growth are critical factors in the establishment of new orchards (4, 5).

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Effects of Rootstocks on Wine Grape Scion Vigor, Yield, and Juice Quality

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Additional index words. Juice pH, °Brix, total acids, hardiness, *Vitis*

Abstract. **Forty cultivars of wine grapes (*Vitis spp.*) grafted on 'Dogridge' and 'Couderc 1613' rootstock and self-rooted vines were planted in 1974 at the Texas Agricultural Experiment Station near Lubbock. From fourth to 13th leaf vines were evaluated for vigor, winter hardiness, yield, and juice quality (°Brix, pH, and acids). Although each cultivar responded differently to rootstock, some general observations are made regarding acceptance or rejection of stocks. Compared to self-rooted cultivars, 'Dogridge' significantly increased vigor on 37% of cultivars while reducing vigor on 7%, reduced winter hardiness on 22% while increasing hardiness of 7%, and reduced yields on 32% while increasing yields on 17%. The most detrimental effect of the 'Dogridge' rootstock was on pH, which was increased on 50% of cultivars while reduced on none. In comparison, 'Couderc 1613' expressed more moderate effects on most scion cultivar parameters tested.**

Rootstocks are commonly used in grape production to provide resistance or tolerance to various production problems, including phylloxera, rootknot nematode, and cotton rootrot. Phylloxera resistance has been researched extensively over the past 100 years, with the general conclusion that *Vitis vinifera* L. cultivars grown in phylloxera-infested areas require resistant stocks to sustain adequate growth and production (11, 14, 19). Considerable research also is available relating to the importance of root-knot nematode resistance for vines grown in nematode-infested soils (8, 17, 19). Although limited, some research is available concerning rootstock resistance to cotton rootrot (18, 20–22). Most conclude that the increase in growth and yields from vines propagated on resistant stocks grown in infested soils is because these stocks overcome the losses attributed to pest pressure. The intrinsic value of these stocks on other parameters (vigor, winter hardiness, yield, quality), in the absence of pest pressure, has not been well-established.

Shaulis (23) attributed the "apparent" positive vigor response of 'Concord' on 'Couderc 3309' rootstock to lack of fruitfulness induced by the 'Couderc 3309' rootstock, and stated that it was the lack of fruit load that caused the increased vigor and not the rootstock per se. He stated that American and hybrid cultivars are less likely to respond to rootstock induced vigor than are *V. vinifera* cultivars, presumably because they are less susceptible to pest pressures. Harmon and Synder (8) found that, in root-knot nematode-infested soil, the scion cultivar Sultanina (*V. vinifera*) was significantly more vigorous on 'Dogridge' rootstock than on 'St. George' or self-rooted. Both vigor and yield were higher on 'Dogridge'. Vigor and yield on 'St. George' were lower than for self-rooted vines. There was some doubt expressed about the nematode infestation. Lider et al. (13, 14) found that scions on 'St. George' were low-yielding but excessively vigorous. Cook and Lider (4) found that scion petiole nitrate was increased by 'St. George' rootstock and they correlated increased petiole nitrate levels with increased vigor of the scion on 'St. George' rootstock. No reference was made to pest pressure. Randolph (22) found that 'Dogridge' rootstock increased the vigor of 'Carmen', 'Virginia', and 'Delaware' grapes by 49% to 81%. Again, no reference was made to pest pressures. These inconsistencies in rootstock contributions to vigor may be attributed to several factors, including scion/rootstock graft union compatability (11); vigor balance of stock to scion under unique environments (11); vine spacings (10); soils, cultivation, nitrogen, and crop load (23); water availability (7); and the presence or absence of pest pressure (19).

Effects of rootstocks on yield (without pest pressures) are likewise not well-established. The vigorous 'St. George' decreased yields (8, 14), whereas the vigorous 'Dogridge' in the same trial increased both yield and vigor (8).

Another parameter of primary concern where *V. vinifera* are produced in harsh winter environments is the effect of rootstock on winter survival. No literature was found on this topic, although Howell and Shaulis (9) found that those factors that contributed to

Table 1. Grape cultivars included in the 1974 cultivar rootstock planting at Texas Agricultural Experiment Station, Lubbock.

Vinifera	Hybrid
Aligote	Baco Noir
Barbera	BS 2862
Burger	Marechal Foch
Carignane	Chambourcin
Chenin Blanc	Landal
Flora	Landot 4511
French Colombard	Ravat 51
Grenache	Aurore
Gray Riesling	Planet
Helena	Chancellor
Petite Sirah	Colobel
Peverella	Verdelet
Royalty	Chelois
Rubired	Seyval Blanc
Red Veltline	Roucaneuf
Souzao	Villard Blanc
Turiga	Vidal Blanc
White Riesling	American
Zinfandel	Canada Muscat
	Missouri Riesling
	Wine King

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winter hardiness of cultivars were early maturity (dark periderm development) and lack of vigor (medium cane diameter and lack of persistent lateral canes).

Effects of rootstocks on fruit qualities are well-documented on many other fruit and nut crops (5, 6, 15), but poorly documented on wine grapes. Shaulis (23) reported rootstock effects on quality were similar to other vine-size increasing treatments, but only °Brix was used to define quality. Jackson (12) concluded from fruited cuttings that increased pH with extended shoot growth was not mediated by lack of light exposure, but was a direct response to shoot growth.

In recent years, pH has been recognized as a key parameter in determining the wine quality potential of mature grapes as pH imbalance results in instability in the wine (2, 3, 16, 24). The objective of the current research was to determine the intrinsic effects of rootstocks on scion vigor, winter survival, yield, and juice quality in the absence of pest pressure.

A cultivar/rootstock planting was initiated in 1974 at the Texas Agricultural Experiment Station near Lubbock. The trial included *V. vinifera*, American, and hybrid cultivars (Table 1) grafted on 'Dogridge' and 'Couderc 1613' rootstocks and self-rooted. The cultivars were selected to provide a wide range of genetic material for areas of Texas where grapes had not previously been grown. Rootstocks were selected to overcome anticipated problems with cotton rootrot, phylloxera, and nematodes. Vines were planted 2.3 m apart in 3-m rows. Each cultivar/rootstock combination was replicated three times in split plot experimental design with one vine per plot.

The soil was a deep, well-drained Olton series fine sandy loam (Aridic Paleustolls, fine mixed thermic) with pH 7.3–7.7. Annual fertilizer applications averaged 5 to 7 $kg \cdot ha^{-1}N$ as $(NH_4)_2SO_4$. Irrigation (by drip) averaged 7.6 cm/year and rainfall 46 cm. The planting was on a high plain (984 m elev.) (3231 ft) with mean temperatures of 15° to 15.5°C (59°C to 60°F) and growing degree-day heat summations (1 Apr.–31 Oct.) of 4000 to 4200. As it was a new grape production area, there was a freedom of phylloxera and cotton rootrot (19), and these particular soils were free of rootknot nematodes. No evidence of infestation or differential injury was observed during the trials. Vines were trained to a four-arm Kniffin system with cordon/spur pruning (four cordons) for *V. vinifera* cultivars and cane pruning for all others.

Data were recorded annually for winter injury, vine vigor (canopy size), yield, and fruit quality. Winter injury and vigor ratings were made at the time of pruning. Because resources precluded actual weighing of wood and counting buds for every vine, a rating system was employed to rate vigor and adjust dormant-season pruning level to the vigor level of individual vine, based on visual evaluation of the preceeding season's growth. Occasional checks were conducted by weight for a guide. The essentials of this system are included in Table 2. Likewise, vines were rated for winter injury. The following ratings were assigned: 1 = vines dead to lower trunk; 2 = one or both upper or lower arms dead; 3 = some entire canes dead to basal buds; 4 = canes dead to 0.9 cm wood; and 5 = cambium alive to the tip of smallest wood. This rating was made at pruning and later upgraded after budbreak.

Table 2. System employed to evaluate vigor and adjust pruning to the past season's growth.

	Predominant cane sizes		Pruning level imposed		
Vigor rating	Diam (cm)	Length (m)	Spurs/vine	Buds/spur	Buds[z]
1	<0.6	<0.3	10	1	10
2	0.6–1.0	0.3–1	12	1 to 2	12–24
3	1 –1.5	1 –1.5	14	2	28
4	1.5–2	1.5–2	14	2 to 3	28–42
5	>2	>2	14	3	42

[z]Equal number of buds left on cane-pruned vines.

Table 3. Analyssi of variance table of 10 years of data across all cultivars on cultivar/rootstock planting Texas Agricultural Experiment Station, Lubbock.

	Significance					
Variable	Vigor	Winter hardiness	Yield	°Brix	pH	Total acids
Cultivars	***	***	***	**	***	***
Rootstocks	***	**	***	NS	***	***
Cultivar × rootstocks	***	***	***	NS	***	*
Rootstock – interaction[z]	**	NS	**	NS	***	**

[z]Interaction term partitioned out (Alder and Rosessler).

*,**,***,NSSignificantly different at the 5%, 1%, and 0.1% levels and not significant, respectively.

Beginning at fourth leaf, fruit were harvested from each vine at 20°Brix, weighed, and analyzed for juice composition. A six-cluster sample was taken at random from the harvest container, destemmed, macerated 15 sec in a Waring blender, and filtered through cheesecloth. A 25-ml sample of filtered juice was analyzed immediately for sugars by refractometer, pH by lab pH meter, and total acids by titration to the 8.3 pH endpoint with 0.1 N NaOH. All data were analyzed as a split-plot by analysis of variance and means separated by orthogonal single-degree-of-freedom comparisons.

There were highly significant cultivar differences for all parameters measured (Table 3). The differences between cultivars in °Brix occurred in spite of the effort to harvest individual vines at 20°Brix. The failure to achieve this goal was due primarily to the differential susceptibility of cultivars to Botrytis bunch rot and the need, in wet years, to harvest susceptible vines prior to 20°Brix to avoid complete losses to rot. Rootstocks also resulted in highly significant differences for all parameters measured except °Brix (no difference was anticipated as we harvested by °Brix). There was a highly significant cultivar–rootstock interaction, indicating a differential response of cultivars to rootstocks for every parameter measured except °Brix, where rootstocks had no effects on °Brix at harvest. When the cultivar × rootstock interaction degrees of freedom were partitioned [Alder and Rosessler technique (1)], there remained rootstock differences for vigor, yield, pH, and total acids. This significant difference implies only that the means of these parameters for all cultivars together for 10 years were different for rootstocks and self-rooted vines. To determine specific effects of rootstocks on each cultivar, orthogonal comparisons were performed for rootstock effects on each individual cultivar for every parameter for the 10 years from 1977–1986 (Tables 4 and 5). The data support the statement by Nesbitt (19) that stock–scion interactions are specific for scion cultivar and in each environment and are not predictable. Although each cultivar–rootstock combination must be considered individually, some general observations can be made regarding the possible acceptance or rejection of these rootstocks in this environment. For 92% of cultivars tested, the 'Dogridge' rootstock produced vines that were as vigorous or more vigorous than self-rooted vines (Table 4). There was no significant correlation between vigor and yield when comparing all cultivars, because, in some instances, the more vigorous vines on 'Dogridge' rootstock suffered increased winter injury and yields were decreased (i.e., 'French Colombard', 'Grey Riesling', 'Landal'), whereas, in other instances, the more vigorous vines on 'Dogridge' had increased yields (i.e., 'Chenin Blanc', 'Grenache', 'Ravat'). Yields on 'Dogridge' rootstocks were significantly lower for 27% of the cultivars compared to self-rooted vines. Only 17% of cultivars were significantly higher-yielding on 'Dogridge' rootstock. Probably the most detrimental effect of the 'Dogridge' rootstock was its effect on juice pH. Fifty percent of cultivars had significantly higher pH on 'Dogridge' rootstock compared to self-rooted vines. No cultivars had significantly reduced pH on 'Dogridge' rootstock. The increased pH potentially would be damaging to wine stability (2, 3, 16, 24). Since °Brix was used as an indicator to determine harvest date, some variation in pH may be attributed to differences in actual "maturity". The

Table 4. Orthoganol single-degree-of-freedom comparisons of cultivars on 'Dogridge' or on 'Couderc 1613' vs. selfrooted cultivars from 1977–1986, Texas Agricultural Experiment Station.

	Increase or decrease in parameter											
	on Dogridge						on Couderc 1613					
Own rooted cultivar	Vigor	Winter hardiness	Yield	°Brix	pH	Acid	Vigor	Winter hardiness	Yield	°Brix	pH	Acid
Aligote	+[z]						+		+	+	+	
Aurore	++		(−)(−)(−)		+		++		+		(−)	
Baco Noir			(−)									
Barbera	++					+	+++	+	+			
BS 2862	+	(−)(−)									(−)(−)(−)	+
Burger				+	++	(−)				+	++	(−)(−)
Canada Musc	(−)(−)	(−)(−)	(−)(−)		+	(−)(−)					+	
Carignane									(−)(−)			
Chambourcin	+	+							+++			
Chancellor	+						+++	(−)(−)		(−)		
Chelois		(−)(−)										
Chenin Bl.	++	+	+		+++		+					+
Colobel			++		+				++			
Flora						+						
Marechal Foch			++		+				++		(−)(−)(−)	
F. Colombard	+	(−)	(−)(−)(−)		++		(−)(−)					
Grenache	+++	(−)	+		+							
Grey Riesling	+		(−)(−)(−)		++	+	+++		++			++
Helena			(−)(−)		++		(−)(−)(−)					
Landal	+		(−)(−)		+		+					
Landot 4511		(−)								+		
Missouri Ries			(−)(−)		+				(−)			
Petite Sirah		(−)	(−)		++	+	(−)(−)	(−)(−)				+
Planet												
Peverella			(−)(−)						++			
Ravat 51	+		+	(−)		(−)	++		+++			
Red Veltliner												+
Roucaneuf	(−)(−)	(−)(−)	++		++		+		+++		(−)	
Royalty	(−)(−)				+						(−)	
Rubired		+					++	(−)				
Seyval Blanc	+		+++		++	+						
Souzao					++					+	+	
Touriga			(−)(−)(−)		+++						+	
Valdepena			(−)			++			+			
Verdelet	+++				+						(−)	
Vidal Blanc			(−)(−)				+					
Villard Blanc					+				+			
White Riesling												
Wine King		(−)										
Zinfandel	+										++	

[z]+, ++, +++, or (−), (−)(−), (−)(−)(−) Indicate significant increase or decrease in parameter at 5%, 1% or 0.1% levels, respectively. No sign indicates nonsignificance.

possibility that the higher pH on 'Dogridge' was due to delayed harvest for cultivars on that rootstock is refuted by the fact that 92% of the cultivars expressed equal or higher total acids on 'Dogridge', an indicator of early rather than late harvest (as grapes mature there is an increase in pH and a decrease in total acids).

'Couderc 1613' had a more moderate effect than did 'Dogridge' on most of the variables measured when compared to self-rooted cultivars. Twenty-seven percent of cultivars were more vigorous on 'Couderc 1613' than when self-rooted. Only 7% of the cultivars were less winter-hardy on 'Couderc 1613' as compared to selfrooted, and 30% were significantly higher-yielding. Only 'Carignane' and 'Missouri Riesling' were significantly lower-yielding on 'Couderc 1613' compared to self-rooted. The effect of 'Couderc 1613' on pH was also moderate. 'Couderc 1613' significantly increased the pH on 15% reduced the pH on 15%, whereas the other 70% were not different.

Additional evidence results from comparing a given cultivar on 'Dogridge' vs. that cultivar on 'Couderc 1613' (Table 5). 'Couderc 1613' resulted in significantly higher vigor for 12% of the cultivars and significantly lower vigor for 27% of the cultivars compared to 'Dogridge'. 'Couderc 1613' also generally resulted in more winter hardiness and higher yields compared to cultivars on 'Dogridge' rootstock. Twenty two percent of cultivars on 'Couderc 1613' were more winter hardy than on 'Dogridge', whereas only 2% were less winter hardy. In yields, 27% of the cultivars were higher-yielding on 'Couderc 1613' compared to 'Dogridge,' and 17% yielded less.

Regarding juice quality and, specifically, the pH imbalance problem, 50% of cultivars had significantly lower pH on 'Couderc 1613' than on 'Dogridge' rootstock, with no cultivar on 'Couderc 1613' having a higher pH than on 'Dogridge.'

Rootstocks historically have been used to overcome problems of the soil such as rootknot nematodes, phylloxera, and cotton roototrot. Although considerable recent interest is directed toward the influence of vine vigor on pH and wine stability (2, 3, 12, 16, 24) and of the influence of vine vigor and delayed maturity on winter survival (9), the direct influence of rootstock as it affects a cultivar's vigor, winter hardiness, yield, and pH has not been established. In an area such as the Texas High Plains, where winter injury is the primary production risk and where juice quality is of critical importance to the development of markets, the ideal rootstock would reduce vigor, improve chances of winter survival, maintain yields, and not adversely effect the pH–acid balance. If three of the measured parameters are considered (winter hardiness, yield, and pH) in judging these two rootstocks, 'Dogridge' would be rejected for most of the above cultivars in the High Plains environment. 'Dogridge' rootstock had a positive effect on only two cultivars, whereas, 'Couderc 1613' had a positive effect on 14 cultivars. Positive effect implies that the scion was enhanced in at least one of the three parameters while remaining neutral (not different from selfrooted) in the other two. 'Dogridge' had a neutral effect on nine cultivars, whereas 'Couderc 1613' had no effect on 14 culti-

Table 5. Orthoganol single-degree-of-freedom comparisons of cultivars on 'Dogridge' rootsotock vs. cultivars on 'Couderc 1613' rootstock for 1977–1986, Texas Agricultural Experiment Station, Lubbock.

Cultivar on Dogridge	Increase or decrease on 'Couderc 1613' compared to on 'Dogridge'					
	Vigor	Winter hardiness	Yield	°Brix	pH	Total acids
Aligote						
Aurore		+	+ +		(−)	
Baco Noir						
Barbera	(−)(−)[z]					
BS 2862	(−)	+			(−)(−)	(−)
Burger						
Canada Muscat	+ +	+	+ +		(−)(−)	+ + +
Cariganane			(−)			
Chambourcin			+ +			
Chancellor	(−)(−)	(−)	(−)(−)			
Chelois						(−)
Chenin Bl.					(−)(−)	
Colobel					(−)	
Flora						(−)(−)
Marechal Foch			(−)(−)(−)		(−)(−)	(−)
F. Colombard	(−)	+	+ + +			
Grenache	(−)(−)(−)		(−)(−)		(−)	
Grey Riesling	(−)(−)(−)		+ +		(−)(−)(−)	(−)(−)(−)
Helena	(−)(−)(−)	+				
Landal			+ + +			
Landot 4511	(−)	+ +	+			
Missouri Ries			+ + +		(−)(−)	
Petite Sirah			+ +		(−)(−)	
Planet						(−)
Peverella	+					+
Ravat 51	(−)(−)	+		+		
Red Veltliner						
Roucaneuf		+ +			(−)(−)(−)	
Royalty	+ +				(−)(−)	
Rubired	+					
Seyval Blanc	(−)(−)		(−)(−)		(−)	
Souzao					(−)(−)	
Touriga			+		(−)(−)(−)	
Valdepena					(−)	
Verdelet	(−)(−)(−)		(−)(−)		(−)	
Vidal Blanc	+		+			
Villard Blanc			(−)		(−)	
White Riesling					(−)	
Wine King		+				
Zinfandel						

[z] +,++,+++ or (−),(−)(−),(−)(−)(−) indicates significant increase or decrease of the parameter on 'Couderc 1613' rootstock as compared to the cultivar on 'Dogridge' rootstock at the 5%, 1%, and 0.1% levels, respectively. No sign indicates nonsignificance.

vars. 'Dogridge' rootstock adversely affected 29 cultivars (at least one of the three parameters) compared to 12 cultivars adversely affected by 'Couderc 1613' rootstock.

That 'Dogridge' rootstock should impart vigor to the scion is not a new revelation (8, 22). That increased vigor should result in a high pH also is documented (12, 16, 24). What is different is that the pH of so many cultivars was increased by 'Dogridge' rootstock whether or not there was a corresponding change in vigor, yield, or acid content. The same cannot by said for 'Couderc 1613' rootstock (Table 5). Compared to selfrooted vines, only six cultivars had higher pH on 'Couderc 1613', and none was higher than 'Dogridge'. It should be noted that winter hardiness ratings primarily addressed wood injury and not fruit bud injury. Often the effects of partial vine damage is late-emerging adventitious shoots, which prolong growth into the fall. This extended shoot growth may be responsible for some of the pH response on 'Dogridge' rootstock. Jackson (12) noted that increased pH was caused by extended shoot growth and not by shade and leaf/bunch exposure. Whatever the cause, the data raise some doubt about the potential of 'Dogridge' rootstock except in areas confronted by cotton rootrot. The data also lead to a further search for that rootstock that will reduce scion vigor, increase winter hardiness, maintain yields, improve the pH/acid balance, and be resistant to pests encountered in the area.

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Yields of Tomato Phenotypes Modified by Planting Density, Mulch, and Row Covers

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Abstract. **Bare ground (BG), black polyethylene mulch (ML), and polyester row covers with mulch (MRC), combined with three planting densities, provided increasing levels of cropping intensity to study phenotypic response. Four tomato (*Lycopersicon esculentum* Mill) phenotypes, 'Sub Arctic Maxi' (SAM), 'New Yorker' (NY), UNH-328 (328), and 'Westover' (WVR) represented combinations of small and large plant size and early and late maturity. Early and total yield responses to planting density were linear whether in ML, MRC, or BG treatments, and each phenotype also showed predominantly linear yield increases with increasing density. These linear increases were enhanced in SAM by ML and MRC, but the same mulch and row cover treatments tended to reduce the density response in other phenotypes. The difference was believed to relate to flowering pattern and time relative to vegetative development. Within MRC, compact plants were the most responsive to density in total, but not in early, yield. The predominant effect of ML and MRC was to improve earliness, with each treatment contributing an increment increase in early yield. However, the performance of one phenotype (328) was unchanged by ML or MRC, perhaps reflecting inherent stability.**

Within erratic or unfavorable climates, productivity of plants, particularly those adapted to warm temperatures, has been enhanced by altering the micro-environment. Row covers improve early and total yields of several vegetable crops by increasing soil and air temperatures under the cover, thereby accelerating early growth (1, 6, 12). Black polyethylene mulch may increase early and total yields of tomatoes by modifying soil temperature, moisture retention, nutrient availability, and by suppressing weeds (5, 10, 13). In northern areas, the slight insulative effect of row covers (from 1° to 3°C) may be sufficient to allow planting 2 to 3 weeks before the normal planting date (7). Although plastic mulch and row covers add to production costs, economic efficiency of their use might be improved by increasing planting density. Increases in density generally increase both early and total yields per hectare (3, 4, 8, 9, 14), even though interplant competition for nutrients, moisture, and light may decrease per-plant performance. In some environments, disease and insect pressure may increase as density increases.

Yields of tomatoes grown under row covers have been inconsistent. Flower abortion within overheated row covers or increased competition due to early stimulation of vegetative growth may account for this inconsistency. Competition affects individual plant yield most when it occurs early in the growing season, and competition occurs in high planting densities earlier than in normal spacings (2).

Although the effects of planting density on tomatoes differing in plant growth habit have been reported (4, 9), the extent to which specific genetic traits are important for successful production under row covers has not been examined. The objective of this research was to determine a) competitive effects of increased planting density within increasingly intensive production environments, and b) the possible influence of plant habit and earliness on productivity within these environments.

The experimental design was a split-plot with six replications. The main plots were unmulched control (BG), mulched (ML), and mulched + row cover (MRC). Three planting densities and four phenotypes constituted the split-plots. Each phenotype was seeded in Speedling trays (128 size) in the greenhouse on 10 Apr. for the MRC treatment and field-planted on 16 May. Phenotypes for the remaining treatments were seeded 24 Apr. and transplanted 26 May to avoid frost damage. The MRC treatment therefore reflected both the modified environment under the cover and the early planting date. The rows were placed in beds 1.8 m apart on center and 3.6 m long. Guard plants were placed between consecutive plots, between adjacent main plots, and around the entire trial.

The three planting densities included: a) a single row (control) of plants 0.6 m apart (8963 plants/ha); b) a diamond design constructed of three rows 0.3 m apart in beds, with plants in each row spaced at 1.2 m intervals [the center row plants alternated with those in the outer rows to form the end-points of the diamond (13,444 plants/ha)]; and c) a twin row, with rows and plants within rows spaced 0.6 m apart (17,926 plants/ha), but with plants of one row placed midway between plants of the adjacent row. The areas per plant for each planting density were 1.1, 0.83, and 0.55 m^2, respectively. Standard cultural and pest control systems were used. The field was irrigated when necessary to ensure that the experiment received at least 2.5 cm of water each week until harvest began.

Four tomato phenotypes represented contrasting combinations of earliness and plant habit. The early maturing phenotypes were 'Sub-Arctic Maxi' (SAM), a very early small plant, with mean fruit size of 60 g, and 'New

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