花芽分化的时间。 precursor species only. Under optimal conditions for growth, flower forcing

The Effect of Rootstocks on Growth and Flowering of Apple Seedlings

T. Visser

Abstract. Flowering of seedlings was hastened on M IX and retarded on M XVI rootstocks, irrespective of the interstock and irrespective of the influence of rootstock or interstock on growth.Malus sikkimensis (Hook. f.) Koehne and M. hypenesis (Pamp.) Rehd. seedlings used as rootstocks reduced growth and retarded flowering.

Vigor and precocity of a rootstock are independent properties, in that the ability of a rootstock to induce early flowering is determined by its specific precocity only. Under optimal conditions for growth, seedlings on their own roots may flower as soon as on M IX. The latter profit less from such conditions due to the growth retarding effect of the grafting or budding operation proper. Therefore, unless orchard space is limited, there is little advantage in using a rootstock such as M IX for shortening the juvenile period of apple seedlings.

The influence of environment on the growth and on the duration of the juvenile period has been reported (41). Propagation of seedlings on rootstocks is considered as a specific environmental factor.

Notably the precocious and growth reducing rootstock M IX has been found to hasten the onset of flowering, though the extent to which flowering was promoted appeared to vary between experiments (9). Also other growth reducing rootstocks such as M 27 and M VII (5, 6, 7, 8) and apomorphic seedlings of M. sikkimensis (1) have been observed to induce earlier flowering. Seedlings propagated on invigorating rootstocks, such as M X, M XII, or M XVI or on adult trees, did not flower sooner than on their own roots. Seemingly, there is a discrepancy between the performance of a seedling on its own roots in which vigour plays a positive role and that on a rootstock in which the lack of vigour seems important.

Trials were set up in 1965 to gain more insight into the relation between vigour and flowering in various seedling-rootstock combinations.

Materials and Methods

Experiment I. The performance of seedlings (1962 crosses) grafted, when 2 years old, on the dwarfing rootstock M IX and on the invigorating rootstock M XVI with or without an interstock (about 10 cm long) was compared. Seedlings grafted on their own roots (the top part providing the scions) served as a control. The rootstocks and control seedlings were transplanted from the nursery into pots and grafted or double grafted in the greenhouse during early spring (1965). Thereafter, they were brought into a cold frame and kept there for the remainder of the season. They were subsequently transferred into the nursery for another 2 seasons before being planted in the orchard (1968: 5 years from seed). This was later than usual

because growth was weakened by the frequent transfers which, together with collar rot, was probably the main reason that more than half of the seedlings grafted on a rootstock died in the orchard.

**Experiment 2.** Two-year old apomictic seedlings of *Malus hupehensis* and *M. sikkimensis* were used as rootstocks in comparison with 1 or 2 year old M IX of about the same diameter. Seedlings in their third season from seed (1962 crosses) were budded onto the different rootstocks during summer, 1965. Equal numbers of untreated seedlings of the same populations served as a control. The trees were transferred into the orchard after another growing season (1967: 4 years from seed).

**Experiment 3.** In the early spring of 1965 seedlings of crosses made in 1964 were grafted on M IX when 6 weeks old and placed in pots in the greenhouse. These grafts, together with the control seedlings, were kept in a cold frame for the remainder of the season and planted in the nursery in spring of 1966.

In spring of 1967 scions of 2-year old seedlings of the same progenies were grafted on M IX as well as on their own roots. In order to make the latter treatment comparable to the former, the seedlings were cut off near their base and only the top part was grafted back. The trees were transplanted into the orchard after another season in the nursery (1968: 3 years from seed).

In all 3 experiments treatments were randomized; grafting or budding was done near ground level; trunk diameters were measured about 20 cm above ground level and the number of flowering trees recorded each spring.

**Results**

**Experiment 1.** Although the number of surviving trees in this experiment was rather small, the main trends are evident when comparing the rootstock combinations in pairs with the control (Table 1). Flowering on M IX was hastened to the same extent as on M XVI/M IX, and on M XVI was as much retarded as on M IX/M XVI. That is, flowering was either promoted or delayed as on M XVI/M IX, and on M XVI was as much retarded as on M IX. The growth of the M IX/M XVI combination was comparable to that of M IX, and that of the scions on M XVI did not differ much from that of the seedlings on their own roots.

**Experiment 2.** The seedlings on their own roots flowered as soon as those on M IX (Table 2), in contrast to the first trial in which the seedlings on M IX were found to be ahead in flowering. This difference probably results from the fact that the growth of the seedlings in Experiment 1 was retarded because of repeated transfers, and thus was about 2 years behind that of seedlings in this experiment which grew undisturbed. The age of the rootstock (M IX) had no significant effect on the performance of the scions.

There was no difference between the 2 *Malus* stocks. Both depressed growth initially to the same extent as M IX, but in later years grew somewhat faster. They delayed flowering by about 1 year when compared with seedlings on their own roots or on M IX.

**Experiment 3.** The untreated seedlings flowered somewhat later than seedlings on M IX (Table 3). Grafting the seedlings on M IX at a very young stage as compared to 2-year old, did not induce earlier flowering. The seedlings on their own roots had probably already reached the condition for potential flowering in the intervening time. The inherent precocity of M IX shows up well when a comparison is made with the regrafted control seedlings. Both treatments have the grafting operation in common, but are markedly different with respect to flowering. The retarding effect of the grafting operation on growth, and hence on flowering is clear when comparing these trees with the thicker and earlier flowering trees of the untreated control.

**Discussion**

The results of our rootstock/interstock trial with seedlings were essentially the same as those previously reported with scions of 'Starking Delicious' on the same rootstock combinations (3). Our research also showed that the effect of the interstock on flowering was subordinate to the dominant influence of the rootstock. This was positive with M IX and negative with M XVI and the reverse with respect to growth. Growth differences between the trees on the various rootstocks and interstocks were not related to differences in the flowering.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of trees</th>
<th>Year data taken</th>
<th>Flowering '69</th>
<th>Flowering '70</th>
<th>Flowering '71</th>
<th>Diameter in spring '69</th>
<th>Diameter in spring '70</th>
<th>Diameter in spring '71</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Control</td>
<td>53</td>
<td>15</td>
<td>45</td>
<td>78</td>
<td>22</td>
<td>32</td>
<td>42</td>
<td>59</td>
</tr>
<tr>
<td>b. M IX only</td>
<td>15</td>
<td>43</td>
<td>62</td>
<td>73</td>
<td>17</td>
<td>25</td>
<td>32</td>
<td>42</td>
</tr>
<tr>
<td>c. M XVI/M IX</td>
<td>11</td>
<td>45</td>
<td>67</td>
<td>78</td>
<td>18</td>
<td>26</td>
<td>34</td>
<td>47</td>
</tr>
<tr>
<td>d. M XVI only</td>
<td>17</td>
<td>18</td>
<td>24</td>
<td>41</td>
<td>20</td>
<td>28</td>
<td>39</td>
<td>56</td>
</tr>
<tr>
<td>e. M IX/M XVI</td>
<td>10</td>
<td>25</td>
<td>40</td>
<td>19</td>
<td>25</td>
<td>34</td>
<td>46</td>
<td>59</td>
</tr>
</tbody>
</table>

Table 1. The effect of M IX and M XVI as rootstock and interstock on flowering and mean trunk diameter of apple seedlings, 1962 crosses.

2Significance tests indicated treatment effects on flowering: b = c > d = e; and on diameter a = d > b = c = e.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of trees</th>
<th>Year data taken</th>
<th>Flowering '67</th>
<th>Flowering '68</th>
<th>Flowering '69</th>
<th>Flowering '70</th>
<th>Flowering '71</th>
<th>Diameter in spring '67</th>
<th>Diameter in spring '68</th>
<th>Diameter in spring '69</th>
<th>Diameter in spring '70</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Control (own roots)</td>
<td>34</td>
<td>25</td>
<td>59</td>
<td>85</td>
<td>97</td>
<td>28</td>
<td>38</td>
<td>51</td>
<td>67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. M IX (1 yr old)</td>
<td>33</td>
<td>20</td>
<td>45</td>
<td>91</td>
<td>100</td>
<td>10</td>
<td>16</td>
<td>25</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. M IX (2 yr old)</td>
<td>30</td>
<td>30</td>
<td>63</td>
<td>93</td>
<td>97</td>
<td>11</td>
<td>17</td>
<td>24</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. <em>Malus hupehensis</em></td>
<td>35</td>
<td>0</td>
<td>6</td>
<td>69</td>
<td>89</td>
<td>11</td>
<td>16</td>
<td>28</td>
<td>43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. <em>M. sikkimensis</em></td>
<td>34</td>
<td>0</td>
<td>9</td>
<td>62</td>
<td>97</td>
<td>11</td>
<td>17</td>
<td>24</td>
<td>32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2Significance tests indicated treatment effects on flowering a = b = c > d = e; and on diameter '67/69: a > b = c = d = e '70: a > d = e > b = c

Table 2. Flowering and mean trunk diameter of apple seedlings (1962 crosses) budded on M IX and apomictic seedlings of *Malus hupehensis* and *M. sikkimensis*.

7Flowering in '67 was estimated from no. of trees which fruited in 1967.
response in either trial. Similarly the apomictic seedlings of *M. hupehensis* and *M. sikkimensis* depressed growth, initially as much as M IX, while retarding flowering.

Apparently, the influence of the rootstocks on the juvenile period of a seedling is not determined by their influence on growth. On the other hand, with seedlings on their own roots, precocity and vigour are positively correlated (10, 11). This may help to explain that seedlings on the *Malus* rootstocks, which grow more weakly than seedlings on their own roots, were later to flower than seedlings on their own roots. M IX and M XVI being specifically selected, are exceptions to the rule in that the apparent relation between precocity and vigour is negative. Overlooking the specificity of these stocks was probably part of the reason that attempts to induce flowering in juvenile seedlings by retarding rather than by promoting growth was practiced.

The extent to which earlier flowering is induced by one and the same rootstock, such as M IX, appears to vary markedly between untreated and grafted seedlings, and which cannot be attributed to different experimental conditions. The better the growth conditions provided for growth, the sooner flowering occurs (10, 11).

Another factor which limits the difference in performance between untreated and grafted seedlings, and which cannot be compensated for, is the grafting or budding operation. This operation evidently checks growth and thereby delays flowering as is shown by the marked difference between untreated seedlings and seedlings grafted back on their own roots. It also appeared that grafting the seedlings on M IX in a very young state had no advantage over grafting them on 2 year olds. This confirms experiments of Saure (4) showing that M VII did not hasten the flowering of apple seedlings, irrespective of the age of the seedlings when budded on the rootstock. Accordingly, under optimal conditions for growth there is little gained by propagation on such precocious rootstocks as M IX and M VII.

### Table 3. The effect of grafting apple seedlings (1964 crosses) early or late (6 weeks or 2 years old) on M IX and on their own roots (2 years old) flowering and mean trunk diameter.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of trees</th>
<th>Flowering '69 '70 '71</th>
<th>Diameter in spring '69 '70 '71</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Control (untreated)</td>
<td>25</td>
<td>36 76 88</td>
<td>20 30 44</td>
</tr>
<tr>
<td>b. M IX (spring '65)</td>
<td>44</td>
<td>50 81 87</td>
<td>17 25 35</td>
</tr>
<tr>
<td>c. M IX (spring '67)</td>
<td>17</td>
<td>65 88 91</td>
<td>9 17 25</td>
</tr>
<tr>
<td>d. Grafted on own roots</td>
<td>23</td>
<td>8 29 52</td>
<td>12 24 36</td>
</tr>
</tbody>
</table>

2Significance tests indicated treatment effects on flowering $b = c > a > d$; and on diameter: $a > b = d > c$.

Apple seedlings have been observed to flower and fruit 2 years from seed after optimal nursery conditions and *M. hupehensis* seedlings were even found to flower within 1 year under controlled conditions in the greenhouse (2, 11, 12).

These trials confirm that the time factor involved in reaching the flowering stage must be mainly seen against the background of the conditions provided for growth. The better the growth conditions, the sooner flowering occurs (10, 11).

### Literature Cited