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CONTRACT REPORT

NEW ROOTSTOCKS FOR BUSH ROSES

Undertaken for
Horticultural Development Council
Project HNS 6a (Part)
1990-1993

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NEW ROOTSTOCKS FOR BUSH ROSES

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RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

Application

These trials were aimed at evaluating a range of new and older rootstocks to find those with both an improved resistance against Rose Rust and that were capable of producing more Grade 1 bushes, while also monitoring other aspects of their performance such as the degree of sucker shoot production which can affect production costs. The work has identified two selections which can give improved grade-outs and are much less susceptible to Rust than *Rosa* 'Laxa', but which have the drawback of greater production of suckers.

Summary

The great majority of roses in the UK are budded on to one rootstock, *Rosa* 'Laxa'. This stock has been popular since the early 1970's because of its ease of budding advantages (such as long, straight necks and a long budding season), and because it produces very few suckers. However in recent years a Rust disease attacking mainly rootstocks (*Phragmidium mucronatum*) has become more prevalent, possibly because 'Laxa' appears to be very susceptible to it. Severe outbreaks of the disease early in the season can cause premature leaf fall and seriously affect budtake as well as weakening stocks prior to the second year of the production cycle. Although one particular systemic fungicide, myclobutanil (Systhane 6W), has given reasonably good control of the disease so far, use of an alternative rootstock with greater resistance to the disease would be a more reliable control strategy in the longer term. Also, there is a need to improve the yield of Grade 1 bushes of roses to maintain profitability, and alternative rootstocks to 'Laxa' may be capable of producing better quality plants with more strong basal breaks.

Four new selections of *R. canina* ('Kuiper', 'Entree', 'Uniform', and 'Veendam') from Holland, a selection of *R. multiflora* ('Mullan') from Denmark, and two older but less widely grown *R. canina* stocks ('Inermis' and 'Schmid's Ideal'), were compared to *R. dumetorum* 'Laxa' using three popular scion cultivars in trials from 1990 - 1993.

All the rootstock selections under test showed considerably more resistance to Rust than 'Laxa' in the one year of the project when Rust was prevalent. This included 'Inermis' which was reputed to be susceptible to Rust. In a subsequent trial since this project, 'Inermis' has again shown more resistance to Rust than 'Laxa'. Many of the selections showed greater susceptibility to Powdery Mildew than 'Laxa', but, unlike Rust which can cause premature defoliation, Powdery Mildew is regarded as being much less serious in the budding year.

Two rootstocks, 'Uniform' and 'Inermis', gave better grade-outs than 'Laxa' producing a significantly higher percentage of Grade 1 bushes with more thick basal shoots > 10 mm

diameter. This effect was particularly pronounced on the weakest growing scion cultivar Margaret Merril. Of those rootstocks successfully budded, *R. multiflora* 'Mullan' also had a high proportion of Grade 1 plants, but because of the short and twisted necks with thin skins on this rootstock, a large proportion of stocks could not be budded resulting in a poor net yield of saleable bushes overall. This rootstock cannot therefore be recommended for general use as a replacement for 'Laxa'.

The remaining *R. canina* rootstock selections, 'Kuiper', 'Entree', 'Veendam' and 'Schmid's Ideal', either gave poorer grade-outs or gave no significant improvement over 'Laxa', although they had better resistance to Rust. They also suckered more freely, especially 'Entree' and 'Veendam'.

The most promising rootstocks in terms of plant grade-out tended to produce significantly more suckers than 'Laxa'. For example between May and September 1993, 'Uniform' and 'Inermis' averaged a total production of 1.5 suckers per plant compared to 'Laxa' with only 0.15 suckers per plant. It appeared that increased rootstock vigour which created the potential for a better plant grade-out could also encourage more suckering.

Action Points

- Grower's should consider carrying out their own trials with 'Inermis' and 'Uniform' rootstocks, particularly with scion cultivars which are shy to produce basal breaks and where a more vigorous rootstock might help improve the yield of Grade 1 plants.

- For nurseries where the economics of production could not support the higher costs for removing extra suckers from 'Uniform' and 'Inermis' rootstocks, then 'Laxa' is likely to remain the best choice of rootstock for the majority of rose cultivars. However other factors, including an increase in problems with Rust due to resistance to fungicides for example, might alter the equation in favour of these or other stocks in future.

INTRODUCTION

Rosa dumetorum 'Laxa'[1] has long been the most popular rootstock for bush roses, particularly in the UK, but also in most of N. Europe. This is largely because the stocks feature long straight root collars or 'necks' suitable for easy budding, sap flow remains good ensuring a high percentage bud take over a long budding season, and finally 'Laxa' is noted for requiring very little sucker removal in the maiden bush production year which helps keep down labour costs.

In recent years, however, rootstock Rose Rust (*Phragmidium mucronatum*) has badly affected some crops of 'Laxa' stocks. This disease, although different from the rust species that typically attacks the flowering cultivars (*Phragmidium tuberculosum*), can nevertheless weaken the stocks, cause premature leaf drop, and may even result in poor budtake if the disease strikes early enough in the year. The fungicide myclobutanil (Systhane 6W) is presently giving reasonably good control of the disease, but long term reliance on this fungicide for control would be unwise, and some resistance to the disease by an alternative rootstock would clearly be of benefit.

A national average grade-out of Class 1 bushes is about 60% of the number of rootstocks planted from a crop of 'Laxa'. The need to improve on this to help maintain profitability also added to the need to evaluate alternative rootstocks.

Rose rootstock breeding and selection is a low priority within European research institutes. The last comparative trials on rootstocks carried out in the UK were in the late 1960's and early 1970's at Shardlow Hall, Derbyshire which led to 'Laxa''s widespread uptake in the industry. However in 1990, some new *R. canina* selections from Holland were made available through agents for the Dutch grower co-operative, Rosaco, for trialling under this project, together with a *R. multiflora* selection from Danplanex in Denmark.

The objectives of the work carried out between 1990 and 1993 was to test these new rootstock selections with 'Laxa', and two other traditional *R. canina* selections, with the aim of finding one with better Rust resistance and capable of producing an improved proportion of Class 1 bushes, while hopefully retaining 'Laxa''s good characteristics of ease of budding and low sucker production.

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1 'Laxa' is named as a selection of *Rosa dumetorum* Thuill. (syn. *R. corymbifera* Borkh.) by most nurserymen and listed under this species by Leemans (1964). However botanically it more correctly *R. coriifolia* Fries var. *froebelii* Rehd., introduced by Froebel, Zurich, Switzerland from the Near East in 1890. It is closely related the wild Dog Rose *R. canina* L., and comes within the same section of the *Caninae* family.

MATERIALS AND METHODS

Three crops of rootstocks were planted successively in 1990, 1991 and 1992 and maiden bushes lifted at the end of 1991 - 1993 respectively. The condition of the rootstocks on arrival for the first year trial was poor, which subsequently reduced establishment of some rootstock selections. There was also severe wind damage (blow-out) the following year particularly on one of the three scion cultivars used. Consequently no meaningful grade-out data could be obtained from Trial 1, and a detailed consideration of this trial is not included in this report. Nevertheless, some valid observations of disease susceptibility and general plant habit etc. were obtained from this first trial, and these are included in the results and discussion as appropriate.

Site

Trials were grown on a sandy silt loam of the Efford soil series in Field S11 (Trials 1 and 2 to the North and Trial 3 to the East of the field). Soil sample analyses prior to planting Trial 1 and Trial 3 were as follows:

	Trial 1 - sampled early Jan 1990		**Trial 3 - sampled late Oct 1991**	
pH	7.3		6.6	
P	51 mg/litre	(ADAS Index 4)	80 mg/litre	(ADAS Index 5)
K	250 mg/litre	(ADAS Index 3)	422 mg/litre	(ADAS Index 4)
Mg	74 mg/litre	(ADAS Index 2)	56 mg/litre	(ADAS Index 2)
O.M.	na		2.2%	

A stable manure dressing of about 75 tonnes/ha was applied to the sites used for Trials 1 and 2 in early March 1990, and a similar rate to the site for Trial 3 in late November 1991. The addition of the stable manure was primarily to improve the organic matter status of the soil. This manure was relatively low in nitrogen compared to most farmyard manures. A base dressing of 50 kg/ha N + 50 kg/ha K_2O + 25 kg/ha Mg was applied as inorganic straight fertilisers prior to planting Trial 2, but no base dressing was used for Trials 1 and 3. In addition, a top dressing of 50 kg/ha N was applied to each crop of rootstocks later in spring to boost growth, as well as appropriate top dressings in the spring of the maiden bush years.

Treatments

Rootstock selections used in Trials 2 and 3:

A	*Rosa dumetorum* 'Laxa'
B	*R. canina* 'Kuiper'
C	*R. canina* 'Inermis'
D	*R. canina* 'Entree'
E	*R. canina* 'Uniform'
F	*R. canina* 'Veendam'
G	*R. multiflora* 'Mullan'*
H	*R. canina* 'Schmid's Ideal'

* *R. multiflora* 'Mullan' was dropped from Trial 3.

'Laxa' was included as the current standard rootstock against which the others were compared. Rootstocks B, D, E, and F were all new *R. canina* types selected in Holland. Rootstocks C and H, *R.canina* 'Inermis' and 'Schmid's Ideal', are both old well established types which have become much less popular for field production since the advent of 'Laxa', but which produced good grade-outs in the early trials at Shardlow Hall. 'Inermis' was also believed to be somewhat susceptible to Rust, and was included as an indicator for this disease. *R. multiflora* 'Mullan' was understood to have good cold tolerance, and was included because it had performed well in previous trials in Denmark. All the *R. canina* selections and 'Laxa' were propagated in Holland and obtained through UK agents for the Rosaco co-operative. Rootstocks of 5 - 8 mm collar diameter grade were used at planting.

Rootstocks were budded with three flowering cultivars:

Royal William	Deep Crimson	Hybrid Tea
Margaret Merril	Pearly White	Floribunda
Freedom	Yellow	Hybrid Tea

Freedom was included as a test of the rootstocks' performance, as yellow cultivars are reputed to produce poorer grade-outs, along with cv. Margaret Merril which can be a weaker grower.

Design and layout

See Appendix I, p. 35 for details of the field plans and layout. The rootstock treatments were laid out in incomplete Latin Square (Youden Square) arrangements containing four replicates, with a separate arrangement for each of the three flowering cultivars.

With four replicates of eight rootstocks for three cultivars (Trial 2) and seven rootstocks (Trial 3), there were 96 and 84 plots in total for the two trials respectively. Plants were spaced 0.2 m apart in-row in wide double rows 0.8 m apart at 1.83 m wheelings giving a plant density of 54,645 plants/ha (22,114 plants/acre). Plots were four rows wide x 10 plants long which included a ring of guard plants leaving the central two rows of eight plants per plot used for recording.

Culture

A diary of the main cultural operations including planting, budding, sprays etc. is given in Appendix II, p. 37.

Rootstocks had few sprays against diseases in the first year of each crop after planting so as to assess their susceptibility to foliar diseases. However in late August 1991, once Rose Rust and Powdery Mildew assessments had been completed, sprays of bupirimate (Nimrod), benodanil (Calirus) and myclobutanil (Systhane 6W) were used to try and check further development of the diseases before plants went into winter dormancy. In 1992, bupirimate (Nimrod) applications were started earlier in the season to try and keep foliage relatively clear of Powdery Mildew, as a good indication of relative susceptibilities to this disease had been established for the different stocks by then, however no sprays were applied against Rust. In the second year of each trial following heading back, standard full spray programmes were applied to reduce the likelihood of disease outbreaks masking effects of the rootstocks on scion growth.

Records

Records of the rootstocks' characteristics were made which included features such as overall plant size, their habit, leaf shape and colour, thorniness, and ease of budding.

Disease susceptibility in the rootstock growing year was also scored. In practice this was possible only for Powdery Mildew (*Sphaerotheca macularis*) and Rust (*Phragmidium mucronatum*). Although Black Spot (*Diplocarpon rosae*) was seen, it occurred relatively late on after leaves had already become infected with powdery mildew, and it was regarded as only of secondary importance in rootstocks. It could easily be confused with leaf spot symptoms caused by other fungi including *Cercospora* spp. which were also identified. No Downy Mildew (*Peronospora sparsa*) was recorded.

For each trial, the budtake of scions on the rootstocks was recorded, together with the proportion of buds that had 'shot', ie. those that had grown prematurely following budding rather than remained dormant until the following spring.

The weight of rootstock tops removed at heading back was recorded for Trial 2 as an additional measure of rootstock vigour.

Sucker shoots produced during the maiden bush year were counted on two occasions in the summer for Trial 2, and four times for Trial 3. The number of shoots that had 'blown out' (ie. been broken off at the bud union due to wind damage) was also recorded on these four assessment dates for Trial 3.

Final quality assessments were made prior to lifting the bushes. The numbers of 'thick' (> 10 mm diameter) and 'thin' (6 - 10 mm diameter) basal shoots per plant were counted. Bushes were also given an overall commercial plant grade from Grade 1 (best quality) to Grade 3 (waste) depending on the number and thickness of basal shoots present.

Some observations were also made on the overall vigour and fibrousness of the root systems of plants after lifting.

Analysis of results

Analyses of variance (ANOVA) were used to analyse shoot counts and data has been presented as mean numbers of shoots per plant present at the final grading. Data for percentage grade-outs were angle transformed prior to subjection to ANOVA. The grade-out data was analysed on the basis of a nominal full plant stand of 16 plants per plot to give a more commercially relevant measure of overall final yields taking into account budtake failures etc.

Sucker production in Trial 2 was analysed as the mean number of suckers produced per budded plant. In Trial 3, because of the variability of suckering, statistical analysis was more appropriate on the numbers of plants within the plot which had one or more suckers present. This was done for each of the four assessment dates. A mean total number of suckers per plant produced was also calculated.

The ANOVA was also used, where appropriate, to analyse the Powdery Mildew scores and weights of rootstock tops records.

RESULTS

General rootstock characteristics

The main easily observable characteristics are summarised in Table 1 below.

Table 1: General characteristics of rootstocks

Rootstock	Habit	Overall vigour	Stem thorniness	Leaflets / stems
A 'Laxa'	upright	moderate	moderate	dull grey-green hairy leaflets
B 'Kuiper'	upright	moderate	few	large dull green leaflets, not channelled
C 'Inermis'	spreading / bushy	vigorous	very few	small thin matt light green leaflets
D 'Entree'	spreading / bushy	vigorous	few	large long glossy medium green leaflets
E 'Uniform'	upright / bushy	vigorous	very few	small dull bluish-green leaflets
F 'Veendam'	upright	moderate	moderate	dull dark bluish-green leaflets reddish stems
G 'Mullan'	v. spreading bushy	vigorous	few	large glossy light green leaflets
H 'Schmid's Ideal'	upright	moderate	few	small slightly shiny mid green rugose leaflets, not channelled

In mid November 1991 in Trial 2, it was noticed that leaves were still present on 'Inermis', 'Uniform', 'Mullan', and some on 'Schmid's Ideal', whereas they had all fallen by this time on the remaining cultivars.

Disease susceptibility

In summer 1990 and 1991, Trials 1 and 2 were observed for disease and scored on a 0 - 5 basis, a score of 5 representing the highest level of disease. In Trials 1 and 2, scores were given on an estimate of levels for each rootstock over all the plots. In Trial 3, Powdery Mildew scores were made for each plot on 10 July 1992, enabling results to be statistically analysed.

Table 2: Susceptibility of rootstocks to Powdery Mildew and Rose Rust scored on a scale of 0 (clean) to 5 (severely affected)

Rootstock	Powdery Mildew 1990	1991	1992	Rust 1991
A 'Laxa'	1	0	(0.63)	5
B 'Kuiper'	5	5	4.58	1
C 'Inermis'	3	4	2.25	0
D 'Entree'	0	1	(0.54)	0
E 'Uniform'	2	4	2.75	0
F 'Veendam'	4	5	4.75	0
G 'Mullan'	2	0	-	0
H 'Schmid's Ideal'	-	4	3.75	0
SED (36df)			*0.292*	
LSD (5%)			*0.59*	
Significance, P			*0.001*	

Means in brackets excluded from statistical analysis

In all three rootstock growing years, a similar trend for susceptibility to Powdery Mildew was observed. 'Kuiper' and 'Veendam' were the most susceptible to the disease followed by 'Schmid's Ideal', 'Inermis' and 'Uniform'. 'Laxa', 'Entree' and 'Mullan' were only slightly affected by Mildew. Rust only developed severely enough to make recording worthwhile in Trial 2 in early September 1991, and in that year 'Laxa' developed a severe infection whereas virtually all the other selections remained clean. A slight trace of rust was observed on 'Laxa' in Trial 3 late in 1992.

Ease of budding

It was not possible to assess this formally in this work. Observations made during budding of Trials 1 and 2, however, clearly showed *R. multiflora* 'Mullan' as being the most difficult rootstock to bud, mainly on account of its often short and 'twisted' necks leaving little clean length of root collar free of emerging roots or shoots in which to insert a bud. The spreading and vigorous nature of the top growth also made budding difficult. Consequently up to 30% of stocks on this rootstock could not be budded at all.

The rootstocks for Trial 1 did not arrive until the first week of April 1990, and were in poor condition at planting. Consequently establishment was relatively slow with a significant proportion of failures, and budding was delayed until the first week of September, by which time growth had improved and was much more vigorous than a month earlier. Sap flow in the stocks at this time was sufficiently good for budding, and no large differences could be detected between the rootstock selections, although 'Laxa' appeared slightly 'fresher'.

Although there was significant rainfall in June - mid July 1991, conditions were dry prior to budding Trial 2 in the first two weeks of August. This showed up some differences in the sap flow in the rootstocks and ease of opening the rind and inserting the scion buds. 'Laxa' was the easiest to open and had good sap flow. 'Veendam' was moderately good, but the remaining stocks were drier and more difficult to bud. Often the rind was thin and brittle, and it tended to split at the base of the 'T' cut. 'Kuiper' was the worst in this respect, and a significant number of stocks could not be budded successfully.

More irrigation was applied prior to budding the stocks for Trial 3 in 1992, and all stocks appeared equally easy to bud, although following the previous two years experience with 'Mullan', this selection was not included in Trial 3.

Budtake and shot bud

See Tables 3 and 4, pp. 11 and 12. In Trial 2, fewer plants of *R. multiflora* 'Mullan' were capable of being budded than any of the other rootstocks for the reasons outlined above. Less than 50% of those to be budded with Margaret Merrill on this rootstock were actually budded, although over 80% of the Royal William area was budded. This apparent variation in the quality of rootstock over the different areas of the trial is difficult to explain apart from chance of positional effects. 'Kuiper' also had slightly fewer stocks budded than the other rootstocks in this trial. In Trial 3, under better conditions and without the inclusion of 'Mullan', nearly all the stocks were budded.

Budtake on 'Mullan' was also lower in Trial 2, but there was no clear pattern with budtake for the remaining rootstocks across the three scion cultivars. In most cases well over 90% of the stocks budded took successfully. Likewise in Trial 3, there was no indication that any of the rootstocks produced a consistently higher or lower budtake, which in this trial was > 95% for most rootstock / scion combinations.

Results on the proportion of shot buds were variable between cultivars, but taken overall there was an indication that 'Schmid's Ideal' encouraged more shot bud than the remaining rootstocks. Shot buds occurred more frequently with the scion cultivar Royal William, where the rootstocks 'Kuiper', 'Inermis' and 'Uniform' also produced a higher proportion of early shoot growth, while with Freedom, shot buds were greatest with the rootstock 'Entree'.

Table 3: Trial 2: Proportions of plants budded, and % budtake and shot bud of plants budded.

Rootstock	% budded of nominal 64 total	% budtake of those budded	% shot bud of those budded
	cv. Freedom		
A 'Laxa'	98.4	88.8	1.8
B 'Kuiper'	79.7	82.4	0.0
C 'Inermis'	92.2	96.6	1.7
D 'Entree'	90.6	91.4	12.3
E 'Uniform'	92.2	89.8	1.8
F 'Veendam'	98.4	96.8	8.2
G 'Mullan'	64.1	70.7	0.0
H 'Schmid's Ideal'	89.1	96.5	0.0
	cv. Margaret Merril		
A 'Laxa'	95.3	91.8	0.0
B 'Kuiper'	85.9	92.7	3.9
C 'Inermis'	95.3	95.1	6.9
D 'Entree'	93.8	90.0	3.5
E 'Uniform'	98.4	92.1	5.1
F 'Veendam'	96.9	95.2	3.4
G 'Mullan'	46.9	76.7	0.0
H 'Schmid's Ideal'	98.4	98.4	19.4
	cv. Royal William		
A 'Laxa'	95.3	88.5	9.3
B 'Kuiper'	82.8	98.1	17.3
C 'Inermis'	90.6	96.6	8.9
D 'Entree'	95.3	95.1	8.6
E 'Uniform'	98.4	98.4	14.5
F 'Veendam'	100.0	95.3	9.7
G 'Mullan'	82.8	88.1	8.3
H 'Schmid's Ideal'	93.8	95.0	14.0

Table 4: Trial 3: Percentage budtake and shot bud as proportion of nominal 64 plants/treatment total

Rootstock	% budtake	% shot
	cv. Freedom	
A 'Laxa'	100.0	0.0
B 'Kuiper'	100.0	1.6
C 'Inermis'	96.9	0.0
D 'Entree'	96.9	9.4
E 'Uniform'	100.0	1.6
F 'Veendam'	100.0	1.6
H 'Schmid's Ideal'	98.4	4.7
	cv. Margaret Merril	
A 'Laxa'	98.4	0.0
B 'Kuiper'	96.9	3.1
C 'Inermis'	93.8	6.3
D 'Entree'	95.3	9.4
E 'Uniform'	93.8	3.1
F 'Veendam'	100.0	3.1
H 'Schmid's Ideal'	100.0	12.5
	cv. Royal William	
A 'Laxa'	98.4	3.1
B 'Kuiper'	96.9	7.8
C 'Inermis'	95.3	7.8
D 'Entree'	98.4	3.1
E 'Uniform'	96.9	3.1
F 'Veendam'	98.4	0.0
H 'Schmid's Ideal'	95.3	12.5

Weight of rootstock tops

Table 5, p. 13 shows the mean fresh weights from a sample of eight rootstock tops per plot recorded for Trial 2. The pattern for these weights broadly followed that for overall vigour (Table 1, p. 8), namely that 'Inermis', 'Uniform' and 'Mullan' produced significantly more shoot growth (80% more) than 'Laxa', 'Kuiper' and 'Schmid's Ideal' ($P<0.001$). 'Entree' and 'Veendam' were intermediate.

Table 5: Trial 2: Mean rootstock top fresh weight/grammes at heading back in February 1992.
Figures are means of 8 plants/plot.

Rootstock	Scion cultivar: Freedom	M. Merril	R. William	Rootstock treatment mean
A 'Laxa'	80	112	102	98
B 'Kuiper'	117	114	96	109
C 'Inermis'	176	178	188	181
D 'Entree'	116	151	150	139
E 'Uniform'	187	186	188	187
F 'Veendam'	113	116	133	121
G 'Mullan'	152	175	198	175
H 'Schmid's Ideal'	89	94	100	94
Scion treatment mean	129	141	144	

Comparisons of individual scion x rootstock means

	within scions		*between scions*
SED (62 df)	*12.6*		*14.6*
LSD (5%)	*25*		*29*
Significance, P		*0.058*	

Comparisons of main treatments

	scion means	*rootstock means*
SED	*8.6 (6df)*	*7.3 (62df)*
LSD (5%)	-	*15*
Significance, P	*NS*	*<0.001*

Sucker production

Rootstock suckers were defined as shoot arising from below the scion bud union, and often these arose direct from the root system. Crown shoots frequently develop from adventitious buds around top of the stock after heading back. Failure to head back close enough to the top of the scion bud shield tends to encourage more crown shoots to develop, but a few are inevitable even following the best nursery practice. These were assessed as well as sucker numbers, but since it was found that the pattern of crown shoot production followed a similar trend to suckering between the different stocks, they have not been included in the tables of results.

It was clear from the two suckering assessments in Trial 2 (Tables 6 and 7, pp. 15 and 16), and those from Trial 3 (Table 8, p. 17), that the rootstock selection had a large influence on the numbers of suckers produced. The influence of the scion cultivar on suckering was in most cases not significant, although there was an indication from the June assessment in Trial 2 that stocks budded with Freedom produced fewer suckers than those budded with Margaret Merril or Royal William.

In Trial 2, 'Entree', 'Inermis' and 'Mullan' produced most suckers in May, while 'Entree' and 'Inermis' produced most suckers, on average, from the June assessment. In both cases 'Schmid's Ideal', 'Laxa' and 'Kuiper' produced the least number of suckers.

The total number of suckers produced per plant over the period early May to early September 1993 in Trial 3, gives a broadly similar pattern. Although there was no statistical analysis of these totals, 'Entree' clearly grew many more suckers than the other rootstocks (almost averaging 4 per plant). This was followed by 'Veendam', 'Uniform' and 'Inermis' which averaged about 1.5 suckers per plant. 'Schmid's Ideal', 'Kuiper' and 'Laxa' produced relatively low numbers, with 'Laxa' suckering on only a few isolated plants giving an average of 0.15 per plant.

The same trend is borne out by the data in Table 8 which shows the proportion of plants at each assessment which had at least one sucker shoot present. Suckers were removed after each assessment. Over 60% of 'Entree' plants had suckered during the first two records. 'Veendam', 'Inermis' and 'Uniform' followed, then 'Schmid's Ideal', with only 2 - 8 % of 'Laxa' and 'Kuiper' plants suckering throughout the trial period.

Table 6: Trial 2: Mean number of suckers per budded plant recorded in May 1992

Rootstock	Scion cultivar Freedom	M. Merril	R. William	Rootstock treatment mean
A 'Laxa'	0.13	0.26	0.36	0.25
B 'Kuiper'	0.33	0.19	0.09	0.20
C 'Inermis'	0.81	1.16	1.07	1.01
D 'Entree'	0.77	0.77	0.75	0.76
E 'Uniform'	0.27	0.33	0.44	0.35
F 'Veendam'	0.15	0.42	0.50	0.36
G 'Mullan'	0.68	1.30	1.01	1.00
H 'Schmid's Ideal'	0.11	0.08	0.03	0.07
Scion treatment mean	0.41	0.56	0.53	

Comparisons of individual scion x rootstock means

	within scions		*between scions*
SED (63df)	*0.213*		*0.219*
LSD (5%)	-		-
Significance, P		*NS*	

Comparisons of main treatments

	scion means	*rootstock means*
SED	*0.092 (6df)*	*0.123 (63df)*
LSD (5%)	-	*0.25*
Significance, P	*NS*	*<0.001*

Table 7: Trial 2: Mean number of suckers per budded plant recorded in June 1992

Rootstock	Freedom	Scion cultivar M. Merril	R. William	Rootstock treatment mean
A 'Laxa'	0.03	0.19	0.46	0.23
B 'Kuiper'	0.47	0.46	0.13	0.35
C 'Inermis'	0.36	0.80	1.01	0.72
D 'Entree'	0.35	0.79	1.06	0.74
E 'Uniform'	0.43	0.42	0.62	0.49
F 'Veendam'	0.36	0.45	0.86	0.56
G 'Mullan'	0.06	0.51	0.23	0.27
H 'Schmid's Ideal'	0.07	0.05	0.17	0.09
Scion treatment mean	0.27	0.46	0.57	

Comparisons of individual scion x rootstock means

	within scions		*between scions*
SED (63df)	*0.219*		*0.217*
LSD (5%)	-		-
Significance, P		*NS*	

Comparisons of main treatments

	scion means	*rootstock means*
SED	*0.072 (6df)*	*0.127 (63df)*
LSD (5%)	*0.18*	*0.25*
Significance, P	*0.016*	*<0.001*

Table 8: Trial 3: Proportion of plants with suckers present at four assessments, and mean total suckers produced per plant. Main rootstock treatment effect averaged over scion cultivars

Rootstock	% plants with suckers 05/05/93	07/06/93	29/06/93	07/09/93	Mean total suckers/plant over 4 assessments
A 'Laxa'	(2.1)	(2.6)	(7.3)	2.1	0.15
B 'Kuiper'	(4.2)	(4.7)	(7.3)	8.2	0.22
C 'Inermis'	22.4	28.6	21.9	15.0	1.27
D 'Entree'	67.7	60.9	43.2	27.2	3.96
E 'Uniform'	29.2	31.2	21.4	9.5	1.34
F 'Veendam'	30.7	40.1	30.2	9.2	1.74
H 'Schmid's Ideal'	12.5	14.1	(16.1)	5.8	0.60
Comparison of main rootstock treatment means					
SED	*5.23 (36df)*	*4.52 (36df)*	*5.11 (27df)*	*3.17 (36df)*	*NA*
LSD (5%)	*10.6*	*9.2*	*10.5*	*6.4*	*NA*
Significance, P	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*NA*

Means in brackets, not included in statistical analysis

Blow out damage

Following experience in 1991, where blow out damage on the tall cultivar Royal William had been significant, in Trial 2 young shoots on all the Royal William were pruned or 'tipped back' to a length of about 30 - 50 mm at the end of April 1992. This was probably beneficial as there was little damage from blow outs in that trial. However, as the practice of tipping back is not always carried out commercially, and because it could affect the pattern of basal shoot production from the different rootstocks, it was decided not to tip back Trial 3, when again blow out damage was observed.

In this trial the numbers of blown out shoots were counted at each assessment date at the same time rootstock suckering was assessed. As shown in Table 9, p. 18, cv. Royal William was the cultivar most affected with from 5 - 30% of plants affected (ie losing one or more shoots) over the season. Wind damage such as this tends to be quite randomly distributed, and although not statistically analysed, there was no clear indication that any of the rootstocks were more or less susceptible to the problem. Table 9 also shows the proportion of rootstocks planted which reached final grading. There were appreciable numbers of missing plants of Royal William on 'Kuiper', 'Inermis', 'Entree' and 'Uniform', but most other stock / scion combinations had over 90% of planted stocks present. Budtake failures (or stocks which could not be budded) would have contributed to the losses, but it appears that blow out damage was the major cause.

Table 9: Trial 3: Proportion of plants which suffered some blow-out damage, and % reaching final grading (from nominal 64 plants/treatment total)

Rootstock	% plants with blow-outs	% rootstocks planted which reached final grading
	cv. Freedom	
A 'Laxa'	9.4	97
B 'Kuiper'	1.6	98
C 'Inermis'	6.3	94
D 'Entree'	10.9	88
E 'Uniform'	14.1	95
F 'Veendam'	3.1	100
H 'Schmid's Ideal'	7.8	92
	cv. Margaret Merril	
A 'Laxa'	1.6	97
B 'Kuiper'	1.6	97
C 'Inermis'	4.7	88
D 'Entree'	0.0	89
E 'Uniform'	6.3	91
F 'Veendam'	0.0	98
H 'Schmid's Ideal'	0.0	100
	cv. Royal William	
A 'Laxa'	15.6	91
B 'Kuiper'	25.0	77
C 'Inermis'	31.2	72
D 'Entree'	14.1	75
E 'Uniform'	23.4	78
F 'Veendam'	14.1	94
H 'Schmid's Ideal'	4.7	92

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HRI EAST MALLING

Miss Gail Kingswell BSc DipManStudies	Statistician

AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature ....Margaret A. Scott.......... Margaret A Scott
Science Co-ordinator

Date ...6/3/95...............

Report authorised by ....M R Shipway..........
Signature

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Date 6. 3. 95..........

Final plant quality - shoot numbers

Figure 1, p. 20 summarises the effects of the different rootstocks on the numbers of basal shoots per plant produced averaged across the three scion cultivars. The results are expressed as means per plant based on the numbers of plants present at the final grading. The total height of the bars represents the total number of shoots ≥ 6 mm diameter with the proportions of those > 10 mm dia. and 6 - 10 mm dia. shown as solid and shaded bars respectively. The data and statistical analyses are shown in Appendix III, Tables 10 - 12, pp. 41 - 43 for Trial 2, and Tables 13 - 15, pp. 44 - 46 for Trial 3.

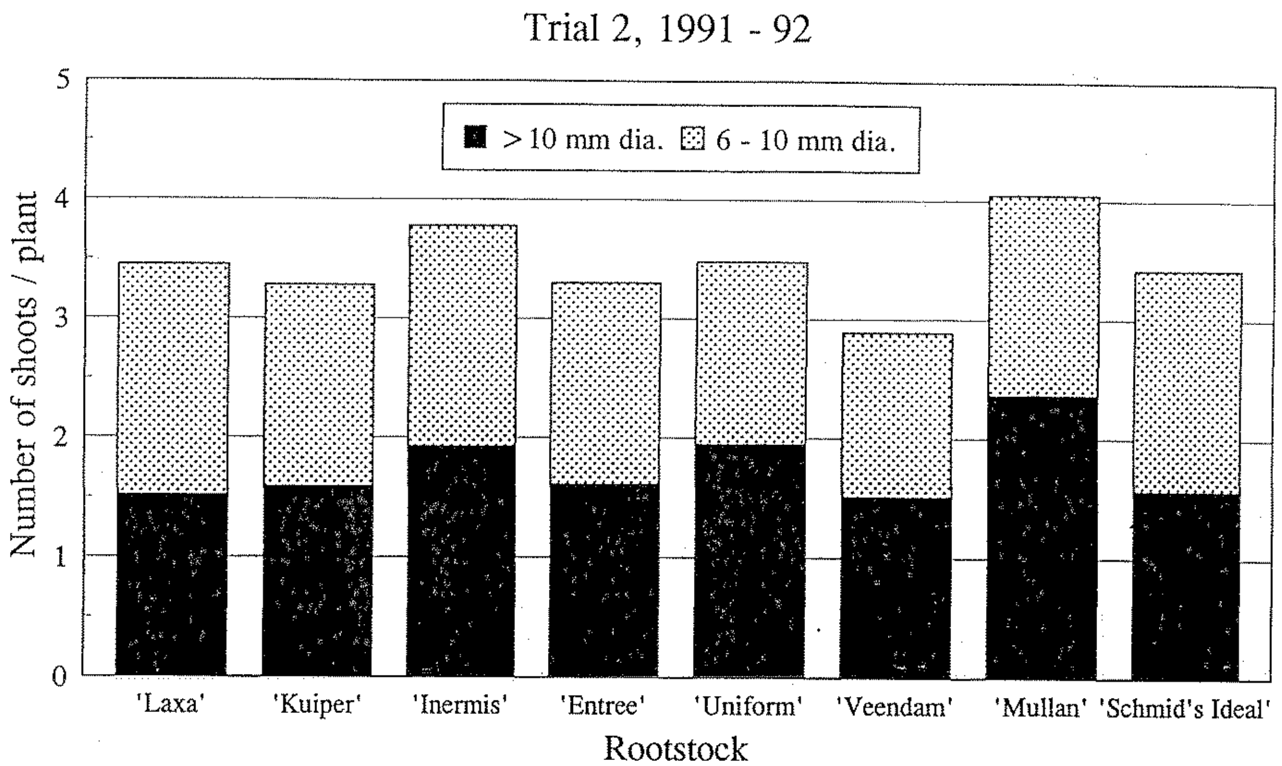
In both trials, Freedom produced the most total shoots on average, and the most thick shoots > 10 mm diameter, whereas Margaret Merril produced the fewest in each case. However, there were no significant treatment interactions for numbers of shoots between rootstocks and scion cultivars, so the results were summarised in the main rootstock treatment effects.

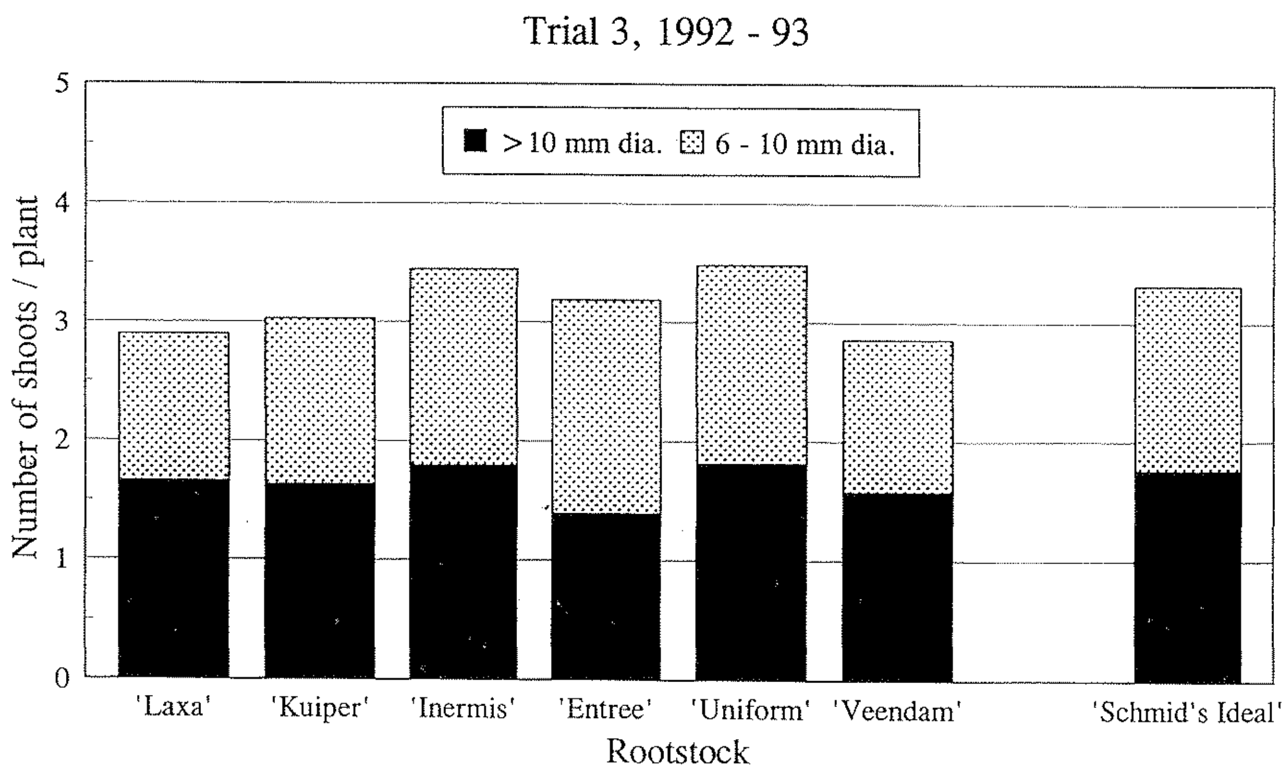
In Trial 2, 'Mullan', 'Inermis' and 'Uniform' produced significantly more thick shoots than the remaining cultivars. 'Mullan' was not included in Trial 3, but here 'Inermis' and 'Uniform' again produced the highest mean numbers of thick shoots, although this did not prove to be significantly different to 'Entree' and 'Veendam'.

Total shoot numbers ≥ 6 mm diameter for 'Mullan' in Trial 2 were significantly greater than all rootstocks except 'Inermis', and 'Inermis' produced significantly more shoots than 'Kuiper', 'Entree', 'Veendam' and 'Schmid's Ideal'. In Trial 3, 'Inermis' and 'Uniform' had more shoots in total than 'Laxa', 'Kuiper', 'Entree' and 'Veendam'.

Figure 1. Trials 2 & 3, Numbers of basal shoots per plant present at final grading

Means of scion cultivars





Final plant quality - plant grades

Grade-out criteria were based on specifications detailed in BS 3936 Part 2 (1990). This standard gives only a minimum specification which approximated to the Grade 2 used in this trial, with higher specifications required for Grade 1 bushes defined as follows:

Grade 1 = Minimum of 3 main basal shoots. The sum of the diameters of 2 of the shoots > 20 mm.

Grade 2 = Minimum of 2 basal shoots. Sum of diameters > 20 mm.

Grade 3 = 1 shoot only, or sums of diameters of 2 shoots < 20 mm.
(waste)

Shoots < 6 mm diameter were ignored.

Plant grades expressed as the % Grade 1, 2 and waste of rootstocks planted, are summarised in Figures 2 & 3, pp. 23 and 24 for Trials 2 and 3. The data used for statistical analysis is presented in Appendix IV, Tables 16 - 18, pp. 47 - 49 for Trial 2 and Tables 19 - 21, pp. 50 - 52 for Trial 3. The data was analysed using angle transformations, and these figures are shown in the tables in Appendix IV. However the actual % grade-outs are used for Figures 2 and 3.

The proportion of Grade 1 plants in Trial 2 showed a broadly similar pattern across each scion cultivar, and there were no significant interactions between scion and rootstock treatments. The proportion of Grade 1 plants was greatest for 'Inermis' and 'Uniform' rootstocks, with the means averaged across the scions being significantly greater than any of the other rootstocks except 'Schmid's Ideal' ($P<0.05$). In Trial 3, the pattern for Grade 1 plants varied between the scions. For Freedom, there were no significant differences except for 'Entree' which produced the fewest Grade 1 plants, and for Royal William where 'Schmid's Ideal' produced significantly more than the other rootstocks except for 'Uniform' ($P<0.05$). Margaret Merril, with less Grade 1 plants on average compared to the other scions, performed best on 'Uniform', 'Schmid's Ideal' and 'Inermis' where significantly more Grade 1 bushes were produced than with the other rootstocks.

The proportion of 'marketable' plants (Grade 1 + 2) followed a somewhat different trend to that for Grade 1 plants. An improvement in quality with a large proportion of Grade 1 was sometimes accompanied by a smaller proportion of Grade 2 resulting in little net difference in the amount of total marketable plants. Nevertheless, for Trial 2, the proportion marketable was lowest for 'Mullan' and 'Kuiper'. In Trial 3, differences were generally small, particularly for Freedom and Margaret Merril. With Royal William, the higher proportion of missing plants with 'Kuiper', 'Inermis', 'Entree' and 'Uniform' had clearly had a knock-on effect on the total numbers of marketable plants, even though the numbers of Grade 1 plants appeared less affected.

The proportion of Grade 1 bushes overall was somewhat better from Trial 3 than Trial 2. Differences in the numbers of bushes successfully budded may have contributed to this, but it is also possible that some adverse competition from weeds in this Trial 2 in June and early July 1992 was partly responsible. Despite a standard residual herbicide treatment having been applied in late February, a significant amount of Knotgrass and Fat Hen germinated in this trial together with the emergence of Field Bindweed and Thistles. These perennial weeds were treated with glyphosate gel using a weedwiper in early July, and the whole trial was hoed by hand in mid July before re-applying a residual herbicide.

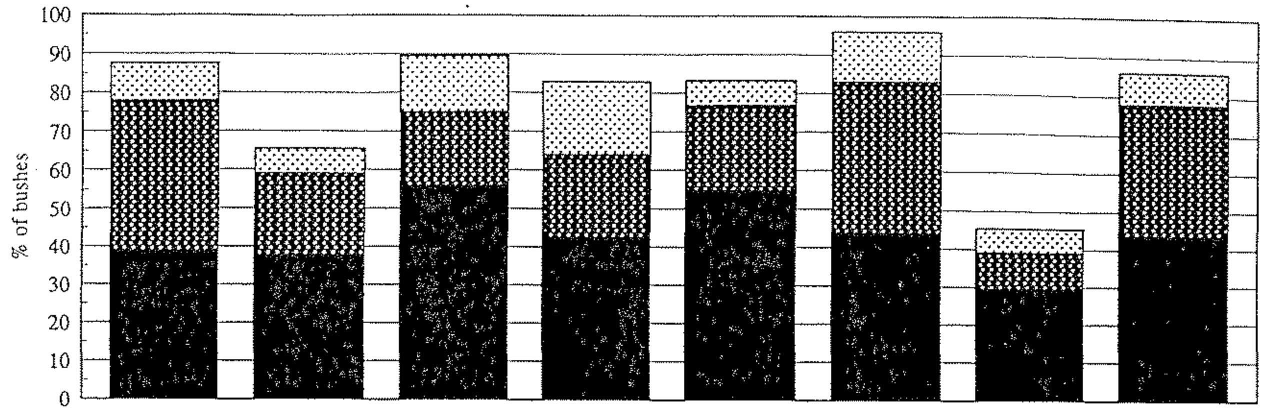
Figures 2 and 3 also illustrate the larger proportion of waste present with cv. Margaret Merril compared with Freedom and Royal William which is consistent with the relative differences in the proportion of Grade 1 bushes in each cultivar. There was less waste in Margaret Merril on the rootstocks 'Inermis' and 'Uniform', particularly in Trial 3.

Figure 2.

Trial 2, 1991-92. Final Grade-Out

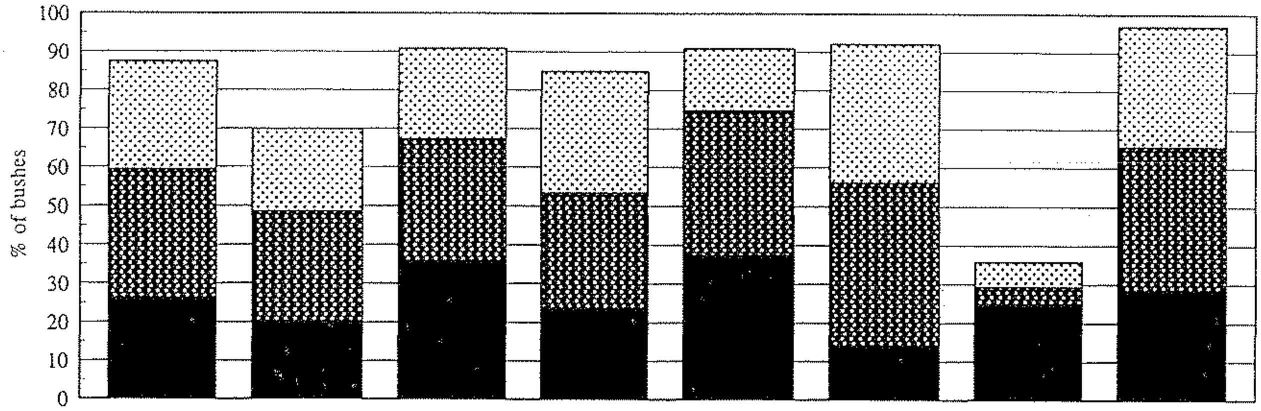
Grades as % of rootstocks planted

cv. Freedom



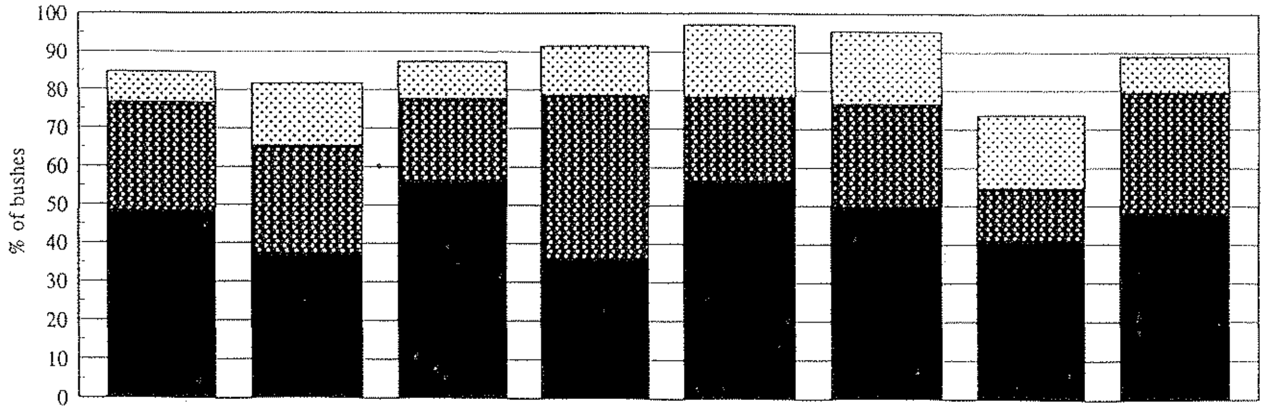
Rootstock	'Laxa'	'Kuiper'	'Inermis'	'Entree'	'Uniform'	'Veendam'	'Mullan'	'Schmid's Ideal'
Grade 1	39	38	56	42	55	44	30	44
Grade 2	39	22	19	22	22	39	10	35
Waste	10	6	14	19	6	13	6	8

cv. Margaret Merril



Rootstock	'Laxa'	'Kuiper'	'Inermis'	'Entree'	'Uniform'	'Veendam'	'Mullan'	'Schmid's Ideal'
Grade 1	27	21	36	24	38	14	25	28
Grade 2	33	28	31	30	38	42	5	38
Waste	28	21	24	32	16	36	6	31

cv. Royal William



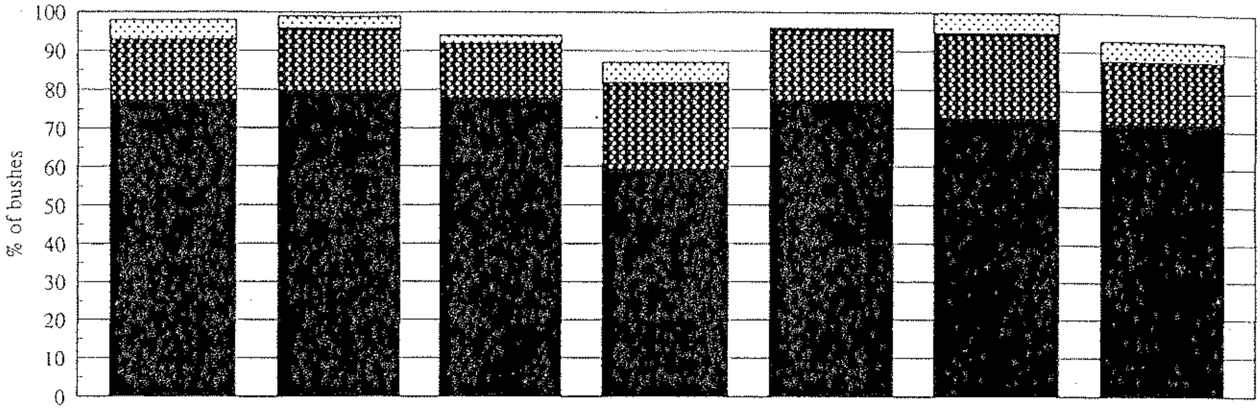
Rootstock	'Laxa'	'Kuiper'	'Inermis'	'Entree'	'Uniform'	'Veendam'	'Mullan'	'Schmid's Ideal'
Grade 1	49	38	56	36	56	50	41	49
Grade 2	28	28	22	43	22	27	14	31
Waste	8	16	10	13	19	19	19	9

Figure 3.

Trial 3, 1992-93. Final Grade-Out

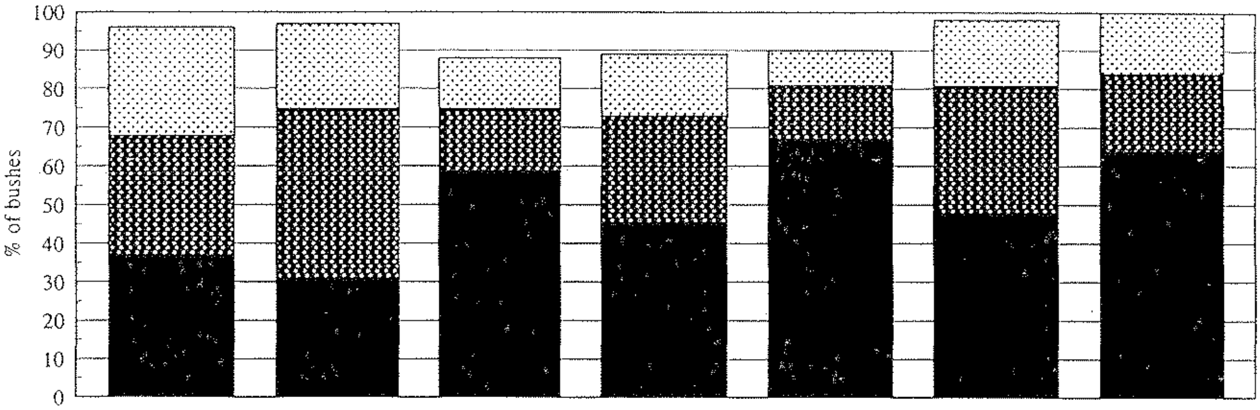
Grades as % of rootstocks planted

cv. Freedom



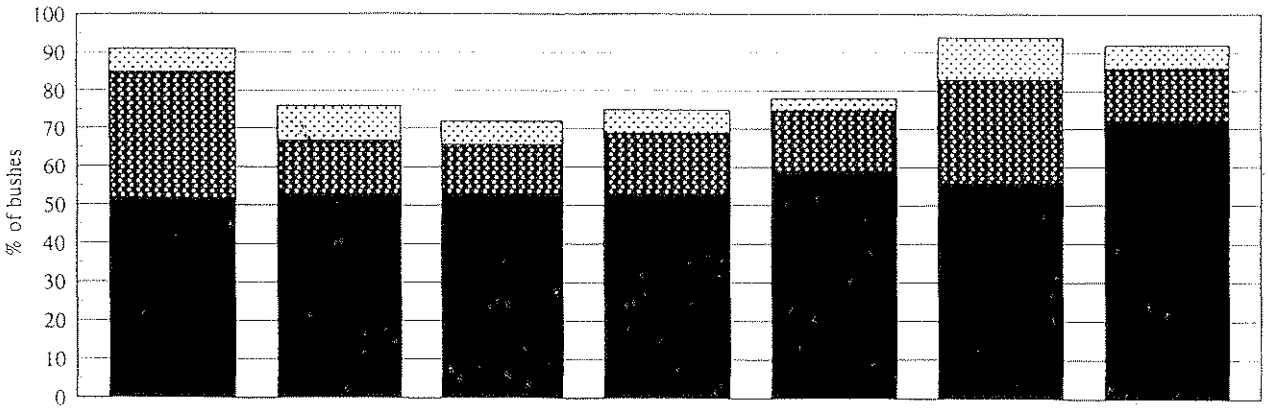
Rootstock	'Laxa'	'Kuiper'	'Inermis'	'Entree'	'Uniform'	'Veendam'	'Schmid's Ideal'
Grade 1	77	80	78	59	77	73	72
Grade 2	16	16	14	23	19	22	16
Waste	5	3	2	5	0	5	5

cv. Margaret Merril



Rootstock	'Laxa'	'Kuiper'	'Inermis'	'Entree'	'Uniform'	'Veendam'	'Schmid's Ideal'
Grade 1	37	31	59	45	67	48	64
Grade 2	31	44	16	28	14	33	20
Waste	28	22	13	16	9	17	16

cv. Royal William



Rootstock	'Laxa'	'Kuiper'	'Inermis'	'Entree'	'Uniform'	'Veendam'	'Schmid's Ideal'
Grade 1	52	53	53	53	59	56	72
Grade 2	33	14	13	16	16	27	14
Waste	6	9	6	6	3	11	6

Observations on root systems of lifted bushes

The root systems of some lifted plants from Trial 3 were compared visually. 'Laxa' stood out as having thicker and stiffer roots than the other rootstocks. On some 'Laxa' stocks there were just one or two long thick tap roots, but on other plants there were several, more spreading roots, but they were characterised by being thick and fleshy with relatively few fine branch roots.

The root system on 'Inermis' generally appeared weaker than many of the other stocks, particularly 'Laxa'. The main roots were typically thinner, shorter and often less numerous. It was difficult to generalise about the remaining rootstocks. 'Kuiper' and 'Entree' appeared to be slightly more vigorous than most of the others though less vigorous overall than 'Laxa'. However, a more detailed study with larger samples would be needed to confirm this.

There appeared to be an indication that the vigour of the scion cultivar was reflected in the growth of the rootstock root system which was generally weaker for plants of Margaret Merril than for Freedom or Royal William.

DISCUSSION

General rootstock characteristics and vigour

The degree of thorniness of the rootstock selections will have a bearing on how easy the stocks are handled during budding, and the comfort of those involved in hoeing out, budding and patching. Most of the new selections had less stem thorns than 'Laxa', although all had small thorns on the leaf undersides which could inflict scratches. Although there were differences in the amount and habit of top growth produced, this was unlikely to be a significant problem in practise during budding except possibly with *R. multiflora* 'Mullan' where growth could be particularly spreading and untidy. The degree to which rootstock tops are trimmed before planting will affect the amount of shoot present before budding. Where top growth does develop excessively, perhaps following insufficient pruning at planting, a particularly vigorous growing season, or where budding is delayed, a tractor mounted cutter bar to trim back shoots can be used effectively. The operation is perhaps best done two weeks or so prior to budding to ensure that any check to sap flow has past as new growth develops.

The weight of rootstock tops removed may or may not be a practical consideration in the choice of rootstocks. According to a report of early Shardlow work on rootstocks (1967 - 70), the weight of rootstock tops that were carted from the field and burnt could typically exceed 5 tonnes / ha (2 tons / acre) and therefore constituted a significant cost in time and labour. In Trial 2, the more vigorous 'Inermis', 'Uniform' and 'Mullan' had 80% more material to be removed than 'Laxa', 'Kuiper' and 'Schmid's Ideal' which could be of economic significance.

Disease susceptibility

Although the most serious foliage disease, Rose Rust (*Phragmidium mucronatum*), only really developed in one of the three trials in the project, the difference in rootstock susceptibility observed in Trial 2 in 1991 was very clear cut. The virtual absence of this Rust species from any of the rootstocks other than 'Laxa', while under a high disease pressure from severely infected plots of 'Laxa' in close proximity, was a convincing demonstration of their resistance to the disease. It was surprising, though, that 'Inermis' showed no sign of the disease in Trial 2. According to the standard guidebook to rootstocks for roses (Leemans, 1964), 'Inermis' is "somewhat sensitive to rust", whereas no mention of susceptibility is indicated for 'Laxa'. It is possible that races of the disease have developed and changed over the years and that populations of those adapted to infecting 'Laxa' have increased in line with the expansion of this rootstock's popularity. A subsequent crop of 'Laxa' and 'Inermis' stocks planted in 1994 at Efford confirmed differences in their susceptibility to Rust when the disease developed in late summer and had defoliated 'Laxa' by mid October, whereas 'Inermis' still had most of its leaves present. Some Rust pustules were observed on 'Inermis' leaves on this occasion, but the disease was present only at a low level.

The most damaging aspect of Rust infection in the rootstock year is likely to be a general weakening of the stocks which could affect their vigour in the following maiden bush production year, and a loss of yield due to poor budtake if infection occurs early enough to cause premature leaf fall near to the time of budding. It should be noted, however, that a high incidence of rootstock Rust is not necessarily linked with a high level of Rust on the scion cultivars the following year. Most Rust on flowering roses in the UK appears to be a different species, *Phragmidium tuberculosum*.

Apart from 'Entree' and 'Mullan', the remaining rootstock selections were more susceptible to Powdery Mildew than 'Laxa'. This disease, though, probably has a less deleterious effect on the plant than Rust as they usually retain their leaves even when severely affected by Powdery Mildew. Also, the amount of inoculum carried over to the maiden crop is likely to be small as Powdery Mildew typically overwinters as mycelium on green plant tissue which is largely removed when rootstocks are headed back.

Ease of budding

The availability of adequate water for the stocks prior to budding was highlighted as an important factor affecting the ease of making and opening the 'T' cuts in the rind and inserting the scion buds. In 1991, irrigation prior to budding would probably have made budding easier, and irrespective of the type of stock used it is advisable to apply water at this time if soil conditions are dry. The availability of irrigation on most nurseries means that dry weather prior to budding should not be a significant problem. Where irrigation is not available, however, then 'Laxa' does appear to be better at coping with dry conditions. It may be that the thicker, fleshier roots on 'Laxa' offers a degree of buffering against a lack of soil moisture.

Budtake and shot bud

Despite the differences apparent between 'Laxa' and the other rootstocks regarding the ease of budding in Trial 2, the budtake of those actually budded was not adversely affected in most cases. The instances of poorer take on 'Mullan' and 'Kuiper' could have been due mainly to the rind splitting and poor contact between the bud and the stock rather than because the stocks were too dry.

It is not clearly understood what encourages premature shooting of the bud (shot bud). In this work it did not appear to be simply related to the overall vigour of the stocks as 'Inermis', 'Entree', 'Uniform' and 'Mullan' did not consistently induce more shot bud. Neither did shot bud appear to be directly related to the vigour of the scions. Although Royal William generally had more shot bud in Trial 3, this was not the case in Trial 2. Previous trials experience both at Efford with both different scion and standard stem selections budded on to 'Laxa', and at Shardlow, have shown that both rootstocks and scion types can influence the amount of shot bud.

The condition of the budwood and the stocks may also influence the likelihood of premature shoot development. It is also generally accepted that budding earlier in the season tends to increase shot bud compared with budding later. Shot buds are typically pruned back to within about 5 mm of the stocks at the time of heading back, and there is no evidence to indicate that final plant quality is adversely affected. The extra work involved is small, and so shot bud is not usually regarded as a significant problem commercially.

Blow outs and 'tipping back'

The damage from blow outs leading to the downgrading or even total loss of plants can be a very significant factor with tall growing cultivars such as Royal William. It is the unpredictable and erratic nature of the damage that makes it difficult to deal with. In some years, particularly in sheltered sites, there may be negligible losses, whereas in other years it can be devastating. The most susceptible time seems to be in late May and June when shoots are tall enough to be unstable in the wind, but before they have lignified appreciably and the union between stock and scion has strengthened fully. Unfortunately, while damage occurring at this time can be reduced by cutting back these shoots say by half, new shoots then arise from the top of the remaining portion of the shoot rather than as new basal shoots. Therefore the decision whether or not to 'tip back' is best made early in the year before shoots have reached around 150 mm in length when they are cut hard back, rather than leaving the decision until later in the summer according to circumstances. A policy of tipping back, possibly requiring several passes at intervals during the early summer, can be costly in terms of labour involved, and is therefore not so commonly carried out on the larger scale nurseries.

It is not certain whether tipping back early in the season increases the number of basal breaks and improves the final grade-out of bushes or not. Most shoots, if left alone, will eventually terminate in a flower which then typically encourages the formation of further basal breaks. This process will continue right through the season so that the late summer period from August through to October can be significant in adding quality to the bushes. Another reason frequently given for tipping back is to reduce the proportion of single shooted plants; ie it encourages the two (or more) secondary buds either side of the base of the primary shoot to grow. This seems to be required more with some cultivars than others. The removal of budwood from a crop in early summer before terminal flower buds are fully developed may also possibly interrupt the process of basal shoot production and encourage shoots to grow instead from the upper part of the cut stem. Tipping back early, then, may at least ensure that very few single shooted plants will be produced. On balance, assuming labour is available, tipping back may be a worthwhile practice, particularly on cultivars where single breaks are a problem, and for top heavy cultivars and in exposed fields where there is more risk of blow out damage. More trials are needed though to investigate the complex of factors involved.

Final plant quality

While yellows have a reputation for being weaker growers, the cultivar Freedom gave the best average shoot number and grade-out in both Trials 2 and 3. The weaker growing Margaret Merril, however, gave the poorest grade-out as expected. Because the three scion cultivars were planted in discrete areas and not randomised throughout the trials, some apparent differences between them may have been due to positional effects. Nevertheless a similar pattern was shown in both Trials 2 and 3, and has been borne out by experience in other trials, and this adds confidence to it being a real effect.

The diameter criteria for 'thin' and 'thick' shoots was decided upon by examination of a number of plants across a range of HT and floribunda cultivars, together with consideration of the BS 3936 Part 2 specifications. They allowed treatment differences between the rootstocks to be detected within a manageable two categories for recording. Also the numbers of basal shoots were presented as means per plant graded, ignoring missing plants and thus provided an indication of treatment differences on a 'biological' basis rather than a commercial basis. Surviving plants of 'Mullan', in Trial 2, actually produced the highest average of both total and thick shoots. What cannot be determined, however, is how far this was due to the rootstock, and how far the lack of competition from the large number of missing plant gaps within the plots contributed to improved growth of the survivors.

As the final grades were expressed as a proportion of the numbers of rootstocks planted, rather than only those graded, they are more directly applicable to commercial conditions, although they do include plant and shoot losses due to budtake failure and blow out so need to be interpreted carefully, particularly if these other factors are not necessarily related to the treatments.

The plant grades, while based on the numbers of shoots and their thicknesses, allowed some flexibility in substituting a larger number of thinner shoots for fewer thick shoots within the same grade. BS 3936 Part 2 (1990) does not specify commercial grade-outs as used in practice, but rather gives general guidelines on minimum standards that should be met by roses of marketable grade. There are no formally agreed standards on what constitutes a Grade 1 or Grade 2 plant, and this tends to vary in practice between nurserymen, markets, and according to the type of rose. A three shooted plant is generally regarded as a minimum for Grade 1, and this has been the basis of the grading used in this trial. It is likely that the strict adherence to the shoot number and thickness criteria required for trial purposes has tended to err on downgrading compared to what might be the commercially accepted norm, and this should be borne in mind when comparing the trial results to commercial situations. In some cases for example, a plant with one shoot > 10 mm plus two of 6 - 10 mm would be regarded as Grade 1 rather than Grade 2 as used in this trial.

'Mullan' showed a relatively poor yield of Grade 1 plants as a % of the rootstocks planted in Trial 2, mainly because this rootstock had so many plants that could not be budded. However a large proportion of the 'Mullan' plants present at lifting were Grade 1, particularly for Freedom and Margaret Merril. As remarked above for the number of basal shoots, it is difficult to determine how far this was due to the rootstock and how much the lack of competition due to missing plants. It is likely that 'Mullan', being a vigorous stock, would produce a relatively good grade-out of those successfully budded. Nevertheless, the poor growth habit and form of the neck, which makes budding so difficult, justifies the rejection of this stock for rose cultivars which are normally budded on 'Laxa' or *R. canina* type stocks.

Of the remaining stocks, 'Inermis', and the new selection 'Uniform', performed best overall with some improved grade-outs over 'Laxa' that could be of commercial as well as statistical significance. They looked particularly promising with the weaker growing Margaret Merril where grade-out improvements would be particularly valuable. Nurserymen might find it worth trialling these stocks further with other weaker growing cultivars where it is difficult to achieve a good yield of Grade 1 plants. 'Schmid's Ideal' also performed quite well, although overall it did not show significant improvements over 'Laxa'.

Sucker production

Removal of rootstock suckers during the maiden bush production year can be a significant labour cost, and it was largely because 'Laxa' produces so few that this rootstock became popular with growers. The gardening public have now also become used to not having so many suckers to remove from their rose bushes. The rootstocks 'Inermis' and 'Uniform' have met the criteria identified in the two main objectives of this project, namely greater resistance to Rust and an improved grade-out compared with 'Laxa'. However, they both produce a significant number of suckers. For these two rootstocks to obtain wider use commercially, the Rust resistance and grade-out advantages need to outweigh the extra labour cost involved in removal of suckers. In addition, consumer reaction to roses which sucker more freely might be unfavourable unless possible benefits of a new rootstock such as better basal shoot production and greater plant longevity were promoted.

To some extent, it appears that rootstock vigour, sucker production, and ability to improve plant grade-out are linked, in that the vigorous stocks 'Inermis' and 'Uniform' performed relatively well but produced a lot of suckers, whereas 'Kuiper', a weaker growing stock, produced few suckers and poorer grade-outs. The correlation does not hold true for all rootstocks though, as on the basis of, say, suckering, one would have expected 'Entree' to have performed better, and 'Schmid's Ideal' to have performed worse. Nevertheless, it is logical to expect high vigour in the rootstocks to be directed towards more shoot growth whether this be in the form of scion shoots or suckers. Others have commented on the relative merits of *R. canina* selections such as 'Inermis', and suggested that it is better and more reliable than 'Laxa', but that as long as there is a demand for minimal suckering, the public shall get roses budded on 'Laxa' (Harkness, 1981).

Root systems

The structure of the root system is an important consideration for roses lifted for containerisation. The characteristics of 'Laxa' with its often long thick tap roots are well known, and this can cause problems when potting. Severe pruning is often required to physically get the root system into the pot and to centralise it. This pruning looks particularly drastic when there is little fine branched root left. Special deep 4 litre containers are now used as standard for many potted roses in an attempt to cope with this rootstock, but some hard root pruning is still invariably required. Other rootstocks with more flexible and finer roots should have advantages for containerising. Trials in Project HNS 56 are currently under way where a range of rootstock pruning and undercutting treatments are being investigated both on 'Laxa' and 'Inermis' with the objective of improving the root framework for containerisation.

The observation that rootstocks budded with Margaret Merril generally produced a weaker root system than those budded with Freedom or Royal William, indicates that the influence of rootstocks and scions can work both ways. Taller and more vigorous scions, which are swayed more by the wind, may encourage the rootstock to produce thicker, tougher, anchor roots to support them. Rowley (1961) found that vigorous scion cultivars such as Peace induced more suckers across a range of rootstocks than weaker scions, and that vigorous growing rootstocks such *R. multiflora* in his trial ('Inermis' was not included), produced more scion growth in total than stocks such as 'Laxa'. In his trial, the numbers of basal shoots were not discussed, but *R. multiflora* encouraged more branching higher up the shoots and consequently more flowers, causing Peace to appear more like a floribunda than the less branched hybrid tea habit found on 'Laxa'.

CONCLUSIONS

The objectives of the work carried out between 1990 and 1993 were to test several new *R. canina* and a *R. multiflora* rootstock selections compared with 'Laxa', and two other traditional *R. canina* selections, with the aim of finding one with better Rust resistance and capable of producing an improved proportion of Class 1 bushes, while hopefully retaining 'Laxa''s good characteristics of ease of budding and low sucker production.

1. All the rootstocks tested had a much better resistance to *Phragmidium mucronatum* Rose Rust than 'Laxa'. Although quite good fungicidal control of Rust is still being achieved through the use of myclobutanil (Systhane) and other fungicides, the evolution of fungicide resistant strains of Rust in the future may force growers to consider using more Rust resistant rootstocks. Although 'Laxa' appeared to be much less susceptible to Powdery Mildew than many of the other rootstocks, a relatively high level of this disease appears to be acceptable in the rootstock year without affecting budding or plant health in the following year.

2. The new rootstock *R. canina* 'Uniform', and the old established rootstock *R. canina* 'Inermis', both produced better plant grade-outs than 'Laxa'. These stocks may well be worth further trialling by growers, particularly on cultivars that a shy to produce basal breaks and that require a stronger rootstock to achieve a good proportion of Grade 1 plants.

3. Together with most of the other rootstocks tested, suckering was significantly greater on 'Uniform' and 'Inermis' compared to 'Laxa'. More suckers appear to be an unavoidable downside to achieving higher grade-outs through more vigorous rootstocks.

4. Although a high proportion of *R. multiflora* 'Mullan' stocks that were budded successfully produced Grade 1 bushes, the difficulties of budding this stock due to the thin skins and short, twisted necks led to a disappointing commercial yield overall. It cannot be recommended as a substitute for 'Laxa'.

5. A significant shift from using 'Laxa' as the first choice of rootstock for the majority of roses is not likely while such a high premium is placed upon the virtual absence of suckering by both producers and consumers. However, the relative benefits of improved grade-out, Rust resistance and possible advantages for containerisation with 'Uniform' and 'Inermis' stocks may become greater in the future, and growers should consider their own trials with these alternatives.

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Leemans, J. A. (1964)	Rootstocks for roses - characteristics and cultural value. Publ. Plant Publicity Holland, Boskoop, Netherlands
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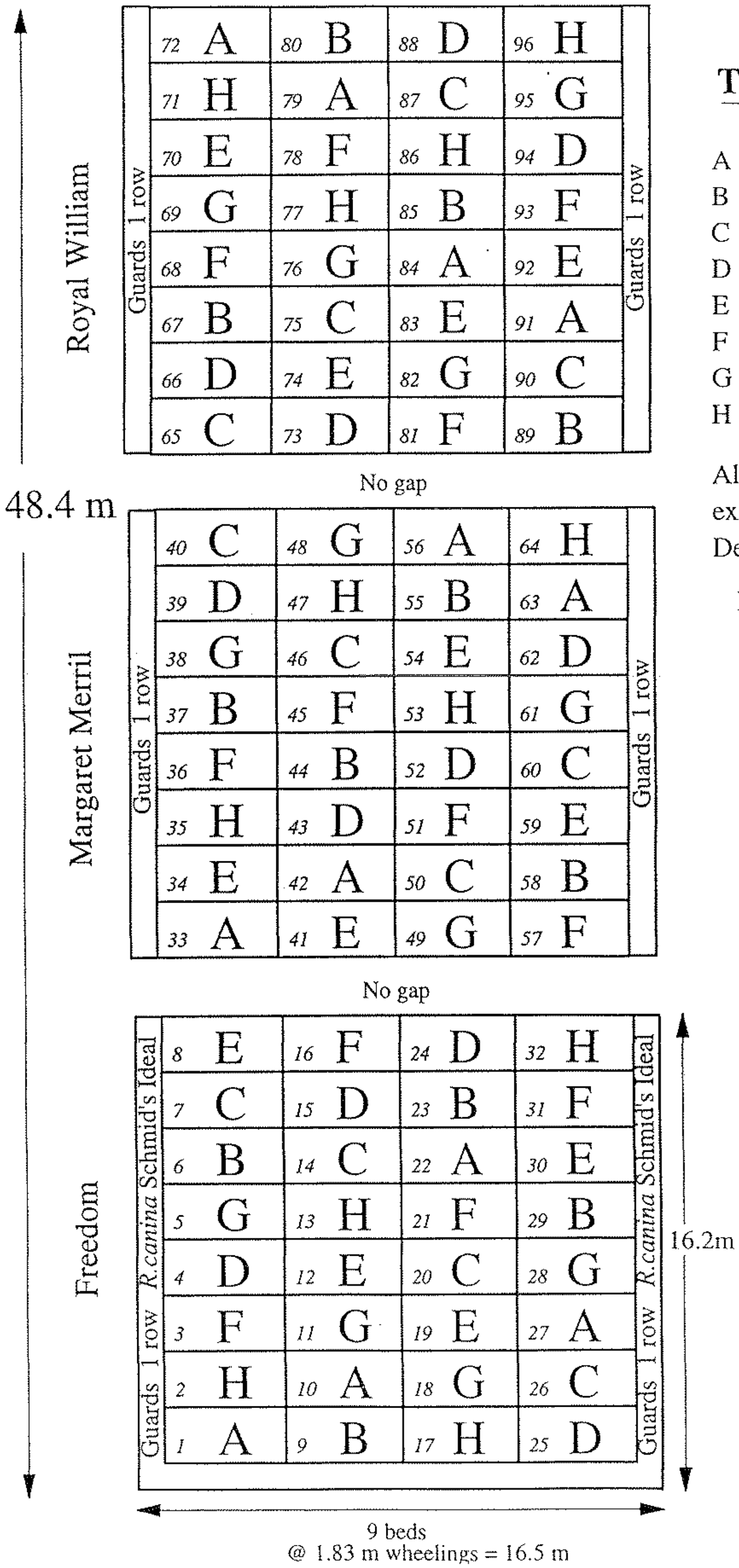
APPENDICES

Appendix I **Planting plans and layout**

HDC Rose Rootstock Comparison 2 1991/92

Field S11 (north) N

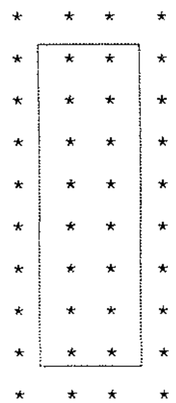


Treatments - Rootstocks

A *Rosa* 'Laxa'
B *R.canina* 'Kuiper'
C *R.canina* 'Inermis'
D *R. canina* 'Entree'
E *R. canina* 'Uniform'
F *R. canina* 'Veendam'
G *R multiflora* 'Mullan'
H *R. canina* 'Schmid's Ideal'

All rootstocks from Rosaco, Holland except 'Mullan', from Danplanex, Denmark

Plot detail :-



4 rows x 10 plants = 40 / plot
Recorded plants = 16 / plot
Spacing 0.9 m x 0.2 m

480 Plants / rootstock + 516 guards
1440 - Margaret Merril
1458 - Freedom and Royal William
= 4356 total no. roses

Youden square trial design

Trial area 16.5 m x 48.4 m
= 800 m²

HDC Rose Rootstock Comparison 3 1992/93

Field S11 (north east) N

44 m

Royal William

Guard					Guard
Guard	63 D	70 H	77 F	84 A	Guard
Guard	62 A	69 D	76 C	83 E	Guard
Guard	61 C	68 F	75 E	82 H	Guard
Guard	60 H	67 C	74 B	81 D	Guard
Guard	59 F	66 B	73 A	80 C	Guard
Guard	58 B	65 E	72 D	79 F	Guard
Guard	57 E	64 A	71 H	78 B	Guard

1m gap

Margaret Merril

Guard					Guard
Guard	35 F	42 C	49 E	56 H	Guard
Guard	34 B	41 F	48 A	55 C	Guard
Guard	33 H	40 D	47 F	54 A	Guard
Guard	32 A	39 E	46 H	53 B	Guard
Guard	31 C	38 H	45 B	52 D	Guard
Guard	30 D	37 A	44 C	51 E	Guard
Guard	29 E	36 B	43 D	50 F	Guard

1m gap

Freedom (14 m)

1 row *R.* Laxa Guard					1 row *R.* Laxa Guard
	7 H	14 C	21 D	28 B	
	6 A	13 D	20 E	27 C	
	5 B	12 E	19 F	26 D	
	4 E	11 A	18 B	25 H	
	3 C	10 F	17 H	24 E	
	2 F	9 B	16 C	23 A	
	1 D	8 H	15 A	22 F	

9 beds @ 1.83 m wheelings = 16.5 m

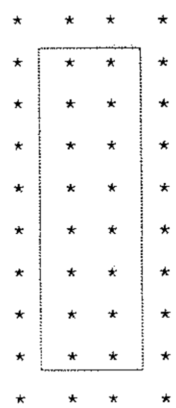
Treatments - Rootstocks

A *Rosa* 'Laxa'
B *R.canina* 'Kuiper'
C *R.canina* 'Inermis'
D *R. canina* 'Entree'
E *R. canina* 'Uniform'
F *R. canina* 'Veendam'
H *R. canina* 'Schmid's Ideal'

(nb. no G - *R. multiflora* 'Mullan' in this trial)

All rootstocks 5-8 mm grade from Rosaco, Holland

Plot detail :-



4 rows x 10 plants = 40 / plot
Recorded plants = 16 / plot
Spacing 0.9 m x 0.2 m

480 Plants / rootstock +
420 extra *R.* 'Laxa' side guards

1260 x 3 scions = 3780 bushes total

Youden square trial design

Trial area 16.5 m x 44 m = 726 m²

Appendix II **Diary of cultural operations**[1]

Trial 2

1991

15 Jan	Trial 2 grassed area sprayed with glyphosate as Roundup 4.0 litres/ha.
25 Feb	All rootstocks except 'Mullan' and 'Schmid's Ideal' received, roots covered with moist perlite, sprayed with iprodione as Rovral 1.5 g/litre HV, and cold stored.
12 Mar	*R. multiflora* 'Mullan' received and treated as above.
27 Mar	Site chisel ploughed followed by rolling.
8 Apr	Base dressings applied - 50 kg/ha N + 50 kg/ha K_2O + 25 kg/ha Mg as Nitram, sulphate of potash and kieserite respectively. Rotary cultivated land and bedded out.
10 Apr	Hand planted stocks (except 'Schmid's Ideal').
15 Apr	'Schmid's Ideal' stocks received and planted.
23 Apr	Residual herbicide simazine as Gesatop 500L at 3.4 litres/ha + metazachlor as Butisan S at 2.5 litres/ha applied.
5 Jun	Top dressed with 50 kg/ha N (per treated area as 0.5 m wide band down rows) with Nitram.
17 Jun	Hand weeded annual weeds (mainly Fat Hen).
16 Jul	Hand removal of some Field Bindweed.
5 Aug	Commenced budding stocks.
9 Aug	Completed budding.
28 Aug	Sprayed with bupirimate as Nimrod at 3.8 ml/litre + Agral wetter at 0.5 ml/litre HV against Powdery Mildew.
10 Sept	Nimrod + Agral as above.
17 Sept	Sprayed myclobutanil as Systhane 6W at 1.0 g/litre HV against Rust now that disease assessment complete.
25 Sept	Sprayed benodanil as Calirus at 1.0 g/litre + Agral wetter at 0.5 ml/litre HV for Rust.
2 Oct	Systhane spray as above.
10 Oct	Calirus spray as above.
19 Oct	Systhane spray as above.

[1] Irrigations using Wright Rain overhead sprinklers were also applied as required during the trials

24 Oct	Calirus spray as above.
25 Oct	Demeton-S-methyl as Metasystox at 0.38 ml/litre HV for Aphids.
11 Nov	Electric wire fence erected around site against roe deer.

1992

11 - 14 Feb	Rootstocks headed back and samples of tops weighed.
28 Feb	Simazine + Butisan S residual herbicide spray as above.
13 Apr	Top dressed with 75 kg/ha N + 19 kg/ha P_2O_5 + 56 kg/ha K_2O as Kemira 20:5:15 at 375 kg/ha.
22 Apr	Heptenophos spray as Hostaquick at 0.75 ml/litre for Aphids spot treatment as required.
30 Apr	Royal William shoots shortened to 30 - 50 mm to protect against blow outs.
5 May	Systhane 6W + Metasystox spray against foliar diseases and Aphids.
14 May	Bupirimate + triforine as Nimrod T at 3.2 ml/litre HV spray for foliar diseases. Suckers and Field Bindweed removed by hand.
10 Jun	Systhane + Metasystox spray as above.
29 Jun	Systhane spray as above.
6 Jul	Field bindweed treated with Roundup gel.
7 Jul	Nimrod T spray as above.
14 Jul	Hoed out remaining weed and removed bindweed.
23 Jul	Nimrod T spray as above.
1 Aug	Residual herbicide simazine + Butisan S applied via hand lance with single wide angle Polijet nozzle between rows.
11 Aug	Nimrod T spray as above.
1 Sept	Systhane spray as above.
15 Sept	Systhane spray as above.
29 Sept	Nimrod T spray as above.
24 Oct	Undercut trial with Damcon undercutter prior to final plant quality recording and lifting.

Trial 3

1991

15 Oct	Grassed site sprayed with glyphosate as Roundup at 5.0 litres/ha.
23 Nov	Stable manure at about 75 tonnes/ha applied to site.

1992

24 Jan	Received rootstocks and held in cold store.
27 Jan	Site chisel ploughed.
30 Jan	Site disc cultivated, bedded out and rotary cultivated.
3 Feb	Rootstocks hand planted.
20 Mar	Residual herbicide Simazine as Gesatop 500L at 3.4 litres/ha + metazachlor as Butisan S at 2.5 litres/ha applied.
6 May	Demeton-S-methyl as Metasystox at 0.38 ml/litre HV spray against aphids.
26 May	Metasystox as above.
4 Jun	Metasystox as above.
24 Jun	Top dressed with 50 kg/ha N (treated area as 0.5 m wide band down rows) as Nitram.
26 Jun	Metasystox as above + bupirimate as Nimrod at 3.8 ml/litre + Agral wetter at 0.5 ml/litre HV spray for Aphids and Powdery Mildew.
15 Jul	Trimmed back rootstock tops to about 350 mm to reduce surplus growth prior to budding.
16 Jul	Nimrod + Agral as above.
23 Jul	Nimrod + Agral as above.
31 Jul	Commenced hoeing out ridges from stocks in preparation for budding.
7 - 8 Aug	Budded stocks.
26 Aug	Simazine + Butisan S herbicide application as above.
29 Aug	Nimrod + Agral as above.
4 Sept	Nimrod + Agral as above.
18 Sept	Nimrod + Agral as above.
28 Sept	Nimrod + Agral as above.
10 Oct	Nimrod + Agral as above.

1993

8 Feb	Rootstocks headed back.
5 Mar	Residual herbicide simazine as Gesatop 500L at 3.4 litres/ha + oxadiazon as Ronstar Liquid at 4.0 litres/ha.
18 Mar	Pirimicarb as Pirimor at 0.5 g/litre HV spray against aphids.
8 Apr	Top dressed with 75 kg/ha N + 19 kg/ha P_2O_5 + 56 kg/ha K_2O as Kemira 20:5:15 at 375 kg/ha.
30 Apr	Myclobutanil as Systhane 6W at 1.0 g/litre + demeton-S-methyl as Metasystox at 0.38 mls/litre HV spray for foliar diseases and Aphids.
12 May	Bupirimate + triforine as Nimrod T 3.2 mls/litre + Metasystox as above for foliar diseases and Aphids.
18 May	Removed suckers after assessment.
21 May	Cypermethrin as Ambush C at 0.25 mls/litre HV for Caterpillars and Aphids. Also Systhane 6W as above.
28 May	Nimrod T spray as above.
1 Jun	Systhane 6W + Pirimor spray as above.
9 Jun	Removed suckers after assessment.
15 Jun	Systhane 6W + Pirimor spray as above.
23 Jun	Hoed weed as required.
25 Jun	Nimrod T spray as above.
21 Jul	Systhane 6W + Pirimor spray as above.
3 Aug	Removed suckers after assessment.
10 Aug	Systhane 6W + Pirimor spray as above.
20 Aug	Gesatop 500L + Butisan S as above applied with hand lance using a single wide angle Polijet nozzle between the rows.
3 Sept	Systhane 6W as above.
4 Nov	Commenced undercutting prior to lifting.

Appendix III **Final plant quality - shoot numbers**

Table 10: Trial 2: **Mean numbers of thick (> 10 mm dia.) shoots/plant based on plants present at final grading**

Rootstock	Scion cultivar: Freedom	M. Merril	R. William	Rootstock treatment mean
A 'Laxa'	1.44	1.33	1.80	1.52
B 'Kuiper'	1.91	1.25	1.62	1.59
C 'Inermis'	2.16	1.60	2.02	1.93
D 'Entree'	1.96	1.27	1.59	1.61
E 'Uniform'	2.22	1.62	2.02	1.95
F 'Veendam'	1.64	1.21	1.77	1.51
G 'Mullan'	2.87	2.23	2.01	2.37
H 'Schmid's Ideal'	1.76	1.21	1.75	1.57
Scion treatment mean	1.99	1.45	1.82	

Comparisons of individual scion x rootstock means

	within scions		*between scions*
SED (63df)	*0.256*		*0.294*
LSD (5%)	-		-
Significance, P		*NS*	

Comparisons of main treatments

	scion means	*rootstock means*
SED	*0.171 (6df)*	*0.148 (63df)*
LSD (5%)	*0.42*	*0.30*
Significance, P	*0.049*	*<0.001*

Table 11: Trial 2: Mean numbers of thin (6-10 mm dia.) shoots/plant based) on plants present at final grading

Rootstock	Freedom	M. Merril	R. William	Rootstock treatment mean
	Scion cultivar			
A 'Laxa'	2.49	1.36	1.94	1.93
B 'Kuiper'	2.04	1.35	1.68	1.69
C 'Inermis'	1.81	1.50	2.25	1.85
D 'Entree'	1.30	1.55	2.23	1.69
E 'Uniform'	1.66	1.38	1.55	1.53
F 'Veendam'	1.38	1.15	1.59	1.38
G 'Mullan'	2.26	1.11	1.68	1.68
H 'Schmid's Ideal'	2.20	1.62	1.74	1.85
Scion treatment mean	1.89	1.38	1.83	

Comparisons of individual scion x rootstock means

	within scions		*between scions*
SED (63df)	*0.381*		*0.397*
LSD (5%)	-		-
Significance, P		*NS*	

Comparisons of main treatments

	scion means	*rootstock means*
SED	*0.174 (6df)*	*0.220 (63df)*
LSD (5%)	*0.43*	-
Significance, P	*0.048*	*NS*

Table 12: Trial 2: Mean number of total shoots/plant (≥ 6 mm) based on plants present at final grading

Rootstock	Scion cultivar Freedom	 M. Merril	 R. William	Rootstock treatment mean
A 'Laxa'	3.93	2.69	3.74	3.45
B 'Kuiper'	3.95	2.60	3.31	3.28
C 'Inermis'	3.96	3.10	4.27	3.78
D 'Entree'	3.26	2.82	3.82	3.30
E 'Uniform'	3.88	3.00	3.57	3.48
F 'Veendam'	3.02	2.27	3.36	2.88
G 'Mullan'	5.13	3.34	3.69	4.05
H 'Schmid's Ideal'	3.96	2.82	3.49	3.42
Scion treatment mean	3.89	2.83	3.66	

Comparisons of individual scion x rootstock means

	within scions		*between scions*
SED (63df)	*0.493*		*0.498*
LSD (5%)	-		-
Significance, P		*NS*	

Comparisons of main treatments

	scion means	*rootstock means*
SED	*0.189 (6df)*	*0.285 (63df)*
LSD (5%)	*0.46*	*0.57*
Significance, P	*0.003*	*0.009*

Table 13: Trial 3: Mean numbers of thick (> 10 mm dia.) shoots/plant based on plants present at final grading

Rootstock	Scion cultivar Freedom	 M. Merril	 R. William	Rootstock treatment mean
A 'Laxa'	2.13	1.09	1.79	1.67
B 'Kuiper'	1.98	1.14	1.80	1.64
C 'Inermis'	2.21	1.24	1.94	1.80
D 'Entree'	1.75	0.94	1.52	1.40
E 'Uniform'	1.99	1.47	2.01	1.82
F 'Veendam'	2.09	0.92	1.73	1.58
H 'Schmid's Ideal'	2.13	1.19	1.94	1.76
Scion treatment mean	2.04	1.14	1.82	

Comparison of:	*scion means*	*rootstock means*
SED (36df)	*0.171*	*0.099*
LSD (5%)	-	*0.20*
Significance, P	*NS*	*0.002*

Formal comparisons of scion main treatment means not possible.

Table 14: Trial 3: Mean numbers of thin (6-10 mm dia.) shoots/plant based on plants present at final grading

Rootstock	Scion cultivar: Freedom	M. Merril	R. William	Rootstock treatment mean
A 'Laxa'	1.28	1.33	1.07	1.23
B 'Kuiper'	1.50	1.50	1.18	1.39
C 'Inermis'	1.86	1.86	1.24	1.65
D 'Entree'	1.77	1.93	1.66	1.79
E 'Uniform'	1.94	1.84	1.23	1.67
F 'Veendam'	1.13	1.69	1.03	1.28
H 'Schmid's Ideal'	1.60	1.95	1.12	1.56
Scion treatment mean	1.58	1.73	1.22	

Comparison of:	*scion means*	*rootstock means*
SED (36df)	*0.224*	*0.129*
LSD (5%)	-	*0.26*
Significance, P	*NS*	*<0.001*

Formal comparisons of scion main treatment means not possible.

Table 15: Trial 3: Mean numbers of total shoots/plant (≥ 6 mm dia.) based on plants present at final grading

Rootstock	Freedom	M. Merril	R. William	Rootstock treatment mean
	Scion cultivar			
A 'Laxa'	3.41	2.43	2.86	2.90
B 'Kuiper'	3.48	2.64	2.98	3.03
C 'Inermis'	4.07	3.10	3.18	3.45
D 'Entree'	3.52	2.87	3.19	3.19
E 'Uniform'	3.93	3.31	3.24	3.49
F 'Veendam'	3.23	2.61	2.76	2.86
H 'Schmid's Ideal'	3.73	3.14	3.07	3.31
Scion treatment mean	3.62	2.87	3.04	

Comparison of:	*scion means*	*rootstock means*
SED (36df)	*0.192*	*0.111*
LSD (5%)	-	*0.23*
Significance, P	*NS*	*<0.001*

Formal comparisons of scion main treatment means not possible.

Appendix IV Final plant quality - plant grades

Table 16: Trial 2: Mean percentages of Grade 1 bushes (angle transformed data) at final grade-out based on a full plant stand (nominal 16 recorded/plot)

Rootstock	Scion cultivar Freedom	 M. Merril	 R. William	Rootstock treatment mean
A 'Laxa'	38.5	30.9	44.3	37.9
B 'Kuiper'	37.5	26.7	37.7	33.9
C 'Inermis'	48.7	36.7	48.7	44.7
D 'Entree'	40.5	28.7	36.7	35.3
E 'Uniform'	47.9	37.6	48.7	44.7
F 'Veendam'	41.5	18.5	45.0	35.0
G 'Mullan'	32.5	29.7	39.9	34.0
H 'Schmid's Ideal'	41.3	31.8	44.1	39.0
Scion treatment mean	41.0	30.1	43.1	

Comparison of:	*scion means*	*rootstock means*
SED (63df)	*5.76*	*3.33*
LSD (5%)	-	*6.7*
Significance, P	*NS*	*0.003*

Formal comparisons of scion main treatment means not possible.

Table 17: Trial 2: Mean percentage of Grade 2 bushes (angle transformed data) at final grade-out based on a full plant stand (nominal 16 recorded/plot)

	Scion cultivar			Rootstock treatment mean
Rootstock	**Freedom**	**M. Merril**	**R. William**	
A 'Laxa'	38.5	34.8	31.9	35.0
B 'Kuiper'	27.0	31.9	30.8	29.9
C 'Inermis'	25.5	33.9	27.0	28.8
D 'Entree'	27.9	32.7	40.5	33.7
E 'Uniform'	27.9	37.6	27.7	31.1
F 'Veendam'	38.7	40.5	30.3	36.5
G 'Mullan'	15.3	10.6	17.5	14.5
H 'Schmid's Ideal'	34.7	37.4	32.8	35.0
Scion treatment mean	29.4	32.4	29.8	
Comparison of:	*scion means*			*rootstock means*
SED (63df)	*5.44*			*3.14*
LSD (5%)	-			
Significance, P	*NS*			*<0.001*

Formal comparisons of scion main treatment means not possible.

Table 18: Trial 2: Mean percentage of marketable (Grades 1 + 2) bushes (angle transformed data) at final grade-out based on a full plant stand (nominal 16 recorded/plot)

Rootstock	Freedom	M. Merril	R. William	Rootstock treatment mean
		Scion cultivar		
A 'Laxa'	62.3	50.5	61.8	58.2
B 'Kuiper'	50.5	44.3	54.3	49.7
C 'Inermis'	60.6	55.5	62.3	59.5
D 'Entree'	53.4	47.2	62.6	54.4
E 'Uniform'	62.7	60.1	62.7	61.8
F 'Veendam'	66.4	48.6	62.1	59.0
G 'Mullan'	38.2	32.7	48.4	39.8
H 'Schmid's Ideal'	66.7	54.4	67.0	62.7
Scion treatment mean	57.6	49.2	60.1	

Comparison of:	*scion means*	*rootstock means*
SED (63df)	*6.60*	*3.81*
LSD (5%)	-	*7.6*
Significance, P	*NS*	*<0.001*

Formal comparisons of scion main treatment means not possible.

Table 19: Trial 3: Mean percentage of Grade 1 bushes (angle transformed data) at final grade-out based on a full plant stand (nominal 16 recorded/plot)

	Scion cultivar			Rootstock treatment
Rootstock	**Freedom**	**M. Merril**	**R. William**	**mean**
A 'Laxa'	61.0	37.6	47.8	48.8
B 'Kuiper'	61.5	33.1	45.4	46.7
C 'Inermis'	62.7	51.8	45.6	53.4
D 'Entree'	50.8	40.5	48.2	46.5
E 'Uniform'	61.7	52.9	51.4	55.3
F 'Veendam'	60.0	45.2	47.5	50.9
H 'Schmid's Ideal'	59.0	55.6	57.9	57.5
Scion treatment mean	59.5	45.2	49.1	

Comparison of:	*scion means*	*rootstock means*
SED (36df)	*4.85*	*2.80*
LSD (5%)	*9.8*	*5.7*
Significance, P	*0.029*	*0.001*

Formal comparisons of scion main treatment means not possible.

Table 20: Trial 3: Mean percentage of Grade 2 bushes (angle transformed data) at final grade-out based on a full plant stand (nominal 16 recorded/plot)

	Scion cultivar			
Rootstock	**Freedom**	**M. Merril**	**R. William**	**Rootstock treatment mean**
A 'Laxa'	22.5	32.8	34.6	30.0
B 'Kuiper'	24.9	43.3	21.4	29.9
C 'Inermis'	21.5	19.7	20.2	20.4
D 'Entree'	26.5	33.2	24.0	27.9
E 'Uniform'	24.3	20.1	23.2	22.5
F 'Veendam'	28.2	34.3	30.7	31.1
H 'Schmid's Ideal'	20.0	26.6	21.3	22.6
Scion treatment mean	24.0	30.0	25.0	

Comparison of:	*scion means*	*rootstock means*
SED (36df)	*4.59*	*2.65*
LSD (5%)	*9.3*	*5.4*
Significance, P	*0.016*	*<0.001*

Formal comparisons of scion main treatment means not possible.

Table 21: Trial 3: **Mean percentage of marketable (Grades 1 + 2) bushes (angle transformed data) at final grade-out based on a full plant stand (nominal 16 recorded/plot)**

	Scion cultivar			
Rootstock	**Freedom**	**M. Merril**	**R. William**	**Rootstock treatment mean**
A 'Laxa'	75.6	55.3	72.6	67.8
B 'Kuiper'	79.6	61.7	53.4	64.9
C 'Inermis'	78.0	59.5	52.1	63.2
D 'Entree'	63.6	58.6	59.3	60.5
E 'Uniform'	80.8	63.4	61.6	68.6
F 'Veendam'	84.3	65.3	64.4	71.3
H 'Schmid's Ideal'	70.2	70.4	68.3	69.6
Scion treatment mean	76.0	62.0	61.7	

Comparison of:	*scion means*	*rootstock means*
SED (36df)	*5.52*	*3.19*
LSD (5%)	*11.2*	*6.5*
Significance, P	*0.008*	*0.020*

Formal comparisons of scion main treatment means not possible.

Appendix V **Copy of contract**

Contract between BSHR (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

PROPOSAL

1. TITLE OF PROJECT: Contract No: HNS 6a

CLONAL ROOTSTOCKS FOR TREES AND ROSES TO IMPROVE QUALITY AND QUANTITY OF PRODUCTION

2. BACKGROUND AND COMMERCIAL OBJECTIVE:

A significant proportion of the £100 million FGV derived from field production in the Nursery Stock Sector involves bud-grafting. The rootstock has an important role in determining quality and quantity of production, which in turn influences marketable yield. Clonal rootstocks also offer the opportunity to screen for resistance to soil-borne diseases (such as Verticillium wilt), for compatibility with the scion, and for effects on size and flowering, the last of relevance to open ground and containerised production. Most progress on this topic has been made to date with fruit trees, and the uptake of the rootstock Colt for flowering cherries is an example of the benefits that can derive from this work. The objective is to develop similar benefits in important groups of hardy nursery stock trees and shrubs, especially roses.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY:

Successful introduction of clonal rootstocks will increase the uniformity of nursery production and remove the variation introduced by seedling rootstocks in terms of responses to budding and other processes. Realistically, it will only be possible to address this opportunity for a few key species and complementary work to upgrade the performance of seedling populations is also required (see HNS 7a - budding). The extent to which implementation of clonal rootstocks will be cost-effective will depend on acceptance of the long-term nature of this type of work, and the need for industry to absorb the relatively small increase in the cost of clonal rootstocks compared to seedlings, set against the clear rewards.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK:

Ways need to be found of identifying naturally occurring genotypes with useful rootstock characteristics (clean stems, prolific cutting production) and developing screening methods based on current technology for other essential characteristics (propagation, compatibility, growth control, disease resistance). There may be advantages in identifying unrelated provenances and/or carrying out controlled crosses if parents with desirable features can be identified.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS:

Resume of work in HNS 6, 1987-1990: The HDC-funded project to compare ten sources of clonally produced standard rose rootstocks was described to nurserymen at Luddington EHS in July 1989. Rosa rugosa clones were less vigorous and had poorer bud-take than other selections. While there were no outstanding selections 'Harwhippet'. 'Kiese' and 'De La Grifferiae' showed promise and evaluation will continue. Rootstock material has now been transferred to Efford EHS. A herbicide evaluation trial was also undertaken at Luddington of budded varieties on Rosa laxa rootstocks.

At East Malling a previously MAFF funded project has developed clonal rootstocks for Tilia spp. and is making progress with Acer platanoides. This work, previously co-ordinated with complementary work at Luddington EHS, will not be funded by MAFF from 1981-2 and there is the need for HDC to take over its support.

Strategic studies:

The essential and complementary strategic studies will be in place at East Malling to devise techniques to create new varieties and rootstocks for HNS. This is likely to be based on tissue culture and breeding systems aimed at the methodology rather than the actual production of rootstocks, and disease resistance is included in the objectives.

It is unlikely that in the HDC programme all desirable characters will be combined in one genotype from a nature source. In this case, the product will be introduced into the strategic programme for refining.

6. DESCRIPTION OF THE WORK:

A co-ordinated East Malling-Efford approach will be undertaken. Regular reviews will address the balance of rose and tree work between sites, and with respect to funding within each site.

East Malling - Initially to work on all non-fireblight susceptible trees:-

a) Continue to develop and screen current selections of Tilia spp. and Acer platanoides, and test commercially.

b) Liaise with pathologists to effect screening for Verticillium wilt via HNS 29.

c) Develop cost-effective screening for rootstocks of other genera.

d) Liaise with HNS 7a to develop the complementary approach of upgrading seedling populations as an interim stage towards clonal rootstocks.

<u>Efford</u> - Initially to work on roses and fireblight susceptible trees, with the likelihood of diverting most funding to roses:-

a) Complete existing programmes to select rose clonal standard stems ex Luddington.

b) Propagate selected clones by summer cuttings to provide self-rooted stocks for comparison with grafted stems. (East Malling facilities will be used if winter cuttings are attempted).

c) Screen new selections of bush rose rootstocks to find replacements for Rosa laxa with respect to improved resistance to rose rust and winter cold.

d) Seek replacements for herbicides such as Clout (being withdrawn), triazine-based materials (environmental concerns) and simazine (resistant groundsel). (East Malling work in HNS 7a on improved rose budding will be relevant to the rose programme at Efford).

7. COMMENCEMENT DATE AND DURATION:

Efford	01-04-90 for 3 years
East Malling	01-01-91 for 3 years

8. STAFF RESPONSIBILITIES:

Efford	C M Burgess
East Malling	B H Howard

9 LOCATION:

BSHR, East Malling and Efford sites.