Supplementary Materials

Table S1. Summary of the *lpa* mutants isolated in different species. nd, not determined; OE, overexpression; RNAi, RNA interference.

Gene Function	Species	Locus	Origin of Mutation	Mutant (Ecotype)	Seed PA Reduction	Metabolites and/or Genes DOWN Regulated	Metabolites and/or Genes UP Regulated	Other Phenotypic Alterations	Ref.
MIPS1	*Arabidopsis thaliana*	At4g39800	T-DNA insertion	*atips1-1* (Col), *atips1-2* (Ws)	nd	phytic acid, *myo*-inositol and galactinol in leaves		reduced cell proliferation in seedling causing strong modification of the root cap and shorter seedling; abnormal cotyledons; leaf lesions on adult plants modulated by light intensity and developmental stages, due to SA-dependent PCD (increase in SA content); increased resistance to oomycete	[1,2]
MIPS1	*Arabidopsis thaliana*	At4g39800	T-DNA insertion	*mips1-2* (Col), *mips1-4* (C-24), *mips1-5* (Col)	nd			defects in: embryogenesis, cotyledon vein patterning, epidermal cell division, root growth and gravitropism, root cap cell patterning, apical dominance, auxin response	[3]
MIPS1	*Arabidopsis thaliana*	At4g39800	T-DNA insertion	*mips1-2* (Col), *mips1-3* (Col)	nd	*myo*-inositol, ascorbic acid, phosphatidyl inositols	ceramides	smaller plants, curly leaves, spontaneus lesions, increased sensitivity to ABA and NaCl in germination	[4]
MIPS2	*Arabidopsis thaliana*	At2g22240	T-DNA insertion	*atips2* (Col)	none	phytic acid in leaves		increased susceptibility to viruses, fungi, bacteria	[1,5,6]
MIPS3	*Arabidopsis thaliana*	At5g10170	T-DNA insertion	*atips3* (Col)	none			lethal	[2,5,6]
MIPS1	*Glycine max*	Glyma18g02210	γ-rays	*Gm-lpa-TW75-1*	50%	*myo*-inositol, galactinol, raffinose, stachyose, galactopinitol A, galactopinitol B, fagopyritol B1, galactinol	sucrose, glycerol, sorbitol	reduced field emergence (seeds produced in subtropical environment)	[7–9]
MIPS1	*Glycine max*	Glyma18g02210	*N*-nitroso-*N*-methylurea	*LR33*	50%	*myo*-inositol, raffinose, stachyose	sucrose	reduced field emergence (seeds produced in subtropical environment)	[10,11]

Table S1. *Cont.*

Gene Function	Species	Locus	Origin of Mutation	Mutant (Ecotype)	Seed PA Reduction	Metabolites and/or Genes DOWN Regulated	Metabolites and/or Genes UP Regulated	Other Phenotypic Alterations	Ref.
MIPS1	*Glycine max*	Glyma18g02211		*V99-5089*	50%		sucrose		[12,13]
MIPS1	*Glycine max*	Glyma18g02212	RNAi	Δ*GmMIPS*	35%–95%			seed abortion in fully silenced seeds	[14]
MIPS	*Solanum tuberosum*		antisense	antisense *StIPS*	nd	Phytic acid in tubers, *myo*-inositol (leaf and tuber), galactinol, raffinose (leaf), sucrose, starch (tuber)	sucrose, starch (leaf)	reduced apical dominance, delayed flowering, increased leaf thickness, precocious leaf senescence, mini tubers, no anthocyanins in tuber skin, increased susceptibility to virus	[1,15]
MIPS	*Oryza sativa*	Os03g09250	antisense	antisense *RINO1* under olesin 18kDa promoter (*Ole18*)	75%			affected only embryo and aleurone layer; no negative effects on seed weight, germination and plant growth	[16]
IMP	*Arabidopsis thaliana*	At3g02870	T-DNA insertion	*vtc4*	nd	*myo*-inositol, ascorbic acid	galactose		[17]
IMT from *M. crystallinum*	*Brassica napus*		over-expression	pN*IMT* (*IMT* under napin promoter) and pPh*IMT* (*IMT* under phaseolin promoter)	20%–30%	galactinol, raffinose	galactose, stachyose, sucrose		[18]
MIK	*Arabidopsis thaliana*	At5g58730	T-DNA insertion	*atmik-1*	62%	IPK2β, ITPK1, ITPK4, MRP, 2PGK		reduced germination on NaCl, mannitol, H_2O_2	[5]
MIK	*Arabidopsis thaliana*	At5g58730	T-DNA insertion	*atmik-2*	66%				[5]
MIK	*Zea mays*	GRMZM2G361593	*Mu* insertion	*lpa3*	45%	lower InsPs	*myo*-inositol		[19]
MIK + ITPK	*Zea mays*	GRMZM2G361593 GRMZM2G456626	*Mu* insertion	*lpa2-lpa3*	66%		molar increase of lower InsPs		[19]
MIK	*Oryza sativa*	Os03g52760	γ-rays + sodium azide	*Os-lpa-XS110-1*	64%	InsP	*myo*-inositol, raffinose, galactose, galactinol, fructose, glucose	seed dry weight reduction, low grain yield, reduced germination (particularly after aging), reduced field emergence. Proteomic study shows 23 proteins UP-regulated in the mutant	[20–23]
MIK	*Oryza sativa*		EMS	*lpa N15-186*	75%		*myo*-inositol		[24]

Table S1. *Cont.*

Gene Function	Species	Locus	Origin of Mutation	Mutant (Ecotype)	Seed PA Reduction	Metabolites and/or Genes DOWN Regulated	Metabolites and/or Genes UP Regulated	Other Phenotypic Alterations	Ref.
2-PGK	*Arabidopsis thaliana*	At5g60760	T-DNA insertion	*Oslpa1 like*	66%	MIK, ITPK1, ITPK4, MRP	IPK2β, IPK1	reduced germination on NaCl, mannitol, H_2O_2	[25,5]
2-PGK	*Oryza sativa*	Os02g57400	γ-rays	*XQZ-1*	40%		molar increase of lower InsPs	seed dry weight reduction, low grain yield, reduced germination (particularly after aging)	[22]
2-PGK	*Oryza sativa*	Os02g57400	γ-rays	*KBNT lpa1-1*	40%		molar increase of lower InsPs	normal plants, reduced size of globoids	[24]
IPK2β	*Arabidopsis thaliana*	At5g61760	T-DNA insertion	*ipk2*β*-1*	35%				[26]
IPK2β	*Arabidopsis thaliana*	At5g61760		*ipk2*β*-2*	48%	MIK, ITPK1, ITPK4, 2PGK	IPK1, MRP	reduced germination on NaCl, mannitol, H_2O_2	[5]
ITPK1	*Arabidopsis thaliana*	At5g16760	T-DNA insertion	*atitpk1*	46%	MIK, 2PGK	IPK1, MRP	reduced germination on NaCl, mannitol, H_2O_2	[5]
ITPK4	*Arabidopsis thaliana*	At2g43980	T-DNA insertion	*atitpk4-1*	51%	MIK, 2PGK	IPK1, MRP	reduced germination on NaCl, mannitol, H_2O_2	[5]
ITPK4	*Arabidopsis thaliana*	At2g43980	T-DNA insertion	*atitpk4-2*	40%				[5]
ITPK	*Zea mays*	GRMZM2G456626	*Mu* insertion	*lpa2*	30%		molar increase of lower InsPs	seed dry weight reduction	[27,28]
ITPK	*Oryza sativa*	Os09g34300	EMS	*itpk*	46%–68%			seed dry weight reduction, low grain yield, reduced germination	[29]
IPK1	*Arabidopsis thaliana*	At5g42810	T-DNA insertion	*ipk1-1*	83%			altered Pi homeostasis (smaller leaves and epinasty at standard Pi concentration, longer roots at lower Pi concentration, attenuated ability to sense Pi increase)	[26]
IPK1	*Arabidopsis thaliana*	At5g42810	T-DNA insertion	*ipk1-1*	49%	MIK	IPK2β, ITPK1, ITPK4, MRP, 2PGK	reduced germination on NaCl, mannitol, H_2O_2	[5]
IPK1	*Arabidopsis thaliana*	At5g42810	T-DNA insertion	*ipk1-1*	nd	phytic acid in leaves		increased susceptibility to viruses, fungi, bacteria	[1]

Table S1. *Cont.*

Gene Function	Species	Locus	Origin of Mutation	Mutant (Ecotype)	Seed PA Reduction	Metabolites and/or Genes DOWN Regulated	Metabolites and/or Genes UP Regulated	Other Phenotypic Alterations	Ref.
IPK1	*Arabidopsis thaliana*	At5g42810	T-DNA insertion	*ipk1-1*	nd			increased Pi uptake and increased root to shoot translocation, Pi deficiency-like root system architecture	[30]
IPK1	*Arabidopsis thaliana*	At5g42810	T-DNA insertion	*ipk1-1*	nd			early flowering, seed yield 52% of wt, reduced sensitivity to salt stress	[31]
IPK1	*Arabidopsis thaliana*	At5g42810	T-DNA insertion	*ipk1-2*	nd			not viable	[30]
IPK1	*Glycine max*	Glyma14g07880	γ-rays	*Gm-lpa-ZC-2*	46%		*myo*-inositol, syringic acid, total isoflavones, molar increase of lower InsPs	shorter plants, but no yield reduction	[7]
IPK1	*Zea mays*	GRMZM2G067299	ZFN-DNA editing	*ipk1*	50%				[32]
IPK1	*Oryza sativa*	Os04g56580	RNAi under Oleosin 18 promoter	*ipk1*	70%			unchanged levels of *myo*-inositol	[33]
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*atmrp5-1* (Ws)	nd			on 0.5 × MS decreased root growth and increased lateral root formation, on 1 × MS reverse phenotype, increased level of auxin in root, no effect of sulfonylurea glibenclamide on stomatal opening	[34]

Table S1. *Cont.*

Gene Function	Species	Locus	Origin of Mutation	Mutant (Ecotype)	Seed PA Reduction	Metabolites and/or Genes DOWN Regulated	Metabolites and/or Genes UP Regulated	Other Phenotypic Alterations	Ref.
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*atmrp5-1* (Ws)	nd			more resistant to drought stress, increased water use efficiency, stomata closer under light, no sensitivity to Ca2+ and ABA on stomatal closure, no sensitivity to auxin for opening under darkness, reduced ABA sensitivity during germination	[35]
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*atmrp5-1* (Ws)	nd			impairment in activation of slow S-type anion channels in the plasma membrane of GCs	[36]
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*atmrp5-2* (Ws)	nd			hypersensitivity to salt stress	[37]
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*mrp5-1* (Ws), *mrp5-2* (Col)	73%–80%	34%–37% reduction in total P; reduction in Na, Mg, Ca, K content			[38]
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*atmrp5-1 and 5-2* (Col)	73%–80%	MIK, IPK2βITPK1, ITPK4, 2PGK	IPK1	reduced germination on NaCl, mannitol, H_2O_2	[5]
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*atmrp5* (Col)	nd			enhanced lateral roots and root hair growth	[30]
MRP	*Arabidopsis thaliana*	At1g04120	T-DNA insertion	*atmrp5*	nd			increase in InsP5, InsP7 and InsP8 in siliques	[39]
MRP	*Glycine max*	Glyma03g32500 Glyma19g35230	EMS	*CX1834*	80%	palmitate, stearate, oil		reduced seedling and field emergence (seeds produced in subtropical environment)	[12,13, 40–43]
MRP	*Phaseolus vulgaris*	Phvul001g165500	EMS	*lpa1*	90%	*myo*-inositol, raffinosaccharides, MIPS, IMP, IPK2,ITPKα, IPK1		down-regulation of genes (MIPS, IMP, IPK2, ITPKα, IPK1) for PA biosynthetic pathway, germination hypersensitivity to ABA	[44]

Table S1. *Cont.*

Gene Function	Species	Locus	Origin of Mutation	Mutant (Ecotype)	Seed PA Reduction	Metabolites and/or Genes DOWN Regulated	Metabolites and/or Genes UP Regulated	Other Phenotypic Alterations	Ref.
MRP	*Zea mays*	GRMZM5G820122	EMS	*lpa1-241*, *lpa1-7*	90%	*myo*-inositol, MIPS	Mg, K	seed dry weight reduction, down-regulation of MIPS, altered morphology of globoids (number and size), altered embryo development, size, germination, seedling growth rate, ear size, increased susceptibility to oxidative stress	[45–50]
MRP	*Zea mays*	GRMZM5G820123	EMS	*lpa1-1*	66%	MIPS	*myo*-inositol	reduced germination, reduced vigour under stress conditions, altered morphology of globoids (number and size)	[27,32, 51–53]
MRP	*Oryza sativa*	Os03g04920	γ-rays + sodium azide	*Os-lpa-XS110-2*	20%	*myo*-inositol, raffinose, galactose	24-methylencycloartanol (steroid)	seed dry weight reduction, low grain yield, reduced germination (particularly after aging), reduced field emergence.	[20–22, 54]
MRP	*Oryza sativa*	Os03g04920	γ-rays + sodium azide	*Os-lpa-XS110-3*	100%		*myo*-inositol	(lethal)	[20,54]
MRP	*Oryza sativa*	Os03g04920	T-DNA insertion	*4A-02500*	90%		*myo*-inositol	(lethal)	[20,53]
PAP	*Arabidopsis thaliana*	At3g07130	over-expression	*OE-PAP15*	nd	phytic acid in leaves	ascorbic acid	altered salt, osmotic stress, and ABA sensitivities, enhanced salt tolerance, and decreased abscisic acid sensitivity	[55]
Sultr3;3	*Hordeum vulgare*		sodium azide	*lpa1-1 (M422)*	50%	IMP	Increase in free Pi and small increases in Ins(1,2,3,4,6)P_5	reduced test weight and percentage plump kernels, mutation affects only aleurone. Breeding can abolish/reduce negative traits	[56–60]
Sultr3;3	*Oryza sativa*	Os04g0652400	γ-rays	*MH86-1*	44%		molar increase in free Pi	seed dry weight reduction, low grain yield, reduced germination (particularly after aging)	[20,22]

Table S1. *Cont.*

Gene Function	Species	Locus	Origin of Mutation	Mutant (Ecotype)	Seed PA Reduction	Metabolites and/or Genes DOWN Regulated	Metabolites and/or Genes UP Regulated	Other Phenotypic Alterations	Ref.
unknown	*Pisum sativum*	unknown	EMS	*1-150-81*; *1-2347-144*	60%–65%		molar increase in free Pi	decreased seed weight, decreased yield	[61,62]
unknown	*Hordeum vulgare*	unknown	sodium azide	*lpa3-3 (M635)*	65%	IMP, MIPS	*myo*-inositol, galactinol	reduced test weight and percentage plump kernels, reduced yield. Breeding can abolish/reduce negative traits	[56–59]
unknown	*Hordeum vulgare*	unknown	sodium azide	*M955*	90%	IMP, MIPS	*myo*-inositol, raffinose, galactinol, sucrose	reduced test weight and percentage plump kernels, reduced yield. Breeding can abolish/reduce negative traits	[56,57, 59,63]
unknown	*Oryza sativa*	unknown	γ-rays	*Z9B-1*	45%		low increase in free Pi	seed dry weight reduction, low grain yield, reduced germination (particularly after aging)	[20,22]

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