



UNIVERSITÀ
CATTOLICA
del Sacro Cuore

Stress idrico, risposta delle varietà di vite ed irrigazione

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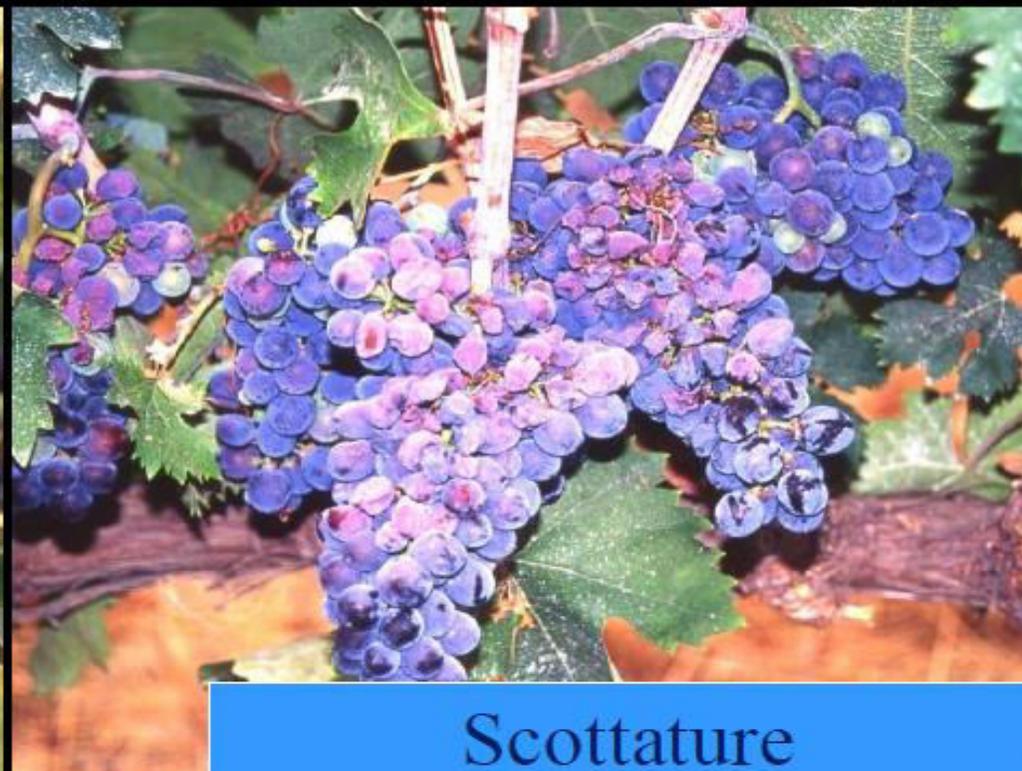
Il Summer School Sanguis Jovis, Montalcino, 14 settembre 2018.

I temi di oggi

- E' davvero cambiata la 'mentalità' nei confronti di apporti supplementari di acqua in vigneto?
- Alcuni elementi critici del bilancio idrico del vigneto
- Origine dello stress: suolo o atmosfera?
- Elementi di diagnostica precoce dello stress
- Tolleranza allo stress idrico di vitigni e portinnesti
- Irrigazione di precisione: limiti attuali e prospettive
- Cose da fare.....



Scarsa colorazione



Scottature



Stress idrico



DANNI DA GELO TARDIVO!!

Irrigazione “ordinaria”

Di solito meno di 400 mm/anno. In estate non piove quasi MAI!
(es. California)

Irrigazione “straordinaria”

Piuvosità annuale più elevata e, in estate, PUO' anche piovere
in modo irregolare e/o abbondante



Vigneti di pianura

(produzione e vigoria elevate,
qualità da migliorare)



Vigneti di collina

(resa e vigoria più basse, qualità
spesso già buona, si cerca
l'eccellenza)

Si legge da un certo disciplinare di produzione....



.....i sesti di impianto, le forme di allevamento ed i sistemi di potatura devono essere quelli generalmente usati e, comunque atti a non modificare le caratteristiche delle uve e dei vini derivati.

E' vietata ogni pratica di irrigazione e di forzatura.

Le rese massime di uva ad ettaro di vigneto in coltura specializzata per la.....

.....e da un altro.....

..è' vietata ogni pratica di forzatura. **E' ammessa la sola irrigazione di soccorso, per non più di due volte all'anno prima dell'invasatura.**

La resa massima di uva ammessa per la produzione dei vini.....

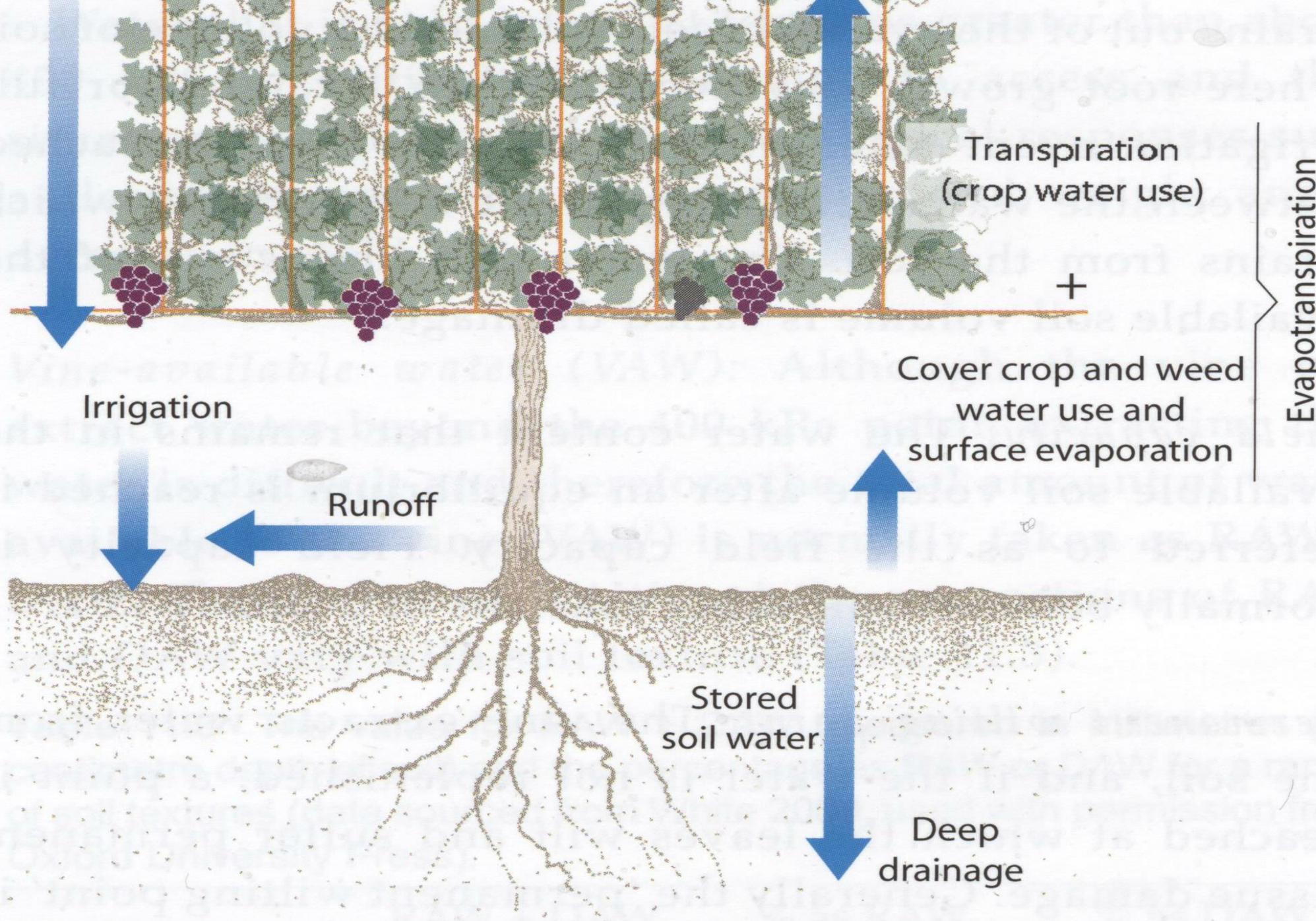


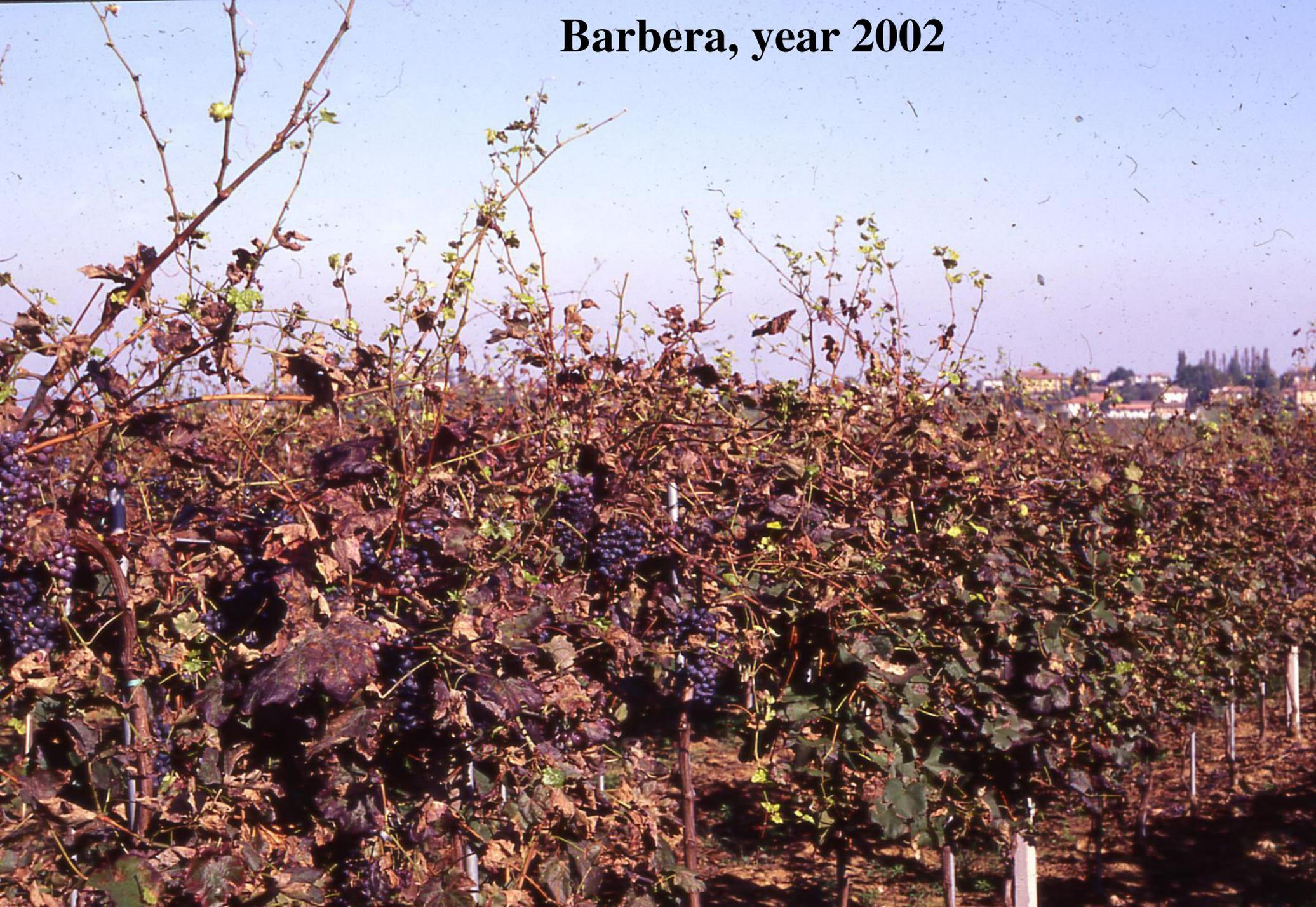
Tabella 1. Valori orientativi di quantità di acqua disponibile in vari tipi di suoli a diversa tessitura (da Shockley, 1956).

Tessitura	Acqua disponibile (mm per metro di suolo)	
	Intervallo	Media
Sabbia grossolana	33-42	36
Sabbioso-limoso	62-83	67
Medio impasto, leggero	83-125	104
Limoso	125-192	158
Argilloso-limoso	146-208	175
Argilloso	133-208	167

Alcuni fattori «critici» (e talvolta trascurati) che contribuiscono al bilancio idrico del vigneto

- ✓ **Clima**
- ✓ **Forma di allevamento**
- ✓ **Gestione del suolo**
- ✓ **Orientamento dei filari**
- ✓ **Carica di uva**

Barbera, year 2002



Same vineyard...year 2003.....

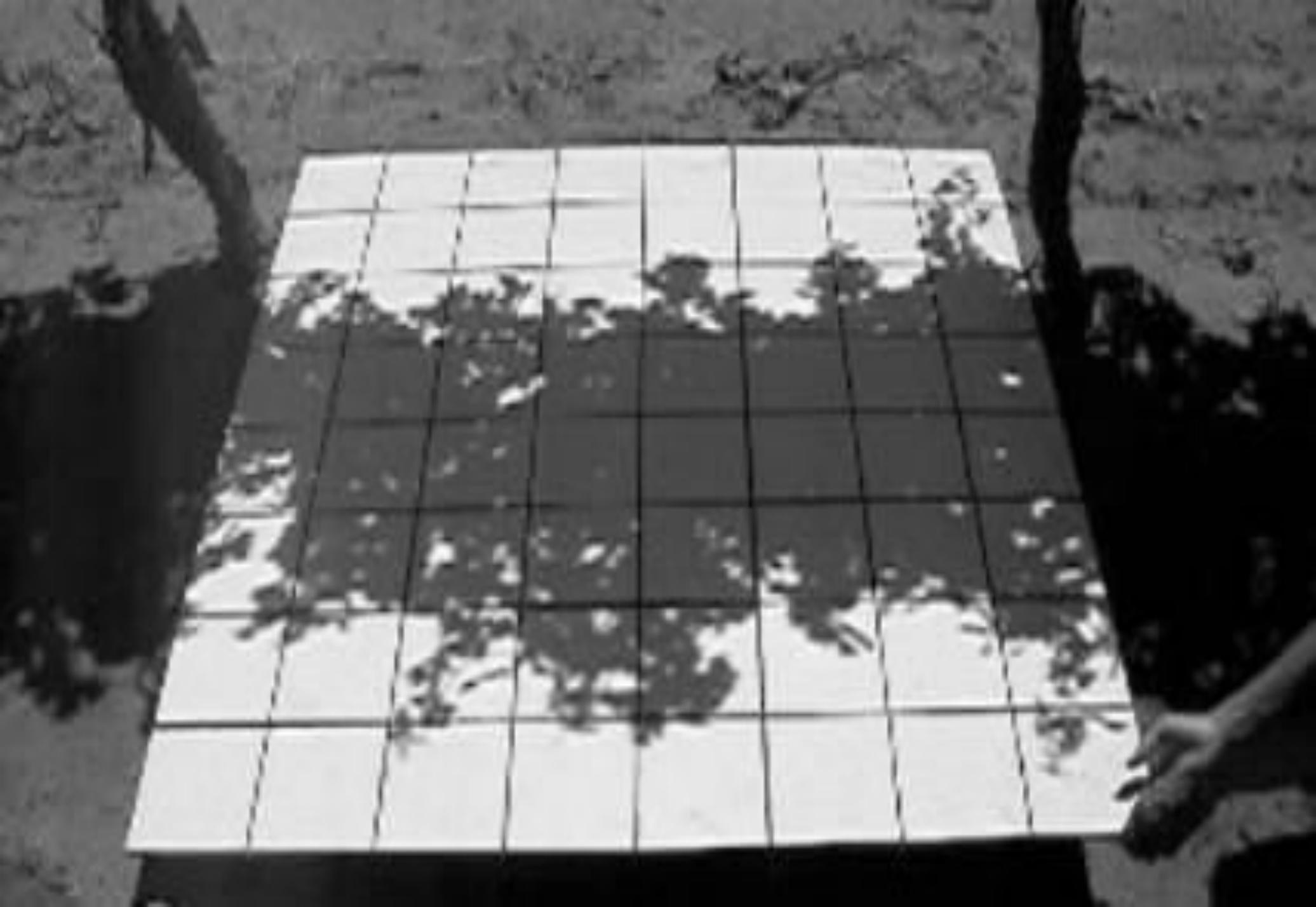


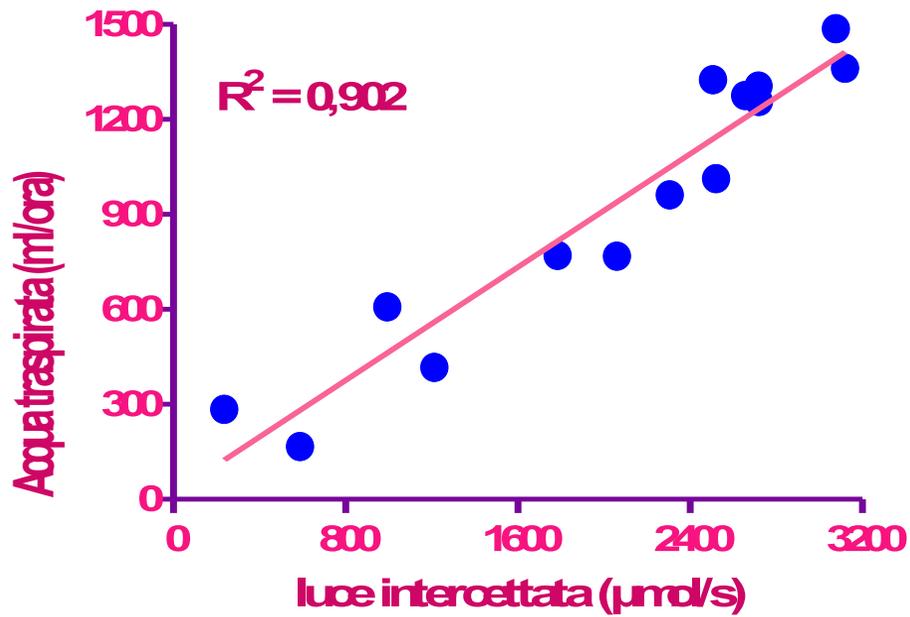


**Tendone
(90-100 %
di luce
intercettata)**

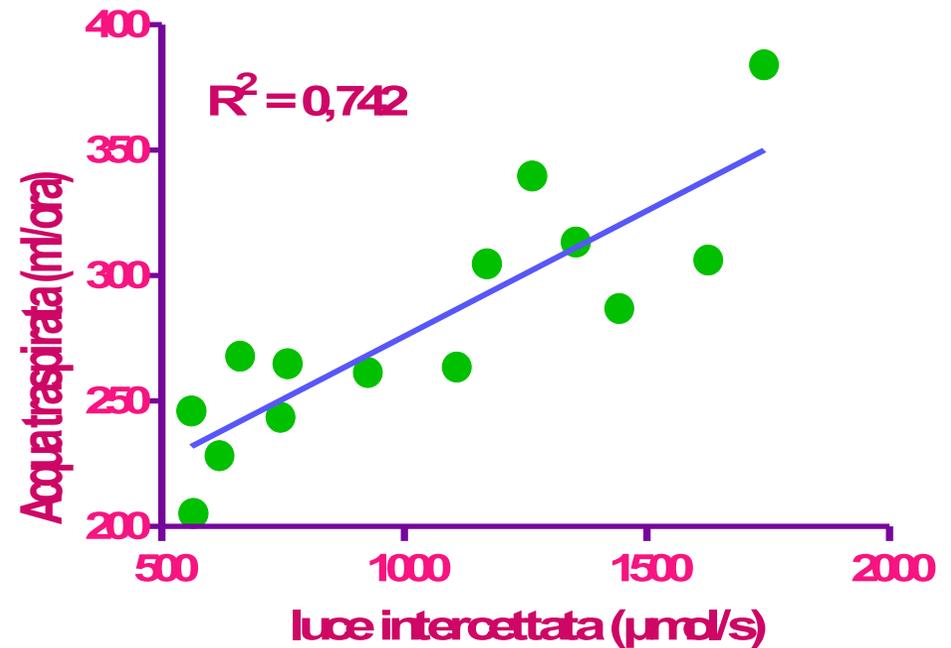


**Controspalliera
(40-70% di luce
intercettata)**





Tendone



Cordone speronato

La luce intercettata e la traspirazione
sono correlate

Da Mattii et al., 2004



Tabella 2. Consumi idrici su Cabernet S. in funzione di vari sistemi di allevamento e sestì di impianto (da Williams , 2000)

Forme	Sesto (tra-su)	Densità (viti/ha)	K_c	ET_c (mm)	ET_c (m ³ /ha)	ET_c (L/vite)
CSP	1,8 x 1,8	2984	0,81	40,5	405	136
CSP	2,7 x 1,8	1996	0,54	27,0	270	136
Lira	2,7 x 1,8	1996	0,83	41,5	415	208
GDC	3,7 x 1,8	1493	0,75	37,5	375	251
HD	1 x 1	10000	0,91	45,5	455	45,5

Dati relativi alla California, periodo di post-invaiatura. Bilancio di una settimana.

Lavorazione



Diserbo



Pacciamatura



Inerbimento



Quale il consumo idrico del cotico prima e dopo lo sfalcio ?

Quale quello di un terreno nudo?



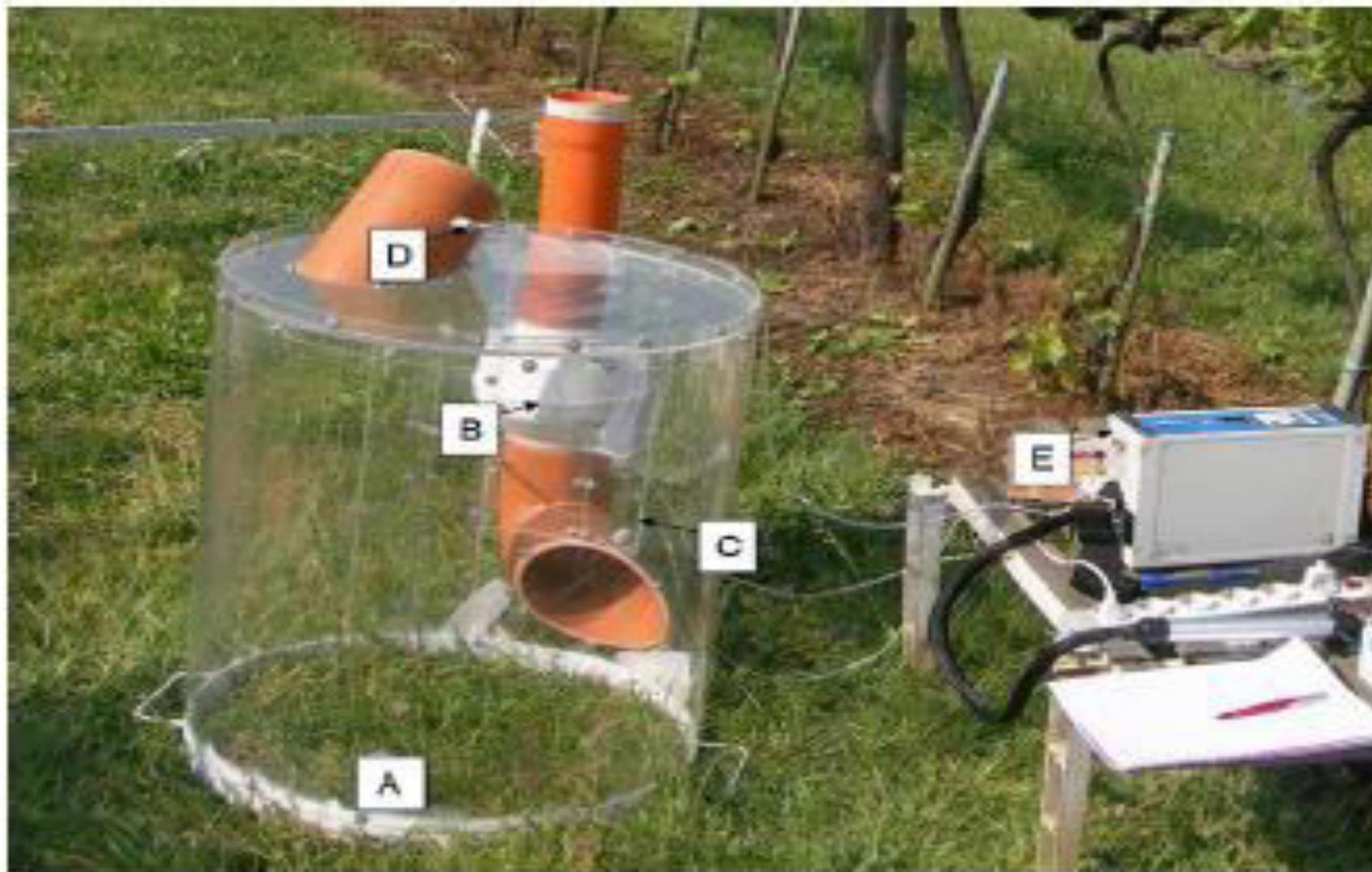


Fig. 1. Open chamber system positioned over a cover crop plot in one inter row of the vineyard. The main components are: (A) cylindrical Plexiglas structure; (B) outer alternating current fan; (C) chamber inlet; (D) chamber outlet; (E) CIRAS-1 infrared gas analyzer.

Mini-lisimetri



Ripreso da Centinari et al. 2013, AJEV

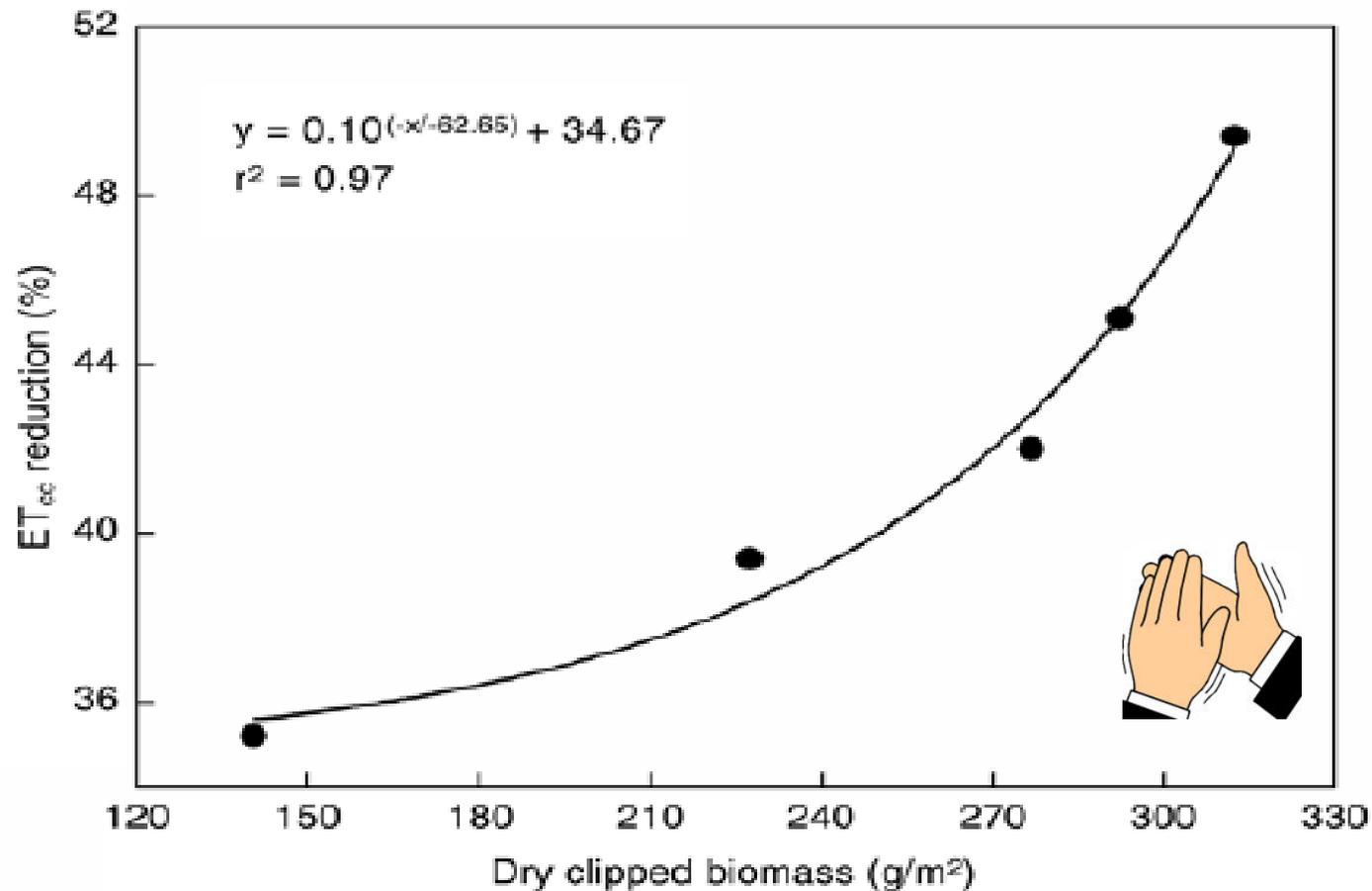
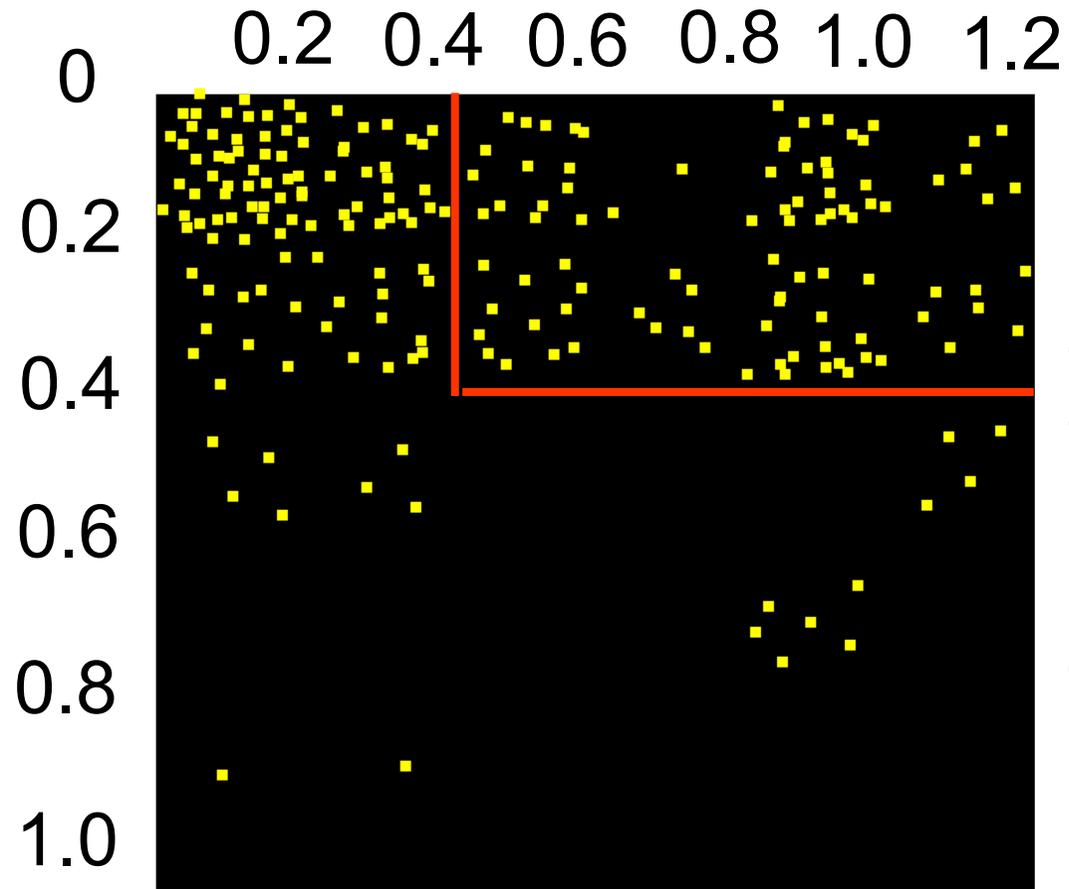


Figure 3 Relationship between the percentage of cover crop evapotranspiration (ET_{cc}) reduction and dry biomass (g/m²) clipped at the time of mowing (DOY 142, 193).

Ripreso da Lopes et al., 2004. Geisenheim, Germania

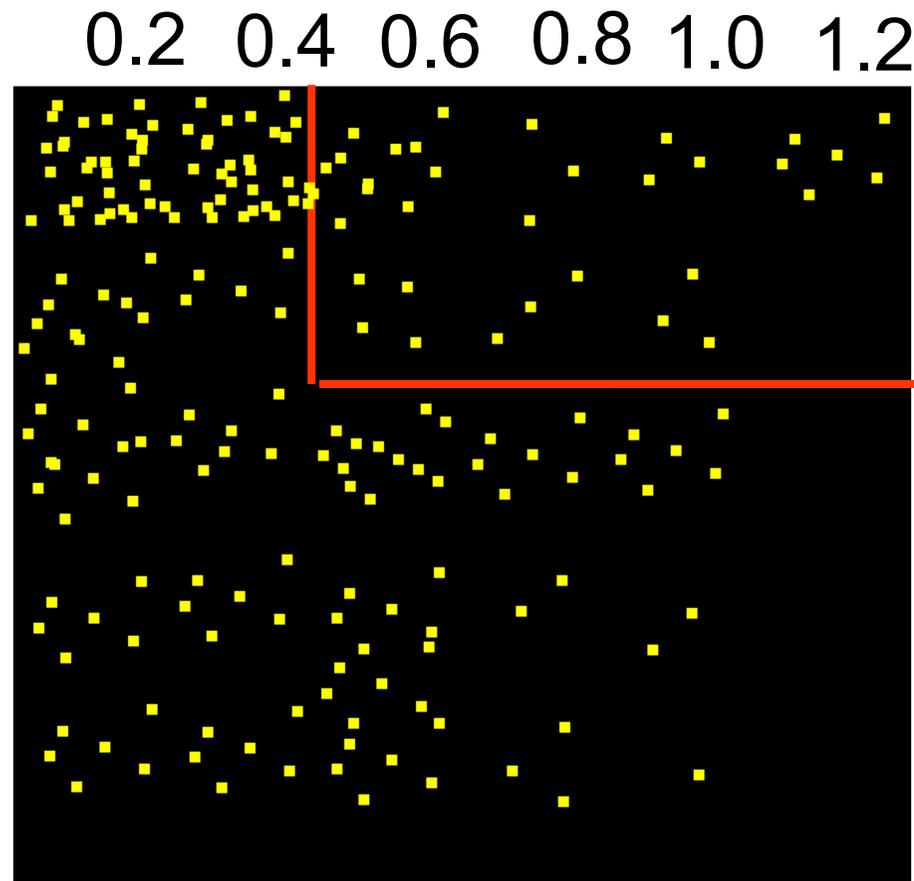
Specie	18h Σ 8h (1 m ⁻² LA)	LAI (m ² m ⁻²)	Trasp. (mm gg ⁻¹)
Medicago lupulina	1.94	1.28	2.48
Festuca rubra	0.60	1.18	0.71
Chenopodium album	2.93	0.76	2.21
Cirsium arvense	1.74	1.22	2.12
Malva neglecta	4.79	0.93	4.45
Taraxacum officinale	2.08	1.38	2.48
Vite	0.46	2.31	0.89

DISERBO

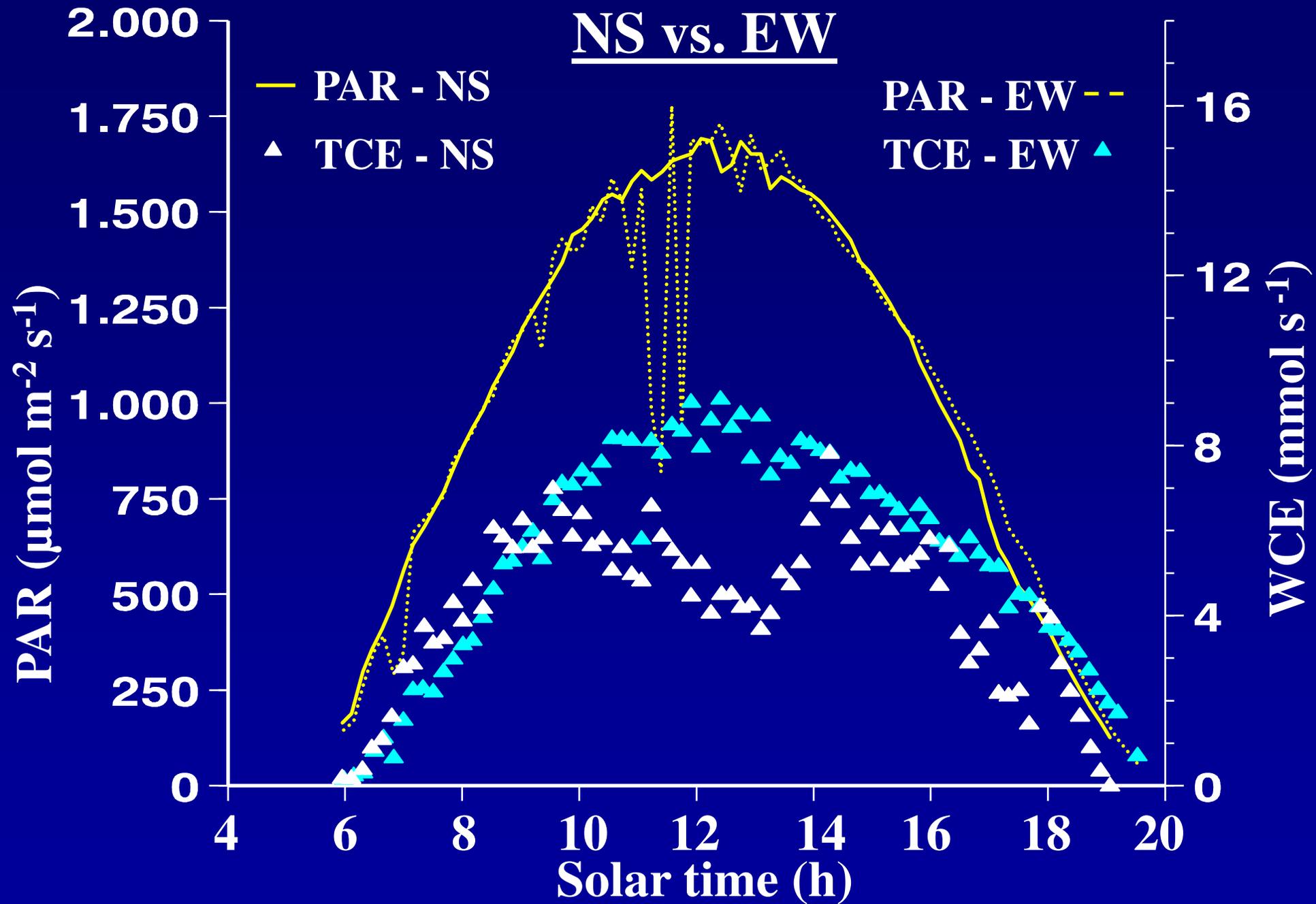


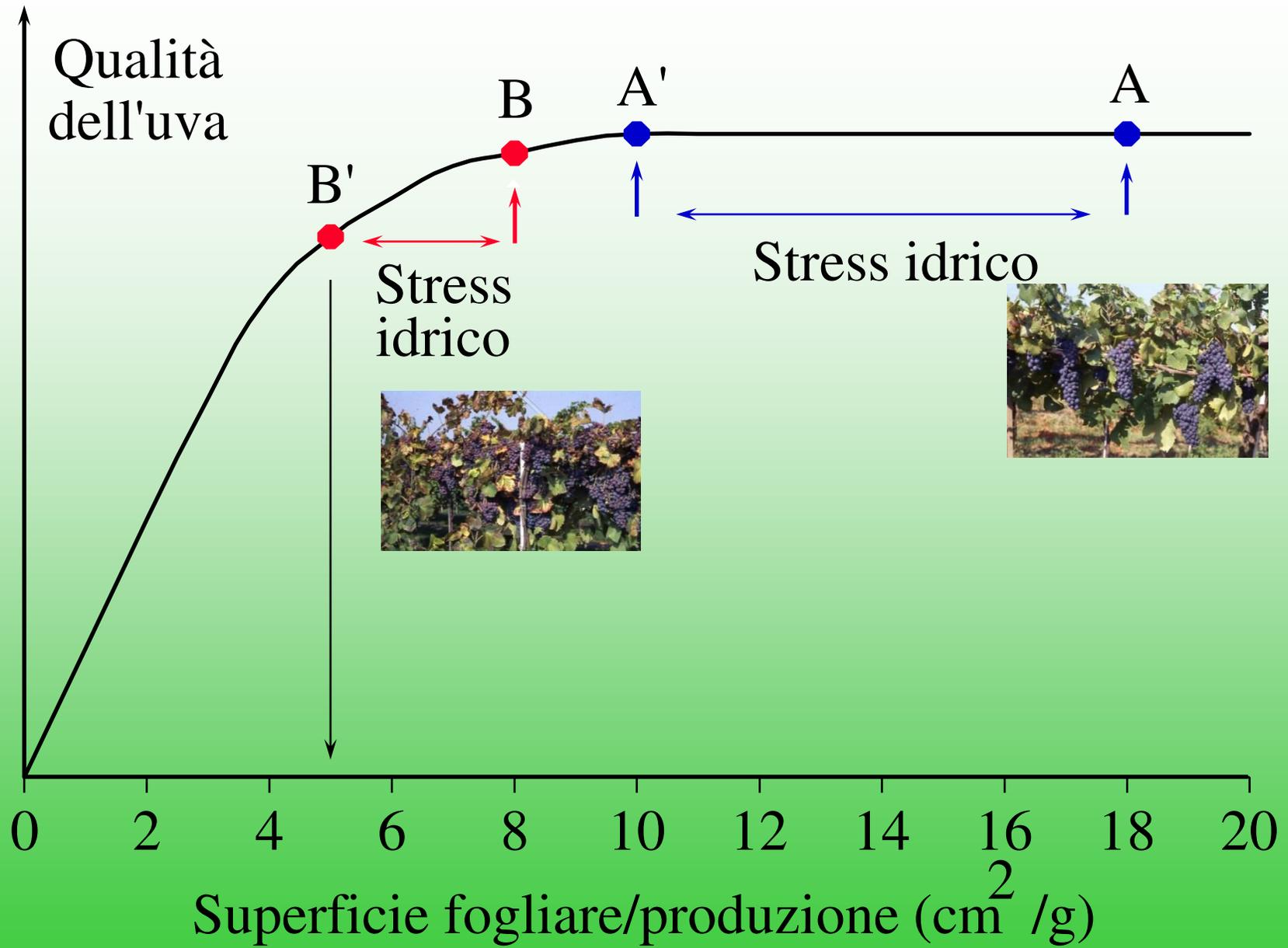
(erba mazzolina)

Dactylis glomerata



Distanza dal centro del filare (m)







Scouting for water stress

Active shoot growth



No shoot growth

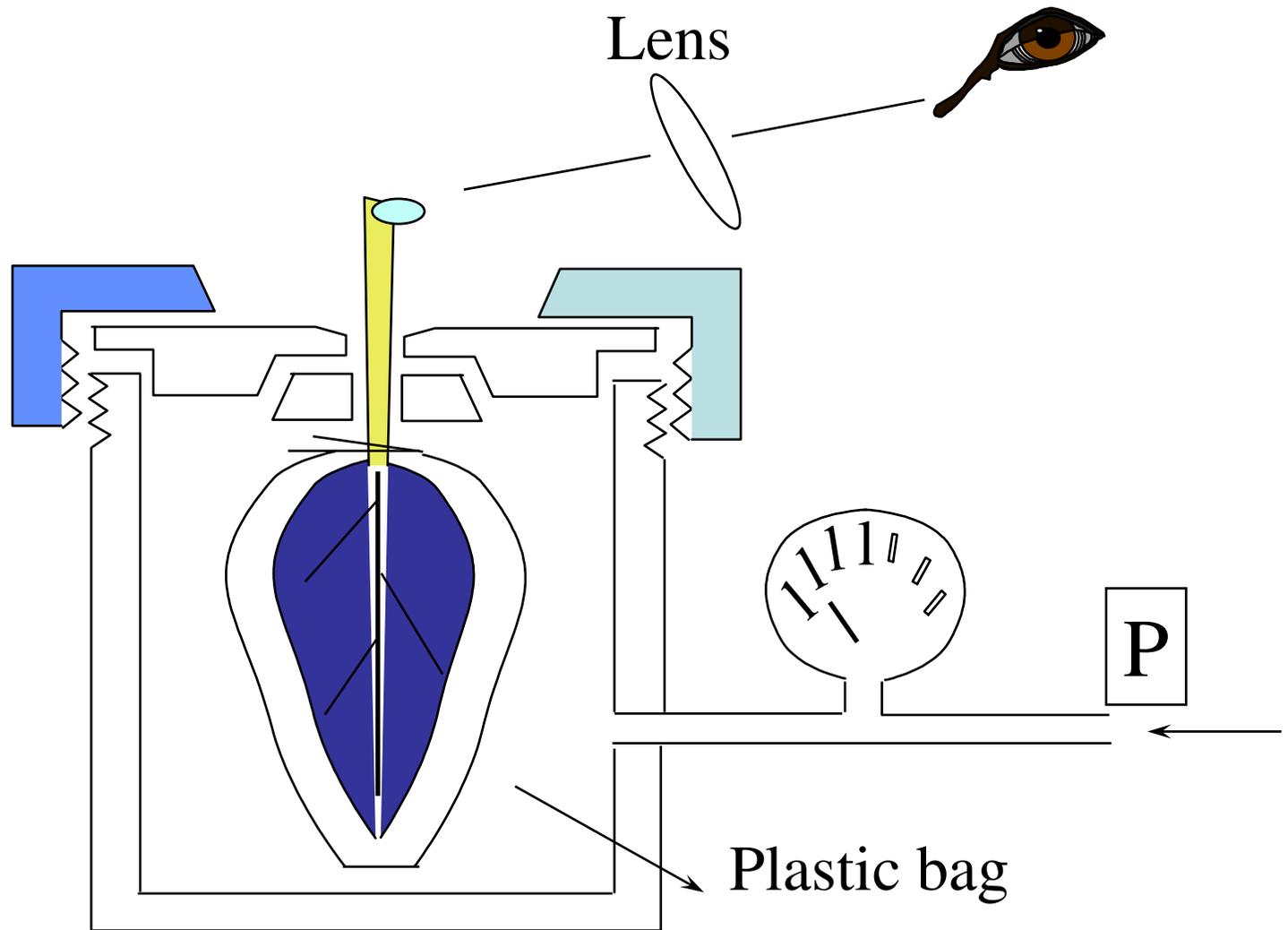


No stress – normal leaf angle

Stressed – vertical leaves

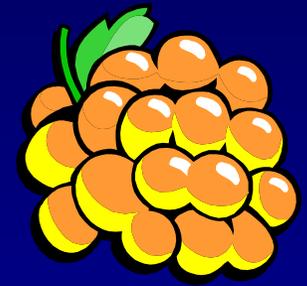
Very stressed – “escaping” leaves



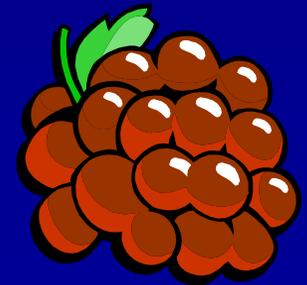


In California (San Joaquin, Napa and Sonoma Valley) the most common method for identifying the timing of first irrigation is based on **mid-day leaf water potential**

On white cultivars, the threshold is around -10 bars (-1.0 MPa)



On red cultivars, the threshold is around -12 bars (-1.2 MPa)



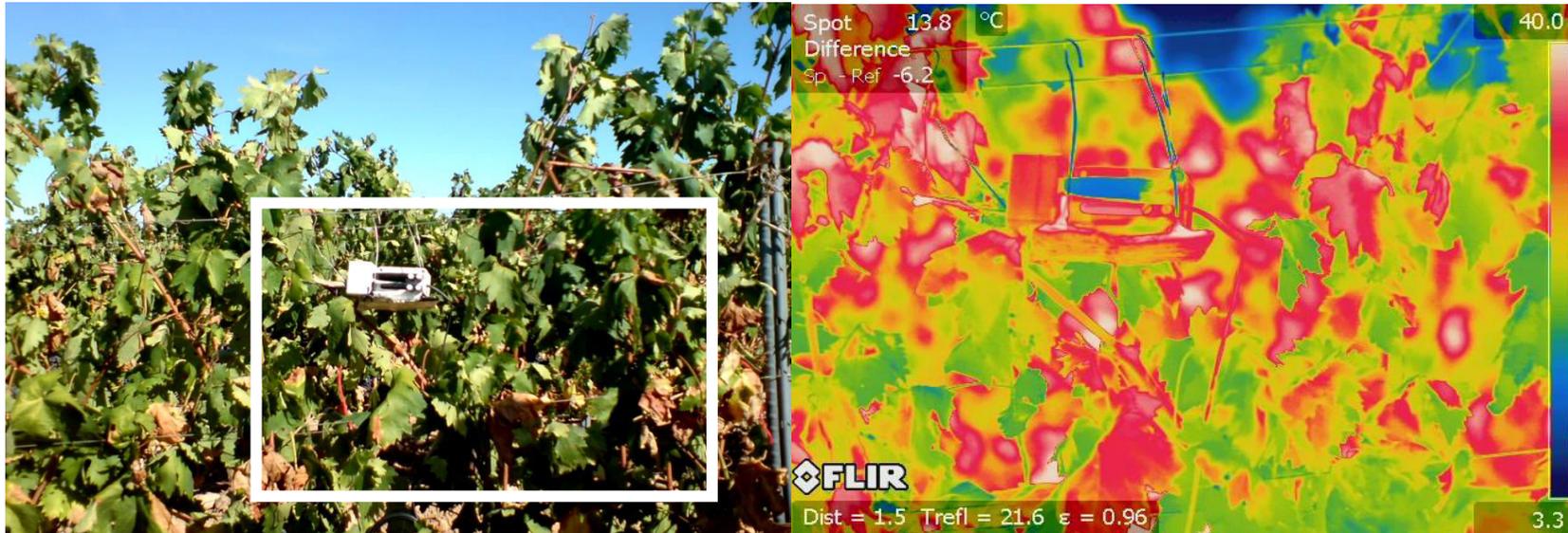


assessment of vine water stress

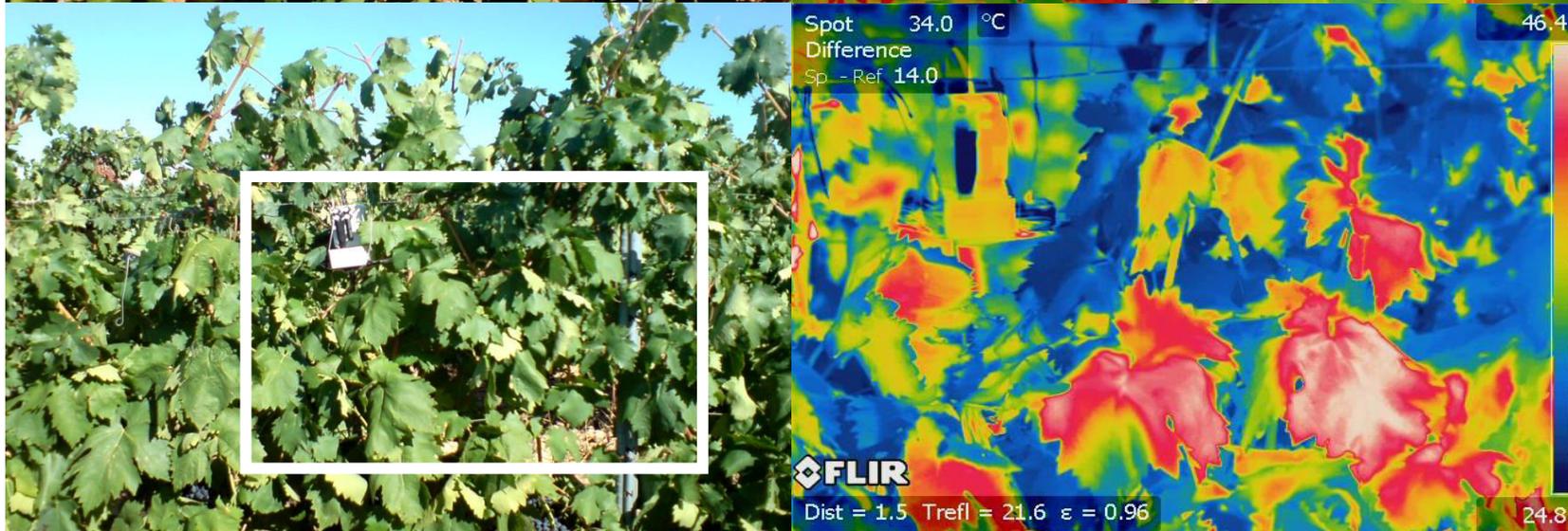


UNIVERSIDAD
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stressed



non-
stressed



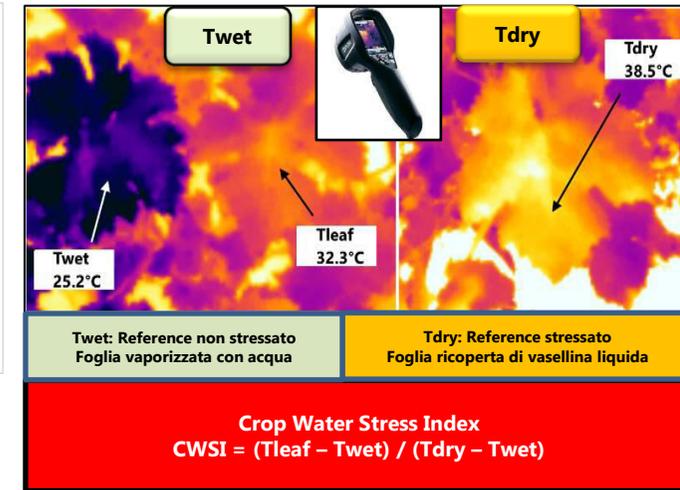
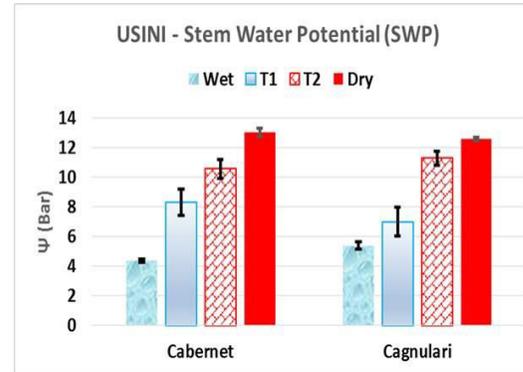
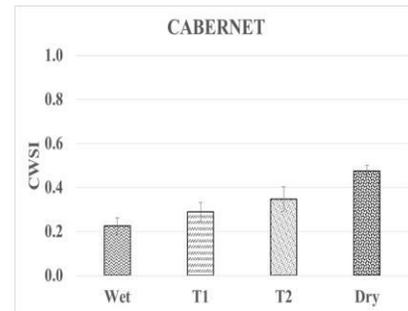
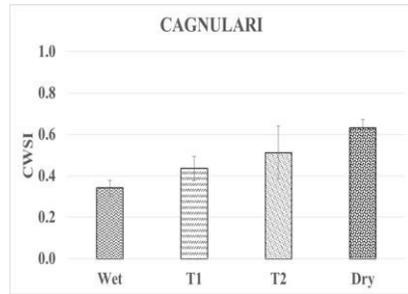
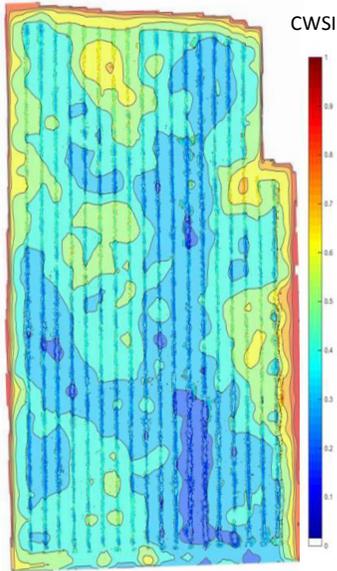
TERMI
CO



PRODOTTI

MAPPA DI STRESS

Misura dell'**EMISSIVITÀ** della cortina fogliare nell'infrarosso termico per il calcolo dell'**indice di stress CWSI** correlato alla temperatura fogliare e allo stress idrico



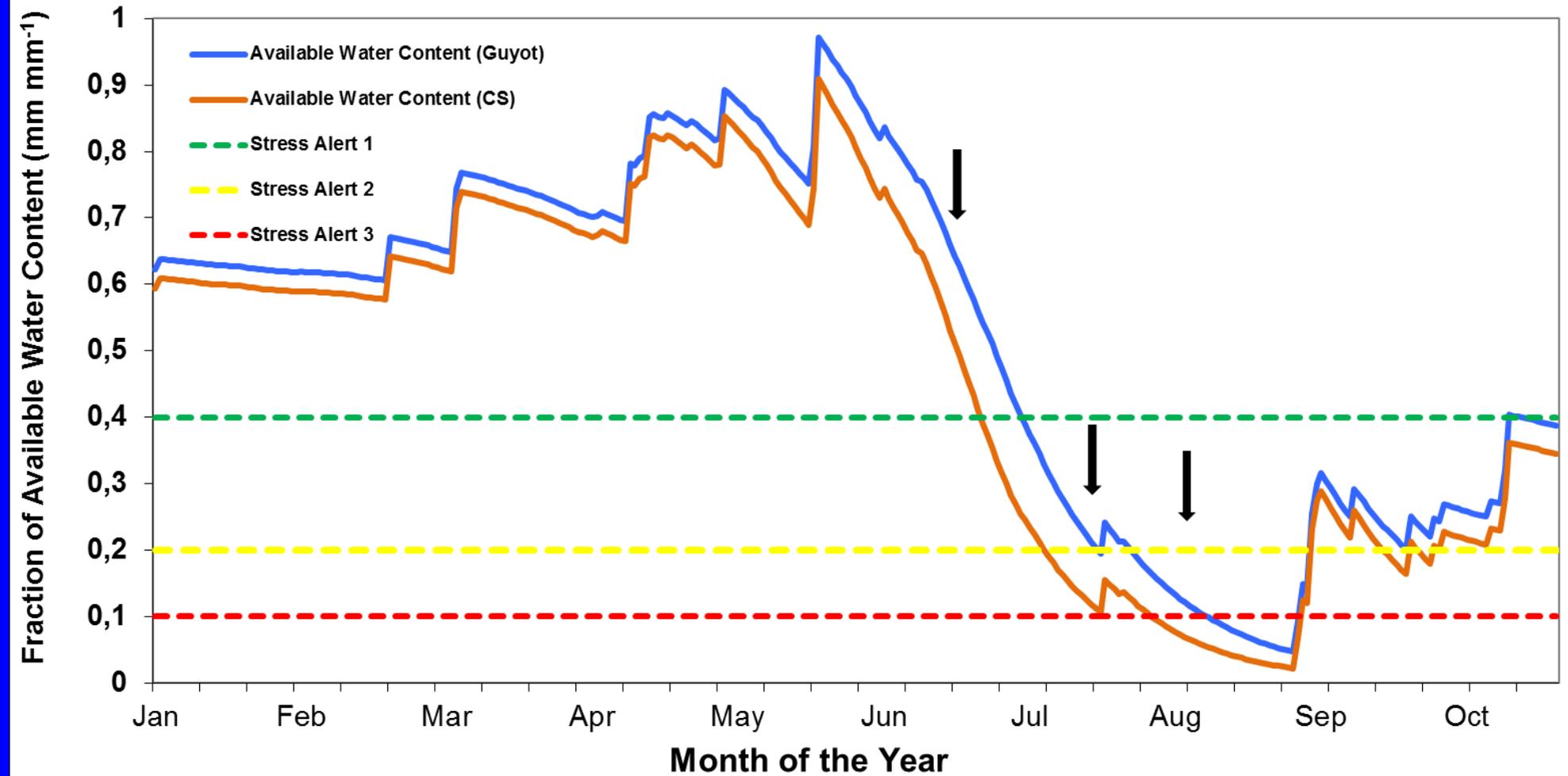
POTENZIALITÀ

1. OTTIMA CORRELAZIONE CON LWP (potenziale idrico fogliare)
2. PUO GUIDARE IRRIGAZIONE DI PRECISIONE
3. MISURE A TERRA TIME CONSUMING
4. CAMERE PER DRONI O CAMERE A TERRA

LIMITI

1. INDICE ISTANTANEO
2. DIFFICILE DA CALCOLARE TREF (TDRY & TWET)
3. CONDIZIONI METEO RILEVANTI
4. PRODOTTI SATELLITARI (TIR) A BASSA RISOLUZIONE

Water Balance Yr. 2012 [Guyot vs CS]



Risposta dei vitigni allo stress idrico



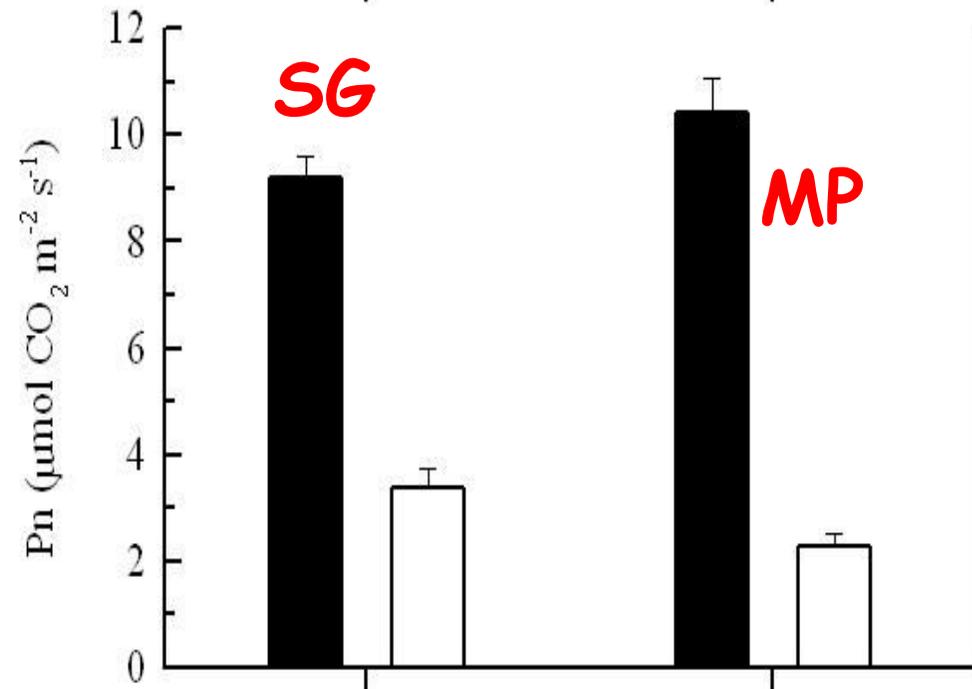
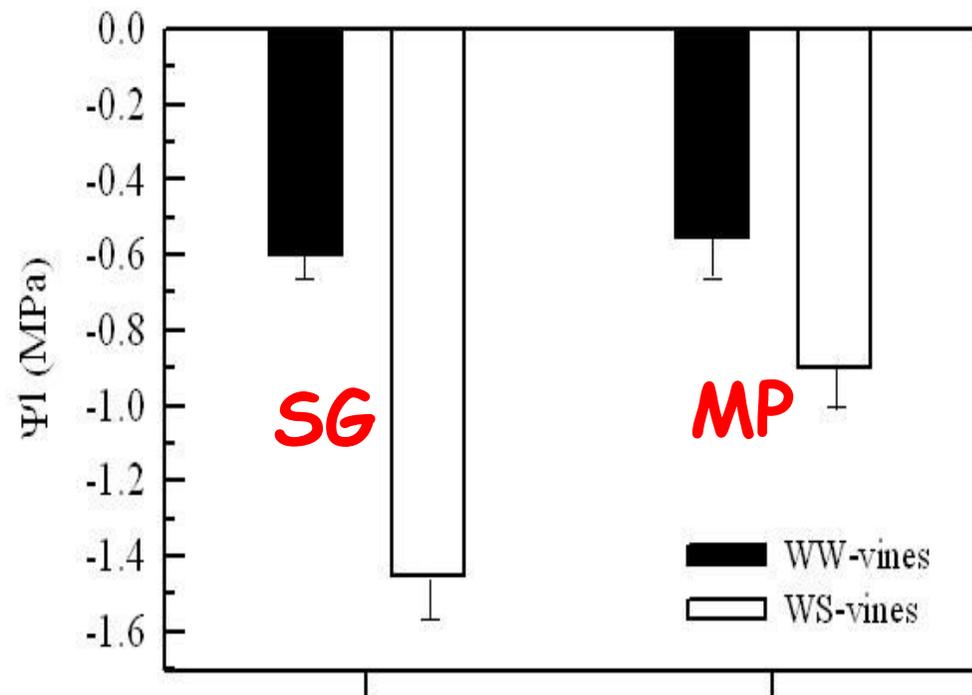
cv. SANGIOVESE



cv. MONTEPULCIANO

Quale dei due si sta comportando meglio?





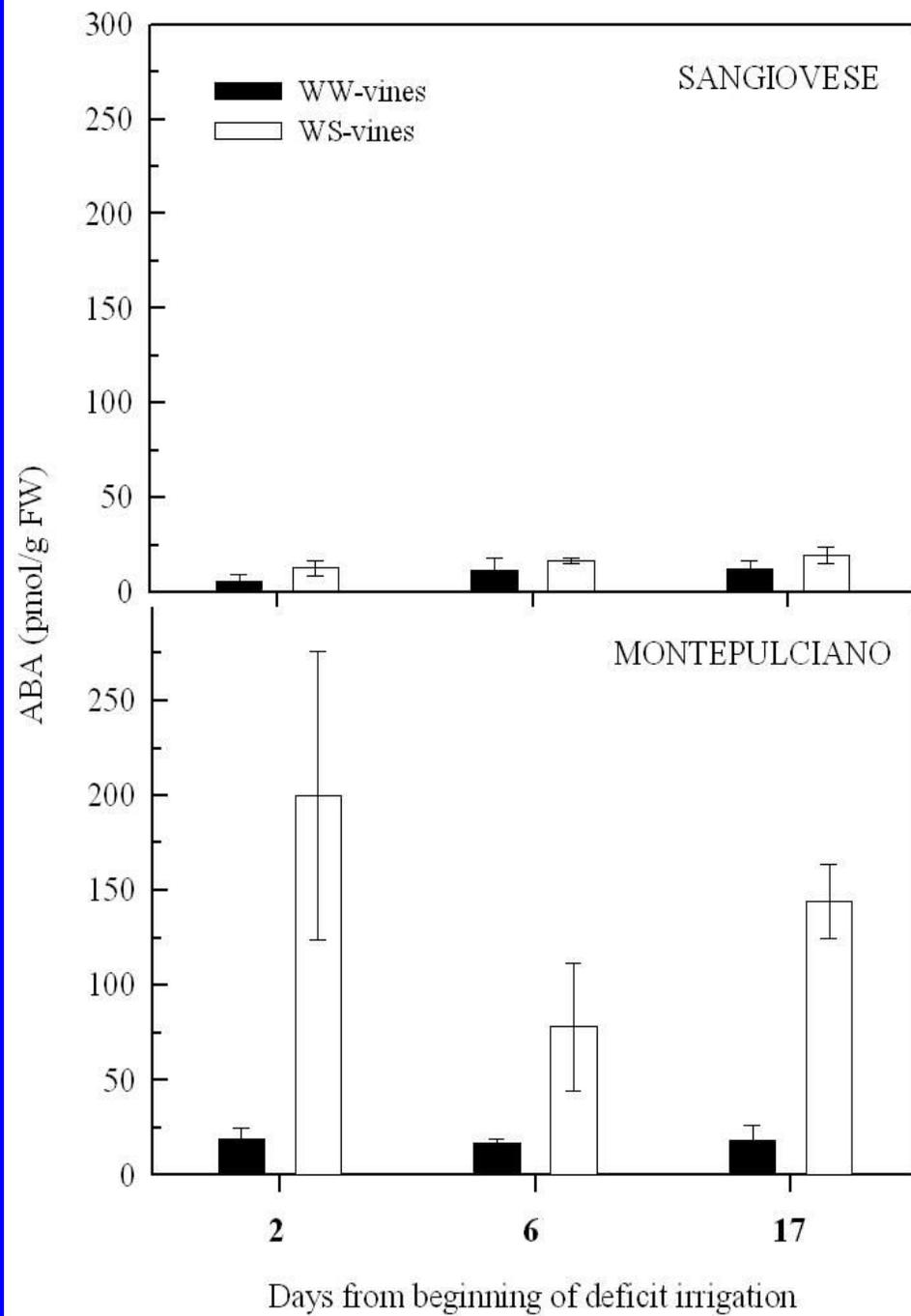






Foto 4. Ceppi di Grechetto G109 con evidenti fenomeni di clorosi e necrosi delle foglie, soprattutto basali, conseguenti a fenomeni di fotoinibizione cronica verificatesi nell'estate del 2003 a causa della combinazione stress idrico ed elevati regimi termici e radiativi.



Foto 5. Ceppi di Grechetto G5 caratterizzati nell'estate del 2003 da assenza di fotoinibizione e da foglie pienamente turgide e verdi, indipendentemente dall'età e dalla posizione nella chioma.

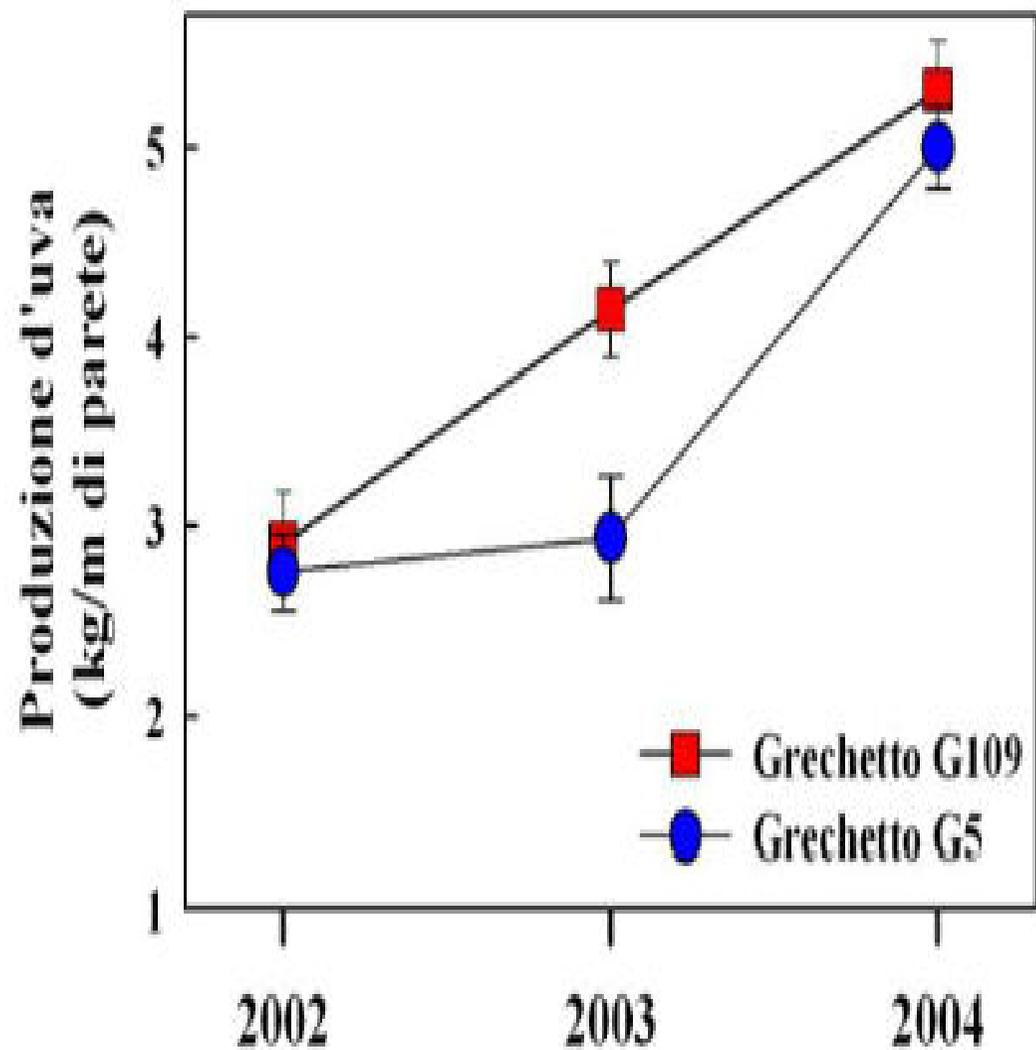


Figura 5. Produzioni d'uva rilevate triennio 2002/2004 nel Grechetto G109 e Grechetto G5 entrambi innestati sul portinnesto SO4 ed allevati a cordone libero.

TABLE 1. List of grapevine varieties categorized as a function of the response of the water potential to water deficit (iso- or anisohydric), cultivated in soil (F) or in pots (P), with the corresponding range of values of water potential measured in each experiment

Variety	Category	Set-up	Range of ψ (MPa)	References
'Chardonnay'	Anisohydric	F and P	-0.4 to -1.0	Tyerman (2007), Vandeleur <i>et al.</i> (2009), Rogiers <i>et al.</i> (2009)
'Cabernet Sauvignon'	Anisohydric	F	-0.7 to -1.5	Williams and Baeza (2007)
	Isohydric	F	-0.25 to -1.5	Chalmers (2007)
'Falanghina'	Near-isohydric	F	-0.7 to -1.8	Giorio <i>et al.</i> (2007)
'Kékfrancos'	Near-isohydric	F	-0.1 to -1.2	Zsófi <i>et al.</i> (2008, 2009a, b)
'Grenache'	Near-isohydric	F and P	-0.2 to -1.4	Schultz (2003), Santesteban <i>et al.</i> (2009)
	(Not clear)	P	-0.2 to -0.4	Chouzouri and Schultz (2005)
'Lambrusco'	Isohydric	P	-0.6 to -1.2	Poni <i>et al.</i> (2009)
'Montepulciano'	Anisohydric	F	-	Silvestroni <i>et al.</i> (2005)
'Manto Negro'	Isohydric	F	-0.05 to -0.7	Medrano <i>et al.</i> (2003)
	Anisohydric	-	-	Lovisoló <i>et al.</i> (2010)
'Merlot'	Anisohydric	F	-0.8 to -1.3	Williams and Baeza (2007), Shellie and Glenn (2008)
'Portugiesier'	Near-isohydric	-	-0.1 to -0.9	Zsófi <i>et al.</i> (2008)
'Riesling'	Anysohydric	-	-	Lovisoló <i>et al.</i> (2010)
'Sangiovese'	Isohydric	F and P	-0.2 to -1.3	Poni <i>et al.</i> (2007), Silvestroni <i>et al.</i> (2005)
	Anysohidric	P	-0.55 to -1.3	Poni <i>et al.</i> (2007)
'Seedless Thomson'	Anysohidric	F	-0.7 to -1.3	Williams and Baeza (2007)
'Semillon'	Anisohydric	F and P	-0.4 to -1.8	Rogiers <i>et al.</i> (2009)
'Sultana'	Isohydric	P	-0.15 to -0.8	Paranychianakis <i>et al.</i> (2004)
'Syrah'	Anisohydric	F and P	-0.2 to -0.8	Schultz (2003), Chalmers (2007), Rogiers <i>et al.</i> (2009), Santesteban <i>et al.</i> (2009)
	(Not clear)	P	-0.2 to -1.4	Chouzouri and Schultz (2005)
'Tempranillo' (syn. 'Aragonez')	Isohydric	F and P	-0.05 to -1.3	Medrano <i>et al.</i> (2003), Antolín <i>et al.</i> (2006), Sousa <i>et al.</i> (2006)
	Near-isohydric	F	-0.2 to -1.5	Intrigliolo <i>et al.</i> (2005)
	Anisohydric	F and P	-	Lovisoló <i>et al.</i> (2010), Santesteban <i>et al.</i> (2009)
'Touriga Nacional'	Anisohydric	F	-0.2 to -1.5	Moutinho-Pereira <i>et al.</i> (2004)
'Viognier'	Near-isohydric	F	-	Shellie and Glenn (2008)

Teleki 5 C.	Sigmund Teleki (H)	1896	1
Teleki 8 B.	Sigmund Teleki (H)	1896	-
Teleki 8 B. Ferrari	Ferrari (I)	1921	-
Cosmo 2	Italo Cosmo (I)	1931	-
Cosmo 10	Italo Cosmo (I)	1931	-
Geisenheim 5 C	Heinrich Birk (D)	?	-
RSB1	Léné, Birolleau e Lafon (F)	1896	-
Binova	Franz Kober (A) ?	?	-
1103 Paulsen	Federico Paulsen (I)	1895	499
110 Richter	Franz G. Richter (F)	1902	188
140 Ruggeri	Antonio Ruggeri (I)	1894	176
775 Paulsen	Federico Paulsen (I)	1894	32
779 Paulsen	Federico Paulsen (I)	1894	21
1447 Paulsen	Federico Paulsen (I)	1896	-
17.37	Millardet e de Grasset (F)	~1900	-
57 Richter	Franz G. Richter (F)	~1902	-
99 Richter	Franz G. Richter (F)	1902	-
41 B	Millardet e de Grasset (F)	1892	13
Fercal	Pouget INRA (F)	1959	-
Gravesac	Pouget INRA (F)	1962	-
Börner	Carl Börner (D)	1989	
106.8	Millardet e de Grasset (F)	1882	
Golia	Alberto Pirovano (I)	1913	-
1045 Paulsen	Federico Paulsen (I)	1895	-
1616 Couderc	Georges Couderc (F)	~1900	-
Geisenheim 26 G	R. Goethe e H. Birk (D)	~1900	-
M 1	Università di Milano (I)	2014	-
M2	Università di Milano (I)	2014	-
M 3	Università di Milano (I)	2014	-
M 4	Università di Milano (I)	2014	-
Stano 50	Università di Bologna (I)	2014	-

Classifications of rootstocks based on their adaptations to water deficit

Name	Crossing	1971	1977	1985
		Samson and Castéran	Fregoni	Carbonneau
110R	<i>V. rupestris</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Good	High resistance	High resistance
140Ru	<i>V. rupestris</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Average	High resistance	High resistance
44-53M	<i>V. riparia</i> × <i>V. cordifolia</i> - <i>V. rupestris</i>	Good	High resistance	High resistance
1103P	<i>V. rupestris</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Good	High resistance	Resistance
SO4	<i>V. riparia</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Weak	Weak resistance	Resistance
99R	<i>V. rupestris</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Average	Average resistance	Resistance
3309C	<i>V. riparia</i> × <i>V. rupestris</i>	Good	Weak resistance	Sensitive
420A MGt	<i>V. riparia</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Weak	Weak resistance	Sensitive
Percal	<i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2' × <i>V. vinifera</i>	Average		Sensitive
5BB	<i>V. riparia</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Bad	Weak resistance	Sensitive
161-49C	<i>V. riparia</i> × <i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2'	Weak	Mid resistance	Sensitive
41B MGt	<i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2' × <i>V. vinifera</i>	Average	High resistance	Sensitive
Rupestris du Lot	<i>V. rupestris</i>	Bad	Weak resistance	Sensitive
101-14 Mt	<i>V. riparia</i> × <i>V. rupestris</i>	Bad	Weak resistance	Very sensitive
Riparia Gloire de Montpellier	<i>V. riparia</i>	Bad	Weak resistance	Very sensitive
333EM	<i>V. cinerea</i> var. <i>helleri</i> 'Ressequier#2' × <i>V. vinifera</i>	Good	Mid resistance	Very sensitive

Several rankings of drought tolerance due to :

- differences in soil properties and climate
- intensity and duration of water deficits
- choice of drought-related parameters.

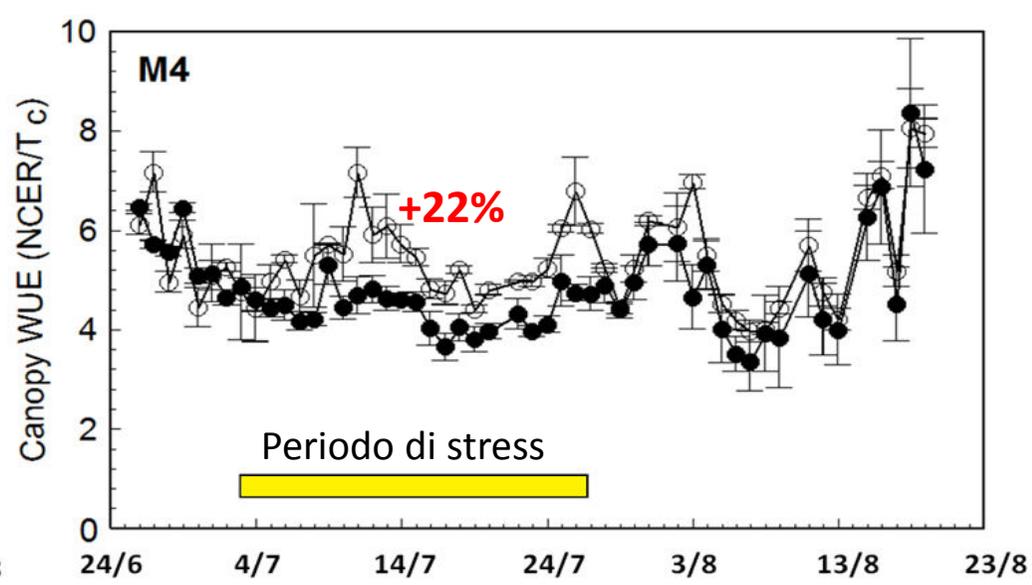
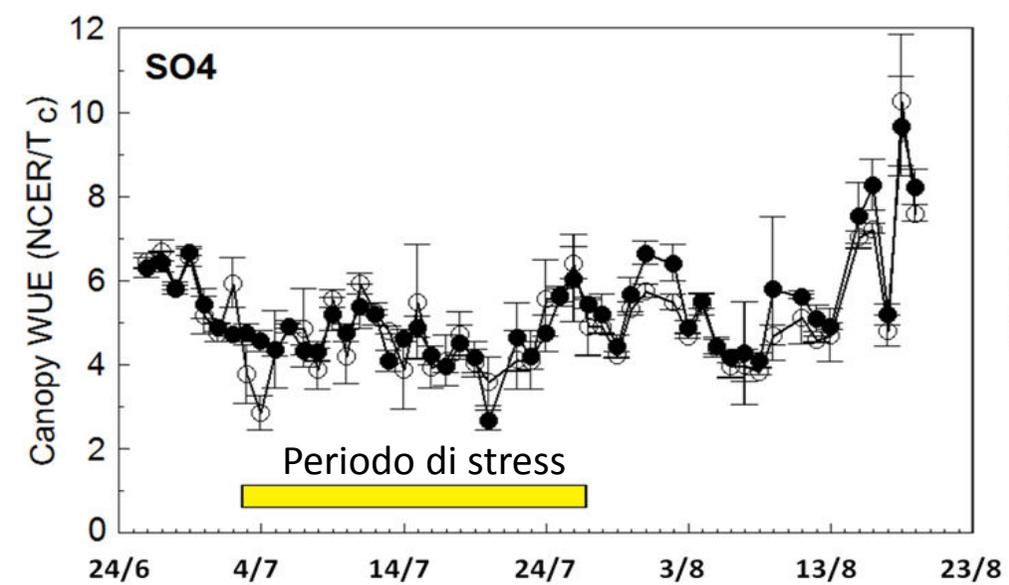
Portinnesti e stress multipli estivi



M3

M4

SO4



● Tesi irrigate ○ Tesi stressate



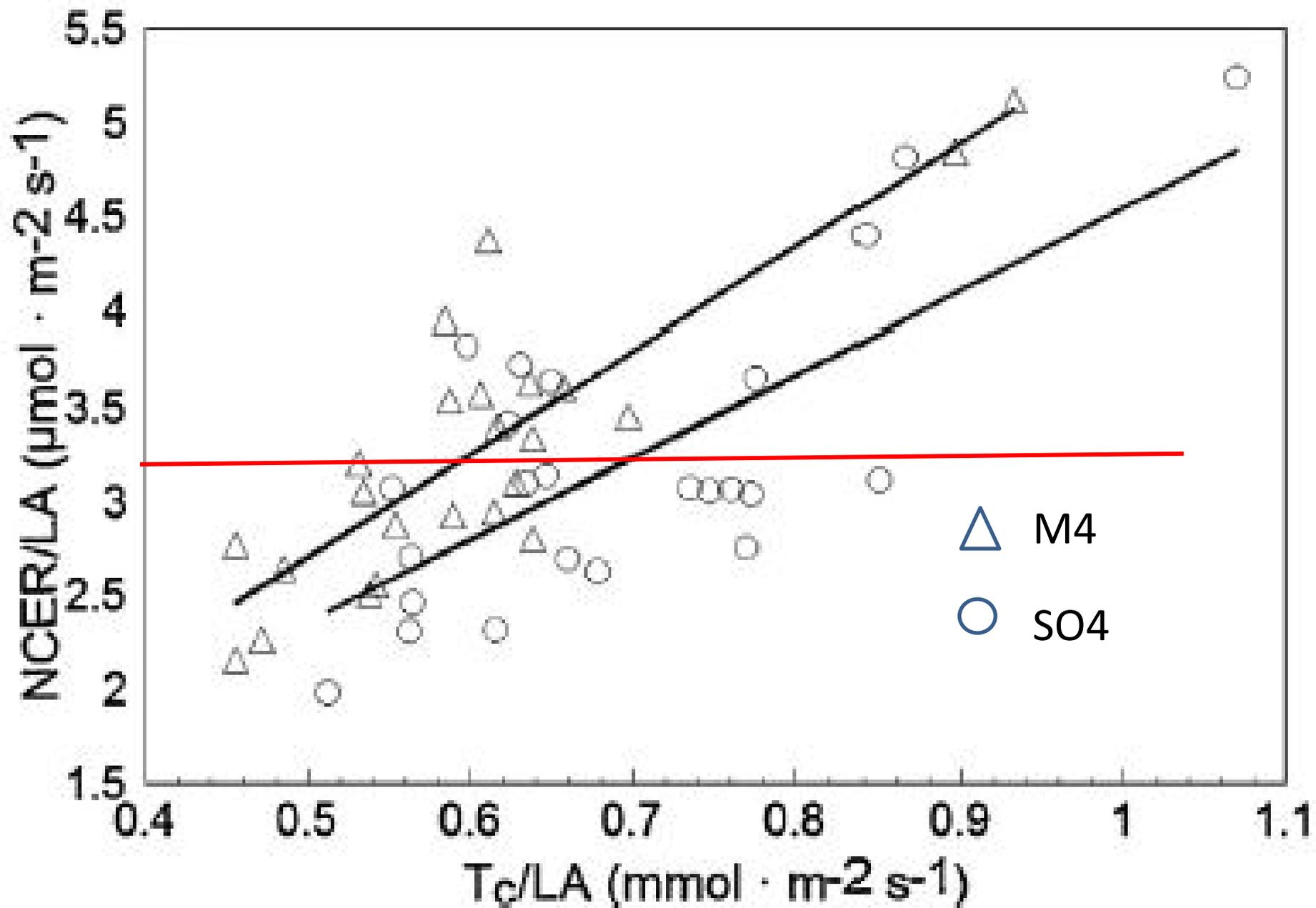


Table 1

Vegetative growth, yield components and source-sink balance indices (vine basis) recorded on Sangiovese grapevines either well-watered (WW) or subjected to a 50% canopy transpiration (T_c) water stress (WS) from DOY 184 until DOY 208. * and ** denote significant differences between treatments at $p < 0.05$ and 0.01 according to within column mean separation performed with SNK-test. ns = not significant. LA = leaf area.

	Shoots/vine	Pre-stress total LA (m ²)	Total final LA (m ²)	Primary LA (m ²)	Lateral LA (m ²)	Shed and yellow leaves/vine (% of total)	Clusters/vine	Cluster weight (g)	Yield/vine (kg)	LA/yield (m ² kg ⁻¹)	Carbon/fruit mass (nmol s ⁻¹ g ⁻¹)
WW-SO4	7.67	1.79	3.35	1.54	1.81	16.6	12.3	284a	3.50a	1.07b	4.447ab
WS-SO4	7.33	1.58	2.72	1.13	1.59	25.4	11.7	223b	2.60ab	1.22b	3.733b
WW-M4	8.33	1.88	3.45	1.57	1.88	16.1	10.3	272a	2.81 ab	1.40b	5.247ab
WS-M4	6.67	2.08	3.63	1.73	1.90	25.6	8.3	223b	1.86b	2.25a	6.427a
sig.	ns	ns	ns	ns	ns	ns	ns	**	*	**	*

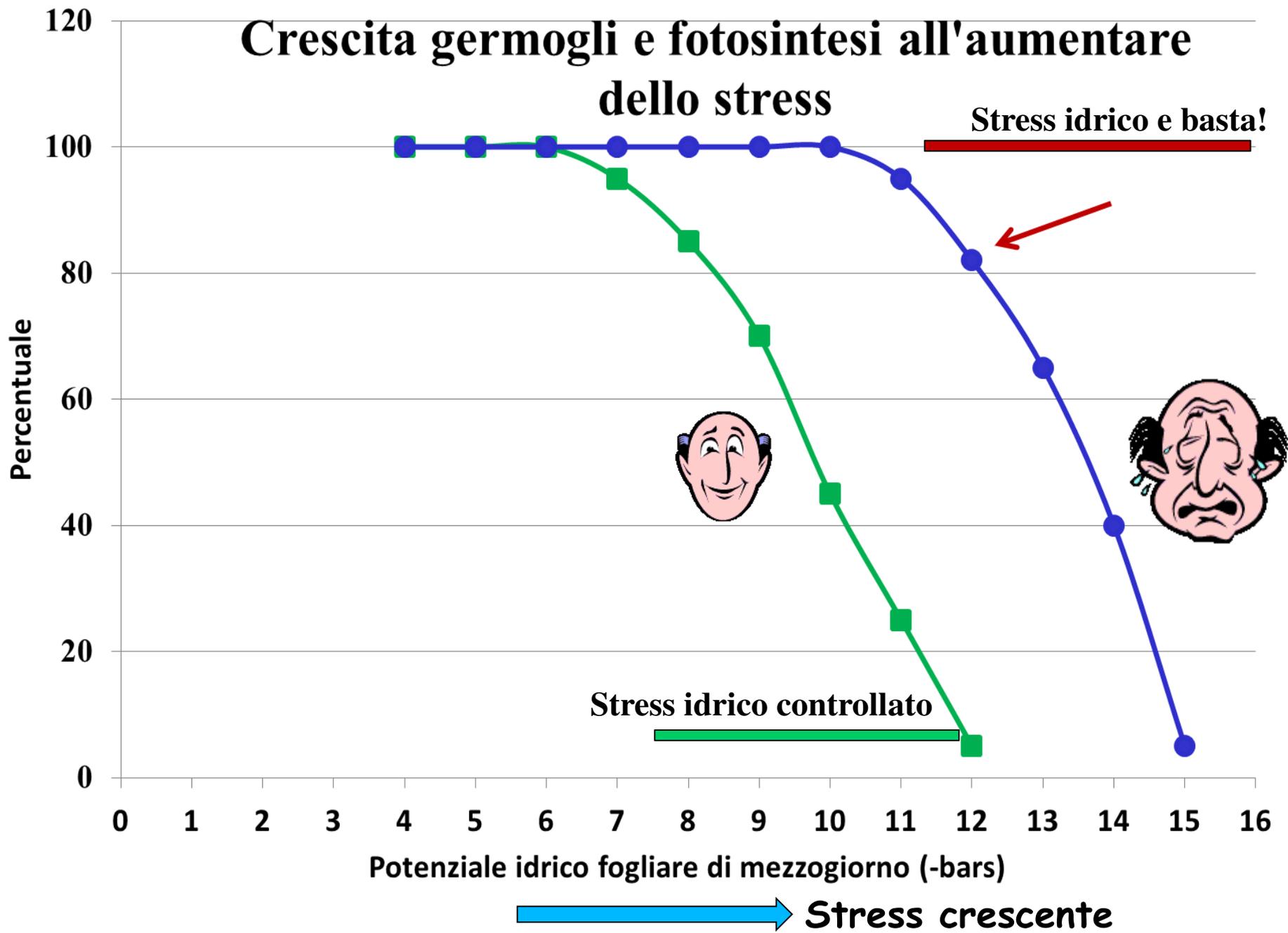
**Table 3**

Must composition recorded on Sangiovese grapevines either well-watered (WW) or subjected to a 50% canopy transpiration (T_c) water stress (WS) from DOY 184 until DOY 208. * and ** denote significant differences between treatments at $p < 0.05$ and 0.01 according to within column mean separation performed with SNK-test. ns = not significant.

	Total soluble solids (°Brix)	pH	Titrateable acidity (g L ⁻¹)	Tartaric acid (g L ⁻¹)	Malic acid (g L ⁻¹)	K ⁺ (ppm)	Total anthocyanins mg berry ⁻¹ mg g ⁻¹	Total phenolics mg berry ⁻¹ mg g ⁻¹		
WW-SO4	18.7b	3.17b	7.41a	8.69a	2.36b	1689b	1.27a	0.45a	4.83a	1.73b
WS-SO4	18.1b	3.19ab	7.22a	8.30b	1.98b	1750ab	0.61b	0.25b	4.19b	1.72b
WW-M4	18.6b	3.27ab	7.54a	7.90c	3.01a	1776ab	1.09ab	0.39ab	4.85a	1.73b
WS-M4	20.4a	3.32a	6.38b	7.61c	2.21ab	1809a	1.27a	0.49b	5.33a	2.07a
sig.	**	**	**	**	**	*	**	*	**	**



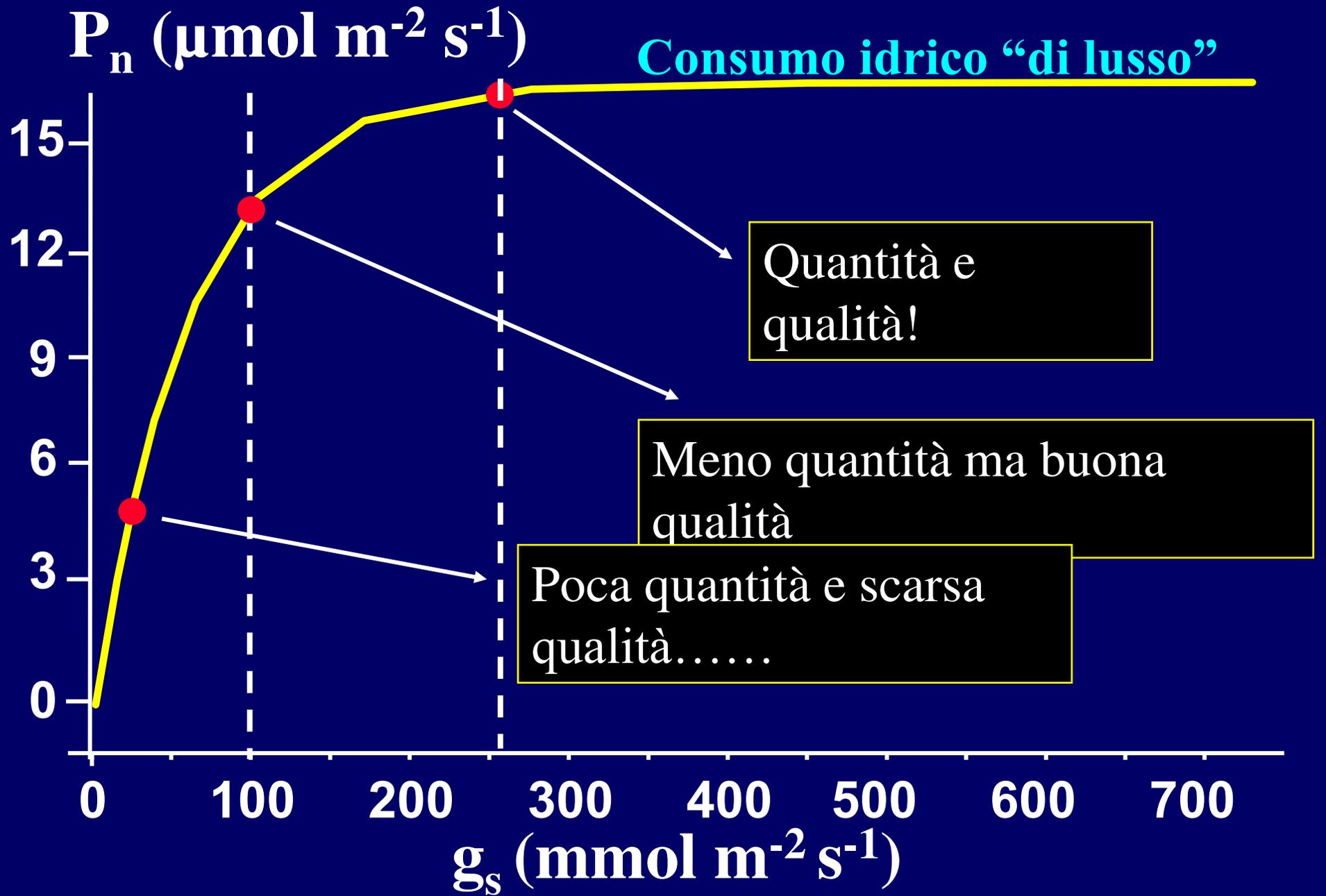
Crescita germogli e fotosintesi all'aumentare dello stress



Stress idrico e basta!

Stress idrico controllato

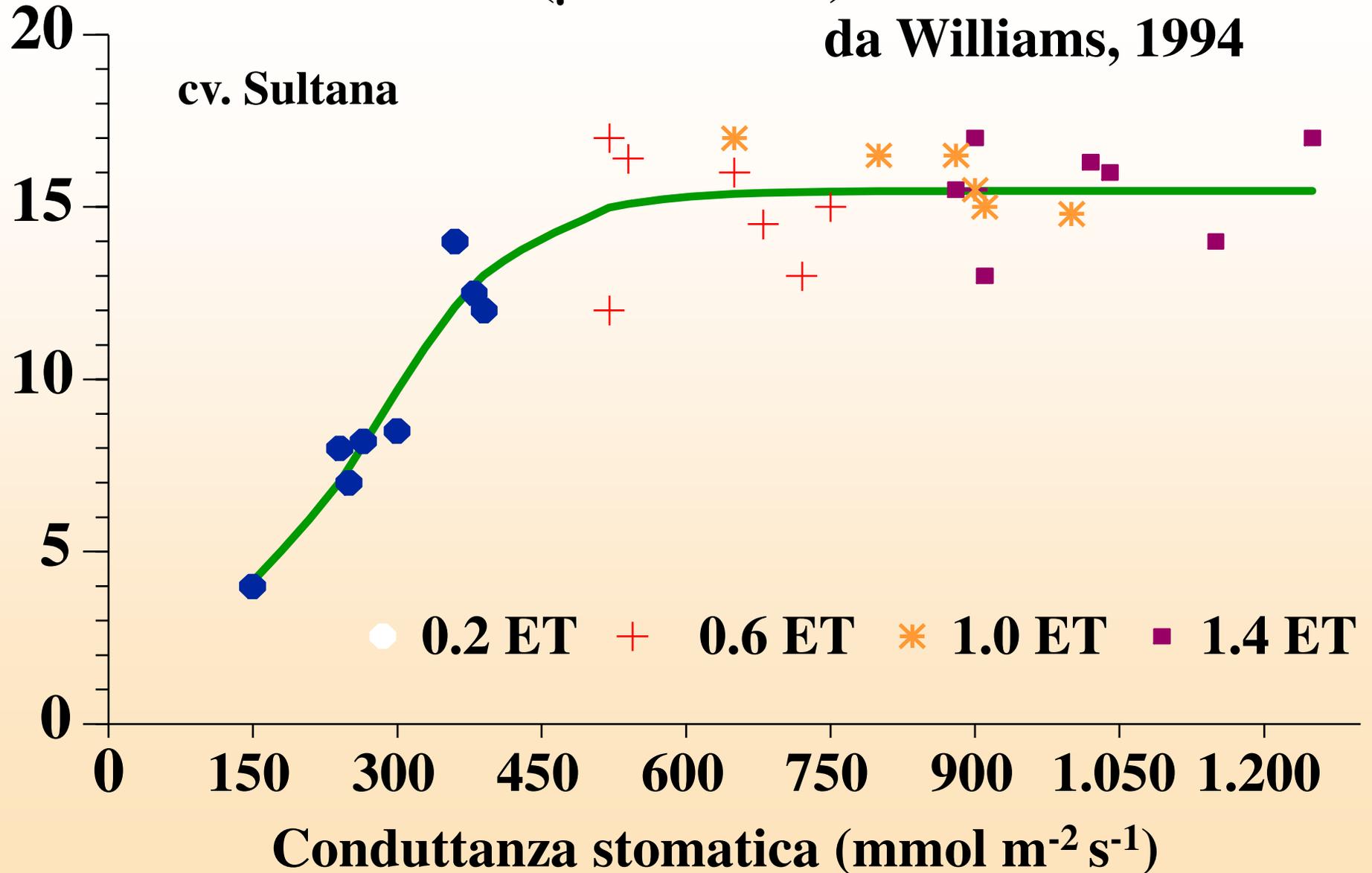
Stress crescente



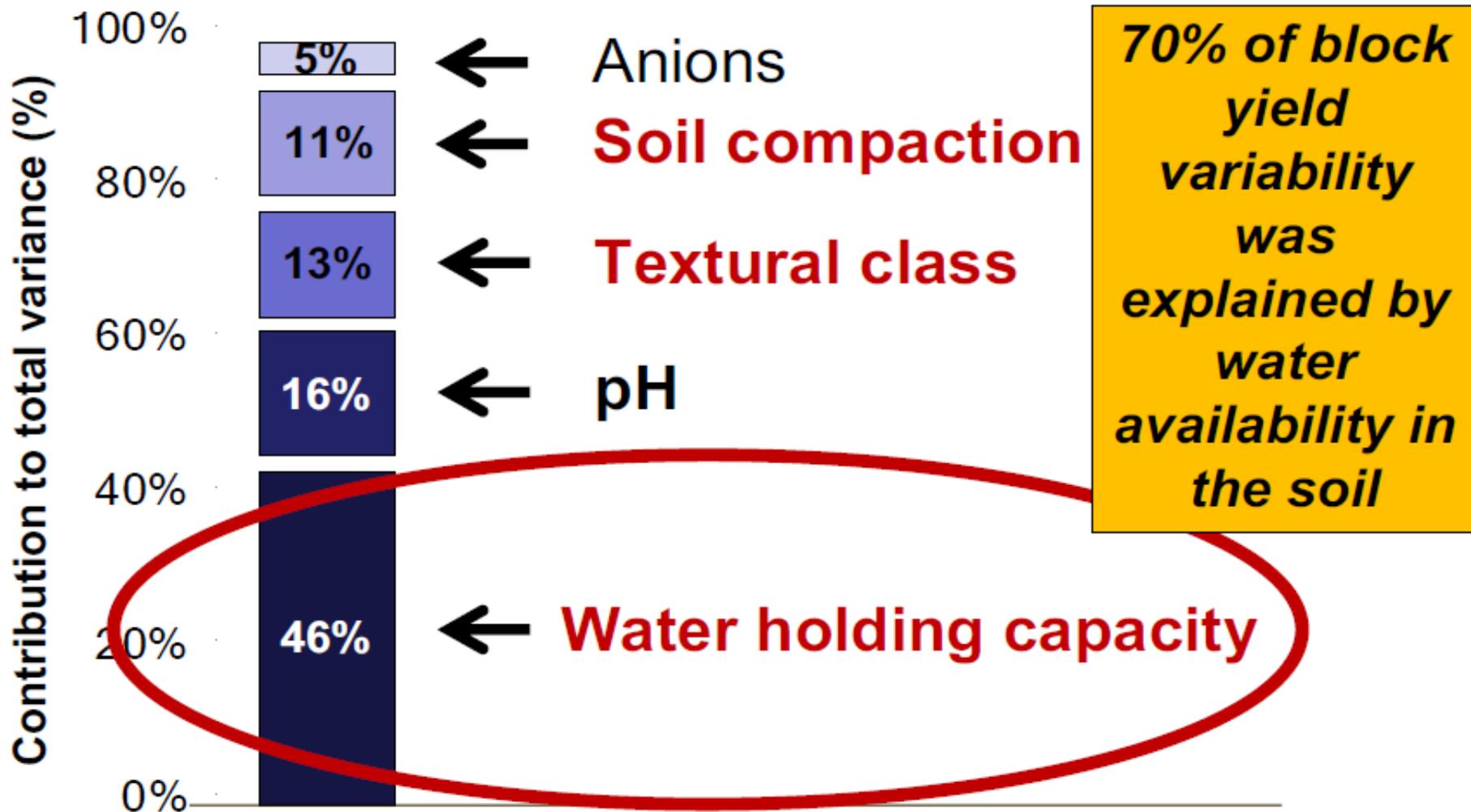
Fotosintesi netta ($\mu\text{mol m}^{-2} \text{s}^{-1}$)

da Williams, 1994

cv. Sultana

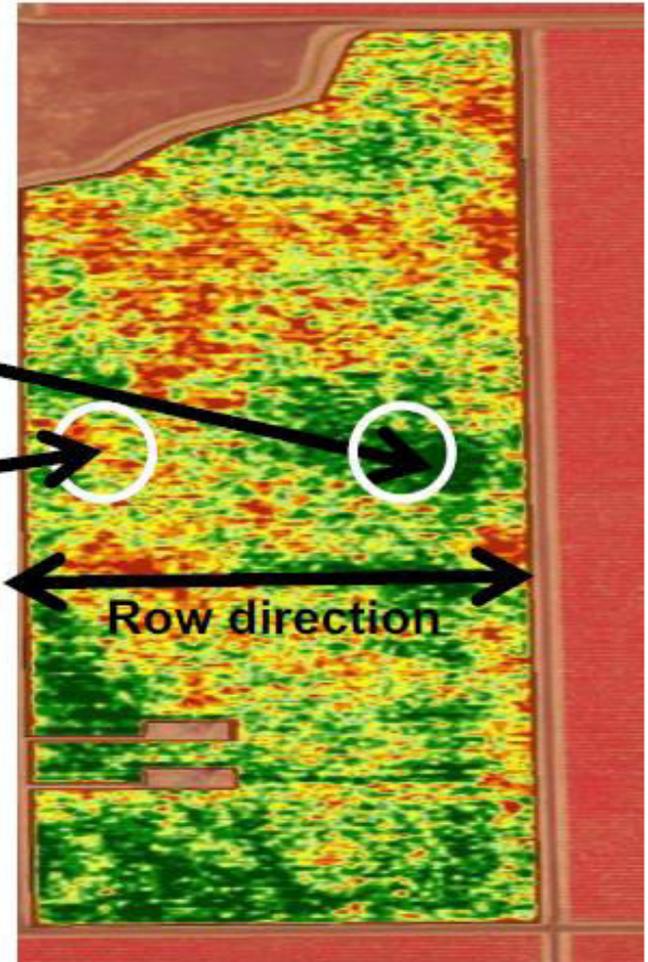
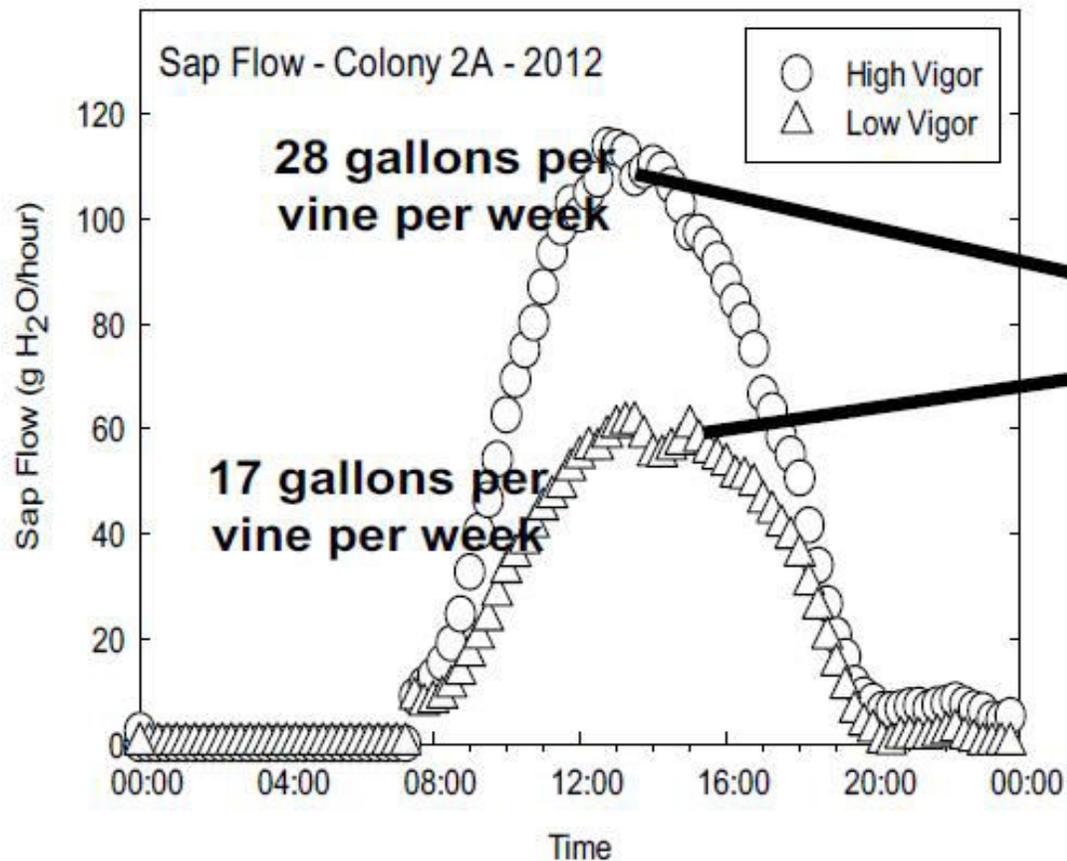


Relative importance of soil parameters to block yield variability

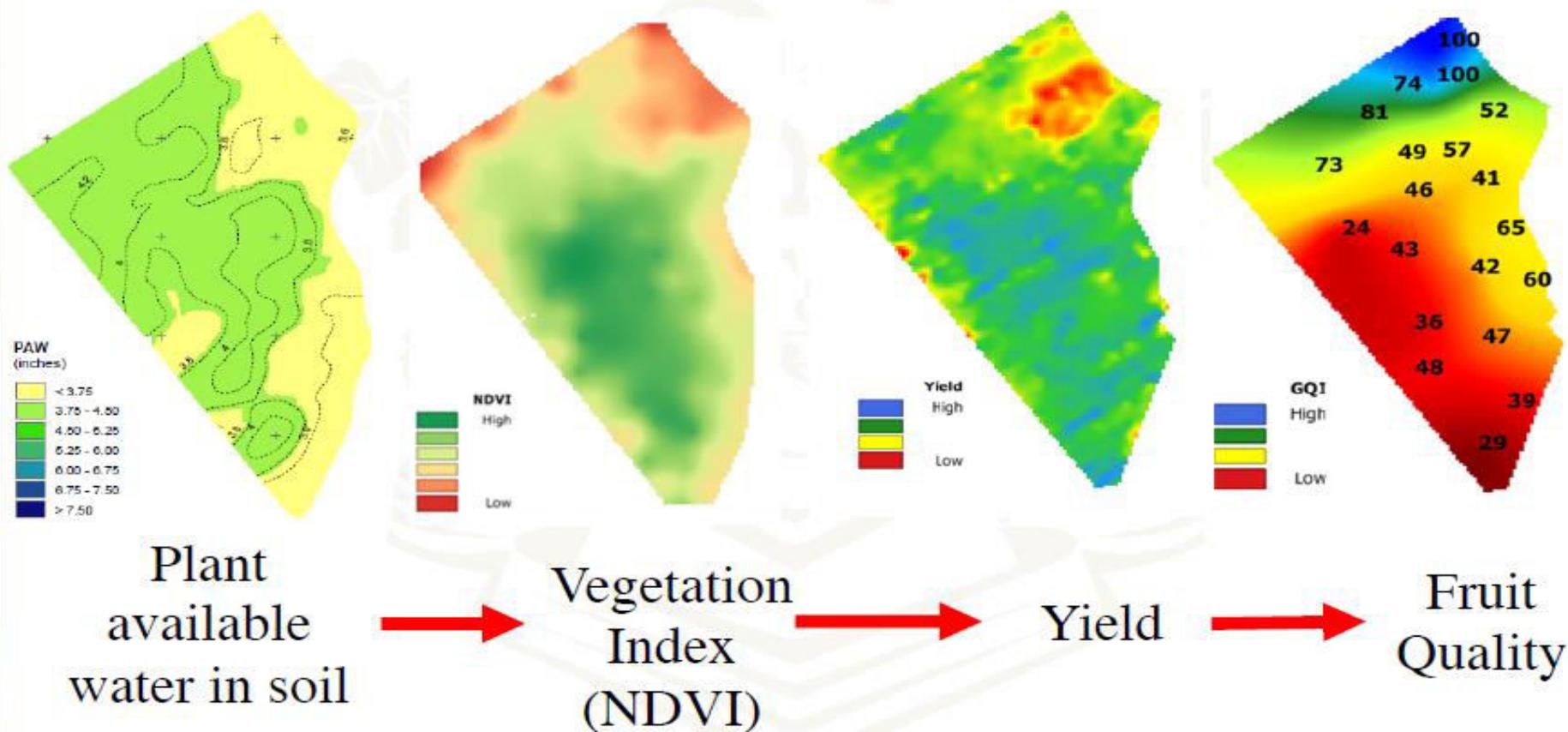


Real-time data analytics

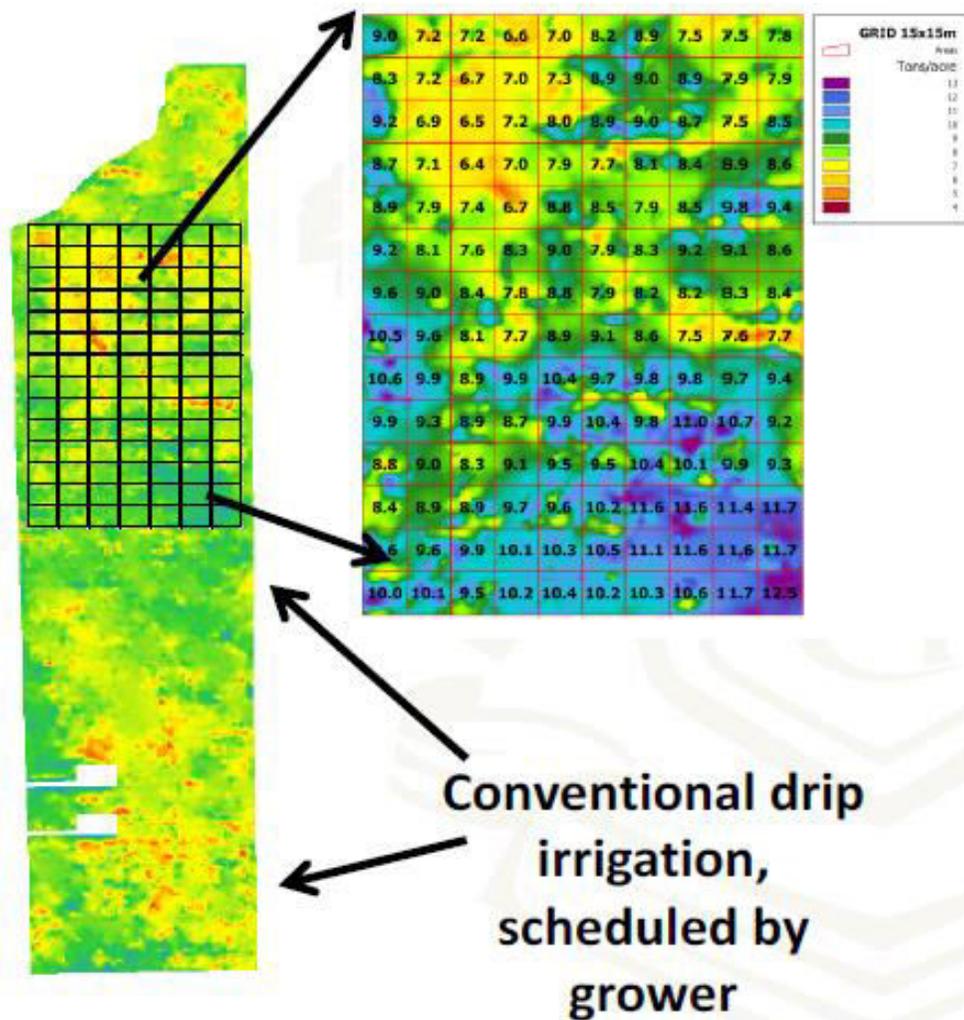
Water use variability



Integrated data analytics - modeling



Variable rate drip irrigation



Block selected for study based on characterized yield variability

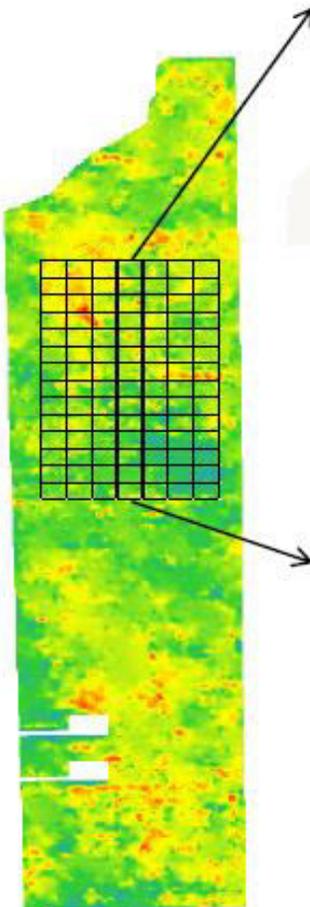
Block size ~30 acres; 10 acres placed under VRDI

VRDI block divided into 140, 50 vine irrigation zones – interpolated from LANDSAT 30m x 30m pixels

Each zone (50 vines) controlled independently

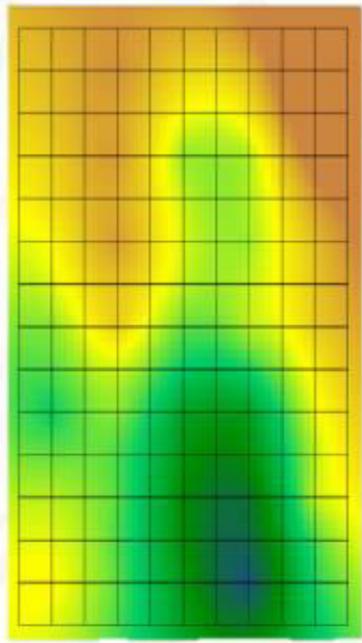
Adjacent portion of block run with standard drip irrigation for comparison

Changes in canopy vigor (NDVI)

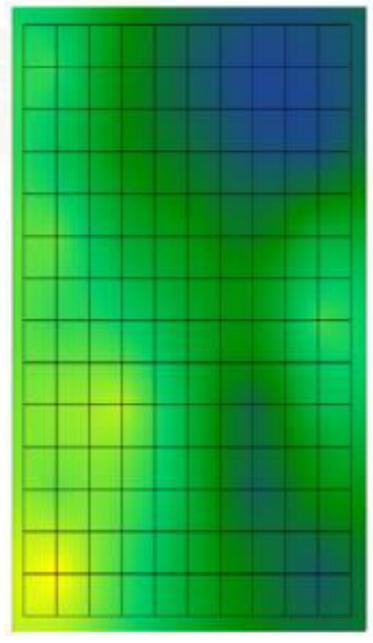


GRID 15x15m										
Area										
Tons/acre										
9.0	7.2	7.2	6.6	7.0	8.2	8.9	7.5	7.5	7.8	
8.3	7.2	6.7	7.0	7.3	8.9	9.0	8.9	7.9	7.9	
9.2	6.9	6.5	7.2	8.0	8.9	9.0	8.7	7.5	8.5	
8.7	7.1	6.4	7.0	7.9	7.7	8.1	8.4	8.9	8.6	
8.9	7.9	7.4	6.7	8.8	8.5	7.9	8.5	9.8	9.4	
9.2	8.1	7.6	8.3	9.0	7.9	8.3	9.2	9.1	8.6	
9.6	9.0	8.4	7.8	8.8	7.9	8.2	8.2	8.3	8.4	
10.3	9.6	8.1	7.7	8.9	9.1	8.6	7.5	7.6	7.7	
10.6	9.9	8.9	9.9	10.4	9.7	9.8	9.8	9.7	9.4	
9.9	9.3	8.9	8.7	9.9	10.4	9.8	11.0	10.7	9.2	
8.8	9.0	8.3	9.1	9.5	9.5	10.4	10.1	9.9	9.3	
8.4	8.9	8.9	9.7	9.6	10.2	11.6	11.6	11.4	11.7	
9.6	9.6	9.9	10.1	10.3	10.5	11.1	11.6	11.6	11.7	
10.0	10.1	9.5	10.2	10.4	10.2	10.3	10.6	11.7	12.9	

Colony 2A
Cabernet Sauvignon
2012 yield map



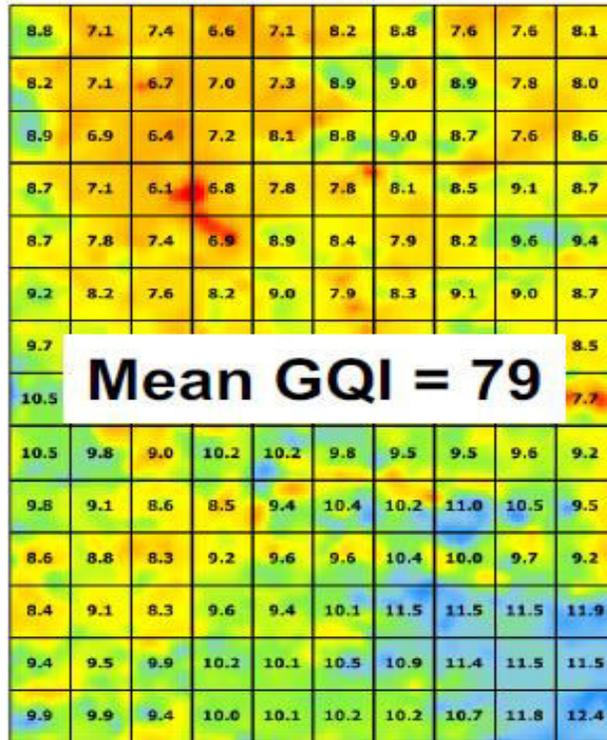
July 2012



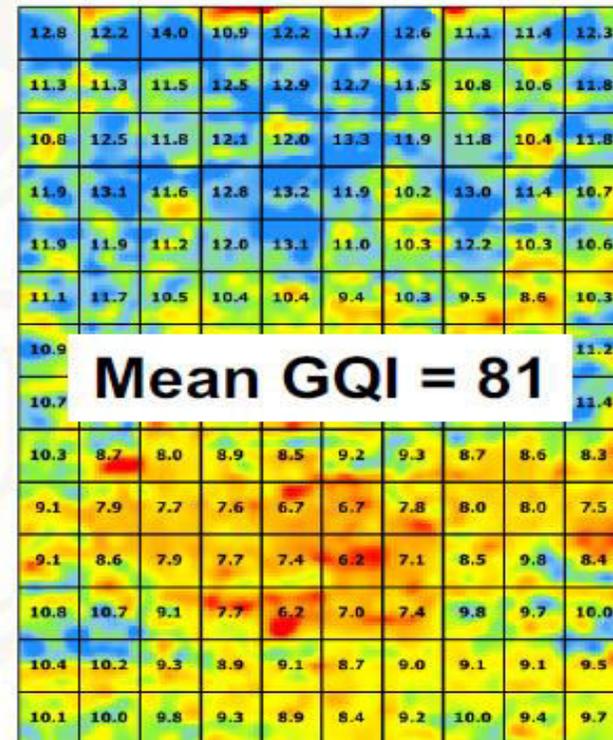
July 2013

Variable rate drip irrigation

Impact of Precision Irrigation



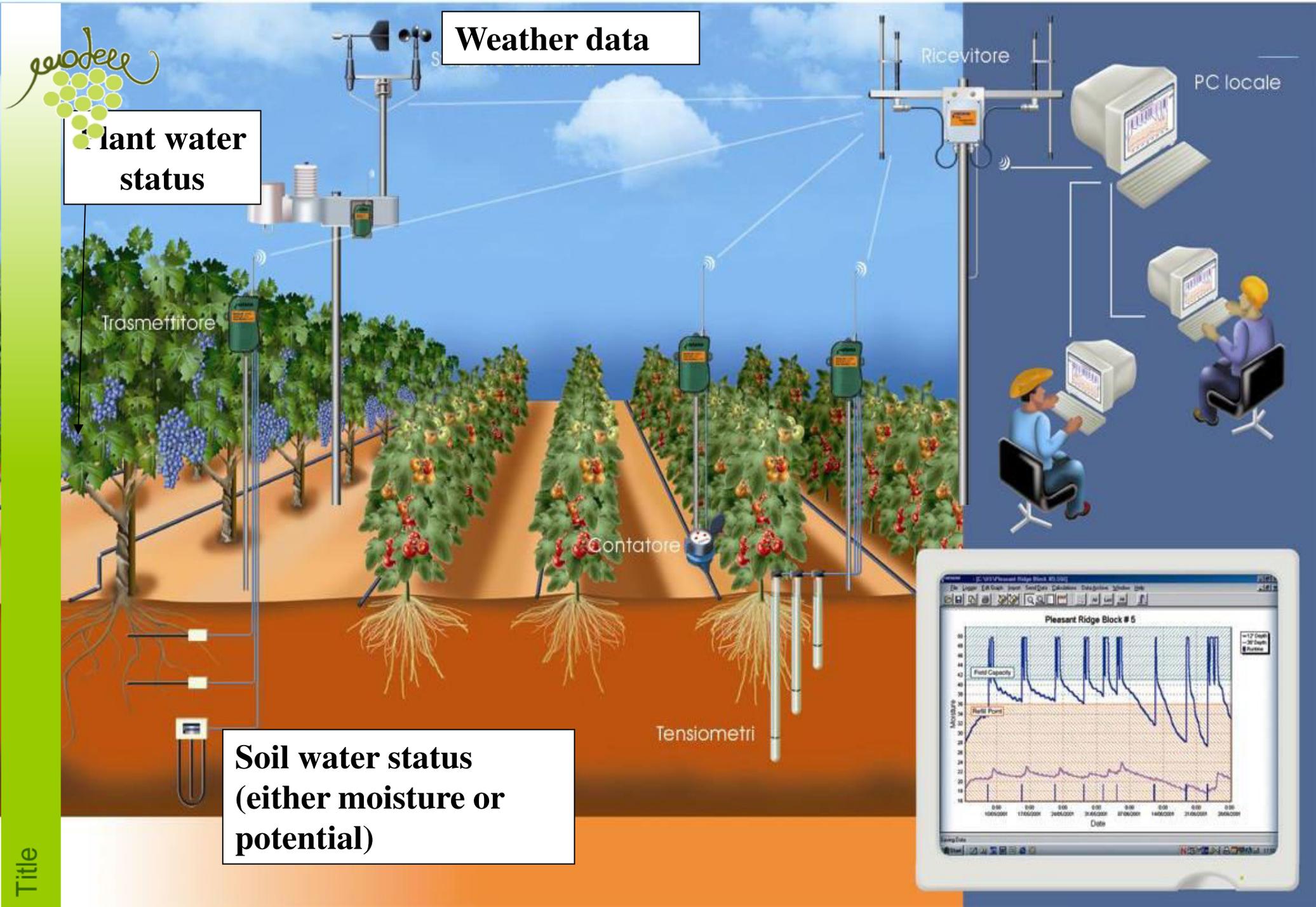
2012 Block Yield
15.1 tons/ha



2014 Block Yield
18.5 tons/ha

Yield improved 20%; Water use efficiency improved 30%





Weather data

Plant water status

Trasmettitore

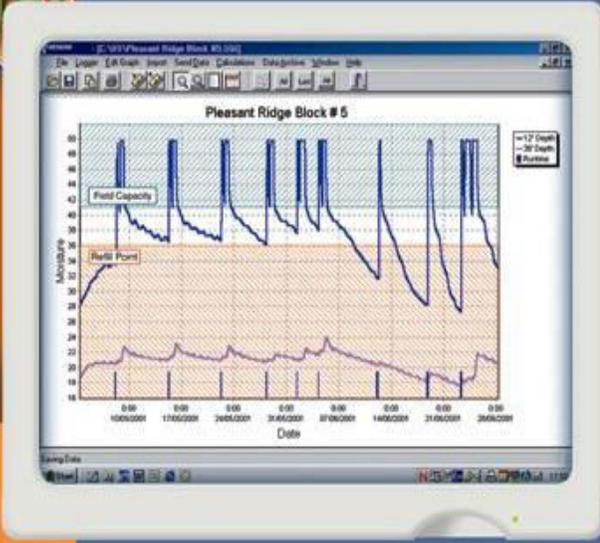
Contatore

Tensiometri

Ricevitore

PC locale

**Soil water status
(either moisture or potential)**



Disegnare il vigneto 4.0 a «basso consumo idrico»

- Favorire la capacità di invaso primaverile dei suoli
- Il ruolo dell'inerbimento (deve aumentare la capacità di infiltrazione ma non competere!)
- Regolare lo sviluppo della chioma e la quota esposta al sole (e quindi traspirante) attraverso oculati interventi di potatura estiva
- Scelta consapevole di vigneto/portinnesto basata da dati oggettivi di screening.
- Con ausilio di mezzi ICT (WSN, IoT, DSS, mappe termiche) pervenire a diagnosi **precoci** affidabili!
- Implementare modelli di integrazione idrica di tipo «conservativo» (es. Reintegro di frazione ET, bagnatura porzione radici, ricalcolo dei Kc, interventi di «precisione»).

Espressione di geni marcatori di stress idrico nei principali vitigni Emiliano-Romagnoli



- ✓ Risposta fisiologica e trascrittomica a cicli rapidi di stress idrico seguiti da re-idratazione.
- ✓ Inserimento della variabile «alta» o «bassa» domanda traspiratoria da parte dell'atmosfera.
- ✓ Ricerca di geni comuni marcatori dello stress idrico



**Grazie
dell'attenzione**

