

dom' [1.5], 'Jonafree' [4.2], 'Macfree' [2.1], 'Nova Spy' [2.1], CBR4T29 [2.3] and O-662 [1.2]. Cultivars and selections classed as moderately cold tolerant were 'Rouville' [1.3], 'Trent' [2.0], FAR006A013 [1], O-533 [1], O-5410 [1], and O-654 [2.8].

This report is based on one year's observations. It is recognized that a number of different factors affect the cold hardiness of cultivars. These observations should be useful in comparing the relative cold hardiness of scab resistant cultivars and selections. By comparing their hardiness to the standard cultivars 'McIntosh', 'Empire' and 'Delicious', one can predict the likelihood of survival over the long term in various growing regions.

Literature Cited

1. Blair, D.S. 1935. Winter injury to apple trees in eastern Canada 1933-35. *Sci. Agr.* 16:8-15.
2. Crosby, J.A., J. Janick, P.C. Pecknold, S.S. Korban, P.A. O'Connor, S.M. Ries, J. Goffreda and A. Voordeckers. 1992. Breeding apples for scab resistance: 1945-1990. *Fruit Var. J.* 46:145-166.
3. Embree, C.G. 1984. An assessment and illustration of winter injury to selected apple cultivars in Nova Scotia, 1980-81. *Fruit Var. J.* 38:8-13.
4. Rousselle, G.L. 1983. Tree recovery from 1980-81 winter damage in Quebec province. *Compact Fruit Tree* 16:111-115.
5. Warner, J. 1982. Winter injury to apple trees, 1980-1981. *Fruit Var. J.* 36:99-103.
6. Watkins, R. and R. A. Smith. 1982. Descriptor list for apple (*Malus*). International Board for Plant Genetic Resources, Commission of European Communities: Committee on Disease Resistance Breeding and Use of Genebanks. IBPGR Secretariat, Rome, Italy.

Fruit Varieties Journal 50(2):118-124 1996

Viability of Different Pear Pollen and the Effect on Fruit Set of 'Anjou' Pear (*Pyrus communis* L.)

D. O. KETCHIE, E. D. FAIRCHILD, AND F. R. DRAKE

Abstract

'Anjou' flowers were hand pollinated from 12 different varieties of pears during 1990, 1991 and 1993. There was a wide range in the bloom period of the different cultivars. 'Eldorado' and 'Bosc' pollen had the best viability. Pollen from 'Bartlett', *Pyrus calleryana* and 'Nijissecki' induced the most fruit set in 1990; however, there was no difference in 1991 or 1993. By hand pollinating, no relation was seen between pollen viability and fruit set. It is suggested that for best fruit set in 'Anjou' orchards, hand pollination should be practiced and/or the orchards should have at least 3 pollenizer varieties covering 'Anjou' bloom period. Seed numbers were highest in fruit that had been pollinated with pollen from 'Old Home' x 'Farmingdale' (OH x F) 333 and OH x F 69. Fruit size was different only in 1991 when the largest was from flowers receiving pollen from 'Nijissecki', 'Anjou' or OH x F 333. Fruit size was not related to seed number. No differences were found in quality studies including firmness, soluble solids, internal color, external color and titratable acidity which shows that metaxenia does not exist in 'Anjou' pears.

Production instability due to inconsistent fruit set is a major problem in pear production. This is especially true for the variety 'Beurre d'Anjou', *Pyrus communis* L. The presence of many flowers on 'Anjou' pear in the spring is quite evident but a very low percentage of these flowers set fruit. Pollination is a problem in setting 'Anjou' fruit. Many pears cultivars are not self-fruitful, one of which is 'Anjou'. The bloom period for many pear cultivars does not correspond with that of 'Anjou'. Some varieties have pollen with poor germination and poor pollen tube growth. A desirable pollenizing variety would be one with a high rate of pollen viability and a bloom date corresponding to that of 'Anjou'.

Nebel (2) indicated that metaxenia, defined as the physiological effect of

foreign pollen on the maternal tissue of the fruit (4), may exist in pome fruits. Nyecki (3) confirmed this for pears by showing that the pollen source had an effect on size and firmness of the fruit. Westwood (4) claimed metaxenia only exists in fruit for which the seed is the edible portion. If metaxenia does exist in pears, it may be either a direct effect on fruit quality from the pollen source or an indirect effect from the pollen source, such as an affect of seed number on size and firmness.

The objective of this study was to improve fruit set and possibly fruit quality through selective pollination on 'Anjou' pear.

Materials and Methods

'Anjou' trees were divided into 4 replications. Limbs were chosen on each tree, one from each of the major cardinal directions: north, east, south, and west. First bloom and full bloom were recorded for 'Anjou' and all the cultivars used as a pollen source. The hand-pollinated limbs were caged with cheese cloth bags when bloom was at the full white stage. Between full white and first bloom stages, the flowers were emasculated leaving only the pistil on 2 flowers in each cluster. The remaining flowers in each cluster were removed. At full bloom the flowers were pollinated by manually applying pollen with a soft hair brush. Pollen sources used were: 'Anjou', 'Bartlett' or 'Williams' (*P. communis* L.), 'Bosc' (*P. communis* L.), 'Comice' (*P. communis* L.), 'Dawn' (*P. communis* L.), 'Eldorado' (*P. communis* L.), 'Forelle' (*P. communis* L.), 'Old Home' (*P. communis* L.) x 'Farmingdale' (*P. communis* L.), OH x F 69 (*P. communis* L.), a selection of *P. calleryana*, 'Nijissecki' (*P. pyrifolia* Burm.) and a selection of *P. usseriensis* Max. Cages were removed at petal fall.

Pollen was collected between full white and first bloom stages from 12 different varieties of pears for 1990,

1991 and 1993. The inverted flowers were rubbed over a wire gauze and the anthers were collected in a beaker. Anthers were placed in petri dishes on top white filter paper and covered with cheese cloth at room temperature for at least 24 hours to allow them to dehisce, then pollen was placed in marked test tubes and the tubes were stoppered. When not being used, the pollen was stored at 2°C in the tubes. Part of the pollen collected in 1990 was stored at -4°C in stoppered tubes over CaCl in a dessicator for one year or 2 years.

Viability and pollen tube growth were determined by placing pollen in a 10% sucrose solution on a spotting plate at room temperature. At 5 and 24 hours later, viability and pollen tube growth were observed under phase microscopy. At each time interval, 100 pollen grains from each sample were counted and the % germination of pollen and average pollen tube length in microns was calculated.

At maturity, the fruit was harvested, counted and weighed. Fruit set is presented as number of fruit per 100 clusters. Pears for post harvest analysis were held in regular atmosphere storage at 1°C.

Table 1. Pollen viability of pollen collected 3 different years from select pear cultivars.

Cultivar	1990		1991		1993	
	5 hrs	24 hrs	5 hrs	24 hrs	5 hrs	24 hrs
	(%)		(%)		(%)	
Anjou	10	17	15	14	18	13
Bartlett	13	30	1	0	18	11
Bosc	16	26	39	44	1	
<i>P. calleryana</i>	4	6	10	2	11	6
Comice	11	14	14	13	5	12
Dawn	16	15	10	15	3	
Eldorado	59	73	1		20	37
Forelle	2	4	3	3	2	0
Nijissecki	2	5	0	0	0	2
<i>P. usseriensis</i>	2	3	1	2	1	
OH x F 333			45	41	10	16
OH x F 69			18	64	6	7

¹Pollen was not collected for these cultivars for that particular year.

After 4 months, 20 pears per sample were removed for each treatment. Half the pears were evaluated immediately and the other half were held for 7 days at room temperature before evaluation. Fruit quality factors evaluated were firmness, subjective and objective external and internal color, number of seeds, soluble solids and titratable acidity. Firmness was determined by the TA-XT2 Texture Analyzer (Scarsdale, NY) equipped with a 7.8 mm probe and values are reported in newtons. External and internal color was determined with a CR 300 Minolta Chromometer (Osaka, Japan) using a Hunter L, a, b system and calculated Hue values (Hunter and Harold, 1987). Three values for external color were determined around the circumference of the fruit. Internal color was measured by cutting each fruit in half horizontally and immediately reading the exposed flesh surface of the calyx half. Seeds were counted in the halves of the fruit used to determine internal color. Titratable acidity was determined using the Radiometric titrator, Model TTT85 (Radiometer, Copenhagen). Juice prepared from fruit samples was titrated to pH 8.2 with 0.1 N

NaOH and values expressed as % malic acid. Soluble solids concentration on the extracted juice was determined with an Abbe-type refractometer calibrated at 20°C. Fruit were also visually assessed for physiological disorders by laboratory personnel cognizant with pear characteristics.

Results

Bloom period for all pears varied between years (Table 1). Bloom occurred early in April 1990, mid-April in 1991 and late April in 1993. 'Bartlett,' 'Forelle' and 'Nijissecki' corresponded closest to bloom of 'Anjou' all 3 years. *P. usseriensis* bloomed much too early to be used as a pollinator in the field. *P. calleryana* bloomed earlier than 'Anjou' in 1990 and 1991 but covered the first part of 'Anjou' bloom quite well. 'Bosc,' 'Comice,' 'Dawn,' 'Eldorado,' OH x F 69 and OH x F 333 bloomed during the later part of 'Anjou' bloom and a short time after.

Pollen viability varied between varieties and years; however generally, 'Eldorado,' OH x F 333, OH x F 69 and 'Bosc' had the highest % germination (Table 2). 'Bartlett,' 'Comice,' 'Dawn' and 'Anjou' were intermediate in ger-

Table 2. Comparison of viability between fresh pollen and stored pollen.

Cultivar	1990				1991			
	Fresh		Stored 1 yr ¹		Fresh		Stored 2 yrs ²	
	5 hrs	24 hrs	5 hrs	24 hrs	5 hrs	24 hrs	5 hrs	24 hrs
	(%)		(%)		(%)		(%)	
Anjou	10	17	9	7	15	14	8	5
Bartlett	13	30	23	43	1	0	0	0
Bosc	16	26	11	6	39	44	14	7
<i>P. calleryana</i>	4	6	5	3	10	2	0	0
Comice	11	14	8	10	14	13	4	5
Dawn	16	15	11	14	10	15	0	0
Eldorado	59	73	0	0	³			
Forelle	2	4	0	0	3	3	0	0
Nijissecki	2	5	0	1	0	0	0	0
<i>P. usseriensis</i>	2	3	0	0	1	2	0	0
OH x F 333	³				45	41	0	1
OH x F 69	³				18	34	0	0

¹Pollen collected in 1990 and tested in 1991.

²Pollen collected in 1991 and tested in 1993.

³Pollen not collected for these cultivars for that particular year.

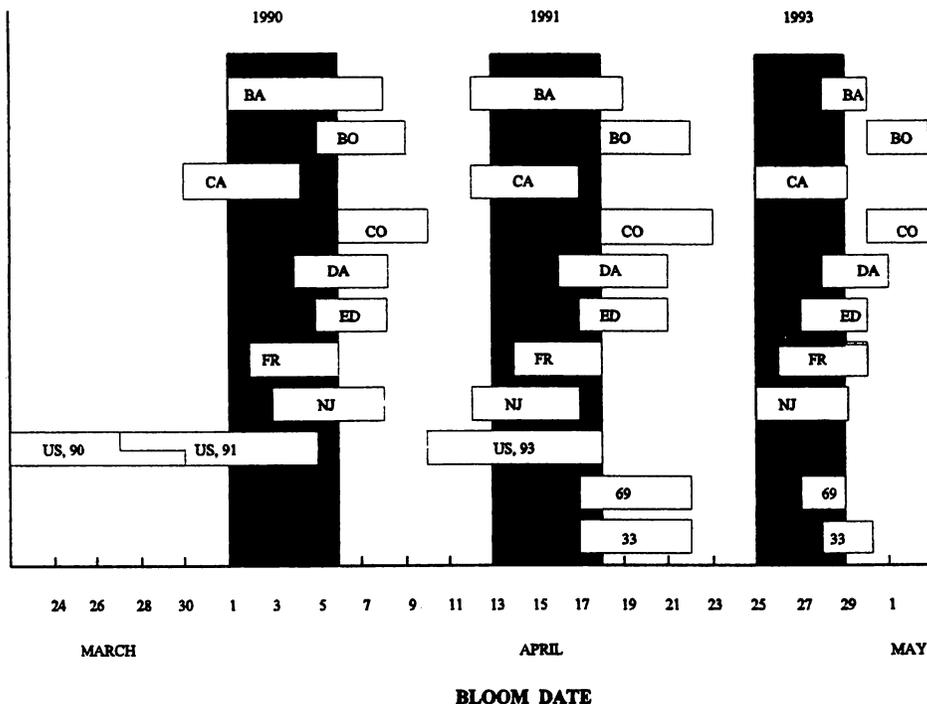


Figure 1. Bloom dates of selected pear cultivars for 1990, 1991 and 1993. Left end of bar represents first bloom and the right end of the bar represents full bloom. The black, vertical bar represents 'Anjou' bloom for the year shown above the bar. The other cultivars for the particular year are grouped close to the 'Anjou' except *P. usseriensis* where the year is given. BA-'Bartlett', BO-'Bosc', CA-*P. calleryana*, CO-'Comice', DA-'Dawn', ED-'Eldorado', FR-'Forelle', NJ-'Nijissecki', US-*P. usseriensis*, 69-OH x F 69 and OH x F 333-33.

mination. 'Forelle', 'Nijissecki', *P. calleryana* and *P. usseriensis* had the lowest rate of germination. In most cases the viability trend that existed at the 5 hr reading carried through in the 24 hr reading; however, *P. calleryana* pollen incubation period appeared to be more optimum at 5 hrs rather than 24 hrs. When pollen was stored for 1 year at -4°C , it lost viability and lost even more viability when stored for 2 years (Table 3). 'Bosc', 'Anjou' and 'Comice' pollen was the only one that germinated after 2 year's storage. 'Bartlett', 'Dawn' and *P. calleryana* still showed reasonable viability after 1 year. The remainder of the pollen tested did not have any viability after storage for one year.

Pollen tube growth of OH x F 333, OH x F 69, 'Bosc' and 'Eldorado' paralleled germination (Tables 2 & 4). 'Dawn' and 'Bartlett' were intermediate. 'Bartlett' retained a very high rate of pollen tube growth after 1 year at -4°C storage (Table 5). 'Anjou', 'Bosc', *P. calleryana*, 'Comice' and 'Dawn' retained a good rate of growth. After 2 years of storage, only Anjou, 'Bosc' and 'Comice' pollen germinated and grew (Table 5).

There was significant difference in fruit set during 1990 but no differences in 1991 and 1993 (Table 6). 'Bartlett', 'Nijissecki', *P. usseriensis* and *P. calleryana* had the highest % of set in 1990. Pollen collected in 1990 and used in 1991 did show some differences in

Table 3. Pollen tube growth collected 3 different years for selected cultivars of pears.

Cultivar	1990		1991		1993	
	5 hrs	24 hrs	5 hrs	24 hrs	5 hrs	24 hrs
	(microns)		(microns)		(microns)	
Anjou	4.1	5.0	4.1	9.0	3.4	8.3
Bartlett	8.0	16.0	0	0	12.9	18.6
Bosc	5.0	9.1	33.8	49.0	5.3	18.2
<i>P. calleryana</i>	2.7	4.7	9.7	0	3.2	11.6
Comice	4.2	5.0	9.6	25.5	7.9	10.0
Dawn	6.3	9.7	19.7	26.4	5.4	3.6
Eldorado	16.3	33.7	1		15.1	41.5
Forelle	3.4	5.6	4.6	10.0	6.5	0
Nijissecki	3.2	5.3	0	0	0	19.0
<i>P. usseriensis</i>	3.2	9.5	8.3	20.1	1	
OH x F 333	1		72.9	92.7	4.4	27.6
OH x F 69	1		32.2	66.8	7.4	14.1

¹Pollen was not collected for these cultivars for that particular year.

fruit set. Stored 'Comice' and 'Dawn' pollen produced the highest % set while the stored *P. calleryana* and 'Eldorado' pollen produced the least % set.

There was a significant difference in fruit weight only in 1991 (Table 7). Fruit produced from 'Nijissecki' pollen was the largest and that derived from *P. calleryana* and 'Dawn' were the smallest fruit in 1991. In 1991 and 1993, seed number in OH x F 69 was

Table 5. Fruit set of 'Anjou' pear after hand pollination by pollen from selected pear cultivars.

Cultivar	1990	1991		1993
	Fresh	Fresh	Stored ¹	Fresh
	(%)	(%)	(%)	(%)
Anjou	10d ²	30 ³		4
Bartlett	65a	14	22cd	39 ³
Bosc	4		32bc	4
<i>P. calleryana</i>	63a	29	20d	50
Comice	4	52a	4	4
Dawn	30b	33	41ab	45
Eldorado	4	25	12d	31
Forelle	20c	24	21cd	27
Nijissecki	50ab	20	31bc	55
OH x F 333	4	29	4	36
OH x F 69	4	21	4	33
<i>P. usseriensis</i>	45ab	24	23cd	4

¹Pollen collected in 1990.

²Mean separation in columns by Duncan Multiple Range test, 5% level.

³Values in these columns not significant.

⁴'Anjou' flowers were not pollinated by that cultivar that particular year.

highest with 7 and 6 respectively. 'Eldorado' was equal to OH x F 69 in 1993 but had the least number of seeds in 1991. 'Anjou' and 'Bartlett' did not have seeds and *P. calleryana*, 'Forelle' and 'Nijissecki' also had fewer number of seeds than the other varieties in 1991. 'Anjou', *P. calleryana* and

Table 4. Comparison of pollen tube growth between fresh and stored pollen.

Cultivar	1990				1991			
	Fresh		Stored 1 yr ¹		Fresh		Stored 2 yrs ²	
	5 hrs	24 hrs	5 hrs	24 hrs	5 hrs	24 hrs	5 hrs	24 hrs
	(microns)							
Anjou	4.1	5.0	3.5	9.3	4.1	9.0	7.2	16.3
Bartlett	8.0	16.0	31.9	60.4	0	0	0	0
Bosc	5.0	9.1	15.9	15.9	33.8	49.0	5.3	18.2
<i>P. calleryana</i>	2.7	4.7	8.8	15.4	9.7	0	0	0
Comice	4.2	5.0	15.1	14.2	9.6	25.5	4.9	5.8
Dawn	6.3	9.7	11.3	16.2	19.7	26.4	0	0
Eldorado	16.3	33.7	0	0	³			
Forelle	3.4	5.6	0	0	4.6	10.0	0	0
Nijissecki	3.2	5.3	0	9.2	0	0	0	0
<i>P. usseriensis</i>	3.2	9.5	0	0	8.3	20.1	0	0
OH x F 333	³				72.9	92.7	0	0
OH x F 69	³				32.2	66.8	0	0

¹Pollen collected in 1990 and tested in 1991.

²Pollen collected in 1991 and tested in 1993.

³Pollen was not collected for these cultivars for that particular year.

Table 6. Fruit size and number of seeds of 'Anjou' pear hand pollinated with pollen from selected pear cultivars.

Cultivar	1990		1991		1993	
	Fruit wt (gms)	Fruit wt (gms)	Seeds (no)	Fruit wt (gms)	Seeds (no)	Fruit wt (gms)
Anjou	211	235ab ¹	0d	161	1b	
Bartlett	179	205bc	0d	201	3ab	
Bosc	2	205bc	4c	2		
<i>P. calleryana</i>	209	187c	4c	214	2b	
Comice	2	2		190	5a	
Dawn	195	193c	5bc	217	3ab	
Eldorado	2	219bc	4c	185	5a	
Forelle	202	199bc	3c	220	2b	
Nijissecki	186	258a	4c	223	3ab	
<i>P. usseriensis</i>	199	220bc	5bc	2		
OH x F 333	2	200bc	6ab	147	3ab	
OH x F 69	2	224ab	7a	218	6a	

¹Mean separation in columns by Duncan Multiple Range test, 5% level.

²Fruit was not collected for these cultivars for that particular year.

'Forelle' had the least number in 1993. There was no correlation (correlation coefficient 0.054) between seed number and fruit weight in 1991 or 1993. Seeds were not counted in 1990.

Pollen source did not effect firmness, external color, internal color, soluble solids or titratable acidity for 1991 or 1993 (Table 7). There were differences between the years.

Table 7. The effect of pear pollen from selected cultivars on the fruit quality of 'Anjou' pear.

Pollen Source	Color				Firmness		Soluble Solids		Titratable Acidity	
	E Hue		I Hue		1991	1993	1991 (%)	1993 (%)	1991	1993
	1991	1993	1991	1993						
Anjou	27.27	108.9	97.89	98.03	11.22	5.49	13.38	14.44	0.321	0.309
Bartlett	50.66	109.0	97.69	98.66	12.75	5.35	13.47	14.31	0.310	0.327
Bosc		107.3		99.14		4.05		14.45		0.287
<i>P. calleryana</i>	17.36	108.9	98.32	98.38	11.54	4.86	13.50	14.45	0.309	0.302
Comice		109.9		98.94		4.11		14.17		0.308
Dawn	17.36	110.1	97.93	98.78	10.90	4.28	12.93	14.15	0.299	0.295
Eldorado	12.75	109.7	98.04	99.39	10.95	4.34	13.30	14.23	0.269	0.292
Forelle	35.55	108.0	97.68	98.62	12.00	4.46	13.56	14.53	0.293	0.320
Nijissecki	65.20	115.4	102.20	98.92	11.70	4.98	13.23	14.23	0.315	0.324
<i>P. usseriensis</i>		20.12		98.38		11.28		13.33		0.307
OH x F 333	71.61	109.5	97.84	98.36	10.72	4.58	13.30	14.33	0.304	0.298
OH x F 69	1.24	117.0	97.67	97.15	10.08	5.39	13.23	14.49	0.299	0.320
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Discussion

There were large differences in pollen germination and pollen tube growth between the different sources, but only in 1991 was there an effect on fruit set (Table 2, 4 and 6). Even in 1990 when there was a difference in fruit set, 3 of the pollen sources that had the highest fruit set, (i.e. *P. calleryana*, 'Nijissecki' and *P. usseriensis*) also had the lowest germination and pollen tube growth. 'Bartlett' did have a high percent of fruit set and moderate germination and pollen tube growth in 1990. Pollen stored at -4°C for 1 or 2 years had a lower % germination and shorter pollen tube growth than the fresh pollen (Table 3 and 5) but fruit set in the field was equal and sometimes better than fresh pollen (Table 6). It only takes a few viable pollen grains to fully pollinize a flower. These flowers were hand pollinated and hundreds of pollen grains were placed directly on the stigmas. Much less than 1% would have to germinate and grow to properly pollinize a flower. Hand pollination may be one of the best methods to set fruit on 'Anjou' pears (E. A. Stahly, unpublished data).

Bloom dates differ in various pear varieties spread over a long period (Table 1). Multiple pollinizers, at least

3, covering the bloom period of 'Anjou' may insure good pollination. An example would be to have *P. calleryana* to cover the early bloom period, 'Bartlett' to cover the main bloom period and 'Bosc' to cover the later part of the bloom period of 'Anjou.'

In 1991 and 1993, there were differences in seed count but a difference in fruit weight was reported only in 1991 (Table 7). Seed count differences are a direct result of the number of ovules fertilized. Since the weight differences only occurred 1 out of 3 years, it may have been by coincidence. There were no differences in firmness, external color, internal color, soluble solids or titratable acidity during the 3 years.

As there was no solid evidence from this study supporting the existence of metaxenia, (i.e. effect of the pollen source on quality), in 'Anjou' pear, agreement is more with Westwood (4) than with Nebel (2) or Nyecki (3).

Literature Cited

1. Hunter, R. S. and R. W. Harold. 1987. The measurement of appearance. 2nd Edition. John Wiley & Sons. NY.
2. Nebel, B. R. 1930. Xenia and metaxenia in apples. N. Y. Ag. Expt. Sta. Technical Bul. 170. 16 pp.
3. Nyecki, J. 1972. Metaxenia studies of pear varieties. Act Agronomica Scientiarium Hungarica, Tomus 21:75-89.
4. Westwood, M. N. 1978. Temperate-zone Pomology. W. H. Freeman and Co., San Francisco. 428 pp.

Fruit Varieties Journal 50(2):124-130 1996

Influence of Eight Rootstocks on the Performance of 'White Riesling' and 'Cabernet Franc' Over Five Years

D. C. FERREE, G. A. CAHOON, M. A. ELLIS, D. M. SCURLOCK, AND G. R. JOHNS¹

Abstract

'White Riesling' clone Niederhausen 378 and 'Cabernet Franc' were established in 1988 on the following eight rootstocks at Kingsville, OH near Lake Erie: own rooted, 3309C, 101-14 Mgt., 5C, 1616E, SO4, 18-815C and 5BB. 'Cabernet Franc' on its own roots had a lower cumulative yield and cluster number than on any other rootstock. Own rooted 'Riesling' also had low yields along with 'Riesling' on 101-14 Mgt., 1616E and 5BB. There was an interaction with yield and cluster number due to the much higher yields on 1616E and 5BB with 'Cabernet Franc' compared to 'Riesling.' 'Riesling' on 3309C, 5C, SO4 18-815C and 5BB had three times the cumulative pruning weight than own rooted vines. 'Cabernet Franc' on SO4 had very low cumulative pruning weights. No interaction between rootstock and cultivar occurred for cluster and fruit quality data. Own rooted vines had small clusters with smaller and fewer berries. Vines on SO4, 5C and 18-815C tended to

produce large clusters with more berries. Soluble solids in berries from 101-14 were higher than from berries on 1616E and 5BB. Over five years, juice pH from fruit on 3309C, 5C and SO4 was higher than juice from 1616E. Rootstock had no effect on total acidity. 'Cabernet Franc' had higher pruning weights and yields than 'Riesling,' but did not survive the low winter temperatures as well and had more crown gall.

Introduction

Although most American type grapes are grown commercially on their own roots, *Vitis vinifera* cultivars are commonly grown on rootstocks, due to phylloxera, an insect inadvertently exported to Europe from the United States (8, 13). Since native American species survived in concert with phyl-

Salaries and research support provided by state and federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University, Journal Article No. 114-95.

¹Present Address: Horticulture & Crop Science, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster, OH 44691.