

Effects of canopy architecture and microclimate on grapevine health in two training systems

C. KRAUS^{1),4)}, T. PENNINGTON^{1),2)}, K. HERZOG³⁾, A. HECHT³⁾, M. FISCHER¹⁾, R. T. VOEGELE⁴⁾, C. HOFFMANN¹⁾, R. TÖPFER³⁾ and A. KICHERER³⁾

¹⁾ Julius Kühn-Institute, Federal Research Centre of Cultivated Plants, Plant Protection in Fruit Crops and Viticulture, Siebeldingen, Germany

²⁾ University of Koblenz-Landau, Institute for Environmental Sciences, Landau, Germany

³⁾ Julius Kühn-Institute, Federal Research Centre of Cultivated Plants, Institute for Grapevine Breeding Geilweilerhof, Siebeldingen, Germany

⁴⁾ University of Hohenheim, Department of Phytopathology, Hohenheim, Germany

Table S1

Canopy architecture characteristics of the two grapevine varieties 'Chardonnay' and 'Reberger' as a function of training system, 2016 (a) and 2017 (b). Additionally, a comparison of the different trellis zones is shown. T test; **P* < 0.05, ***P* < 0.001

a)

2016	Chardonnay				Reberger		
	Zone	BBCH	SMPH	VSP	SMPH	VSP	
Number of shoots [per 0.5 m]	1	10	2.6 ± 2.0	2.4 ± 1.3	3.1 ± 3.9	3.3 ± 1.3	
	2	10	5.8 ± 1.9	5.1 ± 1.7	5.1 ± 3.8	3.3 ± 0.5	
	3	10	20.0 ± 1.5	0.8 ± 0.3	9.1 ± 4.5	0.0 ± 0.0	
	4	10	13.6 ± 4.3	0.0 ± 0.0	10.5 ± 4.4	0.0 ± 0.0	
	5	10	26.3 ± 5.5	0.0 ± 0.0	16.5 ± 2.0	0.0 ± 0.0	
	Average total	10	68.3 ± 9.6	8.3 ± 1.3	**	44.4 ± 6.9	6.5 ± 1.8
Number of inflorescences/ bunches [per 0.5 m]	1	65	0.0 ± 0.0	0.0 ± 0.0	2.0 ± 1.6	0.3 ± 0.5	
	2	65	3.0 ± 0.8	3.5 ± 0.6	4.3 ± 3.6	8.8 ± 2.9	
	3	65	7.0 ± 3.4	5.3 ± 1.3	2.3 ± 2.9	0.3 ± 0.5	
	4	65	11.5 ± 9.5	0.3 ± 0.5	5.8 ± 6.3	0.0 ± 0.0	
	5	65	18.5 ± 9.7	0.0 ± 0.0	15.8 ± 8.1	0.0 ± 0.0	
	Average total	65	40.0 ± 5.9	9.0 ± 0.8	**	30.0 ± 7.9	9.3 ± 3.1
LAI	1	75	1.5 ± 1.3	0.0 ± 0.0	0.5 ± 1.0	1.3 ± 1.5	
	2	75	1.0 ± 1.4	3.8 ± 1.5	7.8 ± 4.2	6.5 ± 2.4	
	3	75	5.3 ± 4.2	5.5 ± 2.6	4.0 ± 2.2	0.0 ± 0.0	
	4	75	7.3 ± 4.2	0.3 ± 0.5	5.5 ± 3.0	0.0 ± 0.0	
	5	75	4.0 ± 2.4	0.0 ± 0.0	7.3 ± 4.9	0.0 ± 0.0	
	Average total	75	19.0 ± 7.7	9.5 ± 3.7	n.s.	25.0 ± 11.5	7.8 ± 3.1
Average leaf size [cm ²]	1	81	0.3 ± 0.5	0.3 ± 0.5	1.0 ± 0.8	1.5 ± 2.4	
	2	81	1.8 ± 1.0	2.0 ± 1.4	2.5 ± 1.9	8.0 ± 3.7	
	3	81	5.8 ± 3.5	5.3 ± 2.8	1.3 ± 1.0	0.0 ± 0.0	
	4	81	2.8 ± 1.0	0.0 ± 0.0	3.0 ± 2.2	0.0 ± 0.0	
	5	81	1.0 ± 1.4	0.0 ± 0.0	2.5 ± 1.3	0.0 ± 0.0	
	Average total	81	11.5 ± 2.4	7.5 ± 3.7	n.s.	10.3 ± 3.8	9.5 ± 5.8
Canopy volume [m ³]	65	47046.0 ± 6770.8	9945.5 ± 1122.6	**	25884.4 ± 10246.0	12094.6 ± 728.5	n.s.
	75	28041.6 ± 2350.2	17234.5 ± 3139.9	*	26322.2 ± 4797.8	18604.0 ± 3796.0	n.s.
	81	31120.9 ± 2787.9	17986.3 ± 3139.9	**	31812.4 ± 4608.5	19209.8 ± 5902.6	*
Bunch weight [g]	89	96.5 ± 37.3	152.3 ± 40.0	*	126.7 ± 27.1	182.6 ± 69.0	*
Bunch length [cm]	89	11.2 ± 2.0	12.9 ± 1.1	*	11.3 ± 2.5	13.3 ± 3.3	n.s.
Bunch width [cm]	89	6.9 ± 1.3	8.7 ± 1.8	*	8.7 ± 1.9	9.6 ± 1.1	n.s.
Berry number per bunch	89	78.1 ± 26.9	110.1 ± 27.5	*	71.3 ± 17.1	85.6 ± 24.1	n.s.
Ø berry size [mm]	89	12.0 ± 1.0	12.4 ± 1.0	*	14.2 ± 1.2	14.2 ± 1.3	n.s.

Tab. S1, continued

b)		Chardonnay			Reberger			
2017	Zone	BBCH	SMPH	VSP	SMPH	VSP		
Number of shoots [per 0.5 m]	1	10	5.8 ± 2.5	1.0 ± 0.8	7.3 ± 3.8	5.8 ± 0.5		
	2	10	16.0 ± 6.1	8.0 ± 1.4	14.8 ± 5.1	3.3 ± 1.0		
	3	10	40.3 ± 7.4	1.0 ± 1.2	16.5 ± 5.2	0.0 ± 0.0		
	4	10	49.3 ± 4.6	0.0 ± 0.0	26.8 ± 18.9	0.0 ± 0.0		
	5	10	38.5 ± 16.1	0.0 ± 0.0	35.3 ± 21.4	0.0 ± 0.0		
	Average total	10	150.0 ± 14.4	10.0 ± 1.2	**	101.0 ± 11.3	9.0 ± 0.8	**
2017	Zone	BBCH	SMPH	VSP	SMPH	VSP		
Number of inflorescences/ bunches [per 0.5 m]	1	65	0.0 ± 0.0	0.0 ± 0.0	3.3 ± 3.3	0.5 ± 0.6		
	2	65	1.5 ± 1.3	3.3 ± 1.5	12.0 ± 6.7	7.0 ± 2.2		
	3	65	2.8 ± 1.3	6.5 ± 1.9	6.0 ± 5.4	0.0 ± 0.0		
	4	65	6.5 ± 3.8	0.0 ± 0.0	7.0 ± 0.8	0.0 ± 0.0		
	5	65	7.8 ± 5.0	0.0 ± 0.0	23.3 ± 9.7	0.0 ± 0.0		
	Average total	65	18.5 ± 6.5	9.8 ± 2.2	n.s.	52.0 ± 15.4	8.0 ± 2.1	*
Number of inflorescences/ bunches [per 0.5 m]	1	75	1.0 ± 2.0	0.0 ± 0.0	0.3 ± 0.5	1.8 ± 1.5		
	2	75	1.3 ± 1.0	6.3 ± 1.7	3.8 ± 3.3	6.0 ± 1.6		
	3	75	5.5 ± 2.4	2.8 ± 2.2	3.8 ± 2.6	0.0 ± 0.0		
	4	75	7.0 ± 5.7	0.0 ± 0.0	4.8 ± 3.8	0.0 ± 0.0		
	5	75	4.3 ± 2.9	0.0 ± 0.0	5.5 ± 1.0	0.0 ± 0.0		
	Average total	75	19.0 ± 7.5	9.0 ± 0.8	*	18.0 ± 8.0	7.8 ± 3.0	n.s.
LAI	1	81	0.5 ± 0.6	0.3 ± 0.5	1.8 ± 1.5	1.8 ± 1.7		
	2	81	0.5 ± 1.0	3.3 ± 0.5	7.5 ± 0.6	5.3 ± 2.6		
	3	81	2.0 ± 2.2	6.3 ± 2.6	2.0 ± 0.8	0.0 ± 0.0		
	4	81	4.5 ± 3.1	0.0 ± 0.0	10.5 ± 4.7	0.0 ± 0.0		
	5	81	4.8 ± 2.2	0.0 ± 0.0	5.8 ± 3.5	0.0 ± 0.0		
	Average total	81	12.3 ± 4.5	9.8 ± 2.2	n.s.	27.5 ± 6.4	7.0 ± 1.6	n.s.
Average leaf size [cm ²]	65		3.5 ± 0.4	1.1 ± 0.3	**	3.7 ± 0.3	0.8 ± 0.1	**
	75		3.0 ± 0.3	2.6 ± 0.5	n.s.	2.6 ± 0.5	1.5 ± 0.5	*
	81		3.5 ± 0.7	2.1 ± 0.4	*	4.0 ± 0.6	2.1 ± 0.2	*
Canopy volume [m ³]	65	35039.0 ± 4414.3	10726.4 ± 2860.0	**	36713.1 ± 3465.7	8288.9 ± 1196.5	**	
	75	30205.5 ± 3148.3	25861.5 ± 4969.6	n.s.	26167.3 ± 5174.9	15326.1 ± 5108.7	*	
	81	34957.6 ± 6964.7	20611.1 ± 4041.3	*	40488.8 ± 6456.3	20934.6 ± 1851.5	*	
Bunch weight [g]	89	76.2 ± 34.8	163.7 ± 33.0	**	101.4 ± 35.7	257.7 ± 83.5	**	
Bunch length [cm]	89	8.7 ± 2.6	12.0 ± 1.4	*	10.9 ± 2.3	14.7 ± 2.2	*	
Bunch width [cm]	89	6.9 ± 1.7	8.9 ± 1.6	*	6.9 ± 1.7	8.9 ± 1.6	*	
Berry number per bunch	89	57.8 ± 23.7	125.1 ± 26.8	**	56.0 ± 20.5	134.1 ± 45.5	**	
Ø berry size [mm]	89	12.2 ± 1.0	13.2 ± 1.3	**	12.8 ± 2.0	15.3 ± 1.7	**	

Table S2

Skin characteristics from SMPH and VSP trained grapevine berries obtained from the I-Sensor (n = 30 berries), TA.XT Texture (n = 50 berries) and microscopy analysis (n = 20 berries), 2016 (a) and 2017 (b). T test; * $P < 0.05$, ** $P < 0.001$

a)	2016	SMPH	VSP	
	relative impedance Z_{rel}	810.1 ± 130.2	823.9 ± 122.5	n.s.
	maximum break force [N]	0.9 ± 0.2	0.9 ± 0.2	n.s.
	skin break energy [mJ]	0.5 ± 0.1	0.53 ± 0.1	n.s.
	skin thickness [μm]	90.1 ± 11.6	85.6 ± 11.5	n.s.
b)	2017	SMPH	VSP	
	relative impedance Z_{rel}	642.6 ± 92.1	626.7 ± 97.7	n.s.
	maximum break force [N]	0.8 ± 0.2	0.8 ± 0.2	n.s.
	skin break energy [mJ]	0.5 ± 0.3	0.5 ± 0.2	n.s.
	Skin thickness [μm]	85.0 ± 4.2	87.1 ± 4.2	n.s.

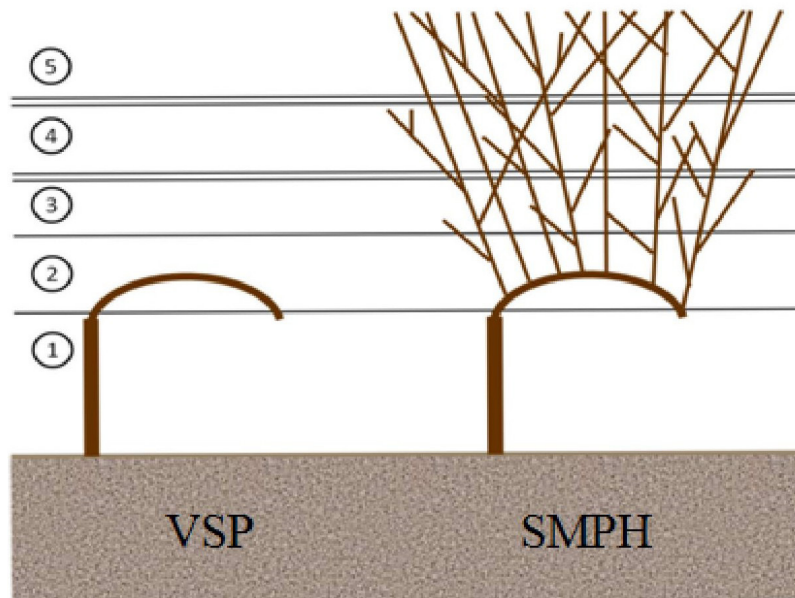


Figure S1: Schematic illustration of the pruning systems VSP (left) and SMPH (right) during dormancy (BBCH 00). Numbers indicate horizontal zones in the trellis, which were used to study canopy architecture.