Effects of Irrigation and Pruning on 'Concord' Grape Productivity and Seasonal Root Development

Alan N. Lakso[1], David M. Eissenstat[2], Louise Comas[2], and Richard Dunst[1].
[1]Cornell Univ., Dept. of Horticultural Sciences, New York State Agricultural Experiment Station, Geneva, NY 14456. [2]The Pennsylvania State Univ., Dept. of Horticulture, University Park, PA 16802.

Abstract: A trial of heavy vs minimal pruning with and without supplemental irrigation was established in a mature Concord (Vitis labruscana Bailey) grape vineyard in a cool humid climate in Fredonia, New York in 1990. In the main trial minimal pruning gave significantly higher and more stable yields than with balance pruning, but fruit Brix levels were lower. Irrigation had its most positive effects in the minimal pruning treatment, but had few long-term effects on the severe pruning treatment. Clear butyrate minirhizotron tubes were installed in fall of 1996, and seasonal root production patterns were observed with remote video monitoring at 2 week intervals for the past 5 years. Patterns of root production varied from season to season. Root production was not apparently affected by pruning, but was strongly impacted by drought, or irrigation. In irrigated vines, total new root production varied from year to year; the variation in total numbers appeared to be best related to the amount of August root growth as influenced by crop level. Differences in new root production due to drought were primarily related to the lack of a pre-veraison August peak of root growth in the dry treatments. Computer simulations of carbon supply from the canopy and demands of the shoot and crop growth suggest that the pre-veraison period would provide the most available carbon for root growth. Irrigation maintained vine production so that there was carbon available for root growth. Irrigation did not consistently affect fine root lifespan.

Introduction

'Concord' (Vitis labruscana, Bailey) grapevines are grown in the cool, humid climate of Northeastern US primarily near the Great Lakes. The grapes are used mostly for fresh juice, and irrigation has been rare. Since the price paid per ton is relatively low and is the same as it was in 1972, to remain profitable growers have had to increase yields while also reducing production costs. The primary method to accomplish this is to leave more buds at winter pruning, so that the vines will produce more shoots with more crop. An extreme version of this is to essentially not prune the vines except trimming to keep the vines off the ground. This is called "minimal" pruning.

Compared to standard pruning, minimal pruning leads to much earlier canopy development on many more shoots, and heavier crops, typically 20-30% higher (Ralph, 1984; Clingeleffer and Krake, 1992; Pool, 1995). The early canopy development leads to more sunlight interception and thus higher productivity, but also uses more water early in the season. This combination of characteristics, while being very productive in low stress years, predisposes the vines to additional stresses such as drought due to the higher water use and the added stress of heavier crops. Irrigation studies in NY in the 1950's by Dr. Nelson Shaulis found no significant benefit of irrigation in normally-pruned vines with lower crop levels.

These factors led to the hypothesis that the effects of irrigation over time would be much greater on vines with minimal pruning than normally pruned vines. Consequently, studies were initiated in 1990 to examine the effects of supplemental irrigation on vine productivity in three levels of pruning severity over many years. This report covers 12 years of this study.

Additionally, in some vineyards and years, there are significant problems with poor crop development of Concord grapes in the Northeast leading to erratic bearing from year to year. The problems appear to be related to accumulated stresses such as heavy cropping from high node numbers over several years, drought years, etc. One consistent effect of heavy cropping on fruit crops is the reduction of growth of the root system. Yet, no measurements or observations on root systems of native American vines with or without these symptoms have been made. So we have monitored fine root production in this trial since 1997 to examine the effects of pruning, irrigation/drought, and the interactions on fine root production.

Materials and Methods

Plant Materials – The trial was established in a mature, 24-year-old, own-rooted 'Concord' (Vitis labruscana L.) vineyard at the Cornell University Vineyard Laboratory in Fredonia, NY near the shore of Lake Erie. The vines were planted at 2.44 m between vines and x 2.74 m between rows. The vineyard was located on a deep Chenango gravelly loam that was very well drained, had a relatively low water-holding capacity, but was at least 6 m deep.

Vine Management - The vines were trained as high wire cordons at about 1.8 m high. Until the late winter of 1990, all vines were pruned to approximately 80 buds per vine and averaged about 0.8 kg of cane pruning weight per vine after the 1989 season. The vineyard soil management consisted of a 1 m wide clean residual herbicide strip and row-middle glyphosate treatments at bloom (mid-June) each year. This led to a cover of primarily annual natural grasses. In this soil and with this management, vines in adjacent blocks have been found to have significant root numbers down to at least 2 m. Generally, this soil management system is considered to be quite water conservative.

Treatments – Six treatments in a split plot were applied in 1990; three pruning x two irrigation (main plots). The pruning treatments were:

- Balance pruned – 44 nodes per kg of cane pruning weight from the previous season
- 80 Node Constant – 80 nodes per vine (33 nodes/m) every year
- Minimally pruned – Only a low hedging cut at 1 m to eliminate low-hanging canes

The irrigation treatments were:

No irrigation – natural rainfall in the summer averages about 70 mm/month
Supplemental irrigation – applied as drip irrigation at weekly intervals when needed based on neutron probe monitoring and observations of vine appearance, shoot growth rates, leaf gas exchange, or vine stem water potentials.

Root Growth Observations. Fine root production was monitored since 1997 with remote microvideo camera (Bartz Technology, Santa Barbara, CA) photos through 5 cm diameter clear plastic tubes inserted in the soil under the vines in late 1996 (see Comas et al., 2000). This method is called the minirhizotron (McMichael and Taylor, 1987: Taylor, 1987). Observations were made at 14-day intervals from early April until December each year to determine when new fine roots were produced.

Results and Discussion

The rainfall in NY is generally adequate but is very erratic. For the May-September period the long-term total is 450 mm (monthly average rainfall of 90 mm), but can vary from 220 to 780 mm. In the 12 years of the trial the amounts of irrigation applied to the irrigated plots averaged 100 mm varied from 0 to 225 mm.

In the main trial minimal pruning gave significantly higher and more stable yields than with balance or 80 Node pruning, but fruit sugar levels were lower as expected with higher yield. As with the rainfall variation, yields and the effects of irrigation varied from year to year (Fig. 1). With balanced pruning the greatest benefit of irrigation was only about 2 t/ha and those increases only occurred in 3 years. With minimal pruning the increases exceeded 4 t/ha in 5 years and reached a maximum effect of 8 t/ha. Within the minimal pruning replicate plots there were even greater differences related to soil water holding capacity. One plot with better soil never showed a benefit of irrigation while a drier plot showed a long-term 20% increase in yields. There was very little variation amongst plots of the irrigated treatments.

Over the full 12 years of the study, several conclusions could be made. First, the minimal pruning gave 41 and 28% increases in yield over the balance and 80 Node pruning treatments. Additionally, irrigation gave no significant effect on yields of balance or 80 Node-pruned vines, but gave a 9% or 2.2 mT/ha increase in mean annual yields.

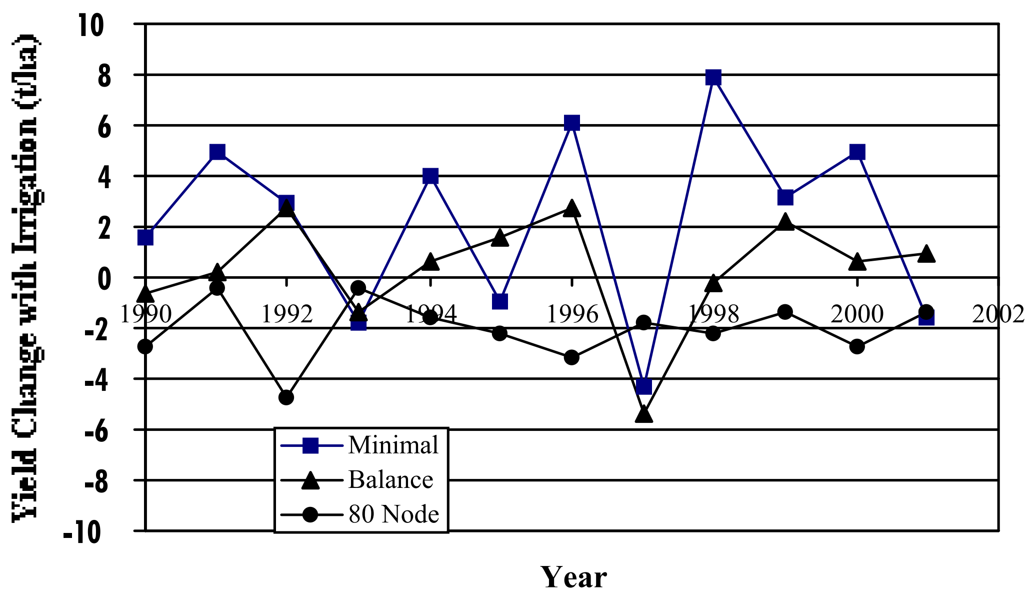

Figure 1. Yearly effects of irrigation vs the non-irrigated 'Concord' grapevines with balanced, 80 Node, and minimal pruning in Fredonia, NY.

Root observations indicated several led to several general conclusions:
• New roots could be produced at many times during the season between April and November, but generally peak root production occurred around bloom in June and again before veraison (the beginning of fruit ripening) in late-July and early-August.

• In dry years new root production was inhibited in dry soil, especially during July and August when droughts are typically the most severe in the Northeast.
• In wet years the numbers of new roots produced were similar, but in a very dry year, 1999, the non-irrigated vines produced only about 1/3 as many roots. McLean (McLean, 1993) also found a strong reduction in grape root growth with dry soil.
• There was no apparent effect of pruning regime on new root production.

From this study in the climate of New York, irrigation is not necessary for normally-pruned 'Concord' grapevines if a conservative soil management is used. With minimal pruning, however, irrigation may be of value, depending on the soil and soil/cover crop management. In this study over 12 years, 12 additional tons of yield/ha generated approximately $7400 of additional income/ha even though the prices per ton for 'Concord' grapes were quite low, averaging only about $275/ton. In a related experiment with mature 'Concord' at the same location, but on a somewhat drier site, irrigation gave 15 and 23 % increases for balance and minimally-pruned treatments, respectively, during a 5-year period when the irrigation in the study reported here gave no increase for balance pruning and an 11% increase with minimal pruning.

In conclusion, the need for irrigation of grapes in a cool humid climate is not assured. It depends not only on the rainfall patterns, but also on other factors, such as pruning and soil type that affect water requirements or soil reserves. To address the need for irrigation, a risk assessment approach for water balance is needed (Lakso, 1999).

Literature Cited

Clingeleffer, P.R. and L.R. Krake. 1992. Responses of Cabernet franc grapevines to minimal pruning and virus infection. Amer. J. Enol. Vitic 43:31-37.

Comas, L.H., D.M. Eissenstat and A.N. Lakso. 2000. Assessing root mortality and decomposition in a study of canopy pruning in Concord grape. New Phytologist 147:171-178.

Lakso, A.N. 1999. Supply and demand: water supply and demand influence vineyard management. Amer. Fruit Grower April:2,4-5.

McLean, M. 1993. The efects of water stress, rootstock, and crop load on carbohydrate partitioning and gas exchange of Seyval grapevines during year one and year two of vineyard establishment. PhD Thesis, Michigan State University.

McMichael, B.L. and H.M. Taylor. 1987. Applications and limitation of rhizotrons and minirhizotrons. p. 1-13. In: H. M. Taylor. Minirhizotron observation tubes: methods and applications for measuring rhizosphere dynamics. Amer. Soc. Agron. Spec. Publ. 50, Madison, WI.

Pool, R.M. 1995. Predicting and controlling crops of machine or minimal pruned grapevines. Ktbl Schrift 11-22.

Ralph, W. 1984. Minimal pruning increases grape production. Rural Research 25-27.

Taylor, H.M. 1987. Minirhizotron observation tubes: Methods and applications for measuring rhizosphere dynamics. ASA Spec. Publ. No. 50. Amer. Soc. Agron, Madison. WI.