

Table 2. Summary of typically observed variation in leaf metabolism and thermal responses across the vertical gradient and/or between sun and shade leaves

trait	Symbol	units	response	forest type(s)	reference(s)*
Stomatal conductance					
max stomatal conductance	$g_{s\ max}$	$\text{mol m}^{-2} \text{s}^{-1}$	↑ with height	TrB, TeB, BoN	1, 2, 4
			↑ with light	TrB, TeB, TeN, BoN	8, 9, 10, 7, 4
leaf hydraulic conductance	K_{leaf}	$\text{m}^{-2} \text{s}^{-1} \text{MPa}^{-1}$	↑ with light	TeB	41
stomatal conductance limitation with temperature	g_s	$\text{mol m}^{-2} \text{s}^{-1}$	↑ with height	TrB, TeN	9, 40, 5, 6, 7
stomatal conductance at optimal temperature	$g_s \text{ at } T_{opt}$	$\text{mol m}^{-2} \text{s}^{-1}$	↑ with light	TrB, TeN	9, 40, 7
			≈↑ with height	TeB	11
boundary-layer conductance	g_a	$\text{mmol}^{-2} \text{s}^{-1}$	↓ with height	TrB	40
			≈↑ with light	TrB	8
			↑ with height	TrB	3
	g_{bv}	mm s^{-1}	↑ with height	TeN	12
	g_{bv}	mm s^{-1}	↑ with light	TrB	3
Photosynthesis	$A_{max\ area}$	$\text{mol m}^{-2} \text{s}^{-1}$	≈ with light	TeN	12
			≈ with height	TeN	12
			≈ with light	TeN	12
	$A_{max\ mass}$	$\text{nmol g}^{-1} \text{s}^{-1}$	↑ with height	TrB, TeB, BoN	14, 11, 15, 4
			≈↓ with height	TeB	16
maximum photosynthetic capacity	$A_{max\ area}$	$\text{mol m}^{-2} \text{s}^{-1}$	↑ with light	TrB, TeB, TeN, BoN	14, 17, 18, 19, 10, 4
			≈ with height	TrB	20, 21
			≈ with light	TrB, TeB, TeN	20, 21, 19
maximum light-saturated net photosynthesis	A_{sat}	$\mu\text{mol m}^{-2} \text{s}^{-1}$	↑ with height	TrB, TeB	22, 23
A_{sat} at optimum temperature	A_{opt}	$\mu\text{mol m}^{-2} \text{s}^{-1}$	↑ with light	TrB, TeB	8, 23
			≈↑ with height	TrB, TeB	13, 11
			↑ with height	TrB	40
			↑ with light	TrB	8, 13

trait	Symbol	units	response	forest type(s)	reference(s)*
optimum temperature for photosynthesis	T_{opt}	°C	≈ with height	TrB, TeB	24, 11, 13
			↓ with height	TrB	40
			≈ with light	TrB, TeB	9, 8, 11
photosynthetic light compensation point	LCP	μmol m ⁻²	↑ with height	TrB, TeB, TeN	25, 16
			↑ with light	TrB, TeB, TeN	8, 17, 16
maximal carboxylation rate	$V_{cmax\ area}$	μmol m ⁻² s ⁻¹	↑ with height	TrB, TeB	2, 23, 14
			↑ with light	TrB, TeB, BoN	9, 23, 14, 10
	$V_{cmax\ mass}$	nmol g ⁻¹ s ⁻¹	≈ with height	TrB, TeB	2, 23
			≈ with light	TrB, TeB	2, 23
		nmol CO ₂ g ⁻¹ s ⁻¹	≈↓ with light	TeB	26
optimum temperature for V_{cmax}	$V_{cmax}(T_{opt})$	μmol m ⁻² s ⁻¹	≈↑ with height	TeB	11
			≈ with light	TrB	9
electron transport rate	$J_{max\ area}$	μmol m ⁻² s ⁻¹	↑ with height	TrB, TeB	2, 40, 23, 14
			↑ with light	TrB, TeB	9, 23, 27, 14
	$J_{max\ mass}$	nmol g ⁻¹ s ⁻¹	≈ with height	TrB, TeB	2, 23
			≈ with light	TrB, TeB	2, 23
		nmol e ⁻¹ g ⁻¹ s ⁻¹	≈↓ with light	TeB	26
optimal temperature of J_{max}	T_{optETR}	°C	↓ with height	TrB	40
	$J_{max}(T_{opt})$	μmol m ⁻² s ⁻¹	≈ with light	TrB	9
photosynthetic heat tolerance	T_{50}	°C	↓ with height**	TrS	31
			≈↑ with light	TrB, TeB	8, 17
critical temperature beyond which Fv/Fm declines	T_{crit}	°C	≈↑ with light	TrB, TeB	8
high-temperature CO ₂ compensation point	T_{max}	°C	≈ with height	TrB	22
			≈ with light	TrB	8

trait	Symbol	units	response	forest type(s)	reference(s)*
Respiration					
respiration rate at 25 °C	R	$\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$	↑ with height	TrB, TeB, TeN	40, 32, 33, 34
		$\mu\text{mol CO}_2 \text{ kg}^{-1} \text{ s}^{-1}$	≈ with height	TrB, TeB, TeN	32, 33
dark respiration	$R_{dark a}$	$\mu\text{mol m}^{-2} \text{ s}^{-1}$	↑ with light ↑ with height	TrB, TeN TrB, TeB, BoN	32, 34, 22, 14, 35, 23, 39
	$R_{dark m}$	$\text{nmol g}^{-1} \text{ s}^{-1}$	↑ with light ≈ ↑ with height ≈ with light	TrB, TeB, TeN, BoN TrB TrB	22, 14, 23, 17, 10, 39 2, 36 2, 36
dark respiration at reference T	$R_{dark}(T_{ref})$	$\mu\text{mol m}^{-2} \text{ s}^{-1}$	↑ with height	TrB, TeB, TeN	22, 14, 35, 33
		$\mu\text{mol (kg leaf)}^{-1} \text{ s}^{-1}$	↑ with height	TrB, TeB, TeN	22, 14, 35, 33
		$\mu\text{mol (kg N)}^{-1} \text{ s}^{-1}$	↑ with height	TeB, TeN	35, 33
temperature sensitivity of R_{dark}	Q_{10}	$\mu\text{mol m}^{-2} \text{ s}^{-1} \text{ }^{\circ}\text{C}^{-1}$	↑ with light ≈ with height	TrB, TeB TrB, TeB, TeN	22, 8, 35. 22, 40, 35, 34
		$^{\circ}\text{C}^{-1}$	≈ ↑ with height ≈ ↓ with light ↑ with light	TeB, TeN TrB, TeB, TeN TeB	37, 33 22, 35, 34 37
light respiration	R_L	$\mu\text{mol m}^{-2} \text{ s}^{-1}$	↑ with height ↑ with light	TrB TrB	22 22
activation energy of respiration	E_0	$\text{kJ mol}^{-1} \text{ K}^{-1}$	≈ with height ≈ with light	TrB, TeB, TeN TrB	22, 38, 33 22, 8

*1. Kafuti et al. 2020; 2. Van Wittenberghe et al. 2012; 3. Roberts et al. 1990; 4. Dang et al. 1997; 5. Marenco et al. 2017; 6. Ambrose et al. 2015; 7. Zweifel et al. 2001; 8. Slot et al. 2019; 9. Hernandez et al. 2020; 10. Urban et al. 2007; 11. Carter and Cavaleri 2018; 12. Martin et al. 1999; 13. Mau et al. 2018; 14. Kosugi et al. 2012; 15. Niinemets et al. 2015; 16. Bachofen et al. 2020; 17. Hamerlynck and Knapp 1994; 18. Coble et al. 2017; 19. Wyka et al. 2012; 20. Rijkers et al. 2000; 21. Ishida et al. 1999; 22. Weerasinghe et al. 2014; 23. Scartazza et al. 2016; 24. Miller et al. 2021; 25. Harris and Medina 2013; 26. Legner et al. 2014; 27. Kitao et al. 2012; 28. Fauset et al. 2018; 29. Rey-Sanchez et al. 2016; 30. Muller et al. 2021; 31. Curtis et al. 2019; 32. Mier et al. 2001; 33. Turnbull et al. 2003; 34. Araki et al. 2017; 35. Bolstad et al. 1999; 36. Kenzo et al. 2015; 37. Harley et al. 1996; 38. Xu and Griffin 2006; 39. Atherton et al. 2017; 40. Carter et al. 2021; 41. Sack et al. 2003