Vineyard Practice

Ronald S. Jackson PhD, in Wine Science (Fourth Edition), 2014

Planting Density and Row Spacing

Although not directly an aspect of training, planting density and row spacing can significantly influence system choice. They also markedly affect vine growth and vineyard economics (Hunter, 1998). Examples are illustrated in Plate 4.3 and 4.4Plate 4.3Plate 4.4.

Regrettably, it is difficult to separate the direct effects of planting density, such as competition for water, from indirect influences of canopy microclimate, or from the impact of unrelated factors, such as the training system and soil structure. The situation is further complicated by vineyards having the same average planting density, but different between- and within-row vine spacing. Thus, vines having similar *average* soil volumes may experience markedly different degrees of root and shoot crowding. These factors probably help explain much of the diversity in opinion and data on the relative merits of various planting densities.

Planting densities commonly used in Europe have changed considerably since the 1850s. Before the phylloxera epidemic, planting densities occasionally reached 30,000 to 50,000 vines/ha (Freese, 1986; Champagnol, 1993). Visual evidence can be seen in paintings of the time, if represented accurately ('September' as portrayed in *Les Très Riches Heures du Duc de Berry*, c. 1416, f.9.v; and a wood cut from Hieronymus Brunschwig, *Liber de Arte Distillandi de Simplicibus*, 1500, see Johnson, 1989 and Unwin, 1991, respectively). Such dense plantings were promoted by the pre-phylloxera habit of vine propagation by layering, and the frequent training of a series of vines in a pyramid-like arrangement around a single stake. Under such conditions, cultivation was manual, due to there being little space for horse- or ox-powered equipment. Values for narrow-row plantings in Europe currently tend to vary between 4000 and 5000 vines/ha, occasionally rising to above 10,000 vines/ha. In California and Australia, common figures for wide-row plantings range from about 1100 to 1600 vines/ha (2700–4000 vines/acre).

Vineyards planted at higher vine densities often, but not consistently, show desirable features, such as improved grape yield and wine color (Table 4.3); the lower productivity of individual vines being compensated for by their greater number and higher photosynthetic efficiency. Improved grape quality is usually explained in terms of limited vegetative vigor (a lower level of bud activation and restricted shoot elongation), and the improved canopy microclimate resulting in enhanced flavor and wine color. These benefits are similar to those of canopy division, i.e., vine devigoration, desirable light exposure, and improved air flow in and around the clusters. What canopy division systems lack is the prestige associated with traditional use.

Table 4.3. Effect of Plant Spacing on the Yield of 3-year-old Pinot noir Vines

Plant spacing (m)	Vine density (vine/ha)	Leaf area (m/vine)	Leaf area (cm^2/g grape)	Yield (kg/vine)	Yield (kg/ha)	Wine color (520 nm)
1.0×0.5	20,000	1.3	22.03	0.58	11.64	0.875
1.0×1.0	10,000	2.7	26.27	1.03	10.33	0.677
2.0×1.0	5000	4.0	28.25	1.43	7.15	0.555

Plant spacing (m)	Vine density (vine/ha)	Leaf area (m/vine)	Leaf area (cm^2/g grape)	Yield (kg/vine)	Yield (kg/ha)	Wine color (520 nm)
2.0×2.0	2500	4.0	15.41	2.60	6.54	0.472
3.0×1.5	2222	4.5	18.01	2.50	5.51	0.419
3.0×3.0	1111	6.3	15.36	4.12	4.57	0.438

Source: Data from Archer and Strauss, 1985, Archer, 1987, and Archer *et al.*, 1988.

One of the advantages of high-density planting is a foreshortening of the time taken for a vineyard to come to full production. This suggests that intervine competition is involved. Increased vine (and bud) numbers per hectare may also provide some protection against yield loss due to winterkill. Although little noted in winery promotional literature, increased yield (see Table 4.3) can be a significant factor encouraging its use. Lower yield per vine has more marketing appeal.

The suppression of vegetative vigor associated with dense planting may result from root competition. Alternatively, it may reflect how the reduced soil volume/vine influences the three nitrate uptake systems. One is most efficient at high nitrate concentrations, whereas the other two function optimally at low nitrate concentrations. Although relative nitrate uptake is enhanced by root restriction, absolute uptake is reduced (Yang *et al.*, 2007). Either way, shoot and root growth are restricted, as they are strongly interrelated.

Dense planting restricts lateral root extension, leading to deeper penetration (Fig. 4.18; Table 4.4). The proportion of fine, medium, and large roots is generally unaffected. Although root mass per vine is reduced, overall root density and total soil volume occupied increases (Kubečka, 1968; Archer and Strauss, 1989; Hunter *et al.*, 1996). This can be of considerable value where vines are planted on hillsides, and in less fertile deep soils under dry conditions. In contrast, high- density planting may result in excessive water-deficit on shallow soils. Moderate water deficit between berry set and *véraison*, by initiating early cessation of vegetative growth, often enhances grape quality.

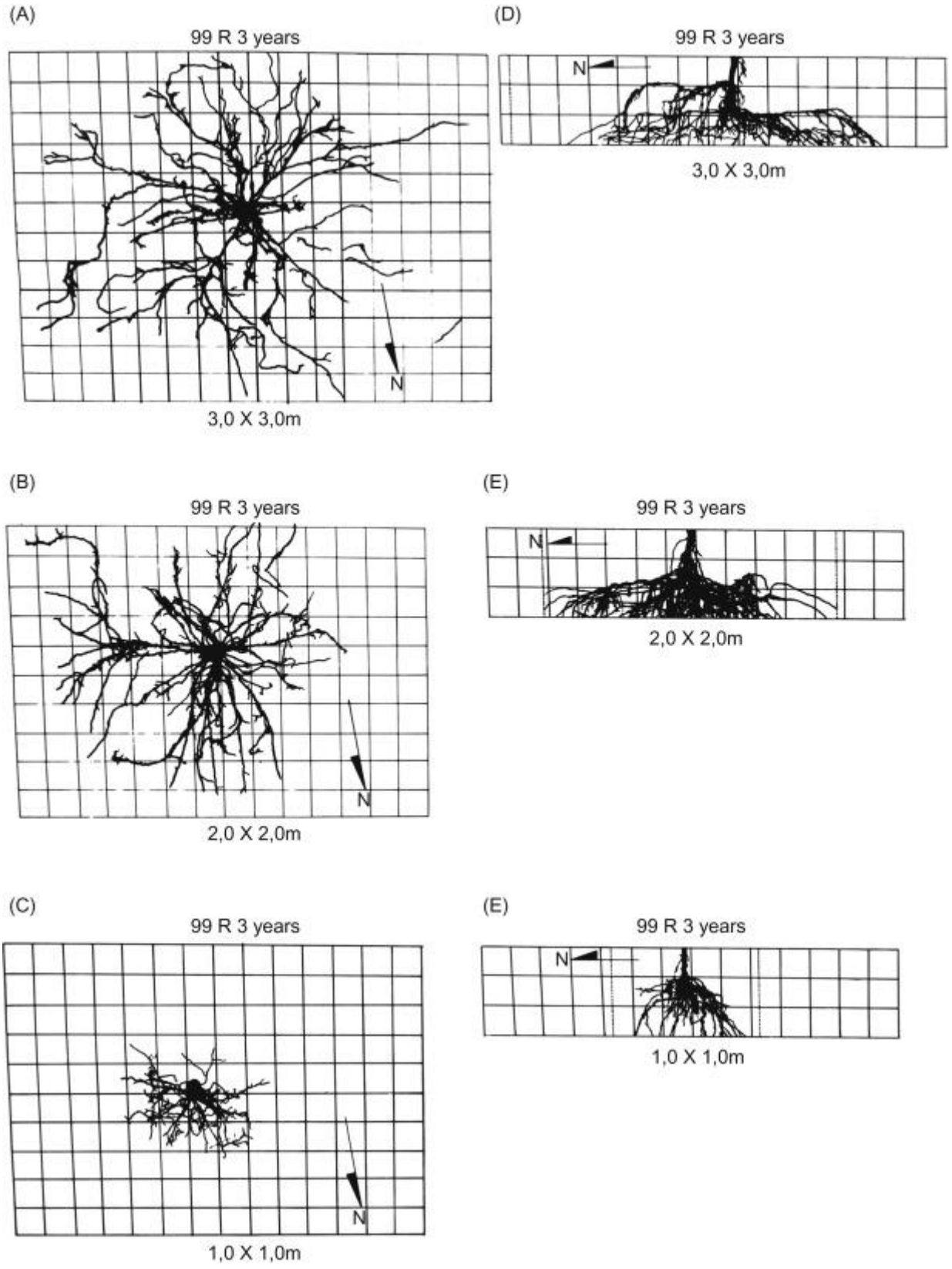

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Figure 4.18. Effect of plant density on vine root distribution. **A**, **B** and **C**: Horizontal distribution. **D**, **E** and **F**: Vertical distribution. Note relative even root distribution around the trunk. Broken lines on vertical distribution depict theoretical available soil. Grid system: 200 mm×200 mm. ●=position of the trunk. (From Archer and Strauss, 1985, reproduced with permission.)

Table 4.4. Effect of Plant Spacing on the Root Pattern of 3-year-old vines of Pinot noir on '99 R' Rootstock

Parameter	Plant spacing (m)					
	3×3	**3×1.5**	**2×2**	**2×1**	**1×1**	**1×0.5**
Primary roots (m)	2.21 (37%)	1.76 (38%)	1.67 (35%)	1.63 (39%)	1.09 (37%)	0.89 (36%)
Secondary roots (m)	2.99 (50%)	2.31 (49%)	2.58 (53%)	1.95 (47%)	1.38 (47%)	1.12 (46%)
Tertiary roots (m)	0.77 (13%)	0.61(13%)	0.59 (12%)	0.56 (14%)	0.46 (16%)	0.46 (18%)
Total root length (m)	5.96×10^3	4.68×10^3	4.84×10^3	4.13×10^3	2.93×10^3	2.45×10^3
Root density (m/m^3)	1.10×10^3	1.73×10^3	2.02×10^3	3.44×10^3	4.89×10^3	8.21×10^3
Angle of penetration	15.3°	22.6°	30.9°	41.1°	58.6°	77.5°

Source: From Archer and Strauss, 1985, reproduced by permission.

In contrast, low-density conditions promote a more extensive, but generally shallower, root system. Low-density plantings are acceptable on fertile soils if there is mild water deficit to restrain excessive vegetative growth (Archer, 1987).

The major disadvantage of dense vine planting is a marked increase in vineyard establishment costs. The expense of planting grafted vines, even at low density, can exceed the cost of all other aspects of vineyard development. Thus, the expense of planting at high density may negate the potential benefits of moderately increased yield and enhanced quality. In addition, improved grape quality is not guaranteed (Eisenbarth, 1992). As noted, the yield/quality equation is neither simple nor direct (e.g., Chapman *et al.*, 2004a,b; 2005). Because increased planting density usually involves the use of narrow rows, additional expense may be incurred by the purchase of special narrow-wheel-base equipment, which is necessary when shifting from low- to high-density planting. Close planting complicates soil cultivation and may increase the need for herbicide use. The requirement for more severe and precise pruning can further add to the maintenance costs of high-density vineyards. Increased expenditures can also result from treating more vines per hectare with protective chemicals. In addition, deep fertile soils may counteract the devigoration produced by vine competition. Finally, the cost/benefit ratio of dense vs. wide planting can vary with the training system, climatic conditions, cultivar characteristics, the need and availability of irrigation water, and the relative marketing value of denoting the use of dense plantings.

A significant feature favoring the retention of wide-row planting, which typifies most New World vineyards, is its adaptation to existing agricultural machinery. With new training systems, widely spaced vines can achieve or surpass the yield and quality of traditional, narrow-row, dense plantings. These features are achieved at lower planting costs, both initially and during replanting. Large vines also appear to live longer than smaller vines. Finally, the more extensive root system of large vines may limit the development of severe water deficit during dry spells.

The major disadvantage of wide-row spacing is its potential for shoot crowding and poor canopy microclimate. In addition, doubling vine row spacing may double the amount of sunlight impacting the ground rather than the vine canopy (Pool, 2000). As noted later, most of these disadvantages can be limited or offset by various vineyard procedures, levering the vine's greater capacity to economic advantage.