid climate. We tested under-trellis cover crops (UTCC) compared to a standard floor management of alleyway cover crops and under-vine herbicide. This strategy was tested in combination with variable planting density over three growing seasons in Southern Uruguay. Two factors were evaluated in a split plot design with five replicates. Treatments were, (1) UTCC (full cover of the vineyard soil with tall fescue (*Festuca arundinacea Shreb*)) versus conventional alleyway tall fescue with 1.0 m wide weed-free strips under the trellis, and (2) two spacings between vines in the row (0.8 vs 1.5 m). To avoid excessive vine water stress, supplemental irrigation was used during water deficit periods. Shoot growth rate, mid-day stem water potential, berry size and berry composition were monitored over the season as well as final yield, cluster and pruning weights. Results showed that UTCC reduced vegetative growth as expressed by pruning weight/m while closer PD resulted in greater vegetative growth parameters. UTCC reduced vine vegetative growth to recommended values of pruning weight per m of row under both plating densities. It also reduced berry size, cluster weight and bunch rot incidence as well as increased total soluble solids and anthocyanin concentration in grapes compared to the standard herbicide treatment. The use of UTCC with supplemental irrigation, showed promise for achieving vine balance in high vine capacity conditions.

1. Introduction

Research has generally shown that grapevine productivity, fruit quality and management efficiency are optimal with moderate vegetative vigor (Smart and Robinson, 1991). Excessive vine growth includes dense, shaded canopies that not only negatively impact fruit and wine quality potential (Dry et al., 2005; Smart and Robinson, 1991), but also foster bunch rot incidence (Guilpart et al., 2017). Conversely, very small vines that are limited by inadequate water or nutrients have reduced vine capacity for ripening the crop due to reduced light interception and reduced leaf function (Lakso and Sacks, 2009; Kliewer and Dokoozlian, 2005). Thus, the goal in many vineyards is to have a good vegetative/reproductive balance giving good vine capacity for yield potential, and having appropriate crop for desired ripening and fruit quality. Several metrics of an appropriate range of vegetative growth have been developed (Dry et al., 2005; Kliewer and Dokoozlian, 2005). Mean pruning weights of vine length greater than 0.5 kg per meter of row or canopy length or dormant cane weights above 50 g tend to indicate excessive vegetative vigor and imbalance.

Although the appropriate balance may vary with variety and desired yield or wine style, regulating vegetative growth is a key vineyard practice. Increasing growth tends to be easier to achieve as adding adequate water, nutrients or soil amendments are practical. Reducing excessive growth, however, is often difficult as removing or limiting resources is more difficult especially in humid climates and deep fertile soils. The use of under-trellis cover crops (UTCC) has been studied in cool humid climates that often experience abundant water availability and fertile soils. Apparently due to competition for soil moisture and mineral nutrients, UTCC has been reported to consistently reduce vine vigor (Hickey et al., 2016; Karl et al., 2016; Giese et al., 2015, 2014; Lopes et al., 2008; Tesic et al., 2007), and improve fruit sunlight exposure (Giese et al., 2015, 2014; Hatch et al., 2011). Additionally, increases of total soluble solids and/or berry skin phenols and anthocyanins have been reported (Hickey et al., 2016; Tesic et al., 2007).

Planting density (PD) is another technique used to control excessive vegetative growth of perennial fruit crops including grapevines. In general, it has been reported that under dry land, restricted and low potential soil conditions, increases in plant density resulted in less

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vegetative growth and less dense canopy (Archer and Strauss, 1990; Champagnol, 1984). With equal shoots per meter of trellis, however generally the opposite has been reported under high capacity conditions. Jackson and Lombard (1993), reported that it is not possible to control excessive vine vigor under high capacity condition by planting density, and recommended the use of divided canopies trellis systems under these conditions.

We propose a change in the current local commercial production practices in the humid climate of Uruguay that, (1) accepts unpredictable periods of water deficit or excess in non-irrigated vineyards, and (2) reduces competition from cover crops. The goal of our study was to evaluate integrated systems of cover cropping with supplemental irrigation to regulate canopy growth to optimize vine balance resulting in improved Tannat grape and wine composition. Our approach was to use under-trellis cover crops (UTCC) to limit vine water availability, reduce vine growth rate and limit final canopy size and density. To avoid excessive water stress due to the cover crop competition, supplemental irrigation was applied during moderate water deficit periods to regulate the stress and thus vine growth and function. Treatments were tested under two different inter-vine planting densities.

2. Materials and methods

2.1. Experimental site

The experiment was conducted over three consecutive growing seasons from 2011 to 2014 in Southern Uruguay (34°44′ S, 56°13′ W). Uruguayan climate can be classified as temperate – humid without a prolonged dry season, Cfa by the Köppen-Geiger system (http,//en.climate-data.org/location/3741/). Historical mean total annual rainfall in Southern Uruguay (1972–2015) is 1100 mm/year, with 650 mm occurring the growing season (Table 1). Further weather data details can be accessed at http,//www.inia.org.uy/gras/agroclima/cara_agro/index.html. The soil has been classified as a Tipic Argiudolls (USDA soil classification system), with a variable depth of 0.90–1.1 m and silty clay texture. A restrictive clay layer (Bt) is located at 40–50 cm, so most of root system is developed above. The total soil available water (field capacity-permanent wilting point) to 1.0 m depth was 117 mm.

2.2. Experimental vineyard and general vine management

Vines were trained to a vertical shoot positioning system (VSP) in north-south oriented rows (2.8 m row spacing). Cordon-trained vines were pruned to seven two-bud spurs per meter during dormancy. The height of the cordon was 1.0 m, and the top of the canopy was approximately 2.1 m above the ground. At approximately 30 cm shoot length, all shoots not located on spurs were removed. During the growing season, shoots were positioned by hand vertically above the spurs and topped 30 cm above the top wire. Catch wires were used to keep shoots in position. To avoid overcropping during ripening, crop level was adjusted by cluster thinning in each experimental plot at veraison (Stage 35 – Eichhorn and Lorenz, 1977). Based on prior research (Coniberti et al., 2011), an optimal crop level was estimated to be about 1 cluster/shoot. With a full canopy this provides a ratio of at least 1.8 m^2 leaf area/kg fruit weight needed for maximize sugar and anthocyanin accumulation.

To estimate the potential yield in every plot, thinned clusters were counted and weighed. Standard disease control fungicide programs were applied for downy mildew, powdery mildew, and *Botrytis* bunch rot. Irrigation water was applied with drip emitters (4 L/min) located directly under the vines and distributed 0.3 m apart. The irrigation system was designed to allow independently-irrigated single experimental plots.

2.3. Treatments

The experiment was conducted on Tannat grapevines grafted on to SO4 rootstock. The vineyard was 7-years-old when an under-trellis cover crop (UTCC) was established in March 2011 (seeding rate, 60 kg/Ha of tall fescue, *Festuca arundinacea*). Two factors were evaluated in a split plot design with five replicates. Main plots compared under-trellis cover crop (UTCC) with conventional under-trellis herbicide floor management (H); and subplots compare the effects of two planting density (PD) (0.8 and 1.5 m between plants), giving a total of four treatments: 0.8H, 1.5H, 0.8UTCC and 1.5UTCC. Since in most Uruguayan vineyards between vines spacing ranged from 0.8 to 1.1 m apart, the combination H treatment and 0.8 PD is considered the Control or standard treatment (0.8H-control). The UTCC treatment consisted of the full cover of the vineyard soil with tall fescue. The conventional management scheme used the same inter-row groundcover except with a 1.0 m wide weed-free strip under the trellis. The under-trellis, weed-free strip was maintained with a combination of herbicides. The five replicate subplots were each comprised of eight adjacent vines but only the central six were evaluated. Buffer rows separated ground cover (GC) treatments, following the same vine spacing as evaluated plots.

To avoid the effect of the treatment due to nitrogen (N) competition, in every UTCC plot ammonium nitrate (NH_4NO_3) was applied twice at a rate of 20 kg/ha N when shoots reached approximately 30 cm and after fruit set (stage 29 – Eichhorn and Lorenz, 1977). No statistically significant differences among treatments were detected in leaf N%, P%, K%, Ca% and Mg% at bloom or veraison (data not shown). Average leaf

Table 1
Irrigation by treatment and evapotranspiration, precipitation and growing degree-days (> 10 °C), from Las Brujas weather station located at 200 m from the experimental site.

	Phenological stage	Degree-days (> 10 °C)	Eto Penman (mm)	Precipitation (mm)				
Historical	budbreak − bloom	338	208	227				
	bloom − veraison	718	359	291				
	veraison − harvest	664	257	266	Irrigation (mm)			
	post-harvest	421	136	252	H0.8	H1.5	UTCC0.8	UTCC1.5
Season 2011/12	budbreak − bloom	328	224	132	0	0	0	0
	bloom − veraison	722	391	177	16.7	22.7	103.5	110.9
	veraison − harvest	665	271	212	23.7	37.9	70.7	80.5
	post-harvest	435	157	147	0	0	0	0
Season 2012/13	budbreak − bloom	403	211	359	0	0	0	0
	bloom − veraison	753	381	288	0	0	42.2	59.0
	veraison − harvest	641	291	199	0	0	9.7	9.7
	post-harvest	352	139	173	0	0	0	0
Season 2013/14	budbreak − bloom	332	214	204	0	0	51.2	51.2
	bloom − veraison	804	398	284	7.3	12	60.2	69.2
	veraison − harvest	692	228	641	0	0	0	0
	post-harvest	395	146	194	0	0	0	0