**Supplementary Material**

**Table S1.** A list of 26 Rosaceae species with their common name, genome version and available link at the Genome Database for Rosaceae (GDR).

| Species                            | Common name           | Version | Link                              |
|------------------------------------|-----------------------|---------|-----------------------------------|
| Gillenia trifoliata                | Bowman's root         | v1.0    | https://www.rosaceae.org/bio_data/10816123 |
| Malus baccata                      | Siberian crabapple    | v1.0    | https://www.rosaceae.org/bio_data/577  |
| Malus domestica                    | Apple                 | v1.0    | https://www.rosaceae.org/bio_data/10816131 |
| Malus sieversii                    | Crabapple             | v1.0    | https://www.rosaceae.org/bio_data/10816132 |
| Malus sylvestris                   | European crab apple   | v1.0    | https://www.rosaceae.org/bio_data/10816134 |
| Prunus armeniaca                   | Apricot               | v1.0    | https://www.rosaceae.org/bio_data/603  |
| Prunus avium                       | Sweet cherry          | v1.0    | https://www.rosaceae.org/bio_data/8674832 |
| Pyrus bretschneideri               | Chinese white pear    | v1.1    | https://www.rosaceae.org/bio_data/570  |
| Pyrus communis                     | European pear         | v2.0    | https://www.rosaceae.org/bio_data/545  |
| Prunus domestica                   | Plum                  | v1.0.a1 | https://www.rosaceae.org/bio_data/531  |
| Prunus dulcis                      | Almond                | v2.0    | https://www.rosaceae.org/bio_data/518  |
| Prunus mandshurica                 | Manchurian apricot    | v1.0    | https://www.rosaceae.org/bio_data/10024324 |
| Prunus mira                        | Smoothpit peach       | v2.0    | https://www.rosaceae.org/bio_data/12080707 |
| Prunus persica                     | Peach                 | v2.0    | https://www.rosaceae.org/bio_data/571  |
| Pyrus pyrifolia                    | Asian pear            | v1.0    | https://www.rosaceae.org/bio_data/9597119 |
| Prunus sibirica                    | Siberian apricot      | v1.0    | https://www.rosaceae.org/bio_data/9955981 |
| Prunus sanyueli                    |                       | v1.0    | https://www.rosaceae.org/bio_data/11745274 |
| Pyrus ussuriensis x communis       | Harbin × European pear| v1.0    | https://www.rosaceae.org/bio_data/608  |
| Fragaria × ananassa                | Garden Strawberry     | v1.0.a2 | https://www.rosaceae.org/bio_data/9642085 |
| Fragaria nilgerrensis              |                       | v1.0    | https://www.rosaceae.org/bio_data/12137894 |
| Fragaria viridis                   | Green strawberry      | v1.0    | https://www.rosaceae.org/bio_data/9155217 |
| Fragaria vesca                     | Woodland strawberry   | v4.0.a2 | https://www.rosaceae.org/bio_data/501  |
| Rubus chingii                      | Chinese raspberry     | v1.0    | https://www.rosaceae.org/bio_data/11326199 |
| Rosa chinensis                     | Chinese rose          | v1.0    | https://www.rosaceae.org/bio_data/457  |
| Rubus occidentalis                 | Black raspberry       | v3.0    | https://www.rosaceae.org/bio_data/567  |
| Rosa rugosa                        | Japanese rose         | v1.0    | https://www.rosaceae.org/bio_data/11775539 |
Table S2. List of duplicated gene pairs identified in MIPS genes of different Rosaceae species. The Ka represents the number of non-synonymous substitutions per non-synonymous site while Ks is the number of synonymous substitution per synonymous site.

| Species name              | Duplicate gene 1 | Duplicate gene 2 | Blastp result | Ka  | Ks  | Ka/Ks |
|---------------------------|------------------|------------------|--------------|-----|-----|-------|
|                           |                  |                  | % Identity   | Query cover |
| *Fragaria ananassa*       | FaMIPS1          | FaMIPS3          | 99.80        | 100 | 0.001 | 0.006 | 0.148 |
|                           | FaMIPS1          | FaMIPS2          | 99.22        | 100 | 0.003 | 0.026 | 0.130 |
|                           | FaMIPS2          | FaMIPS3          | 99.41        | 100 | 0.003 | 0.026 | 0.097 |
| *Gillenia trifoliata*     | GtMIPS1          | GtMIPS2          | 59.63        | 99  | 0.309 | 0.451 | 0.686 |
| *Malus domestica*         | MdMIPS1          | MdMIPS3          | 100          | 100 | 0.014 | 0.164 | 0.084 |
|                           | MdMIPS1          | MdMIPS2          | 100          | 100 | 0.000 | 0.000 | NaN   |
|                           | MdMIPS2          | MdMIPS3          | 100          | 100 | 0.014 | 0.164 | 0.084 |
| *Malus sieversii*         | MsyMIPS1         | MsyMIPS2         | 99.61        | 100 | 0.002 | 0.006 | 0.300 |
|                           | MsyMIPS1         | MsyMIPS3         | 96.86        | 100 | 0.015 | 0.164 | 0.089 |
|                           | MsyMIPS2         | MsyMIPS3         | 96.48        | 100 | 0.016 | 0.157 | 0.104 |
| *Prunus domestica*        | PdMIPS1          | PdMIPS3          | 100          | 100 | 0.000 | 0.000 | NaN   |
|                           | PdMIPS1          | PdMIPS5          | 100          | 100 | 0.000 | 0.003 | 0.000 |
|                           | PdMIPS2          | PdMIPS3          | 99.80        | 100 | 0.001 | 0.003 | 0.299 |
|                           | PdMIPS1          | PdMIPS4          | 100          | 88  | 0.003 | 0.012 | 0.267 |
|                           | PdMIPS2          | PdMIPS3          | 99.80        | 100 | 0.001 | 0.003 | 0.299 |
|                           | PdMIPS2          | PdMIPS5          | 99.80        | 100 | 0.001 | 0.000 | -     |
|                           | PdMIPS3          | PdMIPS4          | 99.78        | 88  | 0.004 | 0.009 | 0.479 |
|                           | PdMIPS3          | PdMIPS5          | 100          | 100 | 0.000 | 0.003 | 0.000 |
|                           | PdMIPS3          | PdMIPS4          | 100          | 88  | 0.003 | 0.012 | 0.267 |
|                           | PdMIPS4          | PdMIPS5          | 100          | 98  | 0.003 | 0.009 | 0.369 |
| *Pyrus bretschneideri*    | PbMIPS1          | PbMIPS3          | 99.80        | 100 | 0.001 | 0.006 | 0.150 |
|                           | PbMIPS1          | PbMIPS2          | 99.61        | 100 | 0.002 | 0.006 | 0.301 |
|                           | PbMIPS1          | PbMIPS4          | 96.67        | 100 | 0.015 | 0.185 | 0.079 |
|                           | PbMIPS1          | PbMIPS3          | 96.47        | 100 | 0.016 | 0.185 | 0.084 |
|                           | PbMIPS1          | PbMIPS6          | 58.19        | 89  | 0.370 | 3.644 | 0.102 |
|                           | PbMIPS2          | PbMIPS3          | 99.80        | 100 | 0.001 | 0.000 | -     |
|                           | PbMIPS2          | PbMIPS3          | 96.67        | 100 | 0.016 | 0.185 | 0.084 |
|                           | PbMIPS2          | PbMIPS4          | 96.67        | 100 | 0.015 | 0.185 | 0.079 |
|                           | PbMIPS3          | PbMIPS4          | 99.80        | 100 | 0.001 | 0.000 | -     |
|                           | PbMIPS3          | PbMIPS5          | 96.67        | 100 | 0.015 | 0.185 | 0.079 |
|                           | PbMIPS4          | PbMIPS5          | 96.86        | 100 | 0.014 | 0.186 | 0.074 |
|                           | PbMIPS4          | PbMIPS6          | 58.40        | 89  | 0.373 | 2.939 | 0.127 |
|                           | PbMIPS5          | PbMIPS6          | 58.19        | 100 | 0.369 | 4.032 | 0.092 |
| *Pyrus communis*          | PcMIPS1          | PcMIPS2          | 94.55        | 75  | 0.049 | 0.244 | 0.199 |
| *Pyrus pyrifolia*         | PpyMIPS1         | PpyMIPS2         | 96.078       | 100 | 0.017 | 0.185 | 0.093 |
| *Pyrus ussuriensis x*     | PuMIPS1          | PuMIPS2          | 96.471       | 100 | 0.016 | 0.182 | 0.085 |
Table S3. The details of nuclear localization signals (NLSs) and predicted subcellular localization of Rosaceae MIPS genes.

| Gene       | Position | Score | Sequence                                            | Mono/Bipartite | Subcellular localization |
|------------|----------|-------|-----------------------------------------------------|-----------------|---------------------------|
| GtMIPS1    | -        | -     | -                                                   | -              | Cytoplasm                 |
| GtMIPS2    | 193      | 4.9   | RANNVIKGTKKEQLQQVVIKDIREFKEKNKVDKV                  | Bi             | Cytoplasm                 |
| MbMIPS1    | 193      | 5.0   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| MbMIPS2    | -        | -     | -                                                   | -              | Cytoplasm                 |
| MbMIPS3    | -        | -     | -                                                   | -              | Cytoplasm                 |
| MdMIPS1    | -        | -     | -                                                   | -              | Cytoplasm                 |
| MdMIPS2    | -        | -     | -                                                   | -              | Cytoplasm                 |
| MdMIPS3    | -        | -     | -                                                   | -              | Cytoplasm                 |
| MsiMIPS1   | -        | -     | -                                                   | -              | Cytoplasm                 |
| MsiMIPS2   | -        | -     | -                                                   | -              | Cytoplasm                 |
| MsiMIPS3   | 193      | 5.0   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| MsiMIPS4   | 193      | 5.0   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| MsiMIPS1   | -        | -     | -                                                   | -              | Cytoplasm                 |
| MsiMIPS2   | -        | -     | -                                                   | -              | Cytoplasm                 |
| MsiMIPS3   | 193      | 5.0   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PaMIPS     | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PavMIPS    | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PdMIPS1    | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PdMIPS2    | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PdMIPS3    | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PdMIPS4    | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PdMIPS5    | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PdMIPS6    | 193      | 4.7   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PcMIPS     | 193      | 5.1   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PpyMIPS1   | 108      | 5.2   | EAMKRAKVLDDLNLQKQYPMKMIKVRKAL                      | Bi             | Cytoplasm                 |
| PpyMIPS2   | 193      | 5.4   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PpyMIPS3   | 268      | 5.0   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| PpyMIPS4   | 64       | 4.0   | LGRKRRKKKTEKMF                                      | Mono           |                         |
| PpyMIPS5   | 10       | 10.0  | LGRKRRKKKT                                         | Mono           |                         |
| PuMIPS1    | -        | -     | -                                                   | -              | Cytoplasm                 |
| PuMIPS2    | 193      | 5.4   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| FaMIPS1    | 193      | 5.8   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| FaMIPS2    | 193      | 5.1   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| FaMIPS3    | 193      | 4.8   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| FnMIPS     | 193      | 4.8   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| FvMIPS1    | -        | -     | -                                                   | -              | Cytoplasm                 |
| FvMIPS2    | 193      | 4.8   | RANNVIKGTKKEQLQQVVIKDIREFKEKSVDKV                  | Bi             | Cytoplasm                 |
| Genus  | Accession | pI  | Protein Sequence | Charge | Location |
|--------|-----------|-----|------------------|--------|----------|
| RchMIPS | 193       | 4.8 | RANNVIKGTKQEQVQQIIKDIREFKEKNKVDKV | Bi     | Cytoplasm |
| RcMIPS  | 193       | 4.8 | RANNVIKGTKQEQVQQIIKDIREFKEKNKVDKV | Bi     | Cytoplasm |
| RoMIPS  | 193       | 4.8 | RANNVIKGTKQEQVQQIIKDIREFKEKNKVDKV | Bi     | Cytoplasm |
| RrMIPS  | 193       | 4.8 | RANNVIKGTKQEQVQQIIKDIREFKEKNKVDKV | Bi     | Cytoplasm |