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STOCK AND SCION INVESTIGATIONS. XV. TWENTY-SIX-YEAR-OLD APPLE ROOTSTOCK TRIAL

By L. A. THOMAS, M.Sc.

SUMMARY

At the termination of a 26-year-old rootstock trial with Jonathan and Granny Smith apples, stock effect on tree vigour in both scion varieties was in the following order:— M.XII, M.XVI, Pomme de Neige Seedling and Northern Spy. Jonathan trees on M.I. proved unthrifty under the non-irrigated conditions.

The order for stock effect for accumulated cropping at 26 years was for Jonathan: M.XVI, M.XII, Pomme de Neige Seedling, Northern Spy and M.I; and for Granny Smith: M.XVI, M.XII, Northern Spy and Pomme de Neige Seedling. Accumulated yields for both Granny Smith and Jonathan were less on rootstock M.XVI than on M.XII during the first 21 years.

The influence of stock on the weight of scion portions of the trees at 26 years was the same as that for girth measurements. The ratios total crop/weight of scion and total crop/unit area of trunk cross-section were greater in trees on rootstocks M.II and Northern Spy than in trees on M.XVI or M.XII.

Applied phosphorus increased both tree growth and accumulated crop. Applied potassium increased cropping only. No significant rootstock x fertilizer interactions were recorded.

I. INTRODUCTION

Thomas (1953) reported on the growth and cropping behaviour of Jonathan and Granny Smith apple trees in this Queensland trial during the first 12 years after they were grafted onto seedling and clonal rootstocks in 1938. The trial terminated in the winter of 1964 when the pattern of growth and cropping had been evident for some time. This paper gives a final assessment of the various rootstock/scion combinations and the effects of certain fertilizer mixtures on tree growth and yield in the variety Jonathan.

II. MATERIALS AND METHODS

Layout.—The trial comprised six blocks each of which contained five rows of Jonathan trees with single-tree plots randomized for the rootstocks M.I, M.XII, M.XVI, Northern Spy and Pomme de Neige Seedling, alternating with five rows of Granny Smith on M.XII, M.XVI, Northern Spy and Pomme de Neige Seedling also randomized for stock type.

The internal guard trees consisted of Jonathan on French Crab Seedling and Granny Smith on M.II and root-grafted M.XIII, sufficiently randomized for statistical analysis. The external guard trees were Jonathan on M.II and Granny Smith on M.XIII root-grafts.

Fertilizer treatments.—The five Jonathan plots in each of the six blocks were used to test the effects of fertilizer mixtures containing sulphate of ammonia, superphosphate and muriate of potash. The composition of these mixtures is given below as lb per tree of each ingredient in the order N, P. K.

Mixture 1	2 : 2 : 1	
2	4 : 2 : 1	
3	2 : 2 : 2	plus 2 : 0 : 0 after fruit set
4	2 : 2 : 2	
5	2 : 0 : 2	

Up to 1948, the rate of fertilizer application per tree was that indicated by the composition of the mixture in lb weight; thereafter the rate was increased by half. Dolomite at 1 ton per acre was applied in 1947 and pulverized lime at the rate of 1 ton per acre in 1955 and again in 1958. A mixture made up of three parts of superphosphate and one part of sulphate of ammonia was applied at the rate of 1¼ cwt/ac each year in autumn over all plots to establish a green manure crop.

Management of the trees.—The vase-shaped trees were regularly pruned in winter to maintain the production of extension growth on both leaders and laterals. Possible deficiencies of copper, zinc and boron were prevented by applying the appropriate foliage sprays. Pests and diseases which could affect tree growth and cropping were satisfactorily controlled.

All experimental trees were grown without supplementary irrigation.

Scion weight.—The unpruned scion portion of each tree was sawn off at the union with the rootstock in the winter of 1964 and weighed.

III. RESULTS

Losses in experimental trees.—During the course of the trial, more Jonathan trees than Granny Smith trees died (Table 1). Losses of young trees were due to pin-hole borer attack, "sour-sap" (which is thought to be the result of chilling injury), and unspecified causes. Losses in older trees were mainly due to drought injury following very dry weather in 1954 and 1957.

TABLE 1

NUMBER OF TREES AND AGE AT DEATH IN 0–26 YEARS AFTER PLANTING

Rootstock	Scion Variety					
	Jonathan			Granny Smith		
	0–5	6–20	21–26	0–5	6–20	21–26
M.I	5	2	8	—	—	—
M.II	1	1	0	0	0	0
M.XII	0	0	1	0	0	0
M.XVI	3	0	0	0	0	0
Pomme de Neige Seedling	5	2	1	1	0	1
French Crab Seedling ..	0	0	0	—	—	—
Northern Spy	0	0	0	0	0	1

Tree growth as determined from trunk girth measurements.—The girth measurements for 1963 are presented in Table 2, which also includes the girth data for trees in the internal and external guard rows.

TABLE 2

MEAN TRUNK GIRTH (CM) IN 1963

Rootstock	Scion Variety	
	Jonathan	Granny Smith
M.XII	58·67	58·57
M.XVI	55·04	53·42
Pomme de Neige Seedling ..	53·55	48·97
Northern Spy	41·57	43·45
M.I	37·85	—
M.XIII	—	†2·35
French Crab Seedling	58·47	—
M.II	52·45	51·14

Significance:—

For Jonathan trees on M.I, M.XII, M.XVI, Pomme de Neige Seedling and Northern Spy: 5%, 3·30; 1%, 4·38.

For Granny Smith on M.II, M.XII, M.XVI, M.XIII, Pomme de Neige Seedling and Northern Spy: 5%, 3·53; 1%, 4·65.

Rootstocks effects on the growth of both scion varieties were consistent with trees on M.XII exhibiting the greatest vigour and those on Northern Spy the least vigour. This result was already evident in the twelfth year of the trial (Thomas 1953). Rootstock M.I gave a poor performance with Jonathan. Jonathan trees on French Crab Seedling outgrew those on Pomme de Neige Seedling. Both Jonathan and Granny Smith trees grew larger on M.II than on the semi-dwarfing Northern Spy rootstock.

Cropping behaviour.—The accumulated crop on both scion varieties for selected periods is given in Table 3.

TABLE 3

ACCUMULATED CROPPING (LB PER TREE)

Rootstock	Scion Variety: Jonathan			Rootstock	Scion Variety: Granny Smith		
	to 1950	1959	1964		to 1950	1959	1964
M.XII	734·5	1,961	3,184	M.XII	645·5	1,653	2,857
M.XVI	624·6	1,795	3,216	M.XVI	621·9	1,664	3,025
Northern Spy ..	573·2	1,460	2,424	Northern Spy ..	723·0	1,702	2,754
Pomme de Neige Seedling	532·2	1,544	2,798	Pomme de Neige Seedling	476·6	1,363	2,495
M.I	485·5	1,012	1,533	M.II	787·0	2,102	3,299
French Crab Seedling	434·0	1,603	3,069	M.XIII	320·5	920	1,682
M.II	562·1	1,662	2,874				

Significance:—

For Jonathan on M.XII, M.XVI, Northern Spy, and Pomme de Neige Seedling: 5%, 424 lb; 1%, 561 lb.

For Granny Smith on M.XII, M.XVI, Northern Spy, Pomme de Neige Seedling, M.II and M.XIII: 5%, 438 lb; 1%, 578 lb.

Jonathan trees on the very vigorous rootstocks M.XVI and M.XII produced the greatest total crop. Granny Smith on M.XVI was outyielded only by trees of M.II, a rootstock which is capable of producing heavy crops with other scion varieties such as Cox's Orange Pippin (Preston 1958*b*).

In both scion varieties, trees on Pomme de Neige Seedling had a relatively poor cropping record in relation to tree size. Compared with trees on M.XVI and M.XII, those on Northern Spy stock gave a relatively heavier crop with Granny Smith than with Jonathan. Root-grafted Granny Smith trees on M.XIII yielded about half the crop harvested from trees on M.II and gave the poorest performance of all rootstocks with the scion variety.

Tree growth as determined by scion weight.—Scion weight data for selected stock/scion combinations are given in Table 4. The weight of the scion portion of the tree at the end of the trial showed the same relative order for stock-induced vigour as that indicated by trunk girth measurements, namely M.XII, M.XVI, Pomme de Neige Seedling and Northern Spy. Jonathan scion weights exceeded those for Granny Smith irrespective of rootstock type.

TABLE 4

SCION WEIGHT (LB), 1964

Rootstock	Scion Variety	
	Jonathan	Granny Smith
M.XII	242·3	229·8
M.XVI	223·2	200·3
Pomme de Neige Seedling ..	187·1	166·6
Northern Spy	122·0	116·2
M.II	—	155·8
French Crab Seedling	229·2	—

Significance:—

For Jonathan: 5%, 36·8 lb; 1%, 48·7 lb.

For Granny Smith: 5%, 32·4 lb; 1%, 42·8 lb.

Relation between growth and cropping.—The ratio for crop/area of trunk cross-section gives an indication of the fruitfulness of the variety. Only occasionally (Preston 1958*a*) have long-term experiments provided data from which the ratio for scion weight/total crop can be calculated. In Table 5, data are presented for both ratios.

TABLE 5

RELATION BETWEEN GROWTH AND CROPPING

Rootstock	Scion Variety			
	Jonathan		Granny Smith	
	R_1*	R_2†	R_1	R_2
Northern Spy	16·94	20·19	17·72	24·42
M.XVI	12·61	14·58	12·67	15·21
Pomme de Neige Seedling ..	11·83	15·74	11·31	17·59
M.XII	11·05	13·46	10·00	12·58
M.II	—	—	15·48	21·99
M.XIII	—	—	10·95	—
French Crab Seedling	10·80	13·91	—	—

Significance:—

For Jonathan: R_1 (5%, 0·85; 1%, 1·13): R_2 (5%, 1·17; 1%, 1·54).

For Granny Smith: R_1 (5%, 1·01; 1%, 1·34); R_2 (5%, 1·90; 1%, 2·51).

* $R_1 = \frac{\text{Crop (lb)}}{\text{Trunk Cross Section (sq cm)}}$

† $R_2 = \frac{\text{Crop (lb)}}{\text{Scion Weight (lb)}}$

The order for the ratios of crop/area of trunk cross-section are much the same for both scion varieties; the reversed position of M.XVI rootstock as compared with Pomme de Neige Seedling is possibly due to its high rate of wood growth.

Of the four rootstocks common to Jonathan and Granny Smith, Northern Spy gave the most fruitful trees and M.XII the least fruitful.

Effect of fertilizer treatments on growth and cropping.—The data for accumulated yields and for trunk girths at 1964 in the several fertilizer treatments applied to the variety Jonathan are presented in Tables 6 and 7. The surviving Jonathan trees on M.I and Pomme de Neige Seedling were too few at that time for statistical analyses and only the results for trees on M.XII, M.XVI and Northern Spy were analysed.

No interactions between rootstocks and fertilizer treatments were recorded for either yield or growth.

TABLE 6

EFFECT OF FERTILIZER ON ACCUMULATED CROP (LB) OF JONATHAN TREES

Rootstock	Fertilizer					Mean
	2/2/1*	4/2/1	2/2/1 plus 2/0/0	2/2/2	2/0/2	
M.XII	3,688	2,986	2,867	3,765	2,648	3,191
M.XVI	3,485	2,777	3,204	3,626	2,909	3,200
Northern Spy	2,524	2,262	2,407	2,904	2,025	2,424
Mean	3,232	2,675	2,826	3,432	2,527	2,938

Significance:—

	5%	1%
Fertilizers ..	.. 445	607
Rootstocks	.. 259	346

* Sulphate of ammonia/superphosphate/muriate of potash in lb per tree per annum. Rates increased by 50% after 1948.

TABLE 7

EFFECT OF FERTILIZER MIXTURES ON TREE GIRTH (CM) IN JONATHAN

Rootstock	Fertilizer					Mean
	2/2/1*	4/2/1	2/2/1 plus 2/0/0	2/2/2	2/0/2	
M.XII	62·3	58·8	58·0	64·3	55·2	59·7
M.XVI	57·1	54·0	57·3	59·6	52·7	56·1
Northern Spy	43·1	41·0	42·6	45·0	39·4	42·2
Mean	54·2	51·3	52·6	56·3	49·1	52·7

Significance:—

	5%	1%
Fertilizers ..	.. 3·4	4·6
Rootstocks	.. 2·1	2·8

* Sulphate of ammonia/superphosphate/muriate of potash in lb per tree per annum. Rates increased by 50% after 1948.

The low yields from trees receiving no phosphorus in spring (treatment 5) confirm the earlier finding of Thomas (1953). These were matched by a corresponding reduction in tree growth irrespective of rootstock.

Trees receiving fertilizer containing high levels of potash (treatment 4) were more productive than those receiving high-nitrogen mixtures (treatments 2 and 3) applied either as a single dressing or as a split dressing. Trunk girths were also larger in the high-potash plots.

IV. DISCUSSION

The vigour characteristics of different scion varieties propagated on a range of East Malling rootstocks in England (Preston 1958*a*, 1958*b*) are similar to those in New Zealand (Mouat 1953; Woodhead 1954) and in Australia (Thomas 1953).

The poor performance of Jonathan on M.I reported for Stanthorpe is in line with the finding of Preston (1958) that, in England, "trees on M.I have shown themselves to be intolerant of shallow soils and drought conditions". Similarly, the poor crop on Granny Smith trees on M.XIII in this trial is in agreement with the results of Dorey (1949), who stated that this stock is unsuited to shallow soils.

The English trials reported by Preston (1958*a*, 1958*b*) with Cox's Orange Pippin and Lane's Prince Albert include two of the rootstocks used at Stanthorpe. The ratios for total crop/tree weight recorded for these varieties are much lower than those for Jonathan and Granny Smith in the Queensland trial. On rootstock M.XVI, the ratios are:—*England*: Cox's 4.7; Lane's 1.8; *Queensland*: Jonathan 12.6, Granny Smith 12.7. These differences may be due to climatic factors; high light intensity during summer and autumn in Queensland may be associated with greater fruitfulness.

Evidence that light influences fruitfulness and growth was given by Gorter (1965), who showed that apple trees subjected to less than the normal day length produced fewer flower buds. Similarly, with low light, there is a reduction in dry weight increment (Maggs 1960) and a marked decrease in net assimilation rate (Heinicke 1966). By contrast, trees receiving supplementary fluorescent light made more growth and produced more spurs (Stahly and Piringer 1962).

As Priestley (1964) showed that from one-third to one-half of the annual root growth may be produced in autumn, it is possible that high light intensities during this period result in a greater accumulation of nutrient reserves in the tree.

Evidence that added phosphorus increased yields in Sturmer Pippin apple trees is given by Tiller (1959). The benefits of high-potash fertilizers have been demonstrated by Baxter (1957) in southern Victoria, where increased yields were obtained with the variety Jonathan.

The adverse effects on yield of high levels of applied sulphate of ammonia are confirmed by the findings of Baxter (1957), who obtained less crop from trees given 4 lb sulphate of ammonia alone than from trees receiving a 2:2:1 mixture containing 2 lb sulphate of ammonia.

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The author, now retired, conducted the work reported here while an officer of the Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, and, later, of the Division of Plant Industry, Queensland Department of Primary Industries, which took over the stock-scion investigations at Applethorpe.