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Apple rootstock studies. I. Preliminary evaluations of several MM.106 × M.27 hybrids

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SUMMARY

Vegetatively propagated clones of *Malus pumila* Mill., selected from the progeny of crosses made between the apple rootstocks MM.106 and M.27 in 1962 and 1964, were evaluated for potential vigour as rootstocks, ease of propagation, formation of suckers or burr knots and resistance to pests and diseases. Fifteen of these clones were compared with M.9, M.26 and MM.106 as rootstocks for the apple scion cv Cox's Orange Pippin in an orchard trial lasting seven years. Most of the clones produced trees of similar size to those formed on MM.106 and some of these, 86.1.25, 86.1.20, 86.1.11 and 10.3.2, cropped very well and exhibited other useful rootstock attributes. One clone, 86.1.24, produced trees smaller than those on M.26 and another, 10.2.5, formed trees smaller than those on M.9. The attributes of all the selections tested are discussed.

APPLE trees grown commercially in Northern Europe are now mostly raised on dwarfing or semi-dwarfing rootstocks. Two rootstocks, the dwarfing M.9 (Jaune de Metz) and the semi-dwarfing MM.106, have proved the most popular with orchardists in recent years, and other East Malling selections such as M.27, M.26 and MM.111 are also utilized where soil, site or scion cultivar warrant. These rootstocks offer a wide range of vigour control enabling fruit growers to produce trees of a predetermined size irrespective of scion vigour or site factors.

Since the introduction of EMLA virus-free apple scions and rootstocks, however, trees raised on many of these rootstocks have proved more vigorous than hitherto, presenting problems to growers wishing to establish high-density planting systems. Also, despite their many merits, all of the rootstocks currently available have one or more drawbacks. Trees on M.9 are difficult to propagate and are poorly anchored, requiring an expensive stake for support on all but the most sheltered sites. Furthermore, although M.9 is resistant to collar rot (*Phytophthora cactorum*) it is susceptible to damage from woolly aphids and to winter cold injury. Trees on M.26 are also poorly anchored and the rootstock is susceptible to collar rot and produces abundant burr knots on the above-ground rootstock trunk. Trees on MM.106 occasionally produce fruits smaller than those of trees on rootstocks of similar vigour control, and this rootstock is extremely susceptible to collar rot on many sites.

These problems have stimulated interest in the breeding and development of improved rootstock clones to replace one or more of the existing rootstocks. This paper describes the screening and preliminary orchard testing of several MM.106 × M.27 clonal rootstocks.

MATERIALS AND METHODS

Crosses made in 1962 and 1964 between the rootstocks MM.106 and M.27 produced 56 (AR 10 series) and 59 (AR 86 series) seedlings, respectively.

After the completion of preliminary screening tests, eight seedlings from the AR 10 series and seven from the AR 86 series were selected for further evaluation. The vigour of each selection, when grown as hard-pruned hedges in the nursery, was recorded between 1979 and 1983 and ranked from 1 (extremely weak) to 9 (extremely vigorous) using the IBPGR descriptor scale (Watkins and Smith, 1982). The potential vigour of the selections when used as rootstocks was estimated from measurements of the percentage of bark tissue in young roots, using techniques first described by Beakbane and Thompson (1947) and later modified by Werts *et al.* (1976). This percentage root bark was measured a number of times between 1974 and 1980 on root samples from all of the 15 selections.

The ability of these selections to root and establish from hardwood cuttings was assessed in a minimum of six separate propagation trials conducted during 10 years. In each test the rooting and subsequent establishment of hardwood cuttings of each selection were evaluated using techniques developed at East Malling Research Station (Howard, 1971).

Burr knot and sucker production was assessed on the hedge plants on a scale of 1 (absent) to 9 (very many) (Watkins and Smith, 1982). The susceptibility of the selections to collar rot (*P. cactorum*) was measured in several ways: in 1979 field-grown plants were inoculated and the infection monitored (Sewell and Wilson, 1973), and in 1980 cut shoots were dipped into spore suspensions (Harris and Stickels, 1981) or glasshouse-grown potted plants inoculated and the effects monitored. The results of these three tests were then averaged and expressed as a susceptibility ranking (Watkins and Smith, 1982).

The incidence of mildew was observed over several years on most of the selections growing as hedges and receiving the standard East Malling Research Station nursery spray programme for pests and diseases. The observations were ranked and expressed on a scale of 1 to 9 as described previously. Similarly they were ranked as resistant to woolly aphid (*Eriosoma lanigerum*) in tests on small potted specimens grown under glass (Lyth and Watkins, 1981). Finally, the field resistance of many of the selections to specific apple replant disease (SARD) was evaluated (Oehl and Jackson, 1980).

All 15 selections were compared with the EMLA selections of M.9, M.26 and MM.106 as rootstocks for the apple scion cv Cox's Orange Pippin. The rootstocks were lined out and budded with the scion in 1974 and the resulting 'maiden' trees planted in the orchard, 3 × 5 m apart, on 27 February 1976. The cv James Grieve on M.9 rootstock was planted as pollinator, one tree for every six Cox's Orange Pippin, evenly distributed throughout the orchard.

The experiment was designed in eight randomized blocks with M.9 rootstocks replicated once in each block and trees on MM.106 and M.26 replicated twice in each block.

A weed-free strip 2 m wide was maintained beneath the tree rows using the herbicides simazine and paraquat, and the trees received the standard East Malling programme of insecticide and fungicide sprays for apples. All the trees were minimally pruned and trained as open-centre bushes.

Total shoot growth was measured at planting in 1976 and in each of the three subsequent years. At the time of grubbing in 1983 (spring) the total weight of the above-ground portion of each tree was recorded. The numbers of floral buds formed on each tree were recorded in the years 1976 to 1980 and fruit set per 100 floral buds in 1978, 1979 and 1980. Yields were recorded in each year between 1978 and 1982 and the fruit graded for colour and size (MAFF, 1973). In both 1981 and 1982 the fruits were additionally graded for the incidence of russet.

Two forms of russetting occur on the cultivar Cox: one form, known as 'smooth russet', is considered characteristic of the cultivar and not taken into account in grading. More severe russetting or skin cracking results in downgrading of the fruits. No such blemishes are permitted on Extra Class Fruits, whereas Class I fruits must have no more than one-twentieth of their skin surface affected, and Classes II and III no more than one-third affected.

RESULTS

Evaluation of the unworked rootstocks

Assessments of nursery vigour and ease of propagation over several years and the tendency to produce burr knots and/or suckers on the 15 seedlings selected for budding and orchard evaluation as rootstocks are shown in Table I. Most of these clones selected for orchard evaluation grew vigorously as hedges; only 10.2.5 and, to a lesser extent, 86.1.25 and 86.1.29 showed more limited growth. Similarly most of the selections appeared to have much the same potential vigour as rootstocks when compared on the basis of root bark percentages; only 10.2.5 gave values indicating considerable dwarfing potential.

TABLE I
The potential vigour, ease of propagation, production of burr knots and suckers of 15 selections originating from MM.106 × M.27 rootstock crosses

Rootstock selection	Vigour		Propagation	Production of	
	Hedge*	% root bark**	%***	Burr knots*	Suckers*
10.1.11	7	50	47	3	NT
10.1.16	9	51	81	5	5
10.2.2	9	53	77	5	0 to 5
10.2.5	3	73	56	3 to 5	5
10.2.7	9	45	33	0	3
10.2.9	9	54	38	3	3
10.2.17	9	51	55	NT	7
10.3.2	5 to 7	55	27	1	1
86.1.11	7	55	65	3	1
86.1.18	7	53	57	1	0
86.1.20	8	57	71	2	3
86.1.22	7	55	56	3 to 7	3
86 1.24	7	57	53	5	2
86.1.25	5	52	63	5	1
86.1.29	5	59	37	5	1

* Ranking (see Watkins and Smith, 1982).
** Previous tests on M.9, M.26 and MM.106 produced mean values of 75, 69 and 59 for percentage root bark respectively.
*** % hardwood cuttings rooting and establishing in the field.
NT = not tested.

Although most of the selections rooted well from hardwood cuttings, 10.2.7, 10.2.9, 10.3.2 and 86.1.29 rooted and established poorly (<40%).

Burr knot production by the selections was quite low. Trees on the selection 10.2.17 produced abundant suckers whereas none was produced by 86.1.18. Other selections exhibiting low suckering were 10.3.2, 86.1.11, 86.1.25 and 86.1.29.

Most of the selections tested were ranked as either resistant (category 3) or moderately resistant (category 4) to collar rot (Table II), but two, 10.3.2 and 86.1.18, were susceptible (category 7) and one, 86.1.24, highly susceptible (category 8).

The results of field observations on resistance to mildew (*Podosphaera leucotricha*) suggested that most of the 15 selections showed good resistance to this pathogen. Six of them, 10.1.16, 10.2.5, 86.1.11, 86.1.18, 86.1.20 and 86.1.29, showed consistent resistance to woolly aphid in several tests whereas selections 10.1.11, 10.2.7 and 10.2.17 were, like M.9 and M.26, consistently susceptible. Selections 10.1.16, 10.2.7 and 10.2.9 showed susceptibility to SARD in experiments where they were planted into replant soils. The other selections showed varying degrees of resistance to SARD in these tests.

Evaluation as rootstocks for Cox's Orange Pippin

Shoot growth and tree vigour: Measurements of the extension shoot growth formed on the Cox trees in the orchard experiment are shown in Table III. The 'maiden' height and branch ('feather') length at the time of planting were greatest for trees on M.26, 10.3.2 and 10.2.17

TABLE II
The susceptibility to collar rot (Phytophthora cactorum), mildew (Podosphaera leucotricha), woolly aphid (Eriosoma lanigerum) and SARD (specific apple replant disease) of selections originating from MM.106 × M.27 rootstock crosses

Rootstock selection	Collar rot*	Mildew*	Woolly aphid	SARD
10.1 11	3	NT	S	MR
10.1.16	4	1	R	S
10.2.2	6	1	Inconclusive	NT
10.2.5	4	2	R	NT
10.2.7	3	3	S	S
10.2.9	3	3	NT	S
10 2 17	3†	3	S	Inconclusive
10.3.2	7	1	NT	MR
86.1.11	3	NT	R	MR
86.1.18	7†	1	R	R
86.1 20	4	3	R	R
86.1.22	4	1	Inconclusive	R
86.1.24	8	2	Inconclusive	R
86.1.25	3†	1	Inconclusive	R
86.1.29	3	3	R	R

* Scale of resistance (see Watkins and Smith, 1982).
R = resistant; MR = moderate resistance, S = susceptible.
NT = not tested.
† Results based on one test only.

TABLE III

The total extension shoot growth made between 1975 and 1978 and grubbing weight of Cox's Orange Pippin trees on 15 MM 106 × M.27 rootstock selections and three standard rootstocks planted in 1976

Rootstock selection	Mean total shoot growth/ tree (m) at planting in 1976 (growth in nursery)	Mean accumulated shoot growth/ tree (m) 1976 to 1978	Mean weight of trees at grubbing (kg) (spring 1983)
10.1.11	4.94	68.4	41.2
10.1.16	4.03	53.5	30.5
10.2.2	4.59	57.3	33.6
10.2.5	2.55	22.9	5.7
10.2.7	4.31	70.3	42.7
10.2.9	3.03	54.4	34.8
10.2.17	5.36	50.4	29.0
10.3.2	5.96	66.4	37.5
86.1.11	3.82	46.6	26.6
86.1.18	3.54	50.1	36.7
86.1.20	4.65	62.4	33.5
86.1.22	4.58	54.7	28.7
86.1.24	4.42	33.4	8.5
86.1.25	3.58	56.1	35.0
86.1.29	3.54	52.6	26.7
M.9	4.24	42.6	11.6
M.26	5.69	48.1	21.1
MM.106	5.13	69.1	38.3
SED (1)	1.29	6.84	2.65
SED (2)	0.91	4.84	1.88
SED (3)	1.11	5.93	2.30
df	109 (10 MV)	107 (12 MV)	109 (10 MV)

SED (1) refers to comparisons between means of all rootstocks except MM.106 and M.26; SED (2) refers to comparisons between means of MM.106 and M.26; SED (3) refers to comparisons between means of either MM.106 or M.26 and all other rootstock means.

and least for trees on 10.2.5, 10.2.9 and M.9. All the trees formed good feathers; trees on 10.1.11, 10.2.2, 10.2.17, 10.3.2, M.26 and MM.106 formed, on average, 15 to 17 laterals per tree, trees on the other rootstocks all formed, on average, more than eight laterals per tree.

Accumulated total shoot growth, made in the first three years following planting, showed that four rootstocks, 10.1.11, 10.2.7, 10.3.2 and 86.1.20, all induced significantly more scion growth than either M.9 or M.26; none of the experimental rootstocks induced more vigorous growth in the first three years than MM.106 (Table III). Indeed, trees on 10 of the experimental rootstocks grew significantly less than trees on MM.106 in this post-establishment period. Two of the experimental rootstocks, 10.2.5 and 86.1.24, induced less growth than M.26 and the latter induced less growth than M.9.

The mean length of individual shoots was least for trees on 10.2.5, 10.2.9 and 86.1.29 at the time of planting. In the subsequent year, 1977, four of the rootstocks, 10.1.16, 10.2.5, 86.1.24 and M.9, induced the formation of significantly shorter shoots than MM.106, whilst 10.2.7 produced longer shoots. This rootstock, and also 10.1.11, 10.3.2, 86.1.18, 86.1.20 and 86.1.25, induced the production of longer shoots than either M.26 or M.9. In 1978, trees on 86.1.24 produced shorter shoots than all three control rootstocks; trees on 10.3.2, 86.1.20 and 86.1.25 all produced shorter shoots than those on M.26. Only trees on 86.1.20 and 86.1.24 produced shoots shorter than those on M.9 trees.

At the time of grubbing in 1983, the trees on 10.2.5 had the lowest weight of above-ground portions; those on 86.1.24 were more similar in size to those on M.9. Trees on all of the other experimental rootstocks were either similar in size to those on MM.106 or intermediate between those on MM.106 and M.26.

Floral bud production and fruit set: Very few floral buds were present on the trees in the year following planting. Rootstock effects on floral bud production and fruit set in the subsequent years are shown in Table IV. Differences in the numbers of floral buds produced between trees on the various rootstocks were inconsistent from season to season. Rootstock effects on the final set per 100 floral buds were also in most instances inconsistent from season to season although in the three years measured, 1978 to 1980, fruit set for trees on 86.1.20 was consistently good.

Yield and fruit quality: Fruit yields were recorded from 1978 until 1982 (Table V), after which the trees were grubbed. Trees on rootstocks 86.1.20, 86.1.25, 10.3.2 and, to a lesser extent, 86.1.24 all cropped consistently well in comparison with the control rootstocks of equivalent vigour and considerably better than trees on many of the other selections.

In the four years 1979 to 1982 the harvested fruits were graded for size, colour and, in 1981 and 1982, skin russeting. Figure 1 shows that in 1979, with the exception of trees on 86.1.24, all trees produced more than 90% of their fruit in Class I or Extra Class ($\geqslant$55 mm diameter) when

TABLE IV
The number of floral buds and the number of fruits harvested per 100 floral buds on Cox's Orange Pippin trees on 15 MM.106 × M.27 rootstock selections and three standard rootstocks

Rootstock selection	Number of floral buds per tree 1977	1978	1979	1980	Number of fruits harvested per 100 floral buds 1978	1979	1980
10.1 11	7	137	475	251	5.6	36.3	26.8
10.1.16	12	131	413	271	1.4	25.7	32.0
10.2.2	2	73	380	367	2.4	16.8	21.4
10.2.5	10	115	165	74	5.9	37.9	47.8
10.2.7	1	64	459	344	3.3	32.8	26.1
10 2.9	3	22	364	406	2.9	25.3	27.7
10.2.17	8	127	438	254	1.7	23.9	31.4
10.3.2	5	127	516	250	9.3	43.2	33 7
86.1.11	1	117	430	190	5.1	35.1	35.6
86.1.18	2	63	309	295	6.0	33.1	24.6
86.1.20	5	182	417	186	9.3	50.4	54.6
86.1.22	11	125	421	127	7.7	43.9	40.1
86.1.24	4	171	201	135	15.8	62.0	17.2
86.1.25	2	147	495	225	10.9	42.2	40.3
86.1.29	6	101	347	205	7.2	40.7	37.3
M.9	18	173	305	114	16.2	39.9	56.6
M.26	31	196	350	167	10.1	42.2	27.3
MM.106	7	114	511	369	2.7	34.8	38.5
SED (1)	5.5	28.9	49.9	48.9	2.7	7.1	8.0
SED (2)	3.9	20.5	35.3	34.6	1.9	5.0	5.7
SED (3)	4.8	25.1	43.2	42.4	2.3	6.1	7.0
df	109 (10 MV) for all variables						

SED (1) refers to comparisons between means of all rootstocks except MM.106 and M.26; SED (2) refers to comparisons between means of MM.106 and M.26; SED (3) refers to comparisons between means of MM.106 or M.26 and all other rootstock means.

graded for size and skin colour. Large rootstock influences were noted however in the proportion of Class I and Extra Class fruit ⩾65 mm diameter. Trees on 10.1.11, 10.3.2, 86.1.11, 86.1.20, 86.1.22, 86.1.24 and 86.1.29 produced the lowest proportion of large fruits, whereas 10.1.16, 10.2.2, 10.2.17, M.26 and MM.106 produced most large fruits. These differences in fruit size were not always related to differences in total yields.

In the subsequent year, 1980, all of the trees produced a greater proportion of Class I and Extra Class fruit (⩾65 mm diameter) than in 1979, but a slightly lower proportion of fruit ⩾55 mm diameter (Figure 2). Rootstock differences were, as in the previous year, more pronounced when fruit yields of the larger ⩾65 mm diameter size were compared. Trees on 10.2.5, M.26, M.9 and 86.1.22 produced the highest proportion of large fruit, whereas 10.1.11, 10.2.9, 86.1.18, 86.1.20 and MM.106 produced the lowest percentages.

In 1981 most of the trees in the experiment produced a very high proportion of Class I and Extra Class fruit when graded for skin colour and fruit size (Figure 3). Trees on 10.2.5, 10.1.16 and M.26 produced the greatest proportion of fruit ⩾65 mm and trees on 86.1.24, 10.1.11, 10.2.2, 10.2.9 and 86.1.20 the lowest proportion of their harvested fruit in the larger size category. Results in 1982 were again very similar, all trees producing a very high proportion of their harvested fruit in the ⩾65 mm diameter category (Figure 4). However, trees on 10.1.11, 10.2.9, 86.1.20 and 86.1.29 produced slightly lower proportions of larger fruit.

Skin russeting was severe in 1981, causing much fruit to be downgraded (Figure 5). Trees on 10.1.16, 10.2.5, M.26 and M.9 produced the highest proportion of russeted fruits, and 10.1.11, 10.2.9 and 86.1.11 the least. Russeting was less severe in 1982, although still sufficient to warrant some downgrading of fruits (Figure 6). Trees on 10.2.5, M.9 and M.26 produced the highest proportion of russeted fruits and 86.1.24 the least.

Accumulations of the graded yields of Class I fruit (⩾55 mm diameter) for the period 1979 to 1982 showed that trees on 86.1.25 produced significantly more than trees on MM.106 and

TABLE V

The weight of fruit harvested from Cox's Orange Pippin trees on 15 experimental MM.106 × M.27 and three standard rootstock selections· 1978 to 1982

Rootstock selection	Mean weight fruit harvested per tree (kg) 1978	1979	1980	1981	1982	Mean accumulated weight harvested per tree (kg) 1978 to 1982
10.1.11	1.21	17.1	7.8	7.0	30.6	63.7
10.1.16	0.39	11.4	10.2	5.7	20.8	48.6
10.2.2	0.44	7.7	9.7	4.6	15.3	37.9
10.2.5	1.06	6.3	4.1	2.9	11.6	26.0
10.2.7	0.41	16.0	11.5	6.0	19.5	53.4
10.2.9	0.00	10.2	10.6	8.1	23.0	51.7
10.2.17	0.40	12.1	10.9	9.2	25.5	58.1
10.3.2	1.55	21.8	11.9	11.2	31.3	77.8
86.1.11	1.14	14.6	9.8	8.1	25.7	59.4
86.1.18	0.63	11.2	8.1	9.3	17.5	46.7
86.1.20	2.40	19.4	13.9	8.5	27.6	71.9
86.1.22	1.19	17.4	7.4	7.9	28.8	62.7
86.1.24	3.08	10.1	3.6	7 7	13.3	37.9
86.1.25	2.65	20.5	12.9	14.6	30.8	81.5
86.1.29	1.39	13.4	10.1	8.0	28.6	61.4
M.9	4.02	11.5	9.4	6.0	19.1	51.8
M.26	2.82	15.7	5.8	7.1	22.4	52.9
MM.106	0.67	14.7	14.5	8.9	29.6	68.4
SED (1)	0.65	2.40	2.12	2.18	5.06	9.18
SED (2)	0.56	2.07	1.84	1.88	4.38	7.95
SED (3)	0.46	1.69	1.50	1.54	3.58	6.49
df		109 (10 MV)				108 (11 MV)

SED (1) refers to comparisons between means of all rootstocks except MM.106 and M.26; SED (2) refers to comparisons between means of MM.106 and M.26; SED (3) refers to comparisons between means of MM.106 or M.26 and all other rootstock means.

similar quantities if graded at the higher (≥65 mm diameter) size. Trees on 10.3.2 also yielded similar quantities of Class I and Extra Class fruit to trees on MM.106. In contrast, trees on 10.1.16, 10.2.2, 10.2.5, 10.2.7, 10.2.9, 86.1.18 and 86.1.24 all produced significantly lower yields of Class I and Extra Class fruit than did trees on MM.106, and two of these, 10.2.5 and 86.1.24, produced lower yields than M.9 and M.26.

DISCUSSION

Although all of the Cox trees cropped rather poorly in the orchard experiment, trees on several of the experimental rootstocks produced crops sufficient to warrant their further testing.

Selection 86.1.25, which produced trees of similar or slightly smaller size to those on MM.106, bore abundant flowers which set fruits efficiently. Yield and fruit grade-out for Cox on 86.1.25 were slightly better than for trees on MM.106. Selection 86.1.25 was also easy to propagate, had few suckers and showed resistance to collar rot, mildew and SARD; tests to evaluate resistance to woolly aphid produced inconclusive results.

Rootstock 86.1.11 produced trees slightly smaller than those on MM.106; fruit set, yield and fruit grade-out were similar to those of trees on the latter rootstock. Selection 86.1.11 propagated easily, formed few suckers or burr knots and showed resistance to collar rot and woolly aphid.

Selection 10.3.2 produced trees similar in size to those on MM.106 and induced good fruit set, giving yields and fruit grades slightly better than those from trees on MM.106. Although this rootstock produced no burr knots or suckers, propagation by hardwood cuttings was more difficult than with many of the other selections and the rootstock showed susceptibility to collar rot. Resistance to woolly aphid was not measured, but some resistance to SARD was recorded.

Selection 86.1.20 also produced trees of similar or slightly smaller size to those on MM.106 and floral bud production and fruit set were both good. However, yields were no better than those on MM.106 and fruit size was

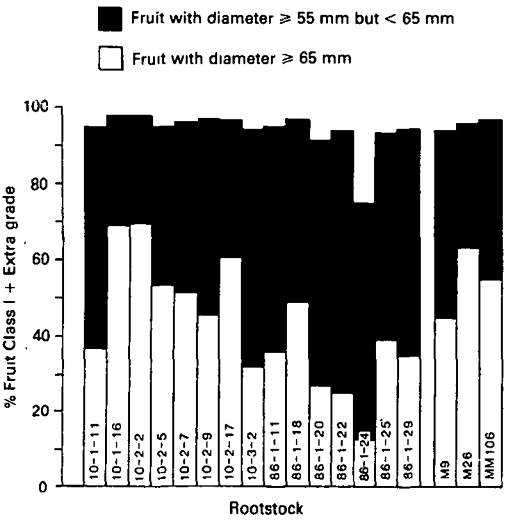

FIG. 1
Class I and Extra Class Cox's Orange Pippin fruits graded for size and colour 1979.

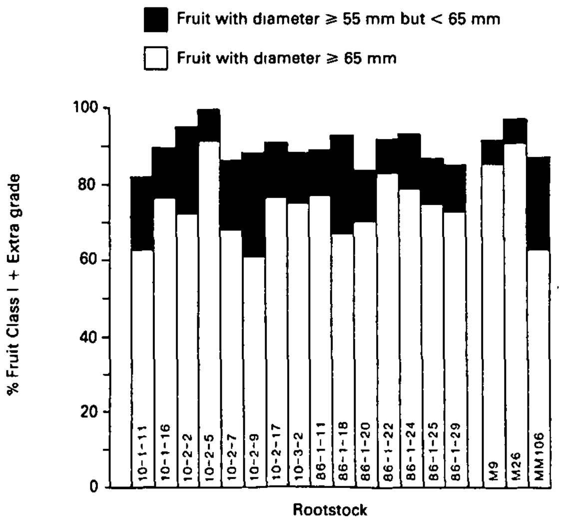

Fig. 2
Class I and Extra Class Cox's Orange Pippin fruits graded for size and colour 1980.

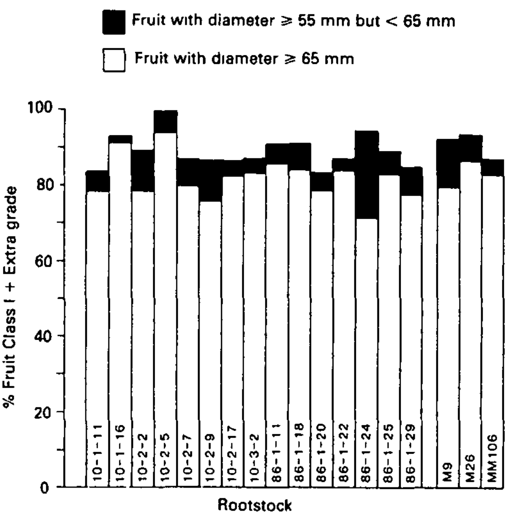

Fig 3
Class I and Extra Class Cox's Orange Pippin fruits graded for size and colour 1981.

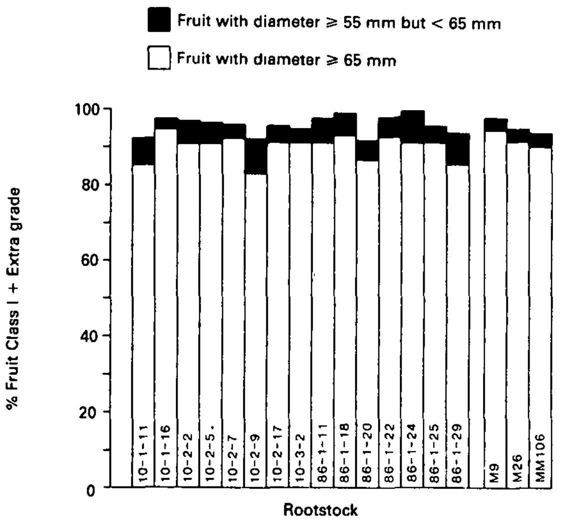

Fig. 4
Class I and Extra Class Cox's Orange Pippin fruits graded for size and colour 1982.

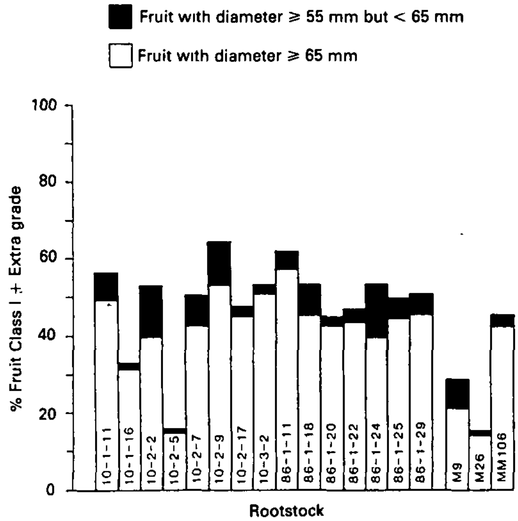

FIG. 5
Class I and Extra Class Cox's Orange Pippin fruits graded for size and russet 1981.

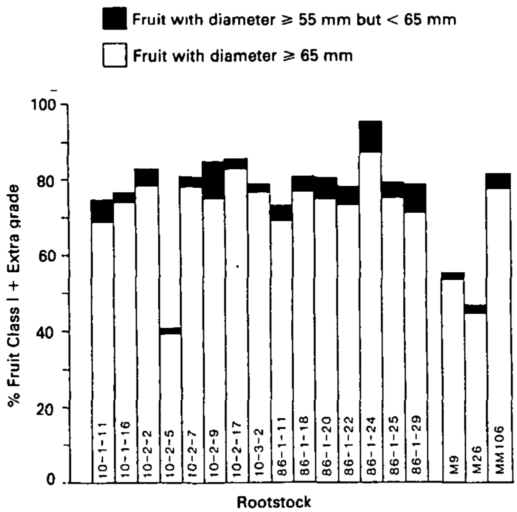

Fig. 6
Class I and Extra Class Cox's Orange Pippin fruits graded for size and russet 1982.

occasionally smaller. This rootstock proved easy to propagate, with few burr knots or suckers, exhibited good resistance to woolly aphid and SARD but only moderate resistance to collar rot.

Rootstock 86.1.24 produced much smaller Cox trees than the selections discussed above; the trees, although rather variable in size, were generally smaller than those on M.26. In most years floral bud production and fruit set for trees on this rootstock were both good. Although yields in relation to tree size were average, trees on this rootstock frequently produced fruits of lower quality than those from trees on control rootstocks. Selection 86.1.24 propagated easily from hardwood cuttings, had no suckers and was resistant to SARD. However, the rootstock was highly susceptible to collar rot and the woolly aphid tests were inconclusive.

Trees on the rootstock 10.2.5 were the smallest in the orchard experiment, much smaller even than trees on M.9, confirming indications of dwarfing potential given by the percentage root bark calculations. Yields on these trees, although low, were relatively good in relation to tree size. Selection 10.2.5 propagated well but had some suckers and burr knots. It showed moderate resistance to collar rot and was resistant to woolly aphid.

Although several of the other clones tested as rootstocks, such as 10.1.11, 10.2.17 and 86.1.22, produced trees similar in size and cropping to those on MM.106, other than their resistance to collar rot they were in no way outstanding. These, and the clones 10.1.16, 10.2.2, 10.2.7 and 10.2.9, all of which performed poorly, probably do not warrant further testing in the UK.

Further evaluation of the more promising selections in this experiment is warranted and Cox trees on several these rootstock selections have already been established in an experiment at the National Fruit Trials, Brogdale, Faversham, Kent, UK. Selections 86.1.25 and 86.1.11, on the evidence of this initial trial, may prove useful replacements for MM.106. Trees on both of these rootstocks performed as well, or better, than trees on MM.106 and had the additional advantage of resistance to collar rot. Only two of the rootstocks tested, 86.1.24 and 10.2.5, proved to be fully dwarfing and neither of these can be considered a replacement for M.9. Although the former rootstock produced trees similar in size to those on M.9, its average cropping and extreme susceptibility to collar rot make it unworthy of consideration on most sites. Rootstock 10.2.5 produced very dwarf trees and warrants comparison with M.27 and/or M.20.

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