

Table2 Tubulin mutants with helical growth phenotypes

Tubulin	Mutation	Root slanting angle*	Phenotype <sup>†</sup>	Transgene experiment <sup>‡</sup>	Position <sup>§</sup>	Ecotype	Mutagen	Independent isolates
Col-0	-	-4±3	-	-	-	-	-	-
TUA4	R2K	17±6	strong	Yes	near GAR	Col,Ler	EMS	3
TUA2	T56I	NT (R)	strong	Yes	Lateral	Col	EMS	2
TUA4	T56I	37±4	strong	Yes	Lateral	Col	EMS	1
TUA6	T56I	22±6	strong	Yes	Lateral	Col,WS	EMS	2
TUA4	V62I	25±4	strong	Yes	Lateral	Col	EMS	1
TUA4	S178Δ	-46±5	medium	Yes	Intardimer	Col	T-DNA	1
TUA3	D205N	-16±4	weak	Yes	Others	Col	EMS	1
TUA5	D251N	31±5	medium	Yes	GAR	Col	EMS	1
TUA4	M268I	52±5	medium	Yes	Lateral	Col	EMS	1
TUA4	S277F	35±7	medium	Yes	Lateral	Col	EMS	1
TUA6	S277F	13±4	weak	Yes	Lateral	Col,WS	EMS	3
TUA6	A281T	49±6	medium	Yes	Lateral	Col	T-DNA	1
TUA2	E284K	32±8	medium	Yes	Lateral	Col	EMS	1
TUA6	P325S	44±81	medium	Yes	Interdimer	Col	EMS	1
TUA2	T349I	-37±8	medium	NT	Interdimer	Col	EMS	1
TUA4	T349I	NT (L)	strong	NT	Interdimer	Col	EMS	1
TUA3	R390W	-9±5	weak	Yes	Others	Col	EMS	1
TUB1	S96F	33±7	medium	Yes	Interdimer	Col	EMS	1
TUB4	S95F	NT (R)	strong	Yes	Interdimer	WS	EMS	1
TUB4	G96D	44±6	medium	NT	Interdimer	Col	EMS	1
TUB4	T178I	-47±10	medium	Yes	Interdimer	Col	EMS	1
TUB4	P220S	21±6	medium	Yes	Interdimer	Col	EMS	1
TUB2	C239Y	NT (L)	strong	Yes	Others	Col	EMS	1
TUB1	G245E	NT (L)	medium	NT	Others	WS	EMS	1
TUB4	L250F	-30±4	medium	Yes	Intardimer	Col	EMS	1
TUB2	P287L	8±5	strong	Yes	Lateral	Col	EMS	1
TUB3	P287L	32±6	strong	Yes	Lateral	Col,WS	EMS	3
TUB4	P287L	NT (R)	strong	Yes	Lateral	Col	EMS	1
TUB4	E288K	-35±8	strong	Yes	Lateral	Col	EMS	1
TUB4	A302V	NT (L)	medium	NT	Interdimer	WS	EMS	1
TUB4	S351F	-37±13	medium	Yes	Intardimer	Col	EMS	1
TUB1	A394T	NT (L)	medium	NT	Interdimer	WS	EMS	1

\*Root slanting angles toward the right side of the agar plates are shown. Minus angles indicate that the roots skewed to the left. NT, slanting angles were not quantified. (R), right-handed twisting, (L), left-handed twisting.

<sup>†</sup>Severity of the cell expansion defects was arbitrarily classified into four groups; very strong, strong, medium, and weak. The weak-type mutants were semidominant in their growth responses to proyzamide, but their heterozygotes were indistinguishable in growth in the absence of the drug.

<sup>‡</sup>“Yes” indicates that the mutant tubulin gene expressed in wild-type *Arabidopsis* plants reproduced the twisting phenotypes. NT; not tested.

<sup>§</sup>Mutated residues were mapped on the tubulin heterodimer structure. “Lateral” positions indicate the interacting regions between adjacent protofilaments. GAR; GTPase-activating region.