Research Progress Reports for 2001

EARLY INTERMEDIATE LEVEL TESTING OF NEW CG. APPLE ROOTSTOCKS IN THE PACIFIC NORTHWEST

Project Leader: Bruce H. Barritt

Intermediate level trials were established at the Tree Fruit Research and Extension Center in 1998, 1999 and 2001. Preliminary tree size, yield and fruit size data for the 1998 trial (Table 1) and the 1999 trial (Table 2) are presented. On such young trees the data are very preliminary and may not be reliable estimates of eventual vigor rankings or of future productivity.

DIFFERENTIAL SUSCEPTIBILITY OF APPLE ROOTSTOCKS TO FOUR STRAINS OF FIRE BLIGHT AND THREE LATENT VIRUSES

Project Leaders: Gennaro Fazio, Terence Robinson, H.T. Holleran, H.S. Aldwinckle

Resistance of Geneva and Other Apple Rootstocks to *Erwinia amylovora* (Abstract)

Norelli, J.L., H.T. Holleran, W.C. Johnson, T.L. Robinson and H.S. Aldwinckle. 2002. Phytopathology 92: (submitted).

Budagovsky (B.) 9, Ottawa 3, Malling 9 and Mailing 26 were the most fire blight susceptible rootstocks when vigorously growing shoots of 49 different apple rootstocks were inoculated

TABLE 1

Yield and TCA at the end of 2001 (year 4) for the 1998 Cornell-Geneva apple rootstock trial at WSU-TFREC Wenatchee (Columbia View).

Gala

	2001			Cumulative ('00-'01)	
Rootstock	TCA (cm^2)	Yield (kg/ tree)	Yield efficiency (kg/cm^2)	Yield (kg/tree)	Yield efficiency (kg/cm^2)
G.65	5.3	1.9	0.4	4.2	0.9
CG.757	5.6	2.4	0.5	6.0	1.1
CG.12	7.2	1.8	0.3	5.5	0.8
M.9E	7.3	2.0	0.4	6.2	0.9
CG.995	8.0	3.0	0.4	7.3	0.9
M.9 WAF	9.3	4.3	0.5	9.9	1.1
CG.602	9.5	3.7	0.4	8.0	0.9
CG.93	9.5	1.6	0.2	5.2	0.6
M.26	10.5	2.9	0.3	6.3	0.6
G.16	12.6	3.7	0.3	9.5	0.8
CG.910	16.4	2.9	0.2	5.6	0.4
P.14	17.9	4.6	0.3	8.9	0.5
LSD p=.05	4.1	2.3	0.3	3.4	0.4

Jonagold

	2001			Cumulative ('00-'01)	
Rootstock	TCA (cm^2)	Yield (kg/ tree)	Yield efficiency (kg/cm^2)	Yield (kg/tree)	Yield efficiency (kg/cm^2)
M.9E	10.7	2.9	0.4	7.6	0.9
CG.41	14.5	3.4	0.3	9.2	0.7
G.16	15.7	1.7	0.2	6.6	0.6
LSD p=.05	5.6	2.9	0.4	3.0	0.6

TABLE 2

Yield and TCA at the end of 2001 (year 3) for the 1999 Cornell-Geneva Fuji apple rootstock trial at WSU-TFREC Wenatchee (Columbia View).

Dwarf

Rootstock	TCA (cm^2)	Yield (kg/tree)	Mean weight (g)
M.9	5.8	2.0	163
SUP.2	8.1	3.8	247
M.26	8.2	0.6	211
SUP.1	9.5	5.0	235
SUP.3	9.5	6.5	255
CG.4013	9.7	4.1	250
CG.5179	10.4	1.6	157
CG.16N	12.3	9.1	290
SUP.4	12.8	0.4	350
CG.16TC	12.9	6.4	209
CG.5935	14.1	4.9	188
CG.5202	14.5	10.0	263
LSD=.05	4.2	5.3	97

Semi-dwarf

Rootstock	TCA (cm^2)	Yield (kg/tree)	Mean weight (g)
M.26	7.0	0.9	218
CG.4814	10.4	0.4	225
CG.7707	11.6	0.1	250
CG.4210	11.9	0.0	—
M.7	13.7	0.7	206
CG.30TC	16.9	0.2	217
CG.30N	19.7	1.3	226
LSD=.05	5.9	1.1	127

in a greenhouse with different strains of *Erwinia amylovora,* and Geneva 11, Geneva 65, Geneva 16, Geneva 30, Pillnitzer Au51-11, Malling 7 and several breeding selections were the most resistant. Significant strain by rootstock interactions were observed in the amount of fire blight that resulted from inoculation. Field-grown fruiting Royal Gala trees on Geneva 16 and Geneva 30 rootstocks were highly resistant to rootstock infection (no tree mortality) when trees sustained severe blossom infection with *E. amylovora*, in comparison with Malling 9 and Malling 26 rootstock clones, which were highly susceptible to infection (36 to 100% tree mortality). In contrast to potted own-rooted B.9 plants inoculated in a greenhouse, B.9 rootstocks of orchard trees appeared resistant to rootstock infection (0% tree mortality). Orchard trees on Geneva 11 were moderately resistant to rootstock infection (25% tree mortality). There was general agreement in the evaluation of resistance under orchard conditions when rootstock resistance was evaluated in relation to controlled blossom inoculation or to natural blossom infection.

2001 Apple Rootstock Fire Blight Strain Specific Experiment

The objective of this experiment was to replicate the test performed in the year 2000 regarding objective 1 of the proposal. On May 8, 2001, 42 apple rootstock genotypes were treated with Ridomil and planted in containers consisting of a peat and vermiculite soil mix. Three weeks after planting, they were trained to a single vegetative shoot. Each genotype was divided into 4 racks (each rack contained 12 rootstocks) and placed on separate tables in the greenhouse. These different rootstocks were to be tested with one to four different strains of fire blight inoculum by direct inoculation into the vigorous shoot growth. The four strains of *E. amylovora* to be used were Ea273, E2002a, E4001a, E2017p. Five weeks after planting, the vegetative shoot began to collapse on several rootstocks across almost all the genotypes. Classic symptoms of *Phytophthora cactorum* infection were noted, however we were not able to verify the presence of *P. cactorum* through standard isolation techniques and therefore could not explain the reason for the necrotic incidents. Nine weeks after planting, 60% of the rootstocks were necrotic and several more showed symptoms of infection. This prevented us from obtaining the numbers needed for the strain specific fire blight experiment. Data were taken for necrosis for all the genotypes. This experiment is to be repeated in the spring of 2002 in a newly built greenhouse and with changes in the protocol for the preparation of liners.

2001 Geneva Rootstock Fingerprinting Experiment

In the past years, several questions have arisen about the identity of Geneva rootstocks from different sources. In the summer of 2001 we set out to shed light on such identity problems and also test a newly developed fingerprint test for apple varieties (thanks to the USDA Plant Genetic Resources Unit in Geneva). The fingerprint test consisted of the amplification of highly variable DNA regions called microsatellites. These microsatellite markers are very specific and a reliable source of genotype information. The fingerprinting experiment included several elite Geneva rootstocks (G.16, G.11, CG.3041, CG.4202, CG.5202 and CG.6210) from different mother trees and stoolbed sources. In the case of G.16, 11 different sources of rootstocks were tested with eight microsatellite markers (Table 3). No significant difference was detected between the original mother tree, three Geneva stoolbeds, stoolbeds from TRECO Nursery, two INRA (France) locations and material at the NRSP-5. However, significant differences were detected between mother trees originally identified as G.16 and root suckers of scion-rooted trees. This fingerprinting technique has the potential of becoming a standard tool for identification of apple rootstock varieties and the creation of a central rootstock fingerprint database should prove useful to the growers and nurseries that have questions about the identity of their rootstocks.

Resistance of Apple Rootstocks to Three Latent Viruses

A virus-testing experiment was set up this past summer (2001) to test Cornell and other commercial rootstocks for Apple Stem Grooving Virus, Apple Stem Pitting Virus, and Chlorotic Leaf Spot Virus. Apple rootstock liners were planted in a field nursery in the spring of 2001. In late August the liners were budded with virus-infected bud wood obtained from NRSP-5. The genotypes used were M.9, CG.5046, G.16, G.30, CG.6874, CG.7707, CG.5935, CG.5179, CG.6210, Maruba, CG.4214, CG.4013, CG.4011, CG.4003, CG.4814, CG.3041.

Fifteen rootstocks were used for each of the three viruses. Three replications of five trees for each virus were budded per genotype, for 45 rootstocks to be tested for each genotype. Data will be taken in early spring on bud take and the budded trees will be grown in a nursery for one growing season. Standard growing practices for nursery trees will be followed. When scion shoots are 18 inches long, the graft strength will be tested by applying pressure to the scion. The following spring the trees will be planted in an orchard and survival will be recorded for 2 years.

SWEET CHERRY ROOTSTOCK EVALUATION IN BRITISH COLUMBIA

Project Leader: Dr. Frank Kappel

1) A, J, M Rootstock Second Test

By the end of the 2001 season there was no difference in tree size among the rootstocks, that is, all trees had similar trunk cross-sectional areas. Regarding yield, Lapins was more productive than Bing, about 70% higher yield in 2001. Lapins fruit were also larger than Bing fruit. Rootstock had no effect on yield or fruit size in 2001. Yield and fruit size data were similar in 2000, that is, no rootstock effect but there was a variety effect.

2) Weiroot Rootstocks

Tree size as measured by trunk cross-sectional area was affected by rootstocks. Trees on F 12/1 and Gi 196/4 were the largest trees and those on W53 and W72 were the smallest trees. In 2000, trees on W154 were also in the smallest category, however in 2001 they were in the intermediate grouping with W158. Trees on Gi 196/4, W158 and W53 had the highest yields followed by W72, W154 and F12/1. In 2000 Gi 196/4 and W53 had the highest yields. There was no difference in fruit size in 2001. Suckering by the Weiroot rootstocks is still a significant problem.

3) Sweetheart Rootstock Trial

Trees on G5 were significantly smaller than any other rootstock (as measured by trunk cross-sectional area). The largest trees were on mazzard and P50. This was the same pattern as in 2000. Trees on G5 produced the most fruit followed by trees on G6. Lowest yields were produced by trees on P50 and mazzard. There was no effect on fruit size.

TABLE 3

Microsatellite allele size data of 11 sources of G.16 apple rootstock obtained by capillary analysis. Rootstocks marked with * are not significantly different.

DNA Source	Allele sizes of Microsatellite Markers												
	GD-12		GD-100		GD-142		GD-147		GD-15	GD-162		GD-96	
	Peak 1	Peak 2	Peak 1	Peak 2	Peak 1	Peak 2	Peak 1	Peak 2	Peak 1	Peak 1	Peak 2	Peak 1	Peak 2
Geneva Orchard 1	147.2		227.57	236.1	131.81	140.17	134.86	186.44	139.99	213.95	233.29	180.79	
Geneva Orchard 2*	147.23	171.95	224.7	243.04	125.63	140.07	120.65	147.51	139.97	188.48	251	152.78	163.76
Geneva Orchard 4	147.14	172.12	225.32	243.76	126.09	140.56	120.44	147.5	140.12	188.36	254.42	153.86	164.45
INRA (France) l*	148.04	172.37	224.05	242.16	126.09	140.56	120.46	147.49	140.13	188.3	254.3	153.89	164.46
NRSP-5*	148.04	172.25	224.32	241.79	126.05	140.61	120.39	147.41	140.51	188.51	250.56	154.01	
TRECO Nursery*	147.97	172.48	224.67	242.65	126.16	140.59	120.66	147.49	140.2	188.4	254.83	153.81	164.41
Geneva Stool 1*	148.02	172.38	224	242.68	125.91	140.42	120.33	147.25	140.07	188.31	251.05	154.11	164.82
INRA (France) 2*	147.29		226.29		134.1	140.3	128.68	134.63	139.81	215.38		172.74	180.73
Geneva Stool 2*	147.06	172.16	224.72	243.04	125.69	140.19	120.96	147.89	139.67	188.54	250.94	153.65	164.58
Geneva Stool 3*	147.44	172.51			125.72	140.29	120.7	147.71	139.76	188.49	250.96	154.08	164.79
Geneva Orchard 3*	148.2	172.46	225.44	243.97	125.99	140.55	120.31	147.34	139.68			153.81	164.46

4) NC 140—Summerland

Tree size can be described by three broad groups. The first are the standard size trees and these include trees on mahaleb, mazzard, Gi 318/17, G6, W13, G7 and W10. The intermediate group includes trees on Gi 195/20, W158 and G5 and these are about 80% the size of the standards. The smallest trees (about 60% of the average size of the standard trees) include trees on W72, edabriz, W154, Gi 209/1, Gi 473/10 and W53. Trees on W10, W154, W158, mahaleb, W13 and mazzard had poor yields in 2001, less than 0.5 kg per tree. The trees on the other rootstocks had yields from 1.1 to 2.6 kg per tree. There was no effect on fruit size. The rootstocks W13 and W154 had very high numbers of suckers, 76 and 68 per tree, respectively. Gi 473/10, W10, W72 and W158 also had high sucker counts, 31 to 52 per tree. Other rootstocks had low counts.

5) Variety/Rootstock Interaction

As expected, the smallest trees were on G5, about 66% the size of trees on mazzard (trunk cross-sectional area). Across rootstocks, the smallest trees were of the varieties Sweetheart, 13S-21-01, Sonata, Celeste and Staccato. Trees on G5 were more precocious than trees on mazzard (again as expected). The most precocious varieties were Sweetheart, Staccato and SPC 103. Symphony and 13N-07-70 were medium. Samba and Summit were the least precocious varieties. There was no difference in fruit size caused by the rootstocks.

FUNDAMENTAL ROOTSTOCK INFLUENCE ON FLOWERING AFFECTS TRAINING AND MANAGEMENT DECISIONS FOR SWEET AND TART CHERRY CROP LOAD AND FRUIT QUALITY

Project Leaders: Gregory A. Lang and Ron L. Perry

Utilizing the 1998 NC-140 cherry rootstock trial plots (both Hedelfingen sweet cherry and Montmorency tart cherry) in Michigan, number of flowering spurs induced per length of 2-year-old shoot, number of flower buds induced per spur, number of individual flowers induced per bud, floral density distribution across 2-year-old shoot growth, fruit yield, fruit quality, shoot length and new lateral branch formation were characterized in 5th leaf trees, using 3 branch samples per tree and 5 tree replications per rootstock. Data were recorded and analyzed for the following rootstocks: Mazzard seedling, mahaleb seedling, Gisela 5, Gisela 6, Gisela 7, Gi 195/20, Gi 209/1, Weiroot 10, Weiroot 13, Weiroot 53, Weiroot 72, Weiroot 158 and Edabriz. Three of the initially proposed rootstocks (Gi 318/17, Gi 473/10 and Weiroot 154) were dropped from the study due to insufficient uniformity or replication among NC-140 trial trees for adequate data development. Flowering characterization of Bing sweet cherry in the Washington NC-140 plot was incomplete due to extended cool bloom weather for the duration of the project's Michigan personnel data collection visits, plus the lack of an ad hoc suitable local cooperator due to the then-unfilled tree fruit faculty position at WSU/Prosser. However, the project's subsequent focus on development of a dynamic, computer-based model that will allow rootstock- and scion-specific inputs will provide an opportunity to extend and modify the information collected in Michigan to not only Washington but other NC-140 locations as well.

Rootstock genotype clearly affected fruiting spur and lateral branch development across both cherry species. By delineating the 2-year-old (fruit spur-bearing) shoot into 3 sections (basal, middle and apical) for the characterization of floral induction, predictions can now be made, on a rootstock-specific basis, regarding how much future crop may be removed by different length pruning cuts. For example (based on this single-year, preliminary data), dormant removal of one-third of the previous season Hedelfingen shoot growth would be expected to eliminate 100% of the potential flower spur sites initiated on that shoot the next year (and thus the potential crop on that shoot 2 years hence) for trees on Mazzard and mahaleb; 75% on W13; 50% on Edabriz; 45% on W158; 40% on W10 and 20 to 25% on Gisela 5 and 6. Dormant removal of two-thirds of the previous season shoot growth would be expected to similarly eliminate 100% of the future spur sites (on that shoot) on Mazzard, mahaleb, W13 and Edabriz; 95% on W10; 90% on W158 and 75 to 80% on Gisela 5 and 6. Among the low vigor rootstocks, the number of sweet cherry flower buds per spur averaged 2.2 on W72, 2.8 on W53, 3.2 on Gisela 5 and 4.0 on Gisela 7, with buds/spur increasing from basal to apical along the shoot.

The number of flowers per bud did not vary among rootstocks as much as buds per spur, nor did it vary as much along the length of the shoot. Floral results were relatively similar for Montmorency tart cherry. However, the complexity of the floral trends between rootstocks and along the fruiting shoot length indicated that a modeling approach is needed to assimilate and compare these data to better illustrate the differences in flowering architecture and fruit placement within the tree canopy. With development of such a model during the second year of the project, it is anticipated that pruning and crop load management of young cherry trees can be better tailored to the unique floral initiation traits of each new precocious rootstock.

NC-140 ROOTSTOCK TRIALS DATA SUMMARIZATION

Project Leader: Richard Marini

Last year's funds were used by coordinators of 6 rootstock plantings to summarize data from the 2000 growing season. Annual reports for each planting, including means with statistical analyses, were presented to the NC-140 Technical Committee in Parlier, CA, in November 2001. During the past year, NC-140 cooperators published a total of eight papers. Five papers summarizing various aspects of the 10-year 1990 apple cultivar/rootstock planting were published in the J*ournal of the American Pomological Society*. A paper summarizing data from the 1990 rootstock trial with Gala as the scion and a paper summarizing the 1990 apple systems trial were also published. A 5-year summary of the 1994 peach rootstock trial was published in *Acta Hort.* Three papers were also published in *Compact Fruit Tree*. Below are some of the most important results presented in the 2001 summary reports.

1) In the 1994 peach rootstock planting, tree survival was highest on Stark Redleaf, GF 305, S.2729 and H7338013, and lowest on Myran, Ta Tao 5 interstem and Lovell. Trunks are largest for Lovell and Guardian and smallest for Ishtara and Tzim Pee Tao. Cumulative yield was highest for Lovell and GF 305 and lowest for Ishtara and Ta Tao 5 interstem.
2) Data from the 1990 Gala rootstock trial were used to evaluate the effect of rootstock on average fruit size. Newly developed statistical procedures were used to

TABLE 4

Treatments applied during 2001 growing season.

Treatment[Z]	Trunk cross-sectional area Nov. 2000 (cm^2)	Pruning wts 2000 (kg/tree)	Leaf nutrients 2001 N (% dw)	Leaf nutrients 2001 K (% dw)	Yield 2001 (kg/tree)	Fruit quality 2001 Size (g)	Fruit quality 2001 SS (%)	Fruit quality 2001 All splits (%)
1. Low N	40.5a	1.7ab	2.89cd	2.22a	13.5	10.1a	18.9b	9.1
2. Med. N	36.9a	1.4abc	3.05abc	2.00abc	13.1	9.5ab	18.8b	8.7
3. High N	35.1a	1.2bcd	3.17a	1.78c	13.3	9.2b	18.8b	11.1
4. Med. N + P	40.9a	1.7a	3.18a	2.12ab	13.6	9.3ab	18.5b	11.7
5. Med + K	38.2a	1.4abc	2.97bcd	1.93bc	13.0	9.4ab	18.9b	12.0
6. Broadcast + N	35.6ab	1.0cd	2.85d	1.81c	14.3	9.0b	19.1ab	9.9
7. Broadcast + N + postharvest	35.9ab	1.3abcd	3.09ab	1.99abc	13.8	9.5ab	19.9a	9.3
8. Medium N drip	29.7b	0.8d	3.00abcd	1.48d	14.5	7.3c	17.4c	5.6
	*	**	*	****	NS	****	***	NS

[Z]All treatments except (8) irrigated with microsprinkler with irrigation scheduled according to evaporation as measured by an atmometer. Means with the same letter not significantly different.

estimate average fruit size for each rootstock after adjusting it for number of fruit per tree or for the number of fruit per cm^2 of trunk cross-sectional area. Mac.39, B.9, M.27 and M.9 fairly consistently produced the largest fruit, whereas P.1 and M.26 consistently produced the smallest fruit.

3) The six M.9 clones in the 1994 trial are quite different. RN29 and Pajam 2 are nearly as large as M.26 EMLA, followed by M.9 EMLA and Pajam 1. NAKBT337 and Fleuren 56 are the smallest of the M.9 clones. Rootstock significantly influenced yield efficiency at most locations. Yield efficiency was highest for P.16 in the most dwarfing size class, and O.3, MARK and M.9 NAKBT337 in the intermediate size class. M.26 EMLA had lower yield efficiency than V.1, M.9 RN29 and M.9 Pajam 2.
4) In the 1994 semi-dwarf trial four rootstocks (M.26 EMLA, P.1, V.2 and G.30) are being compared. Tree mortality is greatest on G.30 and M.26 EMLA and relatively low for P.1 and V.2. At 10 of the 19 locations rootstock did not significantly influence TCA. At locations where rootstock is significant, the smaller trees were on V.2 and G.30. Yield was significantly affected by rootstock at only 5 of the 19 locations. For those locations, G.30 tended to have the highest yields.
5) In the 1999 dwarf apple rootstock trial 13 rootstocks are being compared with either McIntosh (4 locations) or Fuji (7 locations) as scions. In general, the largest trees were on CG.4013 and the smallest were on M.9 NAKBT337. Greatest yields were harvested from Supporter 1 (Fuji) and Supporter 3 (McIntosh) where rootstock differences existed.
6) In the 1999 semi-dwarf apple rootstock trial 8 rootstocks are being compared at 6 locations with Fuji as the scion and at 3 locations with McIntosh as the scion. For Fuji largest trees were on G.30N, and for McIntosh they were on Supporter 4. Trees on M.7 EMLA yielded the most in 2000.

NUTRIENT AND WATER MANAGEMENT IN HIGH DENSITY SWEET CHERRY IN BRITISH COLUMBIA

Project Leaders: D. Neilsen and G. Neilsen

Treatments were reapplied during the 2001 growing season. Treatments were: (1-3) three rates of fertigated N applied as a $CA(NO_3)_2$; (4) medium N rate with fertigated P in spring; (5) medium N rate with fertigated K in June; (6) broadcast N only; (7) postharvest N (August); (8) medium N rate drip-irrigated. Excepting treatment (8), irrigation was supplied via microsprinkler. All irrigation was scheduled to meet evaporative demand based on an electronic atmometer. This year was the fourth growing season and third fruiting season. Yield continued to increase in 2001 averaging 13.6 kg/tree over all treatments and for the first time treatment differences with respect to fruit quality became apparent. Selected data are presented in Table 4.

A dramatic result has been the reduced size of drip-irrigated trees relative to those irrigated by microsprinklers (Table 4). This is apparent from small tree cross-sectional area and reduced pruning weights following the 2000 growing season. Yield had been higher for these drip-irrigated trees in 1999 and 2000 but this pattern was not observed for the 2001 harvest when yields were much greater overall and not significantly different among treatments. However, fruit size was significantly affected by treatment being smallest for the drip-irrigated trees but also decreased as rate of fertigated N increased. For the first time other cherry fruit quality parameters were influenced by treatments with the smaller fruit from the drip-irrigated treatments being firmer (data not shown) but having lower soluble solids content. A range in leaf N concentration was apparent in 2001 from low N to high N but this did not result in increased tree yield and fruit size was actually greater at low N. The reduced tree size associated with drip-irrigated trees offers the potential for higher density plantings, but the reduction in fruit size is a potential limitation unless apparent water stress can be overcome or fruit are thinned. This needs to be defined more closely.

HIGH DENSITY PLANTING SYSTEMS TRIALS FOR SWEET CHERRIES IN THE NORTHEAST

Project Leaders: Terence Robinson, Robert Andersen and Steve Hoying

Sweet cherries offer an opportunity for diversification for many apple growers in the northeastern U.S. The introduction of dwarfing cherry rootstocks and newer varieties has allowed new possibilities for developing high density cherry orchards with smaller trees that will be more precocious and productive and can either be covered with rain exclusion shelters or treated with $CaCl_2$ to prevent rain cracking. This project seeks to compare high density production systems and dwarfing rootstocks for sweet cherries and to help growers successfully adapt the best systems for commercial orchards.

In 1999 we established a replicated cherry systems trial at Geneva, NY, with 3 cultivars (Hedelfingen, Lapins and Sweetheart) and 3 rootstocks (Gi.unknown, Gi.6 and MXM2). The purpose of this trial is to compare high density training systems that utilize precocious rootstocks and new pruning and training strategies. We chose to compare 6 systems (Table 5).

All trees were planted on 12-inch berms to control winter damage associated with excessive soil moisture. In addition, a subsurface tile line was installed in the center of each tractor alley to remove excess moisture in the spring and during heavy rainfall before harvest.

In 2000 (the second year) we compared three methods of stimulating lateral branching along the leader. 1) Leaders were sprayed bud swell with 5,000 ppm Promalin mixed with diluted white paint. 2) Every third bud along the leader was notched above the bud with a hacksaw blade at bud swell. 3) We removed two-thirds of the buds along the leader (every third bud was left). The Promalin and notching treatments were not very effective in stimulating lateral branching in the lower and middle sections of the leader. However, the bud removal treatment was very effective and gave a relatively uniform distribution of lateral branches along the shoot.

Hedelfingen had the greatest number of lateral branches. Sweetheart had an intermediate number and Lapins the least. The bud removal treatment should prove to be very useful for sweet cherry growers in the Northeast. It provided good lateral branch development without heading the leader. This should allow more rapid development of the canopy and earlier production. However in the humid Northeast where bacterial canker infection is a high risk in the spring, we recommend the application of a copper sprays immediately before or after the buds are removed.

In 2001 the trees cropped for the first time. Among rootstocks, yields of the Gi.unknown rootstock were highest (1.79 kg/tree) with Gi.6 yields intermediate (1.59 kg/tree) and MXM2 with the lowest yield (0.35 kg/tree). Among systems, the Zahn system had the highest yield followed by the Vogel, Central Leader, Spanish Bush, Marchant and the V system with the lowest yield per tree. On an acre basis the Zahn system had the highest yield (0.96 tons/acre) followed by the Vogel system (0.58 tons/acre), the Marchant system (0.48 tons/acre), the V system (0.35 tons/acre), the Spanish Bush system (0.35 tons/acre) and the Central Leader system (0.18 tons/acre). The yields largely reflected density; however the Zahn system because of its high yield per tree and the highest tree density produced almost double the yield of other systems. In this first crop year fruit size was largest on Gi.6 (7.6 g), intermediate on Gi.5 (7.4 g) and smallest on MXM2 (6.4 g).

Our results so far show the value of the precocious Gisela rootstocks and the value of high tree densities for early yields. Among the pruning systems the Zahn system had the least pruning in the first 2 years and has had the highest yield (Table 6).

NATIONAL EVALUATION OF THE CORNELL-GENEVA APPLE ROOTSTOCKS AND OTHER PROMISING ROOTSTOCKS FROM AROUND THE WORLD

Project Leaders: Terence Robinson and NC-140 Committee

The new series of Cornell-Geneva (CG) rootstocks have the potential to replace existing rootstocks because they have resistance to fire blight and phytophthora root rot. Two clones

TABLE 5

Comparison of 6 training systems.

System	Spacing (ft.)	Tree density/acre
Modified Central Leader	16 X 20	136
Spanish Bush	10 x 16	272
Vogel Slender Spindle	8 X 15	363
Freestanding V	6 X18	403
Marchant Trellis	8 X 13	418
Zahn Vertical Axis	6 X 15	484

are currently being commercialized and about a dozen elite selections are in the pipeline. As these new stocks become available to fruit growers, orchard tests in several climatic areas on a variety of soils are needed. We have established a series of intermediate stage trials in NY, MI and WA to select the most promising clones from the dozens of candidates. We have also begun testing the most promising selections through the national NC-140 group to further evaluate their commercial potential. The NC-140 trials also are comparing other rootstocks from around the world including the Vineland, Supporter, Morioka, Pillnitz-Dresden, Poland, Budagovsky and JTE stocks.

In 2001 we planted two new intermediate stage testing blocks of CG rootstocks in NY and WA. We also propagated trees for three new intermediate stage trials in NY, WA and MI. Through the NC-140 group we propagated trees for a comparison of B.9 clones for planting in 9 states or provinces in 2002. Also in 2002, two smaller 3 to 4 state plantings of several Japan Morioka (JM) stocks and Pillnitz (PiAu) stocks will be planted by NC-140 cooperators. We are continuing to work with commercial nursery people to gain access to other new rootstocks from eastern Europe and Japan. New stoolbeds of 16 rootstock genotypes from three European breeding programs were established at Geneva in 1999 to provide plant material that will be used in biotic and abiotic stress tolerance screens. In particular we will be testing foreign selections for fire blight tolerance. The NC-140 group is propagating an extensive orchard trial for planting in 2003 with stocks from Geneva, Europe and Japan.

From our NY intermediate stage orchard trials of CG rootstocks planted in 1992 to 1998

TABLE 6

Performance of 6 orchard training systems for sweet cherries in the third leaf at Geneva, NY (2001).

Variety	System	Rootstock	Fruit no./ tree 2001	Yield 2001 (kg/tree)	Av. fruit size (g)	Fruit soluble solids (%)
Hedelfingen	Mod. Central Leader	MXM2	59.9	0.4	7.3	15.9
		Gi.6	111.2	0.8	7.3	17.9
		Gi.unknown	219.2	1.4	6.5	15.4
	Spanish Bush	MXM2	31.9	0.2	5.8	14.3
		Gi.6	122.8	0.8	6.8	17.1
		Gi.unknown	235.0	1.2	5.8	14.5
	Vogel Slender Sp.	MXM2	79.0	0.6	6.4	17.1
		Gi.6	171.4	1.2	7.1	16.6
		Gi.unknown	303.3	2.0	6.4	15.1
	V-Slender Spindle	MXM2	27.5	0.2	6.5	17.5
		Gi.6	85.0	0.6	7.2	17.6
		Gi.unknown	98.5	0.7	7.0	16.1
	Marchant Trellis	MXM2	16.6	0.1	7.2	16.7
		Gi.6	116.7	0.9	7.2	16.0
		Gi.unknown	184.0	1.1	6.0	13.8
	Zahn Vertical Axis	MXM2	102.7	0.6	6.3	14.8
		Gi.6	202.9	1.4	6.8	15.8
		Gi.unknown	208.3	1.3	6.3	14.5
Lapins	Mod. Central Leader	Gi.6	169.9	1.7	8.1	16.6
		Gi.unknown	239.8	2.0	8.0	16.1
	Spanish Bush	Gi.6	167.2	1.4	7.9	16.7
		Gi.unknown	238.0	1.8	7.9	16.4
	Vogel Slender Sp.	Gi.6	183.0	1.6	8.5	16.3
		Gi.unknown	218.4	1.9	8.5	17.3
	V-Slender Spindle	Gi.6	135.2	1.1	8.4	16.0
		Gi.unknown	104.2	1.0	8.2	16.7
	Marchant Trellis	Gi.6	194.6	1.6	8.2	16.1
		Gi.unknown	172.3	1.4	8.1	16.7
	Zahn Vertical Axis	Gi.6	299.0	2.6	8.0	16.2
		Gi.unknown	318.1	2.5	7.9	24.9
Sweetheart	Mod. Central Leader	Gi.6	191.5	1.8	7.7	18.6
		Gi.unknown	288.3	2.2	7.7	18.1
	Spanish Bush	Gi.6	246.3	1.8	7.2	16.0
		Gi.unknown	421.7	3.1	7.3	16.3
	Vogel Slender Sp.	Gi.6	377.8	2.7	7.2	16.5
		Gi.unknown	273.2	2.3	7.8	17.5
	V-Slender Spindle	Gi.6	217.1	1.7	7.9	18.5
		Gi.unknown	168.8	1.3	7.9	18.5
	Marchant Trellis	Gi.6	242.6	1.8	7.2	16.2
		Gi.unknown	232.2	1.7	7.6	17.0
	Zahn Vertical Axis	Gi.6	445.1	3.4	7.7	16.8
		Gi.unknown	343.3	2.8	7.7	17.5
		LSD $p<0.05$	21.1	0.13	0.29	0.56

we have identified CG.3041, CG.3902, CG.3007, CG.4003, CG.4202, CG.4247, CG.5757, CG.6737, CG.3029, CG.50, CG.26, CG.995, CG12.3 and CG.38 as promising dwarfing stocks that have exceeded the performance of M.9 or M.26. Among semi-dwarf stocks, CG.5935, CG.5012, CG.5046, CG.5202, CG.5179, CG.6210, CG.6874, CG.756 and CG.7760 exceeded the performance of M.7. Among vigorous stocks CG.6239, CG.6253, CG.6723, CG.7707 and CG.8189 exceeded the performance of MM.111.

In 1998 we planted a comparison of G.16 and M.9 using Gala and Jonagold (Tables 7 and 8). In 2001, both the Gala and the Jonagold trees in this trial were allowed to crop a second time. Gala had a very heavy crop while Jonagold had a moderate crop. With Gala, G.16 trees were significantly larger than M.9 trees but with Jonagold, G.16 trees were similar in size to M.9 trees. The greater vigor of G.16 trees with Gala may be due to the tissue culture method of propagation of the rootstocks used with Gala compared to the layerbed propagation method used with the rootstocks used in the Jonagold planting. Tissue culture induces a partial juvenile vigor in rootstocks that persists for several years. In 2001 there was evidence that the Gala G.16 trees were slowing down in vigor compared to other more vigorous stocks such as M.26 and P.14. Trees on G.16 have been as precocious and productive as M.9 with both scions. G.16 has had better survival than M.9 in several sites that have experienced severe fire blight epidemics. In sites without fire blight, tree survival has been similar between G.16 and M.9. With the Jonagold plot a second Geneva rootstock was included (CG.3041). It had superior production and a similar tree size to M.9 with good survival. Other productive stocks with Gala were CG.5757, CG.5935 and CG.995.

A rootstock plot planted in 1999 has shown that trees on G.16, CG.3041 and CG.202 are larger than trees on M.9T337 and trees on CG.5935 are larger than trees on M.26. The

TABLE 7

Performance of NY-Geneva apple rootstocks in the 1998 Gala/G.16 trial.

Rootstock	TCA 2001	Fruit no. 2001	Yield 2001 (kg)	Fruit size 2001 (g)	Yield eff. 2001 (kg/cm² TCA)	Cum. fruit no.	Cum. yield (kg)	Av. fruit size (g)	Cum. yield eff. (kg/cm² TCA)
G.65	9.3	55	6.3	108	0.70	64	7.7	133	0.86
CG.026	11.7	79	10.7	131	0.93	86	11.6	135	1.01
CG.3029	12.0	118	13.8	112	1.17	127	15.0	131	1.27
CG.12.3	12.3	155	16.5	111	1.40	169	18.5	128	1.57
CG.5757	12.3	215	22.8	104	1.88	233	25.6	127	2.09
CG.995	13.3	207	24.2	118	1.83	227	27.3	142	2.06
G.11	14.0	128	17.8	144	1.10	164	23.0	148	1.42
M.9	14.6	132	19.2	147	1.35	141	20.5	157	1.45
B.9	14.7	109	14.3	137	1.06	117	15.5	146	1.15
CG.4247	15.5	145	16.1	115	1.04	158	17.9	131	1.15
CG.4179	15.5	159	18.7	119	1.22	179	21.6	133	1.42
CG.5935	15.5	132	15.7	114	0.94	139	16.6	123	1.00
CG.5202	15.6	115	13.6	124	0.91	117	13.9	132	0.93
M.9EMLA	15.6	164	22.6	141	1.44	177	24.5	149	1.56
CG.067	16.2	141	17.4	119	1.05	149	18.6	132	1.13
CG.5046	16.9	132	14.1	109	0.85	137	14.8	132	0.89
CG.4214A	17.5	173	23.9	138	1.32	183	25.3	136	1.40
CG.4013	17.9	129	13.9	111	0.74	138	15.1	123	0.81
CG.002	18.1	75	9.2	128	0.47	75	9.3	135	0.48
CG.066	19.0	68	8.2	139	0.39	68	8.3	147	0.39
CG.701	20.1	89	12.0	142	0.57	91	12.2	138	0.58
CG.4214	20.6	148	19.7	137	0.95	154	20.3	135	0.98
G.16T	20.8	208	25.6	124	1.23	225	28.1	137	1.35
M.26	21.0	171	24.7	146	1.13	178	25.6	150	1.18
CG.91	23.1	60	7.6	119	0.30	60	7.6	119	0.30
CG.756	23.4	188	25.6	132	1.14	197	26.9	141	1.20
BemaliTC	23.8	81	11.6	145	0.48	82	11.7	144	0.48
CG.5701	24.4	261	32.5	120	1.31	280	35.3	135	1.43
P. 14	26.2	231	27.9	119	1.06	246	30.2	136	1.15
LSD p<0.05	3.9	53	8.5	35	0.47	55	8.7	23	0.48

* Rootstocks ranked by trunk cross-sectional area.

TABLE 8

Performance of NY-Geneva apple rootstocks in the 1998 Jonagold/G.16 Trial.

Rootstock	TCA 2001	Fruit no. 2001	Yield 2001 (kg)	Fruit size 2001 (g)	Yield eff. 2001 (kg/cm² TCA)	Cum. fruit no.	Cum. yield (kg)	Av. fruit size (g)	Cum. yield eff. (kg/cm² TCA)
M.9EMLA	14.1	27	6.8	253	0.50	49	12.4	257	0.90
G.16N	14.5	31	7.5	242	0.53	71	15.9	228	1.10
G.16T	15.6	22	4.3	205	0.34	73	13.7	195	0.92
CG.3041	15.7	54	14.8	267	0.99	75	20.1	251	1.28
LSD p<0.05	2.1	25	5.8	37	0.39	18	4.3	26	0.30

* Rootstocks ranked by trunk cross-sectional area.

most efficient stocks were CG.3041, G.16, upporter 2, Supporter 1. Among semi-dwarf stocks the most efficient stock was G.30.

In 2001 we confirmed the identity of G.16 at Geneva and in commercial stoolbeds through DNA fingerprinting. Based on the DNA work and orchard performance we continue to be optimistic that this stock is an excellent alternative to M.9 for North American apple growers. It has excellent production and good fire blight survivability. It appears to produce a tree slightly larger than M.9T337 but smaller than M.26. Its virus sensitivity is its biggest problem. We have now learned that it is highly susceptible to apple stem pitting. It does not appear to be susceptible to apple stem grooving virus or apple chlorotic leaf spot virus. Since some reputed virus-free wood may have a low titer of viruses, nurserymen will need to test bud wood source trees by budding test quantities of G.16 liners with buds from each potential scion wood tree to determine if it is virus free. This characteristic of G.16 will limit the use of scion wood from some of the newest varieties or strains where virus-free wood is unavailable or the virus status of the wood is not known. We believe G.16 with its high fire blight resistance may be the best practical alternative to M.9 for successful high density plantings in the east.

The current status of CG rootstocks is:

1) G.16 and G.30 are being sold commercially by most US nurseries.
2) Stoolbeds of G.11 are being planted by commercial nurserymen in 2002.
3) We have announced to our licensees our intention to release CG.4202 in New Zealand in May 2002. Nurseries are beginning to bulk up these stocks for commercial sale. We also intend to release this stock in the US.
4) We have announced to our licensees our intention to release CG.3041 and CG.5935 in 2003. Nurseries are beginning to bulk up these stocks for commercial sale.

CONVERSION FACTORS ENGLISH VS. METRIC

To convert Column 1 into Column 2, multiply by:	Column 1	Column 2	To convert Column 2 into Column 1 multiply by:
Length			
.621	kilometer, km	mile	1.609
1.094	meter, m	yard	.914
3.281	meter, m	foot, ft	.3048
39.4	meter, m	inch	.0254
.03281	centimeter, cm	foot, ft	30.47
.394	centimeter, cm	inch	2.54
.0394	millimeters, mm	inches	25.40

metric: 1 km = 1000 m; 1 meter = 100 cm; 1 meter = 1000 mm
English: 1 mile = 5280 ft; 1 mile = 1760 yards; 1 yard = 3 ft; 1 ft = 12 inches

Area			
247.1	kilometers^2, km^2	acre	.004047
2.471	hectare, ha	acre	.4047
.4047	trees/hectare	trees/acre	2.471

metric: 1 ha = 10,000 m^2 = .01 km^2
English: 1 acre = 43,560 ft^2

Volume			
1.057	liter	quart (US)	.946

English: 1 US gallon = 4 quarts

Mass—Weight			
1.102	ton (metric), MT	ton (English)	.9072
2.205	kilogram (kg)	pound, lb	.454
52.5	ton (metric) of apples	apple packed box, *carton	.01905

metric: 1 metric ton = 1000 kg
English: 1 ton = 2000 lb; 1 packed box or carton* of apples = 42 lb

Yield or Rate			
0.446	ton (metric)/hectare, MT/ha	ton (English)/acre	2.242
.892	kilogram/hectare, kg/ha	pound/acre	1.121
.991	ton (metric) of apples/hectare, MT/ha	bins* of apples/acre	1.009
.4047	trees/hectare	trees/acre	2.471
0.107	liter/hectare	gallon (US)/acre	9.354

metric: 1 metric ton = 1000 kg; 1 hectare = 10,000 m^2
English: 1 ton = 2000 lb; apple bin* = 900 lb; 1 acre = 43,560 ft^2

Temperature			
1.8 C + 32	Celsius, C	Fahrenheit, F	.555 (F-32)

**Commercial cartons (packed boxes) of fruit and field/storage bins of fruit do not have universal weights. The weight of fruit in a packed box or carton varies around the world and with the type of fruit, but is here taken for apples as 42 lbs (19.05 kg); the weight of fruit in a bin also varies but is here taken for apples as 900 lbs (408.2 kg).*