

Table 1 Experimental estimates of flux control coefficients for enzymes in the Calvin–Benson cycle and the pathways of sucrose and starch synthesis

Enzyme	FCC	Excess	Species	Reference	Comments
Calvin–Benson cycle, FCC estimated for photosynthesis under ambient growth conditions					
RubisCO	0.35		Tobacco	Stitt and Schulze (1994); Mate <i>et al.</i> (1993)	This is the FCC under ambient conditions for plants grown under moderate light. The FCC rises to 1 if plants are suddenly transferred to saturating light, and falls to 0 if they are transferred to low light.
<i>GAPDH</i>	–	3	Tobacco	Price <i>et al.</i> (1995)	
<i>TPI</i>	–		Tobacco	Unpublished	
Aldolase	0.2		Potato	Haake <i>et al.</i> (1998, 1999)	Ambient photosynthesis is inhibited under a wide range of growth irradiances
pFBPase	0.1–0.2		Tobacco	Kossmann <i>et al.</i> (1994)	Rates under saturating CO ₂ and high or low light. FCCs are over-estimated because they are based on a transgenic line with a > 60% decrease in activity.
<i>TK</i>	–	< 2	Tobacco	Henkes <i>et al.</i> (2001)	FCC = 0.8 under saturating light and ambient CO ₂ , and 1 under saturating light and saturating CO ₂ . A small (30%) decrease in TK activity led to a decrease in aromatic amino acids and phenylpropanoids.
SBPase	0.2–0.35		Tobacco	Harrison <i>et al.</i> (1998, 2001); Olcer <i>et al.</i> (2001)	FCC approaches 1 under saturating light and CO ₂ . Over-expression increases the rate of photosynthesis in tobacco (Lefebvre <i>et al.</i> , 2005)
PRK	–	> 10	Tobacco	Paul <i>et al.</i> (1995)	FCC approaches 0.8 when plants that were grown under low light are transferred to high light (Paul <i>et al.</i> , 2000)
Starch synthesis pathway, FCC estimated for starch synthesis					
<i>pPGL</i>	0.2	2	<i>Clarkia xantiana</i>	Neuhaus <i>et al.</i> (1989)	Near-total inhibition of starch synthesis in an Arabidopsis mutant where pPGL protein level was below the detection limit (Yu <i>et al.</i> , 2005)
<i>pPGLM</i>	–	2	Arabidopsis	Neuhaus and Stitt, 1990	The null <i>pglm</i> mutant has negligible starch (Streb <i>et al.</i> , 2009)
AGPase	0.46		Arabidopsis	Neuhaus and Stitt, 1990	Arabidopsis null mutants in the genes for the APL1 and APS1 subunits have effectively no starch (Wang <i>et al.</i> , 1998; Neuhaus and Stitt, 1990)
SBE	–	2	Pea	Smith <i>et al.</i> (1990)	
Sucrose synthesis pathway, FCC estimated for sucrose synthesis					
TPT	0.35		Tobacco	Häusler <i>et al.</i> (1998, 2000)	Null insertion mutants of Arabidopsis show a very extreme phenotype (Schneider <i>et al.</i> , 2002)
cFBPase	0.7		Arabidopsis	Strand <i>et al.</i> (2000)	FCC over-estimated due to indirect changes: decrease of total leaf protein and photosynthesis
<i>cPGL</i>	–	2	<i>Clarkia xantiana</i>	Neuhaus <i>et al.</i> (1989)	Decreased cPGL leads to an increase of F _{2,6} BP and inhibition of cFBPase. The precise FCC depends on the light intensity
<i>UGPase</i>	–	> 10	Arabidopsis	Meng <i>et al.</i> (2009)	
SPS	0.2		Arabidopsis	Strand <i>et al.</i> (2000)	Over-estimate due to an indirect decrease of total leaf protein and photosynthesis. Over-expression of heterologous SPS in Arabidopsis increases sucrose synthesis, and, under elevated CO ₂ , photosynthesis (Signora <i>et al.</i> , 1998)

Enzymes that catalyse irreversible reactions *in vivo* are shown in bold, and those that catalyse reversible reactions are shown in italic (Bassham and Krause, 1969; Gerhardt *et al.*, 1987). The determinations were made by quantifying maximum enzyme activity (and in some cases enzyme protein) and the rates of photosynthesis, sucrose synthesis and starch synthesis in mutants or transgenic lines. Flux control coefficients (FCC) are estimated as the fractional change in flux divided by the fractional change in enzyme activity (Kacser and Burns, 1973). Most are over-estimates because experimental determinations require a substantial decrease in target enzyme activity. FCCs are estimated for the pathway in which the enzyme is involved. A small decrease in the rate of sucrose synthesis is compensated for by an increased rate of starch synthesis such that photosynthesis is unaffected, except under saturating light and high CO₂. For enzymes where the FCC was zero, the column labelled ‘excess’ indicates how much of the activity can be removed before there is a marked decrease in flux.