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Variation in Leaf Calcium in a Range of Apple Rootstocks

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Abstract

Forty-nine apple rootstocks were analysed for leaf calcium over 6 years. They showed marked differences in consistency of calcium levels over years. The results are discussed in relation to breeding and selection of improved genotypes.

It has long been established that calcium nutrition and storage disorders of apples are related (1). More recently the subject of calcium nutrition in fruit trees has been reviewed by Vang-Petersen (10) who suggests that the concentration of calcium in the soil seldom limits uptake by roots. The view is largely supported Shear (5). Kennedy, et al. (4) have shown that the ability of apple rootstocks to utilise the available calcium is strongly influenced by genotype and environmental conditions.

Additional Index Words. Apple rootstocks, leaf calcium, genetic variation, year to year environmental variation, breeding.

Since the environmental influence on calcium uptake can be important, its effects on selection of new rootstocks must be investigated. Improved genotypes must not only show increased average calcium levels but also a minimum year to year variation. The purpose of this investigation was to examine the pattern of variation in a population of breeding material tested in a single plot under common management over six years and to assess the effect of year to year environmental variation on particular genotypes.

The trees examined were 49 rootstocks, the identity and parentage of which are shown in the results tables. They may be classified into three broad groups. Firstly a group that has M.9 as a common parent (7). Secondly a group with 'Northern Spy' as a common parent (8). The third group is very heterogeneous comprising the genotypes of unknown parentage which consist of the so-called "Paradise" stocks of Hatton (2) described along with M.18-M.24 and Crab C by Tydeman (9). Also included in this group are 4 more recent acquisitions from Europe (R80, Alnarp 2) and Canada (Robusta 5A, Robusta 5J). The Robusta trees are morphologically very different from the others of this group.

For 6 successive years leaves were sampled in mid-August and the calcium concentration, as percent dry weight of leaf, measured by the standard chemical procedures developed at East Malling Research Station.

Observations in successive years from the same trees provide an indication of consistency over years.

A variance over years was calculated for each genotype. Bartlett Test (6 p. 296) showed these variances to be heterogenous (P 0.005). Since this test is very sensitive to "non-normality in the data a coefficient of variation (CV) was calculated for each tree as a measure of its consistency over years as

$$CV = \frac{(\text{Var (Years)})^{\frac{1}{2}}}{\text{Mean over Years}}$$

The CV values were transformed to approximately constant variance as follows. Since the variance of CV (Var(CV)) is related to its theoretical value V by

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$$\text{Var (CV) OC } V^2 (1 + 2V^2)$$

for normally distributed data (3) the appropriate variance-stabilizing transformation (6 p. 325) is

$$Q = \log \frac{u - 1}{u + 1}$$

$$\text{where } u = (1 + +2(CV)^2)^{\frac{1}{2}}$$

An analysis of variance of the Q values showed significant between genotype variation when tested against that within genotype (P 0.025). Thus there are real differences in consistency over years as measured by the CV values. Mean CV values over replicates ranged from 27.0% for M.26 to 3.9% for MM.111.

The genotypes have been classed according to their CV value as consistent, semi-consistent and inconsistent. The results for these are shown in Tables 1, 2 and 3, respectively. Table 4 summarises the results for the genotypes grouped by parentage.

Members of each parentage group occur in all three consistency classes. However, the "Paradise" group tend to have highest calcium levels, the M.9 group an intermediate level, and the 'Northern Spy' group share low calcium levels with 'Northern Spy' itself. The lowest levels of calcium are consistently found in MM.111, an important commercial rootstock, which has 'Northern Spy' both as parent and as grandparent. M.25 is a notable exception in the 'Northern Spy' group with a very high calcium level.

The genotype showing the greatest inconsistency over years is M.26 (an important rootstock in many countries). This confirms many verbal reports, received by one of the authors (RW), that M.26 can give very erratic orchard performance in some circumstances.

These data suggest that breeding for improved calcium uptake with consistency over years could prove successful. Studies of progenies from controlled crosses are in progress to investigate further the inheritance of these characters.

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Table 1. Consistent genotypes with coefficient of variation (CV) values less than 10%, ranked for leaf calcium content.

Rootstock	Parentage where known	Mean calcium content (% dry wt.) for 1971-1976	CV. (%)
M.8		1.79	6.1
M.19		1.68	6.3
M.4		1.62	6.6
M.9A		1.54	9.1
M.21		1.51	6.9
M.15		1.47	9.8
3430	M.12 × M.9	1.45	9.5
3426	M.7 × M.9	1.36	6.2
3428	M.9 × M.7	1.25	9.6
MM.109	M.2 × Northern Spy	1.20	9.0
MM.110	Northern Spy × M.1	1.18	9.9
M.13		1.09	5.7
Alnarp 2		1.08	8.9
Crab C		1.02	9.4
MM.101	Northern Spy × M.1	0.97	9.0
MM.111	Northern Spy × M.793[z]	0.80	3.9

[z]M.793 parentage = Northern Spy × M.2.

Table 2. Semi-consistent genotypes with coefficient of variation (CV) values ranging from 10-14.5%, ranked for calcium content.

Rootstock	Parentage where known	Mean calcium content (% dry wt.) for 1971-1976	CV. (%)
M.7		1.45	13.7
M.6		1.45	11.2
M.11		1.41	14.1
M.10		1.39	11.0
M.24		1.29	11.3
M.2		1.24	10.5
M.12		1.23	10.1
3438	M.9 × M.12	1.19	10.4
M.9 EMLA[z]		1.19	12.8
M.18		1.16	10.7
MM.115	Northern Spy × Ben Davis	1.12	13.0
MM.112	Northern Spy × Winter Majetin	1.12	12.4
MM.102	Northern Spy × M.1	1.11	12.8
MM.104	M.2 × Northern Spy	1.10	14.3
M.13 (4X)		0.89	13.8
Northern Spy		0.89	12.7

[z]EMLA is the name given to virus free clones.

Table 3. Inconsistent genotypes with coefficient of variation (CV) values greater than 14.5%, ranked for calcium content.

Rootstock	Parentage where known	Mean calcium content (% dry wt.) for 1971-1976	CV. (%)
M.25	Northern Spy × M.2	1.58	14.7
Robusta 5J		1.50	20.1
M.1		1.49	15.7
R.80		1.48	17.9
Robusta 5A		1.46	24.5
M.3		1.39	24.6
M.20		1.37	20.5
M.27	M.13 × M.9	1.25	17.0
MM.106	Northern Spy × M.1	1.23	14.7
M.14		1.19	18.3
M.5		1.14	21.2
MM.105	M.2 × Northern Spy	1.10	21.7
M.793	Northern Spy × M.2	1.09	21.4
M.16		1.08	15.1
MM.113	Northern Spy × M.12	1.07	15.1
M.26	M.16 × M.9	1.06	27.0
M.789	Northern Spy × M.2	0.92	20.9

Table 4. Mean calcium levels (% dry wt.) in three groups of genotypes.

	$\bar{X}$	S.E.	CV (%)	Number in group
Miscellaneous and "Paradise" group	1.34	0.22	16.2	26
M.9 group	1.29	0.15	12.1	8
Northern Spy group	1.09	0.18	16.3	15

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Trends and Geographic Shifts in the Georgia Apple Industry

E. E. HUBBARD AND J. C. PURCELL
GA Agr. Exp. Station Research Rept. 488, 1985

In 1973 south Georgia accounted for 61% of the apple trees compared to 39% in north GA. High night time temperatures in south GA prevented development of the desired shape and color and this coupled with increased pressure from other regions led to a decline in production in south GA. Currently north GA has regained priority as the leading production region. Nearly 77% of GA's apple trees are 'Delicious' and 'Golden Delicious.'

Outlook for 'Granny Smith' Apples in Washington State

A. D. O'ROURKE
WA State University, Res. Bul. 0971, 1986

'Granny Smith' apple represented only 2% of the volume of WA fresh shipment in 1984, but at the present rate of planting, it could make up 8% by 2000. 'Granny Smith' accounted for about 2.5% of world apple production but 10% of world apple exports. Since 1981 mid-size, extra fancy 'Grannys' have earned a premium of $6-8 per box over comparable 'Delicious' and 'Golden Delicious.' It is expected that 'Granny Smith' is likely to have a continuing, although declining, premium over 'Delicious' in most years until the year 2000. As volume increases, direct competition with imports will become more frequent.

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I certify that the statements made by me above are correct and complete. L. D. Tukey, Business Manager. September 19, 1985.