Contract
Mac’s Creek - Yr 2 Cold Hardiness - #18-13-060 - $1,840

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Issue of Interest
Volatile temperatures frequently cause unavoidable damage. While we appreciate the January or March “early thaw,” it is the last thing viticulturists want to see for the vines (i.e., early break of dormancy and early push of buds only to be followed by deadly plunges in temperatures). The winter of 2004 was no exception (e.g., 50°F to 60°F temperatures for two weeks in late March followed by 19°F temperatures in mid May). Damage to primary buds was extensive.

Late frosts or freezes are a way of life in central Nebraska, and they annually take their toll on row crops (e.g., corn) and now, grape crops. Such frosts are expected in early and even mid-May. However, the late-May freeze (third week) and extent of the freeze [19°F] were devastating. Grape crop loss was documented at approximately 95% with primary, secondary, and tertiary bud loss, as well as an approximate 10% loss of plants (McFarland, Personal Communication).

Thus, the problem is not one of a lack of cultivars that can withstand Nebraska winter temperatures; the problem is one of minimizing winter damage from extensive temperature swings resulting in an early dormancy break and early bud break accompanied by a late frost or freeze. Therefore, the purpose of this study is to evaluate treatment techniques designed to enhance grapevines cold hardiness, specifically, effects of late winter spraying of dormant vines with products designed to delay bud break from one to two weeks.

To complete this purpose, the following research questions will be addressed:

- Is there a difference in delayed bud break counts when comparing the three groups (C, Tx1, and Tx2)?
- Is there a difference in harvest yields when comparing the three groups (C, Tx1, and Tx2)?

Approach to Problem
Samples
Three samples of 45 vines each (N = 135) were selected to include three cultivars: Marechel Foch (N = 45), St. Croix (N = 45), and Brianna (N = 45). Sample groups consisted of 15 vines from each of the three sample cultivars (N = 45). Sample vines were selected by alternating sequence/counter balanced selection (e.g. C, Tx1, Tx2; Tx1, Tx2, C; Tx2, C, Tx1). Obvious weakened, fragile plants were omitted. Only visibly healthy plants were selected.

Treatment Procedure

The Control Group (C) received no treatment. Treatment Group 1 (Tx1) sample was treated with Alginate Gel. The first and only application was made on March 19, 2008. Treatment Group 2 (Tx2) sample was sprayed with Amigo Oil spray. Initial treatment was applied on March 17, 2008. A second application was made on April 4, with subsequent applications on April 21 and April 28, 2008. Spray was applied with a stock backpack 4-gallon sprayer sold by Orscheln Farm and Home Supply Company.

All vines were long pruned (i.e., leaving approximately 8-10 buds on each fruiting cane) beginning January 1, 2008, and finished prior to any treatment being applied. Delayed bud break counts were made at bud swell/break, with the buds rated on a scale of 1-5 (1 = no bud swell, 3 = bud swell, 5 = bud break with at least one leaf completely unfurled; see Appendix B). Due to rain, only the Marechal Foch buds were evaluated on May 8. All three cultivars were evaluated on May 13 and 20, 2008. Bud ratings were made by the assistant researcher who remained blind to the group assignment.

A second dependent measure, crop yield at harvest, was taken at harvest time. Clusters were collected for each of the three cultivar samples, divided by the number of plants, and an average of pounds/plant/sample treatment group/cultivar was figured.

Goals/Achievement of Goals

Benefits to Nebraska viticulture could be quite significant. Using the example of one small vineyard (McFarland, 2004) with 2000 vines, suffering a 95% loss, (estimated crop loss of approximately 10-12 tons) the one year crop income loss was estimated at $10,000 - $12,000, given the average grape price for that year. Perhaps even more important is the longer term loss, as 50% to 75% of these vines continued to under-produce for at least one additional year with an estimated loss of $5,000 - $8,000. Finally, the loss of 10% of the vines resulted in a three- to four-year loss (i.e., 200 vines @ 20lbs./vine = 2 tons over 4 years = 8 tons/$8,000). Thus, total crop loss translates to $23,000 - $28,000.

Additional intangible loss, such as consistency of crop quality (ripeness, maturity of vines, length of growing season being hampered by late bud break of tertiary buds) is even more profoundly felt by the winemaker trying to produce quality wine from questionable grapes.

Furthermore, countless additional vineyard management hours are incurred in retraining new shoots, trellis positioning, weed control, and other tasks, as many of these plants come back from the roots after 100% bud kill on the trellis. Finding techniques that can be effective on cold hardy cultivars in the Midwest could make the difference between devastating damage, which negates any profitability, not to mention a sustainable, quality wine and grape industry.

Results, Conclusions, Lessons Learned

Delayed Bud Break Counts

Is there a difference in delayed bud break counts when comparing the three groups (C, Tx1, and Tx2)? To address this question, the sets of data were analyzed using a three-way analysis of variance with repeated measures on two factors (Anova3r2). Independent variables were Tx groups (Control, Tx1, and Tx2), bud location (proximal and distal-repeated), and dates of data collection (May 8, 13, and 20 for Marechal Foch; May 13 and 20 for Brianna and St. Croix repeated). The dependent variable was bud development rating using a scale of 1-5. Correlations between proximal and distal bud development were computed (Marechal Foch r = .80; St. Croix r = .69; Brianna r = .71). Because of these high correlations, proximal and distal buds were combined into one group and not analyzed separately.

The Anova3r2 was computed separately for each of the three cultivars (Marechal Foch, St. Croix, Brianna). The results were similar for each, but there is a significant difference among the experimental and control groups in delayed bud development, $p < .05$ (see Tables 1, 2, and 3).

- **Table 1**
  Mean bud ratings (1= no bud swell, 5= unfurled leaf) and standard deviations of control, alginate gel, and amigo oil groups when used on Marechal Foch Grapevines:

	Day								
	May 8			May 13			May 20		
Group	M	(SD)	n	M	(SD)	n	M	(SD)	n
Control	3.30	(1.00)	22	4.11	(0.64)	22	4.36	(0.71)	22
AlgiGel	2.02	(0.81)	28	2.88	(1.01)	28	4.25	(0.79)	28
AmigoOil	1.75	(0.53)	28	2.54	(0.98)	28	2.89	(0.77)	28

- **Table 2**
  Mean bud ratings (1=no bud swell, 5=unfurled leaf) and standard deviations of control, alginate gel, and amigo oil groups when used on St. Croix Grapevines:

	Day					
	May 13			May 20		
Group	M	(SD)	n	M	(SD)	n
Control	3.88	(0.39)	28	4.36	(0.55)	28
AlgiGel	3.52	(0.66)	26	4.27	(0.71)	26
AmigoOil	2.45	(0.49)	28	3.04	(0.68)	28

Table 3

Mean bud ratings (1=no bud swell, 5=unfurled leaf) and standard deviations of control, alginate gel, and amigo oil groups when used on Brianna Grapevines:

Day

	May 13		May 20	
Group	M (SD)	n	M (SD)	n
Control	3.34 (0.65)	22	3.50 (0.84)	22
AlgiGel	2.57 (0.66)	22	3.50 (0.66)	22
AmigoOil	2.13 (0.48)	24	3.13 (0.60)	24

Conclusions
Neuman Kuels post hoc analyses were applied to further analyze these results for each cultivar. Alginate Gel resulted in a non-significant delay in bud development for all three cultivars as compared to the Control Group ($p > .05$). Amigo Oil resulted in a significant delay in bud development, as compared to the Control Group ($p < .05$). Amigo Oil resulted in a significant delay in bud development, as compared to the Alginate Gel ($p < .05$).

Means of bud development at each of the three data recording dates for Marechal Foch were plotted (see Figure 1). As shown in Figure 1, mean bud development for the Amigo Oil group on May 20 (M = 2.8) is less than mean development for the Control Group on May 8 (M = 3.35). Thus, it can be determined that bud development has been delayed by at least 12 days. Extrapolation of this trajectory results in an estimation of bud delay being between 14 and 21 days.

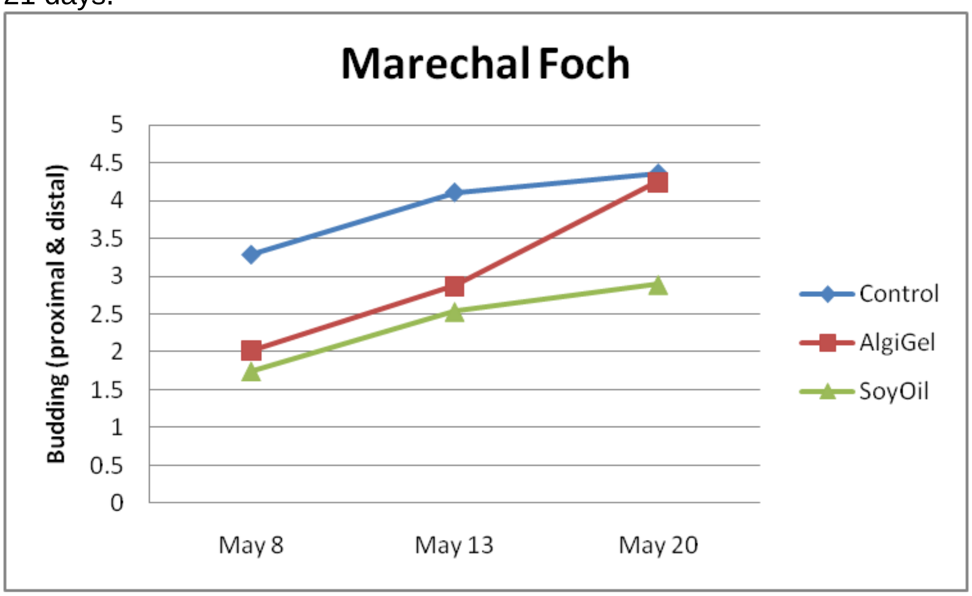

Figure 1. Mean bud development for Marechal Foch grapevines.

Mean bud development for the data recording dates for St. Croix are plotted (see Figure 2). As shown in Figure 2, mean bud development for the Amigo Oil group on May 20 (M = 3.0) is less than mean development for the Control Group on May 13 (M = 3.9). Thus, it can be determined that bud development has been delayed by at least seven days. Extrapolation of this trajectory results in an estimation of bud delay being between 14 and 21 days.

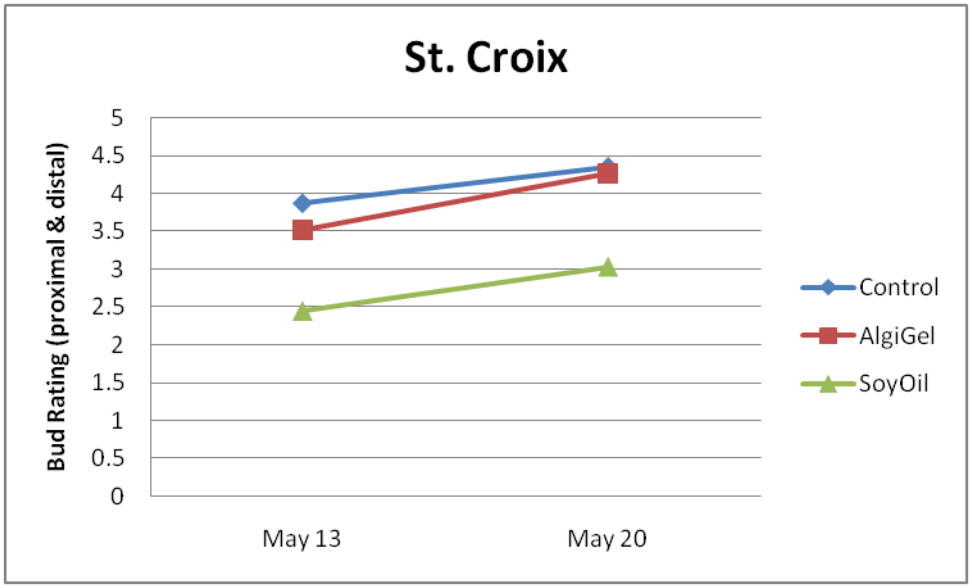

Figure 2. Mean bud development for St. Croix grapevines.

Mean bud development for the data recording dates for Brianna are plotted (see Figure 3). As shown in Figure 3, mean bud development for the Amigo Oil group on May 20 (*M* = 3.2) is less than the mean development for the Control Group on May 13 (*M* = 3.4). Thus, it can be determined that bud development has been delayed by at least seven days.

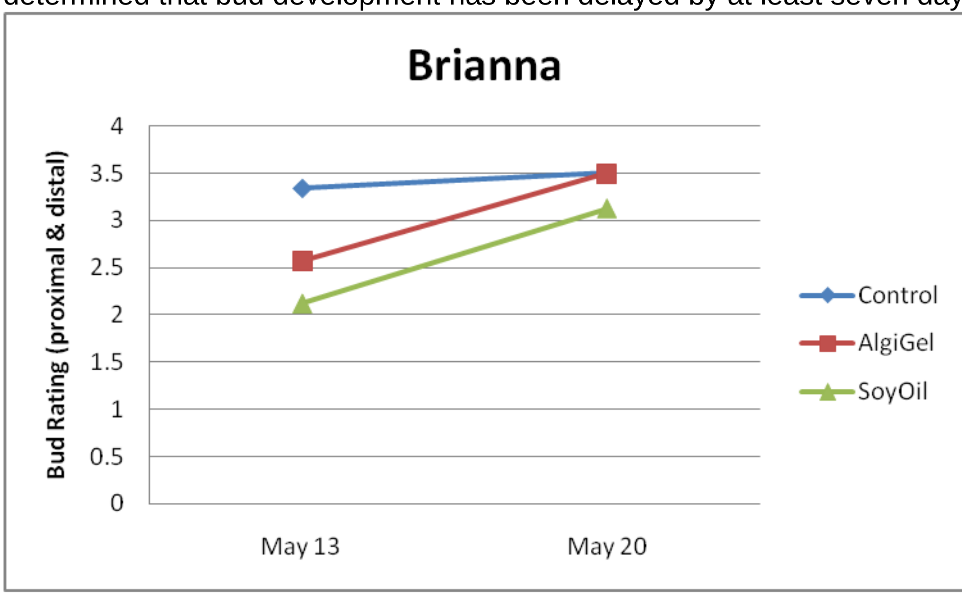

Figure 3. Mean bud development for Brianna grapevines.

Harvest Yields

Is there a difference in harvest yields when comparing the three groups (C, Tx1, and Tx2)? To address this question, average harvest weight per vine was computed for each cultivar and each group (C, Tx1, and Tx2). Descriptive results for Marechal Foch indicate higher average harvest weights for Alginate Gel and the highest average weights for Amigo Oil group when compared to Controls (see Figure 4). Similar results were found for the St. Croix cultivar (see Figure 4). Due to harvest crew confusion, harvest weights for Brianna were not able to be computed.

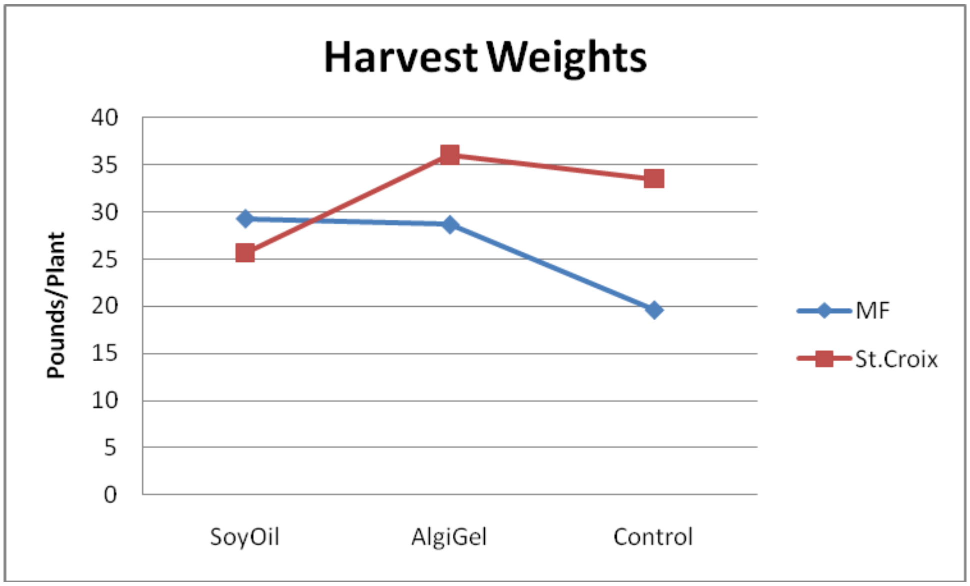

Figure 4. Pounds per plant harvested from each cultivar.

<u>Progress According to Outcome Measures</u>

This study evaluated whether the use of Alginate Gel or Amigo Oil would result in delayed bud development and subsequent delay in bud break. Such delays have already been documented in the literature for the Alginate Gel (Dami & Stushnof, 2005). However, the usage of Alginate Gel could be considered as quite cost and labor prohibitive. In order to apply the Alginate Gel in a thick enough manner to cover the buds, it is recommended that the Gel be painted onto the buds. Thus, one important outcome of this study was the documentation that the use of Amigo Oil exceeds the bud development delay/delay in bud break effects of the Alginate Gel. These results are important to the viticulturist in terms of practical significance considering the ease and cost/labor efficiency of application, i.e., applied via a backpack sprayer. Perhaps the greater effects of Amigo Oil versus Alginate Gel could be expected when one considers that only one application of Alginate Gel (on March 19) was possible due to weather and time constraints, as compared to the Amigo Oil being applied four times (March 17, April 4, 21, and 28). However, this relates to cost, time, and labor efficiency of a sprayed application, which can be reflective of the reality of a small commercial vineyard in the Midwest.

The results of this study are perhaps most dramatic for the Marechal Foch on this particular researcher's site. On this site, Marechel Foch is the earliest cultivar to break bud. By delaying bud break by at least two (possibly three) weeks, the primary buds were able to survive and produce. On this site, that rarely happens. Consequently, harvest weights on vines treated with Amigo Oil, which represented primary buds, were much higher than the harvest weights on the Control vines, many of which were no doubt producing from secondary or tertiary buds. Similar findings for bud delay and harvest weights were found on the St. Croix cultivar. However, perhaps most intriguing are the bud delay findings for the Brianna cultivar. On this site, Brianna is the latest cultivar to break bud each year. Even with this late budding cultivar, and only two data recording dates, the Amigo Oil delay was significant (7 to 10 days).

Thus, the results on this "climate harsh" site were profound. With the average last frost date of approximately May 20th for this site, a two- to three-week delay in bud break can mean the difference between minimal and bountiful harvest, and avoidance of most of the last frost damage. With more cultivars producing on primary buds, additional benefits can be realized, including uniformity of ripening of fruit and most certainly enhanced quality of fruit.

Such treatments may enable viticulturists to work with Mother Nature rather than relying on minimally or non-effective and costly attempts to warm the vineyard in order to minimize damage from the inevitable frost. With future research, it would be helpful to replicate these results across another winter/spring time frame, in that no two winters are alike in the Midwest. Investigation of the differential effectiveness of methods of application would also be helpful (e.g., effectiveness of backpack versus mechanized air blast sprayer) with variable numbers of applications.