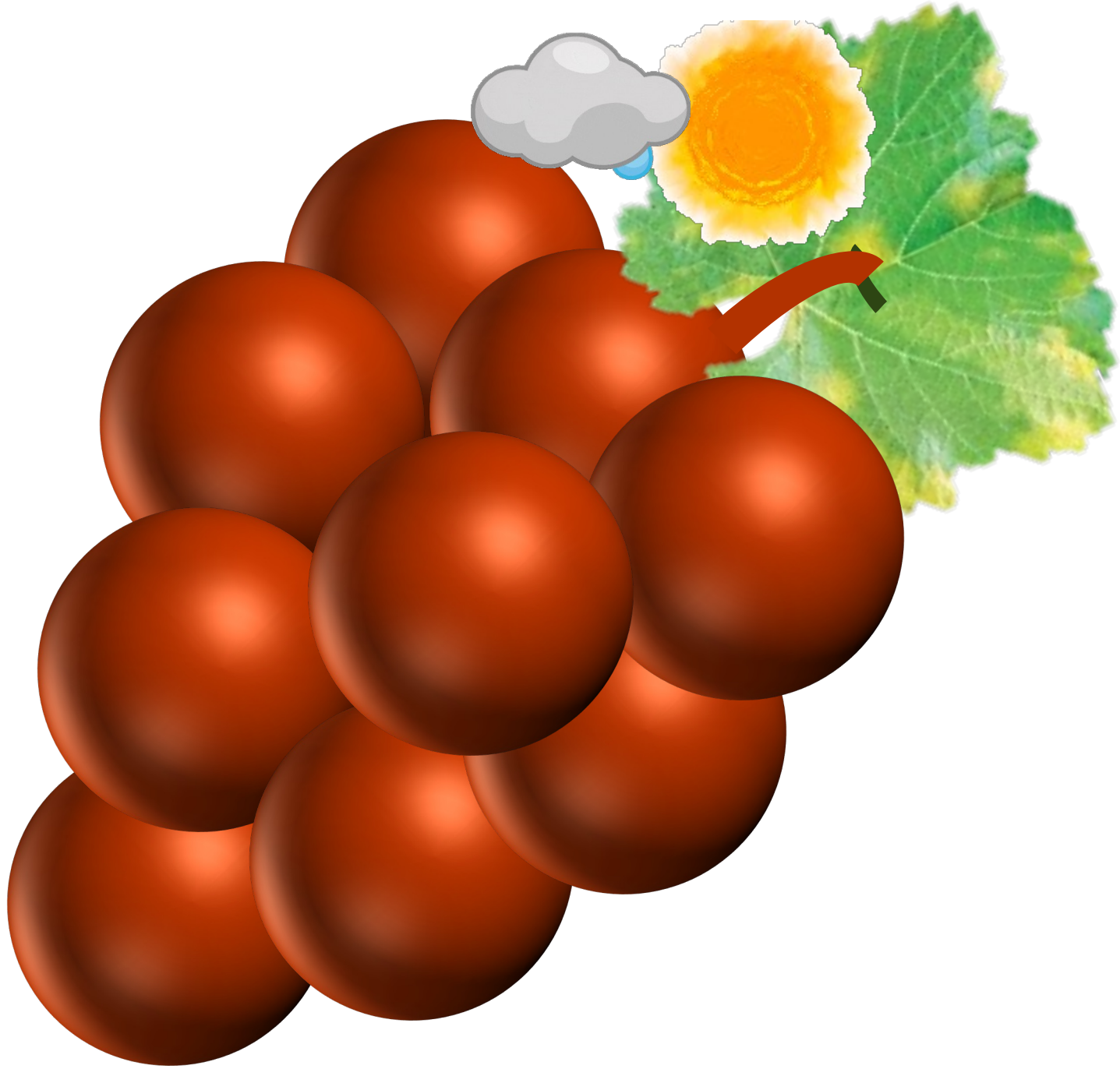
Relationship between physiological indicators and leaf and bunch variables of Crimson Seedless grown with reduced water supply and altered micro-climatic conditions

J. STRYDOM[1*], C.G. VOLSCHENK[1], M. VAN DER RIJST[2], L. DE PALMA[3], V. NOVELLO[4], R. Di LORENZO[5], A. PISCIOTTA[5], J.J. HUNTER[1]

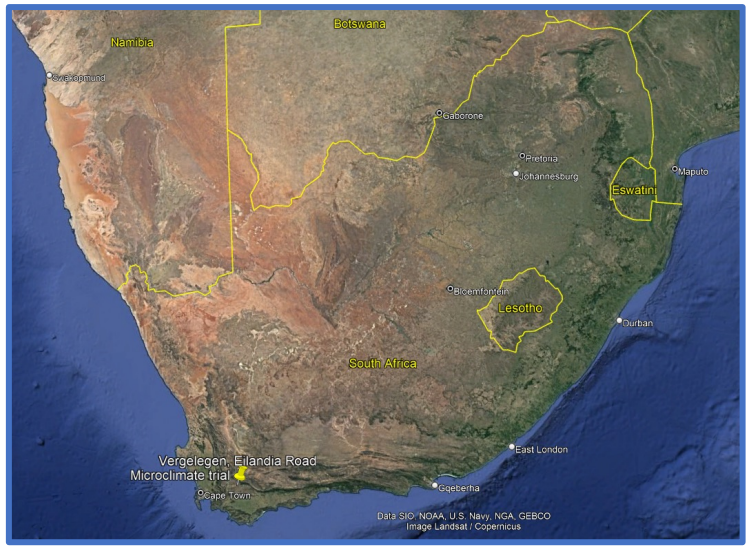
[1]Plant Protection and Viticulture Division, ARC Infruitec-Nietvoorbij, South Africa; [2]Biometry, ARC Infruitec-Nietvoorbij, South Africa; [3]Department of the Science of Agriculture, Food and Environment, University of Foggia, Italy; [4]Department of Agricultural, Forest and Food Sciences (DiSAFA), University of Turin, Italy; [5]Department of Agricultural and Forest Sciences, Palermo, Italy

Aims and objectives

- Challenging conditions
- Require understanding of physiological status
- Aimed to determine the impact of water treatments and altered microclimate
- Recommend a growth balance strategy for table grapes under conditions of reduced water supply and altered microclimate



Materials and Methods



- Crimson seedless / Ramsey
- Stony loam-sand
- Sprinklers 32 L/h
- 1.75m x 3m spacing
- Pergola

Open Field (OF) and Overhead Plastic Covering (OPC)	
Water Treatment (amount measured)	**Ripeness level (°Brix)**
W100 (Commercial practice) **W080** **W070** **W055**	R1 = +-14.4 R2 = 16 °Brix (DAFF* recommended) R3 = 17.6

*Department of Agriculture Forestry and Fisheries (DAFF, 1990)

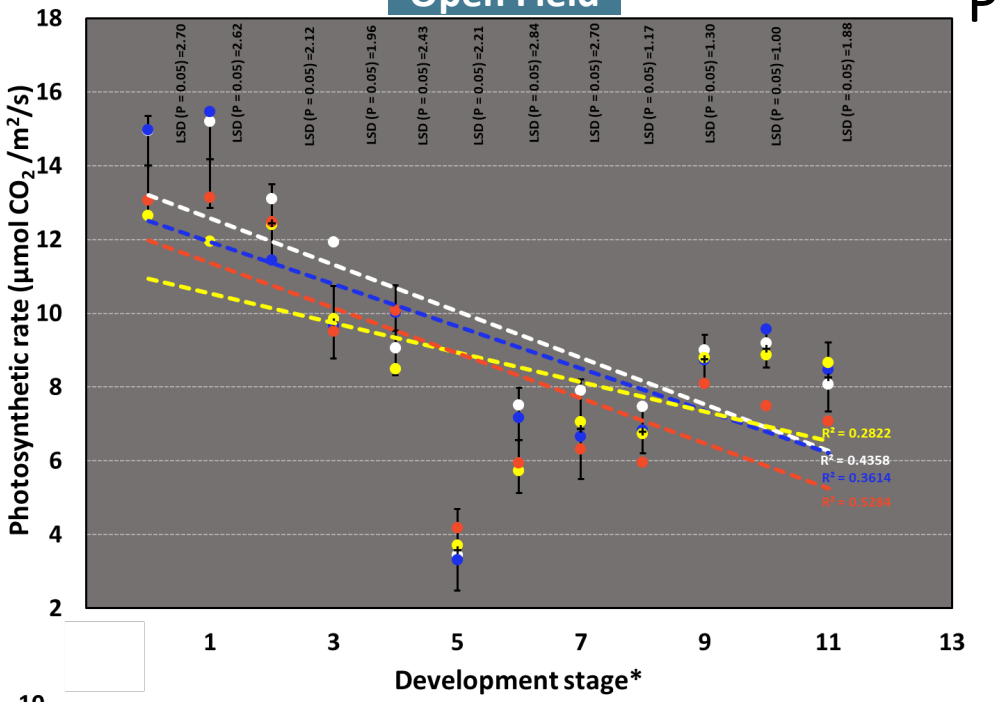
Irrigation scheduling: ET_0 & crop factor (Commercial practice)

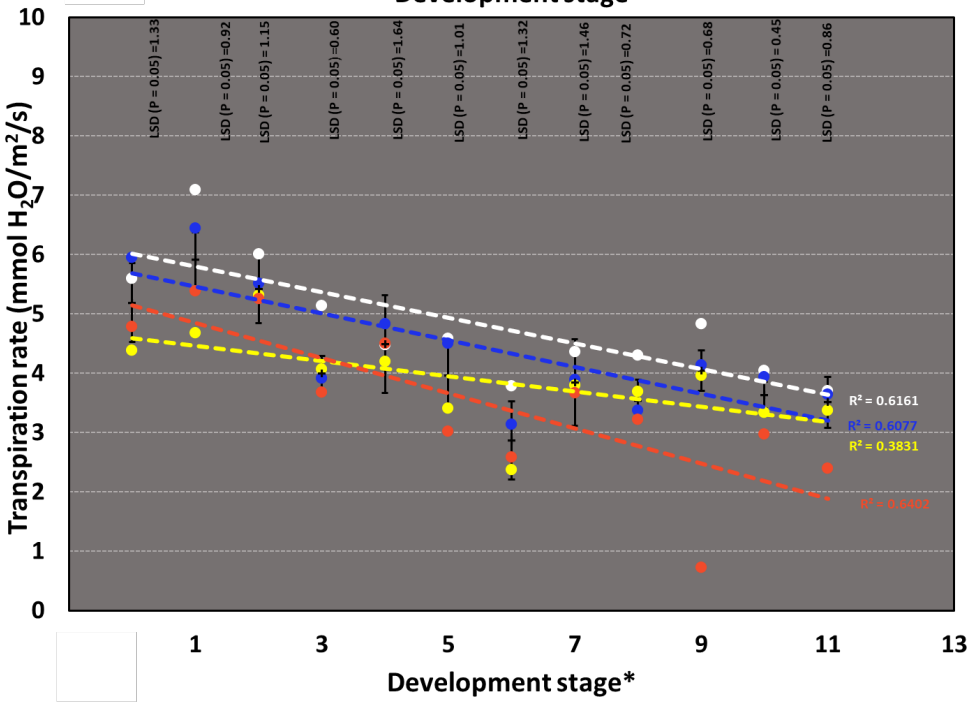
Materials and Methods

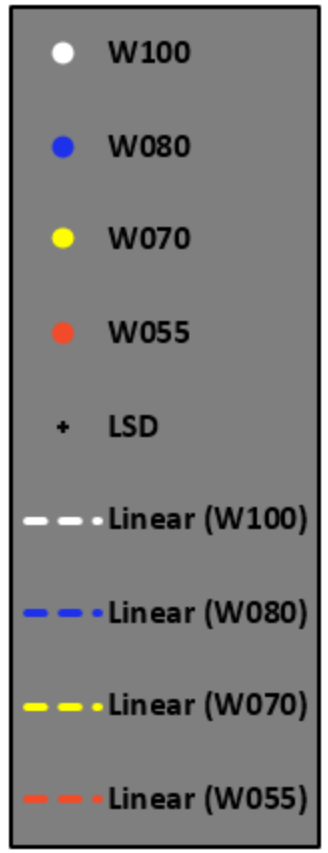
- 21/22 and 22/23 seasons
- Stem water potential (Scholander *et al*., 1965)
- Photosynthetic & Transpiration rate for growth and ripening (LI-6400 portable photosynthesis meter)
- Light intensity (LI-COR Model LI-250 Line Quantum Sensor)
- Bunch and vegetative data for three ripeness levels (harvest dates)
- Berry sugar (refractometer)
- Berry colour (Konica Minolta Chromameter): Colour index (180-h/L+C)
- Micro-climatic variables RH, Temp (Campbell Scientific CR1000 measurement and control systems)
- Statistical analyses: SAS software (Version 9.4; SAS Institute Inc, Cary, USA)
- Multi factor analyses
- Pearson correlation

Physiological variables

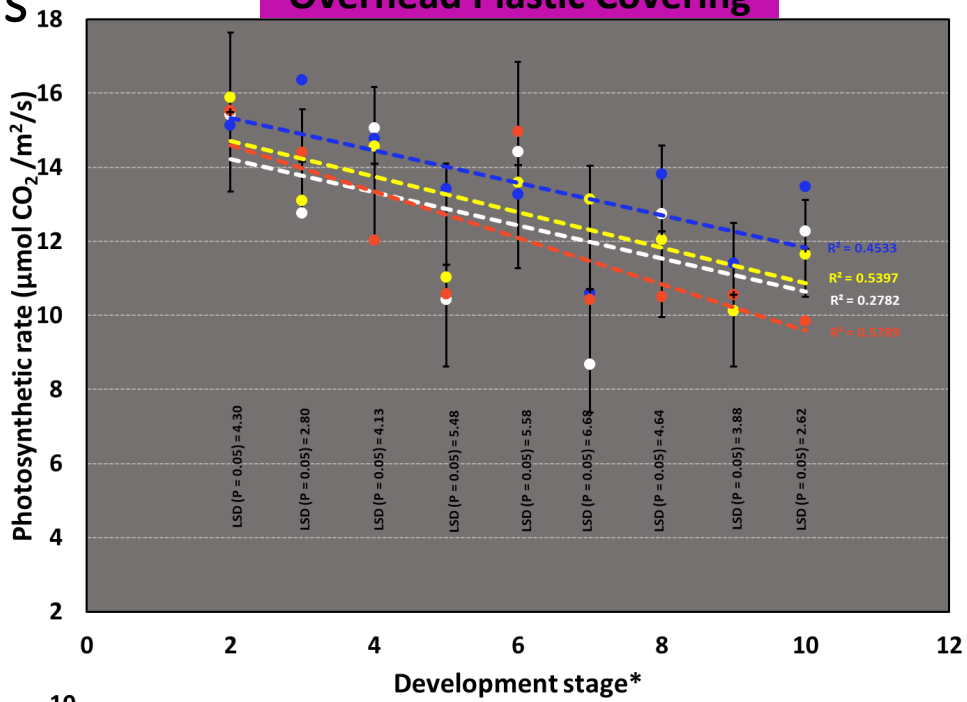
Open Field

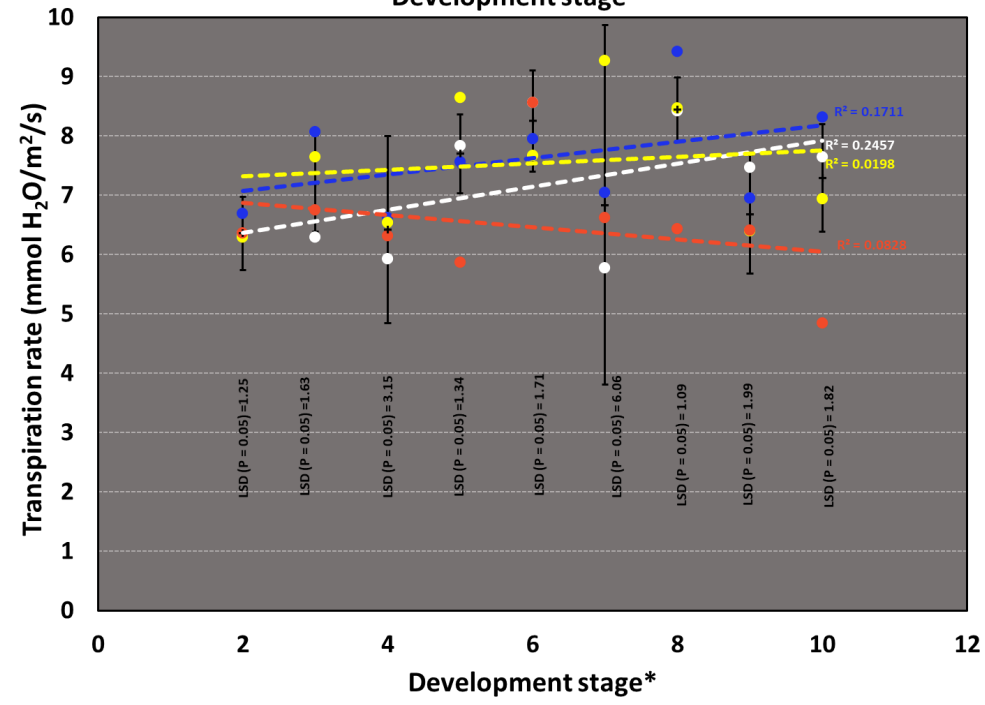






Overhead Plastic Covering

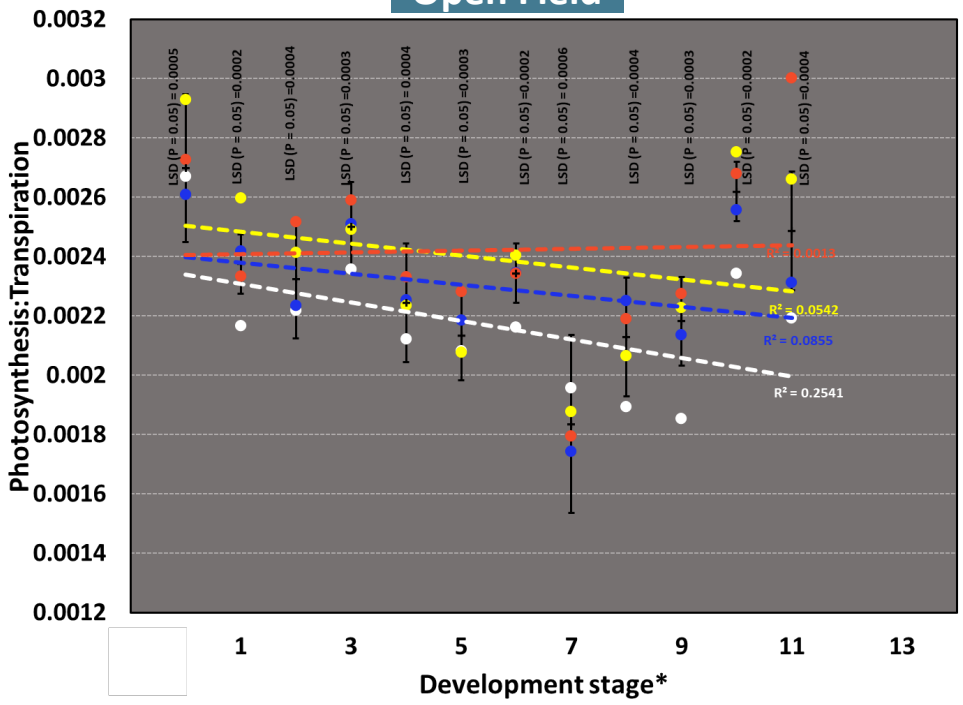


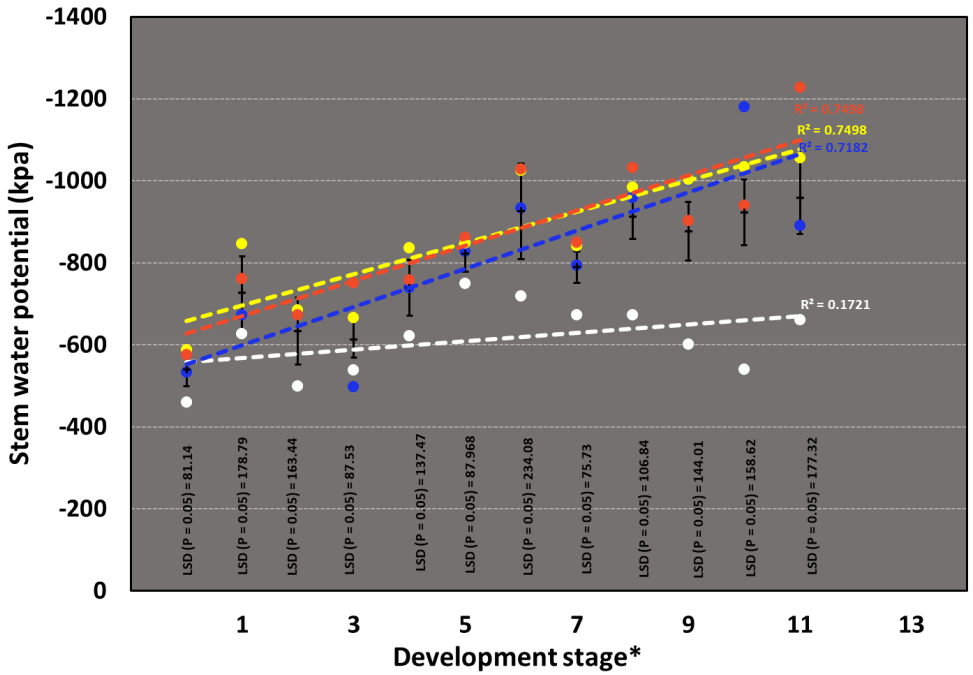


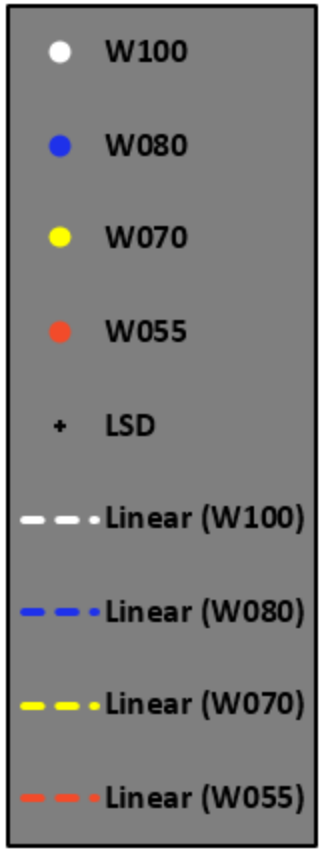
*0-6 = growth phase (0-62 DAFB);
7-11 = ripening (76-112 DAFB)

Physiological variables

Open Field







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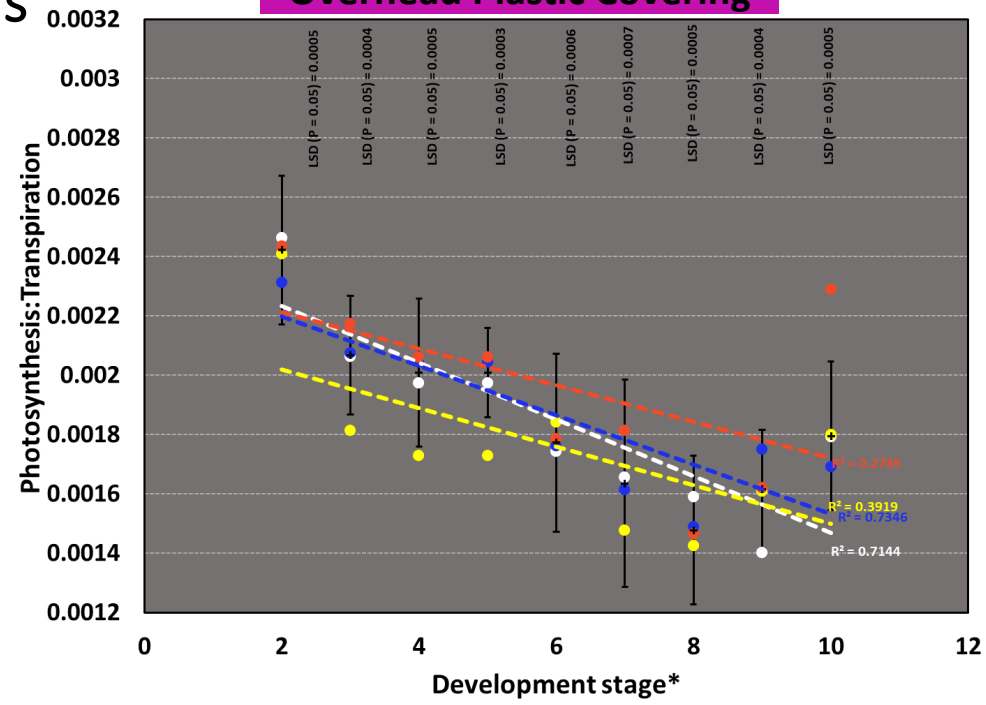
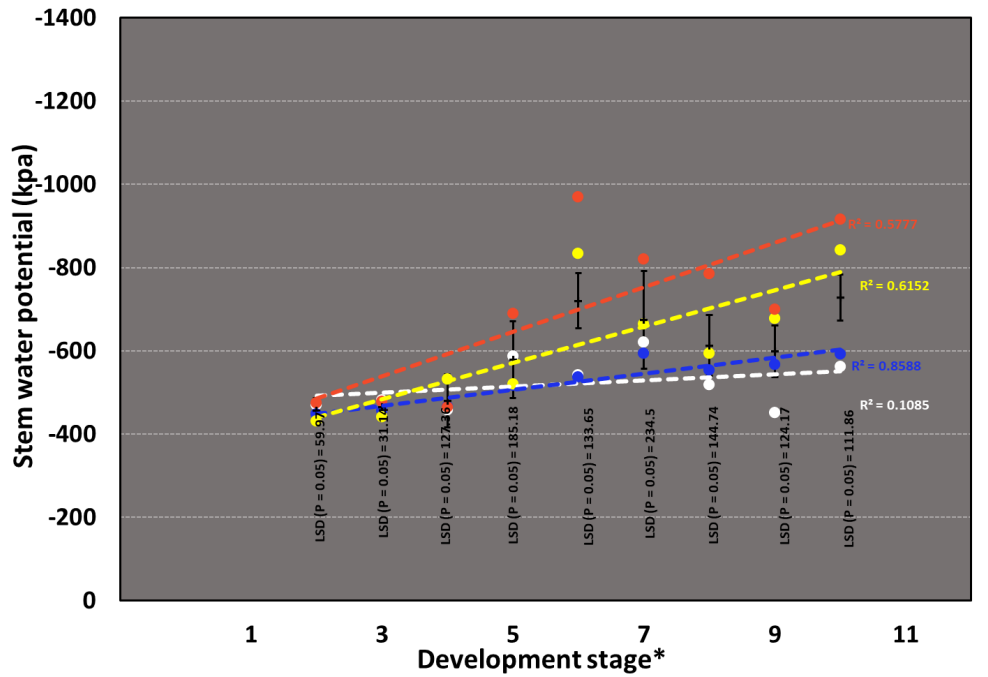
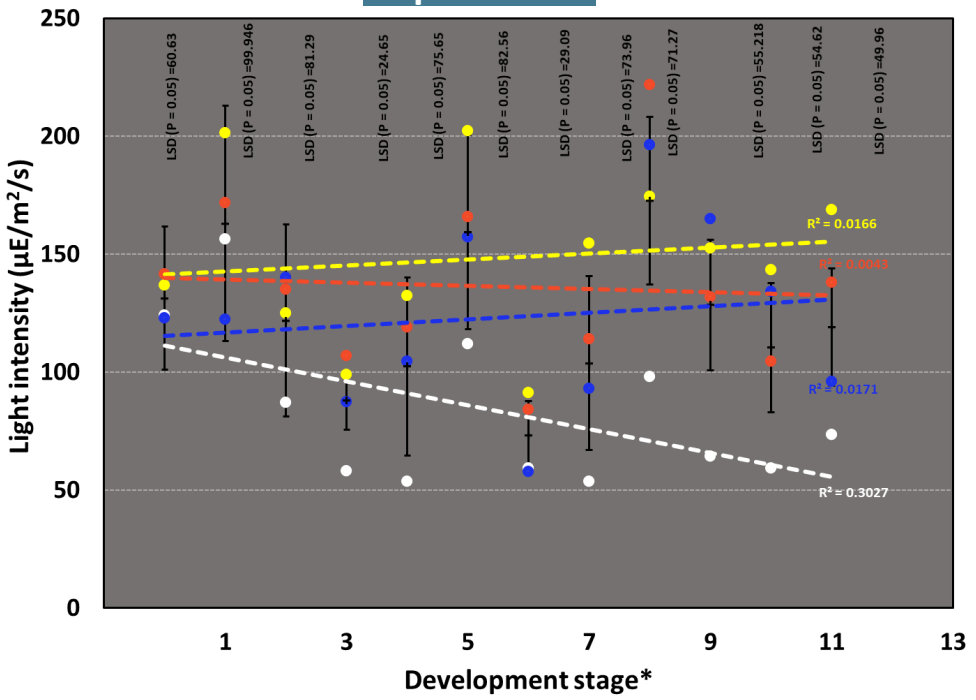
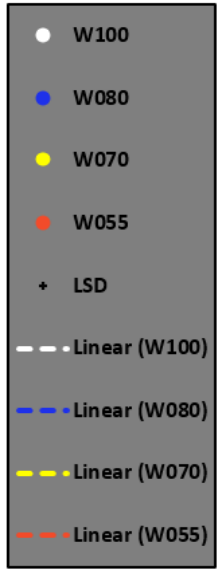




Climate variables

Open Field





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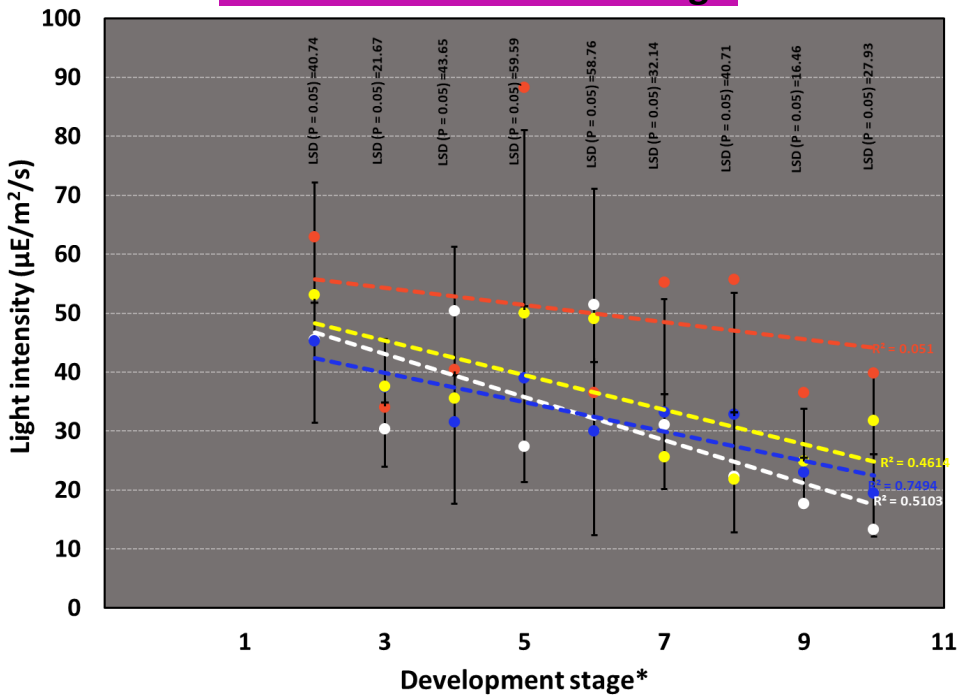
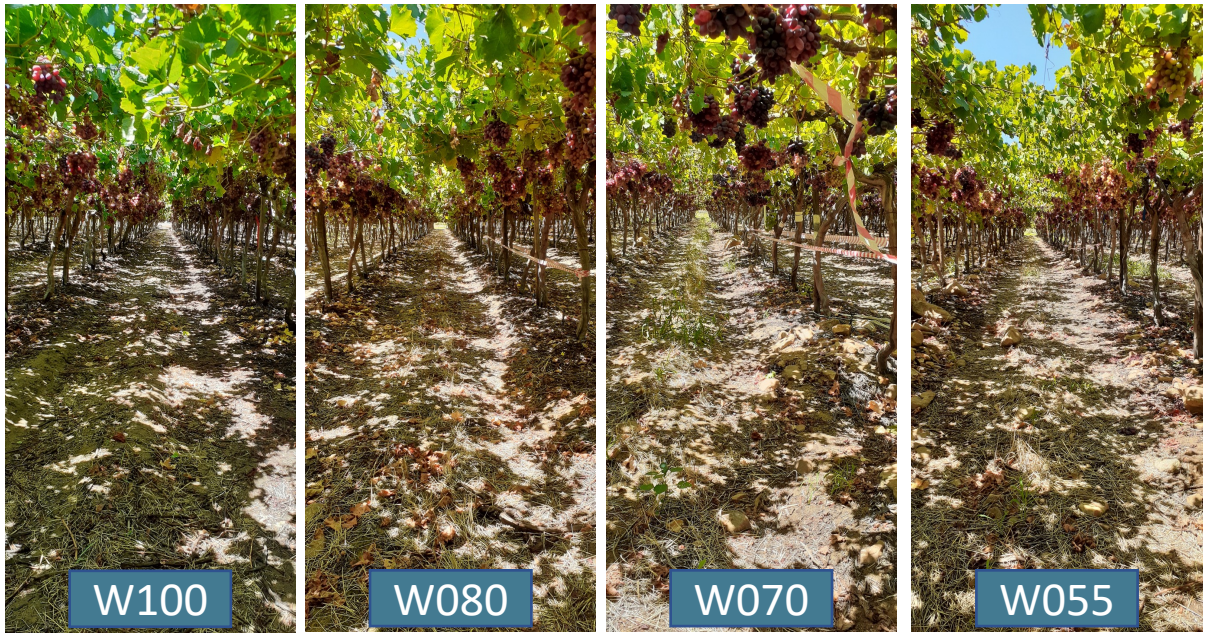




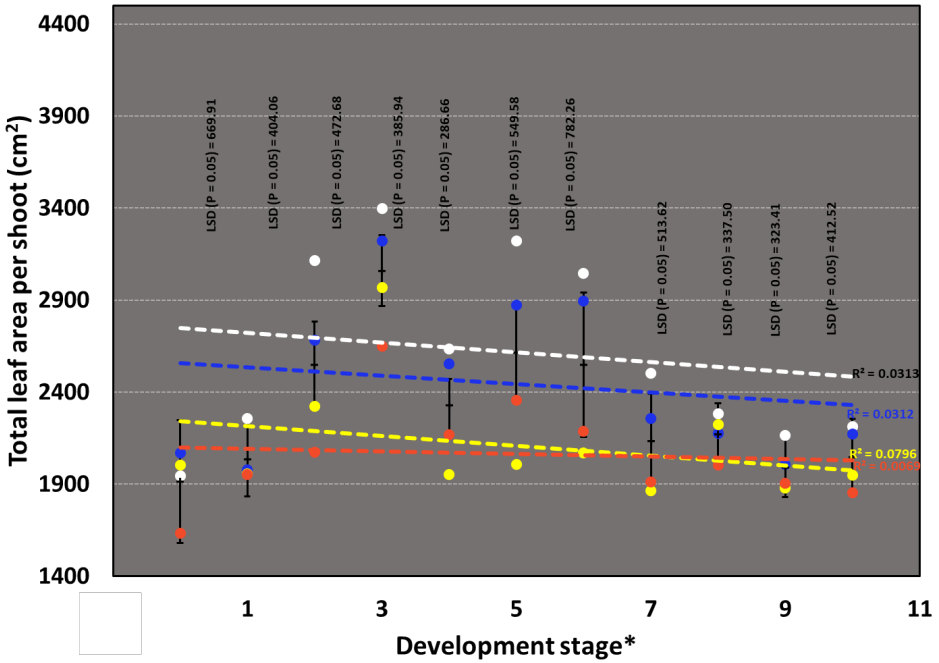
Climate variables

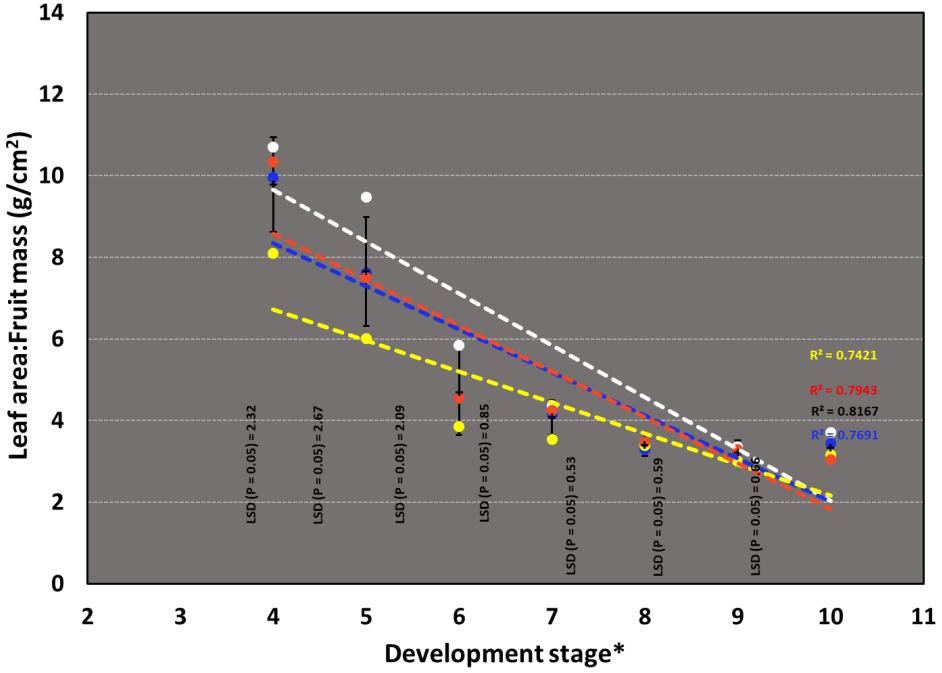
Date	Jan 2022					Feb 2022				
*Climatic variables	Macro	Meso	Water Trtm	Micro OF	Micro OPC	Macro	Meso	Water Trtm	Micro OF	Micro OPC
T_Ave	25.92	25.71	W100	24.57	24.44	25.24	24.95	W100	23.84	24.1
			W080	24.37	22.93			W080	23.66	22.8
			W070	24.48	23.08			W070	23.74	22.94
			W055	24.72	23.2			W055	23.93	22.96
RH_Ave	56.16	63.19	W100	57.59	60.78	56.03	62.93	W100	58.52	62.99
			W080	62.64	65.92			W080	63.39	67.49
			W070	55.82	66.02			W070	57.02	67.14
			W055	60	61.84			W055	61.07	64.3

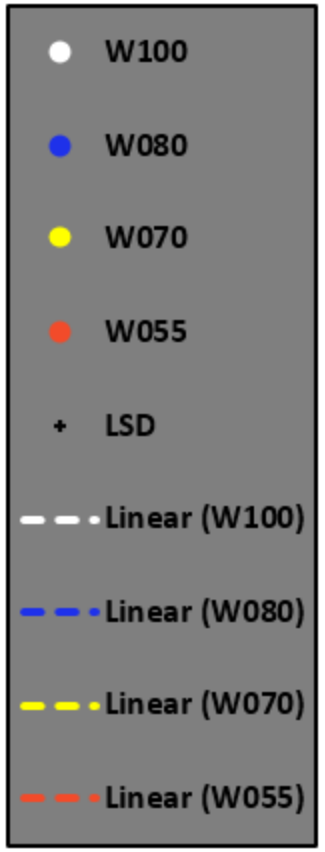
*Macroclimate = climatic conditions in the region, Mesoclimate = climatic conditions around the vineyard / on the farm, Microclimate = climatic conditions in the grapevine canopy and bunch zone

Growth variables

Open Field







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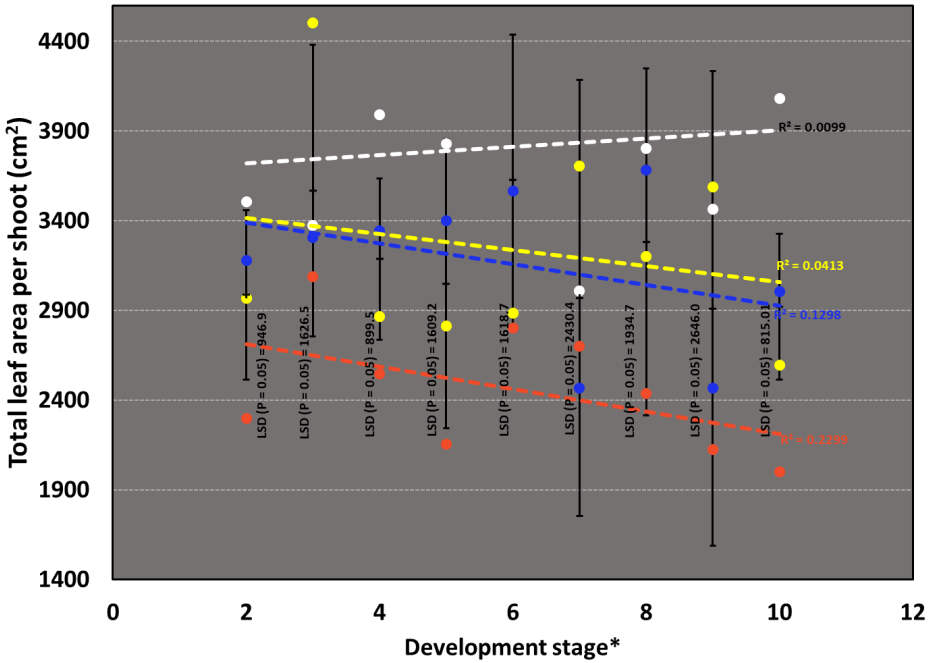
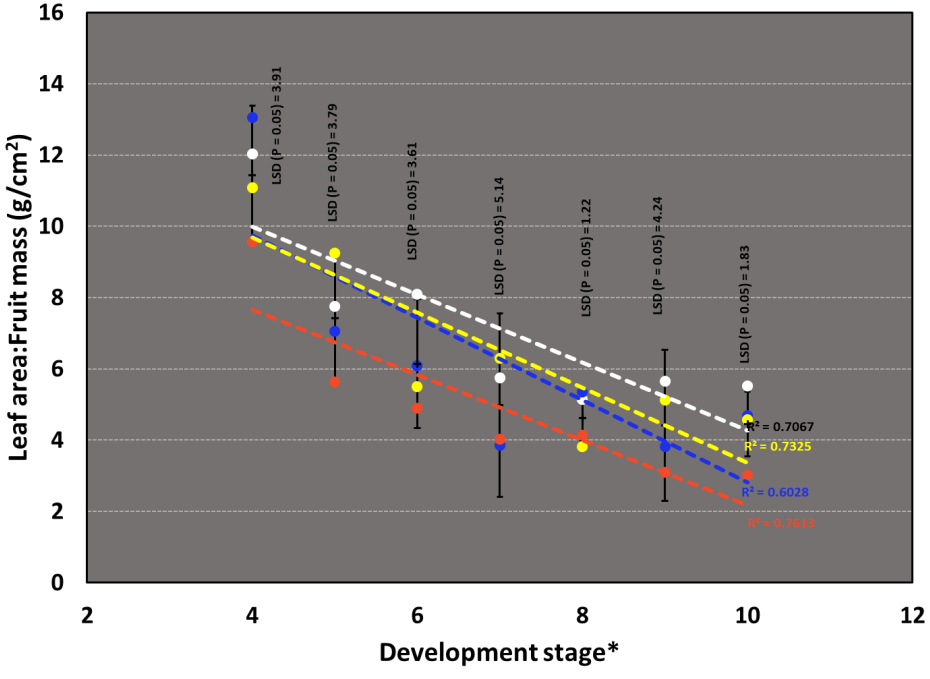
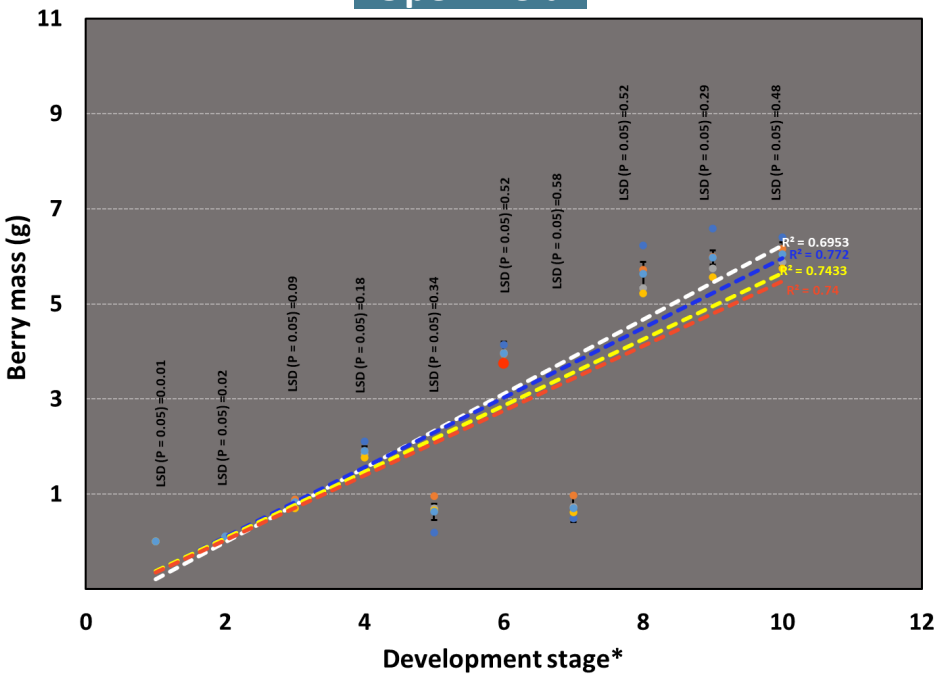
Overhead Plastic Covering

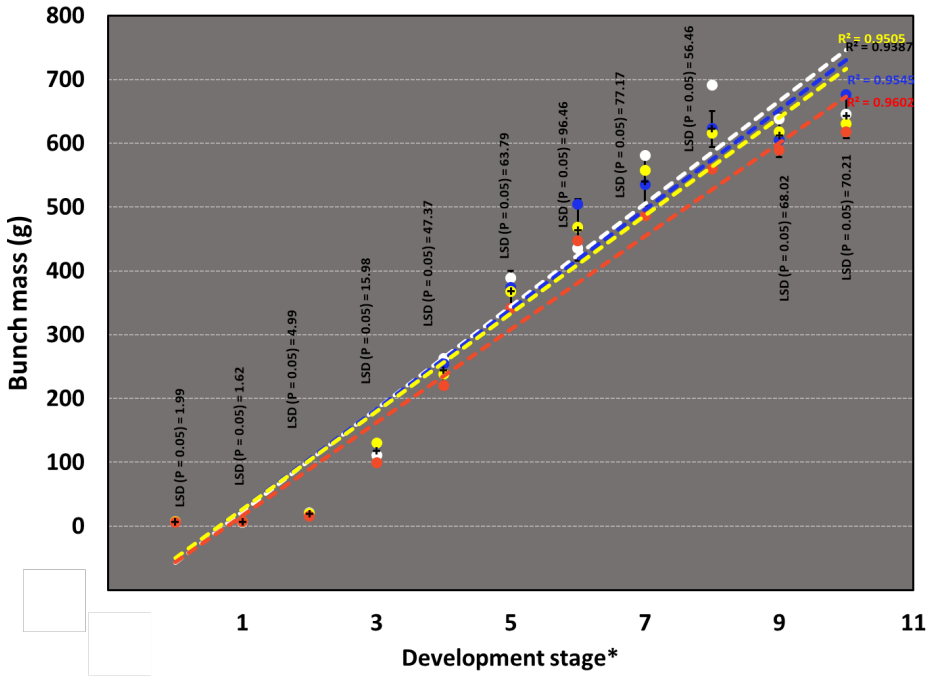


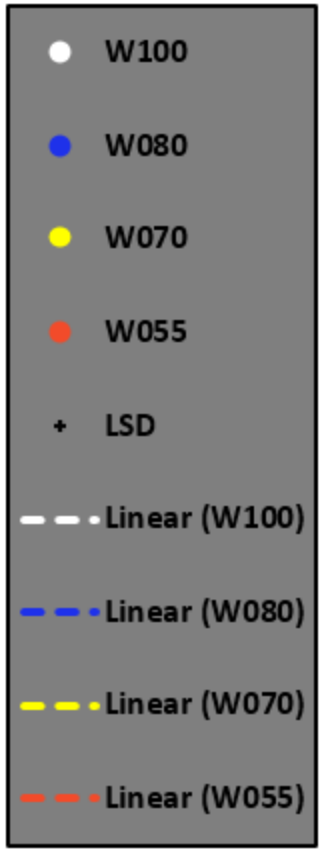


Growth variables

Open Field







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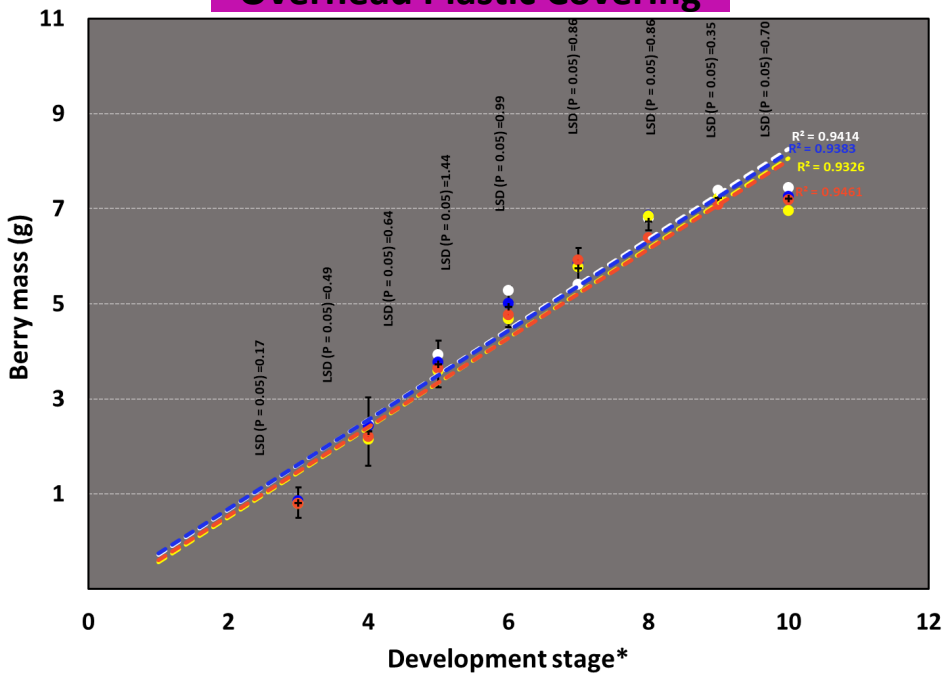
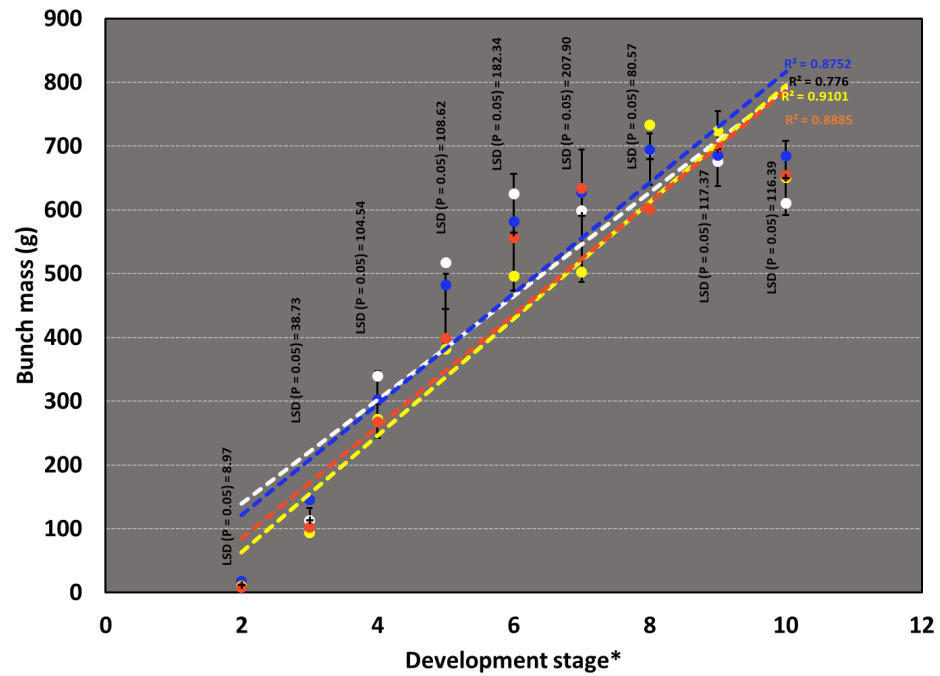
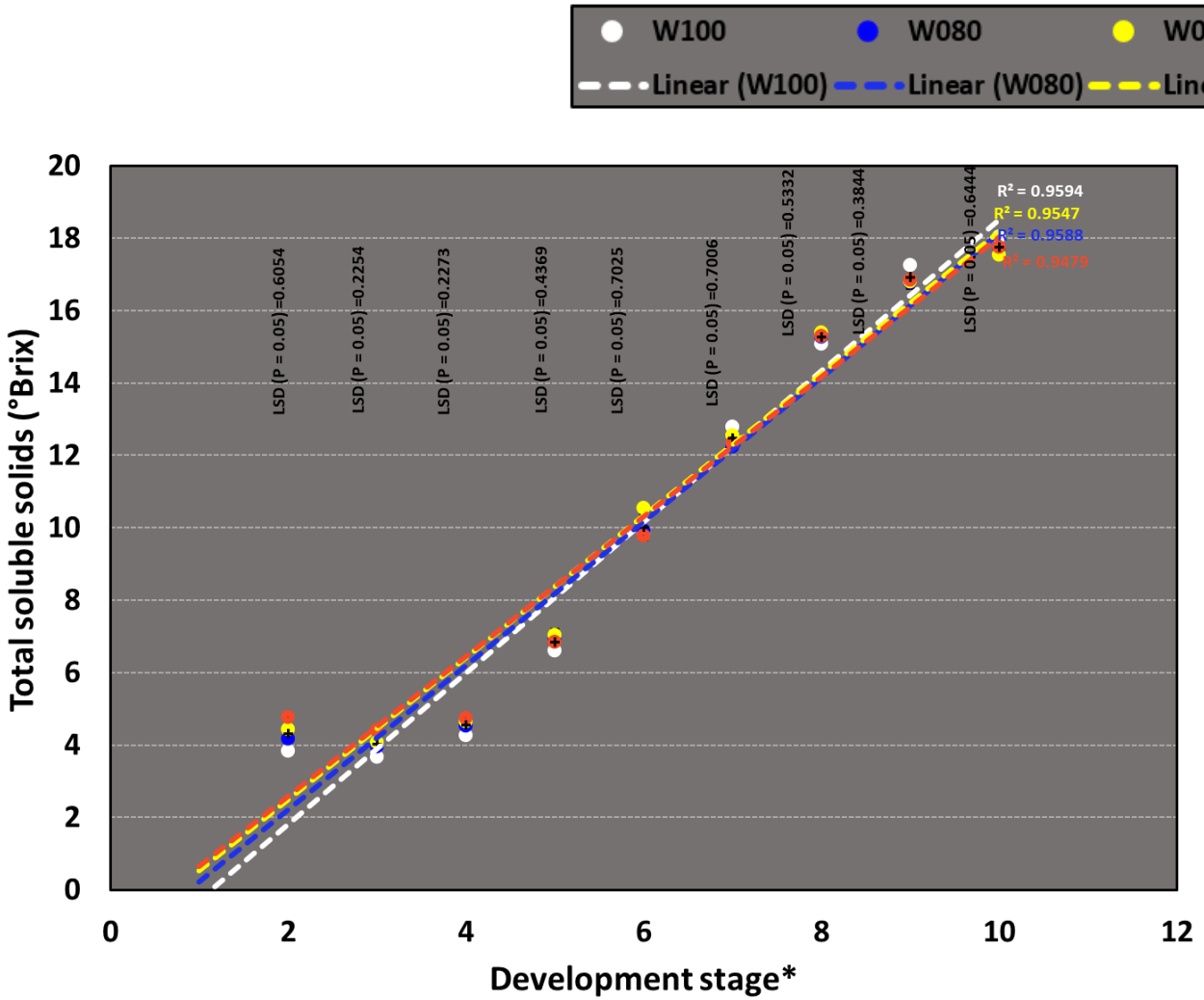


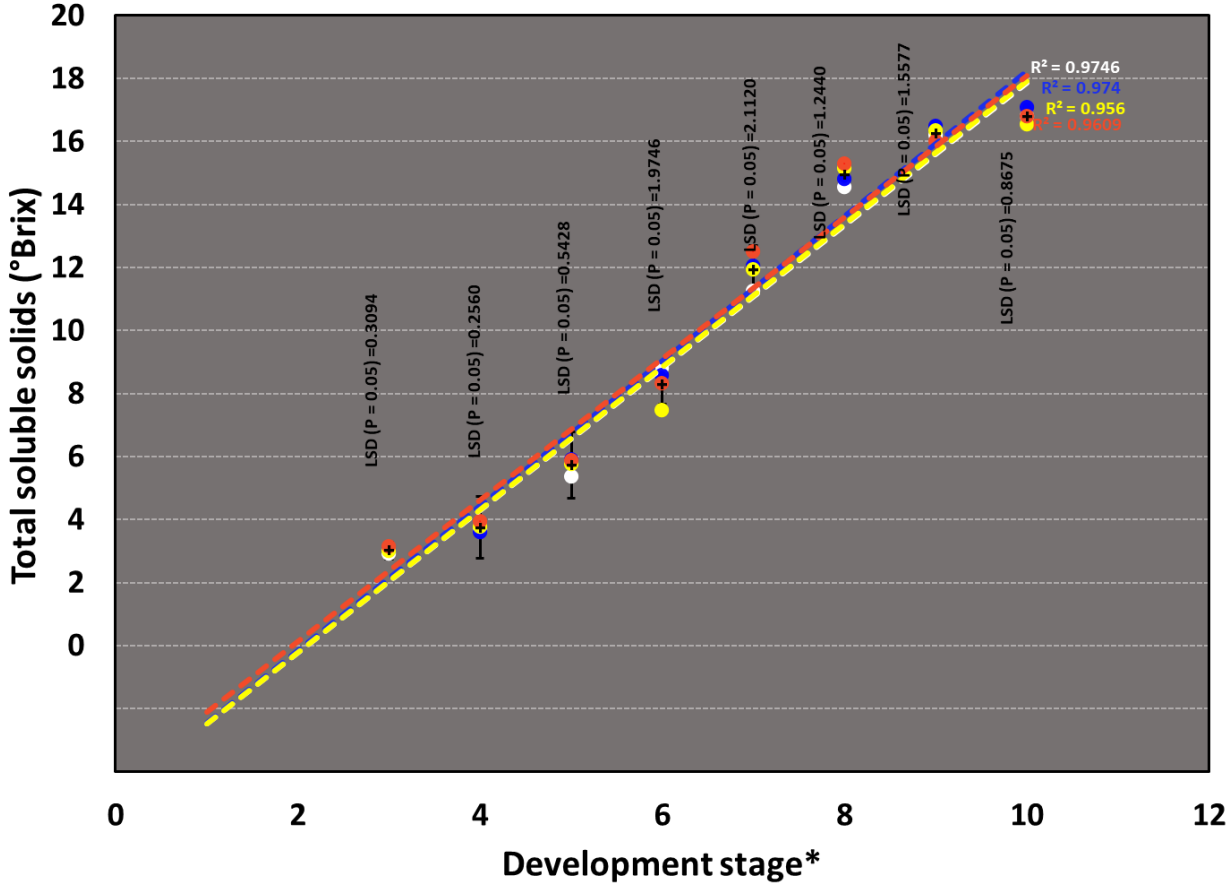


Quality variables

Open Field



Overhead Plastic Covering



*0-6 = growth phase (0-62 DAFB); 7-10 = ripening (76-112 DAFB)

Effect of water treatments on index of Crimson Seedless Open Field (OF) and Overhead plastic covering (OPC) trial in the Robertson area (21/22 and 22/23 seasons)

Colour variable	Treatment	OF Sampling stage*				OPC Sampling stage			
		7	8	9	10	7	8	9	10
Colour Index (180-H/L*+C*)[a]	**W100**	-1.78 a	-3.53	-3.80 a	-3.73 a	1.54 a	-2.75 a	-2.68 a	-2.70 a
	W080	-1.98 a	-3.52	-3.99 a	-3.72 a	1.80 a	-2.66 a	-3.11 a	-3.37 a
	W070	-2.13 a	-3.54	-3.98 a	-3.81 a	1.79 a	-3.61 a	-2.84 a	-3.50 a
	W055	-2.10 a	-3.19	-3.91 a	-3.86 a	1.46 a	-3.37 a	-3.21 a	-3.72 a
	LSD (p = 0.05)	*1.12*	*0.62*	*0.23*	*0.23*	*0.66*	*1.28*	*3.15*	*1.11*

[a] Colour Index facilitates the contribution of the Lightness, hue and Chroma to the perceived colour. Negative values indicate blue / red colours.

*Sampling stage 7 = 1 week prior to harvest, 8 = R1, 9 = R2, 10 = R3

Pack out scenarios

Open Field

		Measured amount of water* (m^3) per season (October to March) per ha	Berry mass (g)	Bunch mass (kg)	Bunch mass per vine	Yield per ha	n 4.5kg cartons**
90 berries / bunch	W100	190	6.41	0.58	14.99	28544.44	6343
	W080	151	6.16	0.55	14.41	27438.11	6097
	W070	130	5.87	0.53	13.74	26167.03	5815
	W055	103	5.75	0.52	13.45	25606.07	5690
100 berries / bunch	W100	190	6.41	0.64	16.66	31716.04	7048
	W080	151	6.16	0.62	16.01	30486.79	6775
	W070	130	5.87	0.59	15.27	29074.48	6461
	W055	103	5.75	0.57	14.94	28451.19	6322
110 berries / bunch	W100	190	6.41	0.70	18.32	34887.65	7753
	W080	151	6.16	0.68	17.61	33535.47	7452
	W070	130	5.87	0.65	16.80	31981.93	7107
	W055	103	5.75	0.63	16.44	31296.31	6955

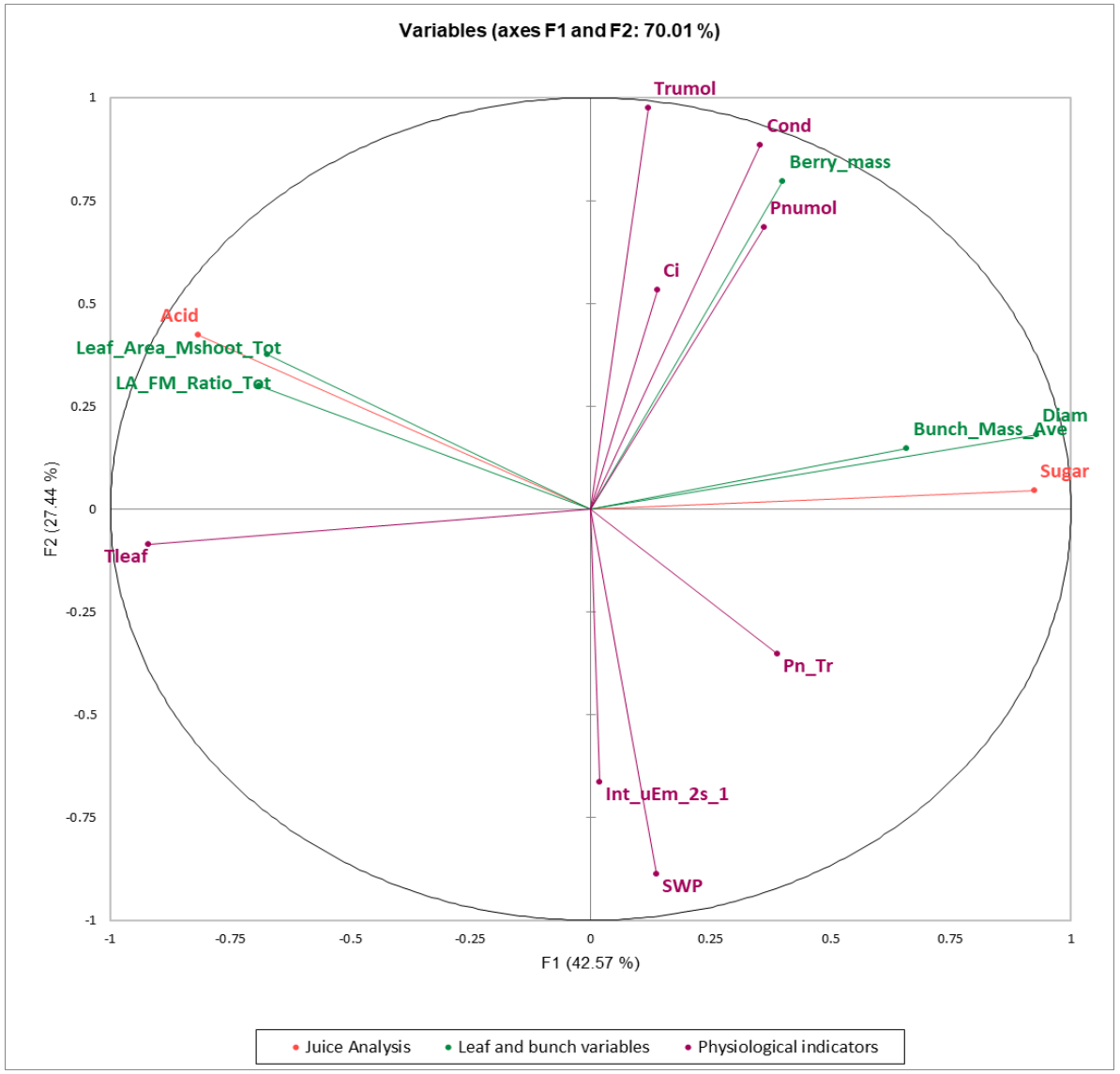
Overhead Plastic Covering

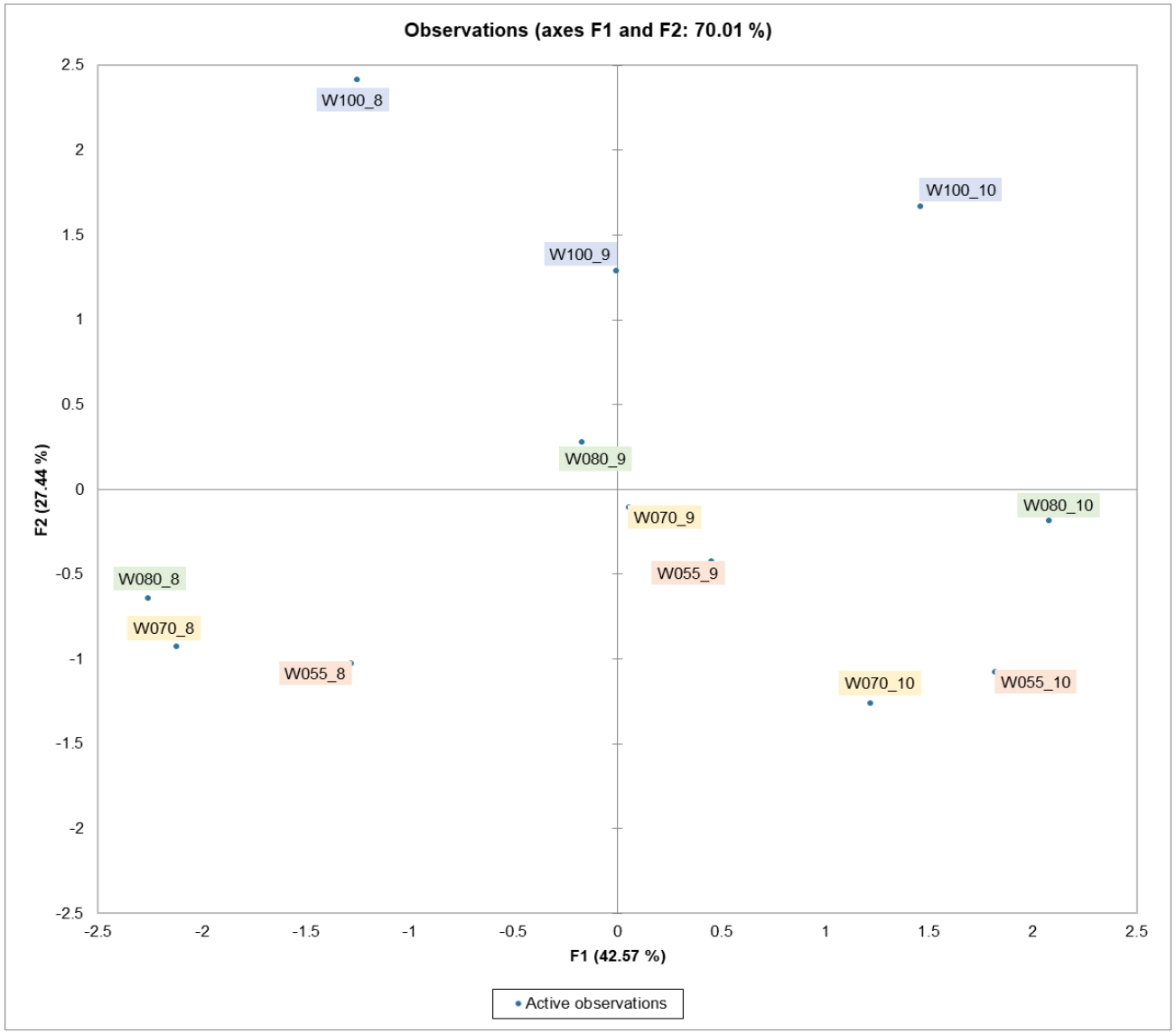
		Measured amount of water (m^3) per season (October to March) per ha	Berry mass (g)	Bunch mass (kg)	Bunch mass per vine (kg)	Bunch mass per ha (kg)	n 4.5kg cartons**
90 berries / bunch	W100	190	7.44	0.67	17.41	33157.20	7368
	W080	151	7.26	0.65	16.98	32334.17	7185
	W070	130	6.95	0.63	16.27	30983.99	6885
	W055	103	7.18	0.65	16.80	31993.31	7110
100 berries / bunch	W100	190	7.44	0.74	19.35	36841.34	8187
	W080	151	7.26	0.73	18.87	35926.86	7984
	W070	130	6.95	0.70	18.08	34426.66	7650
	W055	103	7.18	0.72	18.67	35548.12	7900
110 berries / bunch	W100	190	7.44	0.82	21.28	40525.47	9006
	W080	151	7.26	0.80	20.76	39519.54	8782
	W070	130	6.95	0.76	19.89	37869.32	8415
	W055	103	7.18	0.79	20.54	39102.93	8690

*W100 irrigation applied = farm fractice, using Kc (0.3 at beginning of growth season, going up to 0.6 during ripening until the end) and ET to calculate irrigation need

**Bunch mass and yield calculated using actual berry mass obtained in the 21/22 and 22/23 seasons

Multi Factor Analyses
Physiological, growth and quality variables 2021/2022 Open Field





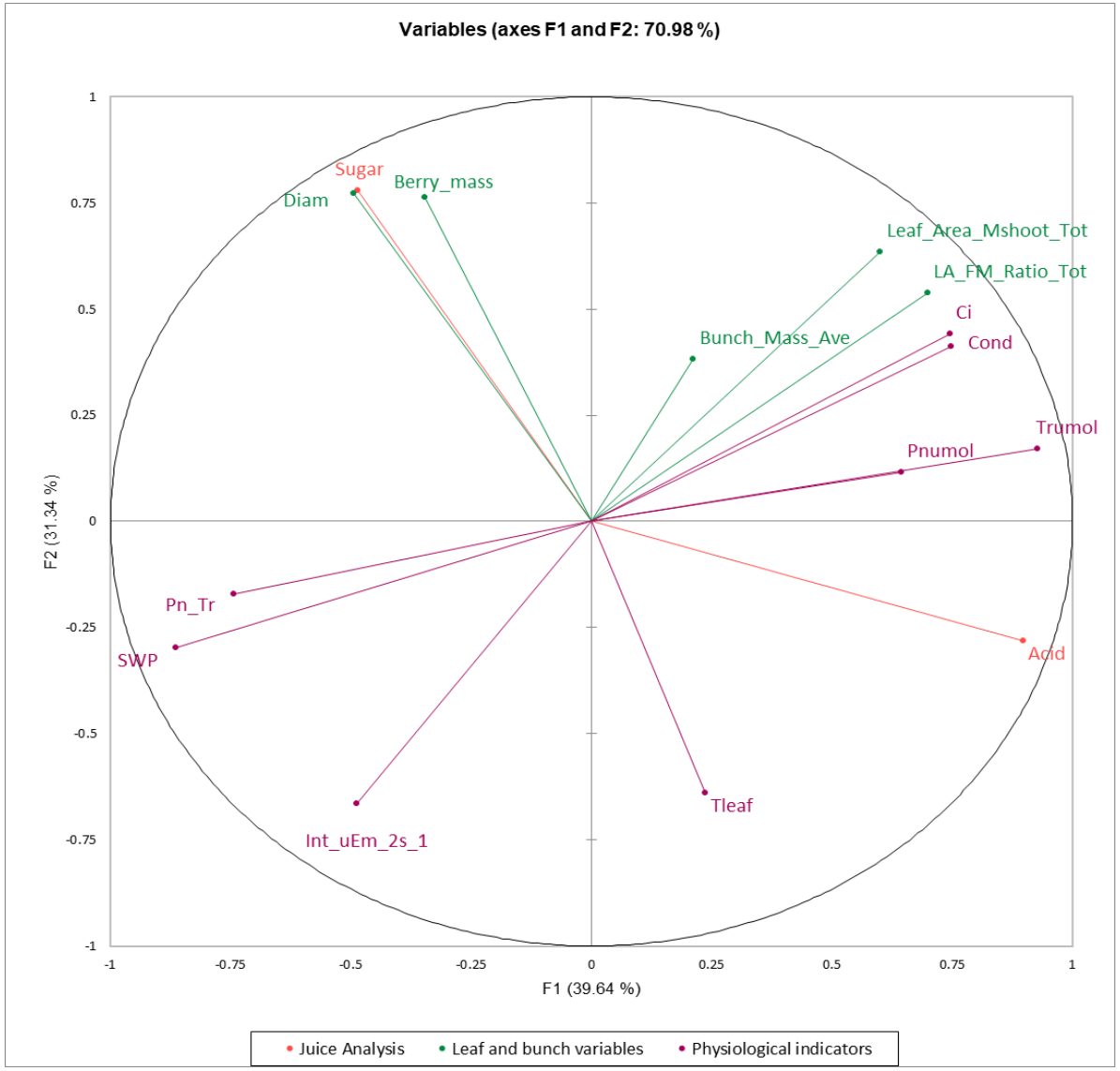
Development stage (DS) 8 = R1, DS 9 = R2, DS 10 = R3

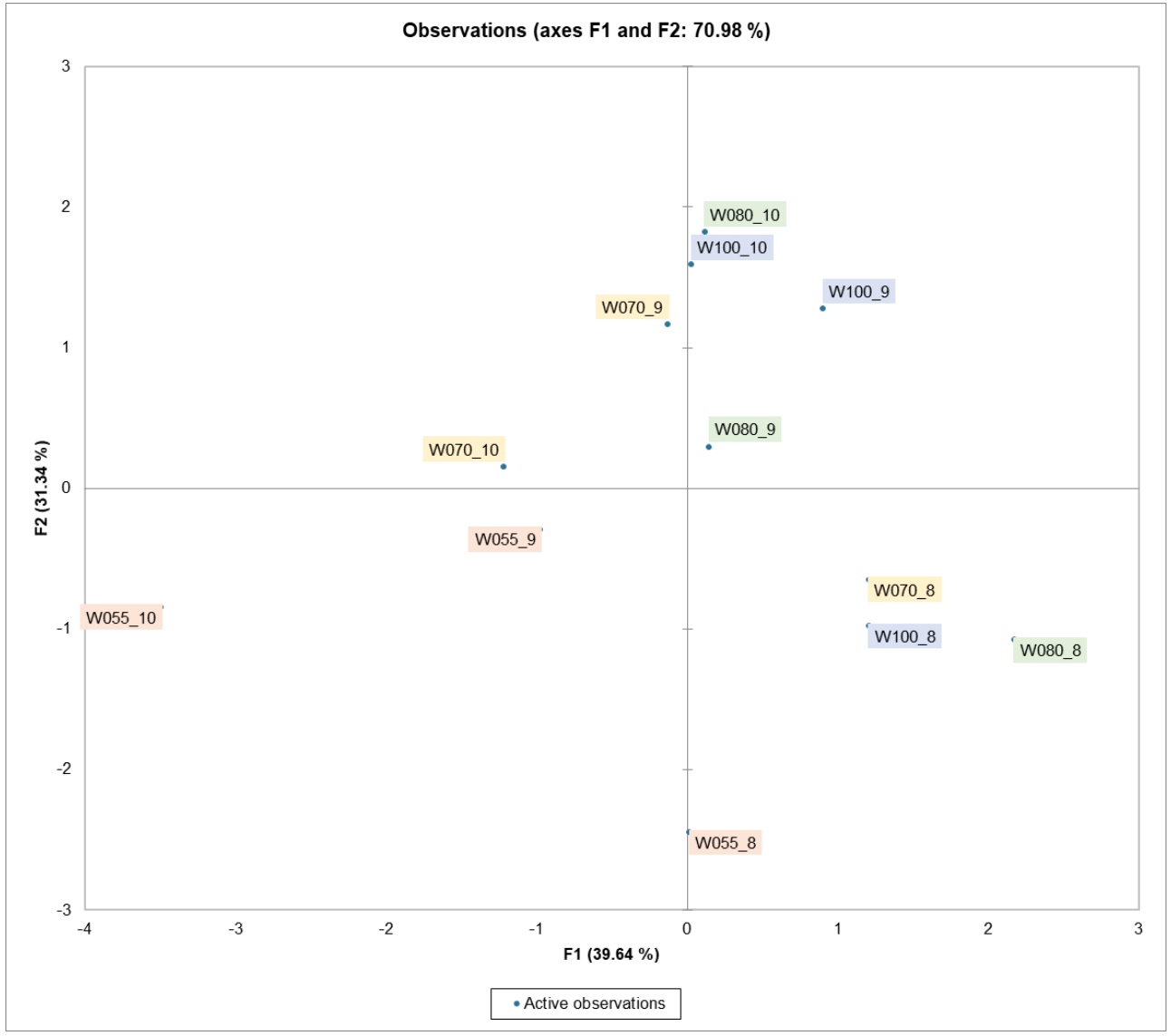
Correlation matrix (Pearson) / Group 21_22_Open Field:

Variables	Leaf_Area_Mshoot_Tot	LA_FM_Ratio_Tot	Bunch_Mass_Ave	Berry_mass	Diam	Sugar	Acid	Int_uEm_2s_1	Cond	Ci	Tleaf	Trumol	Pnumol	Pn_Tr	SWP
Leaf_Area_Mshoot_Tot	**1**	**0.705**	-0.269	0.126	-0.458	-0.560	**0.794**	0.021	0.073	-0.243	0.440	0.218	0.205	-0.040	-0.259
LA_FM_Ratio_Tot	**0.705**	**1**	**-0.755**	-0.008	-0.507	-0.413	**0.636**	-0.165	0.033	-0.141	0.476	0.164	0.091	-0.154	-0.262
Bunch_Mass_Ave	-0.269	**-0.755**	**1**	0.428	**0.587**	0.389	-0.365	0.037	0.358	0.185	**-0.586**	0.206	0.316	0.186	0.039
Berry_mass	0.126	-0.008	0.428	**1**	0.496	0.359	0.038	-0.342	**0.826**	0.310	-0.500	**0.790**	**0.779**	0.080	-0.543
Diam	-0.458	-0.507	**0.587**	0.496	**1**	**0.923**	**-0.651**	-0.056	0.456	0.131	**-0.897**	0.266	0.490	0.383	-0.043
Sugar	-0.560	-0.413	0.389	0.359	**0.923**	**1**	**-0.768**	-0.047	0.369	0.087	**-0.902**	0.147	0.406	0.405	0.088
Acid	**0.794**	**0.636**	-0.365	0.038	**-0.651**	**-0.768**	**1**	-0.059	0.147	-0.129	**0.629**	0.319	0.176	-0.231	-0.396
Int_uEm_2s_1	0.021	-0.165	0.037	-0.342	-0.056	-0.047	-0.059	**1**	-0.475	**-0.939**	-0.191	**-0.654**	-0.020	**0.836**	**0.837**
Cond	0.073	0.033	0.358	**0.826**	0.456	0.369	0.147	-0.475	**1**	0.405	-0.465	**0.935**	**0.870**	-0.067	**-0.675**
Ci	-0.243	-0.141	0.185	0.310	0.131	0.087	-0.129	**-0.939**	0.405	**1**	0.113	0.559	-0.084	**-0.836**	**-0.731**
Tleaf	0.440	0.476	**-0.586**	-0.500	**-0.897**	**-0.902**	**0.629**	-0.191	-0.465	0.113	**1**	-0.180	**-0.614**	**-0.628**	-0.193
Trumol	0.218	0.164	0.206	**0.790**	0.266	0.147	0.319	**-0.654**	**0.935**	0.559	-0.180	**1**	**0.716**	-0.334	**-0.879**
Pnumol	0.205	0.091	0.316	**0.779**	0.490	0.406	0.176	-0.020	**0.870**	-0.084	**-0.614**	**0.716**	**1**	0.400	-0.346
Pn_Tr	-0.040	-0.154	0.186	0.080	0.383	0.405	-0.231	**0.836**	-0.067	**-0.836**	**-0.628**	-0.334	0.400	**1**	**0.667**
SWP	-0.259	-0.262	0.039	-0.543	-0.043	0.088	-0.396	**0.837**	**-0.675**	**-0.731**	-0.193	**-0.879**	-0.346	**0.667**	**1**

Values in bold are different from 0 with a significance level alpha=0.05

Multi Factor Analyses
Physiological, growth and quality variables 2021/2022 Overhead Plastic Covering





Correlation matrix (Pearson) / Group 21_22_OPC:

Variables	Leaf_Area_Mshoot_Tot	LA_FM_Ratio_Tot	Bunch_Mass_Ave	Berry_mass	Diam	Sugar	Acid	Int_uEm_2s_1	Cond	Ci	Tleaf	Trumol	Pnumol	Pn_Tr	SWP
Leaf_Area_Mshoot_Tot	**1**	**0.810**	0.329	0.281	0.078	0.213	0.314	-0.536	**0.635**	**0.683**	-0.247	**0.586**	0.492	-0.533	**-0.595**
LA_FM_Ratio_Tot	**0.810**	**1**	0.178	0.000	0.013	0.165	0.370	-0.545	**0.754**	**0.778**	-0.220	**0.761**	0.542	**-0.626**	**-0.669**
Bunch_Mass_Ave	0.329	0.178	**1**	**0.638**	0.211	-0.016	0.291	-0.454	0.026	0.124	0.236	0.042	-0.121	-0.227	-0.361
Berry_mass	0.281	0.000	**0.638**	**1**	**0.778**	**0.623**	-0.380	-0.459	-0.117	-0.049	-0.337	-0.321	-0.302	0.148	-0.005
Diam	0.078	0.013	0.211	**0.778**	**1**	**0.742**	**-0.612**	-0.366	0.036	-0.047	**-0.748**	-0.280	-0.131	0.317	0.184
Sugar	0.213	0.165	-0.016	**0.623**	**0.742**	**1**	**-0.729**	-0.204	0.013	0.051	**-0.641**	-0.256	-0.201	0.182	0.188
Acid	0.314	0.370	0.291	-0.380	**-0.612**	**-0.729**	**1**	-0.308	0.545	0.430	0.416	**0.756**	0.565	-0.506	**-0.725**
Int_uEm_2s_1	-0.536	-0.545	-0.454	-0.459	-0.366	-0.204	-0.308	**1**	**-0.607**	**-0.729**	0.188	-0.575	-0.214	**0.600**	**0.786**
Cond	**0.635**	**0.754**	0.026	-0.117	0.036	0.013	0.545	**-0.607**	**1**	**0.736**	-0.432	**0.923**	**0.858**	-0.451	**-0.719**
Ci	**0.683**	**0.778**	0.124	-0.049	-0.047	0.051	0.430	**-0.729**	**0.736**	**1**	-0.071	**0.807**	0.373	**-0.896**	**-0.834**
Tleaf	-0.247	-0.220	0.236	-0.337	**-0.748**	**-0.641**	0.416	0.188	-0.432	-0.071	**1**	-0.077	-0.416	-0.357	-0.137
Trumol	**0.586**	**0.761**	0.042	-0.321	-0.280	-0.256	**0.756**	-0.575	**0.923**	**0.807**	-0.077	**1**	**0.776**	**-0.658**	**-0.859**
Pnumol	0.492	0.542	-0.121	-0.302	-0.131	-0.201	0.565	-0.214	**0.858**	0.373	-0.416	**0.776**	**1**	-0.091	-0.455
Pn_Tr	-0.533	**-0.626**	-0.227	0.148	0.317	0.182	-0.506	**0.600**	-0.451	**-0.896**	-0.357	**-0.658**	-0.091	**1**	**0.778**
SWP	**-0.595**	**-0.669**	-0.361	-0.005	0.184	0.188	**-0.725**	**0.786**	**-0.719**	**-0.834**	-0.137	**-0.859**	-0.455	**0.778**	**1**

Values in bold are different from 0 with a significance level alpha=0.05

Discussion and conclusions

- Stem water potential is a good indicator for plant water status
- Reduced water supply caused a lower plant water status
- OPC increased Pn, Tr and water status
- Increased Pn and Tr related to stomatal conductance
- Higher photosynthetic rates equal open stomata, hence increased transpiration
- Vines under OF conditions used water more efficiently
- Plant reaction to abiotic conditions increase under conditions where microclimate is altered by means of OPC
- Higher humidity underneath OPC in favour of photosynthesis
- Lower light intensity underneath OPC not detrimental to photosynthesis
- Colour and sugar development was delayed underneath OPC
- Increased vegetative and reproductive growth underneath OPC due to higher photosynthetic rates
- Similar photosynthetic rates for W080 compared to W100 indicated W100 is excessive
- **For this vineyard, 20% less water is recommended under OF conditions and 30% less water underneath OPC**
- Use the correct type of plastic for the purpose of covering, especially with regards to radiometric properties for light

Acknowledgements

ARC Infruitec-Nietvoorbij staff