The Effects of Pruning Manipulation and Early-Spring Hoop House Use on Hop Production in Southwest Virginia

Justen Dick[1], Emily Belanger[2], Gerald Bresowar[2]

[1] Kelly Ridge Farms LLC., Meadowview, VA; [2] Emory & Henry College, Emory, VA

Introduction

The bulk of America's production of hops (*Humulus lupulus* L.) has been limited to the Pacific Northwest (George 2015). Recently, there has been increasing interest from other regions to develop hop production; spurred largely by the development of the craft brewing industry in the U.S. The financial and regulatory costs associated with interregional hop supply further facilitate interest in the development of more regional and local sourcing.

A major hurdle to hop production in the southeastern U.S. is lower overall production per acre compared to that of traditional production areas. Virginia growers have estimated current average production per acre at approximately 25% of larger Western producers. The ability to achieve an adequate amount of vegetative growth prior to flowering is believed to be a significant barrier to the development of large-scale southeastern hop production. Among the variables controlling vegetative and floral production in hops, photoperiod is identified as a primary limiting factor, with hops being short day/long night plants, and requiring at least 15 hour day lengths for maximum yield. As a result, yields are generally highest between 35th and 55th latitude (Thomas and Schwabe 1969).

Hop cultivation techniques are employed by growers seeking to increase yield and decrease pest prevalence (downy mildew, primarily). Typically plants are pruned early in the growing season in order to provide a barrier to mildew and other leaf pests that overwinter in the soils around the hop rhizomes (Gent et al. 2014). An additional mid-season manipulation of the growing tips (either cut or tied over) ceases vertical growth and is thought to break axillary bud dormancy, leading to increased branching and ultimately increased floral load.

We tested several manipulations on the *H. lupulus* cultivar Cascade in a hopyard in Washington County, southwestern Virginia (Fig. 1), in order to assess the effects of these treatments on vegetative growth. This project was undertaken as a preliminary investigation, with a more focused study based off the results and/or suggested improvements, and implemented during the growing season, 2017.

Resources

Gent, D.H., Grov, G,G, Nelson, M.E., Wolfenbarger, S.N., and Woods, J.L. (2014) Crop damage caused by powdery mildew on hop and its relationship to late season management. Plant Pathology 63: 625-639

George, A. (2015) USA Hops 2015 statistical report. Hop Growers of America, Moxee, WA, USA. http://usahops.org.

Krivanek, J, Pulkrabek, J, Chaloupsky, R, Kudrna, T, and Pokorny, J. (2008) Response of the Czech hybrid hop cultivar Agnus to the term of pruning, depth of pruning and number of trained bines. Plant Soil, and Environment 54: 471-478

Thomas, G.G. and Schwabe, W.W. (1969) Factors controlling flowering in the hop (*Humulus lupulus* L.). Annals of Botany 33: 781-793

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Figure 1. Hop trellises; one experimental section correlating to 16 plants, or 32 bines, between posts.

8	2	3	4	1
5	7	1	2	6
1	3	4	5	8
6	2	7	1	3

1. Control
2. Plastic Hoop House
3. Fabric Hoop House
4. Pruned Early
5. Pruned Middle
6. Pruned Late
7. Tip Over
8. Tip Cut

Figure 2. Layout of sections in four rows by five sections of hops, with corresponding treatment or control regime.

Table 1. One-way ANOVA for three responses to various treatments

	df	SS	Mean Sq	F	P value
Response: Mean Shoot Width					
Treatment	1	2329.00	2329.33	15.38	9.17E-05
Residuals	646	97819.00	151.42		
Response: Total Vine Height					
Treatment	1	3.05	3.05	3.51	6.10E-02
Residuals	646	562.51	0.87		
Response: Internodal Length					
Treatment	1	3.60	3.57	0.53	4.65E-01
Residuals	646	4323.50	6.69		

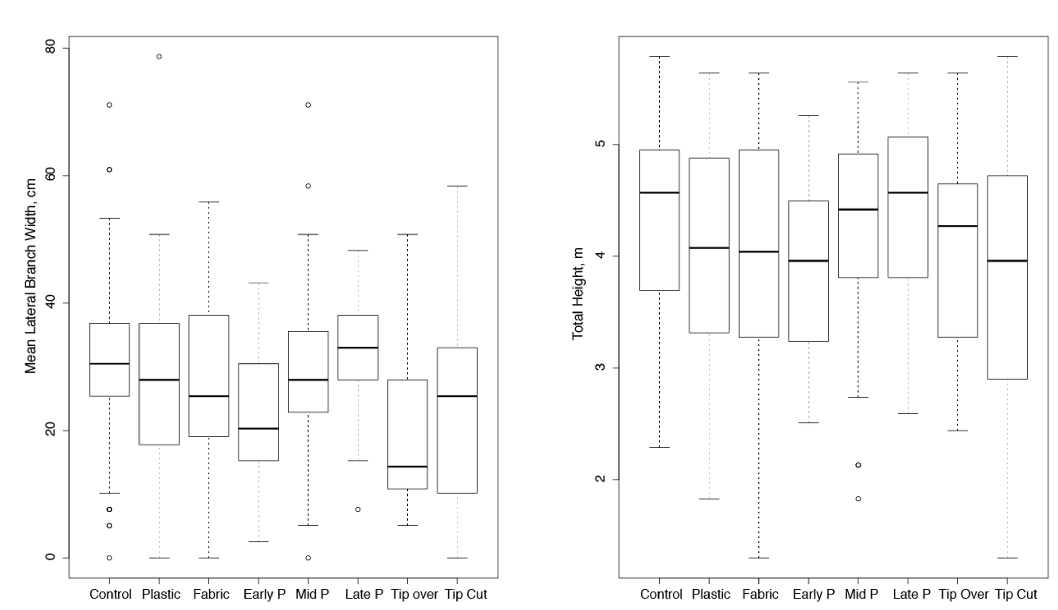

Figure 3. Box chart for (A) effect of treatment on mean shoot width and (B) total plant height. Thick center lines represent median values, Box edges are upper and lower quartile, brackets are 95% confidence intervals, circles represent outliers.

Materials and Methods

We applied a control and the following seven treatments across 16 sections of approximately 18 plants each (~32 vines per plot): plastic covered mini-hoop houses constructed one week prior of breaking of dormancy; fabric mini-hoop houses constructed one week prior to breaking of dormancy; intense pruning April 7th(early); April 14th-21st (middle); and on May 15th (late); tying growing tip over to stop vertical growth; cutting tip off to stop vertical growth (Figure 2). For each vine we report total height, maximum shoot width, average shoot width width, mean internodal length between 1.5 meter and 2.5 meter from base, flowering stage (none, bur, initiating, coning), downy mildew presence/absence, and degree of damage. Statistical analyses, including tests for normality, regression models, and t-tests were executed in R. For all statistical analyses presented here, we report mean shoot width as our dependent variable, as a stand in for overall vegetative production.

Results

Our research incorporated 641 total vines. ANOVA failed to identify relationships between any treatments and measures of vine height or internodal length. ANOVA analyses indicated statistical differences between treatment groups when using mean shoot width (F value = 15.4; p-value = 9.717 $\times 10^{-05}$) and as the the dependent variables. Treatment failed to significantly explain internodal length (Table 1). The most notable tendencies were seen between the different pruning dates, with later dates displaying a tendency toward greater mean lateral branch width. There was less indication of effects of treatment on plant height (Fig. 3), though ANOVA did weakly suggest a treatment effect on height (F value = 3.51, P=0.06; Table 1). PCA analyses failed to discern significant partitioning of variation between treatment groups and the control (not shown)

Discussion

The data suggest pruning date may be suitable for further experimental investigation; a result also suggested in Krivanek et al. (2008). Hoop house application appears to not greatly influence vegetative growth, though we note that application was pushed back due to funding timelines. The timely application of hoop houses one-month or more prior to the normal breaking of dormancy (initiated by ~4°C soil temperature in top 10 cm), which would possibly increase the local soil temperature around the rhizomes, leading to greater vegetative growth prior to floral initiation. We suggest these two treatments be further investigated. Light manipulation may also provide a fruitful methodology to increase production. Specifically, interruption or shortening of dark period may prolong flower initiation, hence permitting additional vegetative growth until optimal release time. Future research at Kelly Ridge Farms is likely to involve premature dormancy interruption and dark period manipulations. A more direct assessment of flower yield would greatly benefit future investigations.