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FOREWORD

During 2011, a milestone was noted, as the Orchard Mesa Site of the Western Colorado Research Center (WCRC-OM) celebrated the 50^{th} anniversary of its establishment and operation.

Dr. Lee Sommers, Director of the Colorado Agricultural Experiment Station (CAES) and Associate Dean for Research, College of Agricultural Sciences at Colorado State University has announced his retirement effective May 31, 2013. Lee joined Colorado State as Professor and Head of the Department of Soil and Crop Sciences in 1985 and became the CAES Director in 1996. In 2006, he assumed the additional responsibility of Associate Dean for Research.

Lee has provided the leadership and oversight of agricultural research programs funded by the CAES in six of the eight colleges at CSU and eight off-campus research sites. He has had a significant impact on developing interdisciplinary agricultural and natural resource programs at Colorado State to address complex problems and issues facing Colorado growers and producers, commodity organizations, and governmental agencies including addressing and public policy issues. Also of significance is his restructuring of the program delivery and support system for combined faculty plant and animal programs at the Agricultural Research, Development and Education Center near Fort Collins.

Lee is a Fellow of the Soil Science Society of America (SSSA) and the American Society of Agronomy (ASA). He has served as President of both societies. He was awarded the Environmental Quality Research Award (ASA) in 1987, the Agronomic Service Award (ASA) in 2010, and the Soil Science Professional Service Award (SSSA) in 2010.

A reorganization of the College of Agricultural Sciences (CAS) and the Colorado Agricultural Experiment Station (CAES) is underway. Dr. Craig Beyrouty will become the CAS Dean/CAES Director. Lee's position will become CAES Deputy Director/CAS Associate Dean for Research and will have responsibility for planning, coordinating, and executing on-and off-campus research programs. A national search is being initiated with an expected start date in April 2013. Additional restructuring is expected due to other retirements during FY 2013.

Closer to "home", Dr. Amaya Atucha has joined the WCRC faculty as an assistant professor at Orchard Mesa. Her responsibilities are to conduct research and outreach activities in support of the commercial tree fruit industry in Western Colorado. Amaya's education, experience and interests include a BS in Horticultural Sciences and a PhD in Horticulture, she worked as a private consultant for the avocado industry in Chile, and her research focuses on soil management systems in relation with tree performance and root growth patterns. We welcome Amaya and wish her a rewarding and productive career at CSU.

This 2013 fiscal year is creating opportunities and challenges to address program and operational needs for filling positions due to vacancies and retirements. The results of these deliberations and decisions will be announced as they occur in Phytoworks, Fruit Facts and/or the 2012 Annual Report.

Stephen Menke, Co-Editor

Site descriptions

Fruita Site

1910 L Road
Fruita, *CO 81521*
Tel (970) 858-3629 *fax* (970) 858-0461

The Fruita site is located 15 miles northwest of Grand Junction. With an average growing season of 180 days at an elevation of 4600 ft, a diversity of agronomic research is conducted at the Western Colorado Research Center at Fruita, including variety performance trials in alfalfa, corn silage, corn grain, canola, grasses, small grains; new and alternative crops; irrigation; cropping systems; soil fertility; and new crop trait evaluation. The Colorado Foundation Bean Program is located at Fruita. The specialized laboratory facilities at Fruita allow research to be conducted on tissue culture and natural rubber extraction and quantification in various plant species.

Orchard Mesa Site

3168 B1/2 Road
Grand Junction CO 81503
Tel (970) 434-3264 *fax* (970) 434-1035

The Orchard Mesa site is located 7 miles southeast of Grand Junction. Site elevation is approximately 4700 ft. with an average growing season of 182 frost-free days. The research conducted at this site includes tree fruits, wine grape production, and ornamental horticulture. This site has alternative crops (e.g. pistachio nuts and edible honeysuckle), greenhouses, offices and laboratory facilities.

Acknowledgments

Dr. Frank P. Johnson, Interim Manager and Dr. Stephen D. Menke were co-editors.
Donna Iovanni was assistant to the editors.

The assistance of the following people, farmer cooperators, and staff is gratefully acknowledged:
Bryan Braddy, Greg Irwin, Fred Judson, George Osborn, and John Wilhelm - Research Associates, Colorado State University, Western Colorado Research Center
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Mike Williams - Farmer cooperator, Hayden
Bruce Talbott, Harry Talbott, John Moore-Talbott Farms, Palisade

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Colorado Department of Agriculture’s Advancing Colorado’s Renewable Energy (ACRE)
Nebraska Grape and Winery Board
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Advisory Committee

The Western Colorado Research Center (WCRC) Advisory Committee has two roles - advocacy and advisory. The advocacy role is to actively promote WCRC research and outreach activities with policy makers, producers, and the general public. Advocacy is the primary mission of the Committee. The advisory role is to provide input and feedback on research and outreach activities conducted through the programs of the Western Colorado Research Center.

The members of the WCRC Advisory Committee for 2011 are listed below. Committee members serve voluntarily without compensation. WCRC Advisory Committee meetings are open to the public. For the current membership list please visit our web page: http://www.colostate.edu/programs/wcrc/.

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SECTION I

Enology

Joint Colorado and Nebraska Wine Quality Assurance Study
Wine Sensory Evaluation Using Quantitative and Hedonistic Panels and a Composite Score

S. D. Menke[1] and S. L.Cuppett[2]

Summary

Evaluation of sensory quality for wines is a difficult problem. Wine is a highly diversified product, which makes applying uniform sensory quality standards very difficult. Also, definitions of sensory quality and market value are often confused. In the method outlined in this article, we attempt to provide a wine sensory quality evaluation system that has both a consumer reference standard and quantifiable aroma standards. We create a sensory evaluation system for wine that combines a traditional hedonistic expert wine tasting panel and a panel trained to smell and quantify wine sensory aroma fault chemicals. Each commercial wine sample evaluated is presented to each member of the fault panel and the hedonistic tasting panel. The evaluation scores of the two panels are combined by a formula to give an overall sensory score, expressed as a market value rating. This combined score is used, by the quality assurance organizations involved in this study, to assign a pass/fail market value rating. Each panel also makes written comments on wine sensory characteristics. Universally available market wine samples in similar price ranges are included in the evaluation. These ratings are compared between panels, and with the combined scores. Also, the comments are reviewed to see how noted sample characteristics vary by panel. This paper presents results of this method, used in a joint quality assurance evaluation of 138 Colorado and Nebraska commercial wines.

Introduction

Product evaluation by quality assurance (QA) methods is regarded as a necessary and integral part of production operations. If the product does not fit the expectations of the consumer of the product, the producer will suffer loss of sales and eventual marginalization or elimination of its product. This is especially true of a product, like wine, whose sale depends on being perceived as having unique characteristics that are deemed of superior quality and of good value.

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Mention of a trade name or proprietary product does not imply endorsement by the author, the Agricultural Experiment Station, or Colorado State University.

Quality is defined as the degree to which a set of inherent characteristics fulfills requirements, whereas value is related to both intrinsic quality and image (Francis, *et al*, 2005).

Standards for QA evaluations of wine quality differ widely among major producing countries. Most standards are linked to labeling requirements that embrace the concept of terroir, which is broadly defined as the total natural environment of any viticultural site and its effect on the characteristics of the grapes and their resulting wine (Robinson, ed., 2006). Some major producing countries have very prescriptive and detailed government terroir standards for marketing, such as the AOC in France (INAO), the DOC in Italy (Italian law), and DO in Spain (Spanish law). Germany imposes standards that are a combination of terroir and grape chemical composition (Meinhard, 1971). Canada has standards both for terroir and freedom-from-fault sensory characteristics (VQA Ontario, VQA British Columbia). Most countries have generated uniform terroir standards that are less restrictive than France or Italy, including major producers like Australia, USA, South Africa, Chile, and others. In the USA, almost all quality standards are based on terroir standards plus some basic chemical testing for selected chemicals with proscribed legal safety or tax-related limits. (TTB Regulations). There are global standardization organizations, like ISO and SQF (ISO standard, SQF standard), that have generated uniform voluntary QA methods standards for food, including wine. Entities using these standard QA methods can participate in uniform certification processes. Individual countries or companies can use these methods to generate their own specific QA standards. For example, Australia uses SQF methodology in its Wine Corporation Act of 1980 (Wine Australia).

However, only a few countries have required human sensory QA standards used for marketing wines. These standards are usually a faults-free standard, and are always done by expert hedonistic panels. Examples of hedonistic sensory export standards are DOC and DOCG in Italy and VQA in Canada. Some geographical wine areas have instituted self-imposed voluntary standards that incorporate hedonistic and/or chemical testing. Some examples in the USA are: Napa Valley, (Napa Valley Vintners), Lake Erie AVA (LEQWA), Pennsylvania (PWQI, PQA), Ohio (OQW), New Jersey (NJQWA), and Iowa (IQWC).

Though hedonistic and/or chemical testing is the norm for quality assurance of wine, there are several large problems with these methods. Chemical testing generally consists of tests against quantitative standards for pH, alcohol, titratable acidity, organic acids, reducing sugars, free SO2, volatile acidity, and presence of microbiological contaminants. The problem is that these tests are not the same as the human sensory apparatus, and thus are poorly correlated with the consumers' hedonistic impressions of aroma and taste quality at time of purchase.

Hedonistic expert ratings are often used for market QA standards. These range from writers who make highly regarded ratings of commercial wines, such as Robert Parker in Wine Advocate magazine, to wine competition medals, to expert panels for most regional wine quality assurance systems. The large problem with these ratings is that they are not subject to replications, uniform control samples, verifiable standards, or uniform training of panelists, and thus are not statistically consistent across evaluations. A recent study (Hodgson, 2008) bore out the inability of the same expert panelists to repeat evaluations consistently on the same wines. There is a testing service, Enologix (Darlinton, 2005), that correlates grapes and wine by quality standards derived from a database of wines categorized by industry price and expert hedonistic evaluations. However, these database standards for price and hedonistic evaluations are proprietary and not subject to independent analysis.

Sensory testing of wine consumer hedonistic components is done by researchers using various sensory techniques, usually permutations of Quantitative Descriptive Analysis (Kemp, *et al*, 2009). Principal Component Analysis (Abdi and Williams, 2010) (Chapman, et al, 2001) is usually done on these descriptions to yield wine sensory profiles. Countless chromatographic separations of wine aromatic chemicals have been done over the years (Pola´sˇkova´, et al, 2008). It is theoretically possible that good correlations of consumer sensory panels, chromatically separated and quantified aroma chemicals, and consumer perceptions of these chemicals could be done and organized into standardized consumer profiles for wines. Some limited quantifiable and standardized consumer profiles have been done. One beverage example is bitterness in beer (da Silva, *et al* 2012). However, this is an extremely expensive and laborious process, mostly done for a limited number of aromatic components. The industry will not bear the QA costs and time necessary to evaluate the huge number of aromatic chemicals in wine, especially over the wide diversity of grape varieties in wines and small lot sizes of wine production. Evaluation is further complicated by the large variation of styles, geographic and vintage differences, and wide array of winemaking techniques in wines.

So, if strictly hedonistic sensory analysis is unreliable for QA as it relates to the wine consumer, and if chemical standards do not relate easily to sensory evaluation, and if statistically reliable standards that correlate well between hedonistic and quantitative sensory standards are expensive to develop, then what QA approach do we take? Is it possible to develop a QA method for wine that is both relatively inexpensive, and yet provides some correlation of hedonistic and quantitative sensory standards? One possibility is to meld the scores of a panel trained to a quantifiable set of wine aroma fault chemical standards with the scores of a highly experienced hedonistic panel. The resulting combined score could then serve as a link between the reasons for sensory rejection by consumers of wine aroma and taste faults and the reasons for their overall sensory impression of the combined attributes and faults of a wine.

In this paper we will describe testing a methodology that attempts to evaluate wines by a quantitative set of standards for wine aroma fault chemicals that is combined with a hedonistic panel aroma and taste evaluation to give a combined score. The test described in this paper will be evaluated to see if the perceived market value is consistent within each panel, among the panels and with the combined panel score.

Scores of the panelists from an Aroma Faults Panel are added to the scores of the Hedonistic Tasting Panel by a formula to give a Combined Panels Score **[See Materials and Methods below]**. This combined score is designed to correlate the detection of quantitative amounts of fault chemicals with the qualitative consumer evaluation. The applicability of the Combined Score is tested in this study.

Materials and Methods

<u>Evaluation Panels and Protocols</u>

Two panels are used for this study, a Hedonistic Tasting Panel, and an Aroma Faults Panel. This study has four panelists on each panel, instead of five as designed, due to limitations of number of booths in the laboratory used **[See Results and Discussion]**. Each panelist on both panels scores each wine sample separately and blindly. Every individual in both panels scores the wine sample in isolation, using individual sensory booths in a controlled-atmosphere sensory laboratory. A 40 ml sample of wine is poured from freshly opened bottles into a 200 ml glass (standard seven ounce winery tasting room glass) and capped with paper for at least 30 seconds prior to delivery to a panelist. Each panelist is instructed to re-cover the sample for 30 seconds before re-sampling. The scoring criteria are separate for each panel. Each panel has a separate sampling protocol. The Hedonistic Tasting Panel lifts the cover off the glass, sniffs the sample just at the rim of the glass, then swirls briefly before tasting a small sip, rinsing the sip around the mouth, then spitting out the sample. The Aroma Faults Panel lifts the cap from the glass, and sniffs at the rim of the glass. Both panels use the same procedure to clear out sample effects between samples. Each panelist rinses with and spits out or swallows water between samples and then inhales and exhales several times through the nose.

<u>Aroma Faults Panel Training and Selection</u>

Prior to serving as panelists on the Aroma Faults Panel, all panelists undergo a prescribed course of sensory training (Menke, 2009). This course contains an introduction to sensory science and incorporates QDA methodology to learn how to individually identify aroma faults and to quantify the detection of each fault to each one's native ability and experience.

Because the course enables participants to learn how they detect and perceive aromas and how to identify aroma faults, it is valuable in itself as a learning tool for quality assurance, both in production wineries and in marketing of wines. In fact, the training course is deemed valuable enough by the participants that they pay to take the training, whereas researchers and industry QA evaluators normally have to pay the costs of this training. These panelists have thus been prepared to serve on QA evaluations at no cost to the evaluation process, other than per diem costs.

It is notable that detection of an aroma usually begins at concentrations much lower than recognition. As well, fault aromas often suppress desired aroma attributes at detection levels well below recognition thresholds. So we can often sense a fault aroma by noting the changes in other aromas. In this training regimen, we define detection as a change in aroma from a control wine with no chemical added.

Each panelist is calibrated to differences detection of eleven individual aroma fault chemicals, each over a non-linear range of four exact concentrations, those concentrations ranging from below detection to above the published recognition threshold (L. J. van Gemert, 2003) for each chemical **[See Table 1]**. Aroma detection at each concentration is defined by each panelist against seven consumer sensory definition terms. These seven terms are relatively scaled and are imposed upon a relative scale of four levels of consumer acceptance of the fault chemical **[See Figure 1a]**. All panelists are calibrated for their abilities to correlate the consumer definitions with quantitative amounts of each fault chemical. After training to each individual chemical, combinations of chemicals, involved in similar consumer fault terms, are presented to panelists over the same range of concentrations and consumer terms. This results in grouping some chemicals into the same perceptual consumer fault category. For example, ethyl acetate and acetic acid are grouped into a category called volatile acidity. In all, six consumer aroma fault categories are created from the eleven training chemicals. These categories are used for scoring by the Aroma Faults Panel **[See Table 2]**. For this study, each trained panelist on the Aroma Faults Panel has to be able to identify each consumer fault category, on the four term relative market value scale, within a range of two aroma chemical concentrations. Just before the evaluation session, all Aroma Fault panelists are recalibrated to their training solution concentrations.

Aroma Faults Panel Scoring

The score for each panelist for a sample is the result of adding up subtractions of up to 2 fault points for each of the six fault categories, and subtracting those points from a 12 point perfect score. The point score of each panelist is grouped with the other panelists, and the panel average score is determined. This average contributes to the formula used for the Combined Panel Score. In addition, an intentional bias is given to the Aroma Faults Panel, in that it can automatically disqualify a wine from being included in the combined score. This reflects the observation that wines with detectable aroma fault chemicals at higher levels of detection are almost universally offensive, and thus are heavily discriminated against by consumers (Bisson, 2001). A panelist may contribute to disqualification of a sample by giving a failing score in any category or by taking off 7 or more points across all categories. If the majority of the panelists in the Aroma Faults Panel fail the sample in at least one fault category or in total points taken off across categories, the wine will be automatically disqualified from the combined scoring process. Disqualified wines cannot participate in the formula to determine a Combined Score, but are automatically treated as if they had a failing Combined Score.

Hedonistic Tasting Panel Selection

The Hedonistic Tasting Panel consists of panelists who are expert tasters. They are selected by the breadth and depth of their experience in competition and quality assurance hedonistic judging, and are further selected by references. They are designed to represent a highly expert consumer opinion of the market value of a wine. This panel scores use a twenty point modified Davis quantitative scale, with a super-imposed relative scale of market values **[See Figure 1b]**.

Hedonistic Tasting Panel Scoring

The score for each panelist **[See Table 2]**, out of twenty possible points, will be grouped with the other panelists and averaged. This average score contributes to the formula used for the Combined Panel Score. This panel cannot automatically disqualify a sample, no matter what the average score is for the panel.

Combined Panel Score and Quality Assurance Pass/Fail

The combined score for qualified wines is by the following formula:

[12 – (aroma panelists ave. deduction score) + (hedonic panelists ave. score)] = Combined Score

The Combined Score is used to determine the pass/fail status of qualifying samples. In this study, if a qualifying sample has a score of $\geq 0.70 = 22.4/32$ points, it has acceptable market value.

The Combined Score is also used to determine Combined Score Market Value by converting it to a percentage as follows:

$$\frac{[12 - (\text{aroma panelists ave. deduction score}) + (\text{hedonic panelists ave. score})]}{\text{32 possible points}} = \text{Combined Score Market Value}$$

Results and Discussion

Statistical Values

A pre-trained Aroma Faults Panel of four panelists and a Hedonistic Tasting Panel of four panelists were convened and blindly sampled 138 wine samples, including 129 wines from Colorado and Nebraska and 9 nationally marketed control wines, as part of a joint test of the Colorado Quality Assurance Program method of using combined panels. The statistical results are summarized below **[See Table 3]**.

For each panel, panelist's scores for each sample were averaged and standard deviations were computed for each sample. The average score of all samples was also computed for each panel, as well as the panel average of all of the standard deviations for all samples. As well, the percentage of points out of possible points for the average score, called a Market Value score, was computed for each panel. A Market Value Combined Score of 70 % or greater was deemed acceptable for commercial sale.

For each of the Hedonistic Panel and the Aroma Panel, the average standard deviation among panelist scores was low (1.66 and 0.93, respectively), indicating internal consistency of panelists within each panel over the range of samples. Given this, it is notable that there was a difference of 24% in the average % of possible points between the two panels, as well as a 24% difference in commercial acceptability, indicating that the two panels had differing applications of the effects of their different evaluations on the market values of the samples. The Hedonistic panel (ave. score of 64.00% and market acceptability of 76.00%) was tougher on the perception of overall quality than the Aroma Panel (average score of 88.00% and market acceptability of 100%). When the Combined Score formula is applied, the Hedonistic Panel has a greater effect on the Combined Score than the Aroma Panel by a constant of .625/.375, bringing the Combined Score to an average score of 73% and market acceptability of 72.70%.

Differing Intents of the Hedonistic and Aroma Panels

The design of the Combined Score method allows the Aroma Panel to use a relative scale of market value terms, but have each of these relative market value terms proscribed to quantitative detection ranges of each aroma chemical. This way, one can observe the effect of training to quantifiable aroma fault concentrations on the perception of market values. By allowing the Aroma panel to evaluate levels of fault chemicals and to disqualify a wine having higher quantities of one or more fault chemicals, a mimic is created of what level of aroma faults leads to consumer rejection of a faulted wine.

However, consumers do not just decide a wine's fate by detection of aroma faults and rejection, but also by the counterbalancing effects of aroma attributes that are pleasing. The Hedonistic Panel is a mimic of this balance of all sensory parameters when consumer sensory selection of wines occurs.

Sources of Variability

What are the possible sources of the scoring differences in Market Value and Acceptability between panels **[See Table 3]** Does the

Combined Score give a more useful Market Value than either panel alone? Are potential problems with the design of the methodology exposed, and, if so, can they be alleviated?

Sources of variability in the Aroma Faults Panel may lie with how the standards are set for scoring and for disqualification. For example, if the Aroma Fault Market Value relative scale was more discrete, would scoring and disqualification be more coordinate with the Market Value acceptability of the Hedonistic panel and the Combined Score? That is, if the panel were to choose values in quarter or tenth points, rather than cardinal numbers along the 3 point scale, would scores be more consistent with the Hedonistic and Combined Scores? Similarly, would a scale that allowed for a disqualification at a value between 2 and 3 points give more consistent rates of rejection? Another source of variability may be present in the number of panelists in the Aroma Panel. The Aroma Panel was designed to have five members, and in this study there were only four. This makes a difference in the level of panel members needed to disqualify a wine. Instead of 3 out of 5 panelists needed to disqualify a wine (60%), it took 3 out of 4 (75%). There were 10 wines of the 138 that had 50% of panelists voting disqualification and 50% just short of disqualification. If all 10 of these wines would have been disqualified with a five member panel, it would have lowered the Market Value acceptability score on the Aroma Panel by approximately 10%.

By utilizing the Aroma Faults Panel, we know the exact range of quantities detected by the panel during training and can recalibrate them to those concentrations just before the evaluation session. Thus, making the scoring system more discrete will not change the level of detection by the panelist, just fine tune the accuracy of the scoring.

Sources of variability in the Hedonistic Panel are more straightforward, but lie mostly in the lack of sample repetitions. The Hedonistic panel members are not trained to apply quantifiable standards like the Aroma Panel. Since a very discrete 20 point scale is used, the size of the average standard deviation is a good indicator of scoring consistency, though it says nothing about scoring accuracy, since panelists only have a consensus standard, based on variable experience and variable hedonistic training.

The only source of variability in the Combined Score lies in the actual formula, which depends on the ratio of points between the Aroma and Hedonistic Panels that are used to derive the Combined Score. The only way to address this is to change the scoring ratio of the panels and see what the effect is on the Combined Score and the market value.

Panelist Comments

Both panels made comments on the samples as they scored them. These comments are intended for the wineries submitting the samples, and are only released to the individual wineries. It is hoped that both the comments and the actual evaluation scores will be used by the wineries as instruments of quality control. These comments are not quantifiable, but examination of the comments shows that perceptions of the type and degree of wine faults are often different between the Aroma Fault and Hedonistic panels. This is likely an indication of the inherent bias of the Aroma Fault panel only looking for fault levels and the Hedonistic panel balancing faults and positive attributes.

Conclusions and Future Study

This study is currently being repeated with the Colorado and Nebraska quality assurance programs to gather more data. Similar studies are occurring with this system in another quality assurance program in Pennsylvania. Therefore, we will soon have enough combined data to better judge the overall effectiveness of the system.

This study only included control wines judged as acceptable in the general market at a similar price level to the submitted samples. For future studies, it will be necessary to include direct sample comparisons with other quality assurance or commercial evaluation systems. This would mean including more control market wines over a greater range of already accepted market values, as defined by price, rating by critics, rating by other quality assurance systems, and medals won at recognized national and international competitions. This would give a better measure of the true differences among the systems in determining market value.

A future study using the Combined Score system could use differently weighted scoring ratios between the panels, to see if it changes the effect of each panel on the market value calculation.

The effects of altering the quantitative amount/market value calibration of faults detection by the Aroma Panel should be examined more closely. This could be done by either having the scoring done with finer discretions of the relative scales or by using more levels of discrete concentrations within the range used for training the panelists. The panelists would not need to be trained differently, but just trained to finer calibration within their already established range of detection.

At this point, the results have been welcomed by the participant wineries in Colorado, Nebraska, and Pennsylvania. This system seems to engender a higher level of trust among commercial wineries, due to the perceived value of the training received by the Aroma Faults panelists. As more studies using the Combined Score system are done, and as more comparisons are done directly on samples evaluated by other systems, comparative data can be generated. This data then needs to also be tested by surveys at the wholesale and retail purchase level, to compare the market values assigned by the various evaluation systems to actual levels of consumer acceptance.

Figure 1: Preparing samples for presentation to wine QA panelists. Figure 2: Blind presentation of samples to panelists. Figure 3: Evaluation of samples by Hedonistic panelists. Figure 4: Calibration references and evaluation of wine samples by Aroma Faults panelists.

Table 1. Faults Concentration Range (Wine) for Aroma Panel Training

Chemical	Fault Category	Published Wine Recognition Threshold	Training Amount Solution 1	Training Amount Solution 2	Training Amount Solution 3	Training Amount Solution 4
ethyl acetate	volatile acidity	50-300 ppm	10 ppm	200 ppm	500 ppm	2000 ppm
acetic acid	volatile acidity	500-1100 ppm	50 ppm	500 ppm	1000 ppm	4000 ppm
acetaldehyde	oxidized	100-300 ppm	10 ppm	100 ppm	500 ppm	2000 ppm
2,4,6-trichloranisole	corked	4-50 ppt	0.5 ppt	5 ppt	50 ppt	5000 ppt
SO_2	acrid,burnt tingle	60-120 ppm	10 ppm	50 ppm	100 ppm	200 ppm
ethanethiol	reduced sulfur	0.5-1 ppb	5 ppt	1 ppb	10 ppb	100 ppb
Diethyl disulfide	reduced sulfur	2-5 ppb	20 ppt	2 ppb	50 ppb	500 ppb
H_2S* *approximate values -highly reactive	reduced sulfur	1-10 ppb*	10 ppt*	5 ppb*	50 ppb*	500 ppb*
4-ethylphenol	brett-like	100-150 ppb	1.5 ppb	50 ppb	400 ppb	4000 ppb
4-ethylguaiacol	brett-like	50-500 ppb	500 ppt	250 ppb	1000 ppb	5000 ppb
Isovaleric acid	brett-like	30-100 ppb	500 ppt	250 ppb	500 ppb	5000 ppb
Market Value Range (as per Figure 1a)		1 to 3 = detected flaw up to recognized unaccepted fault	0 to 2 = not detected up to recognized flaw	1 to 3 = detected flaw up to recognized unaccepted fault	1 to 3 = detected flaw up to recognized unaccepted fault	2 to 3 = recognized flaw up to recognized unaccepted fault

Fig. 1a Super-imposed Relative Scales of Consumer Fault Concentrations and Market Acceptability Terms for Aroma Faults Panel Training and Evaluation

Evaluation 0 ____________ 1 ________________ 2 ________________ 3

NNN ☐ ☐DNR☐ ☐DFL☐ ☐DFT☐

Training ---

NNN ☐ ☐RNF☐ ☐RFL☐ ☐RFT☐

Training ---

ppm amount ☐Lowest ppm☐ ☐published threshold☐☐highest ppm☐

0 = no chemical detected, highly acceptable
1 = some minor amount of chemical, acceptable
2 = noticeable amount of chemical, flawed and still somewhat acceptable
3 = large amount of chemical, faulted and unacceptable
NNN = no fault aroma detected
DNR = detected aroma, but not recognized or flawed
DFL= detected aroma, not recognized, flawed
DFT= detected aroma, not recognized, faulted
RNF = aroma recognized, but not flawed
RFL = aroma recognized, flawed
RFT = aroma recognized, faulted

Fig. 1b Super-imposed Relative Scales of Modified Davis Hedonistic Quality Score and Market Acceptability for Hedonistic Tasting Panel Evaluation

```
.__.__.__.__.__.__.__.__.__.__.__.__.__.__.__.__._ .__._ .
0  1  2  3  4  5  6  7  8  9  10 11 12 13 14 15 16 17 18 19 20
-------------------------------------------------------------
   U        O    G    E    S
```

U = unmarketable
O = ordinary market value
G = good market value
E = excellent market value
S = superior market value

Table 2. Evaluation Scoring for Hedonistic and Aroma Faults Panels

HEDONISTIC PANEL Score 0-20 points relative to marketability of sample. Panel average is used in formula for Combined Score
APPEARANCE Color and Clarity 0-3 points
Aroma/Bouquet Intensity, Complexity, Character of variety or style 0-5 points
TASTE Fruit-sweet/acid balance, retro-nasal intensity, complexity, varietal character, lack of faults 0-6 points
BODY Appropriate tannin, bitters and astringency, appropriate warmth 0-3 points
AFTERTASTE/FINISH Retro-nasal persistence, appropriate persistence of acid/bitter/astringency, lack of faults 0-3 points
TOTAL POINTS
QUANTITATIVE FAULTS PANEL Points are deducted for amount of chemical detected in each fault category . Each panelist can score a sample disqualification for a deduction of 3 points in any category or for a sum of categories of 7 points deducted or more. Panel average deduction of 7 points or more disqualifies wine, or if a majority of panelists have at least one disqualifying deduction in any category.
VOLATILE ACIDITY Ethyl acetate, acetic acid 0,1,2 points deducted 3-DISQUALIFY
OXIDATION Acetaldehyde 0,1,2 points deducted 3- DISQUALIFY
CORKED 2,4,6 trichloranisole 0,1,2 points deducted 3- DISQUALIFY
SULFITES SO2 0,1,2 points deducted 3- DISQUALIFY
REDUCED SULFUR H2S, ethanethiol, diethyldisulfide 0,1,2 points deducted 3- DISQUALIFY
BRETT 4-ethylphenol, 4-ethyl guaiacol, isovaleric acid 0,1,2 points deducted 3- DISQUALIFY
TOTAL POINTS DEDUCTED

Table 3. Comparison of Market Value by Panels and Combined Score

Market Value Category	Percentage of Total Samples
% Wines with Accepted Market Value Combined Score	72.70
% Wines with Accepted Market Value Aroma Panel Score	100.00*
% Wines with Accepted Market Value Hedonic Panel Score	76.00
	Average Sample Score by Panel
Ave. of Combined Scores	23.26/32 = 73 % Market Value
Std. Dev. of Combined Scores	1.88
Ave. of Aroma Scores	10.51/12 = 88% Market Value
Ave. of Std. Devs. of Aroma Panelist Scores	0.93
Ave. of Hedonic Scores	12.75/20 = 64% Market Value
Ave. of Std. Devs. of Hedonic Panelist Scores	1.66

***[See Results and Discussion]**

Bibliography

Abdi, H. and Williams, L.J., 2010, *Principal component analysis*, Wiley Interdisciplinary Reviews: Computational Statistics, 2: pp. 433–459.

Bisson, L., 2001, *Course VEN124 Wine Production, Lesson 1*, http://lfbisson.ucdavis.edu/PDF/VEN124%20Section%201.pdf

Chapman K.W., *et al*, 2001, *Quantitative Descriptive Analysis and Principal Component Analysis for Sensory Characterization of Ultrapasteurized Milk*, J. Dairy Sci. 84: pp.12–20

Darlington, D., *The Chemistry of a 90+ Wine*, August 7, 2005, The NY Times Magazine http://www.nytimes.com/2005/08/07/magazine/07ENOLOGI.html?pagewanted=all

Da Silva, *et al*, 2012, *Correlation of quantitative sensorial descriptors and chromatographic signals of beer using multivariate calibration strategies*, Food Chem. 134: pp. 1673–1681

Francis, L., *et al*, 2005, *Objective measures of grape quality - are they achievable?*, ANZWIJ, 20:3: pp.12-19
o

- Hodgson, R., 2008, *An Examination of Judge Reliability at a major U.S. Wine Competition*,
    - Journal of Wine Economics, 3:2: pp. 105–113
- INAO, http://www.inao.gouv.fr/
- IQWC, http://iowawinegrowers.org/pdfs/IQWCguidelines_20120522.pdf
- ISO Beverage Standards, http://www.iso.org/iso/home.htm
- Italian DOC law, LEGGE 10 FEBBRAIO 1992, N. 164,
    - http://members.xoom.virgilio.it/mercurio2000/vino/L100292.htm
- Kemp, S.E., et al, 2009, Sensory Evaluation, a Practical Handbook, Wiley-Blackwell, pp. 96-119

LEQWA, http://www.lakeeriewine.com/

Meinhard, H., 1971, German Wines, Oriel Press

Menke, S., 2009, Colorado Wine Industry Quality Assurance Program, Wine Aroma Faults Panelist Training Manual, Colorado State University

Napa Valley Vintners, http://napavintners.com/

NJQWA, http://www.newjerseywines.com/qualitywine.html

OQW, http://www.grapeandwineryboard.nebraska.gov/oqw_overview_nebraska2010.pdf

Pola´sˇkova´, P., *et al*, 2008**,** *Wine flavor: chemistry in a glass*, Chem. Soc. Rev., 2008, 37, pp. 2478–2489

PWQI, http://wine.appellationamerica.com/wine-review/547/Quality-Assurance.html
http://extension.psu.edu/enology/wine-production/workshop-seminar-summaries

Robinson, J., ed., 2006, Oxford Companion to Wine, pp. 693-695

Spanish law, Ley 24/2003 de la Viña y del Vino,
http://noticias.juridicas.com/base_datos/Admin/l24-2003.html

SQF Standards, http://www.sqfi.com/

TTB, Code of Federal Regulations, Title 27 CFR, Parts 1, 4, 9, 12, 13, 16, 24, 27, 28, 107-188
http://ecfr.gpoaccess.gov/cgi/t/text/textidx?c=ecfr&tpl=/ecfrbrowse/Title27/27tab_02.tpl

van Gemert, L. J., 2003, Odour Thresholds, Oliemans Punter and Partners, pp. 5

VQA Ontario, http://www.vqaontario.com/Home

VQA British Columbia, http://www.winelaw.ca/cms/

SECTION II

Agronomy

Roundup-Ready Soybean Variety Performance Trial and Number of Seed Rows on a Bed at Fruita, Colorado 2011

Calvin H. Pearson[1]

Summary

Commercial acreage of soybeans is being grown by some producers in the Grand Valley of western Colorado. Soybeans are of interest to growers in the area because they are relatively easy to grow. Also, growers currently have the equipment to grow soybeans, and soybeans work well in rotation with other crops grown in the area such as corn. Soybeans do not require high levels of costly production inputs and soybeans provide organic nitrogen for succeeding crops. Furthermore, in many years farm gate prices for soybeans have been attractive. Numerous new Roundup-Ready soybean varieties continue to be available for commercial production. The objective of this research was to evaluate ten Roundup-Ready soybean varieties for seed yield and related agronomic performance. Weed control in the soybean variety trial in 2011 was excellent. Weeds in the field and plot area were controlled with two Roundup applications. Maturity ratings for the ten varieties ranged from Group 2 to mid-Group 3. Average seed yield of the ten soybean varieties was 2702 lbs/acre (45.0 bu/acre). Seed yields ranged from a high of 3098 lbs/acre (51.6 bu/acre) for S31-L7 to a low of 1846 lbs/acre (30.9 bu/acre) for S20-Y2. Seed yield for the twin seed rows was 221 lbs/acre (3.7 bu/acre) higher than the single seed row. The represents an 8.5% increase in yield when twin seed rows were compared to yields on a single seed row on a 30-inch bed. Compared to a single seed row on a 30-inch bed, planting twin seed rows also increased plant population, seed moisture at harvest, matured slightly later, was taller, set the first pod higher up on the bottom of the plant, and reduced shattering. Based on one year of field results, planting twin seed rows of soybean on a 30-inch bed would be advantageous for commercial soybean producers in western Colorado. Also, Roundup-Ready soybean varieties provide producers with a convenient, cost-effective, and highly effective weed control management tool that results in weed-free fields and promotes soybean productivity. In general, soybean varieties with late maturity Group 2 and early maturity Group 3 produced the highest seed yields.

Introduction

Commercial acreage of soybeans is being grown by some producers in the Grand Valley of western Colorado. New soybean varieties continue to be available for use in commercial agriculture. Selecting the proper variety for local adaptation and performance is critical to the profitability of producing soybean.

Weed control can be a major challenge and can contribute significantly to seed yield variations. Commercial production of soybean using Roundup-Ready varieties offers producers with considerable crop management flexibility. Roundup-Ready soybean varieties can be planted on a more timely and flexible basis than conventional soybeans given that conventional soybean varieties require the use of herbicides that have to be applied following detailed and timely procedures. Commercial production of Roundup-Ready soybean varieties allows for flexible timing application and relative ease for control of weeds during the growing season. Furthermore, applying Roundup can be accomplished more quickly and often with fewer concerns for weed control than operations involving cultivation.

In 2004, a soybean trial was conducted at the

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Western Colorado Research Center at Fruita to evaluate new Roundup-Ready soybean varieties for their adaptation and performance under local conditions (Pearson, 2005). These Roundup-Ready soybean varieties evaluated in 2004 were found to perform similar to the conventional varieties evaluated in western Colorado during the period 1986-1989.

Research conducted in western Colorado years ago showed that the multiple seed rows per bed increased yields (Pearson and Golus, 1988; Pearson et al., 1989). Bruns (2011) recently conducted research in Mississippi and he did not promote twin-row soybean production, but neither did he discourage planting twin seeds rows.

The objective of our 2011 research was to evaluate Roundup-Ready soybean varieties for seed yield and related agronomic performance and determine how these varieties are likely to perform when produced commercially in the Grand Valley of western Colorado. An additional objective in 2011 was to evaluate soybean performance when planted in single and twin-seed rows on 30-inch beds.

Materials and Methods

Soybean Variety Performance Trial

A Roundup-Ready® soybean variety performance test was conducted at the Western Colorado Research Center at Fruita, Colorado during 2011. The experiment was a randomized complete block with four replicates.

Soybean plot samples being processed in the field lab for seed yield, seed moisture, and test weight following harvest in 2011. Photo by Calvin Pearson.

Ten varieties were included in the trial. Plot size was 5-feet wide by 25-feet long (2, 30-inch rows). The previous crop was corn.

Planting occurred on 6 June 2011 with a cone plot planter. Seeding rate was approximately 185,000 seeds/acre.

Glyphosate (Glystar) herbicide at 2 qt/acre plus ½ pt/acre of Activator 90 plus ½ pint/acre Maximizer plus 1.5 qt. of urea ammonium nitrate fertilizer in 100 gals of water was applied at 30 psi in 20 gallons/acre on 14 June 2011. Another application of glyphosate (Glystar) herbicide at 2 qt/acre plus 1 qt/acre of Activator 90 plus 2 gal. of urea ammonium nitrate fertilizer per 100 gal. of water was applied at 40 psi using 27 gallon/acre on 14 July 2011.

The experiment was furrow-irrigated using gated pipe. The plot area was irrigated eight times during the season, averaging 24 hours per irrigation set. Plots were harvested on 10 Oct. 2011 using a Hege small plot combine.

Data were collected for seed yield, seed moisture, test weight, plant population, days to maturity, plant height, height to first pod, test weight, seed shattering, and seeds/lb. Seed moisture and test weight were obtained using a Seedburo GMA-128 seed analyzer. Seeds/lb was determined by hand-counting 200 seeds followed by calculating the number of seeds per pound.

Number of Seed Rows per Bed

In 2011 we planted a single seed row and twin-seed rows on 30-inch beds with 8 inches between the seed rows. The ten soybean varieties in the variety trial were planted on both single and twin-seed rows. Crop production practices and data collection were similar to the variety performance trial.

Results and Discussion

Weed control across the entire plot area was excellent. Application of Roundup was convenient and provided considerable flexibility in applying the herbicide and obtaining effective weed control. Weeds in the field and plot area were readily controlled with the two Roundup applications.

The cost of applying Roundup for commercial production of Roundup-Ready soybeans in western Colorado, based on rates, applicator costs, and adjuvants used in our study, ranges from $20 to $25 per acre per application.

The 2011 growing season in the Grand Valley was short at 157 days. The last spring killing frost occurred on May 3 (28ºF) and the first fall killing frost occurred on October 7 (28ºF). The average growing season for the Grand Valley is 181 days (28ºF). Adequate irrigation water was available during the growing season and was not a limiting factor for crop production.

Soybean Variety Performance Trial

Maturity ratings of the ten varieties ranged from Group 2 to mid-Group 3 (Table 1). Seven varieties were Maturity Group 2 and three varieties were Maturity Group 3.

Average seed moisture content at harvest was 9.6% (Table 1). There were significant differences among soybean varieties for seed moisture. Soybean variety S34-N3 had the highest seed moisture content at 10.5%. S20-Y2 had the lowest seed moisture content at harvest at 8.6% and it was an early-maturing variety with a maturity rating of 2.0. In 1987, average seed moisture content of the 15 varieties evaluated in a variety performance test was 6.4% (Pearson and Golus, 1988).

Average seed yield for the ten soybean varieties was 2702 lbs/acre (45.0 bu/acre) (Table 1). Seed yields ranged from a high of 3098 lbs/acre (51.6 bu/acre) for S31-L7 to a low of 1846 lbs/acre (30.9 bu/acre) for S20-Y2. Other high yielding soybean varieties in this study were S34-N3, S28-K1, S28-B4, and S30-F5.

Yields obtained in the 2011 trial were lower compared to yields obtained in previous research conducted in western Colorado in the 1980s and in 2004. Highest seed yields obtained in previous research conducted in the Grand Valley were 73.6 bushels/acre in 1986 (Pearson et al., 1987), 67.8 bushels/acre in 1987 (Pearson and Golus, 1988), 61.9 bushels/acre in 1988 (Pearson, et al., 1989), 55.7 bushels/acre in 1989 (Pearson et al., 1990), and 51.5 bushels/acre in 2004 (Pearson, 2005).

Test weight in 2011 averaged 57.6 lbs/bu and ranged from a high of 58.5 lbs/bu for S31-L7 and S34-N3 to a low of 56.6 lbs/bu for S20-Y2 (Table 1). There were significant differences among the ten soybean varieties for test weights. Test weights in 2011 were comparable to those obtained in most other years. In 2004, test weights averaged 56.6 lbs/bu (Pearson, 2005). In 1986, test weights averaged 58.3 lbs/bu (Pearson et al., 1987), 57.8 lbs/bu in 1987 (Pearson and Golus, 1988), 57.2 lbs/bu in 1988 (Pearson et al., 1989), and 56.3 lbs/bu in 1989 (Pearson et al., 1990).

Average plant population in 2011 in the soybean variety performance study was 120,153 plants/acre (Table 2). S28-B4 soybean variety had the highest plant population at 137,214 plants/acre and S20-Y2 had the lowest plant population at 105,270 plants/acre. Seed quality of the soybean varieties may have been a factor that contributed to the wide range in plant population among the varieties. Based on previous research in western Colorado, grain yields increased as plant populations increased up to 170,000 plants/acre (Pearson et al., 1989). Thus, plant population in 2011 could have been a limiting factor for obtaining higher seed yields, although we also had a shorter growing season than normal.

The average number of days for the soybean varieties to reach maturity was 104 (Table 2). Soybean variety S20-Y2 matured earlier than other varieties at 99 days and S31-L7 and S34-N3 required 112 days to reach maturity.

Plant height in 2011 averaged 29.3 inches and the tallest variety was S30-F5 at 37.0 inches (Table 2). The shortest variety was S22-C5 at 22.4 inches. In 2004, the average plant height of 23 soybean varieties was 47.0 inches. The range in plant height in 2004 was from 37.6 to 54.7 inches (Pearson, 2005).

In 1987, the average plant height of 15 soybean varieties was 37.7 inches. The range in plant height in 1987 was from 29.4 to 49.0 inches (Pearson and Golus, 1988). In 1988, average plant height of 21 soybean varieties was 37.0 inches. The range in plant height in 1988 was from 24.1 to 46.1 inches (Pearson et al., 1989).

Height to first pod is an important harvest factor. Pods that are produced close to the soil thus, reduce yields. Harvest efficiency is increased when the first pod is set higher up the plant. Average height from the soil surface to the first pod in 2011 was 4.5 inches (Table 2). Soybean varieties with the greatest height to the first pod were S31-L7 at 5.6 inches, S28-K1 at 5.3 inches, S34-N3 at 5.1 inches and S30-F5 at 5.0 inches. Soybean varieties with the lowest height to the first pod were S22-C5 at 3.2 inches, and S21-E4 at 3.8 inches.

Average height from the soil surface to the first pod in the 2004 trial was much higher than that in the 2011 trial (Pearson, 2005). The average height to the first pod in 2004 was 9.1 inches and heights ranged from a high of 11.8 inches to a low of 6.8 inches.

In 1987, the average height to the first pod of 15 soybean varieties was 5.7 inches. The range in height to first pod was from 2.9 to 7.4 inches (Pearson and Golus, 1988). In 1988, average height to the first pod of 21 soybean varieties was 3.9 inches. The range in height to the first pod was from 2.6 to 5.3 inches (Pearson et al., 1989).

The desired height to the first pod should be at least 6 inches so the combine head will be able to cut low enough without leaving pods still attached to the stem and still be high enough that soil does not get into the head and into the combine. Thus, all of the varieties evaluated in 2011 had pod heights that were lower than desired.

Seed shattering for the ten varieties in 2011 averaged 1.5 (Table 2). The early-maturing variety S20-Y2 had the highest shattering rating at 3.8 while six of the ten varieties had shattering scores less than 1.5. Seed shattering for the twenty-three varieties in 2004 averaged 1.2 (Pearson, 2005). In 1987, seed shattering averaged 0.5 (Pearson and Golus, 1988), 0.7 in 1988 (Pearson et al., 1989), and 0.3 in 1989 (Pearson et al., 1990). Seed shattering in 2011 was higher than in other years. Rain events occurred in fall 2011 which delayed harvest. This harvest delay could have contributed to the higher seed shattering in 2011.

Average seed size for the ten soybean varieties was 2724 seeds/lb (Table 2). S21-E4 had the largest seed size at 2457 seeds/lb and S28-B4 had the smallest seed size at 3066 seeds/lb. There were significant differences among the soybean varieties for seed size. S31-L7 also had a small seed size. S28-K1 also had a large seed size at 2528 seeds lb. In 2004, average seed size for the twenty-three soybean varieties was 2683 seeds/lb (Pearson, 2005). In 1986, seeds/lb averaged 2560 (Pearson et al., 1987), 2550 in 1987 (Pearson and Golus, 1988), 3059 in 1988 (Pearson et al., 1989), and 2366 in 1989 (Pearson et al., 1990).

Number of Seed Rows per Bed

Seed moisture content for the twin seed rows was slightly higher than the single seed row. The difference in seed moisture between the twin and single seed row was only 0.2 percentage points (Table 1).

Seed yield for the twin seed rows was 221 lbs/acre (3.7 bu/acre) higher than the single seed row. The represents an 8.5% increase in yield when twin seed rows were planted compared to a single seed row in a 30-inch bed.

Seed rows per bed did not affect test weight of soybean (Table 1).

Plant population of twin seed rows per bed was 25% higher than the single seed row per bed (Table 2). The reason for the higher plant population on the twin seed rows compared to the single seed row is not readily apparent, but could be due to better germination because twin rows were closer to the furrow and seed may have imbibed water more readily.

Soybeans planted in a single seed row matured one day earlier than soybean grown on twin seed rows (Table 2). Soybean plants grown in twin seed rows were 2 inches taller than soybeans grown on a single seed row. Additionally, soybean plants grown in twin seed rows set their first pod 0.6 inches higher on the plant than soybean planted on a single seed row.

Shattering was 14% higher when soybean was grown in a single seed row compared to a twin seed row (Table 2). Seed size was not affected by the number of seed rows on a 30-inch bed (Table 2).

Summary

Roundup-Ready soybean varieties provide producers with a convenient, cost-effective, and highly effective weed control management tool that results in weed-free fields and promotes soybean productivity. In general, soybean varieties with late maturity Group 2 and early maturity Group 3 produced the highest seed yields.

Compared to a single seed row on a 30-inch bed, planting twin seed rows increased plant population, seed yield, seed moisture at harvest, matured slightly later, was taller, set the first pod higher up on the bottom of the plant, and reduced shattering. Based on one year of field results, planting twin seed rows of soybean on a 30-inch bed would be advantageous for commercial soybean producers in western Colorado.

Acknowledgments

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Publications

Bruns, H.A. 2011. Comparisons of single-row and twin-row soybean production in the mid-South. Agron. J. 103:702-708.

Pearson, C.H. 2005. Agronomic performance of Roundup-Ready soybean varieties at Fruita, Colorado 2004, pps. 47-52. *In*: Western Colorado Research Center 2004 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR05-08. Fort Collins, Colorado.

Pearson, C.H., Miklas, P.N., and Golus, H.M. 1986. Soybean production in the Grand Valley of Colorado, 1986: variety performance test, farmer field sampling, and prospectus. Agricultural Experiment Station. Department of Agronomy. Fruita Research Center. Colorado State University Technical Report TR87-5.

Pearson, C.H. and Golus, H.M. 1987. Variety performance, inoculation, and nitrogen fertilization of soybean in western Colorado, 1987. Agricultural Experiment Station. Department of Agronomy. Fruita Research Center. Colorado State University Technical Report TR88-7.

Pearson, C.H., Golus, H.M., and Judson, F.M. 1988. Variety performance tests, row spacing, and plant population of soybeans in western Colorado, 1988. Agricultural Experiment Station. Department of Agronomy. Fruita Research Center. Colorado State University Technical Report TR89-5.

Pearson, C.H., Golus, H.M., and Judson, F.M. 1989. Variety performance tests, inoculation, and plant population of soybeans in western Colorado, 1989. Agricultural Experiment Station. Department of Agronomy. Fruita Research Center. Colorado State University Technical Report TR90-5.

Table 1. Soybean variety performance trial and number of seed rows on a 30-inch bed. Fruita, CO 2011.

Variety	Maturity group	Moisture (%)	Seed yield (lbs/acre)	Seed yield (bu/acre)	Test weight (lbs/bu)
S20-Y2	2.0	8.6	1846	30.9	56.6
S21-E4	2.1	9.8	2349	39.0	57.1
S22-C5	2.2	9.3	2562	42.9	56.7
S25-F2	2.5	9.5	2753	45.9	57.4
S25-R3	2.5	9.1	2616	43.6	57.5
S28-B4	2.8	9.9	2920	48.6	57.8
S28-K1	2.8	9.9	2977	49.6	58.2
S30-F5	3.0	9.9	2909	48.4	57.8
S31-L7	3.1	9.6	3098	51.6	58.5
S34-N3	3.4	10.5	2993	49.8	58.5
ave.		9.6	2702	45.0	57.6
CV (%)		7.3	13.9	13.9	0.5
LSD (0.10)		0.6	314	5.2	0.2
Seed rows per bed					
Single		9.5	2592	43.2	57.6
Twin		9.7	2813	46.9	57.6
ave.		9.6	2702	45.0	57.6
CV(%)		4.0	12.2	12.2	0.6
LSD (0.10)		0.2	174	3.1	NS

Table 2. Soybean variety performance trial and number of seed rows on a 30-inch bed. Fruita, CO 2011.

Variety	**Plant population (plants/acre)**	**Days to Maturity (no.)**	**Plant height (in.)**	**Height to first pod (in.)**	**Shattering (1-5)[1]**	**Seeds/lb (no.)**
S20-Y2	105,270	99	27.1	3.9	3.8	2581
S21-E4	125,598	102	27.0	3.8	1.1	2457
S22-C5	125,598	100	22.4	3.2	1.8	2617
S25-F2	124,872	102	26.4	4.4	1.0	2773
S25-R3	116,886	102	25.9	4.1	1.9	2705
S28-B4	137,214	102	27.6	4.8	1.5	3066
S28-K1	113,256	102	31.3	5.3	1.0	2528
S30-F5	129,954	107	37.0	5.0	1.1	2917
S31-L7	114,708	112	33.8	5.6	1.0	3033
S34-N3	108,174	112	34.9	5.1	1.0	2559
ave.	120,153	104	29.3	4.5	1.5	2724
CV (%)	25.8	0.9	7.9	16.8	25.1	3.6
LSD (0.10)	NS	0.8	1.9	0.6	0.3	81.1
Seed rows per bed						
Single	106,867	104	28.3	4.2	1.6	2741
Twin	133,439	105	30.3	4.8	1.4	2707
ave.	120,153	104	29.3	4.5	1.5	2724
CV(%)	32.4	0.9	8.2	6.2	14.2	3.7
LSD (0.10)	20,483	0.5	1.3	0.1	0.1	NS

[1]Shattering scale (1 = no shattering, 5 = totally shattered).

SECTION III

Fruit Crops

Evaluation of Peach Rootstocks

Ramesh Pokharel

Summary

A peach rootstock evaluation study was initiated as part of an NC-140 collaborative study to find better rootstocks for higher yield, better fruit quality, pest resistance, and cold tolerance for western Colorado. Redhaven peach trees grafted to 17 different rootstocks were planted in May of 2009 in a completely randomized block design with 8 replications. Measurements were taken initially, and after first, second, and third years, including tree circumference growth, and numbers of dead trees and suckers. In the third year, we recorded fruit yield (total weight per tree), total number of fruits, and weight of individual fruit. In the third year, trees on Controller 5 (K146-43), *Prunus americana* selection, and Microback had the least circumference growth (2.2, 2.5, and 4.0 cm, respectively) while KV010123, Atlas, and KrymskR 86 (Kuban 86) had the greater circumference growth (7.5, 6.2, and 5.9, cm respectively). Sucker numbers ranged from 0.1 Empyrean R2 (Penta) to 5.9 (Microback) in year three. There was no correlation between first and second year's tree circumference growth and sucker numbers. Trees grafted to seven different rootstocks did not have any mortality whereas up to 50% tree mortality was observed with Viking rootstock, and the remaining rootstocks had 12.5% mortality. The tree mortality was less in year three. All tree mortality occurred due to Cytospora canker infection. All trees on Krymskg1 (VVA-1) rootstock did not produce fruit whereas trees on KV010123 (1758.0 grams), and KV010127 (1696.2 grams) had higher yield, and trees on Imperial (California) (131.9 g) and Controller 5 (K146-43) (207.3 grams) had the least fruit yield as compared to the rest of the rootstocks. The total numbers of fruit per tree ranged from 0.9 on Imperial (California) to 10 on KV010123) rootstocks.

Introduction

Peach is the major tree fruit crop in Colorado. Adaptability, growth, and productivity of trees depend on the rootstock's ability to adapt within a soil condition. Western Colorado has different sets of environment and soil conditions characterized by heavy and calcareous soils. The rootstocks performing better in other locations might not perform the same in western Colorado conditions.

Thus, a peach rootstock experiment was initiated in 2009 as part of a multistate NC-140 collaborative project to assess performance of peach rootstocks under western Colorado conditions. This study aims to identify rootstocks suitable to local environment and climate.

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The rootstocks identified in this experiment might be a solution for other areas having similar soil type.

Materials and Methods

Redhaven peach trees grafted to 17 different rootstocks were planted at WCRC-OM site (Grand Junction, CO) on April 6 – 7, 2009 in a completely randomized block design with 8 replications. After two weeks, the trees were marked at 18" above ground level. Tree measurements were carried out a week after marking the trees, after the first (October, 2009) and second year's (October 2010) growth. Tree growth was calculated by subtracting the initial tree measurements from first year's and first year from the second year's tree circumference measurements at 18" height. Total number of suckers produced in each tree was counted, and tree mortality recorded in each year.

Results

In the third year, trees on Atlas , BH-5, and Viking had higher growth whereas Controller 5 (K146-43), Krymskg1 (VVA-1), *Prunus americana* selection, and Fortuna had the least growth. The tree mortality, highest in Viking (50%) and 9 different rootstocks (12.5%), occurred mostly in the first year of planting. However, a few trees died due to Cytospora canker in latter years. The trees on Viking, KrymskR 86 (Kuban 86), HBOK 10, and Controller 5 (K146-43) rootstocks did not produce suckers whereas trees on Microback rootstock produced the highest number of suckers (Table 1).

In 2010, the fruit set and yield was affected by spring frost. Four major late frost events occurred on April 27, April 30, May 1 and May 2 of 2010 with 29.1, 29.7, 27.9, and 28.8 ^{o} F temperatures, respectively. The frost affected late peach varieties and did some damage on flowers affecting the normal crop in this block as the trees were smaller and this block is at the corner of the property. However, this frost had no impact on tree growth.

Trees on all rootstocks except Krymskg1 (VVA-1) produced fruits. However, not all trees of each rootstock produced fruit. Trees on rootstocks KV010123 and KV010127 produced higher yield (grams per tree) and total numbers of fruit per tree whereas Controller 5 (K146-43), Imperial (California), and KrymskR 86 (Kuban 86) had lower yields. Controller 5 (K146-43) and Imperial (California) produced the lowest numbers of fruit per tree. Trees on Atlas, *Prunus americana* selection, and HBOK 10 rootstocks produced higher individual fruit weight.

Table 1. Initial trunk circumference measurements, first, second, and third year circumference growths, and fruit yield of Redhaven peach grafted to 17 rootstocks, including one standard Lovell rootstock planted in 2009 at the WCRC-OM, Grand Junction, CO. Trunk measurements were taken 45 cm (18”) above the graft union.

	Tree growth			Fruit Yield				
Rootstocks	**Year 1**	**Year 2**	**Year 3**	**Total fruit weight (kg)/tree**	**Total fruit per tree**	**Avg fruit wt**	**% of dead trees**	**Number of suckers**
Viking	1.0	2.0	5.8	1213.3	7.5	161.8	0.0	0.0
Atlas	2.0	1.8	6.2	959.3	5.3	181.5	0.3	0.3
BH-5	3.0	2.5	5.5	1087.8	6.5	167.3	1.3	1.3
Microback	4.0	1.3	4.0	369.3	2.7	136.1	5.9	5.9
Guardian (selection 17-7)	5.0	2.2	5.9	906.9	6.6	138.0	1.7	1.7
Lovell	6.0	1.4	4.9	562.8	3.8	150.1	3.5	3.5
KV010123	7.0	0.6	7.5	1758.0	10.0	175.8	2.2	2.2
KV010127	8.0	2.2	5.4	1696.2	9.4	179.9	2.1	2.1
KrymskR 86 (Kuban 86)	9.0	2.2	5.9	367.9	2.9	128.8	0.0	0.0
Empyrean R2 (Penta)	10.0	2.5	5.0	1099.6	8.6	128.3	0.1	0.1
Imperical (California)	12.0	1.9	5.1	131.9	0.9	150.7	0.1	0.1
HBOK 10	13.0	1.3	4.4	1040.6	6.0	173.4	0.0	0.0
HBOK 32	14.0	1.4	4.2	774.9	5.0	155.0	1.4	1.4
Prunus americana selection	15.0	0.6	2.5	837.3	4.8	176.3	1.6	1.6
Fortuna	16.0	1.9	5.7	528.3	4.1	127.5	1.4	1.4
Krymskg1 (VVA-1)	17.0	1.2	4.1	0.0	0.0	0.0	0.9	0.9
Controller 5 (K146-43)	18.0	1.3	2.2	207.3	1.5	138.2	0.0	0.0

Acknowledgment

The funding for this study was provided by the Agricultural Experiment Station. Appreciation is extended to John Wilhelm and Bryan Braddy (Western Colorado Research Center staff) who assisted with this project.

Testing the Benefits of Deficit Irrigation on Western Slope Peach Orchards

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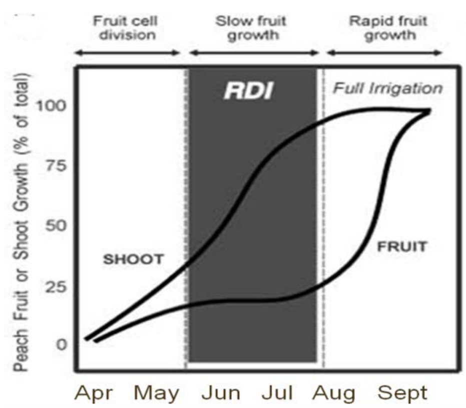
Summary

Since 2009 CSU Extension and the Mesa Conservation District with support from Western Colorado Research Center - Orchard Mesa (WCRC-OM), Palisade orchardists, and the Bureau of Reclamation have been testing the benefits of Regulated Deficit Irrigation (RDI) strategies in Western Colorado peach orchards. RDI was initially developed for peaches and pears in Australia starting in the 1970s, with variations of the protocol now in use throughout the commercial fruit growing world. The strategy takes advantage of the growth lag inherent in the phenology of late season peach cultivars (see Figure 1). This lag is particularly pronounced in varieties such as Cresthaven, Angelus, and O'Henry, where trees prioritize vegetative (or "shoot") growth over fruit development in the middle of the growing season. RDI has proven especially effective where water is scarce and expensive by withholding irrigation water during this period with minimal impact on yields. Western Colorado trials have been exploring RDI's ability to reverse chlorosis or tree yellowing, reduce pruning labor (Figure 2), and limit salinity loading into local waterways.

Figure 1 : The vegetative ("shoot") and fruit growth rates on peaches revealing the growth lag used in RDI



Source: Chalmers, et al. 1981

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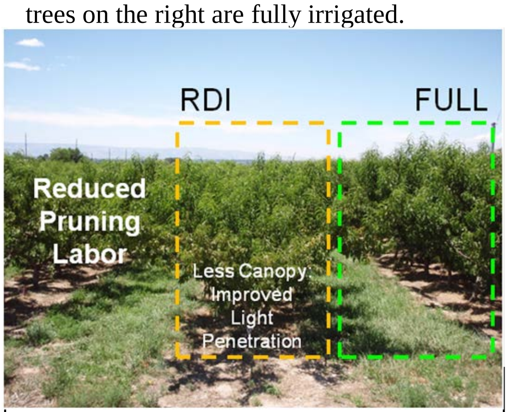
After two encouraging seasons of testing RDI in the Palisade area, 2011 saw the expansion of research into RDI with trials initiated at four orchards: two on Orchard Mesa, one in the East Palisade area, and one on Rogers Mesa near Hotchkiss. Also included was a fully randomized experiment employing irrigation treatments of varying deficit levels under the supervision of Dr. Ramesh Pokharel at the WCRC-OM.

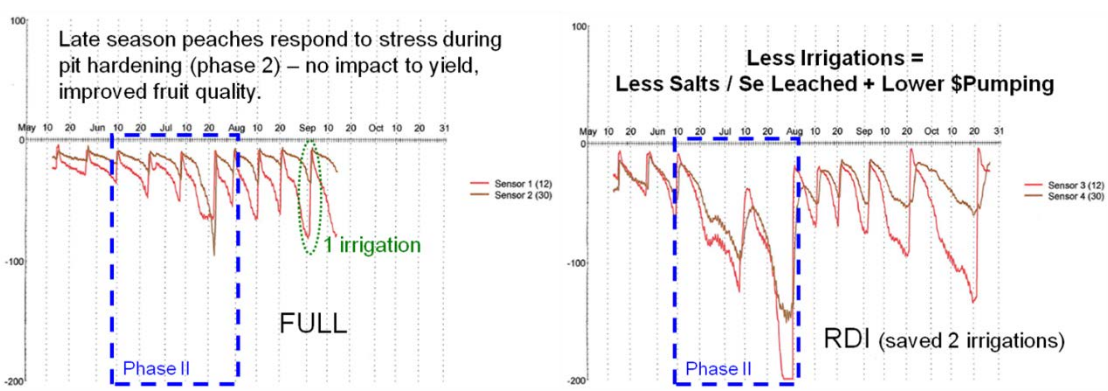
Prior to 2011 some success was achieved eliminating two irrigations during the fruit lag growth stage (figure 1) on an orchard of O'Henrys at Orchard Mesa (Figures 3 and 4). The 2011 orchard treatments were designed to focus on the optimum number of irrigations that could be eliminated during the lag phase of growth within the schedule of a Western Colorado orchardist's busy growing season.

Figure 2 : Trees on left showing the reduced vegetative growth from RDI. The trees on the right are fully irrigated.



The Bureau of Reclamation is generously helping fund two years of expanded testing through the 2011 Water Conservation Field Services Program. Funding is through summer of 2013 and is assisting with the costs of field labor, soil moisture measurement, soil analysis, and fruit testing. Unfortunately a late freeze (Figure 5), late runoff, and wet summer in 2011 conspired to inhibit the degree to which the expanded investigations could proceed. Yield assessments were postponed until the 2012 growing season, with deficit treatments continuing to evaluate any signs of long term stress and impacts on fruit quality.

Figures 3 and 4 : The benefits of RDI were demonstrated in 2009 on an O'Henry orchard at East Orchard Mesa, Colorado. These graphs show soil moisture throughout the growing season where the more negative the measurement the drier the soil.



Source: Reich, Guccini, 2011

Material and Methods

In 2011 growing season, a Cresthaven peach block with 6 rows of 400 feet was selected for testing of four RDI treatments. The experiment was conducted in completely randomized block design with four replications. In each replication, five random trees out of the 10 to 15 trees in each block were selected for yield and quality observation. To manage irrigation treatments, 15 soil moisture sensors were installed in the rows at a depth representative of root zone soil moisture (about 15 inches): one sensor was assigned to an observation tree within each of the four treatments plus control across three of the four replications. All sprinkler emitters were equipped with a controller switch. Depending on soil moisture levels, emitters were opened and closed to permit irrigation of trees consistent with their assigned treatment (Table 1).

Four irrigation treatments were tested against a control treatment of 20 to 24 hour sets every two weeks:

(#1) approximately half the irrigation set length of the control on the same schedule;

(#2) irrigations with control during lag phase of growth triggered at a soil tension of 100 cbars or below;

(#3) irrigations with control during lag phase of growth triggered at a soil tension of 150 cbars or below;

(#4) irrigations with control during lag phase triggered at a soil tension of below 200 cbars.

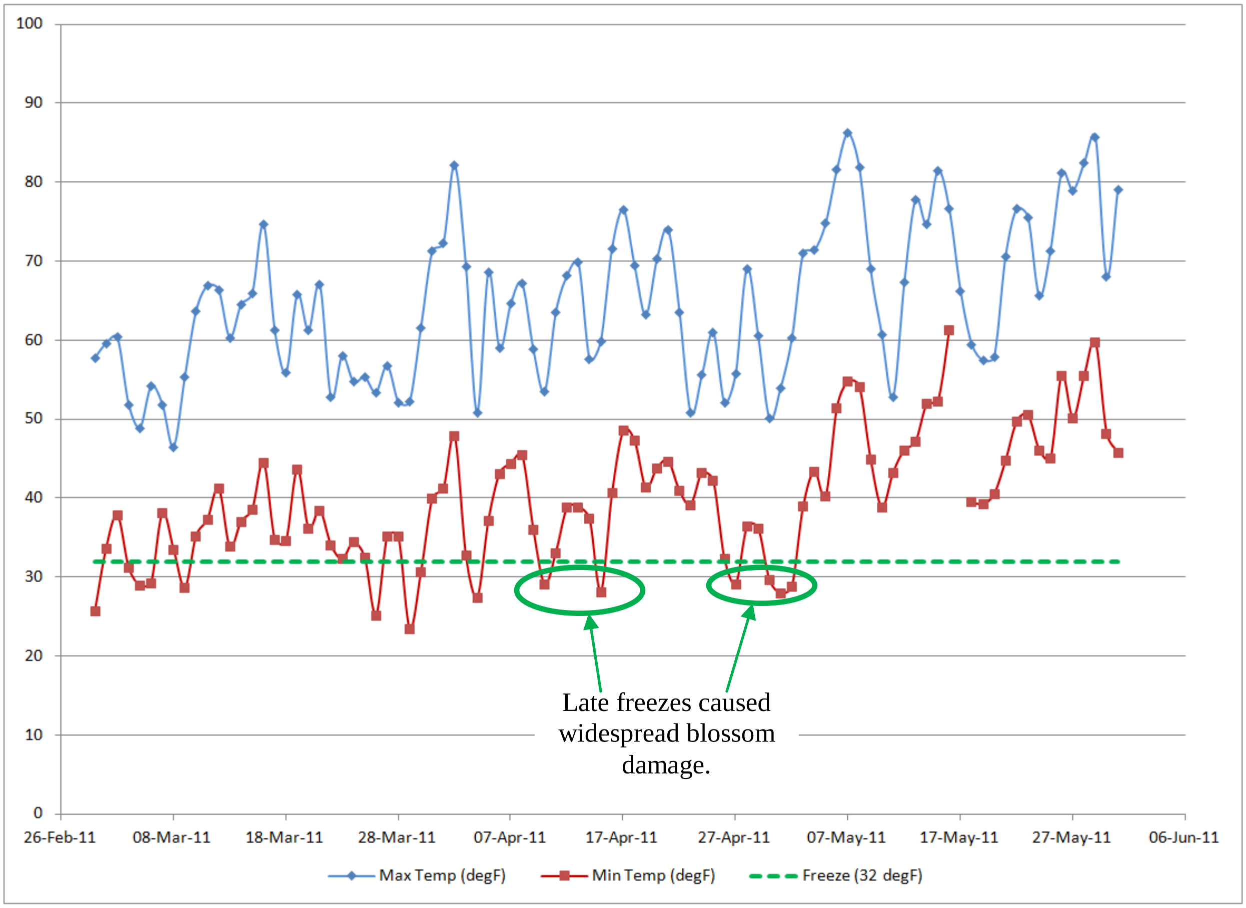
Treatments #2, #3, and #4 followed the control outside the lag phase of growth. Laboratory fruit quality parameters tested were: total brix, pH, tartaric acid, and fruit firmness (sun and shade side). Fruit firmness in both sun side and shade side were taken by fruit Penetrometer (**Agriculture Solutions LLC, 2007).** Fruit juice was extracted from a random half of the random fruit by commercial juice extractor. Brix was measured using portable Refractometer with ATC (0-32 Brix) (Agriculture Solutions LLC). Fruit juice was diluted with water at 1:5 ratios, and pH and tartaric acid were measured by Automatic Titrator (Mettler Toledo DL 50). Collected data were analyzed using a SAS proc GLM to compare the means, by regression analysis, with water used (in CM) as an independent variable, and with brix, pH, tartaric acid, and firmness as independent variables, was performed with Excel™ (Microsoft, 2012).

Results and Discussion

In 2011 due to late frost (Fig 5) there was a significant damage in young fruit. Due to high variability in yield that resulted, the yield data were not evaluated for 2011. Results and discussion are instead focused on fruit quality of the Cresthaven trees at WCRC-OM. The first picking of fruit at WCRC-OM was August 23rd, and the second picking was August 28th. Five fruits were selected randomly from observation trees in each treatment plot (Table 1) for measurement and individual fruit weight, of these five fruits one was randomly selected for other quality parameters.

Most fruit quality parameters showed no detectable response to withholding between one and three-and-a- half irrigations, which suggests that even in years where yield forecasts are low, the risk of fruit damage from RDI is also likely to be low. The three parameters that showed some separation from the control treatment were both sun and shade side firmness and tartaric acid (Figures 6, 7, and 8), suggesting that withholding irrigation water during the lag growth phase has the potential to affect ripening rate. The separation and correlations were low so this is not likely to be a pronounced problem in fully productive years.

Figure 5: Orchard Mesa, Colorado Temperatures: March to May 2011

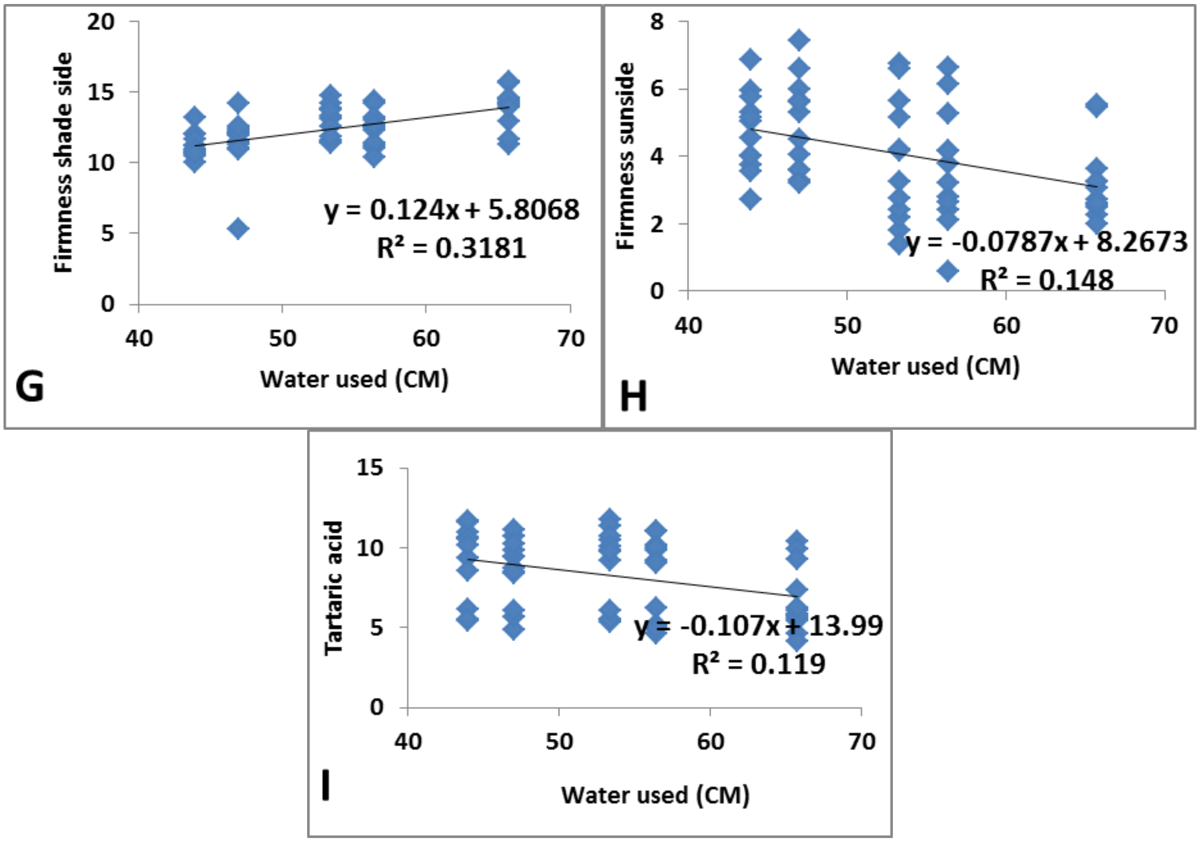


Source: Orchard Mesa Research Center CoAgMet Station

Table 1 : The five RDI treatments at Orchard Mesa Research Center and their 2011 water use.

Consumptive Use (75% eff)		***Inches***	***Irrigations***	**Replication**		
Treatment	**RDI Description**	average	avg saved	South	West	East
C	Control	25.8	0	25.8	25.8	25.8
#1	12hr (½set of C)	18.5	3	18.5	18.5	18.5
#2	100cb trigger	22.2	1.5	22.2	22.2	22.2
#3	150cb trigger	20.9	2	25.8	18.5	18.5
#4	200cb trigger	17.2	3.5	16.0	19.7	16.0

Figures 6, 7, and 8: Fruit quality parameters that had significant response to 2011 RDI Treatments: firmness and tartaric acid.



While weather conditions inhibited a full analysis of RDI's impact of peach production, it was clear that over a single season peach trees could tolerate limited water supplies with minimal impact on fruit quality. Up to 3.5 irrigations or 8.6 inches of water consumptive use was saved during the fruit lag phase of growth on these Cresthaven trees.

While water savings represent little immediate economic benefit to Western Colorado growers, the salt savings and salt impact on trees could be helpful to long term orchard health by reducing chlorosis outbreaks. Limiting soil moisture also limits soil salts from entering solution. This helps prevent raising the root environment pH and inhibiting micro-nutirent uptake. Producers would potentially also see savings in reduced micronutrient foliar sprays as chlorosis takes hold. Monitoring of soil salt content will help establish when this approach should be balanced with a leaching irrigation – a longer irrigation (36 to 48 hours) each season to suppress salt buildup within the root zone.

Conclusions

The first year at WCRC-OM successfully demonstrated minimal impact on Cresthaven fruit quality from RDI. Ripening rate may be slowed but the accompanying statistical analysis suggested this wasn't a pronounced affect. Results showed potential for long term economic benefit by reducing chlorosis and improving an orchard's productivity and longevity. Assuming the 2012 season does not see a repeat of 2011's blossom damage, testing and analysis will expand to include yield and pruning benefits. The project will include field days in orchards and at WCRC-OM.

Acknowledgements

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References

Chalmers, et al. 1981. "Control of Peach Growth and Productivity by Regulated Water supply, Tree Density, and Summer Pruning." *American Journal of Horticultural Science 106:307-312.*

Colorado Agricultural Meteorological Network - http://climate.colostate.edu/~coagmet/

Reich and Guccini. 2010. "2009 Growing Season – Palisade Micro-Irrigation Study . Regulated Deficit Irrigation (RDI) on Peaches." *Annual Report to USBR Water Conservation Field Services Program.*

Plant and soil health on Cytospora incidence, growth, and production in peach

Ramesh Pokharel

Summary

The health of a plant, both above ground and in the soil, plays an important role in productivity of a plant. Despite this fact, the soil component is neglected most of the time when assessing plant health and productivity. An integrated study was conducted to compare the response of different treatments on plant health and soil health. Plant health treatments included: Actiguard, Topsin, Latex paint, Actiguard + Topsin M and control. Soil health treatments included: wood mulching, canola meal application, wood mulch+ canola meal application, and control. Cresthaven peach trees in the same block were used for both parts of the study, looking at the treatment impacts on tree health and productivity. The experiment was laid out at the WCRC-OM site, in 2009 in a randomized block design with 4 replications having 5 trees in each replication. Tree growth and mortality were measured in each year and fruit yield was recorded in third year of establishment. In the third year, the highest tree growth was observed in woodchips +canola meal applied plots, and the lowest was observed in wood chips only applied plots. Similarly in another part of the study, the tree growth was higher in Topsin M and Actiguard+ Topsin M applied plots but were less than woodchip applied trees. Excellent foliage growth without Cytospora Canker incidence was observed in Topsin M applied plots but many trees died by Cytospora canker and lacked vigor in control plot. The tree mortality was the highest in control (41.07%) when no treatment was applied as compared to 0% mortality in canola meal cake and Actiguard applied plots. The highest yield (number of fruits and total yield) was observed in Topsin M treated trees followed by Latex paint treated trees. The lowest yield was observed with Actiguard and Actiguard+Topsin M treated trees.

Introduction

Plant health is mostly considered as the health of above ground plant parts. But to obtain healthier plants and efficient production, both the above ground and soil surrounded plant components are important. Soil health, however, is often neglected due to lack of available information. Soil health, and its impact on soil biological, chemical, and physical conditions, should always be considered to obtain a healthier and more productive production system.

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Soil health of western Colorado fruit orchards is considered to be poor as most soils are low in organic matter, deficient in micronutrients, high in pH and salts, and low in aeration and drainage because soil types are heavy. Several extensive studies on soil microbial population analysis showed a low level of beneficial soil microorganisms (BMO) in most of the conventional fruit production system of Colorado. BMOs play a vital role in improving soil health, because such microorganisms break down both organic and mineral materials in the soil, partly by enzymatic action and partly by taking the materials in as nutrients and metabolizing them further. Most of the breakdown products are used by the plants as nutrients or are lost into the soil environment. BMOs help with soil structure, soil hydrological processes, gas exchange and carbon sequestration (accumulation in soil), soil detoxification, nutrient cycling, decomposition of organic matter, and suppression of pests, parasites and diseases. These BMOs serve as food sources and medicines, establish symbiotic and/or communal relationships with plants and their roots to benefit plants, and affect plant growth control (positive and negative).

Poor soil chemistry in western Colorado fruit orchards, especially due to high soil pH, affects the availability of elements for plant uptake as well as chemical compounds that might be present at levels that are detrimental to plants and soil organisms. Analysis of several growers' orchard soil samples showed deficiency in many plant nutrients and low organic matter content, generally around or below 2%. This might have contributed to the low microbial populations in conventional orchards. Analysis of leaf samples exhibiting yellow peach syndrome (YPS), collected in grower orchards, showed low levels of iron, manganese and zinc in most cases., Growers often use only iron to correct this type of problem without analyzing symptomatic tissues (Pokharel, 2010). This problem is aggravated by high soil pH with irrigation water high in pH and salts further increasing the soil pH.

Physical properties of soil affect soil fertility by altering water movement through soil, root penetration in the soil and water logging. The soil in most of the fruit growing areas of Colorado has a high content of heavy mineral clay, which holds high moisture that impacts drainage, root aeration, and root growth.

This experiment conducted in two parts (plant health and soil health) evaluated the impact of different treatments on general plant health, tree growth, and BMOs, which in turn impact tree productivity. This study was designed with the objective of combining the best practices to get better plant health and production.

Materials and Methods

This experiment was laid out in completely randomized block design with 3 replications with four trees in each replication. Cresthaven peach trees grafted to seedling rootstock were planted following standard planting procedure at 8 x14 ft. spacing. The trees were marked with permanent marker at 18" height from ground level for measurement. The plant health study was conducted in half of the block and the soil health study in the other half.

In the plant health study, Topsin M, Latex paint and Actiguard were applied as per the recommended dose in trees, after a month of leaf development in spring and just before leaf fall in fall each year. In the soil health study, wood mulch and canola meal cake were applied when the trees were established well (1 month after transplanting). Woodchips were applied covering soil up to a height of 6" and replaced and maintained each year in summer at the same height. This block was maintained with all other recommended production practices.

Trees were measured at 18" height after a week of planting and after each year's growth. The disease incidences in each year, especially Cytospora canker, were recorded at the same time as each year's tree growth measurement. Tree growth measurements were calculated by subtracting the previous year's measurement from the current year's measurement and in case of the first year, from the initial measurement. In the third year of tree establishment, the fruits were harvested twice by hand.

In the first harvest, well-developed fruits in size and color were selected and in the second harvest all fruits were harvested. Total fruit numbers and total fruit in each tree were recorded in each picking. Five random fruits in each tree were selected and taken in the laboratory. Average fruit weight and size were determined in the laboratory. Data were tabulated and analyzed.

Results and Discussion

Tree circumference growth in soil health and plant health study of Cresthaven trees planted in 2009

Treatments	Initial circumfer-ence	Tree Growth			Tree Mortality %
		Year 1	Year 2	Year 3	
Wood chips+ canola meal cake	**5.9**	**1.6**	**7.9**	**4.6**	**25.0**
Canola meal cake	**5.5**	**0.6**	**10.7**	**4.3**	**0**
Woodchips only	**6.1**	**1.4**	**7.6**	**4.2**	**8.3**
Latex paint only	**4.2**	**1.8**	**6.8**	**4.3**	**25.0**
Topsin M	**4.2**	**2.3**	**6.8**	**4.3**	**16.7**
Actiguard +Topsin M	**3.4**	**2.0**	**8.9**	**4.3**	**16.7**
Actiguard only	**3.0**	**2.3**	**10.0**	**3.5**	**0.0**
Control	**3.7**	**2.1**	**9.5**	**3.4**	**41.7**

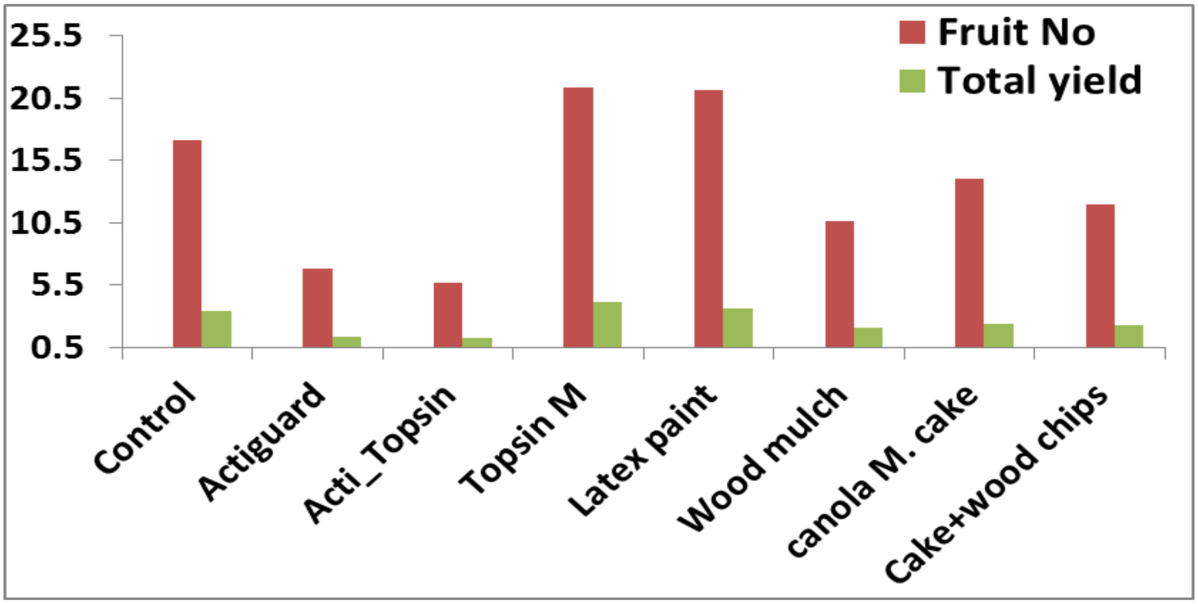
Tree growth. Tree mortality was the highest in the control trees (41.07%) where no treatment was applied as compared to 0% mortality in canola meal cake and Actiguard applied plots. The trees in canola meal applied plots had the least growth in the first year but were the highest in year 2 and in year 3. Trees with applications of either wood chips or canola meal cake showed accelerated growth only in the third year.

The woodchip, a good source of organic matter, is expected to build better soil microbial population, increase plant nutrients and reduce soil pH. This treatment was expected to produce better tree growth. But due to competition of microorganisms and nutrients for trees, in woodchips applied plots trees might have not grown well.

Fruit Yield. The highest yield (fruit numbers and total fruit weight) was observed in Topsin M treated trees followed by Latex paint, but the lowest yield was observed with Actiguard and Actiguard+Topsin M treated trees. These trees with higher yield were healthier, greener, more vigorous, free from Cytospora canker infection than the trees in control where the trees were either killed or weakened by Cytospora canker infection. The number of fruit and yield in the soil health block was low as compared to control and trees treated with Topsin M and Latex paint. This may be because of more damage by frost in that part of block. In 2010 the fruit yield was affected by spring frost. Four major late frost events occurred; April 27, April 30, May 1 and May 2 having 29.1, 29.7, 27.9, and 28.8^{o} F temperatures, respectively. Frost affected late peach varieties such as Cresthaven where about 30% of the normal crop loss was experienced. In this block, more frost damage occurred in the lower side of block where the soil health study is located as compared to the upper half of the block where the plant health study is located. In the soil health experiment, the weed population was very low in the first and second year of planting, but in the third year there was more Bindweed: *Convolvulus arvensis* took over even in mulched areas.

The microbial diversity, pH, and nutrient content in the soil will be assessed in this coming season.

Figure 1. Total numbers and total weight (lbs) of fruits per tree of Cresthaven peach in soil health and plant in health study at WCRC-OM, 2011



Acknowledgements

The funding for this study was provided by Agricultural Experiment Station. Appreciation is extended to John Wilhelm and Bryan Braddy (Western Colorado Research Center staff) who assisted with this project.

Incidence of multiple viruses in western Colorado cherry orchards

R. Pokharel

Summary

A limited survey for viruses in commercial cherry orchards in western Colorado in 2008 and 2009 suggested there may be a correlation between leaf symptoms and viral infection. Thus, further investigations were performed in 2010. Leaf and fruit samples from 116 trees of various sweet and sour cherry cultivars were collected from 25 orchards. Total nucleic acids were extracted and tested for viruses (RT-PCR) and viroids (dot blot hybridization) to correlate the severity of leaf enation symptoms, typically associated with *Cherry rasp leaf virus* **(**CRLV**)**, with the presence of other viruses or viroids. Eight viruses including CRLV, *Cherry virus A* (CVA), *Cherry green ring mottle virus*, *Cherry necrotic rusty mottle virus*, *Plum bark necrosis stem pitting associated virus*, *Prune dwarf virus*, *Prunus necrotic ringspot virus* and *Tomato ringspot virus* were found in various combinations in these trees. No viroids (*Peach latent mosaic viroid* and *Hop stunt viroid*) were detected. At least one virus was detected in 94% of the samples, with CRLV (62%) and CVA (53%) being the most common infections. Two or more viruses were present in 60% of the samples, and combinations of up to 7 viruses were detected in a given tree. The incidence of multiple infections did not correlate with symptom types, varieties or locations. Although trees with leaf enations were infected with CRLV, asymptomatic trees were also found to contain CRLV.

Introduction

Cherry, one of the important tree fruit crops in western Colorado, has high demand and good market price for fruits. However, the acreage under cherry production has remained constant over the recent years, possibly due to several factors contributing to low and unreliable production systems. Among them, spring frost, Cytospora Canker, and Cherry Rasp Leaf Virus are the most common and important factors causing low vigor, low and unreliable production, and tree death each year. Most of the time, severity and impact of such factors are compounded by the presence of more than one factor, and/or the trees are weakened by biotic or abiotic causes.

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Often biotic causes, such as infection of plant viruses, and also abiotic causes, remain asymptomatic in trees but make those trees highly vulnerable to other stress factors. However, some of the viruses commonly observed in growers' fields produce distinct symptoms such as enation followed by reduction in tree vigor, reduction in leaf and fruit size and number, and ultimately tree death. Symptoms other than enation could be caused by many different factors, including several plant viruses. We suspected association of viruses in such symptoms. Thus, we tested for common cherry viruses in such declining trees of varying symptoms severity in 2008. We found an association of higher number of viruses with severely infected trees. In 2009 we tested samples again for common stone fruit virus and viroids, including sour cherry samples, . In 2010, an extensive survey was conducted collecting more random samples to confirm the previous results and study the distribution of such viruses in cherry production areas.

Materials and Methods

In 2009, several growers' symptomatic and asymptomatic cherry orchards, suspected to be infected with virus, especially Cherry Rasp Leaf Virus, were selected for sampling. The symptoms included reduced foliage, small and lower numbers of leaves and foliage (Figure 1), declining trees (Figure 2), and variable patterns of yellow patches (Figure 3). Five trees in an orchard and several leaves in a tree were collected. In 2010, more random orchards and trees were selected for sampling, collecting 80 samples from 25 different orchards. These samples were tested for the presence of common viruses of stone fruits using RT-PCR (Figure 4 A-D) and for the two viroids known to infect stone fruits by dot blot hybridization (Figure 5).

Results

We observe a greater number of viruses in 2010 surveys in both sweet and sour cherry samples when we had higher number of samples tested. At least one virus was detected in 94% of the samples tested. All symptomatic (leaf enation) and some asymptomatic leaves were positive to CRLV. Up to 7 viruses were found in a single tree (Table 1). No correlation was found with the number of viruses and the symptom types. CRLV was the most common and widely distributed virus and was detected in 62% of the samples. CRLV is an important virus in Colorado and is transmitted by dagger nematodes and root grafting. One dagger nematode in 100 cc soil is enough to transmit this disease, and it is present in all fruit growing areas of Colorado at a level of 15-300 nematode per 100 cc soil. In another survey, all cherry varieties, except Royal Duke an old cherry variety, were susceptible to CRLV.

CVA, the second most common virus, was also widely distributed and observed in 53% of the samples. This virus alone does not produce any specific symptoms but causes damage when co-infected with other viruses.

Three sweet cherry samples in 2009 tested positive to APCLV. APCLV is a Trichovirus in Felxiviridae transmitted by mechanical inoculation and grafting (possibly root grafting) but not by pollen or seed. It is a latent virus in cherry and causes split bark or rough bark in cherry.

PNRSV (an Illarvirus) was observed in about 25% of the samples in sweet cherry in both years In 2010, 50% of samples were infected in sour cherry, whereas the single sample collected in 2009 was negative. Its economic importance depends upon fruit species, cultivars and the virus strain. This virus is transmitted by grafting and mechanical inoculation but may be transmitted by seed and pollen in some *prunus* species. This virus produces shock (chlorotic or necrotic leaf spot in spring) in first or second year of infection and later may remain symptomless. It may delay bud break, death of leaf and flower causing terminal dieback.

PVD, (an Illarvirus) was observed in higher percentages of the samples in 2009 as compared to 2010 in sweet cherry but only 20% of samples were infected by this virus in sour cherry. In cherry the infection causes up to 35% yield reduction and greater reduction occurs when co-infection with PNRSV occurs (Kunze, 1988) and co-infected trees showed more profound reduction in trunk circumference and a doubling in production of water sprouts when compared with trees infected with either virus alone. It produces different types of symptoms such as necrotic leaf mottle, chlorotic necrotic ring spot, chlorotic ring spot, ring mosaic, ring mottle, yellow mosaic, and yellow mottle, which are very difficult to distinguish. It is graft transmitted. In this survey only 3 samples in sweet cherry and no samples in sour cherry were found to be infected by both PDV and PNRSV.

Plum pox virus (PPV), the cause of plum pox virus disease, also known as Sharka, is the most damaging stone fruit virus worldwide. In our extensive survey, no PPV was present in western Colorado stone fruit orchards.

PBNSPaV was observed only in sweet cherry in a low percentage of the samples. PBNSPaV was characterized only recently (Amenduni *et al*., 2004) and there are limited reports on the distribution of the virus in the world.

ToRSV in 2010 and LCV-1 in 2009 were observed in sweet cherry but not in sour cherry. ToRSV is believed to be established in the fruit growing area of Colorado, and is transmitted by dagger nematode. It has a wide host range including fruit trees, grapes, and other herbaceous woody plants. It causes a variety of symptoms such as stem pitting, and decline in peach, cherry, apricot, plum and others. There may also be reduced terminal growth, chlorotic leaves, leaves curling upwards and turning red in autumn, premature and permanent defoliation., spongy bark with necrotic spot, and longitudinal pitting and grooving on rootstocks.

CNRMV(GRM1/2) was detected in 19% and 30% of samples tested in 2010 and 2009, respectively in sweet cherry, but in sour cherry only in 2010 and in low incidence.

CGRMV(GRM3/4) was observed in 10% and 18% of the samples in sweet cherry in 2009 and 2010, respectively. No LCV-2, *Peach latent mosaic viroid*, or *Hop stunt viroid* infections were detected. On sour cherry, weak enation on the underside of leaves was observed.

LCV-1 was observed in two samples in 2009, but not in the 2010 survey. Little cherry virus reduces the fruit size to one-half normal size and ruins the flavor, yet causes no tree or leaf symptoms. The rapid rate of spread through the infected area and the serious effects it has on fruit make it a serious threat to sweet cherries in other districts.

Conclusions

Presence of several viruses, especially multiple virus infections not reported in Colorado cherry crops, was found in our current surveys. This indicates the vulnerability of Colorado cherry production systems, which already have other important problems, such as Cytospora canker, frost damage, high soil pH, and micronutrient deficiencies. Virus infection makes plants vulnerable to the above causes and vice versa. Vector management, if any are present, and avoidance of spread of the virus and/or nematode vector by horticultural practices to non-infected orchards/trees, will help to minimize the loss due to the above causes. Presence of most of the viruses in the Colorado cherry crop was not reported or confirmed. However, this was the first attempt to identify cherry virus in Colorado by molecular tests.

Table 1. Positive number of samples with different viruses in sweet and sour cherry orchards in western Colorado cherry growing areas during 2009 and 2010 surveys.

Crops	Sour cherry		Sweet Cherry	
Year	2010	2009	2010	2009
Total number of samples tested	17	1	99	56
APLPV	0	0	0	3
CRLV	8	1	64	28
CNRMV(GRM1/2)	1	0	19	15
CGRMV(GRM3/4)	1	0	18	5
CVA	5	0	56	23
PBNSPaV	0	0	3	1
PDV	3	0	13	11
PLMVd	0	0	0	0
PNRSV	9	0	25	12
ToRSV	0	0	6	0
LCV-1	0	0	0	2
LCV-2	0	0	0	0
HSVd	0	0	0	0
Total # of virus	**7**	**1**	**8**	**9**

References

Amenduni T., Minafra A., Savino V., 2004. Detection of Plum bark necrosis stem pitting-associated virus (PBNSPaV) from different stone fruit species and optimization of diagnostic tools. *Acta Horticulturae* **657**: 93-97.

Kunze L., 1988. Prune dwarf virus, PDV. In: Smith I.M., Dunez J., Lelliott R.A., Philips D.H., Archer S.A. (eds.). European handbook of Plant diseases, pp. 11-12. Blackwell Scientific Publications, Oxford, UK.

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Figure 1. Reduction in foliage (size and number of leaves) in a cherry tree branch infected with Cherry Rasp Leaf Virus at Rogers Mesa, 2010.

Figure 2. Cherry tree declined by combination of Cherry Rasp Leaf Virus and unknown causes in Palisade, CO, 2010.

Figure 3. Cherry leaves, green island suspected to be infected by virus, was collected from Rogers Mesa, CO, 2010.

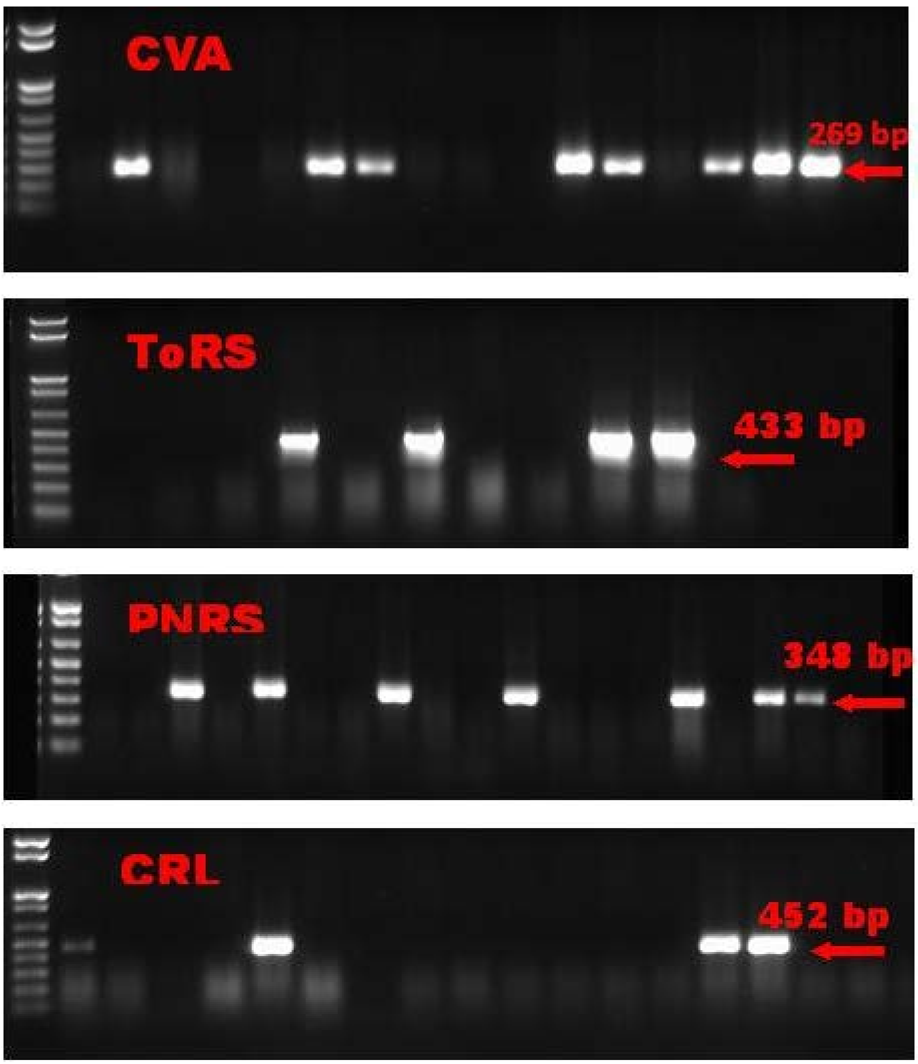
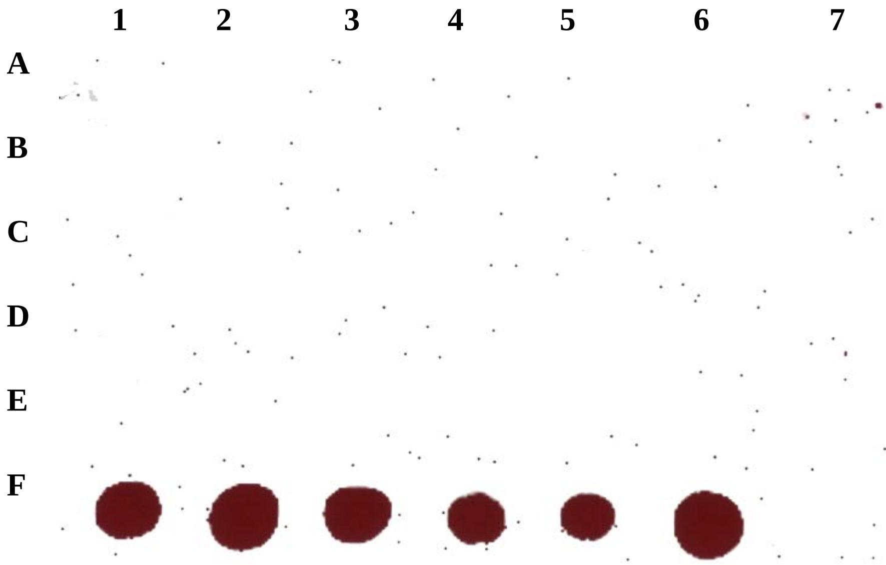


Figure 4. RT-PCR with virus-specific primers detection of CVA, ToRS, PNRS,and CRL.



A1 through D7: apple orchard leaf samples.
E1 through E6: Negative controls, healthy apple leaf samples.
F1 through F7:ASSVd, ADFVd, PBCVd, AFCVd, Hop stunt viroid, Peach latent viroid positive controls.
F1 through F7: Positive Control

Figure 5. Dot-blot hybridization with a poly6 probe for detection of ADFVd, ASSVd, ADFVd , and PBCVd.

SECTION IV

Current Bibliography

Dr. Horst W. Caspari

2011 Research Projects*

Viticulture and enology programs for the Colorado wine industry (Colorado Wine Industry Development Board; S. Menke & R. Pokharel, CSU)*

Coordinated wine grape variety evaluations in the western US (Colorado Association for Viticulture and Enology)

*Sponsors/Cooperators are noted in parentheses.

2011 Publications

Non-Refereed WEB Publications:

Caspari, H. 2011. 2010 Grower Survey. www.colostate.edu/programs/wcrc/pubs/viticulture/Survey2010.pdf

Caspari, H. 2011. Performance of cool-climate grape varieties in Delta County. www.colostate.edu/programs/wcrc/pubs/viticulture/Grape variety evaluation at Rogers Mesa.pdf

Caspari, H. and A. Montano. 2011. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2010/11 (7 updates during 2011). www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm10.pdf

Caspari, H. and A. Montano. 2011. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Orchard Mesa near Grand Junction, Colorado, 2010/11 (14 updates during 2011). www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardiness10.pdf

Caspari, H. and A. Montano. 2011. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Rogers Mesa near Hotchkiss, Colorado, 2011/12 (3 updates during 2011). www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardinessrm11.pdf

Caspari, H. and A. Montano. 2011. Cold hardiness of grapevine buds grown at the Western Colorado Research Center - Orchard Mesa near Grand Junction, Colorado, 2011/12 (10 updates during 2011). www.colostate.edu/programs/wcrc/pubs/viticulture/coldhardiness11.pdf

Dr. Stephen D. Menke

2011 Research Projects

Comparison of scoring for two types of wine quality assurance panels with a derived composite score of both panels, a joint quality assurance evaluation of Colorado and Nebraska wines (S. Cuppett and P. Read/University of Nebraska-Lincoln, Colorado Wine Industry Development Board, Nebraska Grape and Winery Board, Nebraska Winery and Grape Growers Association, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

Development of business and operational plan and successful industry and license approvals for Ram's Point Winery, a CSU educational commercial winery housed at WCRC (L. Sommers, F. Johnson, D. Iovanni/C. Beyrouty/S. Wallner /WCRC/College of Agricultural Sciences/Department of Horticulture and Landscape Architecture, Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology)

Development of Joint Colorado/Nebraska Wine Quality Training and Assessment Program (D. Caskey/ H. Caspari, Colorado Wine Industry Development Board/WCRC, Colorado Association of Viticulture and Enology, Nebraska Grape and Winery Board, Nebraska Winery and Grape Growers Association, CSU Department of Horticulture and Landscape Architecture)

Establishment of crop load aroma profiles for Colorado Cabernet sauvignon wines by GC/MS analysis (H. Caspari, J. Weinke/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

2011 Continuing Research Projects

Production of varietal and blended experimental wines from WCRC grapes (H. Caspari/Western Colorado Research Center, Grande River Winery/ Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture

Development of Colorado Wine Quality Training and Assessment Program (D. Caskey, H. Caspari, M. Mazza/ Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture,)

Establishment of baseline aroma profiles for several Colorado varietal wines by GC/MS analysis (H. Caspari, J. Weinke/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

2012 Continuing Research Projects

Comparison of scoring for two types of wine quality assurance panels with a derived composite score of both panels, a joint quality assurance evaluation of Colorado and Nebraska wines (J. Reiling and P. Read/University of Nebraska-Lincoln, Colorado Wine Industry Development Board, Nebraska Grape and Winery Board, Nebraska Winery and Grape Growers Association, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

Development of Joint Colorado/Nebraska Wine Quality Training and Assessment Program (D. Caskey/ H. Caspari, Colorado Wine Industry Development Board/WCRC, Colorado Association of Viticulture and Enology, Nebraska Grape and Winery Board, Nebraska Winery and Grape Growers Association, CSU Department of Horticulture and Landscape Architecture)

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Establishment of crop load aroma profiles for Colorado Cabernet sauvignon wines by GC/MS analysis (H. Caspari, J. Weinke/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

Establishment of baseline aroma profiles for several Colorado varietal wines by GC/MS analysis (H. Caspari, J. Weinke/ Western Colorado Research Center/Colorado Wine Industry Development Board, Colorado Association of Viticulture and Enology, CSU Department of Horticulture and Landscape Architecture)

*Cooperators/collaborators/sponsors are noted in parentheses

Dr. Calvin H. Pearson

2011 Research Projects*

Completed Extension and AES publication "Intermountain Grass and Legume Forage Production Manual," 2nd ed. (Calvin Pearson, Joe Brummer, and Bob Hammon, eds.)
Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley)
Alfalfa variety performance test (2011-2014) – Fruita (seed companies, breeding companies, private industry)
Evaluation of alfalfa genetic material 2009-2011 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of RR alfalfa genetic material 2011-2013 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of perennial plant species and production input for sustainable biomass and bioenergy production in Western Colorado – (Western Colorado Carbon Neutral Bioenergy Consortium)
Application of bio-stimulant and harvest energy in winter wheat as a sustainable nutrient input – Hayden (Enviro Consultant Service, LLC)
Application of bio-stimulant and harvest energy products in pasture grass as a sustainable nutrient input – Fruita (Enviro Consultant Service, LLC)
An automated control valve for gated pipe to increase furrow-irrigation efficiency – Fruita (Fine Line Industries and Bureau of Reclamation)
Evaluation of corn hybrid breeding material for grain and silage – Fruita (DOW Agrosciences)
Evaluation of corn hybrids for blunt ear syndrome – Fruita (Syngenta)
Demonstration using soybean and sunflower for the production of SVO for use as on-farm biodiesel – Fruita (Denis Reich, Dr. Perry Cabot)
Roundup-Ready soybean variety performance trial – Fruita (Syngenta)
Evaluation of Optunia cactus for potential source of biomass for biofuel – Fruita (Morgan Williams, Flux Farm Foundation)
Evaluation of flax and camelina as alternative crops in NW Colorado – Hayden (Mike Williams, CJ Mucklow, and Dr. Jerry Johnson)
Evaluation of winter yellow pea as an alternative crop in NW Colorado – Hayden (Mike Williams, and CJ Mucklow)
Vertical temperature variation in a corn canopy – Fruita
Co-establishment of legumes and corn in a living mulch cropping system under furrow irrigation (Dr. Joe Brummer)

2012 Research Projects* (Continuing, New, or Planned)

Winter wheat cultivar performance test – Hayden (Mike Williams, Dr. Scott Haley)
Alfalfa variety performance test (2012-2014) – Fruita (seed companies, breeding companies, private industry)
Evaluation of alfalfa genetic material 2011-2013 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of RR alfalfa genetic material 201-2014 – Fruita (Dr. Peter Reisen, Forage Genetics)
Evaluation of perennial plant species and production input for sustainable biomass and bioenergy production in Western Colorado (Fruita, Rifle, and Carbondale) – (Western Colorado Carbon Neutral Bioenergy Consortium)
Evaluation of basin wildrye as a biomass resource – Fruita (Dr. Steven Larson and Dr. Kevin Jensen, USDA-ARS Logan, UT)
Application of bio-stimulant and harvest energy in winter wheat as a sustainable nutrient input – Fruita (Enviro Consultant Service, LLC)

Application of Foliar Blend by Agri-Gro in alfalfa on alfalfa yield and hay quality – Fruita (Bio-Tech Solutions)
Evaluation of seed treatments in alfalfa – Fruita (Seed Enhancements Biologicals USA)
Application of bio-stimulant and harvest energy products in pasture grass as a sustainable nutrient input – Fruita (Enviro Consultant Service, LLC)
Evaluation of corn hybrid breeding material for grain and silage – Fruita (DOW AgroSciences)
Evaluation of canola varieties – Fruita (Dr. Mike Stamm, Kansas State University)
Demonstration using sunflower and canola for the production of SVO for use as on-farm biodiesel – Fruita (Denis Reich, Dr. Perry Cabot)
Roundup-Ready soybean variety performance trial – Fruita (Syngenta)
Evaluation of Optunia cactus for potential source of biomass for biofuel – Fruita (Morgan Williams, Flux Farm Foundation)
Evaluation of oilseeds as alternative crops in NW Colorado – Hayden (Mike Williams, CJ Mucklow, and Dr. Jerry Johnson)
Evaluation of winter yellow pea as an alternative crop in NW Colorado – Hayden (Mike Williams, and CJ Mucklow)
Performance of sub-surface drip irrigation in alfalfa for improved irrigation efficiency and environmental enhancement – Fruita (Denis Reich)

*Cooperators/collaborators/sponsors are noted in parentheses.

2011 Publications

Pearson, C.H. 2011. Alfalfa Introduction. p. 91. In: Intermountain Grass and Legume Forage Production Manual, 2nd edition. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-02. Fort Collins, Colorado. Pearson, C.H. 2011. Field performance of oat varieties at Fruita, Colorado 2009-2010. pps. 13- 19. In: Western Colorado Research Center 2010 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-11. Fort Collins, Colorado.

Pearson, C.H. 2011. Harvest. pps. 163-175. In: Intermountain Grass and Legume Forage Production Manual, 2nd edition. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-02. Fort Collins, Colorado.

Pearson, C.H. and C.J. Mucklow. 2011. Stand establishment (irrigated and dryland). pps. 111-119. In: Intermountain Grass and Legume Forage Production Manual, 2nd edition. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-02. Fort Collins, Colorado.

Pearson, C.H. 2011. The impact of field evaluations of alfalfa breeding material at the Western Colorado Research Center at Fruita 1995- 2010. pps. 8-12. In: Western Colorado Research Center 2010 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-11. Fort Collins, Colorado.

Pearson, C.H. 2011. The impact of field evaluations of corn grain breeding material at the Western Colorado Research Center at Fruita 2007-2010. pps. 20-26. In: Western Colorado Research Center 2010 Research Report. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-11. Fort Collins, Colorado.

Pearson, C.H. and R. Sharp 2011. Variety selection and budget. pps. 93-109. In: Intermountain Grass and Legume Forage Production Manual, 2nd edition. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-02. Fort Collins, Colorado.

Pearson, C.H., Bob Hammon, and Ed Page 2011. Weed control in alfalfa. pps. 149-162. In: Intermountain Grass and Legume Forage Production Manual, 2nd edition. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-02. Fort Collins, Colorado.

Pearson, C.H., J. Brummer, and Bob Hammon. 2011. Organic production of alfalfa and grass. pps. 177-184. In: Intermountain Grass and Legume Forage Production Manual, 2nd edition. Colorado State University, Agricultural Experiment Station and Extension, Technical Report TR11-02. Fort Collins, Colorado.

Pearson, C.H., J.E. Brummer, Bob Hammon, and M.L. Franklin (eds.). 2011. Intermountain Grass and Legume Forage Production Manual (2nd edition). Agricultural Experiment Station and Extension, Colorado State University, Technical Bulletin TB11-02. Fort Collins, Colorado.

Ramesh Pokharel

Ongoing Projects

NC 140-Apple rootstock evaluation study 2008 in high soil pH for normal plating. Brookfield Gala apple trees, grafted to 23 different rootstocks including dwarf, semi-dwarf and normal, are included in this study.
NC 140-Apple rootstock evaluation study 2010; Honeycrisp apple trees grafted to 23 different rootstocks, focused to dwarf rootstocks are established in close planting in western Colorado.
NC 140-Peach rootstock evaluation study: Seventeen rootstocks including the rootstocks for calcareous soil with high pH are planted.
NC-140- Cherry rootstock training system study 2010: comparison of dwarf rootstock under 3 different training systems in western Colorado.
Evaluation of Cherry varieties under upright fruiting off-shoot (UFO) training systems:
Soil and plant health study in peach focused to produce healthy trees with high yield and better quality fruits.
Peach physiology study
Evaluation of small berries as alternative crops
Production studies of exotic and high value vegetables in western Colorado condition.
Apple thinning studies focused to organic growers
Cytospora Canker management studies
Cherry rasp leaf-dagger nematode complex studies
Evaluation of bio-fumigation, soil solarization, and peach rootstocks on stone fruit replant problem.
Water management and deficit irrigation in peach and their impact on fruit development and quality. (Denis Reich, water specialist, Tri-river Extension.
Evaluation of Lavender varieties for western Colorado condition (Curtis Swift, PI).

Journal publications

Reighard, G.L, T.G. Beckman, R. Belding, B.L. Black, J. Cline, W. Cowgill, R. Godin, R.S. Johnson, J. Kamas, M. Kaps, H. Larsen, T. Lindstrom, D. Ouellette, **R. Pokharel**, L. Stein, K. Taylor, C.S. Walsh, D. Ward, M.D. Whiting. 2011. Performance of Prunus rootstocks in the 2001 Nc-140 peach trial. ActHort 93:

Lang, G,, T. Valentino, T.L. Robinson, J. Freer, H. Larsen, **R. Pokharel**. 2011. Difference in mineral nutrient concentration of dormant cherry spurs as affected by rootstocks, scion, and orchard site. ActHort 93:

Book chapters.

Larsen, H. and **R. Pokharel**. 2012. Disease Biology and Monitoring. *In* Utah-Colorado commercial Tree Fruit Production Guide. Marion Murray and Harold Larsen eds. Utah State University Extension and Colorado State University Extension. Pp 17-32.

Murray, M., D. Alston, H. Larsen and **R. Pokharel**. 2012. Pesticide information and Spray Tables. *In* Utah-Colorado commercial Tree Fruit Production Guide. Marion Murray and Harold Larsen eds. Utah State University Extension and Colorado State University Extension. Pp 33-107.

Others

Pokharel, R. 2012. Efficacy of biofumigation and soil solarization on soilborne onion pathogen. Colorado State university, Agricultural Experiment Station Technical Report 12(1): 1-18.

Pokharel, R. 2011. 2008 Apple Rootstock Evaluation (Normal Planting, Brookfield Gala). Western Colorado Research Center Annual Report TB 11-1: 49-52.

Pokharel, R. 2011. 2009 Peach Rootstock Evaluation. Western Colorado Research Center Annual Report 2010-2011. TB 11-1; 38-41

Pokharel, R. 2011. 2010 Apple Rootstock Evaluation (Honeycrisp in Close Planting). Western Colorado Research Center Annual Report TB 11-1: 53-54.

Pokharel, R. 2011. Multiple Viruses Found in a Problematic Apple Orchard in Western Colorado. Western Colorado Research Center Annual Report TB 11-11; 55-60

Pokharel, R. 2011. Cytospora Canker Management Studies from 2007 to 2010. Western Colorado Research Center Annual Report TB 11-11; 42-48.

Pokharel, R. 2011. Efficacy of Different Oils and Tergitol on Apple Blossom Thinning. Western Colorado Research Center Annual Report TB 11-11: 61-64.