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Title: Is RNA editing implicated in group II-intron survival in the angiosperm mitochondrial genome?

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Abstract

Introns may be considered as optional because they are removed from mRNA molecules, but introns are fairly preserved for unknown reasons. Previously, the mitochondrial *rps3* gene of sugar beet (*Beta vulgaris* L., Caryophyllales) was shown to represent a unique example of an intron loss. We have determined the distribution of the *rps3* intron in 19 Caryophyllalean species. The intron was absent from the Amaranthaceae and the Achatocarpaceae. In the Caryophyllaceae, *Dianthus japonicus rps3* was pseudogenized but the intronic sequence was retained. Intact intron-bearing *rps3* copies were cloned from *Portulaca grandiflora* and *Myrtillocactus geometrizans*, members of the sister clade of the Amaranthaceae-Achatocarpaceae-Caryophyllaceae clade. Most of the C-to-U RNA-editing sites in *Portulaca* and *Myrtillocactus rps3* transcripts were homologous in the two species as well as in the sugar beet *rps3*, which, unlike other 12 *rps3* transcripts, lacks editing in the exonic regions around the intron. Provided that the loss of editing preceded the loss of *rps3* intron, it appears conceivable that a requirement for editing could have prevented the loss of group-II introns retained in angiosperm mitochondrial genomes. This interpretation is an alternative to the conventional one that views the loss of editing as a mere trace of RNA-mediated gene conversion.

Keywords: plant mitochondria, mitochondrial genome, evolution, Caryophyllales, Amaranthaceae, group-II intron, retroprocessing

Unlike in animals, introns are prevalent in land plant mitochondrial genes (Knoop 2004; Bonen 2008). In angiosperms, there are ~25 known group I and group II mitochondrial introns that interrupt eleven genes (Kitazaki and Kubo 2010).

The distribution of introns is more or less variable among angiosperm species. A well known example is the group I intron of *cox1*, whose dissemination appears to have involved horizontal transfers and/or occasional losses during angiosperm diversification. As a result, its distribution is not consistent with angiosperm taxonomy (Cusimano et al. 2008; Sanchez-Puerta et al. 2008). Compared to the *cox1* intron, the group II-intron content appears to be rather conservative and intronic variation (presence or absence of the intronic sequence) is fairly well correlated with taxonomy. For example, the distribution of intron 1 of *cox2* (*cox2-il*) in 30 taxa led De Benedetto et al. (1992) to conclude that the presence/absence of *cox2-il* has a potential as a phylogenetically informative character.

There is no report of a group II-intron gain in angiosperm mitochondria (Kubo et al. 2011); intronic variation therefore can be interpreted as resulting from intron loss. Currently available information suggests that the loss of group-II introns could involve retroprocessing, an RNA-mediated homologous recombination in which mRNA is reverse-transcribed into cDNA which subsequently recombines with genomic DNA (Geiss et al. 1994). Intron loss through retroprocessing not only erases intronic sequences from the genome but also reduces the necessity for RNA editing, a post-transcriptional mRNA modification of land plants that alters specific cytosine (C) residues to uracil (U). This is because a cDNA sequence that is substituted for a genomic region contains thymine (T) residues at sites that are occupied by C in the original sequence. Therefore, intron loss can be expected to accompany editing site reduction in the exonic regions around the intron (Geiss et al. 1994). In fact, comparison of intron-bearing and intron-lacking copies of three genes (*cox2*, *nad4* and *nad7*) revealed a reduced number of RNA editing sites (Geiss et al. 1994; Itchoda et al. 2002; Sloan et al. 2010). However, while intronic variation in the *cox2*, *nad4* and *nad7* genes appear to have occurred independently several times in different angiosperm lineages (Gass et al. 1992; Pla et al. 1995; Sloan et al. 2010), no such pronounced variability has been reported from other genes. This suggests that some introns tend to be preserved during angiosperm evolution for unknown reasons.

In this context, the *rps3* gene provides a unique example: the sugar beet (*Beta vulgaris* L.) *rps3* lacks introns, while the other angiosperm genes identified to date contain an intron (Laroche and Bousquet 1999; Kubo et al. 2000). To better understand the implications of the loss of the *rps3* intron, we examined the (taxonomic) distribution of the *rps3* intron among the Caryophyllales, to which sugar beet belongs.

A set of primers (P1 and P2) were designed based on the exon-1 and exon-2 sequences of angiosperm *rps3* (*rps3-ex1* and *rps3-ex2*, respectively) to target *rps3-i* (experimental procedures are detailed in supplementary materials). Total cellular DNAs were isolated from 11 species covering 6 families of the Caryophyllales (Table 1) and subjected to PCR using P1 and P2. As shown in Fig. 1a, six species including sugar beet gave PCR products of 170bp. These PCR products were cloned into plasmid vectors for nucleotide sequencing. The six sequences were highly homologous to the intron-less *rps3* of sugar beet mitochondria (Fig. S1a). On the other hand, four other species gave PCR products of ~1.5 kbp (Fig. 1a), which were found to contain intron- and exon sequences (Fig. S1b). No PCR product was amplified from *Dianthus* (Fig. 1a).

The failure to amplify the *rps3* sequence from *Dianthus* suggests the lack of the intact mitochondrial gene. To test this idea, we first amplified the *rps3-ex1* and *rps3-ex2* regions from petunia total cellular DNA using two primer sets (P3 and P4, and P5 and P6, respectively, designed based on DDBJ/GenBank/ EMBL accession no. X67028). The amplified DNA fragments were labeled and then hybridized with a DNA blot containing *Dianthus* total cellular DNA. As shown in Fig. 2, the *rps3-ex2* probe hybridized to a 1.1-kbp *EcoRI* fragment, but the *rps3-ex1* probe failed to identify any bands from *Dianthus*. Therefore, the *rps3-ex1* sequence seems to be missing or to strongly diverge in the *Dianthus* genome. We may ask whether the *rps3-i* sequence is present immediately upstream of *rps3-ex2* in *Dianthus*. Several primers corresponding to sequences of *rps3-i* conserved in angiosperms were used in combination with the P2 primer for amplification trials. PCR products were obtained when we used primer P7 (Fig. 1b). Nucleotide sequencing revealed that the *Dianthus* amplicon contained both the *rps3-ex2* and *rps3-i* sequences (Fig. S1b).

We examined the organization of the angiosperm mitochondrial *rps3* using data in the

public databases. More than 20 complete mitochondrial sequences as well as *rps3* gene sequences from 18 angiosperms are available but, *rps3-i* was absent only from the sugar beet gene (data not shown). In the mitochondrial genome of *Silene latifolia* Poir., which is a member of the Caryophyllaceae as is *Dianthus*, the *rps3-ex1* sequence was missing but a portion of *rps3-i* and almost the entire *rps3-ex2* were present (Fig. S1b). No species possessed intron-less as well as intron-bearing *rps3* copies (Fig. 1 and data not shown). To summarize, intron-less *rps3* copies were detected in Amaranthaceae and Achatocarpaceae, and it seems reasonable to postulate that *rps3-i* was lost in a common ancestor of the two families. This result is congruent with recent phylogenetic models that resolved Amaranthaceae and Achatocarpaceae as two closely related clades (Soltis et al. 2011), with their closest sister clade being the Caryophyllaceae.

Next we addressed the question whether the five RNA editing sites in sugar beet *rps3*, which were confined to *rps3-ex2* (Matsunaga et al. 2011) (Fig. 3 and Fig. S2), could be interpreted as traces of the retroprocessing that erased *rps3-i*. For this purpose, it was necessary to compare editing sites between intron-less *rps3* and intron-bearing *rps3* copies in Caryophyllales. Although Caryophyllaceae is the closest sister clade of Amaranthaceae-Achatocarpaceae in the phylogenetic tree (Soltis et al. 2011), the Caryophyllaceae *rps3* seemed unsuitable because it appeared to be a pseudo gene as was seen in *Dianthus* and *Silene*. We selected *Portulaca grandiflora* and *Myrtillocactus geometrizans*, which belong to the sister clades of Amaranthaceae-Achatocarpaceae-Caryophyllaceae in the order Caryophyllales.

Genomic DNA fragments of *Portulaca grandiflora* that hybridized with the petunia *rps3* probe were cloned, sequenced and assembled into a contig, in which 74-bp *rps3-ex1*, 1215-bp *rps3-i* and 1615-bp *rps3-ex2* sequences were found (DDBJ/GenBank/EMBL accession no. AB666467). This sequence information was used to design a set of primers (P8 and P9) that subsequently were employed to amplify the complete *rps3* gene of *Myrtillocactus geometrizans*. As a result, *Myrtillocactus rps3* was revealed to consist of 74-bp *rps3-ex1*, 1705-bp *rps3-i* and 1609-bp *rps3-ex2* (DDBJ/GenBank/EMBL accession no. AB666468). DNA gel blot analysis indicated that *Portulaca rps3* and *Myrtillocactus rps3* are single-copy genes (Fig. 2).

To determine the RNA editing sites, reverse transcription (RT) PCR was performed using leaf (*Portulaca*) or stem (*Myrtillocactus*) total RNA as templates with two sets of primers (P8 and P10, and P11 and P9). Nucleotide sequencing of ten independent clones from amplicons of each RT-PCR revealed three and five C-to-U RNA editing sites in *Portulaca* and *Myrtillocactus*, respectively (Fig S2). All but one editing event (depicted as e8 in Fig. S2) improved the similarity of the amino acid sequence with homologues from other species (data not shown). One editing event (e8) in *Myrtillocactus* did not alter the amino-acid specificity of the codon (i.e. silent editing). Three editing sites identified in *Portulaca rps3* transcripts were found also at homologous positions in sugar beet (e22, e27 and e28 in Fig S2). Two editing sites (e14 and e19) that were edited in sugar beet but not in *Portulaca* corresponded to adenosine (A) and T residues in the *Portulaca* genome, respectively. In *Myrtillocactus*, four out of the five editing sites matched with sites in sugar beet (Fig S2). The silent editing in *Myrtillocactus* (e8) was not detected in sugar beet and *Portulaca*. One of the five editings in sugar beet (e19) appeared to be unnecessary in *Myrtillocactus* because a T residue was present at the corresponding site (Fig. S2).

We complemented our own data with the publicly available data regarding *rps3* transcript editing from 12 different plant species (Fig. S2). RNA-editing sites that were experimentally identified or predicted using a computer program (sources are summarized in Table S1) numbered 37 (e1 to e37) in total. This analysis revealed that *rps3* transcripts of sugar beet, *Portulaca* and *Myrtillocactus* are devoid of editing events in their 5' (e1 to e7) and 3' (e29 to e37) regions (Fig. 3 and Fig. S2), and that the number (3 to 5) of RNA editing sites in these three *rps3* transcripts is clearly smaller than that (7-17) in other *rps3* transcripts. We placed *rps3-i* loss and loss or gain of e1 to e7 and e29 to e37 editings at positions on the phylogenetic tree that maximized parsimony (Fig. 3). This analysis favored the loss of the 16 editing sites prior to the evolutionary separation of sugar beet, *Myrtillocactus* and *Portulaca*, although another possibilities cannot be excluded.

There have been some reports suggesting a possible association between RNA editing and group-II intron. For example, the editing frequency at the e4 site of rice *rps3* was lower in unspliced RNA than in spliced RNA (Kurihara-Yonemoto and Kubo 2011). Similar

observations of differential editing status between unspliced and spliced RNA have been reported from petunia *cox2*, maize *cox2*, wheat *cox2*, wheat *nad4* and wheat *nad7* (Sutton et al. 1991; Yang and Mulligan 1991; Li-Pook-Than et al. 2007). Furthermore, mRNAs transcribed from modified mitochondrial genes whose group-II introns had been removed were less frequently edited compared to mRNAs transcribed from the original intron-bearing genes (Castandet et al. 2010). The possible association between RNA editing and the presence of a group-II intron suggested by these reports allows us to speculate that the loss of *rps3-i* from the genome might affect certain RNA editing events. Modification of the editing sites by genomic C-to-T substitution (or cDNA-mediated gene conversion that does not affect intron content but reduces editing sites) would weaken the significance of *rps3-i* for *rps3* expression. Consequently, the loss of *rps3-i* could have become inconsequential in the Caryophyllales lineage leading to sugar beet, *Myrtillocactus* and *Portulaca*. This hypothesis calls for further evaluation in future studies.

Acknowledgements

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Table 1 Plant materials used in this study and presence/absence of *rps3-i*

Species	Family	<i>rps3</i> intron	Cultivar/ Source
<i>Beta vulgaris</i> L.	Amaranthaceae	- ^a	cv. 'TK81mm-O' / Hokkaido Agricultural Research Center, National Agriculture and Food Research Organization, Japan
<i>Chenopodium album</i> L.	Amaranthaceae	-	Botanic Garden, Hokkaido University, Japan
<i>Celosia argentea</i> L.	Amaranthaceae	-	cv. 'Yachiyo Keitou' / Tohoku Seed CO., LTD., Japan
<i>Gomphrena haageana</i> Klotzsch	Amaranthaceae	-	Sakata Seed CO., Japan
<i>Spinacia oleracea</i> L.	Amaranthaceae	-	Local market
<i>Achatocarpus praecox</i> Griseb.	Achatocarpaceae	-	Royal Botanic Gardens, Kew, UK
<i>Dianthus japonicus</i> Thunb.	Caryophyllaceae	+ ^b	Takii & CO., LTD., Japan
<i>Basella alba</i> L.	Basellaceae	+	Sakata Seed CO., Japan
<i>Mirabilis jalapa</i> L.	Nyctaginaceae	+	Sakata Seed CO., Japan
<i>Myrtillocactus geometrizans</i> (Mart. ex Pfeiff.) Console	Cactaceae	+	Local market
<i>Portulaca grandiflora</i> Hook.	Portulacaceae	+	Sakata Seed CO., Japan

^aAbsence, ^bPresence

Figure legends

Fig. 1 PCR amplification of *rps3-i* from the 11 species listed in Table 1. **a** PCR amplification with primers P1 and P2. Size markers are shown on the right (bp). **b** PCR amplification with primers P7 and P2 using *Dianthus japonicus*, *Basella alba*, *Mirabilis jalapa*, *Myrtillocactus geometrizans* and *Portulaca grandiflora* total DNAs as templates. Size markers are shown on the right (bp).

Fig. 2 DNA gel blot analysis using 5 µg of total cellular DNA digested with *Eco*RI. *Petunia rps3-ex1* and *rps3-ex2* sequences were used as probes. The sample was electrophoresed in a 1% agarose gel. Sugar beet (Beta), *Myrtillocactus geometrizans* (Myrtillocactus), *Dianthus japonicus* (Dianthus) and *Portulaca grandiflora* (Portulaca) were subjected to this experiment. Size markers are shown on the left (kbp).

Fig. 3 Phylogenetic relationship among 15 plant species including sugar beet (Beet), *Portulaca grandiflora* (Portulaca), *Myrtillocactus geometrizans* (Myrtillocactus), grapevine (Grape), *Arabidopsis thaliana* (Arabidopsis), rapeseed, *Oenothera berteriana* (Oenothera), sunflower, watermelon, zucchini, petunia, tobacco, papaya, *Magnolia x soulangeana* (Magnolia) and rice, based on Soltis et al. (2011) and the Angiosperm Phylogeny Website (<http://www.mobot.org/mobot/research/apweb/>). Branch length does not indicate phylogenetic distance. Arrows pointing to top indicate loss of editings and intron, while arrows pointing downwards highlight gain of editings. *rps3* organization and its editing status (for e1-e7 and e29-e37 only) is shown on the right (for details, see Fig. S2). Boxes with numbers following the letter ‘e’ indicate specific residues depicted in Fig. S2. Filled, gray and open boxes represent experimentally confirmed editing, editing predicted *in silico*, and no editing, respectively. Horizontal lines between the boxes indicate *rps3-i*.

Experimental details

1. Isolation of nucleic acids

Total cellular DNA was isolated according to Doyle and Doyle ('Isolation of plant DNA from fresh tissue'. *Focus* 12:13-15, 1990). Total RNA was isolated by using RNeasy Plant Mini Kit (Qiagen, Valencia, CA). Isolated RNA samples were further purified by incubation with RNase-free DNase I (Takara Bio, Ohtsu, Japan) according to the manufacturer's instructions.

2. Molecular cloning

PCR was done using BlendTaq (Toyobo Life Science, Osaka, Japan). Reverse transcription (RT) PCR was performed according to Singer-Sam et al. ('Measurement by quantitative PCR of changes in *HPRT*, *PGK-1*, *PGK-2*, *APRT*, *MTase* and *Zfy* gene transcripts during mouse spermatogenesis.' *Nucleic Acids Research* 18: 1255-1259, 1991). PCR products were cloned into the pBluescript vector (Stratagene, La Jolla, CA). Nucleotide sequences were determined using Li-COR4200L (Li-COR, Lincoln, NE) or ABI3130 (Applied Biosystems, Foster City, CA).

3. Hybridization

Genomic DNA was transferred onto Hybond N+ membrane (GE Healthcare UK, Amersham Place, England) after gel electrophoresis. DNA fragments of interest were labeled with alkaline phosphatase using the AlkPhos Direct DNA labeling system (GE

Healthcare UK). Hybridization was done according to the manufacturer's instruction.

4. Nucleotide sequences of oligonucleotide primers

P1, 5'-TTTCGGTAAGGCTGAATCGTAGTTC-3'

P2, 5'-GGAAAGCCAAAGGTGAGTCTCGT-3'

P3, 5'-AGTAAAGTCTAAGCGCATAT-3'

P4, 5'-CTGGGAGAACTAAAAGACTG-3'

P5, 5'-GACTCTATTTATTATTATGGT-3'

P6, 5'-CGTTCAAATAATAGTTGTACCCGTACGG-3'

P7, 5'-CATCTCAAAGTATAGGGCAAAGGA-3'

P8, 5'-ATATATGGCACGAAAAGGAAATCC-3'

P9, 5'-TTTTCATTTTTGACTATAAGAAATCC-3'

P10, 5'-GTATTGAATAAGTATTGCAT-3'

P11, 5'-AGACCTTCCTTCAATTATTTGG-3'

a.			
	Exon 1	Exon 2	
Beta	AGTTGGTTAATGATTATTATTATAGTAAATTAGTATATCAAGATCTCAATCTGAGATCT		60
Chenopodium	AGTTGGTTTAGTGATTATTATTTTGGTAAATTAGTATATCAAGATATCAATCTGAGATCT		60
Celosia	AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT		60
Gomphrena	AGTTGGTTTAGTGATTATTATTTTAGTAAATTAGTCTATCAAGATATCAATCTGAGATCT		60
Spinacia	AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT		60
Achatocarpus	AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT		60
b.			
Basella	CATCTCAAAGTATAGGGCAAAGGAGAAAGGGCTTTGACTTTGTCTACCGGGATTCAACAC		60
Mirabilis	CATCTCAAAGTATAGGGCAAAGGATCAAGCGCTTTTACTTTGTCTCCCGGGATTCAACCAC		60
Myrtillocactus	CATCTCAAAGTATAGGGCAAAGGATCTTTGGTTTTGACTTTGTCTCCAGGGAATCACCAT		60
Portulaca	CATCTCAAAGTATAGGGCAAAGGATCTTTGGTTTTGACTTTGTCTCCAGGGAATCACCAT		60
Dianthus	CATCTCAAAGTATAGGGCAAAGGATGAAGCGCTTTGACTTTGTCTCCCGGGATTGCCCAC		60
Silene	CATCTCAAAGTATAGGGCAAAGGATGAAGCGCTTTGACTTTGTCTCCCGGGATTCAACCAC		76149
Basella	AGGTTTCGGTTTCAGAGCTGTGTGA--TG---GGTAACATCCTGCACGGTTCGGAGAGCA		115
Mirabilis	AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTGACTATCCTGCACGGTTCGGAGAGCA		115
Myrtillocactus	AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTCACTATCCTGCTCGGTTCGGAGAGCA		115
Portulaca	AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTCACTATCCTGCTCGGTTCGGAGAGCA		115
Dianthus	AGGGTGGCTTTGAGAGCCGTGTGATGTGATAGGTTACTTTCTGCACGGCTC-G-GAG-A		117
Silene	AGGTTGGGTTTGAGAGCCGTG-----TGATAGGTTACTATCCTGCACGGTTCGGAGAGCA		76094
Basella	CTTTTAGGCTGACTTGGTGAATGGGAGACAAAGTATCAAGGAAGAAAGAAGGAGTTCTTC		175
Mirabilis	CTTTTCGCTGCGTTGGTGAATGGGAGCCCCCTATCAAGCAAGAAAGAAGCAGTTCTTC		175
Myrtillocactus	CTTATAGTCTGCATTGGTGAATGGAAGAAGACCTATCTTT-----GAGTTCTTC		164
Portulaca	CTTATAGTCTGCATTGGTGAATGGAAGAAGACCTATC-----AAGGAGTTCTTC		164
Dianthus	-TTTATAGTCTGCGTTGGTGAATGGGAGCCCCACTATCAAGCAAGAAAGAAAGAGTTCTTC		176
Silene	CTTTTAGTCTGCGTTGGTGAATGGGAGCCCCACTATCAACAAGAAAGAAACTGTTCTTC		76034
	Intron	Exon 2	
Basella	CCACTTCTACTTAAAATGTCAACATTGACTCTATTATTATTATACTAAATTTTTATATC		235
Mirabilis	CCACGGC-----GGA-GTCACCATTGACTCTATTATTATTATGGTAAATTAGTATATC		228
Myrtillocactus	CCACTTCTACTTAAAATGTAAACATTGACTCTATTATTATTATGGTAAATTAGTCTATC		224
Portulaca	CCACTTCTACTTAAAATGTCAACATTGACTCTATTATTATTATAAAAAATTAGTCTATC		224
Dianthus	CCACGGC-----A-G--AA-ATTGACTCTCTTTATTATTATGGTAAATTAGTATATC		224
Silene	TTT-TT--GAGTAGGGCGG-AA-ATTGACTCTATTATTATTATGGTAAATTAGTATATC		75979

Fig. S1 Sequence comparison of portions of *rps3*. **a** Part of the nucleotide sequences of PCR products shown in Fig. 1a. The boundary between *rps3-ex1* and *rps3-ex2* is shown by a vertical line. **b** Part of the nucleotide sequences of PCR products shown in Fig. 1b. Sequence data of *Silene latifolia rps3* (HM562727) is included. Dashes are included for maximum matching. The boundary between *rps3-i* and *rps3-ex2* is indicated by a vertical line

	e1	e2	
Beet	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Portulaca	ATGGCACGAAAAGGAAATCCTATTTTCGGTAAGGCTAGGGCTGAATCGTAGTTCAGATTCA	60	
Myrtillocactus	ATGGCACGAAAAGGAAATCCGATTTTCGGTCAGACTTGGGCTTAATCGTAGTTCCTTCTTCT	60	
Petunia	ATGGCACGAAAAGGAAATCCTATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Tobacco	ATGGCACGAAAAGGAAATCCTATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Sunflower	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Arabidopsis	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGGAAAAATCGTAGTTCAGATTCA	60	
Rapeseed	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGGAAAAATCGTAGTTCAGATTCA	60	
Papaya	ATGGCACGCAAAGGAAATCCGATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Oenothera	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Watermelon	ATGGCACGAAAAGGAAATCCTATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Zucchini	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Grape	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA	60	
Rice	ATGGCACGAAAAGGAAATCCAATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATCCA	60	
Magnolia	ATGGCACGAAAAGGAAATCCGATTTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATCCA	60	
	e3	e4	e5
Beet	AGTTGGTTTAAATGA	TTATTATTATAGTAAATTAGTATATCAAGATCTCAATCTGAGATCT	120
Portulaca	AGTTGGTTTAGTGA	TTATTATTATAAAAAATTAGTCTATCAAGATATCAATCTCAGATCT	120
Myrtillocactus	TCTTGGTTCAGTGA	TTATTATTATGGTAAATTAGTCTATCAAGATATCAATCTCAGATCT	120
Petunia	AGTTGGTTTAGT---	TATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT	117
Tobacco	AGTTGGTTTAGTGA	TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT	120
Sunflower	AGTCGGTTCAGTGA	TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTTAGATCT	120
Arabidopsis	AGTCGGTTCAGTGA	GTATTATTATGGTAAATTTGTGTATCAAGATGTCAATCTGAGATCT	120
Rapeseed	AGTCGGTTCAGTGA	GTATTATTATGGTAAATTTGTGTATCAAGATGTCAATCTGAGATCT	120
Papaya	AGTTGGTTCAGTGA	TTATTATTATGGTAAATCGGTGTATCAAGATGTAAATCTGAGATCT	120
Oenothera	AGTTGGTTCAGTGA	TTATTATTATGGTAAATCAGTCTATCAAGATGTCAATCTGAGATCT	120
Watermelon	AGTCGGTTCAGTGA	TTATTATTATGGTAAATCACTGTATCAAGATGTCAATCTGAGATCT	120
Zucchini	AGTTGGTTCAGTGA	TTATTATTATGGTAAATCACTGTATCAAGATGTCAATCTGAGATCT	120
Grape	AGTTGGTTCAGTGA	TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT	120
Rice	AGTCGGTTCAGTGA	TTATTATTATGGTAAATCATTGTATCAAGATGTCAATCTTAGATCT	120
Magnolia	AGTCGGTTCAGTGA	TTATTATTATGGTAAATCAGTGTATCAAGATGTCAATCTGAGATCT	120
	e6		
Beet	TATTTTGGTTCGATACGTCCACCTACGAGACTTACCTTTGGCTTTTCGCCTCGGTAGGTGT	180	
Portulaca	TATTTTCGCTTCGATACGCCAACCCACGAGACTCACCTTTGGCTTTTCGACTCGGTAGGTCT	180	
Myrtillocactus	TATTTTCGCTTCGATACGCCAACCCACGAGACTCACCTTTGGCTTTTCGACTCGGTAGGTCT	180	
Petunia	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	177	
Tobacco	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Sunflower	TATTTTCGGTTCGATACGTCCACCTACTAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Arabidopsis	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTCGGCTTTTCGTCTCGGTAGGTGT	180	
Rapeseed	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Papaya	TATTTTCGGTTCGATACGTCCACCTACGAGACTAACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Oenothera	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Watermelon	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Zucchini	TATTTTCGGTTCGATACGTCCACCTACGAGACTGACCTTTGGCTTTTCGTCTTGGTAGGTGT	180	
Grape	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Rice	TATTTTCAGTTCGATACGTCCACCTACGATACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	
Magnolia	TATTTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTTCGTCTCGGTAGGTGT	180	

	e7	
Beet	ATTATTATACATTTTCAAAAACGAACATTCATTAATTTCTTTCTTCTCGTCGACCACAA	240
Portulaca	ATTATTATTCAATTTTCAAAAGAGAACTTTCATTCATTTCTTTATTCCCCGTAGTCCACGA	240
Myrtillocactus	ATTATTATTCAATTTTCAAAAGAGAACTGTAATTCATTTCTTTATTCCCCGTAGTCCACGA	240
Petunia	ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	237
Tobacco	ATTATTATACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	240
Sunflower	ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	240
Arabidopsis	ATTATTCTACATTTTCTAAAGAACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	240
Rapeseed	ATTCTTCTACATTTTCTAAAGAACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	240
Papaya	ATTATTCTACATTTTCTAAAGAACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	240
Oenothera	ATTATTCTACATTTTCCCAAAAGAACATTTATTCATTTCTTTCTTCCCCGTGACCACGA	240
Watermelon	ATTATTTTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCTCGTCGACCACGA	240
Zucchini	ATTATTTTACATTTTCCCAAAATCACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	240
Grape	ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCTCGTCGACCACGA	240
Rice	ATTATTCTACATTTTCCCAAAAGGACATTCATTCATTTCTTTCTTCCCCGTGACCACTA	240
Magnolia	ATTATTCTACATTTTCCCAAAAGGACATTCATTCATTTCTTTCTTCCCCGTGACCACGA	240

	e8 e9	
Beet	CGACGGAACGACGCAAAAAATCCAGACCCGAAAGACGAAG-----	282
Portulaca	CGAAATAAAAAAGGGAAAAATCCAGACGCGAAAGGAAGAAGATAGCAATG-----	294
Myrtillocactus	CGAAAGAAAAAAGGGAAAAATCCAGACGCGAAAGGAAGAAGTACGCAATG-----	294
Petunia	CGACTGAAACGACGCGAAAAATCCAGACCCGTAAAGGAGAAG-----	279
Tobacco	CGACTGAAACGACGCGAAAAATCCAGACCCGTAAAGGAGAAG-----	282
Sunflower	CGACAGAAACGACGCGAAAAATCCAGACCCGAAAGGGGAAG-----	282
Arabidopsis	CGACTGAAACGACGTGAAAAAATAGACCCGAAAGGAGAAG-----	282
Rapeseed	CGACTGAAACGACGTGAAAAAATAGACCCGAAAGGAGAAG-----	282
Papaya	CGACTGAAACGACGCAAAAAAACCAGACCCGAAAGGAGAAG-----	282
Oenothera	CGACTGAAACGAGGCAAAAAATCCAGACCCGAAAGGAGAAG-----	282
Watermelon	CGACTGAAACGACGCGAAAAATCCAAACCCGAAAGGAGAAG-----	282
Zucchini	GGACTGAAACGACGCGAAAAATCCAAACCCGAAAGGATCAG-----	282
Grape	GGACTGAAACGACGCGAAAAATCCAGACCCGAAAGGAGAAG-----	282
Rice	CGACTAAAACGACGCGACAAATCAAGACCCGAAAGGATAAG-----	282
Magnolia	CGACTGAAACGACGCGACAAATCAAGACCCGAAACGTGA-----	280

	e10 e11	
Beet	-----GGCCGGTGGTGGGA---ATTGGGG-----AAAGTCGGGCCGATCGAGTGTCTT	327
Portulaca	AAGATTGCCCAGTGGTGGGA---ATTTGGGCCACCAAAGTAGGGAAGATCGAATGTATT	351
Myrtillocactus	AAGATTGCCCAGTGGTGGGA---ATTTGGGG-----AAAGTAGGGAAGATCGAATGTCTT	351
Petunia	-----GGCCGGTGGGGGGC---ATTTGGG-----AAAGTCGGGCCGATCGGGTGTCTT	324
Tobacco	-----GGCCGGTGGGGGGC---ATTTGGG-----AAAGTCGGGCCGATCGGGTGTCTT	327
Sunflower	-----GGCCAGTGGTGGGC---ATTTGGT-----AAAGTCGGGCCGATCGGGTGTCTT	327
Arabidopsis	-----GGCCGGTGGTGGACGACATTCGGG-----AAAGCCGGGCCGATCGAGTGTCTT	330
Rapeseed	-----GGCCGGTGGTGGACGACATTCGGG-----AAAGCCGGGCCGATCGGGTGTCTT	330
Papaya	-----GGCCGGTGGTGGACGACATTCGGG-----AAAGTCGGGCCGATCGGGTGTCTT	330
Oenothera	-----GCCCGGTGGTGGGA---ATTTGGG-----AAAGTCGGGCCGATCGGGTGTCTT	327
Watermelon	-----GGCCGGTGGTGGGC---ATTTGGG-----AAAGTCGGGCCAATCGGGTGTCTT	327
Zucchini	-----GGCCGGTGGTGGGC---ATTTGGG-----AAAGTCGGGCCAATCGGGTGTCTT	327
Grape	-----GGCCGGTGGTGGGC---ATTTGGG-----AAAGTCGGGCCGATCGGGTGTCTT	327
Rice	-----GGCCGGTGGTGGGC---ATTTGGG-----AAAGTCGGGCCGATCGGGTGTCTT	327
Magnolia	-----	280

Beet	TATTCAA-----GCGAGGGTAGAAAAGAAGAACGAAACGAAGTGAGAGACCGAAGGGGCC	381
Portulaca	TCTTCAACTTCTTTTTCCAGTCGAAAATCAGAAGGAAAGAAAGTGAGAGGCTTTTGTGCC	411
Myrtillocactus	TCTGAAACTTCTTTTTCCAGTCTACAAGAAGAAGGAAAGAAAGTGTTAGGCTTTTGTGCC	411
Petunia	CATTCAA-----GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	378
Tobacco	CATTCAA-----GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	381
Sunflower	CATTCAA-----GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	381
Arabidopsis	CATTCAA-----GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	384
Rapeseed	C-----GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	378
Papaya	CATTCAA-----GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	384
Oenothera	CATTCAA-----ACGATGATACAGAAGAAGAACGAAACGAAGTAGGAGGCCGGGGGGCA	381
Watermelon	CATTCAA-----GCGACGATACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGAGGCA	381
Zucchini	CATTCAA-----GTGACGATACAGAAGAAGAACGAAACAAAGTGAGAGGCCGGGAGGCA	381
Grape	CATTCAA-----GCGACGGTACAGAAGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	381
Rice	CATTCAA-----GCGAGGGTACAGAGGAAGAACGAAACGAAGTGAGAGGCCGGGGGGCA	381
Magnolia	-----GAGGCCGGGGGGCA	294

e12

Beet	GGGAAAAGAGTCGAGTCGAT---CAGGCTTGACGACCAGAAAAAGCAAAACGAAATCCGG	438
Portulaca	GGGAAAAGAGTTGAGTCGAT---CATGCTCGACGACCAGAAAAAGAAAACGAAATCAGG	468
Myrtillocactus	GGGAAAAGAGTTGAGTCGAT---CATGCTCGACGACCAGAAAAAGAAAACGAAATCAGG	468
Petunia	GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGATCGGGAGAAGCAAAACGAAATCAGG	435
Tobacco	GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGATCGGGAGAAGCAAAACGAAATCAGG	438
Sunflower	GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG	438
Arabidopsis	AGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAAAGCAAAACGAAATCCGG	441
Rapeseed	AGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAGAAGCAAAACGAAATCCGG	435
Papaya	GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAGAAGCAAAACGAAATCCGG	441
Oenothera	GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG	438
Watermelon	GAGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGAAAAGCAAAACGAAATTCGG	438
Zucchini	GAGAAAAGAGTGGAGTCGATGATCAGGCTCGACGACCGGGAAAAGCAAAACGAAATTAGG	441
Grape	GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAAGAAGG	438
Rice	GGGAAAAGAGTCGAGTCGAT---C-----GACCGGGAGAAGCAAAACGAAATCAGG	426
Magnolia	GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG	351

e13

Beet	GTTTGCCAAAAAAGAAGCAACGCTATGGATAACCATGACCGATCACCATCGATAAAGAAG	498
Portulaca	ATTTGGAAAAAAGAAGCAAGGCTATGGATAACCATGACCGATCAACATCCATAAAGAAT	528
Myrtillocactus	ATTTGGAAAAAAGAAGCAAGGCTATGGATAACCATGACCGATCAACATCCATAAAGAAT	528
Petunia	ATTTGGCCGAAAAAGAAGCAAGGCTATGGATAACCATGACCGATCACCATCGATAAAGAAA	495
Tobacco	ATTTGGCCGAAAAAGAAGCAAGGCTATGGATAACCATGACCGATCACCATCGATAAAGAAG	498
Sunflower	ATTTGGCCGAAAAAGAAGCAACGCTATGGATAACCATGACCGATCACCATCGATAAAGAAG	498
Arabidopsis	GGTTGGCCGAAAAAACAACGCTATGGATAACCATGACCGATTACCTCGATAAAGAAG	501
Rapeseed	GGGTGGCCGAAAAAACAACGCTATGGATAACCATGACCGATCACCATCGATAAAGAAG	495
Papaya	ATTTGGCCGAAAAAGAAGCAAGGCTATAGATAACCATGACCGATCACCATCGATAAAGAAG	501
Oenothera	ATTTGGCCGAAAAAGAAGCAAGGCTATGGATAACCATGACCGATCACCATCGATAAAGAAG	498
Watermelon	ATTTGGCCGAAAAAGAAGCAACGCTATGGATAACCATGACCGATCACCATCGATAAAGAAG	498
Zucchini	ATTTGGCCGAAAAAGAAGCAAGACTATGGATAACCATGACCGATCACCATCGAGAAAGAAG	501
Grape	ATTTGGCCGAAAAAGAAGCAACGCTATGGATAACCATGACCAATCACCATCGATAAAGAAG	498
Rice	ATTTGGCCGAAAAAGATGCAACGTTATGGATAACCATGACCGATCACCATCGAGAAAGAAG	486
Magnolia	ATTTGGCCGAAAAAGAAGCAACGCTATGGATAACCATGACCGATCACCATCGAGAAAGAAG	411

	e14	
Beet	AATCTTTCTAAATCACTTCGGGTCAGCGGGCCTTCAAGCATCCGAAATACGCCGAGGTT	558
Portulaca	CATCTTTCTAAAGAACTTCGGGGGAGCGGGGAATTAAAGCAGCCGAAATACGCAGAGGTT	588
Myrtillocactus	CATCTTTCGTATCACTTCGGGGAAGCGGGGAATTAAAGCAGCCGAAATACGCAGAGGTT	588
Petunia	AATCTGTCTAAATCACTTCGTGTGACGCGGGCCTTCAAGCATCCGAAATACGCCGGGATT	555
Tobacco	AATCTTTCTAAATCACTTCGTGTGACGCGGGCCTTCAAGCATCCGAAATACGCCGGGATT	558
Sunflower	AATCTTTCTAAATCACTTCGGGTCAGCGGGCCTTCAAGCATCCGAAATACGCCGGGCTT	558
Arabidopsis	AATCTTTCTAAATCACTTCGGATCAGCGGGCCTTCAAGCATCCGAAATACGCCGGGGTT	561
Rapeseed	AATCTTTCTAAATCACTTCGGATCAGCGGGCCTTCAAGCATCCGAAATACGCCGGGGTT	555
Papaya	AATCTTTCTAAATCACTTCGGGTCAGCGGGCCTTCAAGCATCCGAACTACGCCGGGGTT	561
Oenothera	AATCTTTCTAAATCACTTCGGGTCAGCGGGCCTTCAAGCATCCGAAATACGCCGGGGTT	558
Watermelon	AATCTTTCTAAATTACTTCGCGTCAGCGGGCCTTCAAGCATCCGAAATATGCCGGAGTT	558
Zucchini	AATCTTTCTAAATCACTTCGCGTCAGCGGGCCTTCAAGCATCCGAAATATGCCGGAGTT	561
Grape	AATCTTTCTAAATTACTTCGGGTCAGCGGGCCTTCAAGCATCTGAAATACGCCGGGGTT	558
Rice	AATTTTCTAAATCACTTCGGGTGAGCGGGCCTTCAAGCATCCGAAATACGCCGGGGTT	546
Magnolia	AATCTTTCTAAATCACTTCGGGTCAGCGGGCCTTCAAGCATCCGAAATACGCCGGGGTT	471

	e15	e16	e17
Beet	GTAAATGACATAGCCTTTCTGATAGAAAATGATTCTTCCTTCAAAAAACGAAGTTATTC		618
Portulaca	CTAAATAACATAGAATTTCTGATAGAAAAAATCTTCCTTCAAAAAACGAAGTTATTC		648
Myrtillocactus	CTAAATAACATAGAATTTATGATCGAAAAAAGAATCCTTCAAAAAACGAAGTTATTC		648
Petunia	GAAATGACATAGCCTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACAACTTATTC		615
Tobacco	GAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACAACTTATTC		618
Sunflower	GTAAATGACATAGCCCTCCTAAA-----TGACGACTCCTTCAGAAAAACGAAGTTATTC		612
Arabidopsis	GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAAAAAACGAAGTTATTC		621
Rapeseed	GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC		615
Papaya	GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCGAAAAACGAAGTTATTC		621
Oenothera	TTAAATGACATAGCCTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC		618
Watermelon	GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC		618
Zucchini	GTAAATGACATAGCGTTCCTGATCGAAAATGACGACTCCTTCAGAAAAACTCAGTTATTC		621
Grape	GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC		618
Rice	GTAAATGACATAGCCTTCCTGA-----TAGAAAA-----		577
Magnolia	GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACTAAGTTATTC		531

	e18	
Beet	AAGTTCCTTTTCCCAAAGAAGTCA-----CGCTACGACGGCCCGACAAGTCATCTA	669
Portulaca	AAGTTCCTTTTCAAAAAACGAAGTACAG---CTACAAAAAAACATCAAAGTCATCTA	705
Myrtillocactus	TTTTCTTTTCAAAAAACGAAGTACAG---CTACAAAAAAACATCAAAGTCATCCA	705
Petunia	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGACCGCCGACGAGTCATCTA	666
Tobacco	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGACCGCCGACGAGTCATCTA	669
Sunflower	AAGTTCCTTTTCTCAAAGAAGTCAAAGAAGTCCCCCTCCGACAGCCGACGAGTCATCCA	672
Arabidopsis	AAGTTATTTTCCAAAATAAGTC-----CCGCTCCGACGGCCCGACGAGTTATCTA	672
Rapeseed	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGACGGCCCGACGAGTTATCTA	666
Papaya	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGACGACCCGACGAGTCATCTA	672
Oenothera	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGACGGCCCGACGAGTCATCTA	669
Watermelon	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGACGGCCCGACGAGTCATCTA	669
Zucchini	AAGTTCCTTTTCCCAAATCAGTC-----CCGCTCCGACGGCCCGACGAGTCATCTA	672
Grape	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGACGGCCCGACGAGTCATATA	669
Rice	-----TGACGGCCCGACGAGTCATCTA	599
Magnolia	AAGTTCCTTTTCCCAAAGAAGTC-----CCGCTCCGGCGGCCCGACGAGTCATCTA	582

Beet	CTTAAAAGGACCTCCCTGCAGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	729
Portulaca	CTTAAAAGGACACTCGCAGCAGTCAGACCTTCCTTCAATTATTTGGTCATGCAATACTTA	765
Myrtillocactus	CTTAAAAGGACACTCGCAGCAGTCAGACCTTCCTTCAATTATTTGGTCATGCAATACTTA	765
Petunia	CTTAAAAGGACCTCCCCGAGTCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	726
Tobacco	CTTAAAAGGACCTCCCCGAGTCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	729
Sunflower	CTTAAAAGGACCTCCCTGCGGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	732
Arabidopsis	C-----GGACCTCCCTGCAGTGCGCCCTTCCTTGAATTTTTTGGTCATGCAATACTTT	726
Rapeseed	C-----GGACCTCCCTGCAGTGCGCCCTTCCTTGAATTTTTTGGTCATGCAATACTTT	720
Papaya	CTTAAAAGGACCTCCCTGCAGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	732
Oenothera	CTTAAAAGGACCCCCCTGCAGTGCCTCCCTTCCTTGAATTATTCGGTCATGCAATACTAT	729
Watermelon	CTTAAAAGAACCCTCCCCGAGTCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	729
Zucchini	CTTAAAAGAACCCTCCCCGAGTCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	732
Grape	CTTAAAAGGACCTCCCTGCAGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	729
Rice	CTAAAAGGACCTCCCCGTGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTT	659
Magnolia	CTTAAAAGGACCTCCCTGCTGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA	642

Beet	TTGAATACAAAGAAAAAATGCATTCGATCCCGTCCTAGTTCTCAATCATTTTCGTGGCA	789
Portulaca	TTCAATACAAAGAACAAAATACATTTTCGATCCAGTACTAGTTCTAAATCATTTTCGTGAA	825
Myrtillocactus	TTCAATACAAAGAACAAAATACATTTTCGATCCAGTAAGCGTTCGTATCATTTTCGTGAA	825
Petunia	TTGAATACAAAGAACAAAATACATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	786
Tobacco	TTGAATACAAAGAACAAAATTCATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	789
Sunflower	TTGAAGACAAAGAACCAAATGCATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGAA	792
Arabidopsis	TTTAATACAAAGAACCAAATTAATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	786
Rapeseed	TTTAATACAAAGAACCAAATGAATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	780
Papaya	TTGAATACAAAGAACCAAATTCATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	792
Oenothera	TTGAATACAAAGAACCAAATGCATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	789
Watermelon	TTGAATACAAAGAACAAAATGCATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	789
Zucchini	TTGAATACAAAGAACAAAATGCATTTTCGACCCCGTCGGAGTTCTCAATCATTTTCGTGGCA	792
Grape	TTGAATACAAAGAACCAAATTCATTTTCGACTCCGTCGTAGTTCTCAATCATTTTCGTGGCA	789
Rice	TTTAATACAAAGAACAAAATGCATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	719
Magnolia	TGGAATACAAAGAACAAAATGCATTTTCGACCCCGTCGTAGTTCTCAATCATTTTCGTGGCA	702

Beet	CCGGGCGTGGTTGAACCATCCACGATGAATAGAGCTAATGCGCA---GGGAGGAAGCTTA	846
Portulaca	CCGGGAGTGCTTGAAACATCTACGATGAATAGAATACTAGTAAA---GGAAAGAACTTA	882
Myrtillocactus	CCGGGAGTGCTTGAAACATCGCAGATGAATAGAATACGTTTAAA---GGAAAGAACTGT	882
Petunia	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCTAATGCACA---GGGAAGAAGCTTA	843
Tobacco	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCTAATGCACA---GGGAAGAAGCTTA	846
Sunflower	CCGGGCGTGGTTGAACCATCTACCATGGGGGAGCTCATGCACA---GGGAAGAAGCTTA	849
Arabidopsis	CCGGGCGCGCTGAACCATCTACGATGGGGGAGCGAATGCACA---GGGAAGAAGCTTA	843
Rapeseed	CCGGGCGCGCTGAACCATCTACGATGGGGGAGCGAATGCACA---GGGAAGAAGCTTA	837
Papaya	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCGAATGCACA---GGGAAGAAGCTTA	849
Oenothera	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCGAATGCACA---GGGAAGAAGCAAC	846
Watermelon	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCGAATGCACA---GGGAAGAAGCTTA	846
Zucchini	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCGAATGCACA---GGGAAGAAGCTTA	849
Grape	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCGAATGCACA---GGGAAGAAGCTTA	846
Rice	CCGGGTGTGGCTGAACCATCTACGATGGGGGAGC-----GAA---GGGAGGAAGCTTA	770
Magnolia	CCGGGCGTGGCTGAACCATCTACGATGGGGGAGCGAATGAACA---GGGAGGAAGCTTA	759

Beet	GATAAGAGAATACGTTCTCGCATCGCTTTTTTGTGGAAAGCTCGACCAGCCAGAAAAAG	906
Portulaca	GATAAGAGAATACCGTCTCGCATCGCTTTTTTGTGCGAAAGATCGAACAGCGAGAAAAAG	942
Myrtillocactus	CTTCAGAGAATACGTTCTCGCATCGCTTTTTTGTGCGAAAGATCGAACAGCGAGAAAAAG	942
Petunia	GATAAAAGAATAGCTTCTTGCATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	903
Tobacco	GATAAAAGAATACGTTCTTGCATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	906
Sunflower	GATAAGAGAATACGTT-----TCGCTTTTTTGTGCGAAAGCTCGACCAGCGAGAAAAAG	903
Arabidopsis	CAGAAGAGAATACGTTCTCGTATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	903
Rapeseed	CAGAAGAGAATACGTTCTCGTATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	897
Papaya	GATAAGAGAATACGTTCTCGCATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	909
Oenothera	GAGTTGAGAATACGTTCTCGCATCGCTTTTTTGTAGAAAAGCTCGACTAGCGAGAAAAAG	906
Watermelon	GATAAGAGAATACGTTCTCGCATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	906
Zucchini	GATAAGAGAATACGTTCTCGCATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	909
Grape	GATAAGAGAATACGTTCTCGCATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	906
Rice	GATAAGAGAATACGCTCTCGCATCGCTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	830
Magnolia	GATAAGAGAATACGCTCTCGCATCGGTTTTTTTTGTAGAAAAGCTCGACCAGCGAGAAAAAG	819
Beet	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTTCGCCAAGCGAATGATCTTCGC	966
Portulaca	GATTTGACAGAAGAAAAAAGAGCTTGACACACTTCATTTCGAAAAAAAATGATCTGCGA	1002
Myrtillocactus	GATTTGACAGAAGAAAAAAGAGCTTGACACACTTCATTTCGAAAAAAAATGATCTGCGA	1002
Petunia	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTTATTTCGCCAAGCGAATGATCTTCGC	963
Tobacco	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTTATTTCGCCAAGCGAATGATCTTCGC	966
Sunflower	TTTTTGGCCGAAGACAAAAA---GTTGACCCACTTCATTTCGCTGGTTCGAATCATCCTCGC	960
Arabidopsis	TGTTTGGCCGAAGCCAAAAATAGGTTGACCCACTTCATTTCGCTTGCGGAATGATCTTCGC	963
Rapeseed	TGTTTGGCCGAAGCCAAAAATAGGTTGACCCACTTCATTTCGCTTGCGGAATGATCTTCGC	957
Papaya	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTTCGCCAAGCGAATGATCTTCGC	969
Oenothera	AGTTTGGCCGAAGACAAAAAGGGGTTGCCCCACTTCATTTCGCCAAGAGAATGATCTTCGC	966
Watermelon	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTTCGCCAAGCGAATGATCTTCGT	966
Zucchini	TGTTTGGCCGAACCCAAAAAGAGGTTGACCCACTTCATTTCGCCAAGCAATGATCTTCGT	969
Grape	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTTCGCCAAGCGAATGATCTTCGC	966
Rice	TGTTTGGCCGAGCCAAAAAGAGGTTGATCCACTTCATTTCGCCAAGCGAATGATCTTCGC	890
Magnolia	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTTCGCCAAGCGAATGATCTTCGC	879
Beet	TTCGCGGGAAGAAGAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	1026
Portulaca	TTCGAGGGGGACAGAAAAACCAACATACAACCTTTCTTTCTTCGGTGCTACCTTTCTTC	1062
Myrtillocactus	TTCGAGGGGGACAGAAAAACCAACATACAACCTTTCTTTCTTCGGTGCTACCTTTCTTC	1062
Petunia	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTT	1023
Tobacco	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTT	1026
Sunflower	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	1020
Arabidopsis	TTCGCGGGAACAACATAAAACCACCATCTCGCTCTTTCATTCTTCGGTGCTACCTTTTTTC	1023
Rapeseed	TTCGCGGGAACAACATAAAACCACCATCTCGCTCTTTCATTCTTCGGTGCTACCTTTTTTC	1017
Papaya	TTCGCGGGAACAACAAAAACCACGATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	1029
Oenothera	TTCGCTGGAAGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	1026
Watermelon	TTCGCGGGAACAACAAAAACAACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	1026
Zucchini	TTCGCGGGAACAACAAAAACAACCATATCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	1029
Grape	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	1026
Rice	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTT	950
Magnolia	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTTC	939

e22

Beet	TTTCCAAAGGGATGGAGTTAGAGTTTATAATAACCTGTTTTTTAAAGATGCCCGGGAACAA	1086
Portulaca	TTTCCAAAGGGATGGAGTAAGAGTAAATAAGAACAAATTTCCAAAAATGCAAGGGGACGA	1122
Myrtillocactus	TTTCCAAAGGGATGGAGTAAGAGTCAATTCTAAAGAATTTCCAAAAATGCAAGGGAACGA	1122
Petunia	TTTCCAAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGGAGGATGCCCGGGAACAA	1083
Tobacco	TTTCCAAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGGAGGATGCCCGGGAACAA	1086
Sunflower	TTTCCAAGGGATGGGGTTGGGGTGTATAAGAA--ATTTTTTGAGTATGCCCGGGAACAA	1080
Arabidopsis	TTTCTAAGAGATGGGGTTGGGGTGTATAATAACCTT-----GATGCTCGGGAACAA	1074
Rapeseed	TTTCTAAGAGATGGGGTTGGGGTGTATAATAACCTT-----GATGCCCGGGAACAA	1068
Papaya	TTTCTAAGAGATGGGGTTGGGGTGTATAAGAACCTTTTTTTTGGAGGATGCCCGGGAACAA	1089
Oenothera	TTTCCCAGGGATGGGGTTGGGGTGTATAAGCACCTTTTTTTTGGAGGATGCCCGGGAACAA	1086
Watermelon	TTTCCAAAGGGATGGGGTTGGGGTGTATAAAAACCTTTTTTTTGGAGGATACCCGGGAACAA	1086
Zucchini	TTTCCAAGGGATGGGGTTGGGGTGTATAAAAACCTTTTTTTTGGAGGATACCCGGGAACAA	1089
Grape	TTTCCAAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGGAGGATGCCCGGGAACAA	1086
Rice	TTTCCAAAGGGATGGGGTTGGGGTGTATAATAACCCATTTTTTTGAGTATGCCCGGGAACAA	1010
Magnolia	TTTCCAAAGGGATGGGGTTGGGGTGTATAAGGAACCTTTCTTGAGGATGCCCGGGAACAA	999

e23

Beet	CTCCTAGGTCAATTAAGGATAAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG	1143
Portulaca	ATACTAAGAAAATTAAGGAGAAAATGTTGGAACCTCATGGGAAAGGA---TAAGGTAATG	1179
Myrtillocactus	ATAGACAGAAAATGTTGGAGAAAATGTTGGAACCTCATGGGAAAGGA---TAAGGTAATG	1179
Petunia	CTCCTAGGTCAATTAAGGAGAAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG	1140
Tobacco	CTCCTAGGTCAATTAAGGATAAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG	1143
Sunflower	CTCCTACGAAAATTCAGGAAAAAATGTTGGAACCTCATGGCTAAGGA---TAAGGTAATG	1137
Arabidopsis	CTCCTCAATCAATTAAGGGTCAAATGTTGGAACCTCTGGGTAAGGA---TAAGATAATG	1131
Rapeseed	CTACTCAATCAATTAAGGGTCAAATGTTGGAACCTTTTGGGTAAGGA---TAAGGTAATG	1125
Papaya	CTCCTAGAAAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG	1146
Oenothera	CTCCTAGGTCAATTAAGGATCAAATGTTGGAAGCTCATGGGTAAGGA---TAAGGTAATG	1143
Watermelon	CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATA	1143
Zucchini	CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGAGGATAAGGTAATA	1149
Grape	CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---TAAGGTAATG	1143
Rice	CTCCTAGGTCAATTAAGGATCAAATGTAGGAACCTCATGGGTAAGGA---TAAGGTAATG	1067
Magnolia	CTCCTAGGTCAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---GAAGGTAATG	1056

Beet	AAATTGATAGAAAAATTCATAGATCTAGGTGGGATAAGAGAATTGATAAAGGGAATAGAG	1203
Portulaca	AAATTGATAGAAAAATTCATAGATCTGGGGGGGATAAGAGAATTGATAAAGGGAATAGAG	1239
Myrtillocactus	AAATTGATAGAAAAATTCATAGATAACGGGGGGGATAAGAGAATTGATAAAGGGAGTAGAG	1239
Petunia	GAATTGATAGAGAAATTCATAGACCTAAATAGGATAGGAGAATTGATAAAGGGGAATAGAG	1200
Tobacco	GAATTGATAGAGAAATTCATAGACCTAAATAGGATAGGAGAATTGATAAAGGGGAATAGAG	1203
Sunflower	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1197
Arabidopsis	GAATTGATAGAGAAATTAAAAAACCTAGGTGGGATAGAAGAATTGATAAAGGTAATAGAT	1191
Rapeseed	GAATTGATAGAGAAATTCAAAAACCTAGGTGGGATAGAAGAATTGATAAAGGTAATAGAT	1185
Papaya	GAATTGATAGAGAAATTGAGAAACCTAGGTAGGATAGAAGAATTGATAAAGGGAATAGAG	1206
Oenothera	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1203
Watermelon	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1203
Zucchini	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1209
Grape	GAATTGATAGATAAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1203
Rice	GAATTGATAGAGAAATTCATCTACCTAGGTAGGATAGGCATAATTGATAAAGGGAATAGAG	1137
Magnolia	GAATTGATAGAGAAATTCATAGACCTAGGTAGGATAGGAGAATTGATAAAGGGAATAGAG	1116

Beet	ATGATGATAGAGATCATACTGAAAAACATAAGAATTGCTTACGGGTCTAACTCTTATTTG	1263
Portulaca	ATGATGATAGAGATCATACTCAAAAACAGAAGAATTCCTTACGGGTACAACCTCGTATTTG	1299
Myrtillocactus	ATGATGATAGAGATCATACTCAAAAACAGAAGAATTCCTTACGGGTACAACCTCGTATTTG	1299
Petunia	ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTACGGGTACAACCTATTATTTG	1260
Tobacco	ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTACGGGTACAACCTATTATTTG	1263
Sunflower	ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTACGGGTACAACCTTTTATTTG	1257
Arabidopsis	ATGATGATAGAGATCATACTGAGAAAGAGAGGAATTCCTTACAGGTACAACCTTTATTTT	1251
Rapeseed	ATGATGATAGAAATCATACTGAGAAAGAGAGGAATTCCTTATAGGTACAACCTCTTATTTT	1245
Papaya	ATGATGATAGAGATCATATTGAGAAAGAGCAAAATTCCTTACAGGTACAACCTCTTATTTA	1266
Oenothera	ATAATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTACGGGTACAACCTCTTATTTG	1263
Watermelon	ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTATGGGTACAACCTCTTATTTG	1263
Zucchini	ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTATGGGTACAACCTCTTATTTG	1269
Grape	ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTACGGGTACAACCTCTTATTTG	1263
Rice	ATGATGATAGAGATCATACTGAGAAAGAGGATAATTCCTTACGGGTACAACCTCTTATTTG	1197
Magnolia	ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCTTACGGGTACAACCTCTTATTTG	1176

e25

Beet	AACGAAGTGAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT	1323
Portulaca	AACGAAGTCAAAAAAATGAGATCTTTCTTAGCTAATAGAACAAAGACTAATACCTTAATA	1359
Myrtillocactus	AACGAAGTCAAAAAAATGAGATCTTTCTTAGCTAATAGAACAAAGACGTCTACCTTAATT	1359
Petunia	AACGAAGTGAAAAAATGCGATCTTTGTTGTATAATAGAACAAACACTAATACCTTAATT	1320
Tobacco	AACGAAGTGAAAAAATGCGATCTTTGTTGTATAATAGAACAAACACTAATACCTTAATT	1323
Sunflower	AACGAAGTGAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT	1317
Arabidopsis	TACGAAGTCAAAAAAATGCGATCTTTCTTGTCTAATAGAACAAACACTAAGACCTTAATT	1311
Rapeseed	TACGAAGTAAAAAATGCGATCTTTCTTGTCTAATAGAACAAACACTAAGACCTTAATT	1305
Papaya	AACAAAGTCAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT	1326
Oenothera	AACGAAGTGAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCATAATT	1323
Watermelon	AACGAAGTGAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT	1323
Zucchini	AACGAAGTGCAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT	1329
Grape	AACGAAGTGAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT	1323
Rice	AACGAAGTGCAAAAAATGCGATCTTTTTTGTCTAATAGAACAAACACTAATACCTTAATT	1257
Magnolia	AACGAAGTGCAAAAAATTCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT	1236

e26

e27

Beet	GAATCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATATCT	1383
Portulaca	TCATCGAAAAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATATCT	1419
Myrtillocactus	GAATCGAAAAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATATCA	1419
Petunia	GAATCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT	1380
Tobacco	GAATCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT	1383
Sunflower	GAGTCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGATATCTCT	1377
Arabidopsis	GAGTCAGTCAAAATAAAATCTGTTTATCAAAGCGCTTCTCCGATTGCTCAAGACATCTCT	1371
Rapeseed	GAGTCAGTCAAAATAAAATCTGTTTATCAAAGCGCTTCTCTGATTGCTCAAGACATCTCT	1365
Papaya	GAGTCGGTCAAAATCAAATCTGTTTATCAAAGCGCTTCTCCGATTGCTCAAGACATCTCT	1386
Oenothera	GAGTCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT	1383
Watermelon	GAGTCAGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT	1383
Zucchini	GAGTCAGTCAAGATCCAATCCGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT	1389
Grape	GAGTCGGTCAAGATAAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT	1383
Rice	GAGTCGGTAAAGATCAAATCTGTTTATCAAAGTGCTTCTCTGATTGCTCAAGACATCTCT	1317
Magnolia	GAGTCGGTCAAGATCAAATCTGTTTATCAAAGTGCTTCTCCGATTGCTCAAGACATCTCT	1296

e28

Beet	TTTCAACCGAAAAAGAAAAGAGGATCATTTTCGTTCTATTTTGTAGTAAAAATAGTGAAAAAG	1443
Portulaca	TTTCAACCGAAAAACAAAAGAAGATCATTTTCGACAAATTTTGTAGTCAAATTGTCAAGAAT	1479
Myrtillocactus	GTTAAACCGAAAAACAAAAGAAGATCATTTTCGAAAAATTTTGTAGTCAAATTGTAAAGAAT	1479
Petunia	TTTCAACCGAGGAACAAAACAAGATCATTTTCGTTCCATTTTGTAGTAAAAATAGTGAAGGAT	1440
Tobacco	TTTCAACCGAGGAACAAAACAAGATCATTTTCGTTCCATTTTGTAGTAAAAATAGTGAAGGAT	1443
Sunflower	TTTCAACCGAGGAACAAAACAAGATCATTTTCGTTCCATTTTGTAGTCAAATAGTGAAGGAT	1437
Arabidopsis	TTTCAACTGAAGAACAAAAGAAGATCATTTTCATTCCATTTTGTGCTAAAAATAGTGAAGGAG	1431
Rapeseed	TTTCAACTGAAGAACAAAAGAAGATCATTTTCATTCCATTTTGTGCTAAAAATAGTGAAGGAG	1425
Papaya	TTTCAACTGAGGAACAAAAGAAGATCATTTTCGTTCCATTTTGTAGTCAAATAATGAAGAAT	1446
Oenothera	TTTCAACCGAGGAACAAAAGAAGATCATTTTCGTTCTATTTTGTAGTCAAATTGTGAAGGAT	1443
Watermelon	TTTCAACTGAGAAACAAAACAAGATCATTTTCGTTCCATTTTGTAGTAAAAATAGTGAAGGAT	1443
Zucchini	TTTCAACTGAGAAACAAAACAAGATCATTTTCGTTCCATTTTCACTAAAAATAGTGAAGGAT	1449
Grape	TTTCAACCGAGGAACAAAACAAGATCATTTTCGTTCCATTTTGTAGTAAAAATAGTGAAGGAT	1443
Rice	TTTCAACTGGGGAACAATCCAATCTCATTTTCGTTCCATTTTGTAGTCAAATAGTGAAGGAT	1377
Magnolia	TTTCAACCGAGGAACAAAACAAGATCATTTTCGTTCCATTTTGTAGTCAAATAGTGAAGGAT	1356

	e29	e30	
Beet	ATTCCATTAGTAATGAAAAGGGGGTAGAGGGGATCCGTATATGTTGTTTCAGGTCGATTA		1503
Portulaca	ATTCCATTAGTAATGAAAAGGGCGTAGAGGGGATCCGTATATCTTGTTTCAGGTCGATTA		1539
Myrtillocactus	ATTCCATTAGTAATGAAAAGGGCGTAGAGGGGATCCGTATATCTTGTTTCAGGTCGATTA		1539
Petunia	ATTCCATTAGTAATGAAAAAGGGGTGGAGGGGATCCGTATATGTTGTTTCAGGTCGATTA		1500
Tobacco	ATTCCATTAGTAATGAAAAAGGGGTGGAGGGGATCCGTATATGTTGTTTCAGGTCGATTA		1503
Sunflower	ATTCGATTAGTAATGAAAAAGGGGTGGAGGGGATCCGTATATGTTGTTTCAGGTCGATCA		1497
Arabidopsis	ATTCCA-----AAAGGGTGGAGGGAATCCGTATATGTTTTCGGGTCGATTA		1479
Rapeseed	ATTCCA-----AAAAGGGTGGAGGGAATCCGTATATGTTTTCGGGTCGATTA		1473
Papaya	ATTCATTAGTAATGAAAAGGGGGTTGAGGGGATCCGTATATGTTGTTCCGGTCGATTA		1506
Oenothera	ATCCCATTAGTAATGAAAAAGGGGTGAGGGGATCCGTATATGTTGTTTCAGGTCGATCA		1503
Watermelon	ATTCCATTAGTAATGAAAAAGGGGTGAGGGGATCCGTATATGTTGTTTCAGGTCGATCA		1503
Zucchini	ATTCCATTGGAATGAAAAAGGGGTGAGGGGATCCGTATATGTTGTTTCAGGTCGATCA		1509
Grape	ATTCCATTAGTAATGAAAAGGGGGTTGAGGGGATCCGTATATGTTGTTTCAGGTCGATCA		1503
Rice	ATTCCATTAATAATGCCAAAAGGGGTGGAGGGGATACGTATTTGTTGTTCTGGTCGATTA		1437
Magnolia	ATTAATTAGTAATGCCAAAAGGGGTGGAGGGGATCCGTATTTGTTGTTTCAGGTCGATCA		1416

e31

Beet	GAAGGTGCA---GAAATTGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT	1560
Portulaca	GCAGGTGCA---GAAATTGCAAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT	1596
Myrtillocactus	GAAGGTGCA---GAAATTGCAAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT	1596
Petunia	GAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT	1557
Tobacco	GAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT	1560
Sunflower	GAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAATTATGGAAAAACATCTAGTAAT	1554
Arabidopsis	AAAGACGCAGCAGAAAAAGCTCAAATAAATGCTATAAGCATAGAAAAACTTCTCGTAAT	1539
Rapeseed	AAAGACGCAGCAGAAAAAGCTCAAATAAATGCTATAAGCATAGAAAAACTTCTCGTAAT	1533
Papaya	AAAGGCGCA---GAAATAGCGAGAACTGAATGCGGAAAGTATGGAAAGTCTCTCGTAAT	1563
Oenothera	AAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT	1560
Watermelon	GAAGGCGCG---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT	1560
Zucchini	GAAGGCGCG---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT	1566
Grape	GAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT	1560
Rice	GGGGGTGCG---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT	1494
Magnolia	GAGGGTGCA---GAAATAGCTAGAACTAAATGCGGAAAGTATGGAAAAACATCTCGTAAT	1473

	e32e33e34	e35	e36
Beet	GTATTACACCAGAAAATTGATTATGCTTCTGCGGAAGTATCTACTCGTTACGGAATCGTA		1620
Portulaca	GTATTAGACCAGAAAATCGATTATGCTTCTGCGGAAGTATCTACTCGTTACGGAATCTTA		1656
Myrtillocactus	GTATTAGACCAGAAAATCGATTATGCTTCTGCGGAAGTATCTACTCGTTACGGAATCTTA		1656
Petunia	GTATTTAACCAGAAAATAGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA		1617
Tobacco	GTATTTAACCAGAAAATAGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA		1620
Sunflower	GTATTTAACCAGAAAATAGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA		1614
Arabidopsis	GTATTTAACCATAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA		1599
Rapeseed	GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA		1593
Papaya	GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTTA		1623
Oenothera	GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTTA		1620
Watermelon	GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTATGGAATCTCA		1620
Zucchini	GTATTTAACCAGAAAATCGATTATGCTCCGCAGAAGTATCTACTCGTTATGGAATCTTA		1626
Grape	GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA		1620
Rice	GTATTTAACCAGAAAATCGATTATGCTCTTGCGGAAGTATCCACTCGTAACGGAATTTCA		1554
Magnolia	GTATTTACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA		1533
	e37		
Beet	GGTGTCAAAGTGTGGATTTCTTATAGTCCAAAATAA		1656
Portulaca	GGTGTCAAAGTGTGGATTTCTTATAGTCAAAAATGA		1692
Myrtillocactus	GGTGTCAAAGTGTGGATTTCTTATAGTCAAAAATGA		1692
Petunia	GGTGTCAAAGTGTGGATTTCTTATAGTAAAAAAAAAAGGGACGTGCTATATCCGAAACG		1677
Tobacco	GGTGTCAAAGTGTGGATTTCTTATAGTAAAAAAAAAAGGGACGTGCTATATCCGAAACG		1680
Sunflower	GGTGTCAAAGTGTGGATTTCTATATAGTCAAAAAGAAAGGGACGTGCTATATCCGAAACG		1674
Arabidopsis	GGTGTCAAAGTGTGGATTTCTATATAGTCAAAAAGAAAGGGACGTGCTATATCCGAAACG		1659
Rapeseed	GGTGTCAAAGTGTGGATTTCTATATAGTCAAAAAGAAAGGGACGTGCTATATCCGAAACG		1653
Papaya	GGTGTCAAAGTGTGGATTTCTATATAGTTAA		1653
Oenothera	GGTGTCAAAGTGTGGATTTCTTATAGTAAGTAA		1653
Watermelon	GGTGTCAAAGTGTGGATTTCTATATAAAAAAAAAAAGGAACGTGTTATATCCGAAACG		1680
Zucchini	GGTGTCAAAGTGTGGATTTCTATATAAAAAACAAAAAAGGAACGTGTTATATCCGAAACG		1686
Grape	GGTGTCAAAGTGTGGATTTCTATATAGTAAAAAAAAAAGGGACGTGCTATATCCGAAACG		1680
Rice	GGTGTCAAAGTGGATCTCATATAGTCAAAATAAGAAGGGACGTGCTATATCCGAAACG		1614
Magnolia	GGTGTCAAAGTGGATCTCATATAGTAAAAAAAAATAA		1572
Petunia	TACGAAATATAG	1689	
Tobacco	TACGAAATATAG	1692	
Sunflower	TACGAAATCTAG	1665	
Arabidopsis	TACGAAATATAG	1671	
Rapeseed	TACGAAATATAG	1671	
Watermelon	TACGAAATATAG	1692	
Zucchini	TACGAAATATAG	1698	
Grape	TACGAAATATAG	1692	
Rice	TACGAAATATAG	1626	

Fig. S2 Nucleotide sequence alignment of *rps3*-coding regions of sugar beet (Beet), *Portulaca grandiflora* (Portulaca), *Myrtillocactus geometrizans* (Myrtillocactus), grapevine (Grape), *Arabidopsis thaliana* (Arabidopsis), rapeseed, *Oenothera berteriana* (Oenothera), sunflower, watermelon, zucchini, petunia, tobacco, papaya, *Magnolia x soulangeana* (Magnolia) and rice.

Nucleotide residues are numbered from the first base of the initiation codon. Exon/intron boundaries are indicated by vertical lines. Intronic sequences are not considered. Dashes are included for maximum matching. Editing sites are highlighted in black (experimentally confirmed) or gray (predicted), and numbered from e1 to e37. Sources of the data are Matsunaga et al. (Plant Cell Reports, 2011 30: 231-238) and others shown in Table S1