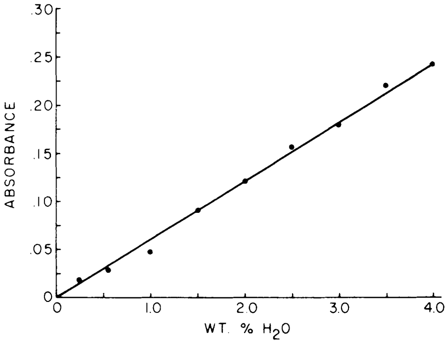

Fig. 2. Standard curve for absorbance versus wt % water in methanol as determined by NIRS at 1440 nm.

Nine samples of walnut seeds containing a range of moisture levels were divided into 2 lots each. One lot was analyzed by NIRS, the other with the CMB. There was close agreement between the % H_2O found by NIRS and that found by the CMB method (Table 2). The differences reflect errors in calculating % H_2O in the methanol extracts from the regression equation $Y = 0.003 + 0.0607 X$, predicted values for absorbance from % H_2O in the standards being both higher and lower than the observed results. Furthermore, the relationship between X and Y may be curvilinear when the range of X is extended. Thus, a small error is introduced by assuming a straight line within the limits of the X values used.

The NIRS method is rapid, and repeatable results are easily obtained. At least twice as many samples can be analyzed per unit time with NIRS as with the CMB procedure. With NIRS the limiting factor is the initial grinding-extraction. Time could be saved by utilizing several blenders.

Table 2. Percent water found in duplicate lots of walnut seeds as determined by NIRS vs. CMB.

	Lot								
Method	1	2	3	4	5	6	7	8	9
NIRS	2.0	2.3	3.6	4.0	10.9	18.9	25.4	29.3	29.5
CMB	2.2	2.4	2.6	3.0	10.5	18.7	25.6	29.3	29.1

Literature Cited

1. Bowers, S. A. and S. J. Smith. 1970. Spectrophotometric determination of soil water content. *Soil Sci. Soc. Amer. Proc.* 36:978-980.
2. Hart, J. R., K. H. Norris, and C. Golumbic. 1962. Determination of the moisture content of seed by near-infrared spectrophotometry of their methanol extracts. *Cereal Chem.* 39:24-99.
3. Keyworth, D. A. 1961. Determination of water by near-infrared spectrophotometry. *Talanta* 8:461-469.

HortScience 11(5):496–498. 1976.

Yield, Fruit Size, and Chlorosis of Grapefruit on 10 Rootstocks[1]

Norman P. Maxwell[2] **and Heinz K. Wutscher**[3]

Texas A&M University Agricultural Research and Extension Center, Weslaco, TX 78596

Additional index words. Citrus paradisi, foot rot, calcareous soil

Abstract. **Grapefruit trees (*Citrus paradisi* Macf.) budded on Karna Khatta and sour orange were most productive in a test including 10 rootstocks. Karna Khatta, sour orange, and Yuzu were tolerant, 'Orlando' tangelo and 'Ortanique' tangor were intolerant of calcareous soil. Trees on Karna Khatta were more susceptible to foot rot than trees on sour orange.**

The performance of 9 citrus species and hybrids as rootstocks for grapefruit was compared with sour orange, the standard rootstock used in commercial groves in southern Texas as part of a series of tests (2, 7, 9). One long-term and 2 short-term tests were conducted between 1963 and 1974. Nucellar CES #3 'Redblush' grapefruit was budded in a nursery in 1962 for the long-term and 1 short-term test on sour orange, (*C. aurantium* (L.); 'Ortanique' [probable hybrid of *C. sinensis* (L.) Osbeck × *C. reticulata* Blanco]; 'Scarlet Emperor', 'Soh Siem', and 'Sanguinea' mandarins (*C. reticulata* Blanco); 'Orlando' tangelo (*C. paradisi* × *C. reticulata*); Assam lemon [*C. limon* (L.) Burm. f.]; Karna Khatta (probable hybrid of rough lemon, *C. jambhiri* Lush.); Yuzu (putative *C. ichangensis* × *C. reticulata* var. *austera* hybrid); and C58-229 [Rangpur lime (*C. reticulata* var. *austera* hyb.?) × Troyer citrange (*Poncirus trifoliata* (L.) Raf. × *C. sinensis*)]. Karna Khatta and sour orange seedlings in pots (15 cm diam with a 2 soil:1 peat:1 perlite mixture) were budded in 1968 with nucellar CES #3 'Redblush' and old-line 'Webb Redblush' grapefruit; 'Valencia' sweet orange, *C. sinensis* (L.) Osbeck; and 'Fairchild' mandarin hybrid [*C. reticulata* × (*C. reticulata*)] for the second short-term test.

Trees budded in 1962 were planted in the field at 2 sites in Feb. 1963. Six trees of each of the 10 rootstock-scion combinations were planted at Weslaco, Texas, on deep, sandy loam soil (pH 7.3, EC of saturation extract 0.37 millimhos/cm) in a randomized complete block design, with single-tree plots and 4.7 × 7.6 m spacing for the long-term performance test. A short-term test for chlorosis with an equal no. of trees, except for the C 58-229 rootstock where only 3 trees were used, was planted at the same time at Monte Alto, Texas, on calcareous, sandy loam soil containing 5% $CaCO_3$ in the top 30 cm, and 20% $CaCO_3$ at the 1 m-level (pH 8.2, EC of saturation extract 0.73 millimhos/cm). Spacing and design were the same as at Weslaco.

The second short-term test, 8 single-tree replications of 4 scion cultivars on Karna Khatta and sour orange rootstock, was planted in 1969 on sandy, loam soil (pH 7.2, EC of saturation extract 1.25 millimhos/cm) at Monte Alto. Design, spacing, and grove care were as in the other tests. Grove care included 3 to 4 insecticide sprays, 4 to 7 irrigations with Rio Grande River water (700–1,200 ppm total salts), and 1 application of 150 kg/ha of N per year.

Most of the trees in the first short-term chlorosis test on calcerous soil at Monte Alto were removed 18 months after planting. Trunk circumferences were determined and trees were rated for chlorosis (Table 1). Only 2 of 6 trees on 'Orlando' rootstock survived and they were severely chlorotic. Trees on 'Ortanique' and 'Sanguinea' were also chlorosis-prone. Trees on sour orange, Karna Khatta, and Yuzu were only mildly chlorotic. The largest trees were on Karna Khatta and sour orange rootstocks, the smallest on 'Sanguinea' and 'Ortanique'.

Three trees on some rootstocks were left in the test plot. A 30-fruit sample was collected from trees on sour orange and Karna Khatta in Feb. 1968 when they were 6 years old. Fruit circumference was 33.3 cm; fruit wt 490 g; rind thickness 6.4 mm; juice content 55.1%; total soluble solids 9.1%; total acids 1.02%; and Brix-acid ratio 8.91 for trees on sour orange rootstock. Values for trees on Karna Khatta were

[1]Received for publication February 9, 1976.

[2]Associate Professor, Texas Agricultural Experiment Station, Weslaco, Texas.

[3]Research Horticulturist; present address: U. S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, Florida 32803.
The authors gratefully acknowledge the support of Rio Farms, Inc., Monte Alto, Texas, with land, labor, grove care and technical help for part of the work on which this report is based.

Table 1. Trunk cross sectional area and chlorosis rating after 18 months of grapefruit trees on 10 rootstocks on calcareous soil at Monte Alto.

Rootstock	Trunk cross sectional area (cm^2)	Chlorosis rating[z]
Sour orange	26.7ab[x]	1.5c
Ortanique	8.6d	4.2a
Scarlet Emperor mandarin	13.1d	2.7bc
Soh Siem mandarin	23.6abc	2.7bc
Assam lemon	23.3bc	2.2c
Sanguinea mandarin	8.4d	3.8ab
Karna Khatta	32.5a	1.8c
Yuzu	18.9cd	1.8c
Orlando tangelo[y]		
C58-229 (Rangpur × Troyer)[y]		

[z]Chlorosis ratings: 0 – normal, 1 – trace of chlorosis, 2 – mild chlorosis, 3 – moderate chlorosis, 4 – severe chlorosis, 5 – very severe chlorosis and defoliation.

[y]Not included in statistical analysis. Only 2 of 6 trees on 'Orlando' tangelo survived at the end of the test (Trunk cross sectional area: 5.6 cm^2, chlorosis rating: 5). Of the 3 trees on C58-229 rootstock planted, 2 survived (Trunk cross sectional area = 10.6 cm, chlorosis rating = 3).

[x]Mean (of 6 replications) separation within columns by Duncan's multiple range test, 5% level.

Table 2. Incidence of foot rot on trees of 4 scion cultivars on Karna Khatta and sour orange rootstock over 4.5 years.

	Karna Khatta		Sour orange	
Scion	Trees infected (%)	Trees dead (%)	Trees infected (%)	Trees dead (%)
CES #3 nucellar Redblush grapefruit	63	63	25	13
Old line Redblush grapefruit	63	38	13	13
Nucellar Valencia orange	38	25	13	13
Fairchild mandarin	50	38	13	0

33.6 cm, 482 g, 6.4 mm, 51.7%, 8.3%, 0.90% and 8.76, respectively. Samples consisting of 30 spring flush leaves from trees on sour orange rootstock collected in July 1968 contained 1.80% N, 0.16% P, 0.92% K, 4.40% Ca, 0.30% Mg, 0.15% Na, 83 ppm Fe, 42 ppm Mn, 21 ppm Zn, and 6 ppm Cu. Levels were 1.87% N, 0.15% P, 1.14% K, 4.17% Ca, 0.27% Mg, 0.12% Na, 95 ppm Fe, 51 ppm Mn, 24 ppm Zn, and 5 ppm Cu respectively, on Karna Khatta rootstock indicating there is probably no significant difference in nutrient uptake between the 2 rootstocks.

Trees on Karna Khatta were more phytophthora-susceptible than trees on sour orange in the second short-term test with 4 scion varieties (Table 2). The same number of trees of old-line and nucellar grapefruit on Karna Khatta became infected with foot rot, but more trees with nucellar scions died. The greater incidence of foot rot in this test compared to the other 2 trials was probably due to location as the plot was lower than the surrounding land.

The phytophthora infection rate was low in the long-term performance test at Weslaco. Only 7% of the trees were lost over 10 years, 2 trees on 'Ortanique', and 1 tree each on Assam lemon and 'Orlando' rootstock. There was no clear-cut relationship between tree size at planting and ultimate size of mature trees (Table 3) confirming the results reported by Gardner (4) with oranges. Trees on sour orange, Assam lemon, and Karna Khatta were the largest when the trial was planted (Table 3). Those on sour orange, and Assam lemon were still relatively large after 10 years, while those on Karna Khatta were smaller than most other trees in the test.

It appears that trees on Karna Khatta diverted more of their photosynthates into fruit production than the other trees, because in spite of their relatively small size, they outproduced trees on the other 9 rootstocks over 6 harvests (1967–72). Trees on sour orange also yielded acceptable crops, but trees on the other rootstocks produced poorly with little difference between them (Table 3). Each Dec., the no. of 31.8 kg (70 lb.) boxes harvested per tree was recorded. Fruit from 4 rows (replications) was picked in 2 stages in 1970, 1971, and 1972. All fruit of size 96 (29.8 cm circumference) and larger was removed first by ring picking, and then the smaller fruit was harvested. The best production year was 1970, but there was almost no fruit of size 96 and larger, except for trees on sour orange and 'Orlando' (Table 3). Trees on Karna Khatta not only produced the largest crops in 1971 and 1972, but fruit size was also large. The highest percentage of size 96 fruit, almost 95% of the crop, was found on C 58-229 (Rangpur × Troyer) rootstock in 1971, but the yield was a third lower than on Karna Khatta.

The results show that trees on Karna Khatta, a rootstock used extensively in India (5) but rarely in other areas, can be very productive. It is xyloporosis- (8) and greening disease-tolerant (3) but tends to accumulate chlorides (6). Its poor phytophthora tolerance (1; Table 2) makes the use of Karna Khatta in commercial orchards questionable. It is outstanding, however, for experimental use where early and heavy fruiting of pot-grown trees is desirable (unpublished observation).

Table 3. Correlation of tree size (cross sectional area) at planting and after 10 years; yield and fruit size, 96 or learger, 1970–72; and cumulative total yield 1967–72 at Weslaco.

	Trunk cross sectional area (cm^2)			1970[z]		1971[z]		1972[z]		Cumulative total yield 1967–72 (kg/tree)
Rootstock	1963	1973	r	Yield (kg/tree)	Size 96 (%)	Yield (kg/tree)	Size 96 (%)	Yield (kg/tree)	Size 96 (%)	
Sour orange	9.1a[y]	398.0a	0.40	135.6ab	14.3	88.4ab	54.4b	61.0b	13.6b	651.5b
Ortanique	4.2c	391.2a	–0.13	76.8c	0.0	59.3bc	19.1bc	67.3b	5.1b	418.8cd
Orlando tangelo	3.8c	386.8a	0.82	63.6c	6.7	70.0bc	24.2bc	66.8b	12.9b	394.6cd
Scarlet Emperor mandarin	5.2bc	383.8a	0.31	73.6c	0.0	66.4bc	26.8bc	47.6b	4.2b	379.8cd
Soh Siem mandarin	5.5bc	367.9[z]	0.14	84.4c	0.0	59.3bc	36.6bc	54.8b	9.6b	477.6c
Assam lemon	6.9ab	354.2a	0.77	79.9c	0.0	46.3c	12.1c	55.5b	4.6b	418.0cd
Sanguinea mandarin	4.1c	351.3a	0.54	84.4c	0.0	51.7bc	16.4c	50.3b	5.2b	401.3cd
Karna Khatta	6.7ab	271.6b	0.17	153.5a	0.0	111.3a	55.8b	116.7a	37.1a	793.6a
Yuzu	5.3bc	240.9bc	0.67	84.4c	0.0	50.3c	55.4b	46.7b	21.6ab	351.0d
C58-229 (Rangpur × Troyer)	3.9c	204.8c	0.75	98.8bc	0.0	73.6bc	94.7a	106.8a	26.1a	395.9cd

[z]Yield figures based on 6 replications, percentage of size 96 or larger fruit based on 4 replications.

[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Literature Cited

1. Broadbent, P. 1969. Observations on the mode of infection of *Phytophthora citrophthora* in resistant and susceptible citrus roots. *Proc. 1st Int. Citrus Symp.* III: 1207-1210.
2. Cooper, W. C., E. O. Olson, N. Maxwell, and G. Otey. 1956. Review of studies on adaptability of citrus varieties as rootstocks for grapefruit in Texas. *J. Rio Grande Valley Hort. Soc.* 10:6-14.
3. Fraser, L. R. and Daljit Singh. 1968. Citrus dieback in India – the contribution of greening virus. *In: Proc. 4th Conference of the Int. Org. of Citrus Virologists,* J. F. L. Childs, ed., Univ. of Florida Press, Gainesville, Florida. p. 141-144.
4. Gardner, F. E. and G. E. Horanic. 1959. Relation of citrus nursery tree size from 1/2 to 7/8 inches to ultimate size and production. *Proc. Fla. State Hort. Soc.* 72:102-105.
5. Hodgson, R. W. 1967. Horticultural varieties of citrus. p. 570 *In* W. Reuther, H. F. Webber, and L. D. Batchelor (ed.), The citrus industry, Division of Agricultural Sciences, Univ. of California, Berkely. Vol. I.
6. Hewitt, H. A., J. R. Furr, and J. B. Carpenter. 1964. Uptake and distribution of chlorides in citrus cuttings during a short-term salt test. *J. Amer. Soc. Hort. Sci.* 84:165-169.
7. Olson, E. O., W. C. Cooper, N. Maxwell, and A. V. Shull. 1962. Survival, size, and yield of xyloporosis and exocortis-infected old line red grapefruit trees on 100 rootstocks. *J. Rio Grande Valley Hort. Soc.* 16:44-51.
8. Salibe, A. A. and S. Moreira. 1965. Reactions of types of citrus as scion and as rootstock to xyloporosis virus p. 70-75 *In* W. C. Price (ed.) *Proc. 3rd Conference of the Int. Org. of Citrus Virologists,* Univ. of Florida Press, Gainesville.
9. Wutscher, H. K., N. P. Maxwell, and A. V. Shull. 1975. Performance of nucellar grapefruit, *Citrus paradisi* Macf., on 13 rootstocks in South Texas. *J. Amer. Soc. Hort. Sci.* 100:48-51.

HortScience 11(5):498–499. 1976.

Effect of Photoperiod on Endogenous Abscisic Acid in *Malus* and *Betula*[1]

Loyd E. Powell[2]

Pomology Department, Cornell University, Ithaca, NY 14853

Additional index words. inhibitors, apple, birch, growth regulator

Abstract. **Seedlings of *Malus hupehensis* Rehd., *M. domestica* Borkh. cv. Northern Spy and *Betula papyrifera* Marsh were grown under short and long photoperiods, with other environmental conditions being similar. *M. hupehensis* seedlings stopped elongation under short days (SD) and continued growth under long days (LD). There was no significant difference in abscisic acid (ABA) content in shoot tips taken from seedlings under either photoperiod. 'Northern Spy' seedlings ceased growth under SD, but neither did they grow vigorously under LD. Shoot tips of these seedlings were not significantly higher in ABA content when grown under SD. *Betula* seedlings discontinued elongation under short photoperiods, while LD promoted growth. *Betula* shoot tips from LD seedlings had more ABA than from seedlings grown under SD. These data do not support the hypothesis that SD causes cessation of shoot elongation by inducing a build up of ABA.**

Abscisic acid originally came to be discovered because of its effect on abscission (5) and shoot development (1). In the latter role an inhibitor, later thought to be ABA, seemed to increase in shoot tips of *Acer pseudoplatenus* during SD and was suggested as being responsible for cessation of shoot elongation and formation of terminal buds under SD (2). More recently this theory has been questioned (3, 6, 7, 10). In this study we have examined changes in ABA in shoot tips of 2 *Malus* species, and *Betula papyrifera* growing under LD and SD.

Plant material. Seeds of *Malus hupehensis*, 'Northern Spy' apple and *Betula papyrifera* were planted in flats of Peatlite artificial soil mix and placed in growth chambers. Day/night photoperiods and temp were 16 hr (24°C) and 8 hr (18°) respectively. Light intensity was about *250 μ einsteins/ M²/sec* at plant level, and was provided by a mixture of fluorescent and incandescent lamps. The 2-months-old seedlings were divided into 2 groups and placed in LD and SD environments. Both groups received only 8 hr of photosynthetic light daily, LD being obtained in 1 group by use of low intensity incandescent lamps during the second 8-hr photoperiod. At 0, 2, 8, 15 and 22 days after placing seedlings under LD and SD, 3 replications of 3 seedlings, each, were collected of each species. Shoot lengths, numbers of internodes, and fresh and dry (lyophillized) wt were recorded. Shoot tips (partially expanded and non-expanded leaves, apex, and associated stem tissue) were analyzed for ABA.

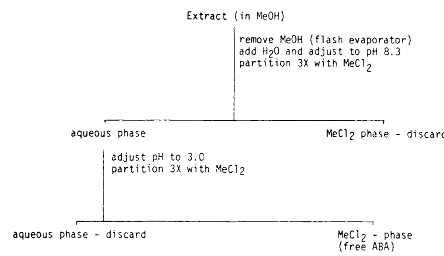

Fig. 1. Fractionation procedure for ABA. Equal volumes of each phase were used in partitions.

ABA analysis. ABA was extracted by homogenizing the tissue in cold 80% methyl alcohol (MeOH), then centrifuging to separate particulate matter from the supernatent liquid. The pellet was resuspended and twice more extracted in a similar manner. The combined extracts were fractionated according to the scheme in Fig. 1. The methylene chloride ($MeCl_2$) fraction containing the free ABA was analyzed by GLC (8, 9) employing 1% GE XE-60 liquid phase on Varaport 30, 100/120 mesh support, in a 4 mm × 2 meter glass column at 180°C.

Malus hupehensis. Shoots of this species stopped elongation under SD photoperiods and produced fewer internodes (Table 1). There was no signi-

Table 1. Effect of LD and SD on number of nodes and shoot length of seedlings of *Malus hupehensis*, 'Northern Spy', and *Betula papyrifera.*

Species	Collection day	No. nodes		Shoot length, cm	
		SD	LD	SD	LD
Malus hupehensis	0	14.6 ± 0.5[z]	14.6 ± 0.5	23.2 ± 0.9	23.2 ± 0.9
	2	14.1 ± 0.2	15.3 ± 0.4	19.0 ± 0.7	24.8 ± 1.3
	8	16.4 ± 0.4	17.2 ± 0.5	17.7 ± 0.7	27.8 ± 1.4
	15	17.0 ± 0.8	22.1 ± 0.5	18.4 ± 1.2	33.1 ± 1.6
	22	18.2 ± 0.7	22.6 ± 0.8	16.9 ± 1.2	35.6 ± 2.2
Northern Spy	0	11.7 ± 0.3	11.7 ± 0.3	19.3 ± 0.5	19.3 ± 0.5
	2	13.1 ± 0.5	12.8 ± 0.4	20.3 ± 0.8	22.5 ± 1.3
	8	14.7 ± 0.6	15.2 ± 0.3	21.3 ± 1.6	29.3 ± 1.5
	15	16.6 ± 0.5	16.3 ± 0.5	22.2 ± 1.4	23.7 ± 1.4
	22	17.8 ± 0.7	16.6 ± 0.5	21.7 ± 1.2	24.2 ± 1.3
Betula papyrifera	0	5.3 ± 0.3	5.3 ± 0.3	7.5 ± 0.6	7.5 ± 0.6
	2	5.6 ± 0.2	5.1 ± 0.3	8.5 ± 0.5	11.0 ± 0.7
	8	8.6 ± 0.3	7.3 ± 0.3	13.0 ± 0.8	15.9 ± 1.0
	15	10.6 ± 0.3	10.1 ± 0.3	12.4 ± 0.8	15.2 ± 1.3
	22	9.9 ± 0.6	9.6 ± 0.5	12.9 ± 0.8	20.5 ± 1.6

[z]SE follows each mean.

[1]Received for publication July 9, 1975.

[2]The author thanks Ruth Bloom for technical assistance, and Suman Singha for the statistical analysis.