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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-i1*) in 30 taxa led De Benedetto et al. (1992) to conclude that the presence/absence of *cox2-i1* 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 *Eco*RI 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.

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

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

[a]Absence, [b]Presence

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'

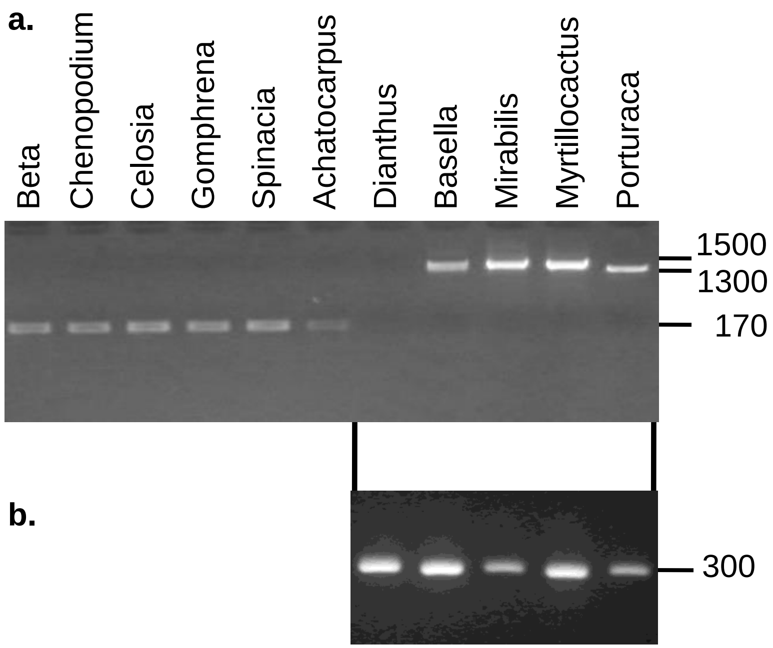
P7, 5'-CATCTCAAAGTATAGGGCAAAGGA-3'

P8, 5'-ATATATGGCACGAAAAGGAAATCC-3'

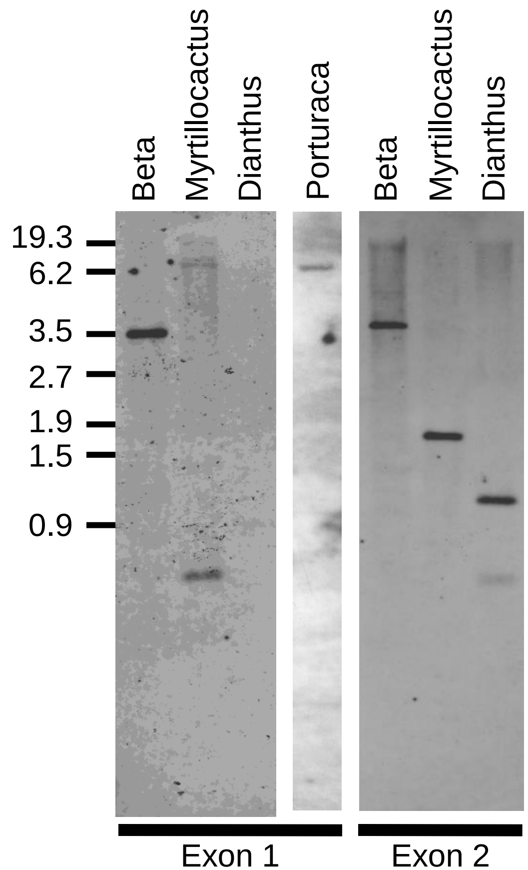
P9, 5'-TTTTCATTTTTGACTATAAGAAATCC-3'

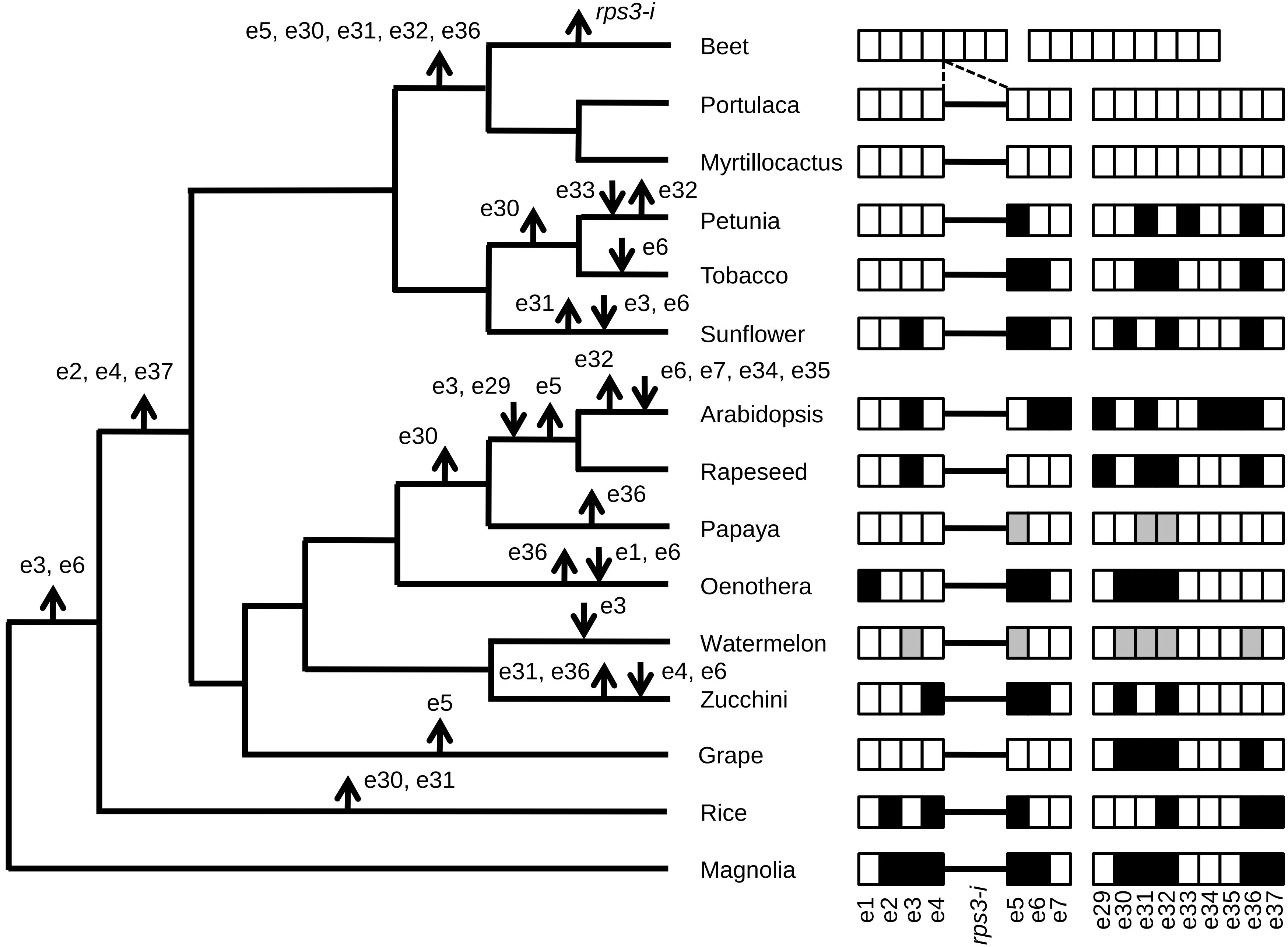
P10, 5'-GTATTGAATAAGTATTGCAT-3'

P11, 5'-AGACCTTCCTTCAATTATTTGG-3'



a.
Beta
Chenopodium
Celosia
Gomphrena
Spinacia
Achatocarpus
Dianthus
Basella
Mirabilis
Myrtillocactus
Porturaca
1500
1300
170
b.
300


Beta
Myrtillocactus
Dianthus
Porturaca
Beta
Myrtillocactus
Dianthus
19.3
6.2
3.5
2.7
1.9
1.5
0.9
Exon 1
Exon 2



rps3-i
e5, e30, e31, e32, e36
Beet
Portulaca
Myrtillocactus
e33
e32
e30
Petunia
e6
Tobacco
e31
e3, e6
Sunflower
e2, e4, e37
e32
e6, e7, e34, e35
e3, e29
e5
Arabidopsis
e30
Rapeseed
e36
Papaya
e36
e1, e6
Oenothera
e3, e6
e3
Watermelon
e31, e36
e4, e6
Zucchini
e5
Grape
e30, e31
Rice
Magnolia
e1
e2
e3
e4
rps3-i
e5
e6
e7
e29
e30
e31
e32
e33
e34
e35
e36
e37

a.

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                  Exon 1            Exon 2
Beta              AGTTGGTTTAATGATTATTATTATAGTAAATTAGTATATCAAGATCTCAATCTGAGATCT     60
Chenopodium       AGTTGGTTTAGTGATTATTATTTGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
Celosia           AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
Gomphrena         AGTTGGTTTAGTGATTATTATTTAGTAAATTAGTCTATCAAGATATCAATCTGAGATCT     60
Spinacia          AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
Achatocarpus      AGTTGGTTTAGTGATTATTATTATGGTAAATTAGTATATCAAGATATCAATCTGAGATCT     60
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b.

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Basella           CATCTCAAAGTATAGGGCAAAGGAGAAAGGGCTTTGACTTTGTCTACCGGGATTCAACAC     60
Mirabilis         CATCTCAAAGTATAGGGCAAAGGATCAAGCGCTTTTACTTTGTCTCCCGGGATTCACCAC     60
Myrtillocactus    CATCTCAAAGTATAGGGCAAAGGATCTTTGGTTTTGACTTTGTCTCCAGGGAATCACCAT     60
Portulaca         CATCTCAAAGTATAGGGCAAAGGATCTTTGGTTTTGACTTTGTCTCCAGGGAATCACCAT     60
Dianthus          CATCTCAAAGTATAGGGCAAAGGATGAAGCGCTTTGACTTTGTCTCCCGGGATTCGCCAC     60
Silene            CATCTCAAAGTATAGGGCAAAGGATGAAGCGCTTTGACTTTGTCTCCCGGGATTCACCAC  76149

Basella           AGGTTCGGTTTCAGAGCTGTGTGA--TG---GGTAACTATCCTGCACGGTTCGGAGAGCA    115
Mirabilis         AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTGACTATCCTGCACGGTTCGGAGAGCA    115
Myrtillocactus    AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTCACTATCCTGCTCGGTTCGGAGAGCA    115
Portulaca         AGGTTGGGTTTAAGAGCCGTGTGA--TG---GGTCACTATCCTGCTCGGTTCGGAGAGCA    115
Dianthus          AGGGTGGCTTTGAGAGCCGTGTGATGTGATAGGTTACTTTCCTGCACGGCTC-G-GAG-A    117
Silene            AGGTTGGGTTTGAGAGCCGTG-----TGATAGGTTACTATCCTGCACGGTTCGGAGAGCA  76094

Basella           CTTTTAGGCTGACTTGGTGAATGGGAGACAAAGTATCAAGGAAGAAAGAAGGAGTTCTTC    175
Mirabilis         CTTTTCGTCTGCGTTGGTGAATGGGAGCCCCCCTATCAAGCAAGAAAGAAGCAGTTCTTC    175
Myrtillocactus    CTTATAGTCTGCATTGGTGAATGGAAGAAGACCTATCTTT-----------GAGTTCTTC    164
Portulaca         CTTATAGTCTGCATTGGTGAATGGAAGAAGACCTATC-----------AAGGAGTTCTTC    164
Dianthus          -TTTTAGTCTGCGTTGGTGAATGGGAGCCCCACTATCAAGCAAGAAAGAAAGAGTTCTTC    176
Silene            CTTTTAGTCTGCGTTGGTGAATGGGAGCCCCACTATCAAACAAGAAAGAAACTGTTCTTC  76034

                                      Intron            Exon 2
Basella           CCACTTCTACTTAAAATGTCAACATTGACTCTATTTATTATTATACTAAATTTTTATATC    235
Mirabilis         CCACGGC------GGA-GTCACCATTGACTCTATTTATTATTATGGTAAATTAGTATATC    228
Myrtillocactus    CCACTTCTACTTAAAATGTAAACATTGACTCTATTTATTATTATGGTAAATTAGTCTATC    224
Portulaca         CCACTTCTACTTAAAATGTCAACATTGACTCTATTTATTATTATAAAAAATTAGTCTATC    224
Dianthus          CCACGGC--------A-G--AA-ATTGACTCTCTTTATTATTATGGTAAATTAGTATATC    224
Silene            TTT-TT--GAGTAGGGCGG-AA-ATTGACTCTATTTATTATTATGGTAAATTAGTATATC  75979
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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              ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Portulaca         ATGGCACGAAAAGGAAATCCTATTTCGGTAAGGCTAGGGCTGAATCGTAGTTCAGATTCA    60
Myrtillocactus    ATGGCACGAAAAGGAAATCCGATTTCGGTCAGACTTGGGCTTAATCGTAGTTCTTCTTCT    60
Petunia           ATGGCACGAAAAGGAAATCCTATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Tobacco           ATGGCACGAAAAGGAAATCCTATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Sunflower         ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Arabidopsis       ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGGAAAAAATCGTAGTTCAGATTCA    60
Rapeseed          ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGGAAAAAATCGTAGTTCAGATTCA    60
Papaya            ATGGCACGCAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Oenothera         ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Watermelon        ATGGCACGAAAAGGAAATCCTATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Zucchini          ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Grape             ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATTCA    60
Rice              ATGGCACGAAAAGGAAATCCAATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATCCA    60
Magnolia          ATGGCACGAAAAGGAAATCCGATTTCGGTAAGACTTGATCTGAATCGTAGTTCAGATCCA    60

                     e3   e4                       e5
Beet              AGTTGGTTTAATGA 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              TATTTTGGTTCGATACGTCCACCTACGAGACTTACCTTTGGCTTTCGCCTCGGTAGGTGT   180
Portulaca         TATTTCGCTTCGATACGCCAACCCACGAGACTCACCTTTGGCTTTCGACTCGGTAGGTCT   180
Myrtillocactus    TATTTCGCTTCGATACGCCAACCCACGAGACTCACCTTTGGCTTTCGACTCGGTAGGTCT   180
Petunia           TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   177
Tobacco           TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Sunflower         TATTTCGGTTCGATACGTCCACCTACTAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Arabidopsis       TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTCGGCTTTCGTCTCGGTAGGTGT   180
Rapeseed          TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Papaya            TATTTCGGTTCGATACGTCCACCTACGAGACTAACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Oenothera         TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Watermelon        TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Zucchini          TATTTCGGTTCGATACGTCCACCTACGAGACTGACCTTTGGCTTTCGTCTTGGTAGGTGT   180
Grape             TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Rice              TATTTCAGTTCGATACGTCCACCTACGATACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
Magnolia          TATTTCGGTTCGATACGTCCACCTACGAGACTCACCTTTGGCTTTCGTCTCGGTAGGTGT   180
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                        e7
Beet              ATTATTATACATTTTCAAAAACGAACATTCATTAATTTCTTTCTTCCTCGTCGACCACAA   240
Portulaca         ATTATTATTCATTTTCAAAAGAGAACTTTCATTCATTTCTTTATTCCCCGTAGTCCACGA   240
Myrtillocactus    ATTATTATTCATTTTCAAAAGAGAACTGTAATTCATTTCTTTATTCCCCGTAGTCCACGA   240
Petunia           ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   237
Tobacco           ATTATTATACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Sunflower         ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Arabidopsis       ATTATTCTACATTTTCCTAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Rapeseed          ATTCTTCTACATTTTCCTAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Papaya            ATTATTCTACATTTTCCTAAAAGAACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Oenothera         ATTATTCTACATTTTCCCAAAAGAACATTTATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Watermelon        ATTATTTTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCTCGTCGACCACGA   240
Zucchini          ATTATTTTACATTTTCCCAAAATCACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240
Grape             ATTATTCTACATTTTCCCAAAAGAACATTCATTCATTTCTTTCTTCCTCGTCGACCACGA   240
Rice              ATTATTCTACATTTTCCCAAAAGGACATTCATTCATTTCTTTCTTCCCCGTCGACCACTA   240
Magnolia          ATTATTCTACATTTTCCCAAAAGGACATTCATTCATTTCTTTCTTCCCCGTCGACCACGA   240

                                         e8    e9
Beet              CGACGGAAACGACGCAAAAAATCCAGACCCGGAAAGACGAAG------------------   282
Portulaca         CGAAATAAAAAAAGGGAAAAATCCAGACGCGAAAGGAAGAAGAAGATAGCAATG------   294
Myrtillocactus    CGAAAGAAAAAAGGGGAAAAATCCAGACGCGAAAGGAAGAAGAAGTACGCAATG------   294
Petunia           CGACTGAAACGACGCGAAAAATCCAGACCCGTAAAGGAGAAG------------------   279
Tobacco           CGACTGAAACGACGCGAAAAATCCAGACCCGTAAAGGAGAAG------------------   282
Sunflower         CGACAGAAACGACGCGAAAAATCCAGACCCGGAAAGGGGAAG------------------   282
Arabidopsis       CGACTGAAACGACGTGAAAAAACTAGACCCGGAAAGGAGAAG------------------   282
Rapeseed          CGACTGAAACGACGTGAAAAAACTAGACCCGGAAAGGAGAAG------------------   282
Papaya            CGACTGAAACGACGCAAAAAAACCAGACCCGGAAAGGAGAAG------------------   282
Oenothera         CGACTGAAACGAGGCAAAAAATCCAGACCCGGAAAGGAGAAG------------------   282
Watermelon        CGACTGAAACGACGCGAAAAATCCAAACCCGGAAAGGAGAAG------------------   282
Zucchini          GGACTGAAACGACGCGCAAAATCCAAACCCGGAAAGGATCAG------------------   282
Grape             GGACTGAAACGACGCGAAAAATCCAGACCCGGAAAGGAGAAG------------------   282
Rice              CGACTAAAACGACGCGACAAATCAAGACCCGGAAAGGATAAG------------------   282
Magnolia          CGACTGAAACGACGCGACAAATCAAGACCCGGAAACGTGA--------------------   280

                                                                e10 e11
Beet              ------GGCCGGTGGTGGGA---ATTGGGG------AAAGTCGGGCCGATCGAGTGTCTT   327
Portulaca         AAGATTGCCCAGTGGTGGGA---ATTTGGGCCACCAAAAGTAGGGAAGATCGAATGTATT   351
Myrtillocactus    AAGATTGCCCAGTGGTGGGA---ATTTGGG------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------AAAGTCGGGCCAATTGGGTGTCTT   327
Grape             ------GGCCGGTGGTGGGC---ATTTGGG------AAAGTCGGGCCGATCGGGTGTCTT   327
Rice              ------GGCCGGTGGTGGGC---ATTTGGG------AAAGTCGGGCCGATCGGGTGTCTT   327
Magnolia          ------------------------------------------------------------   280
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Beet             TATTCAA------GCGAGGGTAGAAAAGAAGAACGAAACGAAGTGAGAGACCGAAGGGCC   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---CATGCTCGACGACCAGAAAAAGAAAAACGAAATCAGG   468
Myrtillocactus   GGGAAAAGAGTTGAGTCGAT---CATGCTCGACGACCAGAAAAAGAAAAACGAAATCAGG   468
Petunia          GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGATCGGGAGAAGCAAAACGAAATCAGG   435
Tobacco          GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGATCGGGAGAAGCAAAACGAAATCAGG   438
Sunflower        GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG   438
Arabidopsis      AGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAAAAGCAAAACGAAATCCGG   441
Rapeseed         AGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAGAAGCAAAACGAAATCCGG   435
Papaya           GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGAAAGAAGCAAAACGAAATCCGG   441
Oenothera        GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG   438
Watermelon       GAGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAAAAGCAAAACGAAATTCGG   438
Zucchini         GAGAAAAGAGTGGAGTCGATGATCAGGCTCGACGACCGGGAAAAGCAAAACGAAATTAGG   441
Grape            GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAAGAAGG   438
Rice             GGGAAAAGAGTCGAGTCGAT---C---------GACCGGGAGAAGCAAAACGAAATCAGG   426
Magnolia         GGGAAAAGAGTCGAGTCGAT---CAGGCTCGACGACCGGGAGAAGCAAAACGAAATCAGG   351

                        e13
Beet             GTTTGGCCAAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Portulaca        ATTTGGAAAAAAAAGAAGCAAGGCTATGGATACCATGACCGATCAACATCCATAAAGAAT   528
Myrtillocactus   ATTTGGAAAAAAAAGAAGCAAGGCTATGGATACCATGACCGATCAACATCCATAAAGAAT   528
Petunia          ATTTGGCCGAAAAAGAAGCAAGGCTATGGATACCATGACCGATCACCATCGATAAAGAAA   495
Tobacco          ATTTGGCCGAAAAAGAAGCAAGGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Sunflower        ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Arabidopsis      GGTTGGCCGAAAAAAAAACAACGCTATGGATACCATGACCGATTACCCTCGATAAAGAAG   501
Rapeseed         GGGTGGCCGAAAAAAAAACAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   495
Papaya           ATTTGGCCGAAAAAAAAGCAAGGCTATAGATACCATGACCGATCACCATCGATAAAGAAG   501
Oenothera        ATTTGGCCGAAAAAGAAGCAAGGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Watermelon       ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGATAAAGAAG   498
Zucchini         ATTTGGCCGAAAAAGAAGCAAGACTATGGATACCATGACCGATCACCATCGAGAAAGAAG   501
Grape            ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCAATCACCATCGATAAAGAAG   498
Rice             ATTTGGCCGAAAAAGATGCAACGTTATGGATACCATGACCGATCACCATCGAGAAAGAAG   486
Magnolia         ATTTGGCCGAAAAAGAAGCAACGCTATGGATACCATGACCGATCACCATCGAGAAAGAAG   411
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                                  e14
Beet             AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGAGGTT   558
Portulaca        CATCTTTCTAAAGAACTTCGGGGAGCGGGGAATTAAAGCAGCCGAAATACGCAGAGGTT   588
Myrtillocactus   CATCTTTCGTCATCACTTCGGGGAAGCGGGGAATTAAAGCAGCCGAAATACGCAGAGGTT   588
Petunia          AATCTGTCTAAATCACTTCGTGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGATT   555
Tobacco          AATCTTTCTAAATCACTTCGTGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGATT   558
Sunflower        AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGCTT   558
Arabidopsis      AATCTTTCTAAATCACTTCGGATCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   561
Rapeseed         AATCTTTCTAAATCACTTCGGATCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   555
Papaya           AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAACTACGCCGGGGTT   561
Oenothera        AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   558
Watermelon       AATCTTTCTAAATTACTTCGCGTCAGCGGGGCCTTCAAGCATCCGAAATATGCCGGAGTT   558
Zucchini         AATCTTTCTAAATCACTTCGCGTCAGCGGGGCCTTCAAGCATCCGAAATATGCCGGAGTT   561
Grape            AATCTTTCTAAATTACTTCGGGTCAGCGGGGCCTTCAAGCATCTGAAATACGCCGGGGTT   558
Rice             AATTTTTCTAAATCACTTCGGGTGAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   546
Magnolia         AATCTTTCTAAATCACTTCGGGTCAGCGGGGCCTTCAAGCATCCGAAATACGCCGGGGTT   471

                                     e15                   e16 e17
Beet             GTAAATGACATAGCCTTTCTGATAGAAAATGATTCTTCCTTCAAAAAAACGAAGTTATTC   618
Portulaca        CTAAATAACATAGAATTTCTGATAGAAAAAAAATCTTCCTTCAAAAAAACGAAGTTATTC   648
Myrtillocactus   CTAAATAACATAGAATTTATGATCGAAAAAAAAGAATCCTTCAAAAAAACGAAGTTATTC   648
Petunia          GAAAATGACATAGCCTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACAAACTTATTC   615
Tobacco          GAAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACAAACTTATTC   618
Sunflower        GTAAATGACATAGCCCTCCTAAA------TGACGACTCCTTCAGAAAAACGAAGTTATTC   612
Arabidopsis      GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAAAAAAACGAAGTTATTC   621
Rapeseed         GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   615
Papaya           GTAAATGACATAGCGTCCCTGATAGAAAATGACGACTCCTTCCGAAAAACGAAGTTATTC   621
Oenothera        TTAAATGACATAGCCTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   618
Watermelon       GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   618
Zucchini         GTAAATGACATAGCGTTCCTGATCGAAAATGACGACTCCTTCAGAAAAACTCAGTTATTC   621
Grape            GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTTCAGAAAAACGAAGTTATTC   618
Rice             GTAAATGACATAGCCTTCCTGA-------------------TAGAAAA------------   577
Magnolia         GTAAATGACATAGCGTTCCTGATAGAAAATGACGACTCCTCCAGAAAAACTAAGTTATTC   531

                                                          e18
Beet             AAGTTCTTTTTCCCAAAGAAGTCA---------CGCTACGACGGCCCGACAAGTCATCTA   669
Portulaca        AAGTTCTTTTTCAAAAAAACGAAGTACAG---CTACAAAAAAAAACATCAAAGTCATCTA   705
Myrtillocactus   TTTTTCTTTTTCAAAAAAACGAAGTACAG---CTACAAAAAAAAACATCAAAGTCATCCA   705
Petunia          AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACCGCCCGACGAGTCATCTA   666
Tobacco          AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACCGCCCGACGAGTCATCTA   669
Sunflower        AAGTTCTTTTTCTCAAAGAAGTCAAAGAAGTCCCCCTCCGACAGCCCGACGAGTCATCCA   672
Arabidopsis      AAGTTATTTTTCCAAAATAAGTC---------CCGCTCCGACGGCCCGACGAGTTATCTA   672
Rapeseed         AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTTATCTA   666
Papaya           AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGACCCGACGAGTCATCTA   672
Oenothera        AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTCATCTA   669
Watermelon       AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTCATCTA   669
Zucchini         AAGTTCTTTTTCCCAAATCAGTC---------CCGCTCCGACGGCCCGACGAGTCATCTA   672
Grape            AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGACGGCCCGACGAGTCATATA   669
Rice             ---------------------------------------TGACGGCCCGACGAGTCATCTA   599
Magnolia         AAGTTCTTTTTCCCAAAGAAGTC---------CCGCTCCGGCGGCCCGACGAGTCATCTA   582
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                                                                        e19
Beet             CTTAAAAGGACCCTCCCTGCAGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   729
Portulaca        CTTAAAAGGACACTCGCAGCAGTCAGACCTTCCTTCAATTATTTGGTCATGCAATACTTA   765
Myrtillocactus   CTTAAAAGGACACTCGCAGCAGTCAGACCTTCCTTCAATTATTTGGTCATGCAATACTTA   765
Petunia          CTTAAAAGGACCCTCCCCGCAGTCCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   726
Tobacco          CTTAAAAGGACCCTCCCCGCAGTCCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   729
Sunflower        CTTAAAAGGACCCTCCCTGCGGTGCGCCCTTCCTTGAATTATTCGGTCATGCAATACTTA   732
Arabidopsis      C------GGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTTTTTGGTCATGCAATACTTT   726
Rapeseed         C------GGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTTTTTGGTCATGCAATACTTT   720
Papaya           CTTAAAAGGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   732
Oenothera        CTTAAAAGGACCCCCCCTGCAGTGCGTCCCTCCTTGAATTATTCGGTCATGCAATACTAT   729
Watermelon       CTTAAAAGAACCCTCCCCGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   729
Zucchini         CTTAAAAGAACCCTCCCCGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   732
Grape            CTTAAAAGGACCCTCCCTGCAGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   729
Rice             CTAAAAAGGACCCTCCCCGCTGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTT   659
Magnolia         CTTAAAAGGACCCTCCCTGCTGTGCGCCCCTCCTTGAATTATTCGGTCATGCAATACTTA   642
                                                                                 e20
Beet             TTGAATACAAAGAAAAAAATGCATTCCGATCCCGTCCTAGTTCTCAATCATTTCGTGGCA   789
Portulaca        TTCAATACAAAGAACAAAATACATTTCGATCCAGTACTAGTTCTAAATCATTTCGTCGAA   825
Myrtillocactus   TTCAATACAAAGAACAAAATACATTTCGATCCAGTAAGCGTTCGTCATCATTTCGTCGAA   825
Petunia          TTGAATACAAAGAACAAAATACATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   786
Tobacco          TTGAATACAAAGAACAAAATTCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   789
Sunflower        TTGAAGACAAAGAACCAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGAA   792
Arabidopsis      TTTAATACAAAGAACCAAATTAATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   786
Rapeseed         TTTAATACAAAGAACCAAATGAATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   780
Papaya           TTGAATACAAAGAACCAAATTCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   792
Oenothera        TTGAATACAAAGAACCAAATGCATTTCGACCCCCTCGTAGTTCTCAATCATTTCGTGGCA   789
Watermelon       TTGAATACAAAGAACAAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   789
Zucchini         TTGAATACAAAGAACAAAATGCATTTCGACCCCGTCGGAGTTCTCAATCATTTCGTGGCA   792
Grape            TTGAATACAAAGAACCAAATTCATTTCGACTCCGTCGTAGTTCTCAATCATTTCGTGGCA   789
Rice             TTTAATACAAAGAACAAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   719
Magnolia         TGGAATACAAAGAACAAAATGCATTTCGACCCCGTCGTAGTTCTCAATCATTTCGTGGCA   702

Beet             CCGGGCGTGGTTGAACCATCCACGATGAATAGAGCTAATGCGCA---GGGAGGAAGCTTA   846
Portulaca        CCGGGAGTGCTTGAAACATCTACGATGAATAGAATACTAGTAAA---GGAAAGAAACTTA   882
Myrtillocactus   CCGGGAGTGCTTGAAACATCGCAGATGAATAGAATACGTTTAAA---GGAAAGAAACTGT   882
Petunia          CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCTAATGCACA---GGGAAGAAGCTTA   843
Tobacco          CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCTAATGCACA---GGGAAGAAGCTTA   846
Sunflower        CCGGGCGTGGTTGAACCATCTACCATGGGGGGAGCTCATGCACA---GGGAAGAAGCTTA   849
Arabidopsis      CCGGGCGCCGCTGAACCATCTACGATGGGGAGAGCGAATGCACA---GGGAAGAAGCTTA   843
Rapeseed         CCGGGCGCGGCTGAACCATCTACGATGGGGAGAGCGAATGCACA---GGGAAGAAGCTTA   837
Papaya           CCGGGCGTGGCTGAACCATCTACGATGGGGAGAGCGAATGCACA---GGGAAGAAGCTTA   849
Oenothera        CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATCGACA---GGGAAGAAGCAAC   846
Watermelon       CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATACACA---GGGAAGAAGCTTA   846
Zucchini         CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATACACA---GGGAAGAAGCTTA   849
Grape            CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATGCACA---GGGAAGAAGCTTA   846
Rice             CCGGGTGTGGCTGAACCATCTACGATGGGGGGAGC------GAA---GGGAGGAAGCTTA   770
Magnolia         CCGGGCGTGGCTGAACCATCTACGATGGGGGGAGCGAATGAACA---GGGAGGAAGCTTA   759
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e21

Beet	GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTGGAAAGCTCGACCAGCCAGAAAAAG	906
Portulaca	GATAAGAGAATACCGTCTCGCATCGCTTTTTTTGTCGAAAGATCGAACAGCGAGAAAAAG	942
Myrtillocactus	CTTCAGAGAATACGTTCTCGCATCGCTTTTTTTGTCGAAAGATCGAACAGCGAGAAAAAG	942
Petunia	GATAAAAGAATAGCTTCTTGCATCGCTTTTTTTGTAGAAAACTCGACCAGCGAGAAAAAG	903
Tobacco	GATAAAAGAATACGTTCTTGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	906
Sunflower	GATAAGAGAATACGTT------TCGCTTTTTTTGTCGAAAGCTCGACCAGCGAGAAAAAG	903
Arabidopsis	CAGAAGAGAATACGTTCTCGTATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	903
Rapeseed	CAGAAGAGAATACGTTCTCGTATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	897
Papaya	GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	909
Oenothera	GAGTTGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACTAGCGAGAAAAAG	906
Watermelon	GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	906
Zucchini	GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	909
Grape	GATAAGAGAATACGTTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	906
Rice	GATAAGAGAATACGCTCTCGCATCGCTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	830
Magnolia	GATAAGAGAATACGCTCTCGCATCGGTTTTTTTGTAGAAAGCTCGACCAGCGAGAAAAAG	819

Beet	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC	966
Portulaca	GATTTGACAGAAGAAAAAAAGAGCTTGACACACTTCATTCGAAAAAAAAATGATCTGCGA	1002
Myrtillocactus	GATTTGACAGAAGAAAAAAAGAGCTTGACACACTTCATTCGAAAAAAAAATGATCTGCGA	1002
Petunia	TGTTTGGCCGAAGCCAAAAAGAGGGTGACCCACTTTATTCGCCAAGCGAATGATCTTCGC	963
Tobacco	TGTTTGGCCGAAGCCAAAAAGAGGGTGACCCACTTTATTCGCCAAGCGAATGATCTTCGC	966
Sunflower	TTTTTGGCCGAAGACAAAAA---GTTGACCCACTTCATTCGCTGGTCGAATCATCCTCGC	960
Arabidopsis	TGTTTGGCCGAAGCCAAAAATAGGTTGACCCACTTCATTCGCTTGGCGAATGATCTTCGC	963
Rapeseed	TGTTTGGCCGAAGCCAAAAATAGGTTGACCCACTTCATTCGCTTGGCGAATGATCTTCGC	957
Papaya	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC	969
Oenothera	AGTTTGGCCGAAGACAAAAAGGGGTTGCCCCACTTCATTCGCCAAGAGAATGATCTTCGC	966
Watermelon	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGT	966
Zucchini	TGTTTGGCCGAACCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCAAATGATCTTCGT	969
Grape	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC	966
Rice	TGTTTGGCCCGAGCCAAAAAGAGGTTGATCCACTTCATTCGCCAAGCGAATGATCTTCGC	890
Magnolia	TGTTTGGCCGAAGCCAAAAAGAGGTTGACCCACTTCATTCGCCAAGCGAATGATCTTCGC	879

Beet	TTCGCGGGAAGAAGAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	1026
Portulaca	TTCGAGGGGGACAGAAAAAACCAACATACAACTCTTTCCTTTCTTCGGTGCTACCTTCTTC	1062
Myrtillocactus	TTCGAGGGGGACAGAAAAAACAACATACAACTCTTTCCTTTCTTCGGTGCTACCTTCTTC	1062
Petunia	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTT	1023
Tobacco	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTT	1026
Sunflower	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	1020
Arabidopsis	TTCGCGGGAACAACTAAAACCACCATCTCGCTCTTTCCATTCTTCGGTGCTACCTTTTTC	1023
Rapeseed	TTCGCGGGAACAACTAAAACCACCATCTCGCTCTTTCCATTCTTCGGTGCTACCTTTTTC	1017
Papaya	TTCGCGGGAACAACAAAAACCACGATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	1029
Oenothera	TTCGCTGGAAGAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	1026
Watermelon	TTCGCGGGAACAACAAAAACAACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	1026
Zucchini	TTCGCGGGAACAACAAAAACAACCATATCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	1029
Grape	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	1026
Rice	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTT	950
Magnolia	TTCGCGGGAACAACAAAAACCACCATCTCGCTCTTTCCTTTCTTCGGTGCTACCTTTTTC	939

e22

Beet	TTTCCAAGGGATGGAGTTAGAGTTTATAATAACCTGTTTTTTAAAGATGCCCGGGAACAA	1086
Portulaca	TTTCCAAGGGATGGAGTAAGAGTAAATAAGAACAAATTTCCAAAAAAATGCAAGGGGACGA	1122
Myrtillocactus	TTTCCAAGGGATGGAGTAAGAGTCAATTCTAAAGAATTTCCAAAAAAATGCAAGGGAACGA	1122
Petunia	TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGAGGATGCCCGGGAACAA	1083
Tobacco	TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGAGGATGCCCGGGAACAA	1086
Sunflower	TTTCCAAGGGATGGGGTTGGGGTGTATAAGAA---ATTTTTTGAGTATGCCCGGGAACAA	1080
Arabidopsis	TTTCTAAGAGATGGGGTTGGGGTGTATAATAACCTT---------GATGCTCGGGAACAA	1074
Rapeseed	TTTCTAAGAGATGGGGTTGGGGTGTATAATAACCTT---------GATGCCCGGGAACAA	1068
Papaya	TTTCTAAGAGATGGGGTTGGGGTGTATAAGAACCTTTTTTTTGAGGATGCCCGGGAACAA	1089
Oenothera	TTTCCCAGGGATGGGGTTGGGGTGTATAAGCACCTTTTTTTTGAGGATGCCCGGGAACAA	1086
Watermelon	TTTCCAAGGGATGGGGTTGGGATGTATAAAAACCTTTTTTTTGAGGATACCCGGGAACAA	1086
Zucchini	TTTCCAAGGGATGGGGTTGGGATGTATAAAAACCTTTTTTTTGAGGATACCCGGGAACAA	1089
Grape	TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCTTTTTTTTGAGGATGCCCGGGAACAA	1086
Rice	TTTCCAAGGGATGGGGTTGGGGTGTATAATAACCCATTTTTTGAGTATGCCCGGGAACAA	1010
Magnolia	TTTCCAAGGGATGGGGTTGGGGTGTATAAGGAACTCTTTCTTGAGGATGCCCGGGAACAA	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	CTCCTCAATCAATTAAGGGTCAAATGTTGGAACCTCGTGGGTAAGGA---TAAGATAATG	1131
Rapeseed	CTACTCAATCAATTAAGGGTCAAATGTTGGAACCTTTGGGTAAGGA---TAAGGTAATG	1125
Papaya	CTCCTAGAAAAATTAAGGATCAAATGTTGGAACCTCATGGGTAAGGA---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	AAATTGATAGAAAAATTCATAGATAACGGGGGGATAAGAGAATTGATAAAGGGAGTAGAG	1239
Petunia	GAATTGATAGAGAAATTCATAGACCTAAATAGGATAGGAGAATTGATAAGGGGAATAGAG	1200
Tobacco	GAATTGATAGAGAAATTCATAGACCTAAATAGGATAGGAGAATTGATAAGGGGAATAGAG	1203
Sunflower	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1197
Arabidopsis	GAATTGATAGAGAAATTAAAAAACCTAGGTGGGATAGAAGAATTGATAAAGGTAATAGAT	1191
Rapeseed	GAATTGATAGAGAAATTCAAAAACCTAGGTGGGATAGAAGAATTGATAAAGGTAATAGAT	1185
Papaya	GAATTGATAGAGAAATTGAGAAACCTAGGTAGGATAGAAGAATTGATAAAGGGAATAGAG	1206
Oenothera	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1203
Watermelon	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1203
Zucchini	GAATTGATAGAGAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1209
Grape	GAATTGATAGATAAATTCATAGACCTAGGTGGGATAGGAGAATTGATAAAGGGAATAGAG	1203
Rice	GAATTGATAGAGAAATTCATCTACCTAGGTAGGATAGGCAAATTGATAAAGGGAATAGAG	1137
Magnolia	GAATTGATAGAGAAATTCATAGACCTAGGTAGGATAGGAGAATTGATAAAGGGAATAGAG	1116

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                                                                   e24
Beet            ATGATGATAGAGATCATACTGAAAAACATAAGAATTGCTTACGGGTCTAACTCTTATTTG  1263
Portulaca       ATGATGATAGAGATCATACTCAAAAACAGAAGAATTCCCTACGGGTACAACTCGTATTTG  1299
Myrtillocactus  ATGATGATAGAGATCATACTCAAAAACAGAAGAATTCCCTACGGGTACAACTCGTATTTG  1299
Petunia         ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTATTATTTG  1260
Tobacco         ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTATTATTTG  1263
Sunflower       ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTTTTATTTG  1257
Arabidopsis     ATGATGATAGAGATCATACTGAGAAAGAGAGGAATTCCGTACAGGTACAACTCTTATTTT  1251
Rapeseed        ATGATGATAGAAATCATACTGAGAAAGAGAGGAATTCCGTATAGGTACAACTCTTATTTT  1245
Papaya          ATGATGATAGAGATCATATTGAGAAAGAGCAAAATTCCGTACAGGTACAACTCTTATTTA  1266
Oenothera       ATAATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTCTTATTTG  1263
Watermelon      ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTATGGGTACAACTCTTATTTG  1263
Zucchini        ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTATGGGTACAACTCTTATTTG  1269
Grape           ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTCTTATTTG  1263
Rice            ATGATGATAGAGATCATACTGAGAAAGAGGATAATTCCGTACGGGTACAACTCTTATTTG  1197
Magnolia        ATGATGATAGAGATCATACTGAGAAACAGAAGAATTCCGTACGGGTACAACTCTTATTTG  1176

                        e25
Beet            AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT  1323
Portulaca       AACGAAGTCAAAAAAATGAGATCTTTCTTAGCTAATAGAACAAAGACTAATACCTTAATA  1359
Myrtillocactus  AACGAAGTCAAAAAAATGAGATCTTTCTTAGCTAATAGAACAAAGACGTCTACCTTAATT  1359
Petunia         AACGAAGTGAAAAAAATGCGATCTTTGTTGTATAATAGAACAAACACTAATACCTTAATT  1320
Tobacco         AACGAAGTGAAAAAAATGCGATCTTTGTTGTATAATAGAACAAACACTAATACCTTAATT  1323
Sunflower       AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT  1317
Arabidopsis     TACGAAGTCAAAAAAATGCGATCTTTCTTGTCTAATAGAACAAACACTAAGACCTTAATT  1311
Rapeseed        TACGAAGTAAAAAAAATGCGATCTTTCTTGTCTAATAGAACAAACACTAAGACCTTAATT  1305
Papaya          AACAAAGTCAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT  1326
Oenothera       AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCATAATT  1323
Watermelon      AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT  1323
Zucchini        AACGAAGTGCAAAAAATGCGATCTTTGTTGTCTAATAGAACAAAGACTAATACCTTAATT  1329
Grape           AACGAAGTGAAAAAAATGCGATCTTTGTTGTCTAATAGAACAAACACTAATACCTTAATT  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
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                        e28
Beet              TTTCAACCGAAAAAGAAAAGAGGATCATTTCGTTCTATTTTTAGTAAAATAGTGAAAAAG  1443
Portulaca         TTTCAACCGAAAAACAAAAGAAGATCATTTCGACAAATTTTTAGTCAAATTGTCAAGAAT  1479
Myrtillocactus    GTTAAACCGAAAAACAAAAGAAGATCATTTCGAAAAATTTTTAGTCAAATTGTAAAGAAT  1479
Petunia           TTTCAACCGAGGAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT  1440
Tobacco           TTTCAACCGAGGAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT  1443
Sunflower         TTTCAACCGAGGAACAAAACAAGATCATTTCGCTCCATTTTTAGTCAAATAGTGAAGGAT  1437
Arabidopsis       TTTCAACTGAAGAACAAAAGAAGATCATTTCATTCCATTTTTGCTAAAATAGTGAAGGAG  1431
Rapeseed          TTTCAACTGAAGAACAAAAGAAGATCATTTCATTCCATTTTTGCTAAAATAGTGAAGGAG  1425
Papaya            TTTCAACTGAGGAACAAAAGAAGATCATTTCGTTCCATTTTTAGTCAAATAATGAAGAAT  1446
Oenothera         TTTCAACCGAGGAACAAAAGAAGATCATTTCGTTCTATTTTTAGTCAAATTGTGAAGGAT  1443
Watermelon        TTTCAACTGAGAAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT  1443
Zucchini          TTTCAACTGAGAAACAAAACAAGATCATTTCGTTCCATTTTCACTAAAATAGTGAAGGAT  1449
Grape             TTTCAACCGAGGAACAAAACAAGATCATTTCGTTCCATTTTTAGTAAAATAGTGAAGGAT  1443
Rice              TTTCAACTGGGGAACAATCCAATCTCATTTCGTTCCATTTTTAGTCAAATAGTGAAGGAT  1377
Magnolia          TTTCAACCGAGGAACAAAACAAGATCATTTCGTTCCATTTTTAGTCAAATAGTGAAGGAT  1356

                                                                e29     e30
Beet              ATTCCATTAGTAATGAAAAGGGGGGTAGAGGGGATCCGTATATGTTGTTCAGGTCGATTA  1503
Portulaca         ATTCCATTAGTAATGAAAAAGGGCGTAGAGGGGATCCGTATATCTTGTTCAGGTCGATTA  1539
Myrtillocactus    ATTCCATTAGTAATGAAAAAGGGCGTAGAGGGGATCCGTATATCTTGTTCAGGTCGATTA  1539
Petunia           ATTCCATTAGTAATGAAAAAAGGGGTGGAGGGGATCCGTATATGTTGTTCAGGTCGATTA  1500
Tobacco           ATTCCATTAGTAATGAAAAAAGGGGTGGAGGGGATCCGTATATGTTGTTCAGGTCGATTA  1503
Sunflower         ATTCGATTAGTAATGAAAAAAGGGGTGGAGGGGATCCGTATATGTTGTTCAGGTCGATCA  1497
Arabidopsis       ATTCCA------------AAAGGGGTGGAGGGAATCCGTATATGTTTTTCCGGTCGATTA  1479
Rapeseed          ATTCCA------------AAAAGGGTGGAGGGAATCCGTATATGTTTTTCCGGTCGATTA  1473
Papaya            ATTCAATTAGTAATGAAAAAGGGGGTTGAGGGGATCCGTATATGTTGTTCCGGTCGATTA  1506
Oenothera         ATCCCATTAGTAATGAAAAAAGGGGTTGAGGGGATCCGTATATGTTGTTCAGGTCGATCA  1503
Watermelon        ATTCCATTAGTAATGAAAAAAGGGGTTGAGGGGATCCGTATATGTTGTTCAGGTCGATCA  1503
Zucchini          ATTCCATTTGGAATGAAAAAAGGGGTTGAGGGGATCCGTATATGTTGTTCAGGTCGATCA  1509
Grape             ATTCCATTAGTAATGAAAAAGGGGGTTGAGGGGATCCGTATATGTTGTTCAGGTCGATCA  1503
Rice              ATTCCATTAATAATGCCAAAAGGGGTGGAGGGGATACGTATTTGTTGTTCTGGTCGATTA  1437
Magnolia          ATTAAATTAGTAATGCCAAAAGGGGTGGAGGGGATCCGTATTTGTTGTTCAGGTCGATCA  1416

                                                                    e31
Beet              GAAGGTGCA---GAAATTGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT  1560
Portulaca         GCAGGTGCA---GAAATTGCAAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT  1596
Myrtillocactus    GAAGGTGCA---GAAATTGCAAGAACTGAATGCGGAAAGTATGGAAAAACATCTTGTAAT  1596
Petunia           GAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT  1557
Tobacco           GAAGGTGCA---GAAATAGCTAGAACTGAATGCGGAAAGTATGGAAAAACATCTCGTAAT  1560
Sunflower         GAAGGTGCA---GAAATAGCTAGAACTGAATGCGAAAATTATGGAAAAACATCTAGTAAT  1554
Arabidopsis       AAAGACGCAGCAGAAAAAGCTCAAACTAAATGCTATAAGCATAGAAAAACTTCTCGTAAT  1539
Rapeseed          AAAGACGCAGCAGAAAAAGCTCAAACTAAATGCTATAAGCATAGAAAAACTTCTCGTAAT  1533
Papaya            AAAGGCGCA---GAAATAGCGAGAACTGAATGCGGAAAGTATGGAAAAGTCTCTCGTAAT  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
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	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	GTATTTAACCAGAAAATCGATTATGCTCCCGCAGAAGTATCTACTCGTTATGGAATCTTA	1626
Grape	GTATTTAACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA	1620
Rice	GTATTTAACCAGAAAATCGATTATGCTCTTGCGGAAGTATCCACTCGTAACGGAATTTCA	1554
Magnolia	GTATTTCACCAGAAAATCGATTATGCTCCTGCGGAAGTATCTACTCGTTACGGAATCTCA	1533
	e37	
Beet	GGTGTCAAAGTGTGGATTTCTTATAGTCCAAAATAA	1656
Portulaca	GGTGTCAAAGTGTGGATTTCTTATAGTCAAAAATGA	1692
Myrtillocactus	GGTGTCAAAGTGTGGATTTCTTATAGTCAAAAATGA	1692
Petunia	GGTGTCAAAGTGTGGATTTCTTATAGTAAAAAAAAAAAGGGACGTGCTATATCCGAAACG	1677
Tobacco	GGTGTCAAAGTGTGGATTTCCTATAGTAAAAAAAAAAAGGGACGTGCTATATCCGAAACG	1680
Sunflower	GGTGTCAAAGTGTGGATTTCATATAGTCAAAAGAAAGGGGACGTGCTATATCCGAAACG	1674
Arabidopsis	GGTGTCAAAGTGTGGATTTCATATAGTCAAAAAAAAGGGAGACGTGCTATATCCGAAACG	1659
Rapeseed	GGTGTCAAAGTGTGGATTTCATATAGTCAAAAAAAAGGGGGACGTGCTATATCCGAAACG	1653
Papaya	GGTGTCAAAGTGTGGATTTCATATAGTTAA	1653
Oenothera	GGTGTCAAAGTGTGGATTTCTTATAGTAAGTAA	1653
Watermelon	GGTGTCAAAGTGTGGATTTCATATAAAAAAAAAAAAAAGGAACGTGTTATATCCGAAACG	1680
Zucchini	GGTGTCAAAGTGTGGATTTCATATAAAAAACAAAAAAAGGAACGTGTTATATCCGAAACG	1686
Grape	GGTGTCAAAGTGTGGATTTCATATAGTAAAAAAAAAAAGGGACGTGCTATATCCGAAACG	1680
Rice	GGTGTCAAAGTGCGGATCTCATATAGTCAAAATAAGAAGGGACGTGCTATATCCGAAACG	1614
Magnolia	GGTGTCAAAGTGCGGATCTCATATAGTAAAAAAAAAATAA	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