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Effect of Canopy Management Practices on Fruit Set, Yield Components and Fruit Composition

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ABSTRACT

The effect of shoot tipping, lateral shoot length and cluster zone leaf removal on yield, yield components, fruit composition and soundness were evaluated on mature Pinot noir grapevines. Shoot tip removal at bloom improved percent fruit set, number of berries per cluster and cluster weight. Elimination of lateral shoots also improved fruit set. There was no effect of cluster zone leaf removal on yield or yield components but must soluble solids decreased slightly. Shoot tipping decreased must soluble solids, pH and anthocyanin content. Brix and pH increased with increasing lateral shoot length.

INTRODUCTION

A significant problem in Oregon viticulture is the considerable fluctuation in yields due to poor fruit set. Weather patterns during bloom affect greatly the number of berries set per cluster, but they is not the only factor contributing to yield fluctuation: carbohydrate assimilation and partitioning also play decisive roles. During bloom, the actively growing shoot tip competes with the inflorescence for carbohydrates. Shoot tip removal eliminates this competition and additional amount of carbohydrates are made available to the inflorescence, resulting in a higher probability of flowers setting into fruits. To retain, hedge, or remove lateral shoots in grapevine canopies has been a matter of controversy in many wine grape production zones in the Old and New World. Lateral shoots are undesirable in vigorous vineyards because they lead to crowded canopies with excessive number of leaf layers, poor light interception, and poor microclimate, resulting in an imbalance favoring vegetative growth over fruit production. It has been shown that, in moderate vigor vineyards, lateral leaves improve fruit quality and are the most important contributors to sugar accumulation in the fruit during ripening, and to starch accumulation in the parent vine.

Photosynthetic rate of grapevine leaves increases until leaves attain full size (approximately 40 days after unfolding) and decreases steadily thereafter. During the ripening period, leaves in the cluster zone are well over 40 days of age and have very low photosynthetic rates compared with fully expanded lateral leaves and main leaves located at the top of the canopy. These leaves can be eliminated without great loss in overall vine photosynthesis. With leaf removal in the cluster zone, there is an improvement in fruit microclimate contributing to fruit quality and decreasing Botrytis bunch rot incidence and severity. It may also improve the effectiveness of pesticide application by allowing better spray penetration. In this study, the effect of shoot tipping, lateral shoot length, and cluster zone leaf removal on overall vine performance were evaluated.

MATERIALS AND METHODS

Experimental design

A factorial design was used to vary shoot tipping, lateral shoot length and cluster zone leaf removal. The experiment was carried out on 180 seven teen-year-old own-rooted Pinot noir grapevines. The following treatments were applied:

Shoot tipping at full bloom, or no shoot tipping. Lateral shoot length: 1) no laterals, laterals removed weekly as they arose, starting at full bloom, 2) Short laterals: laterals cut back to 4 leaves at full bloom, and subsequent lateral growth removed weekly, 3) Long laterals: laterals allowed to grow undisturbed. Leaf removal in the cluster zone 4 weeks after bloom or no leaf removal. Treatment consisted on removing the leaves and laterals opposite to the clusters plus one leaf immediately above and below the cluster.

Each treatment combination was replicated 5 times in sets of 3 vines.

Fruit set

Prior to bloom, one inflorescence per vine was enclosed into a pollination bag to retain all shed flowers. The bags were removed at the end of July, four weeks after full boom, and all the abscised flowers and fruitlets were counted. At harvest, these clusters were picked separately and frozen and the number of berries was later counted. Number of flowers was calculated as the sum of shed flowers and berries. Percent fruit set was calculated as the quotient between number of berries at harvest and the total number of flowers per inflorescence.

Yield and fruit quality

The crop was harvested on October 1. Number of clusters per plant was recorded. One hundred berries from each replicate were chosen randomly to determine mean berry weight. Cluster weight was obtained dividing total yield by number of clusters. Number of berries per cluster was calculated dividing cluster weight by mean berry weight. The fruit of each replicate was separated into two groups: first quality (sound) and second quality (affected with powdery mildew). A sample of 25 clusters per replicate was crushed for determination of soluble solids, pH and titratable acidity. Sugar per vine was calculated multiplying must sugar content in 'Brix (equivalent to percentage by weight of sucrose) by total yield per vine. Berry skin thickness was measured on ten skin disks per replicate. Skin anthocyanin content was determined on the 100-berry samples.

Statistical analysis

The SAS statistical package was used for statistical analysis of data. Results were subjected

to a 3-way analysis of variance (shoot tipping x lateral length x leaf removal). Waller Duncan k-ratio test was used to compare means. Interactions between factors were rare, and the contribution of the interactions to the total variance was very small relative to the main effects. For this reason, we chose to present only the means of the main effects. For completeness, all significant interactions found are also reported on the tables.

RESULTS AND DISCUSSION

Yield and yield components

There was no effect of shoot tipping, lateral shoot length, or leaf removal on total yield per vine (Table 1). Percent fruit set, however, was higher for vines hedged at bloom. Shoot tips compete with the developing inflorescences for assimilates. During bloom, the leaves in the mid and upper shoot section export carbohydrates to the shoot tip. After hedging, the direction of translocation is reversed: instead of moving upwards to the shoot tip assimilates are diverted basipetally, made available to the developing inflorescences, resulting in improved fruit set. Fruit set was also favored by lateral shoot removal. During early stages of development, lateral shoots depend on assimilates provided by the main shoot for growth, competing with other vegetative and reproductive sinks. As soon as they have fully expanded leaves, laterals support their own growth and export the surplus of assimilates to the main shoot. 'ne cluster zone leaf removal treatment was performed four weeks after full bloom, after the critical period for fi-uit set (until three weeks after full bloom) and therefore, no measurable effect on fruit set was observed. As a result of these fruit set differences, final number of berries per cluster and cluster weight were also increased by shoot tip removal. There was no treatment effect on berry weight or volume.

Table 1: Effect of canopy management practices on yield and yield components of Pinot noir grapevines.

	Tipping			Significant Interactions
	No	Yes	F	Tipping x Lateral Length
Yield (kg/vine)	2.74	2.98	ns[1]	ns
Percent fruit set	36	48	***	**
Yield per shoot	136	152	ns	ns
Number of clusters per vine	32	30	ns	ns
Number of shoots per vine	20	20	ns	ns
Cluster weight (g)	87.1	98.9	*	ns
Berry weight (g)	1.3	1.26	ns	ns
Berry volume (cm^3)	0.89	0.79	ns	ns
Number of berries per cluster	68	80	**	ns

	Lateral Length				Significant Interactions
	Absent	Short	Long	F	Tipping x Lateral Length
Yield (kg/vine)	2.91	3.04	2.64	ns	ns
Percent fruit set	49	38	39	***	**
Yield per shoot	147	154	131	ns	ns
Number of clusters per vine	31	32	30	ns	ns
Number of shoots per vine	20	20	20	ns	ns
Cluster weight (g)	95.7	96.6	86.6	ns	ns
Berry weight (g)	1.28	1.27	1.29	ns	ns
Berry volume (cm^3)	0.84	0.88	0.81	ns	ns
Number of berries per cluster	76	77	69	ns	ns

	Leaf Removal		
	No	Yes	F
Yield (kg/vine)	2.97	2.75	ns
Percent fruit set	42	42	ns
Yield per shoot	147	141	ns
Number of clusters per vine	31	31	ns
Number of shoots per vine	20	20	ns
Cluster weight (g)	95.8	90.1	ns
Berry weight (g)	1.27	1.29	ns
Berry volume (cm^3)	0.86	0.82	ns
Number of berries per cluster	77	70	ns

[1]ns,*, ** and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.

Fruit composition and soundness

Must soluble solids, pH, and skin anthocyanin content were reduced by shoot tipping (Table 2). Brix and pH increased with lateral shoot length. Unhedged vines and vines with lateral shoots had a higher proportion of young leaves in the canopy. Leaves start exporting assimilates when they reach 50% of the final size. It has been shown that the presence of fully expanded young leaves is advantageous for sugar accumulation in the fruit. Cluster zone leaf removal decreased must soluble solids but did not decrease percentage of mildewed fruit. There were no significant differences in titratable acidity among treatments. Berries with thicker skin are typically less susceptible to Botrytis infection. Berry skin thickness did not respond to canopy management treatments in this experiment. Total sugar produced per vine was not influenced by any of the treatments.

Table 2: Effect of canopy management practices on fruit composition and soundness of Pinot noir

grapevines.

	Tipping			Significant
	No	Yes	F	Interactions
Soluble solids (°Brix)	23.1	22.5	***1	ns
pH	3.30	3.25	*	ns
Titratable acidity	6.92	7.23	ns	ns
Anthocyanins (mg/g)	0.646	0.610	*	ns
Anthocyanins (mg/berry)	0.827	0.763	ns	ns
Berry skin thickness (µm)	190.4	183.9	ns	ns
Percent diseased fruit (weight)	6.6	9.4	ns	ns
Sugar per vine (g)	627	673	ns	ns

	Lateral Length				Significant
	Absent	Short	Long	F	Interactions
Soluble solids (°Brix)	22.4	22.7	23.2	***	ns
pH	3.23	3.28	3.31	*	ns
Titratable acidity	7.32	6.89	7.01	ns	ns
Anthocyanins (mg/g)	0.626	0.614	0.646	ns	ns
Anthocyanins (mg/berry)	0.79	0.776	0.82	ns	ns
Berry skin thickness (µm)	190.3	187.5	183.8	ns	ns
Percent diseased fruit (weight)	5.7	7.6	10.6	ns	ns
Sugar per vine (g)	655	695	600	ns	ns

	Leaf Removal		
	No	Yes	F
Soluble solids (°Brix)	22.9	22.6	*
pH	3.27	3.27	ns
Titratable acidity	7.20	6.95	ns
Anthocyanins (mg/g)	0.641	0.615	ns
Anthocyanins (mg/berry)	0.803	0.788	ns
Berry skin thickness (μm)	187.8	186.5	ns
Percent diseased fruit (weight)	7.5	8.5	ns
Sugar per vine (g)	680	620	ns

[1]ns,*, ** and *** indicate not significant, and statistically significant at the 0.05, 0.01, and 0.001 levels of probability, respectively.