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2003 Wild Blueberry Project Reports

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2003 Wild Blueberry Project Reports

FOOD SCIENCE AND HUMAN NUTRITION

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1. TITLE: Factors Affecting the Microbial and Pesticide Residues Levels on Lowbush Blueberries

METHODS: Plots were staked out on commercially productive blueberry land in Deblois, ME. Samples were collected and assayed immediately after initial treatment with Imidan WP (phosmet). Sampling and analysis continued every week for three weeks. Freshly harvested berries were transported to the University of Maine and subjected to sprays of sterile water, 100-ppm chlorine, 1.0% or 2.0% hydrogen peroxide, 1.0% citric acid or distilled water before analysis for phosmet residues. Contact times were 60 and 120 sec. Hydrogen peroxide is classified by the U.S. Food and Drug Administration as Generally Recognized as Safe (GRAS) for certain specified food applications (21CFR184.1366). A recent action by the U.S. Environmental Protection Agency exempts use of $\leq$ 1% hydrogen peroxide applied to all post-harvest agricultural food commodities from the requirement of a tolerance (40CFR180.1197). Therefore, if a treatment containing 1% hydrogen peroxide proved to be efficacious in inactivating surface microorganisms and human pathogens on lowbush blueberries, post-harvest applications of hydrogen peroxide would be beneficial to the blueberry industry in improving product quality. Additionally, several studies have reported that applications of hydrogen peroxide and hydrogen peroxyacetic acid are capable of reducing certain pesticides and chemical residues in solution; therefore, if hydrogen peroxide treatments are capable of reducing residual phosmet, blueberry processors in Maine would further benefit from this combination approach to improving product quality. All samples used in this study were extracted by an internally validated laboratory protocol and were analyzed using a gas chromatograph equipped with an atomic emission detector (GC/AED). Samples of 50 g were taken initially and after each processing step. Microbiological analyses of total aerobes, yeast, coliforms and *E. coli* were conducted using FDA Standard Methods. Appropriate decimal serial dilutions were prepared and samples were plated in duplicate. Total aerobic plate counts were performed using Plate Count Agar. Yeast counts were conducted using Acidified Potato Dextrose Agar (FDA, Bacteriological Analytical Manual, 7th ed., 1992). Coliforms and *E coli* were determined by Most Probable Number (MPN).

All tests and treatments were performed in triplicate and plated in duplicate.

RESULTS: Table 1 presents the data for the effect of treatment and contact time on the mean log reduction in microbial populations of total aerobes, yeast, and mold. Figure 1-3 present data on total populations of aerobes, yeast and mold remaining following treatment. Results indicate that reductions in all populations were greatest following treatment with 2% hydrogen peroxide; however, due to regulations, this concentration of hydrogen peroxide may not be tolerable for use on raw agricultural commodities. Microbial reductions were similar in samples treated with 1% hydrogen peroxide and 100ppm chlorine. Log reductions in aerobic bacteria and yeast populations were greatest following treatment with 1% hydrogen peroxide. The effectiveness of

these treatments was influenced by contact time with the greatest reductions observed after 60 seconds in aerobic bacterial populations and after 120 seconds in yeast populations. Significant differences ($p<0.05$) in treatment effectiveness were not observed at either contact time. The same pattern of treatment effectiveness was not observed with mold. Regardless of contact time, the greatest reduction in mold populations was observed in samples treated with 2% hydrogen peroxide followed 100ppm chlorine.

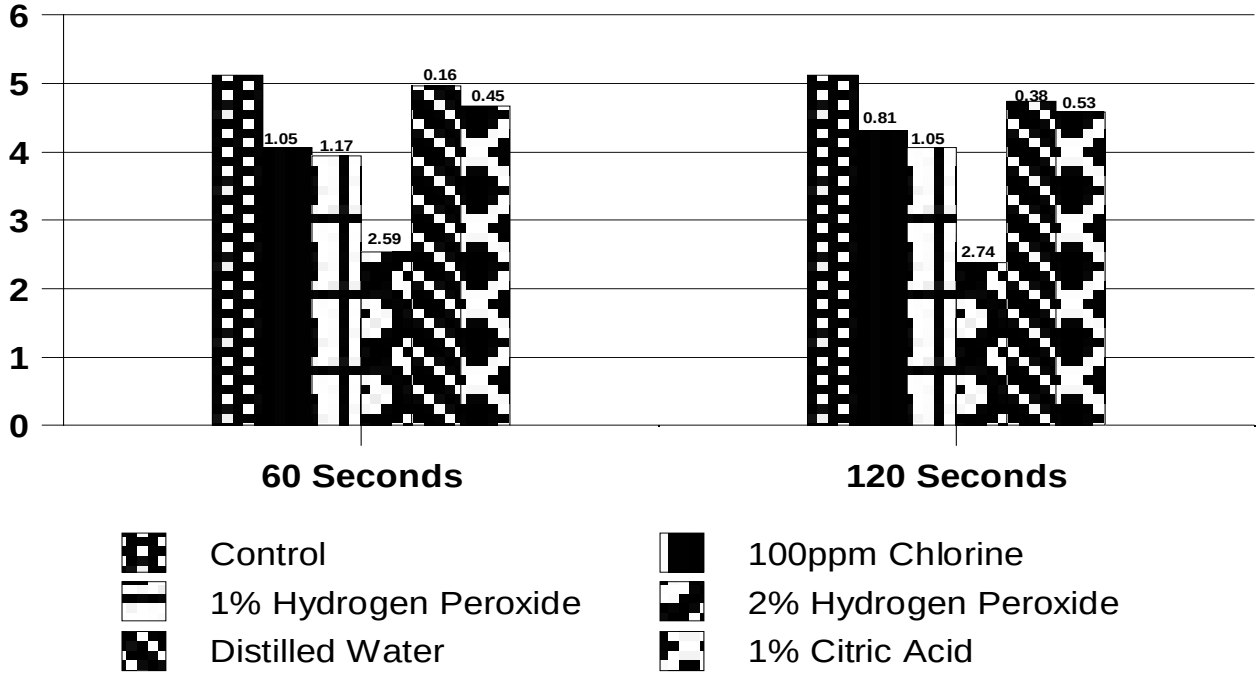
Table 1. Log CFU/g[z] (Mean ± SD) and Log Reduction[y] in Microbial Populations of Treated Blueberries - Crop Year 2003

	APC	Yeast	Mold
Control – 60 Seconds	5.12 ± 0.10	4.58 ± 0.08	3.40 ± 0.10
100ppm Cl_2	1.05	1.14	0.33
1% H_2O_2	1.17	1.02	0.29
2% H_2O_2	2.59	2.16	0.44
1% Citric Acid	0.45	0.49	0.31
Distilled Water	0.16	0.53	0.03
Control – 120 Seconds	5.12 ± 0.10	4.58 ± 0.08	3.40 ± 0.10
100ppm Cl_2	0.81	1.23	0.71
1% H_2O_2	1.05	1.35	0.21
2% H_2O_2	2.74	1.85	0.50
1% Citric Acid	0.53	0.79	0.40
Distilled Water	0.38	0.62	-0.09[x]

[z] All values obtained from analysis were converted to CFU/g blueberries.
[y] Log reduction is the difference between microbial counts before and after treatment. Values above each bar indicate log reductions obtained by treatment.
[y] Negative reductions indicate an increase in microbial counts following treatment.

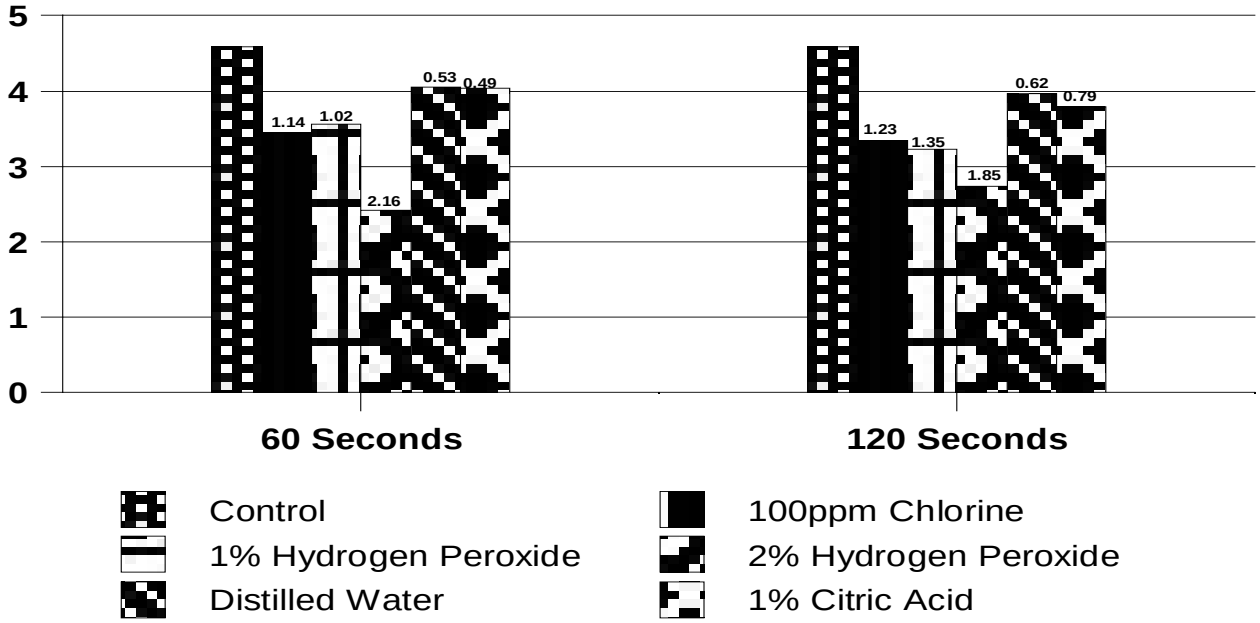
Overall, post-harvest applications of 100ppm chlorine are sufficient to bring about microbial reductions on the surface of lowbush blueberries; however, greater log reductions can be achieved in surface populations of aerobic bacteria and yeast following treatment with 1% or 2.0% hydrogen peroxide. A dose response was observed with increased concentration of hydrogen peroxide.

Figure 1. Mean[z] Log CFU/g[y] and Log Reduction[x] in Aerobic Mesophillic Bacteria (APC) Following Treatment for 60 and 120 Seconds – Crop Year 2003



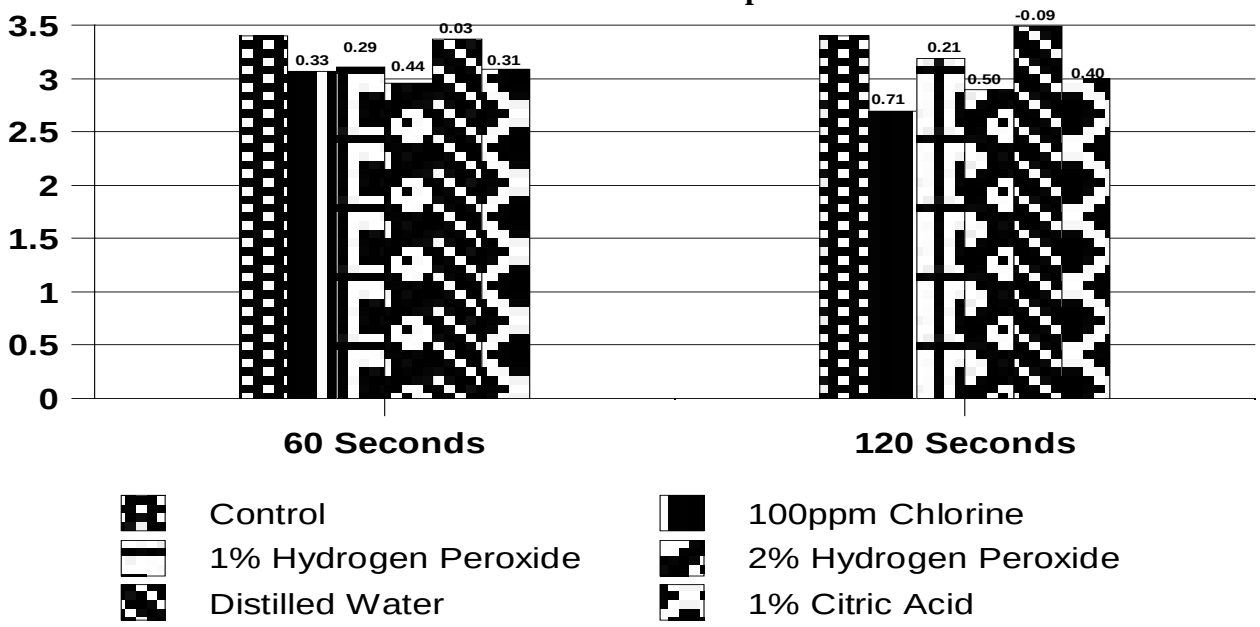
[z] Values represented are the mean of 4 samples treated in duplicate and plated in duplicate.
[y] All values obtained from analysis were converted to CFU/g blueberries.
[x] Log reduction is the difference between microbial counts before and after treatment. Values above each bar indicate log reductions obtained by treatment.

Figure 2. Mean[z] Log CFU/g[y] and Log Reduction[x] in Yeast Counts Following Treatment for 60 and 120 Seconds –Crop Year 2003



[z] Values represented are the mean of 4 samples treated in duplicate and plated in duplicate.
[y] All values obtained from analysis were converted to CFU/g blueberries.[x] Log reduction is the difference between microbial counts before and after treatment. Values above each bar indicate log reductions obtained by treatment.

Figure 3. Mean[z] Log CFU/g[y] and Log Reduction[x] in Mold Counts Following Treatment for 60 and 120 Seconds –Crop Year 2003



[z] Values represented are the mean of 4 samples treated in duplicate and plated in duplicate.
[y] All values obtained from analysis were converted to CFU/g blueberries.
[x] Log reduction is the difference between microbial counts before and after treatment. Values above each bar indicate log reductions obtained by treatment.

Color analysis using the Hunter LabScan Spectrocolorimeter, showed no differences in L, a, or b-values among treatments.

Samples for residual pesticide analyses were extracted and extracts stored at –30 C. They are currently being analyzed with the results expected in the next two months.

RECOMMENDATIONS: Based on just the microbiological data, it appears that hydrogen peroxide could be an effective agent in reducing the microbial load on blueberries. Higher concentrations (up to 3%) need to be examined to determine if a dose response occurs. Commercial ozone generating equipment may also prove of use in the generation of both aqueous and gaseous ozone for treating berries for the frozen and fresh markets, respectively. Equipment for ozone treatment will be installed in the pilot plant during the spring of 2004. This research is being proposed for the next year.

FOOD SCIENCE AND HUMAN NUTRITION

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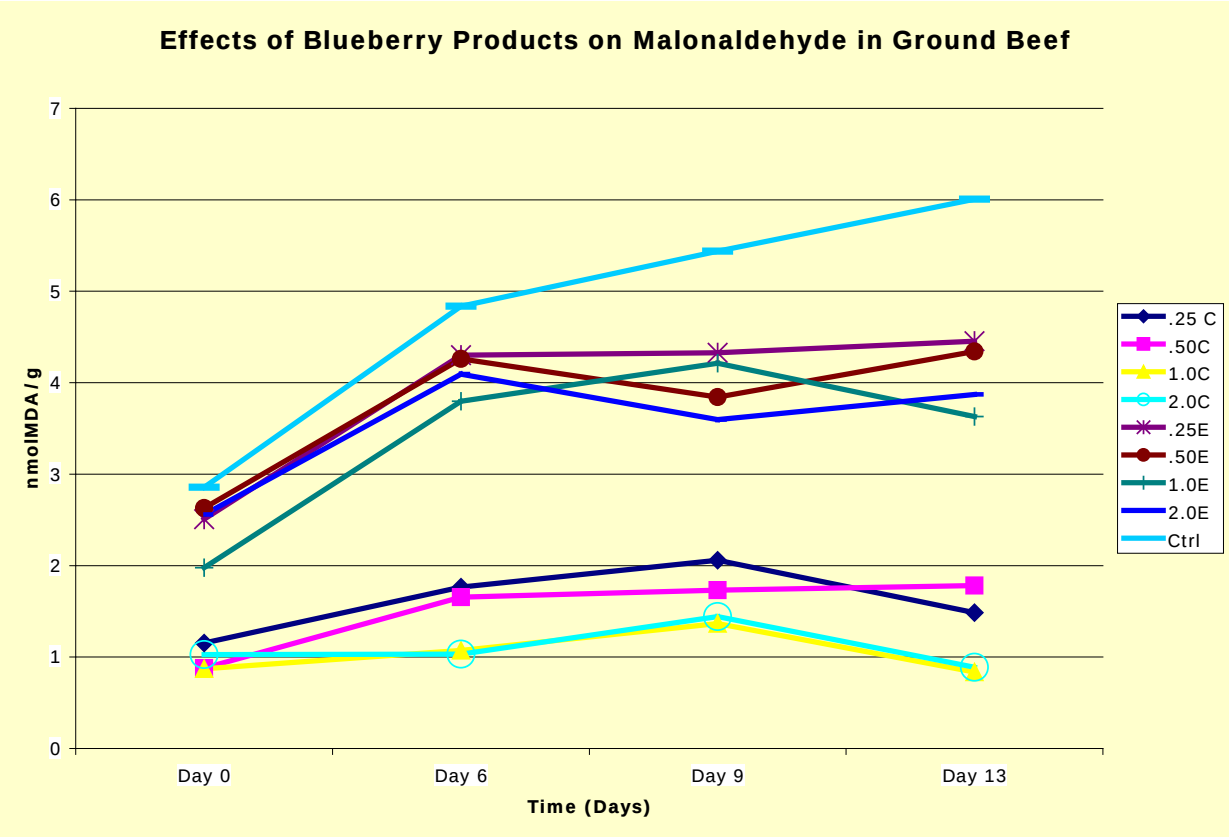
2. TITLE: Effect of Blueberry Products on Oxidation in Ground Beef Patties

METHODS: Ground beef patties were processed from 90% lean ground beef with varying concentration of blueberry concentrate (0.25, 0.50.1.0 or 2.0%), blueberry essence (0.25, 0.50.1.0 or 2.0%) and blueberry powder (0.25, 0.50.or 1.0%) on a wt/wt basis. Untreated ground beef patties were prepared to serve as the negative control. Patties were broiled to an internal temperature of 75 C. Precooked beef patties were stored under refrigeration (4-5 C), and evaluated for oxidation using two chemical methods [Thiobarbaturic acid (TBA) reactive substances at 0, 3, 7, 10 days of storage for blueberry powder and 0.6,9, and 13 days for concentrate and essence. A colorimetric method was used for TBA analyses.

RESULTS: Figure 1 and 2 show the results of the effect of blueberry products on the concentration of Thiobarbaturic Acid Reactive Substances (TBARS) in the ground beef patties over storage time. The blueberry essence did not prevent the formation of TBARS in the ground beef patties. For the blueberry concentrate 1 or 2% retarded TBARS while for the blueberry powder 0.5and 1.0% effectively retarded lipid oxidation. The significance of these results is that they demonstrated that the pigments and non-volatile components of blueberries were responsible for the antioxidant activity in a meat-based system. This observation is based on the fact that these compounds are absence for the blueberry essence. Blueberry powder's greater antioxidant activity may be related to the higher percentage of green, red and red-blue berries used to manufacture this product. The powder is 50% higher in phenolic acids than is blueberry puree or concentrate.

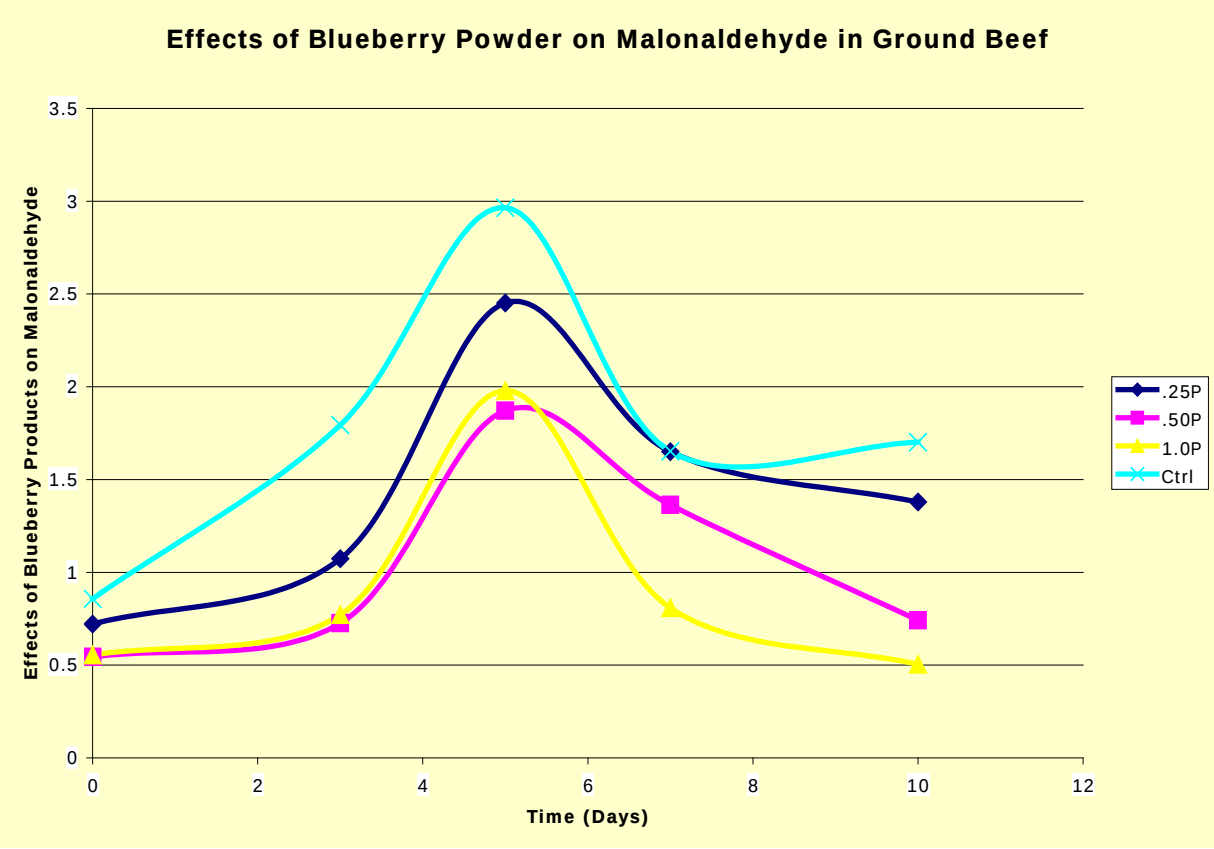
RECOMMENDATIONS: There is potential for incorporating blueberry products into meat-based systems. The blueberry powder, which is produced with higher amounts of green, red and red-blue berries appears to provide greater antioxidant capacity. Other questions that need to be answered include (1) can higher concentrations of blueberry products be added to meat-based systems to improve functionality and nutritional characteristics (2) can blueberry products be incorporated into "veggie burgers" for additional health benefits.

Figure 1.



C = Concentrate; E = Essence. Values are the mean of three replicates.

Figure 2.



P = Powder. Values are the mean of three replicates.

FOOD SCIENCE AND HUMAN NUTRITION

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Collaborators: Dr. Frank Drummond and Judy Collins, Biological Sciences-UMaine
Dr. Floyd Dowell, USDA-ARS-Kansas State University

3. TITLE: Infestation Detection using Near-Infrared Spectroscopy

OBJECTIVE: Exploratory research examining Near-Infrared Spectroscopy (NIRS) as a method to detect maggot-infested blueberries in an IQF processing line.

METHODS

1. Field and sample preparation

After fruit set, during July 2003, Dr. Drummond identified areas where blueberry stems could be harvested for placement in fly cage systems for artificial laboratory infestation.

2. Artificial laboratory infestation and preparation

As laboratory-raised flies hatched they were released into insect cages in the biological engineering laboratory. Blueberry maggot adults were reared from pupae collected in 2002. As they emerged, adults were placed in ovipostion cages in the laboratory. Each cage consisted of a 4.92 L Rubbermaid®, square, Servin'Saver, plastic container or an 8.3 L Rubbermaid®, rectangular, Servin'Saver, plastic container. A service hole ca. 2-3 inches in diameter was cut in the cover of each container and plugged with a piece of cotton cloth to prevent flies from escaping. Each cage also contained one or two, 3 x 4.5 inch sponges soaked with water as a source of moisture. Excess water was wrung out of the sponges. To provide nourishment, feeding stations were made for each cage by cutting a large hole in the cover of a 100 x 10 mm petri dish. Nylon screening was cemented over the hole. The underside of the screening was then smeared with honey.

The flies were allowed to mature for 3, 5, 7, and 10 days at ca. 23-25^{O}C. Once sexual development of female flies was determined, blueberry stems with mature berries were placed in the cage. The stems were in small vials with water and stoppered with cotton. Stems were then removed on a weekly basis in order to collect eggs and larvae within the fruit. This task was performed to artificially inoculate the blueberries with maggots in a laboratory setting. The berries were left in the cages for approximately one week. At that time the blueberries were removed and replaced with freshly harvested blueberry stems. This protocol was followed for four weeks or until the maggot flies expired. The blueberries were taken from the cages and placed in a cool laboratory (approximately 22 C) for one week to allow for development of the maggot egg into the larval stage. These blueberries were observed every other day to assess deterioration (see Figure 1 for a flowchart description). At the appropriate time the blueberries were prepared for near-infrared scanning as described below.

3. Near-infrared spectroscopy (NIRS) scanning and analysis

Once removed from cages (see section IV.2 above), usually once per week, the berries that were damaged during maturation were discarded. Usable blueberries were assigned names according to their origin (e.g., "Jonesboro") and the batch number corresponding to the week in which berries were removed from the infestation cages. Each batch was separated in two to six subsets of 120 berries each and designated with a letter (A, B, C, D, E and F). These berries were then counted and recorded on data sheets. Each scannable berry was further processed as described here.

The first step of the NIRS process was sizing the individual berries. Employing a sizing template device the berries were sized, stem side up, by fitting it through the appropriate slot indicating berry diameter in mm. Berries that were under 6 mm were not used. Each berry was sized and placed in an individually labeled tray, which depicted the date, batch number, set letter and berry number. Once these steps were completed the berries were held no longer than 4 days at cool temperature until they were scanned using one of the two NIRS systems. All berries from each set were scanned on the same day and under the same conditions. Figure 2 gives a schematic of the basic overall berry scan procedure for both UMaine and USDA-ARS-Kansas State University (USDA-KSU) and set up differences are described below.

At UMaine, the berries were scanned with a prototype UV-NIR system from Ocean Optics, Inc. (Dunedin, FL). A wide-spectrum (200 – 1200 nm) halogen light source was focused onto the individual berry at a distance from the culminating lens of approximately 25 mm. A culminating lens mounted at a 45-degree angle from light incidence allowed collection of light reflected from the berry; the reflected light was directed to an A/D converter via a fiber optic cable. After digital conversion, the sample data between 550 and 1100 nm was graphed via the associated software program (OOIBase32, Ocean Optics, Inc.). In addition to the 45-degree reflectance, a bifurcated cable with light through the center and receiving fibers around the outside ring was also used at UMaine. Three replicate scans of each berry were collected using the reflectance chamber along with one using the bifurcated cable.

At USDA-KSU, two detectors (a silicon detector at 400-950 nm and an InGaAS detector for 950-1700 nm) were used. The USDA-KSU receiving fiber was at 360 degrees (right beside) the excitation light and approximately 20 mm from the berry surface. Since most blueberries in Maine are processed frozen, a question has arisen about NIRS and modeling performance with frozen samples. Therefore, during 2003 season a series of experiments were carried out at USDA-KSU to investigate the effects of freezing and thawing on infestation prediction. Five sets of berries of 120 berries each were first scanned fresh. Then they were held in a freezer at -30°C overnight and scanned again the next day, thawed at room temperature for 4 hours and rescanned.

All berries were scanned with stem and calyx end facing the light source. At the beginning of each scan set, two reference spectra (complete light and dark) were taken and saved for later validation. After scanning the berries, all berries were dissected to determine if a maggot was present. The berry is placed in an aluminum plate, dissected and examined under a light microscope (Olympus Model H011, Olympus, Inc., Japan) at 10X magnification and it was recorded on the datasheet whether a maggot was present. For preliminary data analysis of the scan information, the following protocol (see section 4 below) was used as suggested by Dowell (pers. comm., 2001).

4. Prediction model analysis

First, individual spectra were imported into the modeling tool (either GRAMS®, version 6.00, Themo Galactic, Salem, NH or MATLAB, version 5.3, MathWorks, Natick, MA) and standard spectral image files (proprietary SPC file type or MAT file) were created from the raw scan data files. Training (data) sets were built from the individual spectral files in each sample batch and set. The individual spectral files were examined for anomalies, potential outlier samples or particular wavelengths to study in further detail. This information was used when creating the calibration model. The observed anomalies in the raw spectra were compared later with outlier spectra identified by statistical tests on the residuals (error terms) from Partial Least Squares (PLS) models.

PLS analysis was carried out on most of the data from 2003 using GRAMS and MATLAB software. PLS is a spectral decomposition technique that takes advantage of the correlation relationship between the spectral data and the constituent (infestation) information. This involves regression of the independent variations contained in the spectra against the constituent concentrations. All independent variations are captured in separate factors called latent variables. Each factor may represent different physical or chemical properties of the samples such as water or sugar content, color, size etc. The first factors isolated during PLS modeling usually represent the largest variation in the spectral data.

For developing calibrations, non-infested and infested blueberries were arbitrary assigned a value of 1 and 2 respectively (called constituent values). The threshold value was calculated as the arithmetic mean of the assigned arbitrary constituent values for each data set. Samples were considered infested if predicted constituent values were greater than a rejection threshold, and all others were considered non-infested.

Different types of preprocessing and data transformations were examined to determine the best approach for successful prediction by PLS. Preprocessing methods that were tested included mean centering, variance scaling, normalization and light scatter correction methods. Mean centering involves calculating the average spectrum of all the spectra in the training set and then subtracting the result from each spectrum. In addition, the mean concentration for each constituent is calculated and subtracted from the concentrations of each sample. Variance scaling is calculated by dividing the response at each spectral data point by the standard deviation of the responses of all training spectra at that point. The scatter correction methods tested were Multiplicative Scatter Correction (MSC) and Standard Normal Variate (SNV). MSC attempts to remove the effects of light scattering by linearizing each spectrum to the average spectrum while SNV does that by normalizing each spectrum by the standard deviation across the spectral range. These methods are often used in spectroscopic data analysis (Dardenne et al., 2000; Lammertyn et al., 2000; Thygesen et al., 2001) as they further enhance the calibration PLS model.

Data with replicate samples scanned at UMaine were transformed by averaging. Spectral data sets from the same batch scanned with the same instrument and settings were joined together after averaging across replicates. PLS was performed on these large joint data sets of averaged spectra as well as on single data sets from the same batch and results were compared. Scatter correction preprocessing was applied to all models and in many cases it improved the prediction level significantly.

Cross validation was used in the analysis to estimate the robustness of the models. This algorithm attempts to predict unknown samples by using the training data set itself. It removes consecutively a sample or group of samples from the training set and uses the remaining samples to predict the concentrations of the removed sample(s). Then standard error of cross validation

(prediction), SECV, is calculated by comparing the predicted and actual constituent values for each sample. This is repeated until all samples have been left out and predicted at least once. A cumulative SECV value is returned as result indicating the success of prediction. The recommended number of PLS factors is based on the reduction in SECV. Another method for measuring the error of prediction is Prediction Residual Error Sum of Squares (PRESS) where the relationship between PRESS and SECV is PRESS = $SECV^2$*(Number of samples). Cross validation was performed for all models removing consecutively one sample or a group of 3 to 20 samples from the data depending on the size of the data set. PRESS/SECV values are not comparable between the data sets since the number of samples is different in each set and this number is used to compute the cumulative values of PRESS/SECV. However, they were used for identifying the number of factors giving the best data fit by the model as well as to compare results from applying preprocessing within the same data sets or between data sets with similar size.

Spectral and concentration outliers were identified based on the residual plots after calculating the PLS model and cross validating. They were removed from the data sets and the models were recalculated without the outlying samples. Concentration residuals, representing the prediction error for each sample, are the differences between the actual and predicted concentration values. Spectral residuals are the differences between each spectrum and the model reconstructed spectrum which is what the sample spectrum should look like determined by the PLS model.

Beta (calibration) coefficients from PLS were used to test for absorbance bands sensitive to differences between infested and non-infested berries. For any given wavelength, the absolute value of the beta coefficient indicate how important that wavelength was for prediction, where a beta coefficient of 0 suggests no importance for prediction.

RESULTS/CONCLUSIONS

1. Artificial laboratory infestation and preparation

The laboratory experiment to artificially inoculate berries with maggot larvae was very successful this season. Approximately 50 % maggot infestation rate was achieved during the 2003 season. In order to guarantee high maggot counts for use in evaluating the NIRS method of detection, these laboratory artificial infestation cage experiments must be continued to yield high portions of infested berries. Therefore, research by Drummond should continue in this area.

2. NIRS: data preprocessing, modeling and analysis

Data processing. By examining raw spectra differences were found between stem and calyx scans. The regions where the two resulting spectra differed were 700-800 nm for the UMaine spectra and 1400 - 1600 for the USDA-KSU spectra. These differences are potentially interesting for identification of the position of the berry by NIRS. The spectra from the same instrument collected in 2002 and in 2003 did not show any difference in positions of peaks and curvature. There was observed a baseline shift in spectra from USDA-KSU, which is most likely due to differences in the set up or an instrumental drift. This shift has a negative effect on the performance of the models with USDA-KSU data as suggested by this year's modeling results compared to results from 2002 and is discussed in the PLS modeling section below.

When comparing the effects of preprocessing techniques on the result of the PLS models we concluded that mean centering and variance scaling on average improved prediction with 1 –

2 %. The scatter correction methods, MSC and SNV, improved prediction levels 2 to 4 % or more with each method having different effects when modeling different training sets. On average, both of these techniques had the same contribution to prediction. Normalization did not improve prediction significantly. Therefore, all 2003 PLS models were made on centered and scaled data and scatter correction was usually applied.

Modeling and analysis. Initial comparisons between PLS models of berries scanned with stem and calyx end facing the detector showed that for the majority of the cases level of prediction was higher for the stem sets. The reason for this is the higher degree of light scatter caused by the rough surface of the calyx. Therefore, current analysis efforts on the 2003 data are concentrated towards modeling stem sets. However, these findings have to be tested by comparing a larger number of data sets from both stem and calyx.

Prediction. A calibration model built from 2002 data was used to predict samples from different sets from both 2002 and 2003. The prediction model that showed the most optimal results after calibration and validation was calculated using a joint training set consisting of all data sets in the batch Jonesboro 4. After calibration, this set showed a prediction level of almost 89% when using cross validation. Prediction of 100 berry samples was tested by comparing the actual concentration values of spectra from a different data set within the same year (Jonesboro 5A) with their concentrations calculated by the model. The model was able to predict successfully 42 % of the samples. One hundred samples from the 2003 season were again selected out of the Jonesboro 6 A set and predicted by the same model. In this case the prediction level was higher at 64%. However, most of the samples from 2003 were predicted to have concentrations much higher than the expected values. This analysis needs to be continued and validated with more datasets from both 2002 and 2003 and the optimal parameters need to be selected. Then a final conclusion of the performance of the prediction model can be made.

PLS models, single data sets. PLS models were calculated on single data sets and results for selected number of datasets are presented in Table 1. The prediction level of models of spectra scanned at UMaine showed comparable level of prediction with last season's data of 60 – 75% correct prediction. Best prediction results of 73% were achieved with Jonesboro 6 A data from UMaine instrument. Prediction with the model of Jonesboro 7 A (UMaine) was lower at 61 %. It is noted here that the 7A dataset has a greater number of non-infested berries than infested (243 vs. 87) which may lead to a lower correct classification because of the PLS algorithm. The models of KSU data had predictions of 54 and 56%. This relatively low level most likely is due to instrumental drift or change in some parameters. However, these results are still preliminary for 2003 and all data must be analyzed completely before reaching a conclusion.

Generally prediction of infestation was better for data sets with larger number of samples. For achieving good prediction results using PLS, a large number of samples is required to maximize the accuracy of the calibration model.

PLS models, combined data sets. By using large combined data sets for PLS models on blueberries scanned with the same spectrometers, we were able to achieve improved classification (see Table 2). The highest level of correct prediction (73.5 %) was achieved with the Jonesboro 6 joint dataset scanned at UMaine. Performance of the model of Jonesboro 7 data improved significantly from around 60% to 66% after joining all sets from the same batch (compare Tables 1 and 2). These prediction levels are similar to the 60 – 80 % levels with models from 2002 data. Combining datasets from berries scanned at USDA-KSU led to higher prediction rates of 60 and 62 compared to 54 and 56 % respectively (compare Tables 1 and 2).

Although these results are lower than the average prediction level of the 2002 USDA-KSU modeling results, more analysis is needed before reaching a final conclusion. Generally, the prediction levels for 2002 and 2003 data were similar at this stage of analysis, suggesting that season variations can be compensated for by the PLS models.

PLS models, comparison between fresh and frozen. The preliminary modeling results with frozen and thawed berries show a level of prediction comparable and in some cases higher than the prediction levels with fresh berries (see Table 3). These data show that when comparing treatments of samples from Jonesboro 3 A, prediction level for frozen and thawed berries was 5 and 8 % higher respectively, than prediction for fresh berries. For the Jonesboro 3 E set prediction of fresh berries was 1 and 2.5 % higher than that for frozen and thawed berries. The differences observed were within 5 % for the majority of the training sets. As it can be seen on Figure 3 frozen berries had lower absorbance than fresh berries due to the reflective ice glaze on their surface. However, this did not influence NIRS scanning nor the modeling significantly. These observations were true also for thawed berries, which were much more deformed than fresh ones and had lost some juice. Their spectra had higher absorbance than the frozen but lower than the fresh because of their moist surface, which reflects light, but to a smaller degree than the frozen berry surface.

PLS models, water spectrum subtraction. Subtractions of an averaged water spectrum from each spectrum in a training set were tested. Blueberries have high percent of water, which to great extent interferes with the NIR signal since water has high absorbance. The purpose of this analysis was to remove some of the water signal, which dominates the absorbance from the other components. Water has absorbance peaks at 980, 1250 and 1330 nm (Figure 4) with strongest absorbance for wavelengths longer than 1200 nm. Since this same spectral region is where signal due to maggot presence can be found, PLS models were made after water spectrum subtraction and the results for one of them are presented in Table 2. Sample spectra before and after water subtraction are presented in Figure 5. No differences are observed when comparing the two spectra visually. However, after comparing model performance before and after water spectrum subtraction we can conclude that in this case water subtraction leads to improvement in the prediction. Although this change is not considerable (ca. 1.4%), the results suggest that some of the predominant absorbance from water can be removed so that other components in the NIR signal are more pronounced and contribute more significantly in PLS modeling efforts.

Overall results indicate that the data from different season and fields differ, but part of this difference can be attributed to instrument drift and setup variation. The analysis of the models made with spectra from UMaine instrument suggests that comparable level of prediction can be achieved regardless of field and season variation. Results from USDA-KSU experiments prove similar to UMaine. In addition the USDA-KSU work indicates that frozen and thawed berries can be modeled and their concentrations predicted as successfully as fresh ones. However, all these findings need to be further validated and tested by analyzing and comparing the all of the data from the last two seasons.

VI. RECOMMENDATIONS

Continue the study using NIRS during the 2004 and 2005 field seasons. The laboratory inoculation/infestation method (lead by Dr. Drummond) of assuring a high percentage of maggot-infested berries will be used as a primary source of berries for these studies. Dr. Drummond will work to optimize the parameters associated with this portion of the study.

Dr. Donahue will continue to evaluate the NIRS systems in the VIS region (600-1100 nm) at the Biological Engineering laboratory at UMaine and in the NIR (700 – 2000 nm region) through collaboration with USDA-KSU laboratories in Manhattan, Kansas (Dr. Floyd Dowell). Future work will include further refining of the PLS models and validation of calibration models as well as choosing the most adequate parameters for prediction. Tests will be carried out for reliability and repeatability of model performance. Data will be collected in the new harvest seasons allowing us to validate the refined prediction models as well as continue to investigate any variations in the blueberries from season to season.

Dr. Donahue will also begin the initial phases of design of a prototype instrument for in-process-line separation in conjunction with Dr. Bruce Segee, UMaine electrical engineer, to compare with the current separation methods described herein. Funding for this portion of the study will be sought from the Maine Technology Institute and other external sources with the help of the Wild Blueberry Commission of Maine.

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Table 1. PLS results of models on single data sets with samples from Jonesboro, Maine, scanned at UMaine and USDA-KSU. Outliers were removed before the calculation of the model and all models were cross-validated, mean centered and variance scaled.

Place, instrument and settings	**UMaine**		**USDA-KSU**	
Sample sets	6 A	7 A	3 A	3 E
Number of factors	5	5	5	9
Total number of spectra (non-infested, infested)	342 (129, 213)	330 (243, 87)	116 (41, 75)	112 (13, 99)
Correct classification of non-infested, %	78.3	52.7	56.1	84.6
Correct classification of infested, %	70.4	82.8	53.3	52.5
Total misclassification, %	26.6	39.4	45.7	43.8
Total correct classification, %	73.4	60.6	54.3	56.3

Table 2. PLS results from combined training sets. Data were first mean centered and variance scaled. All models were cross-validated and recalculated after leaving out outliers

Place, instrument and settings	**UMaine Reflectance chamber, stem end**		**USDA-KSU Bifurcated cable, stem end**	
Joint sample sets	Jonesboro 6 (A, B & C)	Jonesboro 7 (A, B, C & D)	Jonesboro 3 (A, B, C & D)	Jonesboro 3 (A, B, C & D)
Number of PLS factors	5	9	7	8
Data pre-processing	MSC Averaged spectra	MSC Averaged spectra	SNV	SNV Water spectrum subtracted
Total number of spectra (non-infested, infested)	317 (158, 159)	475 (273, 202)	396 (113,284)	334 (88, 246)
Correct classification of non-infested, %	79.1	62.3	62.8	53.4
Correct classification of infested, %	67.9	71.3	59.9	65.0
Total correct classification, %	73.5	66.1	60.6	62.0

Table 3. PLS results of models on single data sets with fresh frozen and thawed samples from Jonesboro, Maine, scanned at USDA-KSU. All models were cross-validated, mean centered and variance scaled.

Sample data sets	Jonesboro 3 A			Jonesboro 3 E		
Samples treatment	Fresh	Frozen	Thawed	Fresh	Frozen	Thawed
Number of model factors	5	6	3	9	7	7
Total number of spectra (non-infested, infested)	120 (43, 77)			120 (18, 102)		
Correct classification of non-infested, %	56.1	60.5	69.8	61.1	61.1	50.0
Correct classification of infested, %	53.3	58.4	58.4	53.9	52.9	52.9
Total misclassification, %	45.7	40.8	37.5	45.0	45.8	47.5
Total correct classification, %	54.3	59.2	62.5	55.0	54.2	52.5

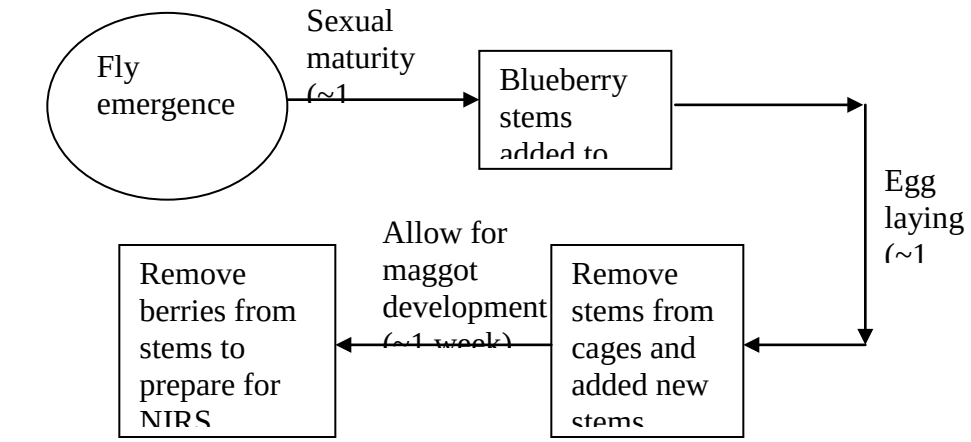


Figure 1. Schematic of the laboratory artificial infestation and preparation for NIRS scanning

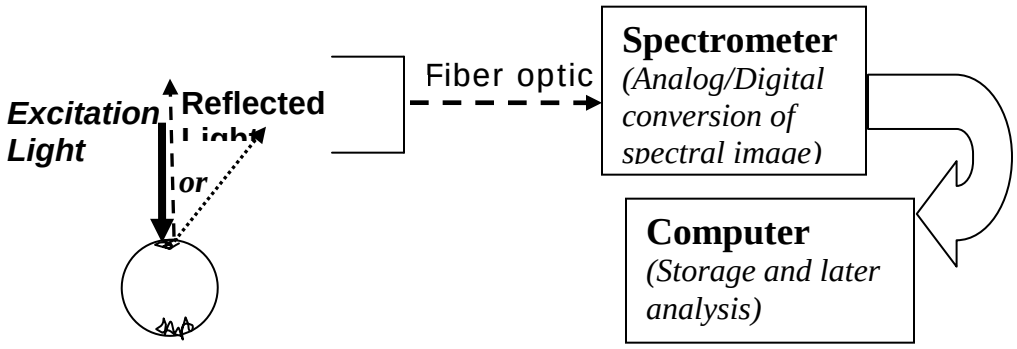


Figure 2. Flow schematic of equipment, light capture, spectrometer and computer. Reflected light will be at 45 or 360 degrees angle measured from the excitation light.

Figure 3. Sample spectra from one non-infested berry scanned at KSU fresh, frozen and thawed

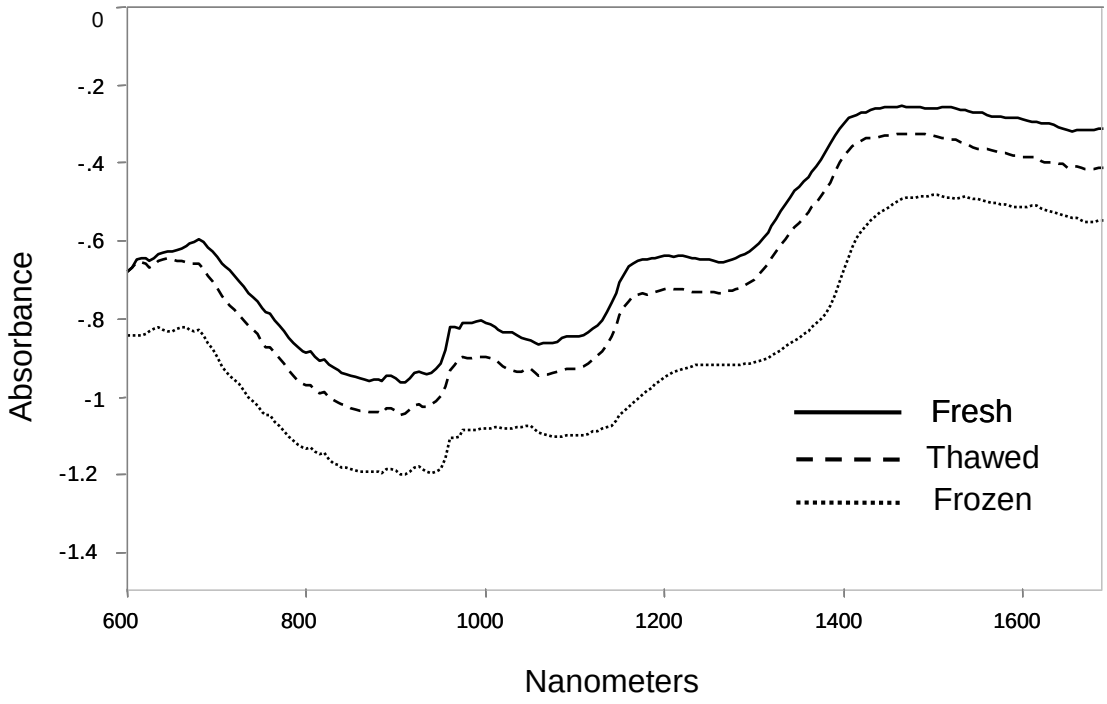


Figure 4. Water spectrum scanned at USDA-KSU.

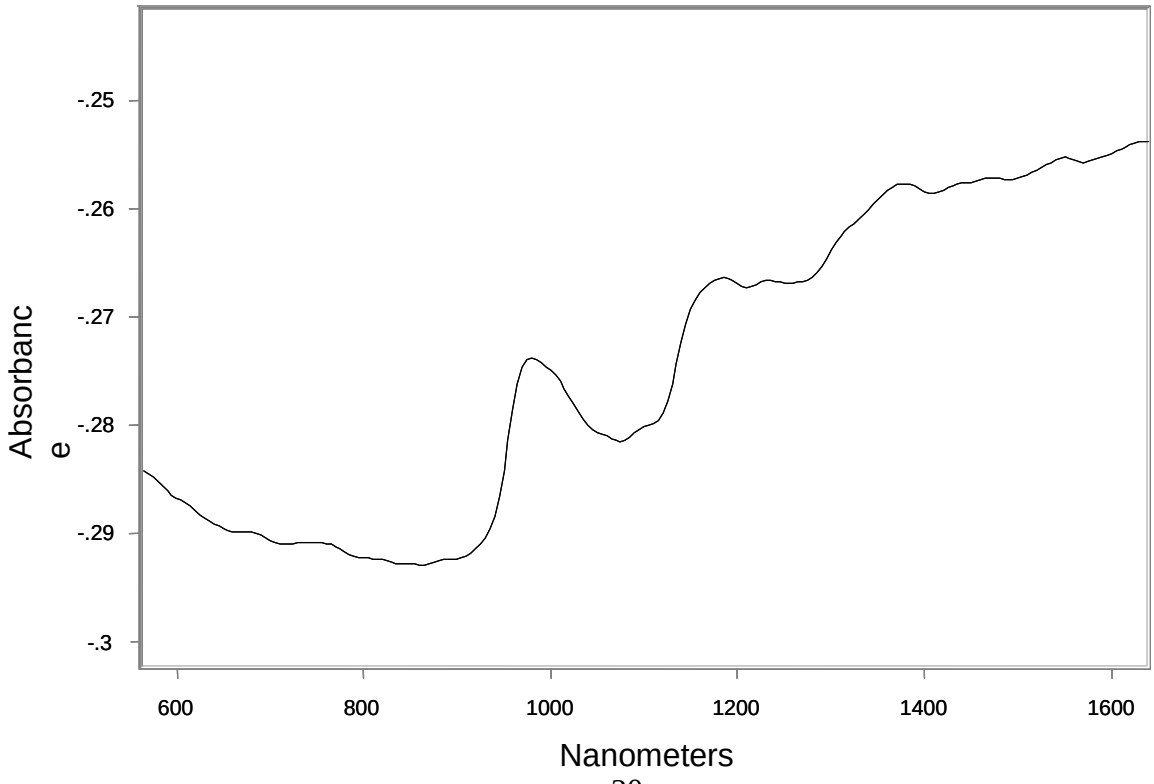
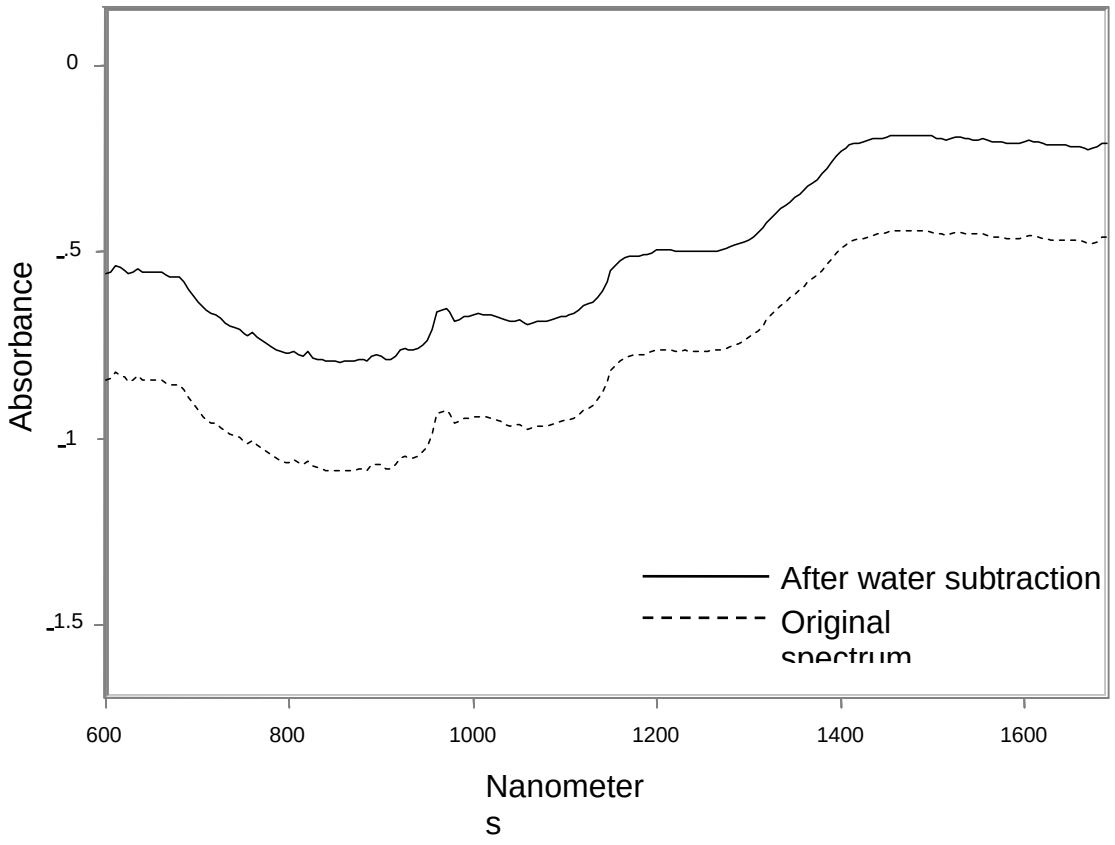


Figure 5. Original spectrum from USDA-KSU and the same spectrum after subtraction of a water spectrum



FOOD SCIENCE AND HUMAN NUTRITION
INVESTIGATOR: D. J. Klimis-Zacas, Professor of Clinical Nutrition

4. TITLE: Whole Wild Blueberries and Arterial Functional Properties

OBJECTIVES: To study the mechanism by which and the site where whole wild blueberries added in the diet of Sprague-Dawley rats act to affect the contractile properties of their arteries.`

METHODOLOGY: Weanling Sprague-Dawley rats (twelve in each group) were placed on the following diets for 13 weeks. 1) Control diet 2) Control diet and blueberries 3) Control diet (for 13 weeks) adding blueberries for eight weeks (reversal diet). Rat weights and food intakes were measured throughout the experiment and rats were fed the above diets for 13 weeks and subsequently sacrificed. Blood and arteries were removed and arterial rings prepared. From each aorta harvested four rings were prepared. Two were left intact and two denuded. Denudation removes the endothelial layer and all factors that aid in vasorelaxation. This aids us in pinpointing where the effect of whole blueberries occurs (in the endothelium or in the smooth muscle cell). Arterial rings were placed in tissue baths and tension applied on them. Vascular reactivity was tested with both mechanical and agonist stimulation. The myogenic response to stretching of the vascular wall was determined by application of graded preload tension of the aortic rings. Tension was incrementally increased and decreased between 1 and 6 g with the resulting steady-state force recorded for each load. Thus the ability of the arteries to return and maintain their initial contractile state was assessed. Vasodilation was studied after preconstriction of the aortic rings with 1M\Phenylephrine. Concentration-response curves were determined for the dilator acetylcholine (10-8 to 10-5 M) and the constrictor Phenylephrine (10-9 to 10-6 M). Additionally, nitric oxide (NO), an endothelium derived relaxing factor, is being presently measured to determine the mechanism of blueberry action. Nitric oxide is a factor synthesized in the endothelial cell that induces relaxation of the arterial smooth muscle. eNOS (endothelial nitric oxide synthase) will be measured by Western blotting.

RESULTS: Weanling Sprague-Dawley rats were randomly fed three different diets (n=8 per group), a control diet (AIN ’93) (C), a blueberry diet (B) for 13 weeks and a reverse diet (R) (C for 13 weeks, switched to B for 8 weeks). Aortae were excised, rings were prepared, and two intact and two denuded rings were immersed in tissue baths containing physiological salt solution (PSS) at 37°C, aerated with 95% 02 and 5% CO2 (pH 7.4). Following equilibration and pre-conditioning under 1.5gm preload, cumulative dose response curves were generated with six doses of the (alpha-1 adrenergic receptor agonist L-Phenylephrine (L-Phe, 10-8 to 3 X10-6M). Relaxation was induced in the rings with Acetylcholine (Ach, 3 x 10-6M). Effective denudation was assessed by the absence of relaxation to Ach and the maximal contraction and relaxation force (Fmax) was determined. Intact arterial rings had a significantly lower Fmax than denuded rings (0.965gm vs. 3.076gm) ($P<0.001$). Mean Fmax of intact rings for C, B, and R groups were 1.097, 0.873 and 0.926gm (SEM=0.0480) respectively. A two-way ANOVA demonstrated that Band R groups had a lower Fmax than C group when contracted with L-Phe ($p<0.050$). There were no significant differences in Fmax means of denuded rings among diet groups ($p=0.070$). Our results indicate for the first time that whole wild blueberries act through the endothelium to affect the action of the smooth muscle cell which in turn influences the contractile machinery of the rat aorta in response to alpha-1 adrenergic receptor.

CONCLUSION: The results of our present study validate the results of last year’s pilot study in supporting the role of whole blueberries to aid in arterial relaxation of acting on the vasodilator tone of the artery. This is essential for blood pressure regulation. Additionally, the results of the present study enable us to pinpoint where blueberries act to affect vasorelaxation of the artery. It seems that whole blueberries affect the action of the contractile machinery of the smooth muscle cell by decreasing vasoconstriction thus reducing vascular resistance to factors such as high blood pressure or stress

hormones. This has obvious implications on the process of CVD and may be used by the Maine Blueberry Industry as a great advertising tool.

RECOMMENDATIONS: Continue study to validate present data and measure eNOS concentration.

IRRIGATION

INVESTIGATOR: G.C. Starr, USDA Agricultural Research Service, New England Plant, Soil and Water Laboratory, Maine
Collaborator: D.E. Yarborough, University of Maine

5. TITLE:[1]Irrigation Water use in Wild Blueberry Production – 2003 Research Results

SUMMARY:

Growers need recommendations to improve both the timing and amount of irrigation water applied to wild blueberries *(Vaccinium augustifolium)* in the humid coastal region of Maine where direct vapor deposition may also supply water to the crop. A study was initiated to quantify the rates and timing of vapor deposition in relation to rates of evapotranspiration (ET). Weighing lysimeters were used to determine rates of net water vapor deposition (VD) or vapor uptake (VU) during hours when rainfall and drainage were not occurring. Vapor deposition occurred throughout the evening, night, and early morning during the fruit bearing year of a two year cropping cycle for the period June 11 to October 8, 2003. The mean values of daily VD, VU, and ET were 0.075 cm/d, 0.335 cm/d, and 0.27 cm/d with a coefficient of variability of 71%, 44%, and 71%, respectively. Thus, VD accounted for around 22% of total water taken up by the plants and amounted to 28% of ET. Under these conditions, classical approaches to irrigation scheduling based solely on rainfall measurements may result in over application of water by failing to account for vapor deposition.

OBJECTIVES/INTRODUCTION:

Wild blueberry (*Vaccinium angustifolium)* yields show a strong response to irrigation (Seymour et al., 2004), and, increasingly growers are adopting irrigation as a production practice in Maine. However, wild blueberry growers need technical support and recommendations for scheduling irrigation to improve their water use efficiency. A common grower irrigation scheduling practice is to supplement rainfall to ensure that roughly 2.5 cm per week of water reaches the plants during the growing season. A common belief is that less irrigation water is required near the Atlantic coast where temperatures are cooler and dense fog and dew occur frequently. The fog is thought to relieve plant water stress even when there is no rainfall. More water is thought to be needed at inland locations where temperatures are higher and humidity lower.

The limited existing literature on the subject supports these grower beliefs and practices. Starr et al. (2004) showed that weighing lysimeters exhibited nighttime increases in weight and inferred that water was being deposited in the lysimeters, particularly at locations near the coast. Kosmas et al. (1998) showed that water vapor deposition on soil was a major contributor to

[1] Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture or the University of Maine.

water balance in a coastal Mediterranean climate. Kosmas et al. (2001) showed that up to 70% of water taken up by evapotranspiration was replenished by water vapor adsorption (deposition) during the dry season and linked this effect to high diurnal fluctuations in relative humidity (>25%) and temperature. The humid coastal region of Southeastern Maine where wild blueberry production is centered may also show significant vapor deposition in the absence of rainfall. Thus, classical approaches to irrigation scheduling based solely on rainfall measurements could result in the over application of water by failing to account for vapor deposition.

Therefore, a study was initiated to quantify rates and governing processes of vapor deposition and uptake under wild blueberry production conditions in Maine. To achieve this, relevant soil and atmospheric parameters were measured in conjunction with weighing lysimeters. The measured parameters include: vapor deposition (VD), vapor uptake (VU), evapotranspiration (ET), rainfall (R), drainage (D), relative humidity (RH), solar radiation (SR), air temperature (T), visibility (V), wind speed (W), and volumetric soil water content (θ_v).

MATERIALS AND METHODS:

This study was conducted at the blueberry hill research farm operated by the University of Maine and located near the Atlantic coast in Southeastern Maine. Wild blueberry plants had formed an organic mat or sod layer consisting primarily of roots, organic matter, and sand that was roughly 15 cm thick overlying a gravelly sandy loam (Sandy-skeletal, mixed, frigid Typic Haplorthods). Four weighing lysimeters (basal area = 0.21 m^2, soil depth = 39 cm) were constructed using the Storlie and Eck (1996) design (Fig. 1) as described in Starr et al. (2004). The design uses a set of springs between inner and outer chambers to balance a rectangular column of soil on a weighing load cell. An intact piece of sod (0.21 m^2) was extracted and installed in each lysimeter over reconstituted subsoil.

Changes in weight averaged over the four lysimeters on an hourly basis were used to determine vapor transfers. The VD (hourly increase in weight) or VU (hourly decrease in weight) were calculated for only those hours when R = 0, D = 0, and irrigation = 0. Daily evapotranspiration was calculated using three different definitions: (1) daily change in weight (expressed as equivalent water depth) on days where R = 0, D = 0, and irrigation = 0 (Storlie and Eck, 1996); (2) depth equivalent daily change in weight minus daily R on days where D = 0 and irrigation = 0; (3) daily sum of VU minus sum of VD for all days.

Soil water content reflectometers (Kosmas et al., 1998) were installed to average θ_v over the top 15 cm (two probes inside and two outside of lysimeters). Hourly changes in θ_v were used as an indicator of changes in soil water storage in the root zone. A weather station obtained from Campbell Scientific Inc. (Logan, UT, USA) was used to measure RH, SR, R, and T. Data were collected from June 11 through October 8, 2003 during the fruit bearing year of the two year production cycle of wild blueberry. Irrigation was applied in 1.3 cm amounts whenever the soil water tension exceeded 20 kPa as measured by eight tensiometers (four inside and four outside of lysimeters).

Linear and quadratic functions were fit to the data to determine which of these parameters would explain the observed variability in liquid-vapor transfer. Only polynomial models with significantly (i.e. with at least 95% confidence as determined by analysis of variance and F-values) better fits than the next lower order polynomial are shown. Data for each hour were combined over all days, thereby forming a composite to show the diurnal variation of parameters.

RESULTS AND DISCUSSION

The ET for the fruit-bearing year in lowbush blueberries was first calculated as the water depth equivalent of daily changes in weight using definition 1. This parameter showed a significant quadratic trend when plotted against day of year over our study interval (Fig. 2). The trend line is very close to the constant 0.36 cm estimated water requirement for the first half of the study period, but it drops below the constant value around day 235 and approaches 0.1 cm by the end of the study period. Although the quadratic trend explained less than half ($R^2 = 0.38$) of the day to day variability in ET, a weekly assessment would average seven days of irrigation requirements thereby reducing scatter around the quadratic trend.

It was a concern that only 74 of the total 115 days could be used with definition (1) and this might inject bias into the ET measurement. The ET was also calculated using definition (2) for 103 days and definition (3) for all 115 days. Using definitions (1), (2), and (3), ET averaged 0.31 cm, 0.27 cm, and 0.26 cm with standard errors of 0.01, 0.02, and 0.02, respectively. Definition (1) gives a slightly higher average than definition (2) or (3), probably because by only using days with no rain, it represents a dry weather estimate for ET. Similarly, by throwing out all hours with rainfall and irrigation, definition (3) may understate true evapotranspiration because it does not accurately quantify the rapid evaporation period immediately following wetting events.

Vapor deposition was a significant factor in the water balance for the study period as evidenced by the mean values of daily VD, VU, and ET (definition 2), which were 0.075 cm, 0.33 cm, and 0.27 cm with a coefficient of variability of 71%, 44%, and 71% in the daily data, respectively. Thus, vapor deposition accounted for around 23% of total water taken up by the crop and amounted to around 28% of ET. However, little of the variation ($R^2 = 0.15$) in vapor deposition could be explained by the marginally significant seasonal quadratic trend model (Fig. 2).

The hourly composite data (Fig. 3) showed that VU was sharply peaked in the mid afternoon and VD was the dominant transport process through most of the night. The VD was greatest in the morning hours between 7:00 and 9:00 a.m. Of the variables examined, the daily maximum T (Fig. 4) and average SR (Fig. 5) during the uptake hours were best able to explain the variability in VU. These results should not be surprising because of the well-documented effect of maximum T and SR on ET. However, the correlation between VD and average SR (Fig. 5) was not expected and needs further explaining. The hourly data (data not shown) for the strongest deposition events indicated a daytime hour, usually in the mid to late morning, when RH dropped sharply from a high level and solar radiation increased dramatically. Evidently, some of the moisture loss from the air accumulated in the lysimeters during morning hours when air temperature increases rapidly, but the soil remains relatively cool. The VD showed a weak linear relationship to soil water storage changes (Fig. 6), suggesting that when VD was occurring water was probably entering the soil and not merely occurring as dew deposition. Much of the scatter in Fig. (6) is caused by error in measuring such small changes in water content.

CONCLUSIONS/RECOMMENDATIONS:

Initial data from a study of plant water use and deposition indicate that vapor deposition accounts for about 22% of the total water uptake and 28% of ET. At the blueberry hill site, supplemental irrigation to provide a constant weekly rate (2.5 cm/wk) matched measured water requirements through about day 235 after which ET fell rapidly and 2.5 cm/wk would be excessive. Given the high rates of water deposition in the absence of rainfall it is important to

have further studies of these phenomena as it may confound traditional irrigation scheduling. The VD may have a profound influence on ET, both over time and spatially at varying distances from the coast. Daily composite data indicated net deposition was greatest between 7:00 and 9:00 a.m. Vapor deposition was weakly correlated with changes in soil water storage suggesting that deposition may be directed into the soil and not merely in the form of dew deposition on plants.

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Starr, G.C., Seymour, R.M., Olday, F., and Yarborough, D.E. 2004. Determination of evapotranspiration and drainage in lowbush blueberries (*Vaccinium angustifolium)* using weighing lysimeters. Small Fruits Rev. (in press).

Storlie, C.A. and Eck, P. 1996. Lysimeter-based crop coefficients for young highbush blueberries. HortScience 31:819-822.

Figure 1. Installed weighing lysimeter.

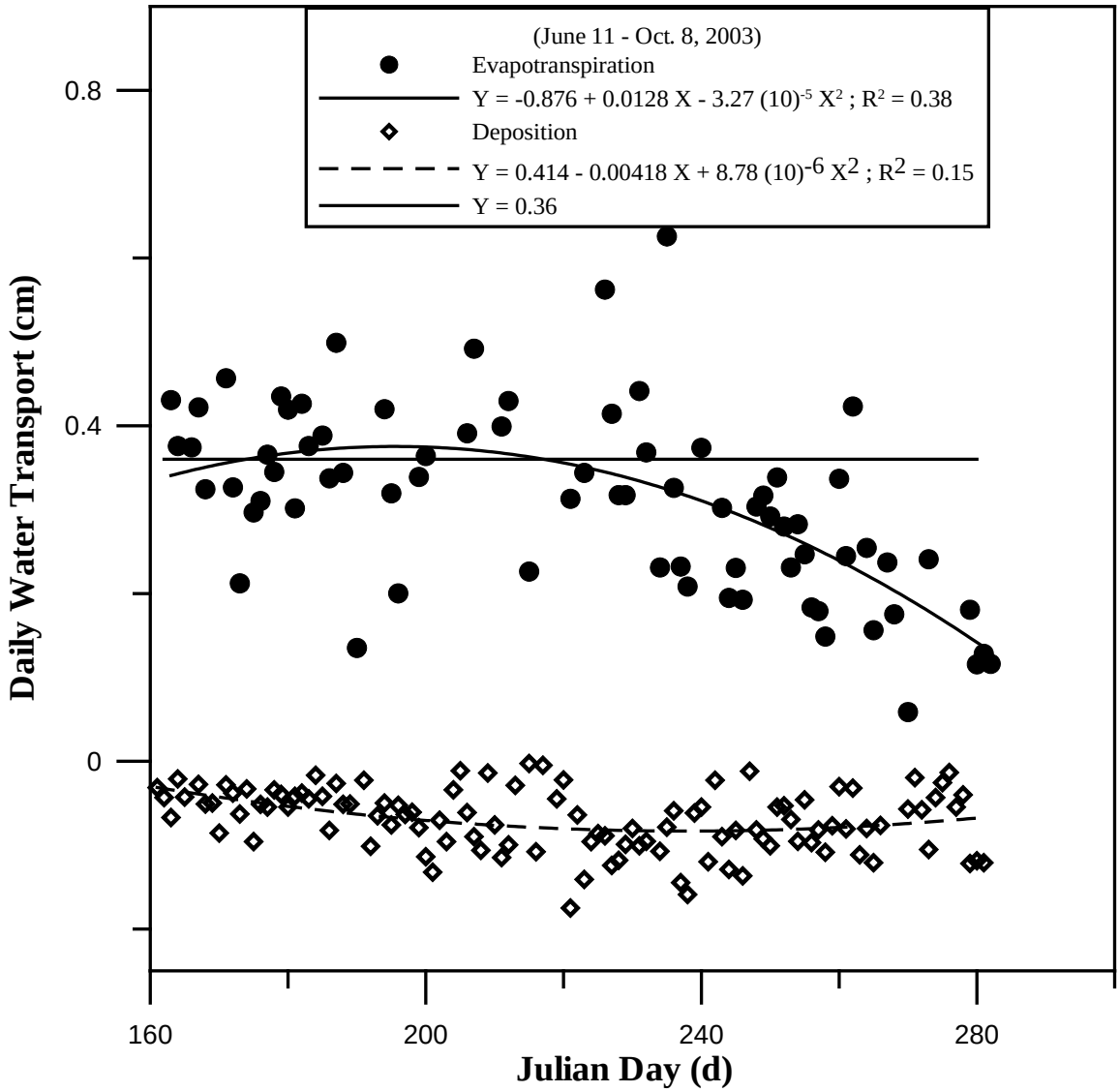


Figure 2. Daily evapotranspiration and deposition trends.

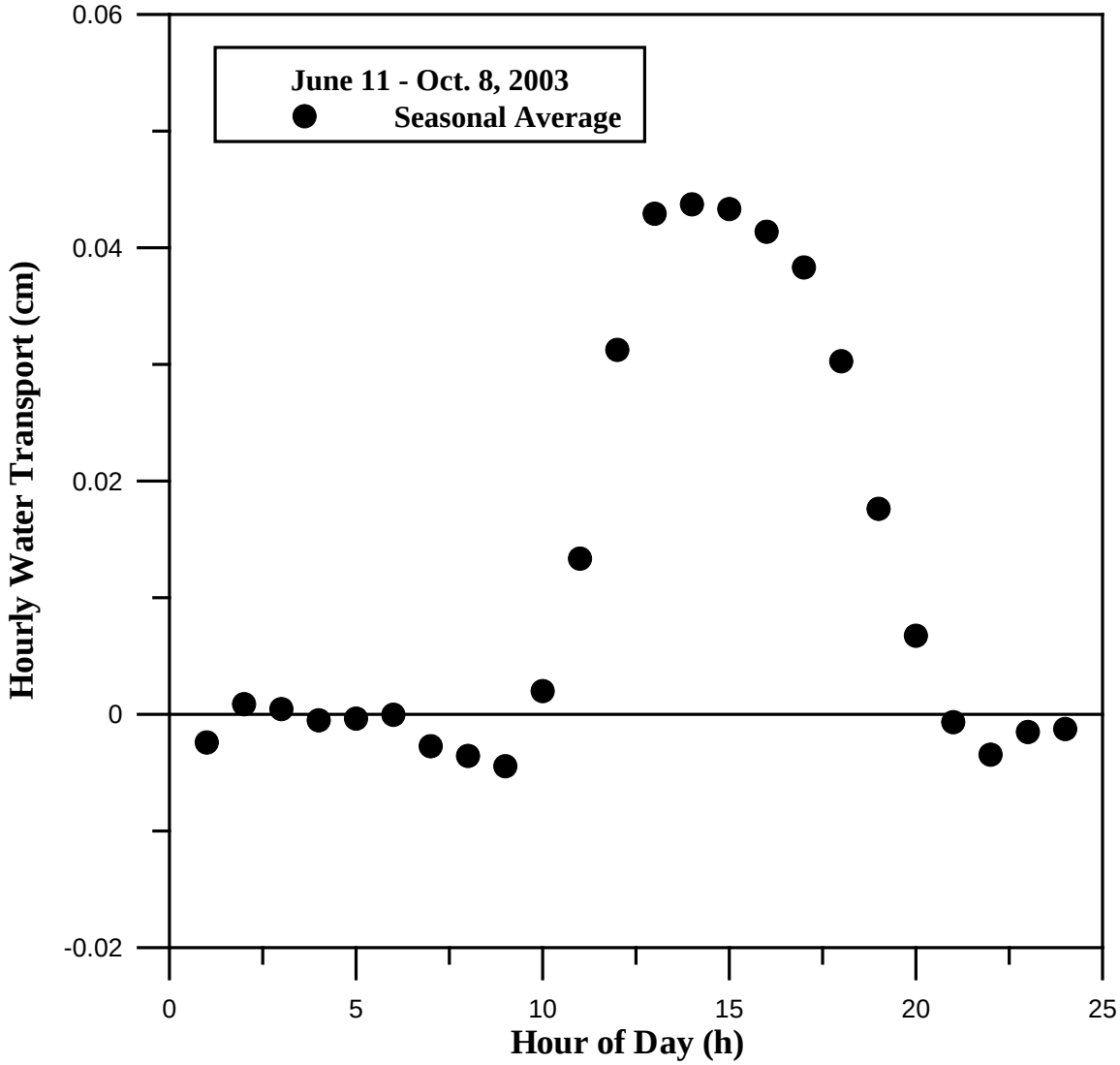


Figure 3. Hourly composite of diurnal pattern of uptake and deposition.

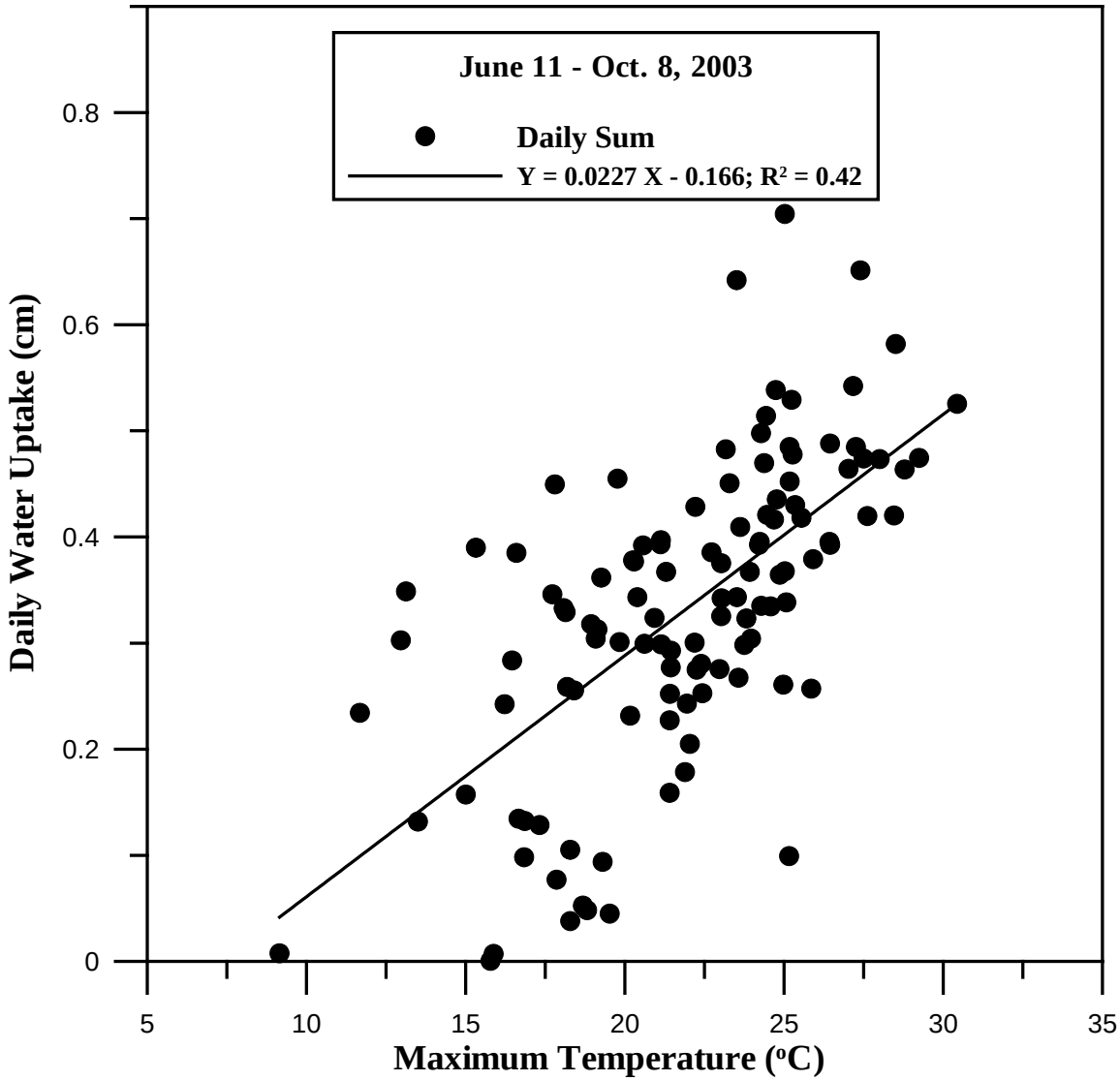


Figure 4. Relationship of daily uptake to maximum temperature during uptake hours.

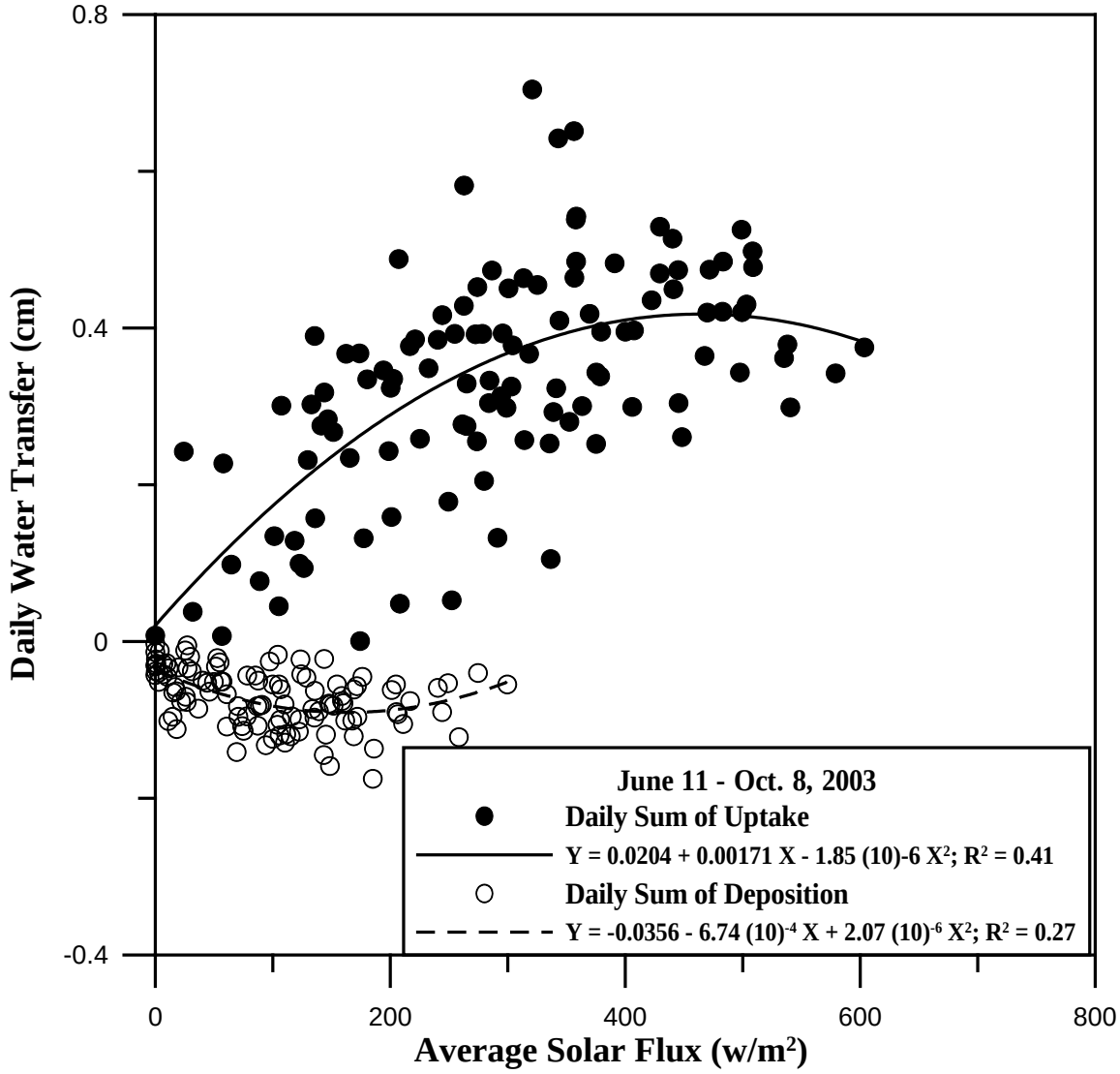


Figure 5. Relationship of daily uptake and deposition to average solar flux.

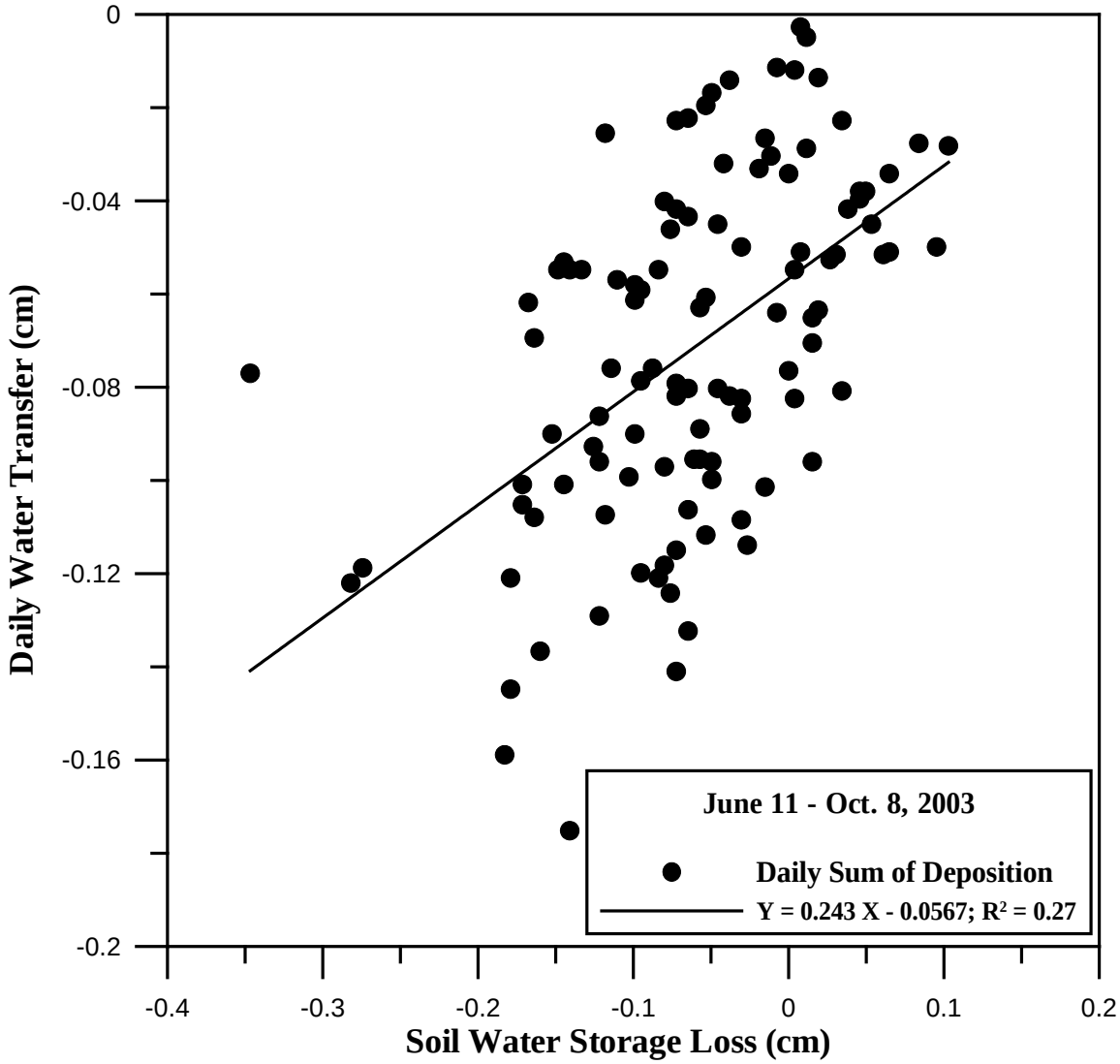


Figure 6. Daily deposition as related to losses in soil water storage.

ENTOMOLOGY

INVESTIGATORS: F. A. Drummond, Professor of Insect Ecology/Entomology
J. A. Collins, Assistant Scientist of Insect Pest Management

7. TITLE: Control Tactics for Blueberry Pest Insects

1. <u>Field evaluation of insecticides for control of secondary pest insects</u>.

METHODS: Trials were completed against blueberry spanworm (SW), strawberry rootworm (SRW) and blueberry thrips (BT). The tests against blueberry spanworm and strawberry rootworm were applied as foliar sprays to fruit-bearing fields. Effectiveness was measured by taking pre- and post-treatment sweep-net samples. In the thrips trial, Admire® was applied as a spray to the soil prior to stem emergence; the remaining materials were applied as foliar sprays. Efficacy was determined by counting the number of infested stems after treatment as evidenced by leaf curling.

RESULTS/CONCLUSIONS: Entrust®, SpinTor®, Confirm®, and Intrepid® all provided excellent seasonal control of blueberry spanworm larvae. Although not performing quite as well, Proclaim® and Calypso® also gave adequate control and reduced seasonal densities of spanworm larvae in comparison to the untreated check plots (ANOVA, $P = 0.0001$)(Table 1). Entrust® and Imidan® were also effective against strawberry rootworm adults (Table 2).

The pre-emergence soil application of Admire® gave excellent control of blueberry thrips. Two applications of SpinTor®, Diazinon®, or Actara® timed to plant emergence performed very well (Table 3).

2. <u>Control of blueberry maggot with ground application of insecticides</u>.

METHODS: The efficacy of three materials (Calypso®, Avaunt®, and SpinTor®) was evaluated following application with an air blast sprayer. Efficacy of all treatments was evaluated based on the seasonal density of adults as measured with baited, yellow, Pherocon® AM traps before and after the applications and on the number of maggots found in the fruit at harvest.

RESULTS/CONCLUSIONS: Although all the materials we tested reduced the seasonal density of adult flies captured over the course of the trial, the differences were not significant (ANOVA, $P = 0.2765$)(Table 4). There were also no significant differences among the treatments in the numbers of maggots found in fruit (ANOVA, $P = 0.2490$). Calypso possibly provided some control. An average of 2.4 maggots/qt were found in fruit treated with Calypso compared to 5.9 maggots/qt in untreated fruit. The remaining materials were less effective. In general, the results were inconclusive due to the limited number of replicated plots available for the experiment.

3. Control of blueberry maggot with ground application of GF-120 Fruit Fly Bait®.

METHODS: GF-120 Fruit Fly Bait® at a rate of 1:5 v/v with water was applied to 3 small field areas at Blueberry Hill Farm. Prespray monitoring of adult flies with baited yellow Pherocon® AM traps indicated the presence of a large population of blueberry maggot. Blueberries were 60-70% ripening and turning blue. The application was made using a 13.5 ft boom mounted on an ATV. There were 8, TeeJet® 8015LP nozzles (19-inch spacing, 20 psi).

RESULTS/CONCLUSIONS: There was no significant difference in BMF captures between treated and untreated check areas prior to the application (ANOVA, $P = 0.2497$)(Fig 1). The application of GF-120 Fruit Fly Bait did result in a significant reduction in the number of BMF captured on AM traps from the treated compared to the check areas (Fig. 1)($P = 0.0007$).

4. Attractiveness of NuLure® insect bait to blueberry maggot.

METHODS: On 27 June, six, 50 x 200 ft plots were established in a crop-year blueberry field in Washington Co. which records indicated had previously been infested with blueberry maggot. Three baited, yellow Pherocon® AM traps were placed in each plot. The traps were placed 50-ft apart down centerline. Three additional traps were placed 50-ft beyond the edge of each plot furthest from the field edge and 50-ft apart parallel to the field edge. The traps were monitored at 2 to 7 day intervals. Any BMF were counted and removed from the traps. On 10 July and again on 17 July, NuLure insect bait was applied at a rate of 48 oz/acre to three of the plots in 20 gallons of water per acre using a CIMA® P55D Atomizer L.V. sprayer mounted on an Agco Allis® 6670 tractor. Speed, psi, and nozzle orientation were adjusted to provide coverage to a 50-ft swath. One untreated check plot was left between each treated plot.

RESULTS/CONCLUSIONS: Numbers of BMF were low throughout the duration of the trial. However, NuLure insect bait does not appear to have been effective in attracting BMF into the treated areas. In other words, the number of BMF in the center of NuLure treated plots was not greater than in the center of check plots (Fig.2)(ANOVA, $P = 0.25$). Check plots consistently had more BMF then plots treated with NuLure.

NuLure was also apparently ineffective in reducing the numbers of BMF moving beyond the perimeter and out into the field (Fig. 3). To test this we compared the ratio of flies captured within plots located along the edge of the blueberry field to fly captures 50 ft beyond the edge plots. ANOVA ($P = 0.30$) suggested that there was no significant difference between the ratios.

RECOMMENDATIONS:

We must continue to developed data to support the registration of chemical insecticides and recommendations of cultural controls for blueberry pest insects. New materials for thrips control tested in 2003 looked particularly promising. The pre-emergence soil application of Admire® looked excellent as did the double application of SpinTor®. This is significant since in the past thrips have been a very difficult pest to control. Both of these compounds have low toxicity to humans. Before recommending these materials for control of thrips we plan to repeat the trials in 2004 with Admire® and SpinTor®, as well as, investigate the organic formulation of SpinTor® (Entrust®).

Entrust®, SpinTor®, Confirm®, and Intrepid® all performed well against blueberry spanworm. We do not hesitate to recommend them for control of blueberry spanworm; however, Entrust and SpinTor in particular have a very short residual activity in the field. We plan to conduct studies in 2004 to measure the residual activity so that better management decisions can be made when selecting an appropriate material.

As far as blueberry maggot fly control is concerned, our 2003 trials showed that the fruit fly bait, GF-120, has potential for controlling blueberry maggot flies. However, several years of trials are necessary before any recommendation is made as to its efficacy for the lowbush blueberry system. Over the past several years, trials with the fruit fly attractant, NuLure®, has led us to conclude that this attractant is not highly effective and therefore we will not recommend its use in perimeter applications.

1. FIELD EVALUATION OF INSECTICIDES FOR CONTROL OF SECONDARY PEST INSECTS.

Table 1. Field control of blueberry spanworm larvae with insecticides.

Material	Amt. form./ acre	Larvae/10 sweeps Prespray 8 May	Post spray 11 May	16 May	19 May	27 May	Seasonal density		
Confirm 2 F	16.0 oz		10.3	0.3	0.0	2.5	0.3	2.4 cd
SpinTor 2 SC	5.7 oz		10.3	0.5	0.0	6.0	0.3	2.7 bcd
Intrepid 2 F	16.0 oz		10.8	0.0	0.0	0.8	0.8	1.2 d
Calypso 480 SC	3.0 oz		11.3	2.3	2.0	10.5	1.8	5.2 bc
Entrust 80 W	2.0 oz		10.3	1.5	0.5	2.5	0.3	2.0 cd
Proclaim 5 SG	3.2 oz		10.3	3.3	3.0	13.0	1.3	6.2 b
No insecticide	-		11.0	10.3	4.5	30.3	5.5	13.9 a

Seasonal densities are trapezoidal integrals of densities over the season divided by the number of day's duration of the experiment. Means followed by the same letter(s) are not significantly different ($P < 0.05$, SNK). The data were transformed by $\log_{10}(X + 0.1)$ prior to analysis.

Table 2. Field control of strawberry rootworm adults with insecticides.

Material	Amt. form./ acre	Larvae/10 sweeps Prespray 6 Jun	Post spray 8 Jun	Post spray 10 Jun	Post spray 16 Jun	Seasonal density
Entrust 80 W	2.0 oz	14.0	0.5	1.0	0.8	2.1 b
Imidan 70 WP	16.0 oz	14.8	2.8	5.5	5.0	5.7 c
No insecticide	-	15.3	7.8	14.5	7.5	11.1 a

Seasonal densities are trapezoidal integrals of densities over the season divided by the number of day's duration of the experiment. Means followed by the same letter are not significantly different ($P < 0.05$, SNK). The data were transformed by $\log_{10}(X + 0.1)$ prior to analysis.

Table 3. Field control of thrips with insecticides.

Material	Amt.	Avg. # stems with form./acre	curls/sq ft
Admire 2 F (pre-emergence)	16.0 oz	0.0 d	
SpinTor 2 SC	5.0 oz	8.0 c	
DNZ Diazinon 50 WP	32.0 oz	6.9 c	
Actara 25 WG	3.0 oz	17.9 b	
No insecticide	_	82.3 a	

Means followed by the same letter are not significantly different ($P < 0.10$, SNK).
The data were transformed by $\log_{10}(X + 0.1)$ prior to analysis.

2. CONTROL OF BMF WITH GROUND APPLICATION OF INSECTICIDES.

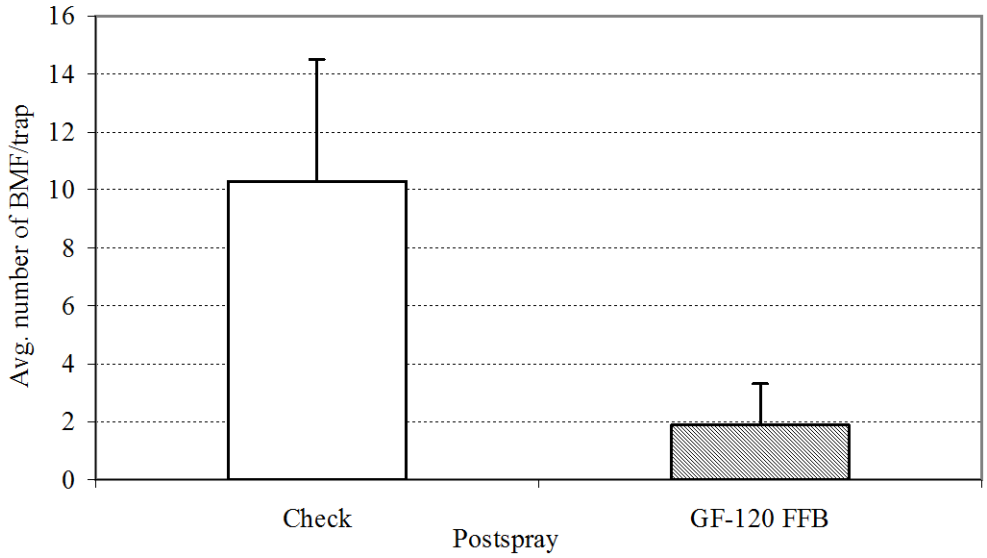
Table 4. Field control of blueberry maggot with insecticides, summary.

	Amt. form./acre	Avg. maggots/qt	Adults/trap seasonal density
SpinTor 2 SC	3.0 oz	6.8	14.3
Avaunt 30 WG	4.0 oz	8.0	6.4
Calypso 480 SC	3.0 oz	2.4	7.2
No insecticide	-	5.9	16.9

Seasonal densities are trapezoidal integrals of densities over the season divided by the number of days duration of the experiment. Data were transformed by $\log_{10}(X + 0.1)$ prior to analysis.

3. CONTROL OF BMF WITH GROUND APPLICATION OF GF-120 FRUIT FLY BAIT.

Fig. 1. Effect of treatment on BMF captures.



4. ATTRACTIVENESS OF NULURE INSECT BAIT TO BLUEBERRY MAGGOT.

Fig. 2. Effect of treatment on seasonal density of BMF.

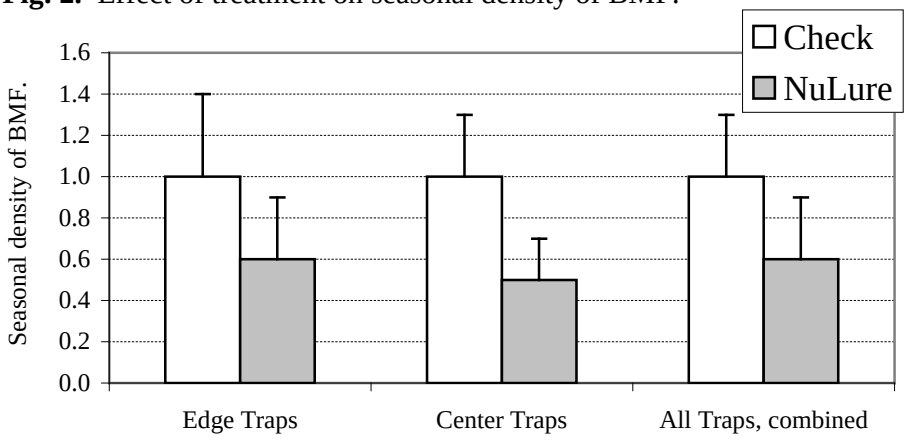
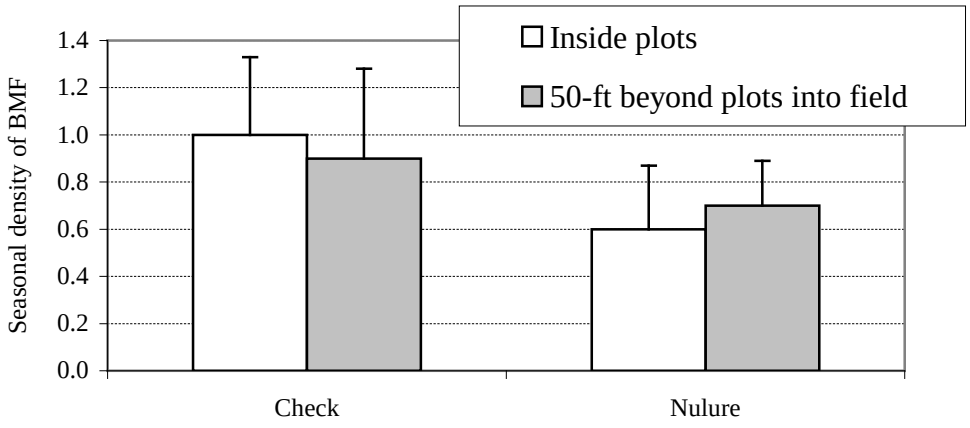


Fig. 3. Effect of treatment on movement of BMF into the field.



ENTOMOLOGY

INVESTIGATORS: F. A. Drummond, Professor of Insect Ecology/Entomology
J. A. Collins, Assistant Scientist of Insect Pest Management

8. TITLE: IPM strategies

BLUEBERRY SPANWORM

1. **Evaluation of flower-bud development subsequent to feeding damage by blueberry spanworm in the pruned year.**

METHODS: In May 2002, six replications (blocks) were established in a pruned field at Blueberry Hill Farm. The field was flail-mowed in the fall of 2001. Five, 4 ft^2 plots were set in each block and one of five different densities of blueberry spanworm larvae was placed in each plot (0, 10, 20, 40, or 60 larvae). Block #1 was set on 16 May using 1st and 2nd instar larvae collected from an infested field. Blocks 2, 3, and 4 were set on 22 May with 1st to 3rd instar larvae. Blocks 5 and 6 were set on 29 and 30 May, respectively with 3rd to 5th instar larvae. Each plot was covered with a mesh cage and sealed with sand around the bottom to prevent movement of the larvae out of the plots.

On 13 June 2002, the mesh cages were removed and the percentage of blueberry cover within each 4 ft^2 plot was estimated, converted to % defoliation, and compared with the initial larval density. A second estimate of blueberry cover was made on 17 July 2002. On 6 May 2003, 50 stems within each plot were cut and brought into the laboratory. The number of flower buds/stem was recorded at each spanworm density. An Analysis of Variance (ANOVA) was conducted comparing average flower buds/stem with initial larval density.

RESULTS/CONCLUSIONS: Table 1 summarizes the % blueberry leaf cover and the resulting % defoliation at each initial spanworm larval density for both 2002 sample dates. As we reported in 2002, there was a significant linear (P = 0.0204) and quadratic (P = 0.0188) trend on the 13 June sample date. Defoliation increased with increasing larval density. Densities of 40 and 60-larvae/4 ft^2 resulted in close to 100% defoliation (96.4 and 91.1% defoliation, respectively).

No such trends were observed on the second sample date on 17 July (linear, P = 0.1492; quadratic P = 0.1214); although, defoliation was slightly higher at the higher densities. It appears that increasing spanworm larval density resulted in increased defoliation of young, newly emerging sprouts in 2002. However, the blueberry plants appeared to have recovered in terms of vegetative cover by the second sample date in mid-July 2002. Blocks infested with 40 or 60 spanworm larvae during the pruned year did develop slightly fewer flower buds (9-15% reduction) compared to the lower levels of infestation; however, the difference was not significant (ANOVA, P = 0.3875) (Table 1 and Fig. 1).

2. <u>Evaluation of feeding damage by blueberry spanworm in the pruned year</u>.

METHODS: In May 2003, six replications (blocks) were established in a pruned field at Blueberry Hill Farm. The field was flail-mowed in the fall of 2002. Five, 4 ft^2 plots were set in each block and one of five different densities of blueberry spanworm larvae was placed in each plot (0, 10, 20, 40, or 60 larvae). Three blocks were set on 8 May using 1st and 2nd instar larvae collected from an infested field. Three additional blocks were set on 28 May with 2nd to 4th instar larvae. Each plot was covered with a mesh cage and sealed with sand around the bottom to prevent movement of the larvae out of the plots.

On 12 June, the mesh cages were removed and the percentage of blueberry cover within each 4 ft^2 plot was estimated, converted to % defoliation, and compared with the initial larval density.

In the spring 2004, 50 stems within each plot will be cut and brought into the laboratory. The number of flower buds/stem will be recorded at each density. Analysis of Variance and Regression analyses will be conducted comparing average flower buds/stem with initial larval density.

RESULTS/CONCLUSTIONS: An Analysis of Variance revealed no significant difference between the blocks (P = 0.0795) and no difference between blocks set in early compared to late May (P = 0.1570). Figure 2 shows the relationship between average % defoliation and initial spanworm larval density. Table 2 summarizes the % blueberry leaf cover and the resulting % defoliation at each initial spanworm larval density. There was no significant linear trend (P = 0.1136); the quadratic trend was only slightly non-significant (P = 0.0565). Defoliation was slightly higher at the higher densities. An analysis of fruit-bud production in the spring will determine whether the plants recovered from the defoliation or if an accompanying yield loss will result.

3. <u>Effect of late-emergence of blueberry stems on flower-bud development</u>.

METHODS: The "upper field" of Blueberry Hill Farm was flail-mowed in the fall of 2002. Portions of the field were heavily infested with blueberry spanworm larvae in the spring of 2003. The subsequent feeding damage resulted in late emergence of the blueberry stems.

The defoliated area was observed at ca.weekly intervals beginning on 4 June. On each of 5 observation dates (4, 13, 23 June and 7, 9 July), an estimate was made of blueberry plant development. Two to five, m^2 plots were established in areas judged to have reached 100% canopy coverage since the date of the previous observation.

RESULTS/CONCLUSTIONS: In the spring of 2004, 50 stems within each m^2 plot will be cut, brought into the laboratory, and counted to determine the number of flower buds/stem. Analysis of Variance and Regression Analyses will be conducted comparing average flower buds/stem with the date of 100% cover.

4. Effect of fertilizer application on flower-bud development in late-emerging blueberry stems subsequent to blueberry spanworm infestation.

METHODS: The "upper field" of Blueberry Hill Farm was flail-mowed in the fall of 2002. Portions of the field were heavily infested with blueberry spanworm larvae in the spring of 2003. The subsequent feeding damage resulted in late emergence of the blueberry stems.

RESULTS/CONCLUSIONS: On 25 July, DAP (10-10-10) fertilizer was applied by hand to 2-m^2 plots located in the defoliated area. Following the applications, each plot was irrigated with a hand-held hose. Two rates were applied, 122 lbs and 244 lbs per acre. Four replications were set in each of three areas of the field for a total of 12 replications of each rate plus 12 untreated checks. In the spring of 2004, 50 stems within each 2-m^2 plot will be cut and brought into the laboratory. The number of flower buds/stem will be recorded at each fertilizer rate. Analysis of Variance and Regression Analyses will be conducted comparing average flower buds/stem with fertilizer rate.

5. Effect of blueberry spanworm larval infestation on yields.

METHODS: In early May, 28 plots were established in a 2nd crop year blueberry field. Each plot measured 20 x 20-ft with a minimum 5-ft untreated buffer zone around and between each plot. On 5 May dates (8, 11, 16, 19, and 27 May), 10 sweeps with a standard 12-inch diameter sweep net were taken systematically through the center area of each plot avoiding plot boundaries. After the larvae were counted, they were distributed back into the same plot.

Yield samples were collected on 31 July (berries 95-100% ripening and turning blue). Using a commercial blueberry rake, all berries within a 1-m^2 quadrant were raked from the center of each plot and weighed in the field. The fruit was hand-winnowed to remove any excess debris. Regression analysis was than used to compare the relationship between seasonal density of spanworm larvae and yield.

RESULTS/CONCLUSIONS: Seasonal densities of spanworm larvae are trapezoidal integrals of densities over the season divided by the number of day's duration of the experiment. Figure 3 shows the relationship between the seasonal density of spanworm larvae and yield (oz). Although a linear regression analysis showed an unexpected trend towards yields increasing with increasing spanworm densities, it was not significant ($P = 0.0603$; $r^2 = 0.13$). In is possible that spanworm feeding resulted in a reduction in number of fruit buds. An assumed reduction in the number of fruit buds due to spanworm feeding may have resulted in the infested plants having more energy to put into the remaining buds and consequently resulted in heavier fruit.

6. Effect of clone type on blueberry spanworm larval density.

METHODS: Ninety-nine blueberry clones were sampled for blueberry spanworm larvae; 20 on 19 May and an additional 79 on 29 May. Sampling was conducted by sweeping with a standard 12" diameter sweep net (10 sweeps/clone). The clones were characterized into types according to flower phenology. In addition, the phenological state of the clone was recorded as swollen bud, tight cluster, loose cluster, early bloom, and bloom. Analysis of Variance (ANOVA) was

used to determine whether flower phenology affected the spanworm density observed on the clones.

RESULTS/CONCLUSIONS: In both 2001 and 2002, we found a significant relationship between spanworm density and blueberry-bloom phenology when data was pooled over all dates and fields within a year (Fig. 4, ANOVA, $P = 0.02$ and Fig. 5, ANOVA, $P = 0.02$; respectively). Larval density was greater on the phenologically younger clones and decreased the more mature (closer to full bloom) the clone. Similar results were obtained again in 2003 (Fig. 6, ANOVA, $P = 0.0001$). To determine if this apparent trend was merely a reflection of the proportion of the field a given phenological stage occupied while sampling (i.e., if just due to chance one would get higher larval densities on phenological stages that are more prevalent) we plotted density of larvae against clone prevalence for each clone type. It does not appear that a consistent relationship exists between density and % occurrence (except for May 19, 2003). Thus, it can be concluded that clone phenology determines spanworm density. Therefore, these results support the hypothesis that blueberry spanworm larvae preferentially feed upon the flower buds and that they leave the plant when the young buds are no longer available or that survival is much greater on plants in the earlier phenological stages.

BLUEBERRY FLEA BEETLE

1. <u>Evaluation of flower-bud development subsequent to feeding damage by blueberry Flea beetle in the pruned year</u>.

METHODS: In May 2002, three replications (blocks) were established in a vegetative field at Blueberry Hill Farm. The field was flail-mowed in the fall of 2001. Four, 4 ft^2 plots were set in each block. One of four different densities of larvae was placed in each plot (0, 10, 30, or 60 larvae). Both blocks were set on 7 June 2002 using late instar flea beetle larvae collected from an infested field. Each plot was covered with a mesh cage and sealed with sand around the bottom to prevent movement of the larvae out of the plots.

On 18 June 2002, the mesh cages were removed and the percentage of blueberry cover within each 4 ft^2 plot was estimated, converted to % defoliation, and compared with the initial larval density. On 6 May 2003, 50 stems within each plot were cut and brought into the laboratory. The number of flower buds/stem was recorded at each density. An Analysis of Variance (ANOVA) was conducted comparing average flower buds/stem with initial larval density.

RESULTS/CONCLUSIONS: Table 3 summarizes the % blueberry leaf cover and the resulting % defoliation at each initial flea beetle larval density. As we reported in 2002, defoliation at initial densities of 10, 30, and 60 larvae, resulted in no significant linear trend, but a positive significant quadratic trend (Regression analysis; $P = 0.5211$ and 0.0326, respectively). The larvae that were placed on the plots were late instar. It is possible that using earlier instar larvae would have resulted in a different defoliation rate over these larval densities. But, most likely the trend in defoliation would still have been a positively increasing one. The trend in defoliation suggests that large flea beetle larvae in a 4 ft^2 plot will result in a high level of defoliation of emerging sprouts.

An analysis of flower-bud production in 2003 coincides with the defoliation results. Analysis of Variance revealed significant differences in numbers of flower buds (ANOVA, P = 0.0033). Blocks infested with 30 or 60 flea beetle larvae during the pruned year developed significantly fewer flower buds compared to non-infested check plots or those infested with only 10 larvae (Fig. 8).

RECOMMENDATIONS:

Over several years now our studies with both blueberry spanworm and blueberry flea beetle suggest that defoliation is much more serious in the prune year than in the fruit-bearing year. Therefore, we would like to recommend that most control be carried out in the crop or fruit-bearing year if possible. The reason for this is as follows: 1) blueberry spanworm and to a lesser extent blueberry flea beetle are much more easy to sample with a sweep net in a fruit-bearing field. This is important if one wishes to use integrated pest management and base decisions for insecticide applications upon recommended thresholds; 2) fruit-bearing fields are more robust to yield loss than pruned fields and so there is a less critical nature in making sure that all fields are sampled early in the season. Blueberry spanworm and blueberry flea beetle can totally defoliate blueberry at densities of 30-60 larvae per 2 m^2. The blueberries will refoliate later in the summer, but resulting yield loss occurs the following year since fewer fruit buds will develop. With densities of 60 larvae 15% loss can occur from spanworm and 66% yield loss from flea beetle. It is the time of the defoliation (later in year for flea beetle) that probably results in the difference in yield loss since this density of larvae for both pests results in 100% defoliation. In 2004, investigations will be made into a better sampling method for pruned fields.

BLUEBERRY SPANWORM

1. EVALUATION OF FLOWER-BUD DEVELOPMENT SUBSEQUENT TO FEEDING DAMAGE BY BLUEBERRY SPANWORM IN THE PRUNED YEAR.

Table 1. Percent blueberry leaf cover, % defoliation, and flower-bud development subsequent to feeding by blueberry spanworm larvae.

Initial spanworm larval density	% cover [1]	% defoliation [2]	% defoliation [3]	Avg. flower buds/ stem [4]
0	28.0 (7.2)	0.0	0.0	4.7 (1.6) a
10	20.0 (11.9)	49.4	5.4	4.9 (2.3) a
20	14.2 (6.6)	45.7	12.9	4.7 (1.7) a
40	1.0 (1.1)	93.6	10.4	4.0 (1.5) a
60	2.5 (3.5)	83.3	10.9	4.3 (2.0) a

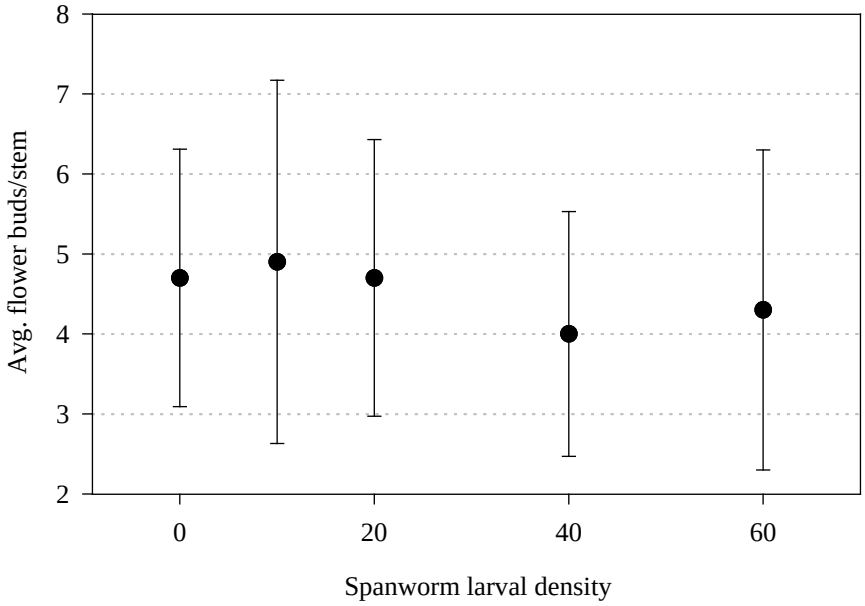
[1] Mean % cover ± standard error, 13 June 2002;

[2] % defoliation, 13 June 2002 = (% cover at 0 density - % cover at selected density) / % cover at 0 density)) * 100;

[3] % defoliation, 17 July 2002;

[4] Avg. flower buds ± standard error, 6 May 2003. Means followed by the same letter are not significantly different (P < 0.05, SNK).

Fig. 1. Relationship between spanworm larval density and flower-bud development, 6 May 2003.



2. EVALUATION OF FEEDING DAMAGE BY BLUEBERRY SPANWORM IN THE PRUNED YEAR.

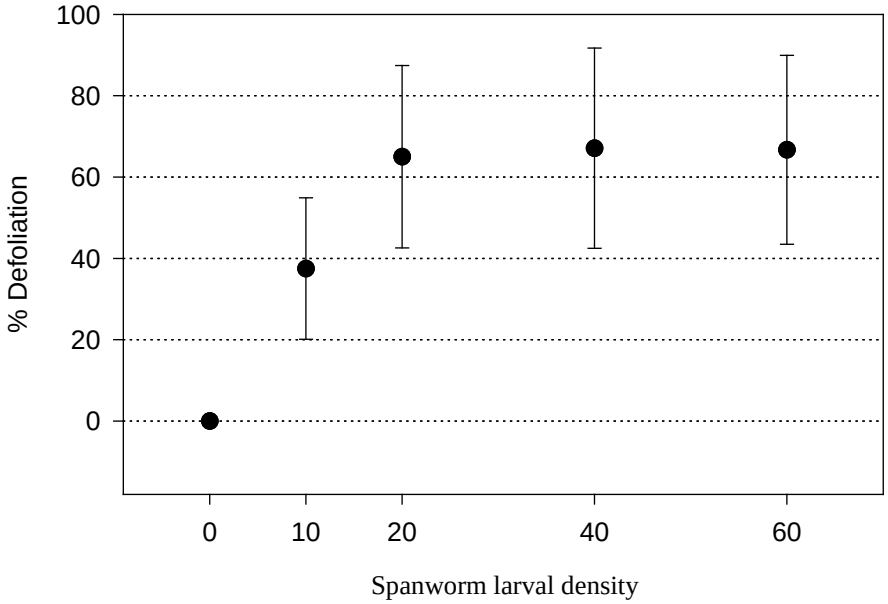
Table 2. Percent of blueberry leaf cover and % defoliation as a result of spanworm larval feeding.

Initial spanworm larval density	% cover [1]	% defoliation [2]
0	20.0 (6.2)	0.0
10	13.3 (7.6)	37.5
20	10.3 (7.0)	65.0
40	8.7 (6.7)	67.1
60	8.3 (5.6)	66.7

[1] Mean % cover ± standard error;

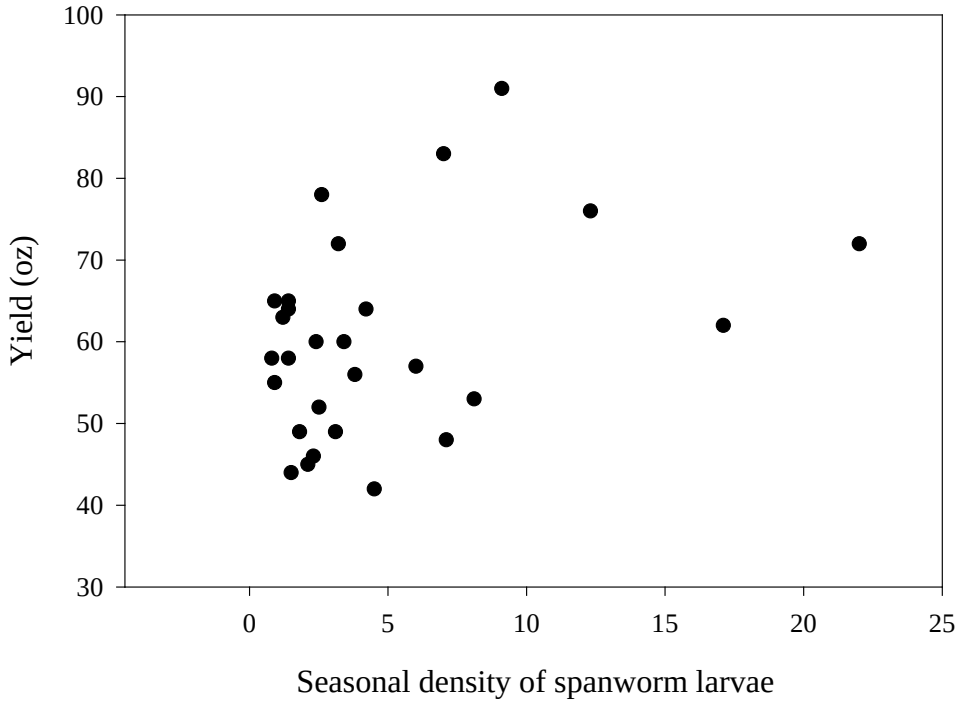
[2] % defoliation = (% cover at 0 density - % cover at selected density) / % cover at 0 density)) * 100.

Fig. 2. Relationship between initial spanworm density and % defoliation.



5. EFFECT OF BLUEBERRY SPANWORM LARVAL INFESTATION ON YIELDS.

Fig. 3. Relationship between seasonal density of spanworm larvae and yield, linear trend.



6. EFFECT OF CLONE TYPE ON BLUEBERRY SPANWORM LARVAL DENSITY.

Fig. 4. Effect of bloom phenology on larval density, 2001.

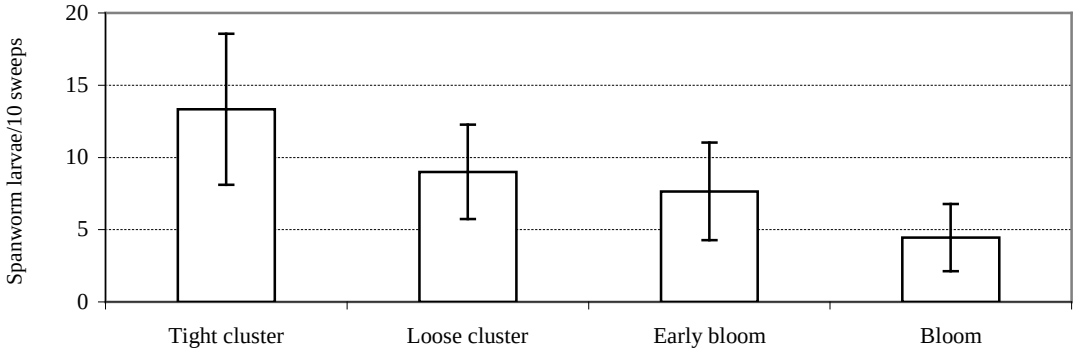


Fig. 5. Effect of bloom phenology on larval density, 2002.

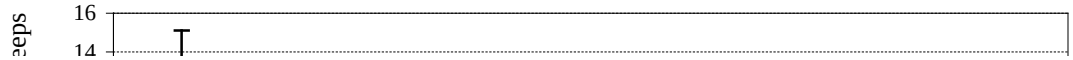
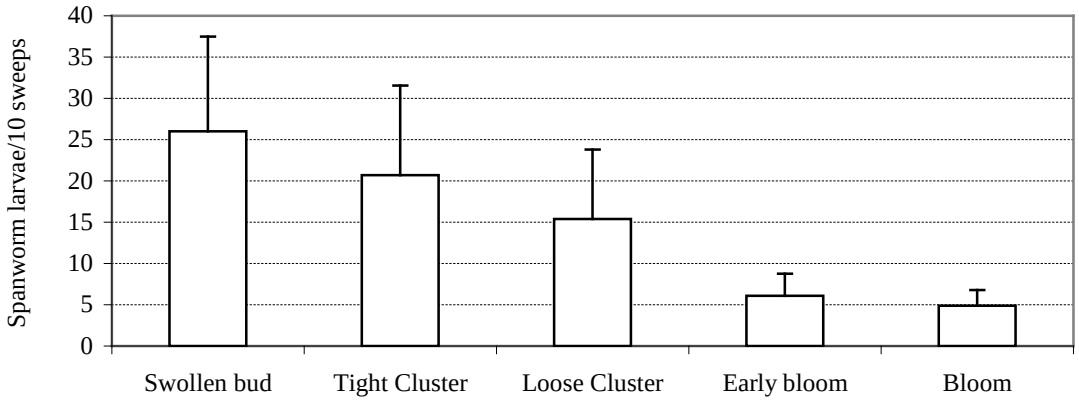


Fig. 6. Effect of bloom phenology on spanworm larval density, 2003.



FLEA BEETLE

1. EVALUATION OF FLOWER-BUD DEVELOPMENT SUBSEQUENT TO FEEDING DAMAGE BY BLUEBERRY FLEA BEETLE IN THE PRUNED YEAR.

Table 3. Percent blueberry leaf cover, % defoliation, and flower-bud development subsequent to feeding by blueberry flea beetle larvae.

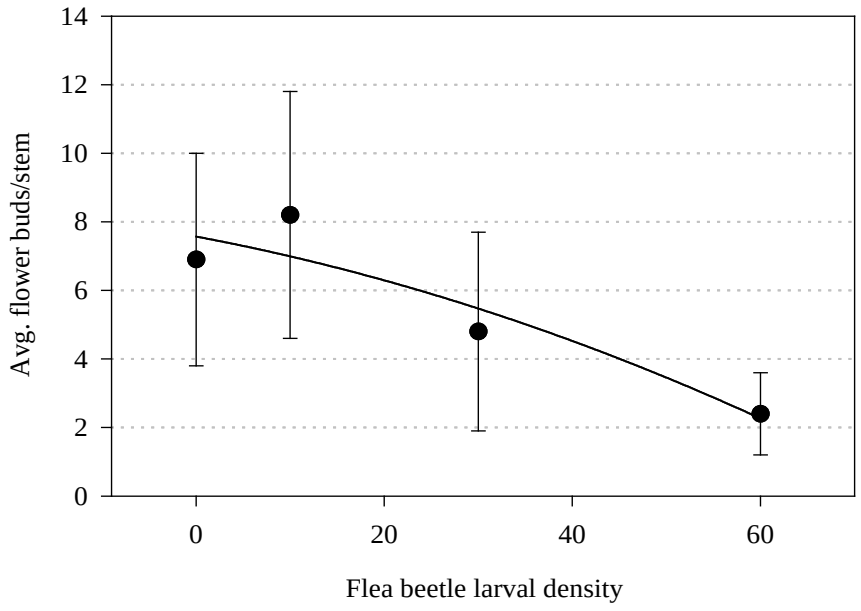
Initial flea beetle larval density	% cover [1]	% defoliation [2]	Avg. flower buds/stem [3]
0	20.0 (5.7)	0.0	6.9 (3.1) a
10	11.7 (4.3)	27.8	8.2 (3.6) ab
30	10.0 (4.9)	52.8	4.8 (2.9) b
60	13.3 (3.3)	27.8	2.4 (1.2) c

[1] Mean % cover ± Standard error, 18 June 2002;

[2] % defoliation, 18 June 2002 = (% cover at 0 density - % cover at selected density) / % cover at 0 density)) * 100;

[3] Avg. flower buds ± Standard error, 6 May 2003. Means followed by the same letter are not significantly different ($P < 0.05$, SNK).

Fig. 7. Relationship between flea beetle larval density and flower-bud development, 6 May 2003.



ENTOMOLOGY

INVESTIGATORS: F. A. Drummond, Professor of Insect Ecology/Entomology
J. A. Collins, Assistant Scientist of Insect Pest Management

9. TITLE: Biology and Ecology of Blueberry Pest Insects, 2003

1. <u>Fruit-color selection by blueberry maggot flies in the laboratory</u>.

METHODS: Blueberry maggot flies (BMF) were reared from pupae collected in 2002. The flies were allowed to mature in cages for at least 7 days at room temperature (18-25^{o}C), and then stems with blueberries in various stages of ripeness (one stem of each color, blue, red, or green) were placed in the cage. The stems were in small vials with water, stopped with cotton and sealed with Parafilm® to slow evaporation. Stems were left in the cage for 3-5 days then removed and incubated at ca. 24^{o}C for 10 days. New stems were placed in each cage. Following the incubation period, the berries were either dissected immediately to determine the presence or absence of BMF larvae, or the berries were placed over sand to allow maggots to pupate. The sand was later examined for the presence of pupae.

RESULTS/CONCLUSIONS: The trial was replicated 12 times. As is illustrated in figure 1, BMF show a distinct preference for blue fruit. No larvae were found in green fruit and only 1.8% of red fruit was infested. In comparison, significantly more blue fruit (57.9%) was infested with BMF larvae (ANOVA, $P = 0.0001$).

2. <u>Wild blueberry maggot fly emergence in fruit-bearing, wooded, and pruned habitats.</u>

METHODS: On 25 June, emergence cages were placed in, and adjacent to, three commercially managed wild blueberry fields in Washington Co. Fifteen cages were set at each site. Five cages were set along the field edge in a fruit-bearing area of the field. Five cages were set along the field edge in a nearby pruned section. The remaining five cages were placed in an adjacent wooded area with unmanaged blueberries in the under story. A Pherocon® AM trap was placed with each set of 5 emergence cages to monitor for the presence of blueberry maggot fly (BMF). The emergence cages and AM traps were checked periodically from 30 June to 28 July and BMF were counted and removed. All AM traps were replaced on 17 July.

RESULTS/CONCLUSIONS: As in 2001, no flies were captured from cages set in fruit-bearing habitats. In the three years that this study has been replicated, only 3 BMF have been captured from an emergence cage set in a fruit-bearing area (3 from one cage on 15 July 2002) (Fig.2). A comparison of captures in 2001 and 2003 shows a wide relative variation in the number of BMF captured in pruned and wooded-area emergence cages. In 2001, 17 BMF or 65.4% of the total BMF captured were taken from woods cages and 9 or 34.6% from prune cages. This trend was reversed in 2003 with 20 BMF (95.2%) taken from prune cages, but only one (4.8%) from a woods cage. For all three years combined, captures from woods and prune traps were 33.3% and 61.1%, respectively (Fig. 2). This supports our hypothesis that BMF are mostly emerging from pruned fields and wooded edges compared to fruit-bearing fields. This results in very few flies being left in the field the next year when it is fruit-bearing. A fruit-bearing field must be re-infested from outside sources, i.e. new pruned fields and adjacent woods

with blueberries in the under story. It also underscores the importance of these areas as sources of infestation.

The results of deploying the AM traps in the three habitats for each of the three years suggests that movement of BMF from the over-wintering sites (pruned fields and wooded edges) into fruit-bearing fields may be very different from year to year (Fig. 3). In 2001, many flies were trapped in wooded edges throughout the season; whereas, flies were caught in large numbers in pruned fields early in the season but not late in the season. The drop in fly numbers in pruned fields coincided with the increase in fly captures in fruit-bearing fields. In 2002, a similar pattern of trap captures was observed with a drop in fly captures in pruned fields occurring mid-season with an associated rise in captures in fruit-bearing fields. This reflects the movement of flies from pruned fields to fruit-bearing fields. Wooded edges were characterized by moderate fly captures the entire season as in 2001. Flies were both emerging and coming into wood edge areas and staying in them to infest fruit. In 2003, similar pattern in moderate trap captures was observed in wooded edges. Captures in pruned fields peaked on July 13 and then again on July 28. Fly movement into fruit-bearing fields was only detected on July 23rd, after the first peak in pruned fields, but overall very few flies were caught moving into the fruit-bearing fields in 2003.

3. <u>Vertical distribution of blueberry maggot flies within the forest perimeter around wild blueberry fields</u>.

METHODS: On 25 or 26 June, baited yellow Pherocon® AM traps were hung from trees near wild blueberry fields in Washington Co. There were twelve sites with one vertical transect at each site. Six sites were adjacent to fruit-bearing blueberry fields and six adjacent to pruned fields. Additionally, within each set of six sites, three were located in areas where coniferous tree were the dominant species and three in areas dominated by deciduous trees. The traps were at 5, 10, 15, and 20 ft above the ground and were hung on a rope attached to a pulley to allow easier monitoring. An additional trap was hung 6-10 inches above the crop canopy from a separate pole. At each site, the tree used for the study was 10 to 20 ft into the woods from the edge of the field. All traps were checked periodically beginning on 2 July and continuing until 5 August. Any captured flies were collected, soaked for 24 hrs in kerosene to remove any sticky residue, and stored in 70% ethyl alcohol (ETOH) prior to inspection in the laboratory to determine gender and oviposition status. All traps were changed on 18 July.

RESULTS/CONCLUSIONS: RESULTS: Figures 4 & 5 show that BMF adults were distributed within the tree canopy surrounding both pruned and fruit-bearing blueberry fields. A high proportion of the flies are found in the highest canopy layer (20 ft), but across all the fields there was no difference in trap capture among the different canopy heights (Fig. 11, $P = 0.599$). A difference in the temporal trend of fly captures was seen in trees surrounding fruit-bearing fields compared to those surrounding pruned fields. Trap captures at all heights in the canopy of trees surrounding pruned fields declined over the fruit fly season; whereas, trap captures fluctuated, but stayed constant over the season in the canopy of trees surrounding fruit-bearing trees (Figs. 4 & 5). The percentage of females relative to male flies ranged from 20-80%, with a higher percentage of males near the forest floor and the highest percentage of females captured at 20 ft above the ground ($P = 0.005$). This trend held for tree canopies surrounding both pruned and fruit-bearing fields (Figs. 6 & 7). The reason for the behavior of female flies differentially

seeking the highest levels of the tree canopy is not known, but may be significant in the colonization of blueberry fields. The ability of flies dispersing from treetops into blueberry fields to "jump" over a perimeter field-edge treatment can lower the efficiency of perimeter insecticide applications. Egg maturation in female flies shows a similar trend whether in trees surrounding prune fields or fruit-bearing fields, with peak maturation occurring in mid-July (Figs. 8 & 9). The percentage of female flies with eggs is slightly higher around fruit-bearing fields than pruned fields, but this is not significantly different ($P = 0.385$). The effect of forest type and crop phenology had no effect on total fly capture (Fig. 10)($P = 0.691$). However, there was a significant interaction observed between trap capture at different heights within the tree canopy and the forest type (Fig. 12, $P = 0.09$). In conifer forests, more flies were captured near the ground with trap capture declining as trap height increased. In deciduous forests surrounding blueberry fields, trap captures of BMF increased as trap height above the forest floor increased. This suggests that perimeter treatments of insecticides might be more efficacious, in the long-term, in blueberry fields surrounded by coniferous forest than fields surrounded by deciduous forest. However, before this conclusion can be made, experiments need to be conducted which measure the dispersal of flies from the tree canopy into blueberry fields.

4. <u>Development of blueberry maggot fly females in the laboratory</u>.

METHODS: Blueberry maggot flies (BMF) were reared from pupae collected in 2002. Cups of vermiculite containing 50 BMF pupae were removed from cold storage and placed in a growth chamber at ca. 25^{o}C. When first adult emergence was observed ca.1 month later, the cup was opened and placed in an oviposition cage in the laboratory. At 3, 6, and 9 days after being placed in the cages, between 2 and 8 females were removed and preserved in 70% ethyl alcohol for later dissection to evaluate them for the presence or absence of eggs.

RESULTS/CONCLUSIONS: Of 17 female BMF collected after maturing for 3 days, none were found to have eggs. Similarly, no eggs were found in females 6 or 9 days old (15 and 9 females, respectively). These results support our conclusions that female flies must mature for at least a week before they are reproductively mature and pose a risk to the blueberry crop.

RECOMMENDATIONS:

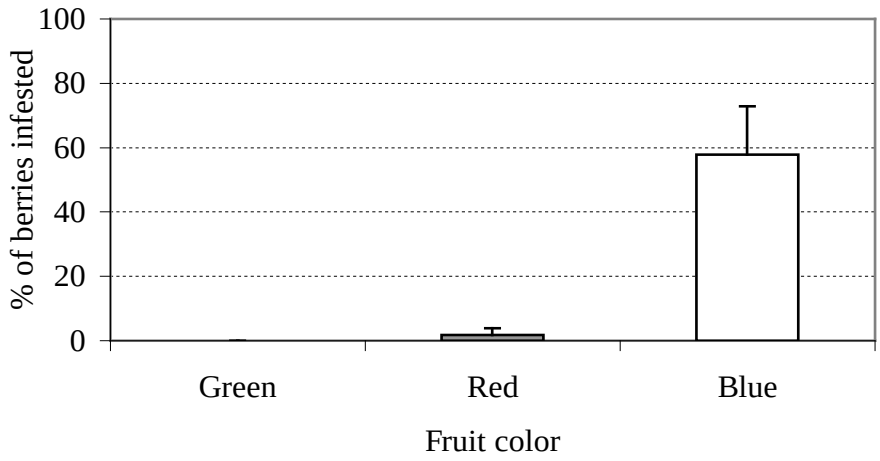
We are beginning to learn much about the basic biology of the blueberry maggot fly. Our studies so far suggest that within the lowbush blueberry landscape the blueberry maggot fly emerges mostly from pruned fields and surrounding forested habitat. It takes female flies 7-10 days to mature their ovaries (although controlled laboratory studies will be continued in 2004 to accurately determine this time period). Before this point, female flies cannot lay any eggs in the blueberry fruit. The flies stay at the initial site of emergence for 3-11 days before moving to fruit-bearing fields. Upon colonization of fruit-bearing fields, the fruit has to be ripe (blue stage) in order for fruit flies to lay eggs (a small percentage of unripe red berries may be attacked, but this is uncommon). Therefore, even if flies have emerged and entered fruit-bearing fields, our recommendation is not to apply any insecticide for control until the fruit becomes susceptible (blue fruit stage).

The vertical movement of flies into trees surrounding blueberry fields may have significant consequences in regards to a perimeter application strategy for control of fruit fly. We have several years' data suggesting that this vertical movement is common every year.

Deciduous trees have a higher proportion of flies in the upper levels of the canopy than coniferous tree field margins. In 2004 we plan to investigate whether flies in the upper levels will disperse into blueberry fields by "jumping" over the perimeter, thereby compromising a perimeter treatment of insecticide.

1. FRUIT-COLOR SELECTION BY BLUEBERRY MAGGOT FLIES IN THE LABORATORY.

Fig. 1. Fruit-color choice by BMF.



2. WILD BLUEBERRY MAGGOT FLY EMERGENCE IN FRUIT-BEARING, WOODED AND PRUNED HABITATS.

Fig. 2. Captures of BMF from emergence cages.

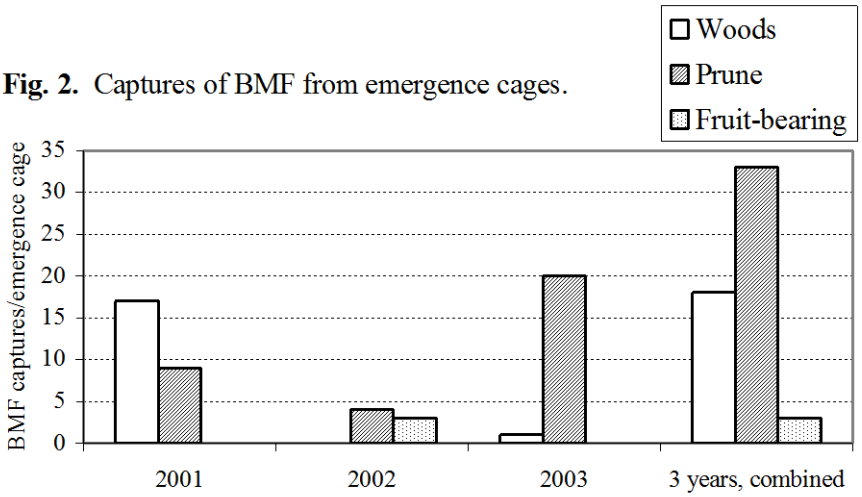
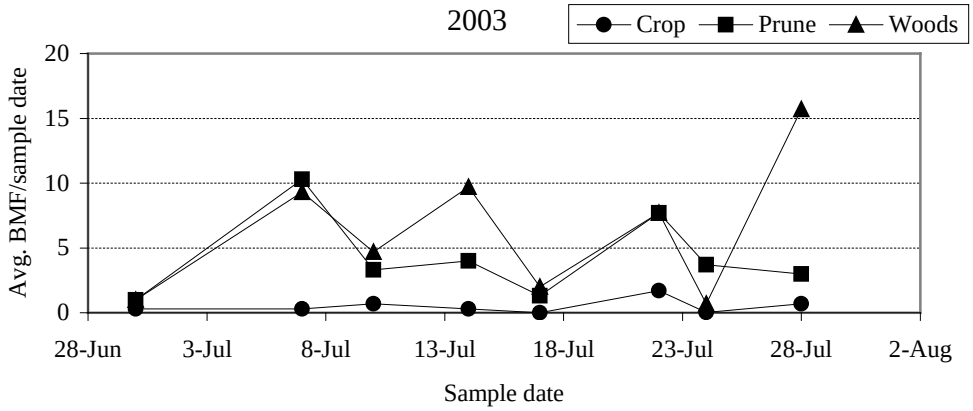
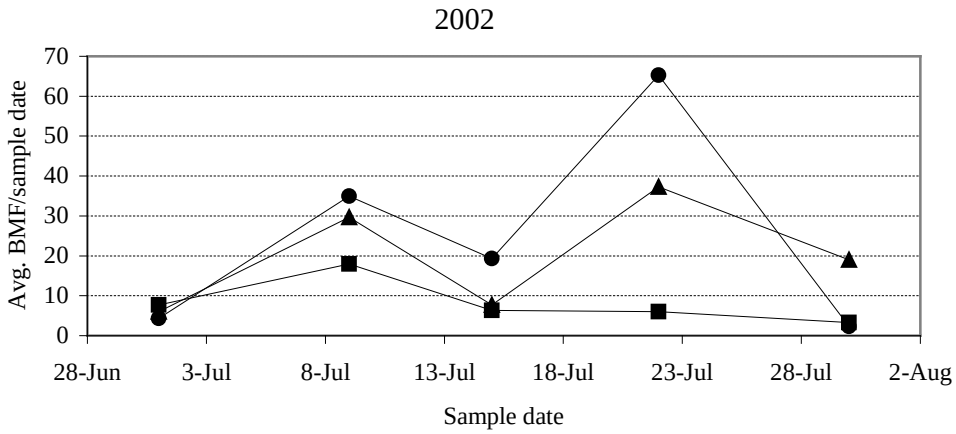
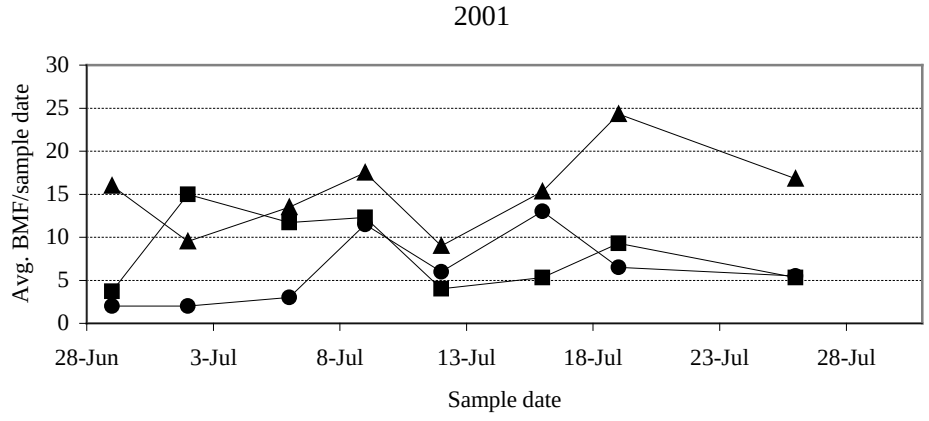


Fig. 3. Seasonal trap captures of BMF.







3. VERTICAL DISTRIBUTION OF BLUEBERRY MAGGOT FLY.

Fig. 4. BMF captures near fruit-bearing fields, by height for each date.

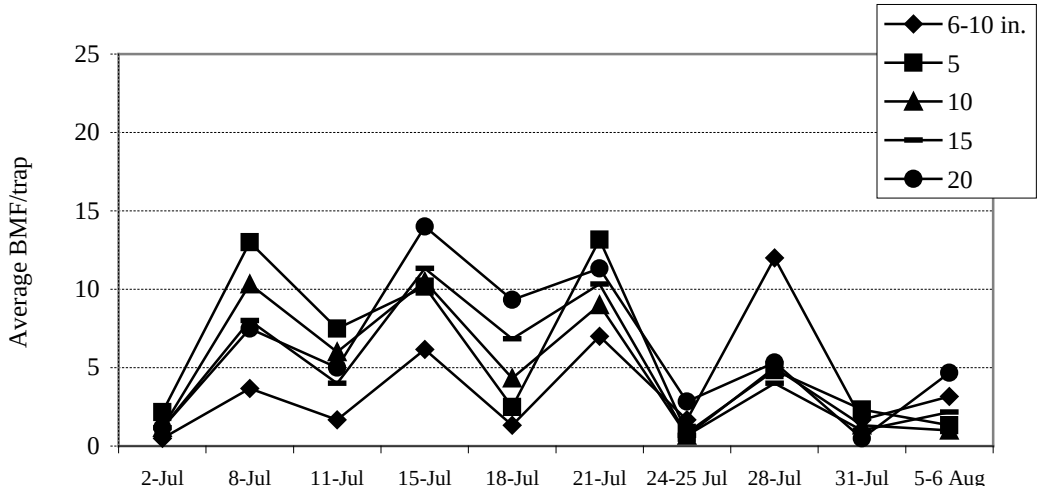


Fig. 5. BMF captures near pruned fields, by height for each date.

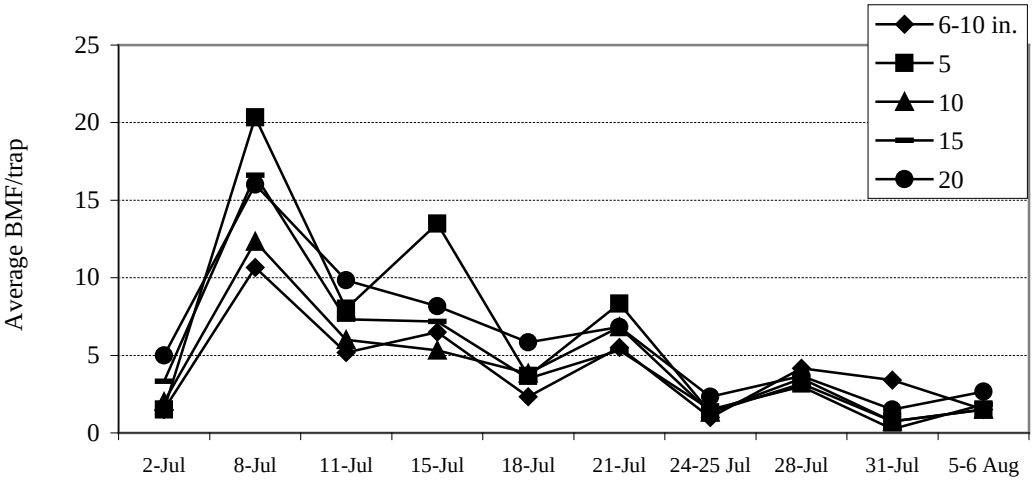


Fig. 6. Percentage of females captured near fruit-bearing fields, by height for each date.

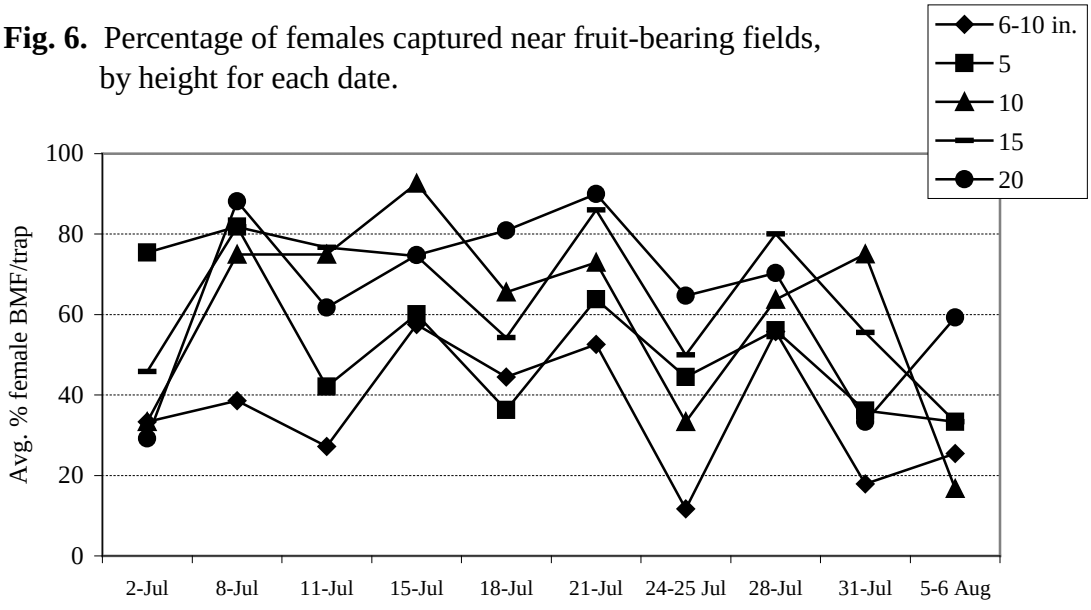


Fig. 7. Percentage of females captured near pruned fields, by height for each date.

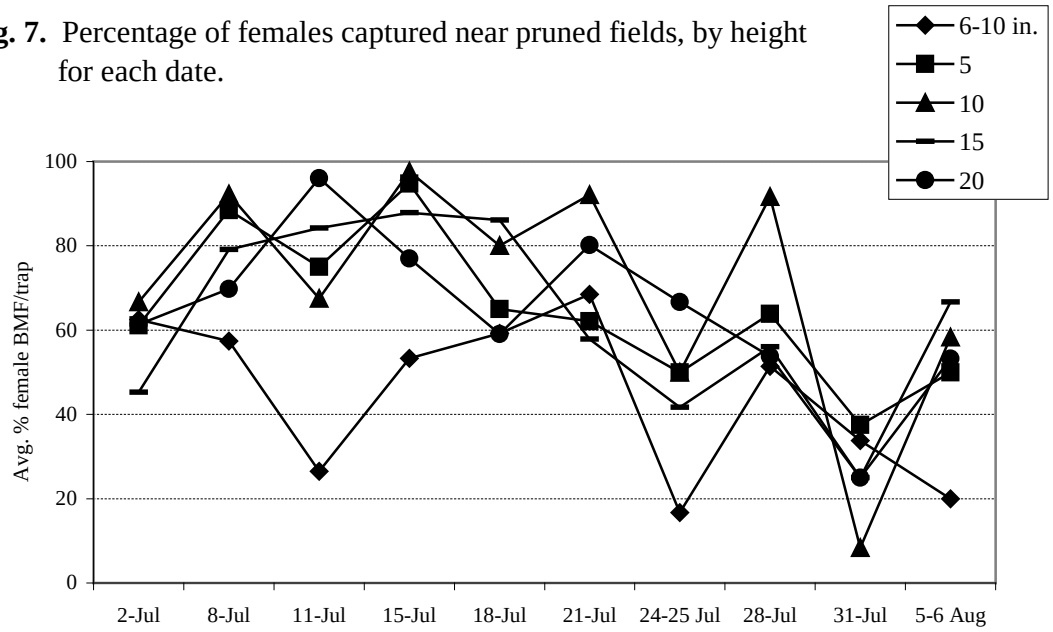


Fig. 8. Percentage of females with eggs captured near fruit-bearing fields, by height for each date.

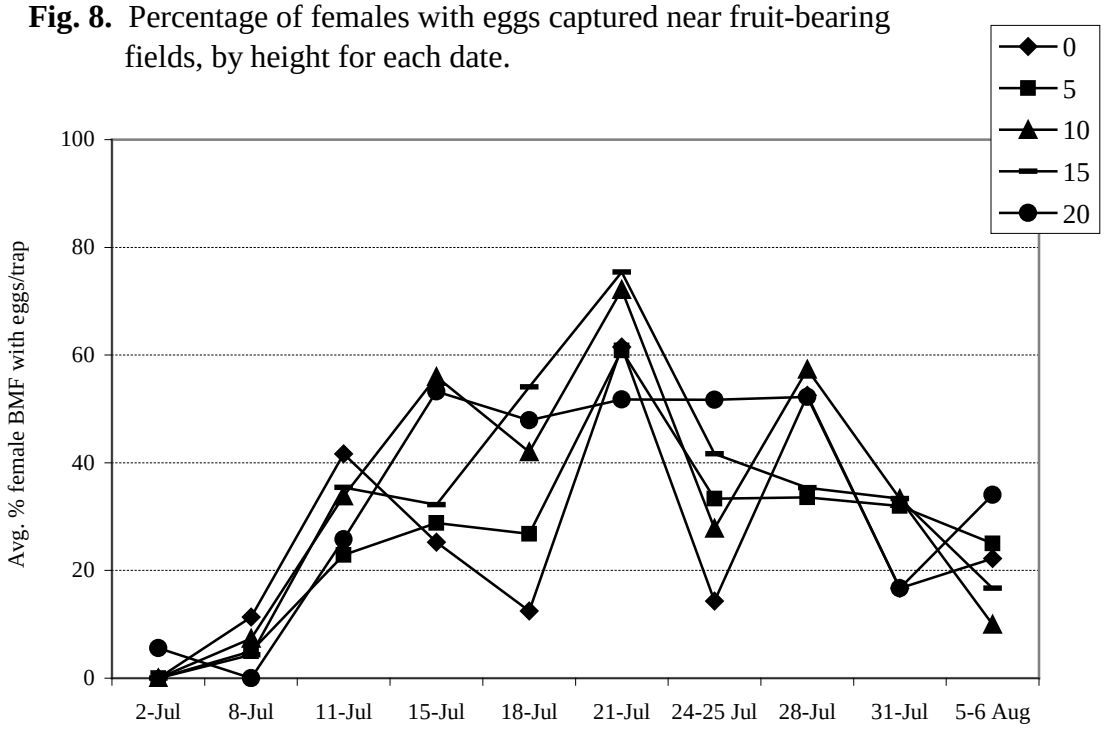


Fig. 9. Percentage of females with eggs captured near pruned fields, by height for each date.

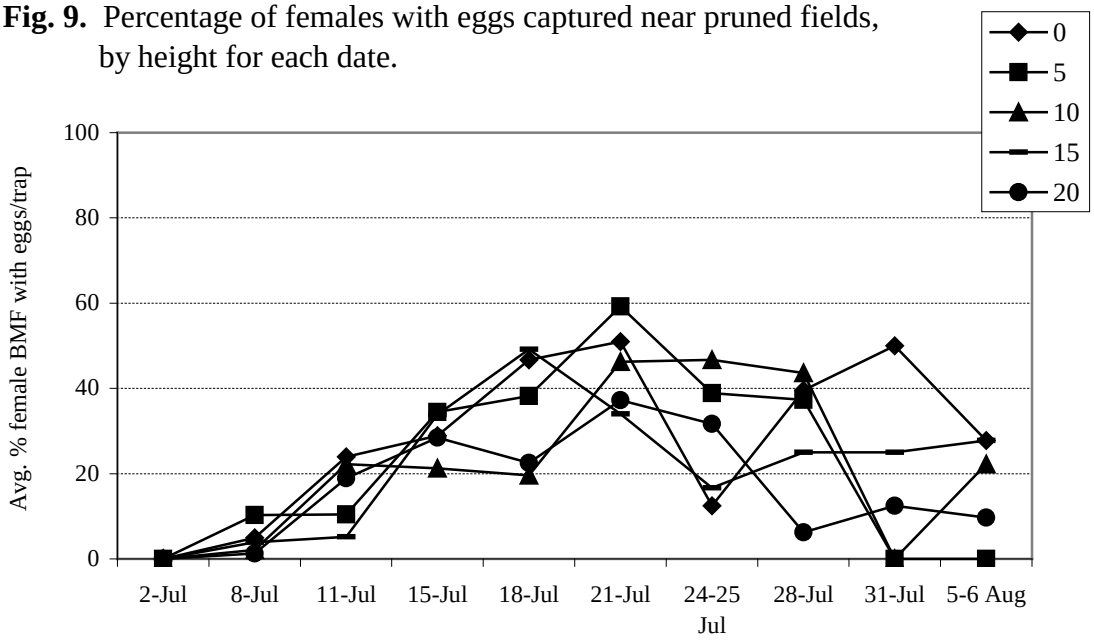


Fig. 10. Effect of forest type on BMF captures near fruit-bearing and pruned blueberry fields.

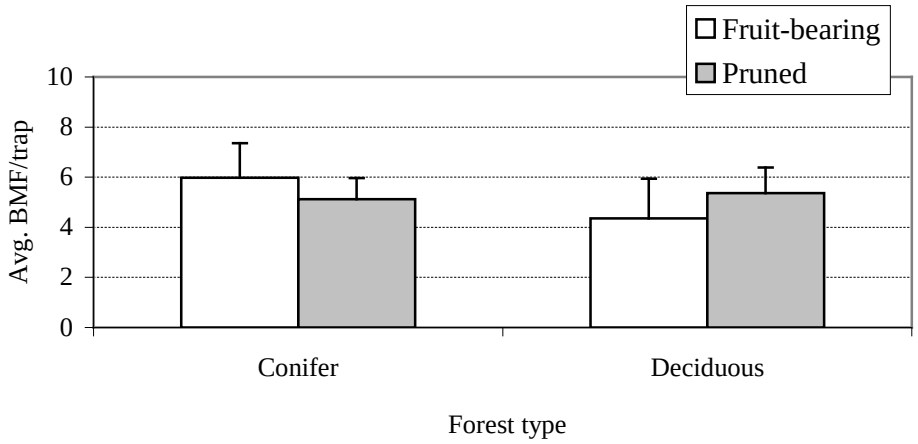


Fig. 11. Effect of trap height on BMF captures.

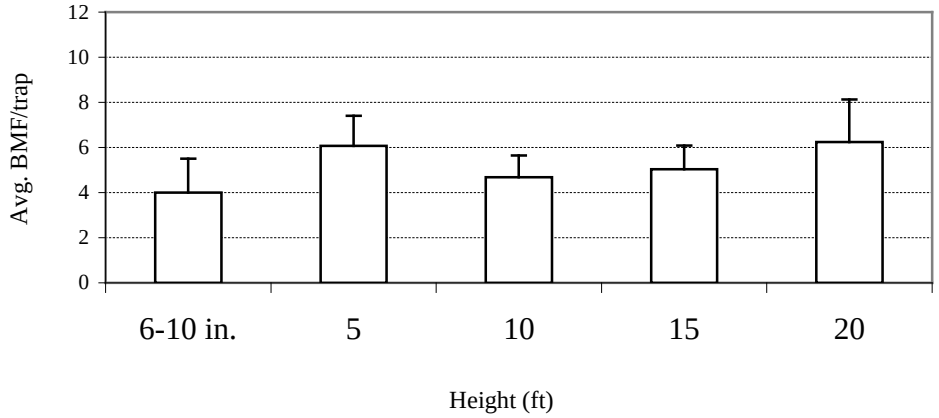
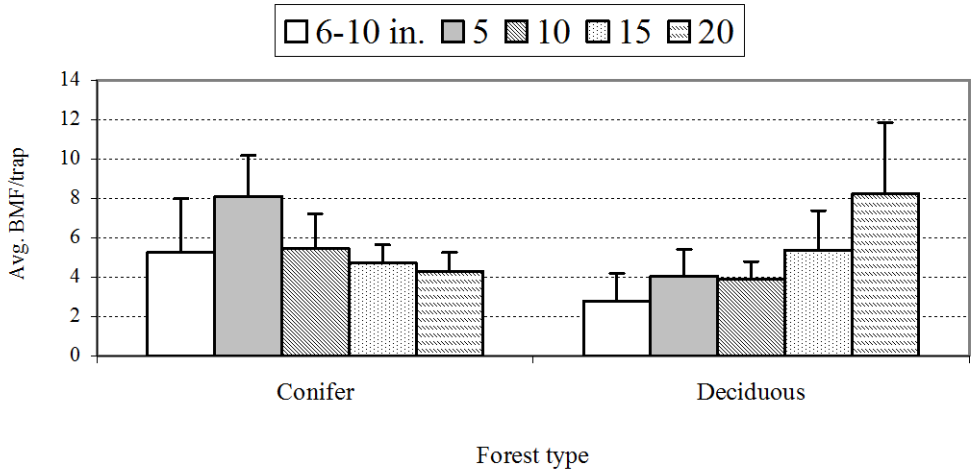


Fig. 12. Effect of forest type on BMF captures at each height.



ENTOMOLOGY
INVESTIGATOR: C. S. Stubbs, Department of Biological Sciences

10. TITLE: Wild Blueberry Pollination Research

OBJECTIVE:

To assess whether commercial *Bombus impatiens* will produce Queens that can over winter in Maine blueberry growing areas.

METHODOLOGY:

Year 2 (2003) of this study was again conducted at the Jonesboro, Blueberry Hill Farm and a farm in Winterport. To determine whether queens marked in 2002 successfully over-wintered, sweep net samples were taken and transects were walked to search for *B. impatiens* queens that had orange/red paint on their dorsal (upper) thorax. Also pan traps (plastic bowls with soapy water) were set out in early May. Pan traps were monitored and all insects collected 5- 6 days per week and stored in alcohol for later identification. Monitoring pan traps continued until the 2003 quads were set out in.

The quads of the commercial bumble bee, *Bombus impatiens*, arrived and two were set out May 25 in Winterport. Two remaining quads were placed in cold storage to keep the bees inactive because bloom was not at 10 % in Jonesboro. Then on May 30 there was adequate blueberry bloom at Blueberry Hill so these two quads were set out there.

Queen production and bumble bee activity was monitored through out the flight period of each colony at both study sites. Newly emerged Queens were captured and each individual Queen placed in a petri dish on ice to render her inactive. Once she became inactive, each Queen was marked with nontoxic model paint and/or a numbered tag affixed to her upper thorax with glue. The Queen was then monitored to make certain she successfully recovered from the chilling.

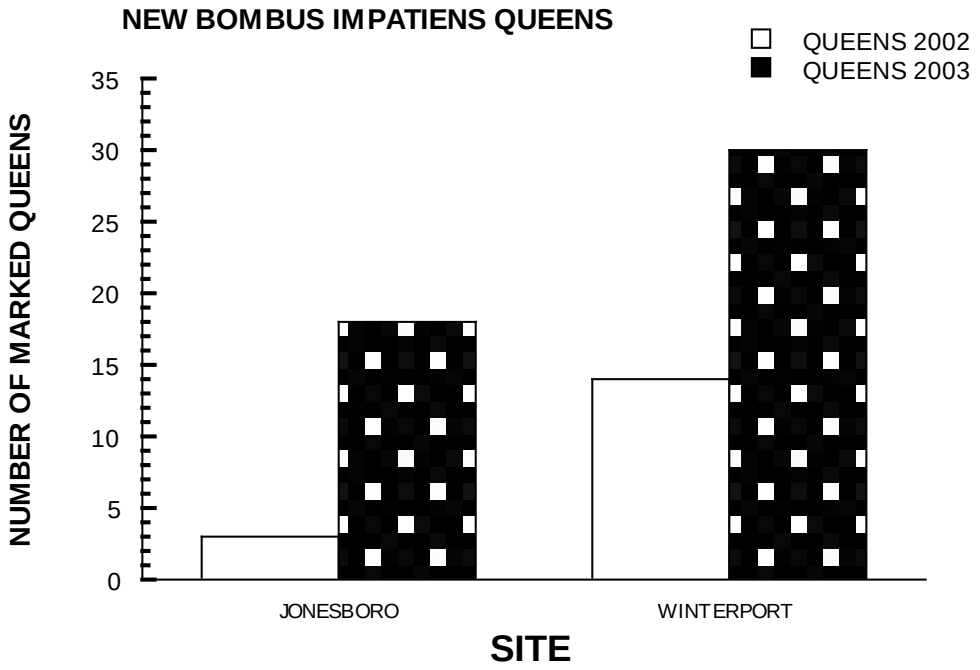
To assess reproductive output the two quads from Jonesboro were taken apart September 26. Dead bees were sexed and counted as well as estimates of cells made.

RESULTS:

On May 17, 2003 at 4:50 PM, a *B. impatiens* queen with faint orange paint on her dorsal thorax was observed on dandelion in Winterport. Numerous *Andrena* bees and 7 *B. ternarius* queens were retrieved collected from the pan traps, but no *B. imaptiens* queens were caught in the traps.

The first newly produced Queens were captured and marked with red paint on May 30 both at Winterport and Jonesboro. Overall in 2003, a total of 48 new Queens were marked and/or tagged (18 at Jonesboro and 30 at Winterport). The final new Queen was marked in Jonesboro on June 20 and on July 21 in Winterport. Several new queens escaped without getting marked and/or tagged. Thus total Queen production may be somewhat higher than recorded. Overall more queens were produced and marked in 2003 than 2002 (Fig.1). Males were observed in Winterport on July 7 and August 4 in Jonesboro.

Fig. 1: New queens produced and marked at two study sites (2002 and 2003).



There was great variability among the colonies in new Queen production ranging from 1 to 15 Queens produced per colony. A possible factor contributing to the greater Queen production in Winterport is there was considerably more alternate forage after blueberry bloom in Winterport than in Jonesboro. Factors possibly contributing to greater queen production in 2003 than 2002 are: 1) one of the quads that went eventually to Jonesboro in 2002 arrived and was set out a day later (May 10). This quad had been damaged in shipment so that some bees probably had been lost prior to arrival in Maine. This damage reduced the worker foraging force for that quad. A reduced worker force, in turn, would result in less nectar and pollen being brought to the hive for the production and feeding of offspring, including new Queens. 2) Some bees were lost when the two quads were shut up and transported to Jonesboro in 2002, which again would reduce the worker force. 3). Based on observations during and after bloom and the dissecting of the colonies from Jonesboro the worker force of all quads was much stronger in 2003 than 2002. A stronger worker force, in turn, would result in more nectar and pollen being brought to the colony for the production and feeding of new offspring, including new Queens.

The dissected colonies from the quads at Jonesboro ranged in worker cells produced from approximately 160 to 300 cells per colony (average 190 worker cells per colony). Queen cells ranged from 1-15.

RECOMMENDATIONS: The retrieval of the marked queen demonstrates that *B. impatiens* queens can successfully over-winter in Maine. This suggests that the pollination benefits from purchasing quads will actually be much greater over time than the initial investment expense.

However, nothing is known about the overall potential contribution of these surviving over-wintering *B. impatiens* bumble bee Queens to the pollinating force in blueberry fields. Therefore field surveys should be conducted to determine and compare the number of Queen and worker *B. impatiens* in blueberry fields that have had *B. impatiens* released versus control fields where they have not be released.

DISEASES

INVESTIGATORS: S.L. Annis, Biological Sciences
C.S. Stubbs, Biological Sciences
COOPERATOR: D. Yarborough, Blueberry Extension Specialist

TITLE: Stem Blight/Dieback and Leaf Spot Diseases in Wild Blueberry Fields

METHODS:

1)Examine the aggressiveness of different strains of disease-causing fungi to lowbush blueberry and susceptibility of different blueberry clones.

Fungi of genera commonly found on stems and leaves were isolated from diseased stem and leaf tissue plated out in the summer of 2001 and 2002. Fungal cultures were maintained on malt-yeast extract or V8 media at 20 C. Spore suspensions were made from one plate of each fungal isolate in sterile water with 2% Tween-20.

Individual wild blueberry plants were grown in 6-inch pots and placed in a dormant state into cold storage (40C) for vernalization for 3 months. After removal from cold storage the plants were grown in the green house at 20-25 C at 16 hr light / 8 hr dark photo period. Lowbush blueberry plants were selected for inoculations by choosing plants with vegetative buds at the correct stage and plants that had similar numbers of vegetative and flower buds. Plants were inoculated 7 to 10 days after transfer to the greenhouse when their vegetative buds were at stages V-3 to V-4.

Three blueberry plants, 1 each from 3 different clones, were inoculated for each fungal isolate. For some genera of fungi, 2 to 3 isolates of the fungus were tested on different blueberry clones to determine if there was variation in aggressiveness of isolates. On each plant, 5 vegetative buds at V-3 to V-4 stage were gently squeezed between two fingers to approximate frost tissue damage and one bud was treated with 20 □l of water as with 20 □ spores/ml in water with 2% Tween-20. After inoculation, plants were gently misted with water and covered in plastic bags for 18 hours. Observations of disease symptoms were taken 6 days after inoculation and then every 2-4 days for 2 weeks. Three to five months after inoculation, plants were re-examined to determine whether they survived or not. For some fungal genera, this experiment was repeated on different blueberry clones.

2) Continue examining the effect on yield of the onset of disease in prune year stems on the subsequent crop year.

In August of 2003, 20 randomly selected 0.25m^2 plots were established in each prune field. All stems within each plot were examined for the incidence of stem diseases. All diseased stems (including totally dead stems) were tagged and the recorded. In November-December plots were re-examined and stems (including totally dead stems) that had become diseased since August were tagged and the recorded. In May 2004, prior to full bloom, we will visit the 20 randomly selected 0.25m2 plots per field that were established in each field in 2003. The

diseased and healthy stems that were marked in 2003 will be reexamined to determine if their health was changed from their initial (2003) diagnoses. Any additional diseased stems within each plot will be will tagged and diagnosed. Also a maximum of three healthy appearing stems will be tagged in each plot. These tagged stems will also be ranked for leaf spot diseases (see next paragraph). All flowers on the tagged stems will be counted and recorded. In late July, fruits will be counted on the marked stems in bearing fields and percentage yield determined on the diseased and healthy appearing stems.

3) Assess the effectiveness of Bravo for decreasing the incidence of leaf spot (with D. Yarborough).

This was a replicated split block design study conducted at two sites. Treatments were Bravo at a rate of 4 pts/acre, Abound at a rate of 15.5 oz/acre and Cabrio at 16 oz/acre sprayed using a CO_2 backpack sprayer at 20 gpa with 80002VS Tjet nozzles on 12' x 50' plots. Each treatment was applied once on 20 June 2003and on 1 July 2003 in the prune year. In the fall plots were assessed for leaf spot disease.

Leaf spot incidence was assessed on 3 October 2003 by estimates of the % of stems with leaf spot and also ranked on a scale of 0 to 4 (0 indicates no leaves have spots-4 indicates all the leaves have spots).

4) Effects of different fungicide treatments on mummy berry blight, leaf spot diseases and blueberry yield.

Plots (6' x 30') were established in two fields (Township 19 and Deblois) under normal management practices except no fungicides had been sprayed by the growers. Six plots, replicated in 4 blocks, were randomly assigned to controls or 5 different fungicide treatments (Table 3) on May 5, 15, 27 and June 3 2003. Plots were treated with a CO_2 backpack sprayer at 20 gpa with 80002VS nozzles. In early June, the percentage of stems infected with mummy berry was determined in 4 sample areas of 6" x 18" for each plot. In early August, leaf spot disease was estimated for severity and incidence in two 6" x 36" sampling areas per plot using the methods described above. Each sampling area was raked and berry weights recorded.

RESULTS:

1) Aggressiveness of different strains of disease-causing fungi to wild blueberry and susceptibility of different blueberry clones.

Buds inoculated with water occasionally had brown leaf tips but did not die. Two out of 3 plants died when inoculated with *Monilinia vaccini-corymbosi*, the causal agent of mummy berry disease of lowbush blueberry, demonstrating the inoculation method could work with a fungus pathogenic to blueberry (Table 1). Plants inoculated with isolates of *Alternaria, Cladosporium, Phomopsis* and *Sphaeropsis,* lost leaf buds or died when inoculated with these fungi demonstrating these fungi are possibly pathogenic to blueberry under the inoculation conditions tested. There were differences in the aggressiveness of isolates of *Alternaria, Cladosporium* and *Sphaeropsis* as determined by the symptoms produced on the leaf buds. Some of the common fungi found on diseased leaves and stems, *Aureobasidium, Epicoccum* and *Pestalotia* were not pathogenic to blueberry under our inoculation methods. One fungus, *Dothiorella,* may be pathogenic to lowbush blueberry but results from inoculations were mixed and will be repeated. The fungi that appear to pathogenic to blueberry will be retested and other common fungal genera will be tested for their pathogenicity in the winter of 2004. If fungal

genera are pathogenic to blueberry then multiple isolates of these fungi will be inoculated onto blueberry plants to test for variation in aggressiveness among isolates.

2)The effect of the onset of disease in stems during the prune year on the yield in the subsequent crop year.

Twenty plots in each of 6 prune fields were examined in August 2003 for stem diseases. All diseased stems were tagged in the plots. There were differences between the different fields in the total number of diseased stems and the majority of the diseased stems were dead (Figure 1). The second most common location for disease was at the stem tip. The plots were re-examined in late fall, 2003 for any further stems that had developed disease after the growing season. These plots will be examined in May for any increases in stem disease and again at the end of the growing season in 2004. Yields will also be determined for selected plots to compare the effect of disease on yield. Selected stems will be collected and plated out to determine the cause of disease in the fall.

3)The effectiveness of Bravo for decreasing the incidence of leaf spot (with D. Yarborough).

The two prune field locations used in this study had similar levels of leaf spot in the control plots (Table 2). Bravo was the only fungicide that significantly decreased the average percentage of stems with leaf spot compared to the control plots at both field sites. The average severity of leaf spot was lower with Bravo treatment compared to the controls at both sites but due to variability among plots there was only a significant difference at the Deblois field site. The Township 19 field site had an average of 21 to 24% weed cover in the plots which was much higher than that found at the Deblois site. The weed cover, particularly tall weeds, may affect the spray coverage of the fungicides, the microclimate of the plants and the horizontal spread of fungi causing leaf spot. However there was not a significant difference in leaf spot between the two field locations.

4) Effects of different fungicide treatments on mummy berry blight, leaf spot diseases and blueberry yield.

Five different fungicide treatments were tested at two field locations for their control of mummy berry disease. The fungicides treatments of Orbit and Abound and Orbit and Fluazinam produced significantly lower levels of mummy berry blight than the control in one field. In the second field no significant differences were found between the plots. All the treatments containing Orbit had lower levels of disease than the control in both fields. The fungicide treatments had no effect on the average percentage of stems with leaf spot or the leaf spot severity compared to the control.

Table 1. Inoculations of lowbush blueberry plants with potential fungal pathogens

Fungus[1]	**Possibly pathogenic to blueberry**	**Differences between isolates**
Altemaria	Yes	Yes
Aureobasidium	No	Not done
Cladosporium	Yes	Yes
Dothiorella	?2	Not tested
Epicoccum	No	No
Pestalotia	No	No
Phomopsis	Yes	Not tested
Sphaeropsis	Yes	Yes
Monilinia vaccinii-corymbosi[3]	Yes	Not tested

[1]Each fungus was inoculated on at least 3 different clones of lowbush blueberry.
[2] Possibly pathogenic, inoculations will be repeated.
[3] Causal agent of mummy berry disease, known pathogen of blueberry used as a control to test inoculation method.

Figure 1. Number of stems with symptoms of disease by location on the stem in 6 prune fields.

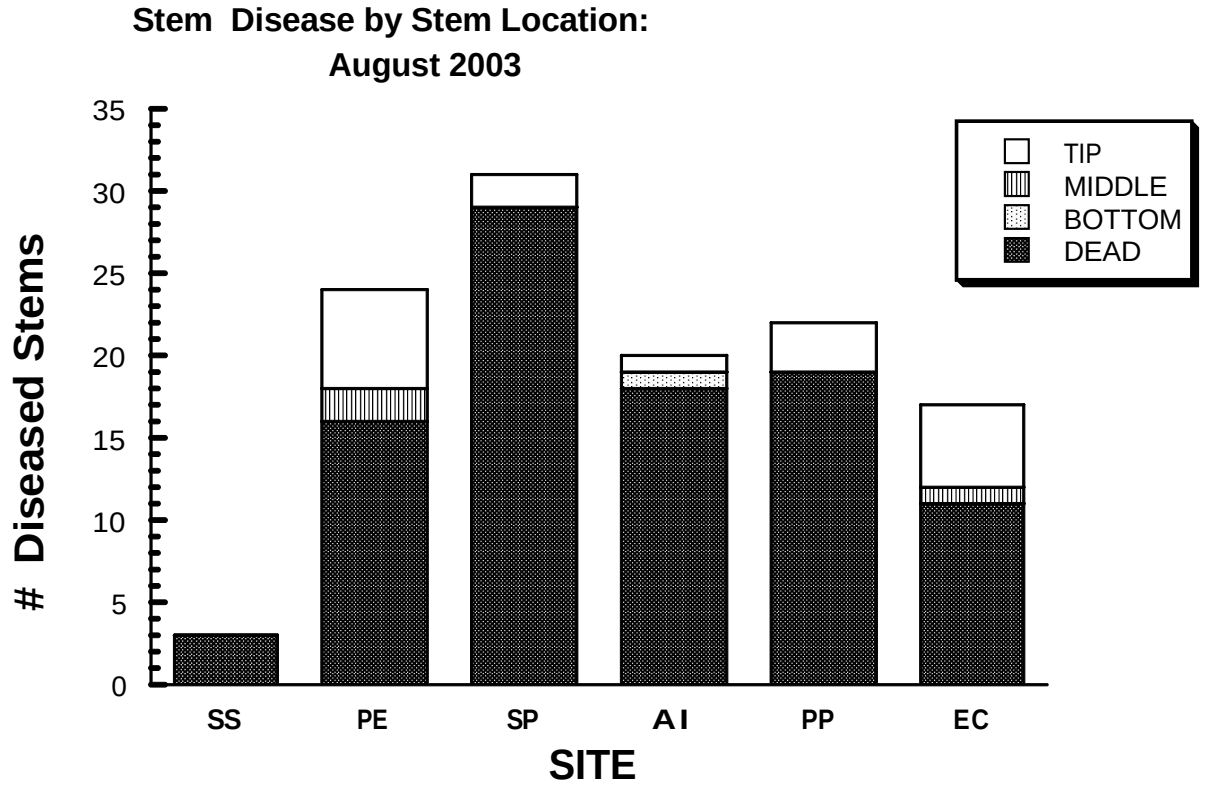


Table 2. Fungicide trial for leaf spot in prune fields, 2003

Field	Treatment	Average % stems with leaf spot	Average leaf spot severity rating	% Weeds and Grasses
Township 19	Control	62.3 (27.5) a	2.0 (0.6)	23.3
	Bravo 4 pts/acre	28.1 (18.4) b	1.2 (0.5)	23.4
	Abound 15.4 oz/acre	59.4 (15.0) a	1.6 (0.4)	24.4
	Cabrio 16 oz/acre	57.3 (16.3) a	1.7 (0.4)	21.7
Deblois	Control	54.1 (21.2) a	2.5 (0.7) a	low
	Bravo 4 pts/acre	19.2 (9.6) b	1.2 (0.3) b	low
	Abound 15.4 oz/acre	41.4 (25.3) ab	1.8 (0.6) ab	low
	Cabrio 16 oz/acre	27.7 (13.1) ab	1.2 (0.3) b	low

Table 3. Efficacy of fungicides for control of mummy berry blight and leaf spot

Field	Treatment	Average % stems with leaf spot	Average Leaf Spot Severity	Average Blighted Stems
Township 19	Control	59.4 (6.6)	1.5 (0)	21.7 (6.7) ab
	Orbit 6 oz/a & Bravo 4 pts/a	40.0 (26.7)	1.3 (0.3)	10.5 (6.2) ab
	Orbit 6 oz/a & Switch 9 oz/a	55.6 (8.3)	1.4 (0.3)	16.1 (12.0) ab
	Orbit 6 oz/a & Abound 15.4 oz/a	61.3 (7.5)	1.5 (0.4)	7.5 (4.0) b
	Orbit 6 oz/a & Fluazinam 8 oz/a	48.8 (11.1)	1.3 (0.3)	4.6 (3.3) b
	Pristine 18.5 oz/a	47.5 (15.5)	1.2 (0.3)	26.7 (11.3) a
Deblois	Control	70 (12.9)	1.6(0.8)	24.0 (22.0)a
	Orbit 6 oz/a & Bravo 4 pts/a	53.8 (21.5)	1.4(0.5)	7.1 (6.4)a
	Orbit 6 oz/a & Switch 9 oz/a	53.8 (13.1)	1.9(0.5)	5.6 (3.8)a
	Orbit 6 oz/a & Abound 15.4 oz/a	67.5 (2.9)	2.1 (0.6)	5.1 (1.7)a
	Orbit 6 oz /a & Fluazinam 8 oz/a	61.3 (2.5)	1.8 (0.9)	4.9 (4.0)a
	Pristine 18.5 oz/a	61.3 (14.4)	1.5 (0.4)	15.4 (16.2)a

FERTILITY

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Ilse W. Fastook, Scientific Technician

12. TITLE: Effect of Foliar N spray on Leaf N Concentration, Growth and Yield of Wild Blueberries

OBJECTIVES: Determine the effectiveness of raising foliar N through a foliar spray and its effect on growth and yield of wild blueberries.

Brief justification:

A fertilizer timing study comparing prune and crop year fertilization study was delayed a year so that an effective method of raising N by foliar spray could be developed. In this study, the most appropriate rate for a foliar N fertilizer using a commercial product (N-SURE®) was tested.

IMPACT OF RESEARCH: Raising leaf N concentration through foliar sprays would enable growers to more quickly correct deficiency of N in the crop year or the prune year.

METHODS: A commercial blueberry field in Franklin, ME which had low N and P concentrations in 2000 leaf samples was used in this study. A commercial product, N-SURE® (28-0-0) (Plant Food Company, Inc. Cranbury, NJ), containing a slow-release nitrogen compound (72%) and urea was used. N-SURE® was applied at 3, 4, 5, or 6 qts/acre and compared to a control (no treatment) and DAP (18-46-0) at 400 lbs/acre. A randomized complete block design was used with 6 replications (blocks). The rates of N-SURE® supply only 1.75, 2.33, 2.92, or 3.5 lb N/acre for the 3, 4, 5, and 6 qts/acre rates, respectively, but it is applied directly to the leaves. The recommendation for highbush blueberry is 4-6 qts/acre at early fruit set and again at early fruit color. Our objective was to elevate leaf N concentrations in the prune cycle so application was made June 18, 2002. Composite leaf samples were collected July 9, 2002 for leaf nutrient analysis. Stem samples from 4 randomly placed 1/4 ft^2 quadrats were collected October 30, 2002 for determining effect on stem length and branching and flower bud formation. Yield will be collected in August 2003.

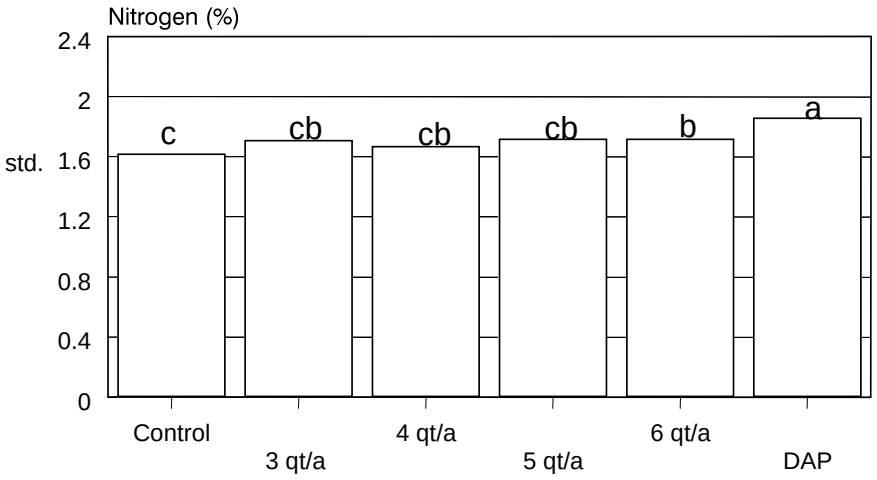
RESULTS: Soil pH ranged from 5.0 to 5.1 among treatment plots. Leaf N concentrations in control plots were above the standard set by Trevett in 1972 (1.6%). The June applied N-SURE® foliar sprays were not effective in raising leaf N concentrations, compared to the control (Fig.1); but preemergent soil applied DAP was. DAP also raised substandard leaf P concentrations to above the standard (Fig.2). Stem density varied among plots (Fig.3) but this probably reflects the variability in the field and not an affect of treatments on stem emergence since all but the DAP treatment was applied after emergence in mid June. Average stem length was increased by treatment with 5 qt/acre N-SURE® but DAP resulted in the tallest stems (Fig.4), compared to the control. Only DAP increased branching slightly (Fig.5) but branch length was not affected (Fig. 6). Flower buds per stem (Fig. 7) and flower bud density (number per unit area)(Fig. 8) were not increased by any treatment, compared to the control. The low flower bud density observed in plots treated with 4 qt/acre N-SURE® was probably a result of the low stem density that was associated with these treatment plots and not a depression of yield by N-SURE®. Grasses were stimulated by the DAP treatment and may have suppressed potential yield. Berry yield was not affected by the rates of N-SURE® applied but DAP reduced

yield compared to the control (Fig. 9).
CONCLUSIONS: Foliar application of N-SURE® at rates from 3 to 6 qts/acre did not raise leaf N concentrations as expected. DAP was more effective in raising leaf N concentrations and increasing stem length and branching, even though leaf N concentration was above the satisfactory level in controls.

RECOMMENDATIONS: No recommendations can be made at this time for use of this product at rates from 3 to 6 quarts/acre. In fields without adequate weed control, DAP should not be applied at the rates recommended for fields with adequate weed control.

Figure 1 N Foliar Rate Study- 2002

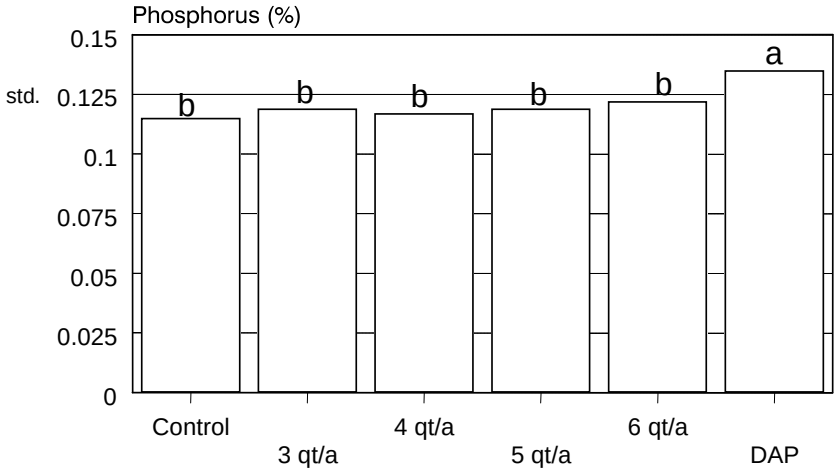
Leaf Nitrogen Concentration



Foliar spray of 28-0-0 (1 qt/acre = .58 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

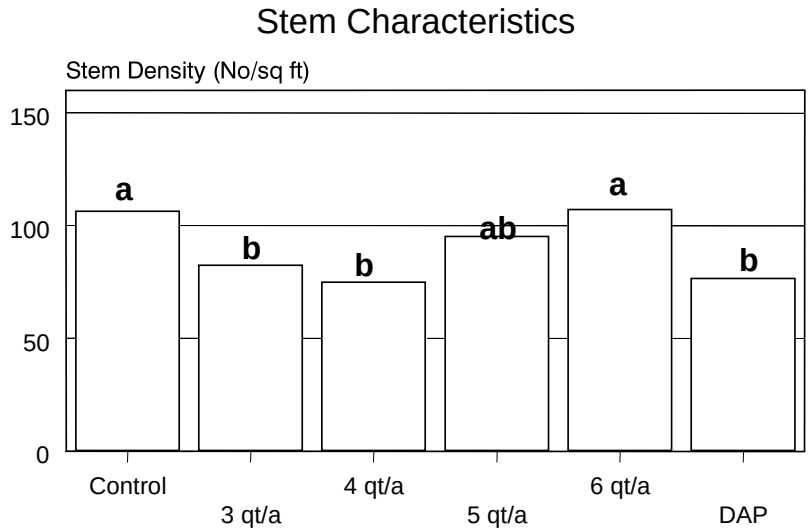
Figure 2 N Foliar Rate Study- 2002

Leaf Phosphorus Concentration



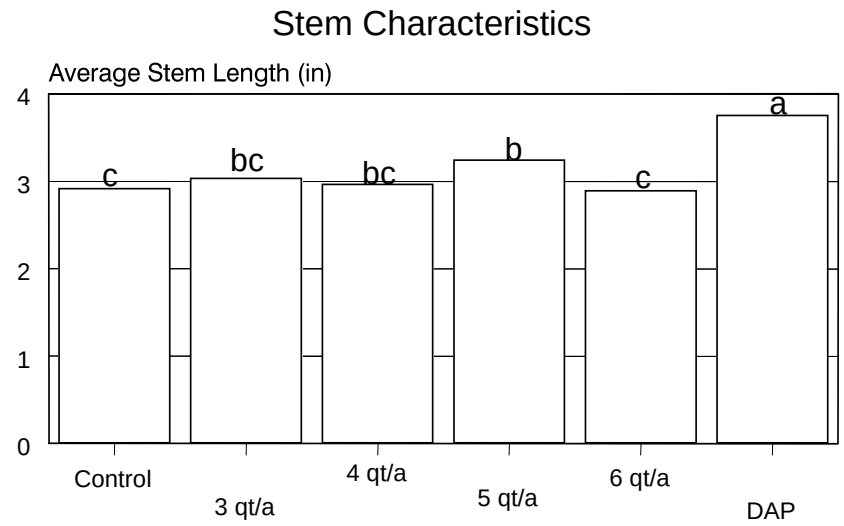
Foliar spray of 28-0-0 (1 qt/acre = .58 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 3 N Foliar Rate Study- 2002



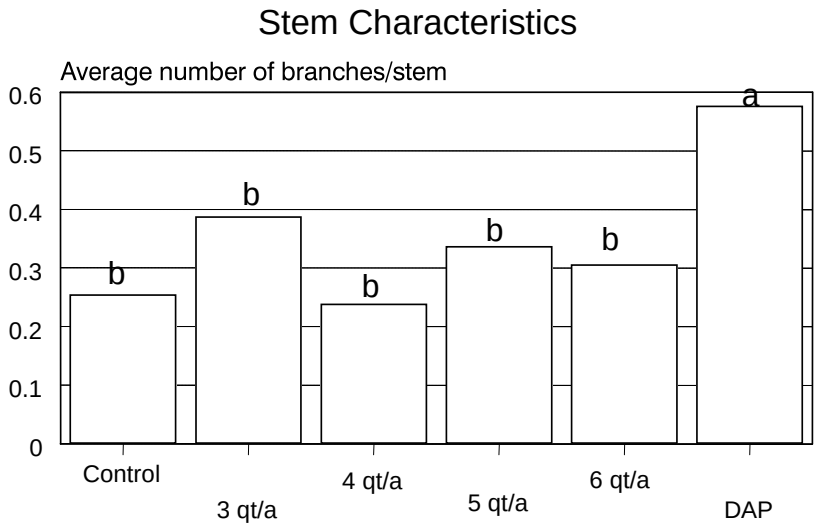
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .1% level.

Figure 4 N Foliar Rate Study- 2002



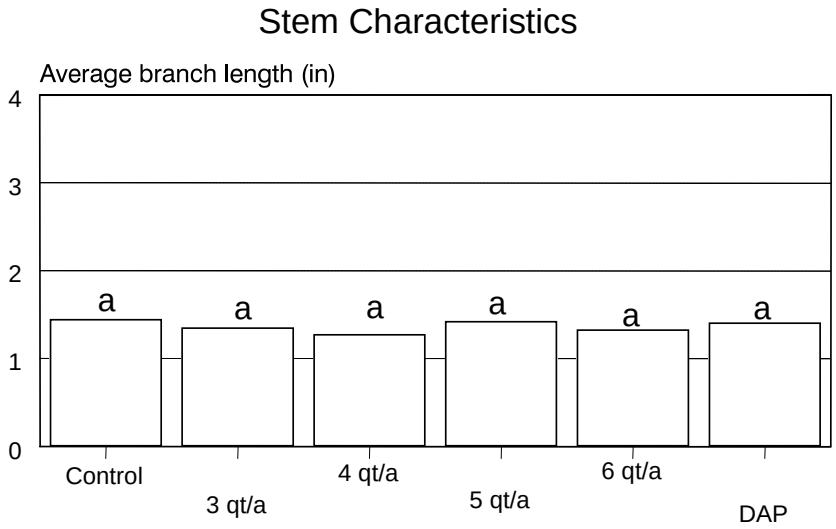
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 5 N Foliar Rate Study- 2002



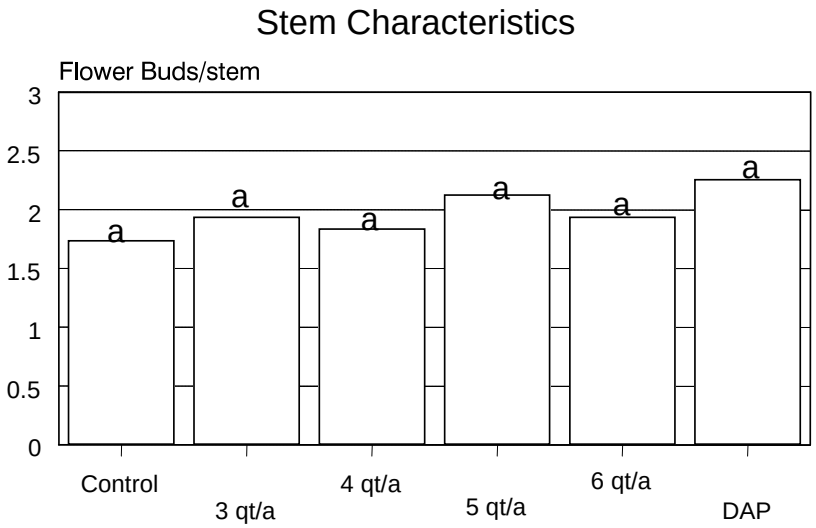
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 6 N Foliar Rate Study- 2002



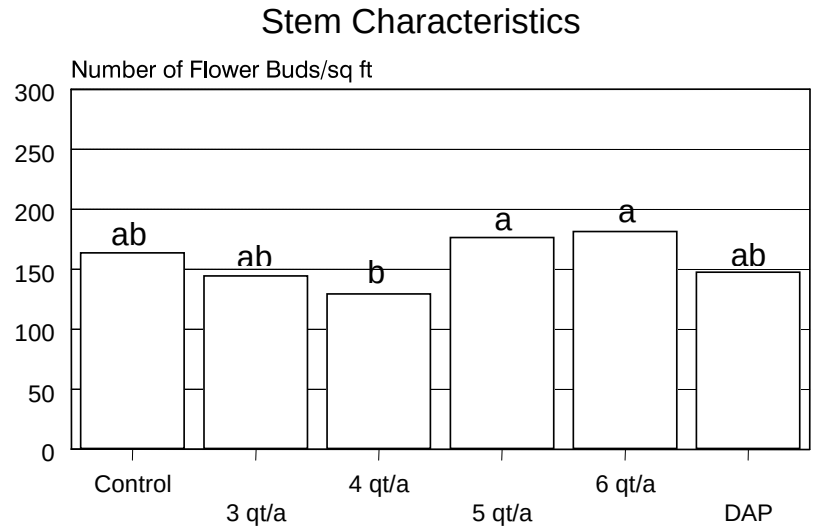
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 7 N Foliar Rate Study- 2002



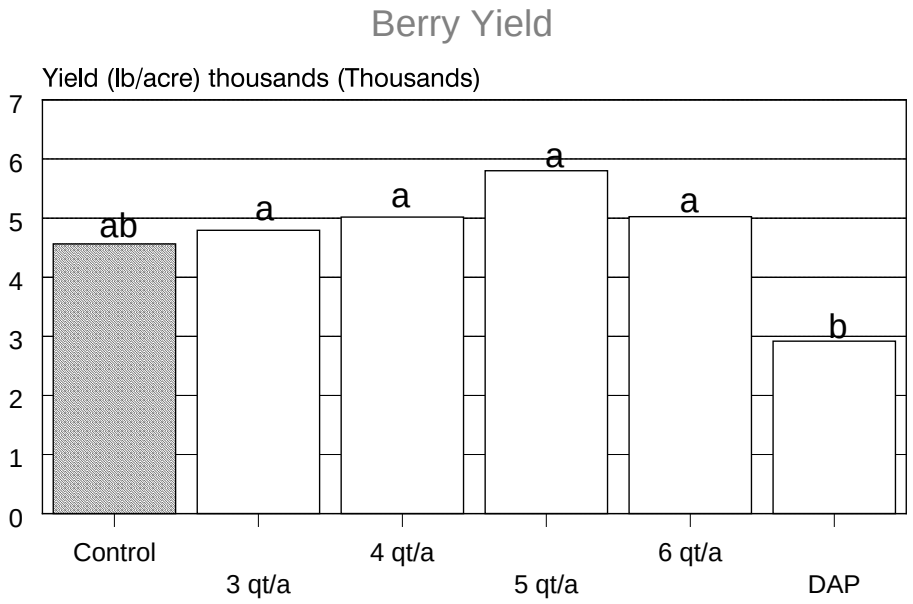
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 8 N Foliar Rate Study- 2002



Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 9 N Foliar Rate Study- 2002



Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

FERTILITY

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Ilse W. Fastook, Scientific Technician

13. TITLE: Effect of Foliar Spray (4-13-15) on Leaf Nutrient Concentration, Growth and Yield of Wild Blueberries

OBJECTIVES: Determine the effectiveness of raising foliar P through a foliar spray and its effect on growth and yield of wild blueberries.

Brief justification:

To compare prune-year and crop-year fertilization an effective method of applying N and P in the crop year is essential. A comparison of prune-year and crop-year fertilization was delayed a year so that an effective method of raising N and P by foliar spray could be tested. A rate study to determine the most appropriate rate for a foliar N and P fertilizer was conducted.

IMPACT OF RESEARCH: Raising leaf P concentration through foliar sprays would enable growers to more quickly correct deficiency of P in the crop year or the prune year.

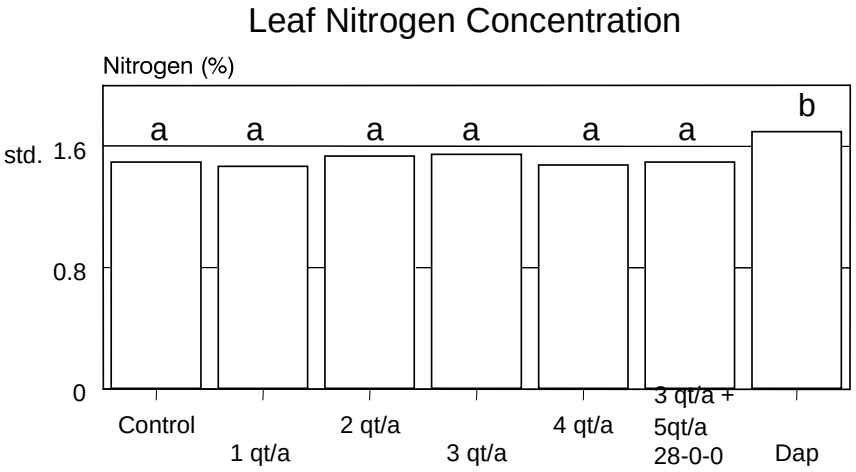
METHODS: A commercial blueberry field in Franklin, ME which had low N and P concentrations in 2000 leaf samples was used in this study. A commercial product manufactured by Plant Food Company, Inc. Cranbury, NJ, with a 4-13-15 analysis plus 10% sulfur was applied at 1,2, 3, or 4 qts/acre and compared to a control (no treatment) and to DAP (18-46-0) at 400 lbs/acre. A treatment of 3 qts/acre plus 5 qts/acre of N-SURE® (28-0-0) was also included. A randomized complete block design was used with 6 replications (blocks). The recommendation for highbush blueberry is 2 qts/acre at early fruit set and again two weeks later. Our objective was to elevate leaf P concentrations in the prune year so a single application was made June 18, 2002. Composite leaf samples were collected July 10, 2002 for leaf nutrient analysis. Soil samples were also taken at this time to characterize the site, particularly it's soil pH. Stem samples from 4 randomly placed 1/4 ft^2 quadrats were collected October 30, 2002 for determining effect on stem length and branching and flower bud formation. Yield was collected in August 2003.

RESULTS: Soil pH was not affected by treatments and ranged from 4.8 to 5.2 among treatment plots. Soil organic matter (LOI) in the 3-inch soil plugs ranged from 4.9 to 13.8 % among treatments, suggesting much variability in the field. The June foliar sprays of 4-13-15 or 4-13-15 plus N-SURE® had no effect on leaf N concentrations, compared to the control (Fig.1). Preemergent DAP application raised the leaf N concentration to above the 1.6 % N standard. DAP also raised leaf P concentrations to above the P standard (0.125 %) (Fig.2). Stem density (Fig. 3) was not affected by any treatment. Average stem length (Fig 4.) and branching (Fig. 5) were increased by DAP, compared to the controls. Branch length was not influenced by any treatment (Fig. 6). Average number of flower buds per stem was not affected by any treatment (Fig. 7). Yield was unaffected by foliar treatments but decreased by DAP due to stimulation of grasses in the plots (Fig. 8).

CONCLUSIONS: Leaf P concentrations were not raised by foliar sprays of a commercial product with an analysis of 4-13-15 when applied at rates up to 4 qts/acre, compared to untreated controls.

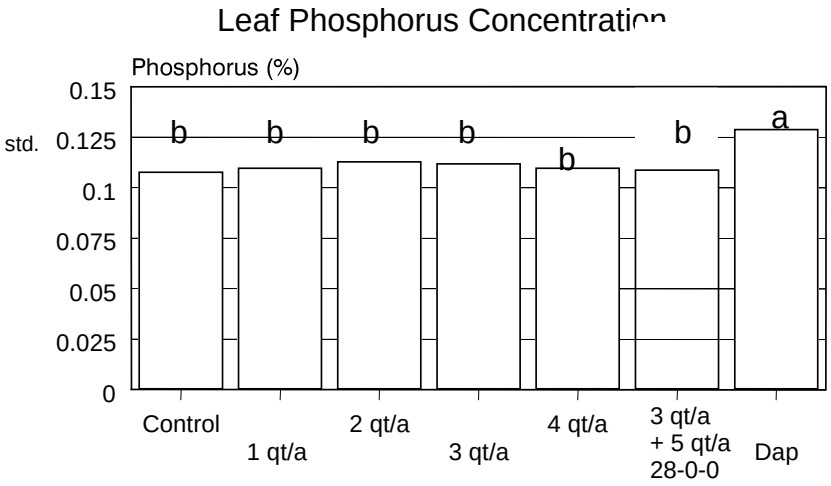
RECOMMENDATIONS: No recommendations can be made at this time for the use of this product at rates up to 4 qt/acre to raise leaf N and P Concentrations of lowbush blueberry. In fields without adequate weed control DAP should not be applied at the rates recommended for fields with adequate weed control.

Figure 1 P Foliar Rate Study- 2002



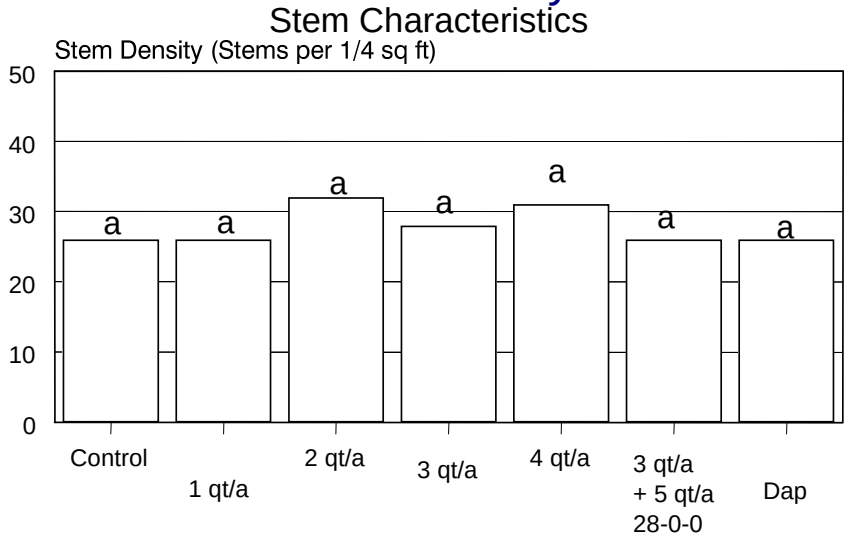
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 2 P Foliar Rate Study- 2002



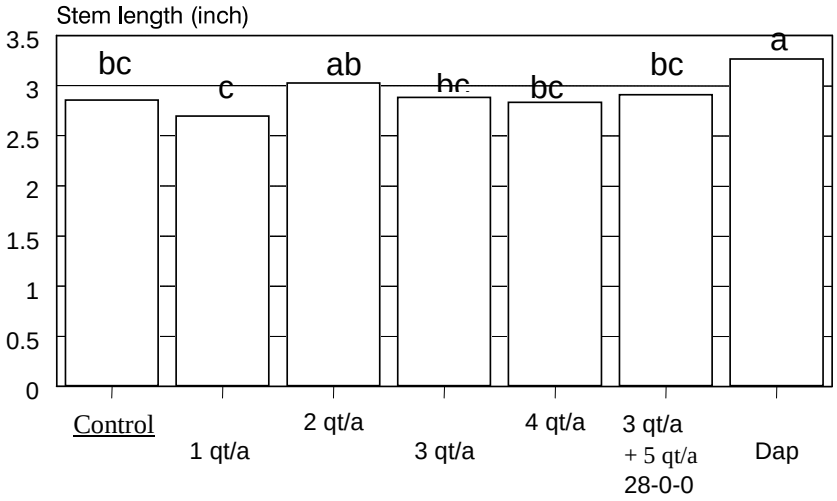
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .02% level.

Figure 3 P Foliar Rate Study- 2002



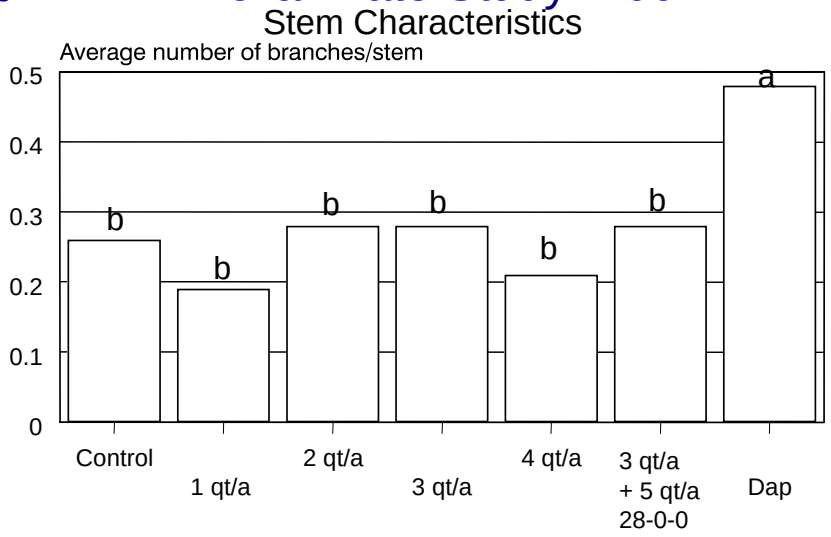
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 4 P Foliar Rate Study- 2002



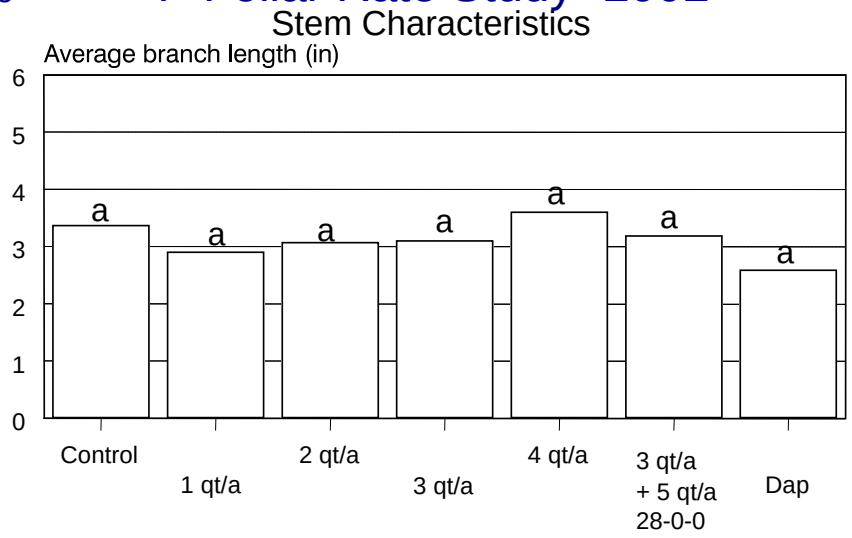
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 5 P Foliar Rate Study- 2002



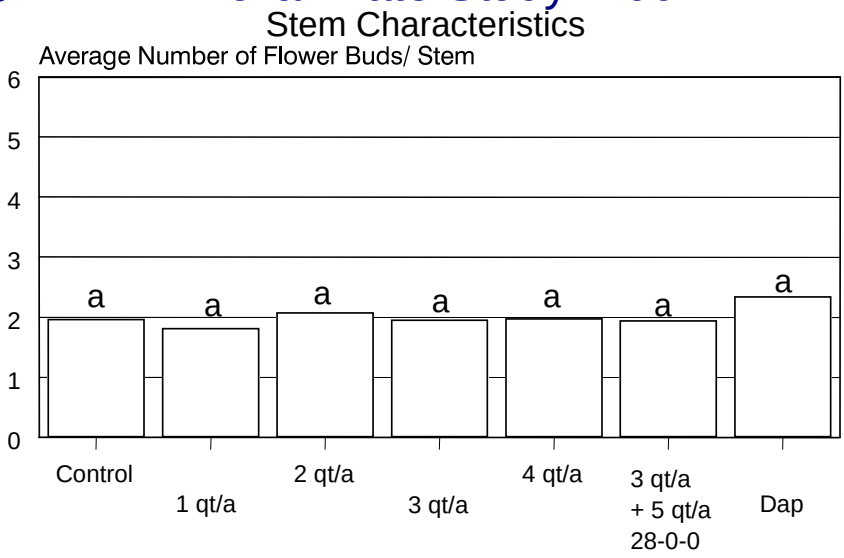
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 6 P Foliar Rate Study- 2002



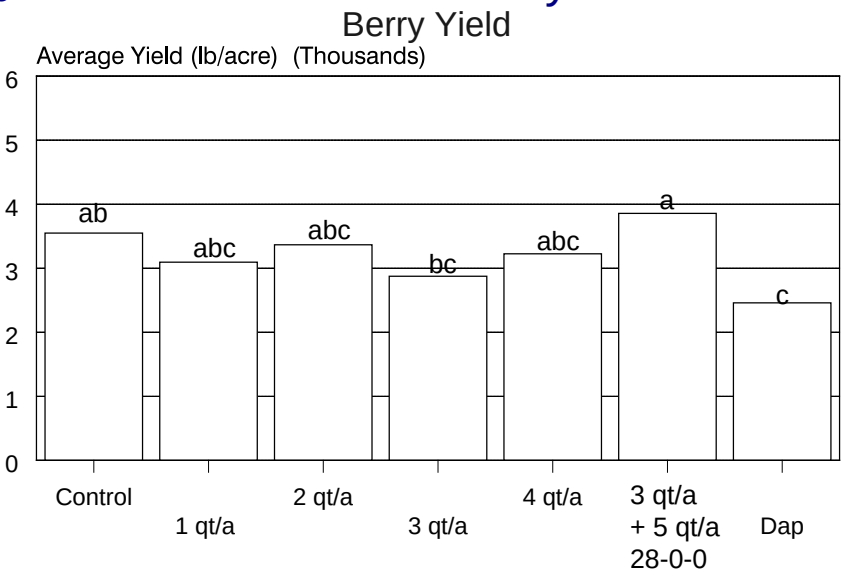
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 7 P Foliar Rate Study- 2002



Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 8 P Foliar Rate Study- 2002



Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

FERTILITY

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Ilse W. Fastook, Scientific Technician

14. TITLE: Effect of Foliar Copper Application on Growth and Yield of Wild Blueberries

OBJECTIVE: Determine the effect of raising foliar copper (Cu) concentrations on growth and yield of wild blueberries.

Brief Justification:

The standard set for Cu by Trevett in 1972 is 7 ppm. Many fields have leaf Cu concentrations below 7 ppm, so raising the leaf Cu concentration to above the standard will test the accuracy of the standard and provide growers with information about methods to raise leaf Cu concentrations. Since Cu is a component of many enzymes and is one of the electron carriers in photosynthesis, we anticipate an increase in growth and flower bud formation with the prune year application of Cu. Fruit development and yield may be enhanced by the prune year application of Cu. A 2000 study using 0.5 lb Cu Chelate/acre had no effect on leaf Cu concentration. A different product will be tried with concentrations up to 2 lb Cu/acre.

METHODS: A commercial wild blueberry field with leaf Cu concentrations below 7 ppm was selected for this study. Cu Keylate (Stoller Enterprises, Inc.) containing 5% Cu was applied as a foliar spray in a volume of 67 gal/acre. Ammonium sulfate at 2.8 lbs/acre was added to the solution to enhance uptake of the Cu chelate. Since several growers are using a product called Micromate calcium fortified mix (Stoller Enterprises, Inc.) to supply secondary and micronutrients along with N and P through diammonium phosphate (DAP), we decided to include this as an additional treatment at the rate they were using. Micromate is a homogeneous granule containing calcium(10%), magnesium(5%), sulfur (1%), boron (1%), iron (2%), manganese(1.5%), zinc (3%) and Cu (0.3%). Treatment plots measuring 6 ft x 50 ft received the following foliar treatments and Micromate on June14, 2001:

1. Control
2. Cu Keylate at 0.5 lb Cu/acre
3. Cu Keylate at 1.0 lb Cu/acre
4. Cu Keylate at 1.5 lb Cu/acre
5. Cu Keylate at 2.0 lb Cu/acre
6. Micromate at 0.04 lb Cu/acre

These treatments were randomly assigned to treatment plots in a randomized complete block design with 7 blocks. Soil samples and composite leaf tissue samples were taken July 13, 2001 from each treatment plot. Stem samples from 4 randomly placed, 1/4 ft^2 quadrats were collected in November 6, 2001 for measurement of stem length and flower bud formation. Yield was determined August 9, 2002.

Because 2001 leaf samples indicated that N and P were deficient and could have masked the effect of corrected Cu deficiency, the plots were maintained through another cropping cycle and treatments were reapplied with or without DAP to correct N and P deficiencies. The blocks were split, creating two 25 ft x 6 ft plots. One half of each block received 400 lbs diammonium phosphate (DAP) per acre on May 19, 2003 to correct the N and P deficiency and the same Cu

Keylate rates as in 2001 were applied on June 17, 2003. Composite leaf tissue samples were taken July 22, 2003. Soil samples were taken July 29, 2004. Stem samples were taken on November 17 and 18, 2003 for growth and potential yield measurements. Yield will be taken in August 2004.

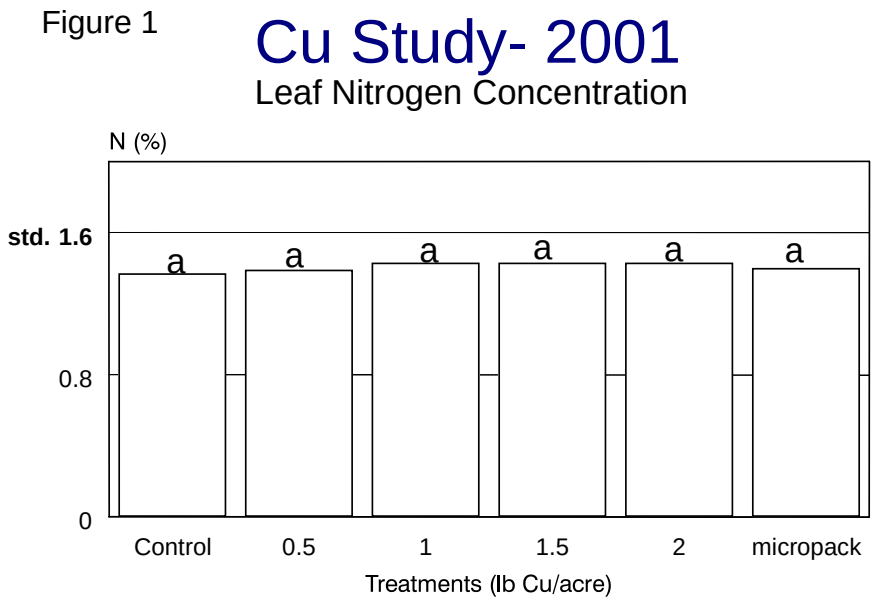
RESULTS: Leaf N concentrations were below the standard (1.6%) and were not affected by any treatment (Fig. 1). Leaf P concentrations were also below the standard (0.125%) (Fig. 2) and was unaffected by treatments. Leaf Cu concentrations increased linearly with increasing Cu rate but Micromate had no effect on leaf Cu concentration, compared to the control (Fig. 3). The level of leaf Cu concentration in the controls indicated a deficiency. The lowest rate of Cu Keylate® (0.5 lb Cu/acre) raised the leaf Cu concentration to above the 7 ppm standard.
The soil analysis indicated that the pH averaged 4.4 across all plots and the organic matter content (loss on ignition) averaged 9.9 %. Soil Cu concentration was not affected by any treatment (Fig. 4).
Stem density, average stem length (Fig. 5), and number of branches (Fig.6) were not influenced by Cu treatments. Branch length was not meaningfully affected by the Cu treatments (Fig.6). Flower buds per stem (Fig. 7), flower bud density (flower buds per unit area) (Fig.8), and berry yield (Fig. 9) were not influenced by any treatment.

Leaf samples taken in 2001 indicated that N and P were deficient and could have masked the effect of corrected Cu deficiency. The Cu treatments in 2001 were very effective in raising leaf Cu concentration but stem characteristics, including flower bud formation and yield were not affected. In 2003, the Cu treatments were reapplied in a split block design with the Cu treatment as the main plots and the DAP as the split plots. DAP increased leaf N (Fig.10) and leaf P (Fig. 11) concentrations. The Cu treatments in 2003 did not raise leaf Cu concentrations to those levels observed in 2001 (Fig. 12). The effect of DAP partially contributed to the lower leaf Cu concentrations (Fig. 13); perhaps, by stimulating more growth and larger leaves, causing a dilution effect. Over all, plots treated with DAP had significantly lower leaf Cu concentrations, compared to those that received no DAP (Fig. 14). A similar dilution effect of DAP on leaf concentrations was observed for iron and boron.

CONCLUSIONS: Cu Keylate was effective in raising leaf Cu levels to a sufficiency level in 2001. The deficiency of N and P, however, may have compromised the test of the Cu standard in 2001 and 2002. Micromate provided inadequate amounts of Cu to raise leaf Cu concentrations above the levels found in the controls. In 2003, leaf N and P concentrations were raised by DAP at 400 lb/acre, but leaf Cu concentrations were lower than in 2001 even though the same rates were applied. DAP application reduced the levels of leaf Cu in the plots receiving the foliar Cu applications and in the control plots.

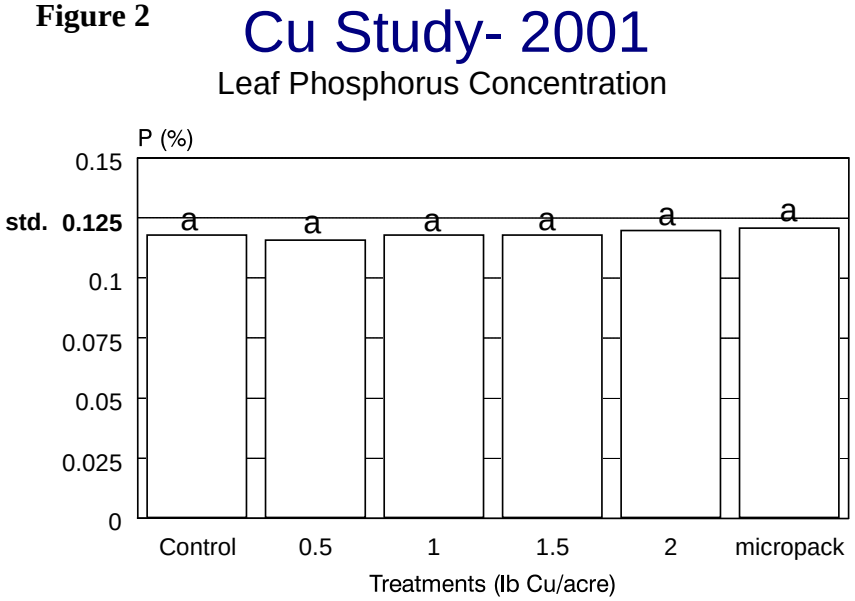
RECOMMENDATIONS: No recommendations for Cu fertilization can be made to growers at this time.

Figure 1



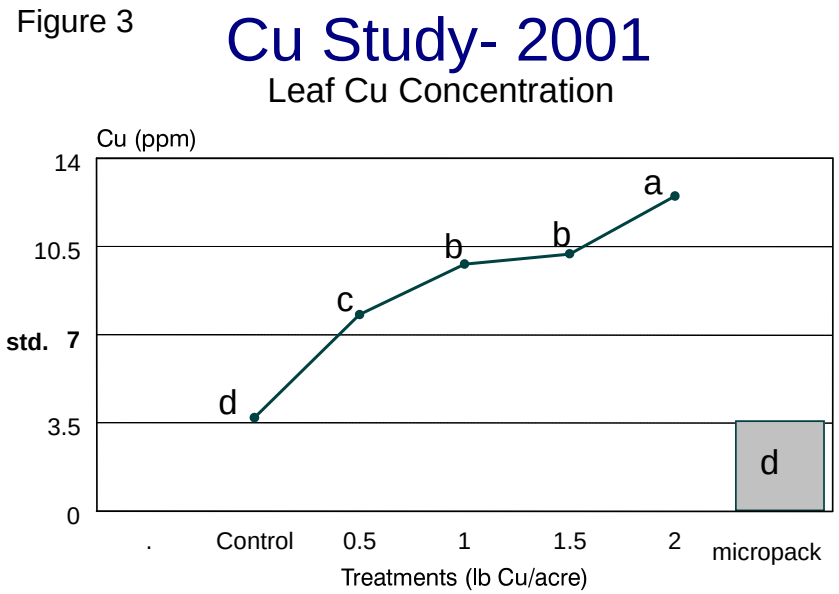
Mean separation by Duncan's Multiple range test, 5% level.

Figure 2



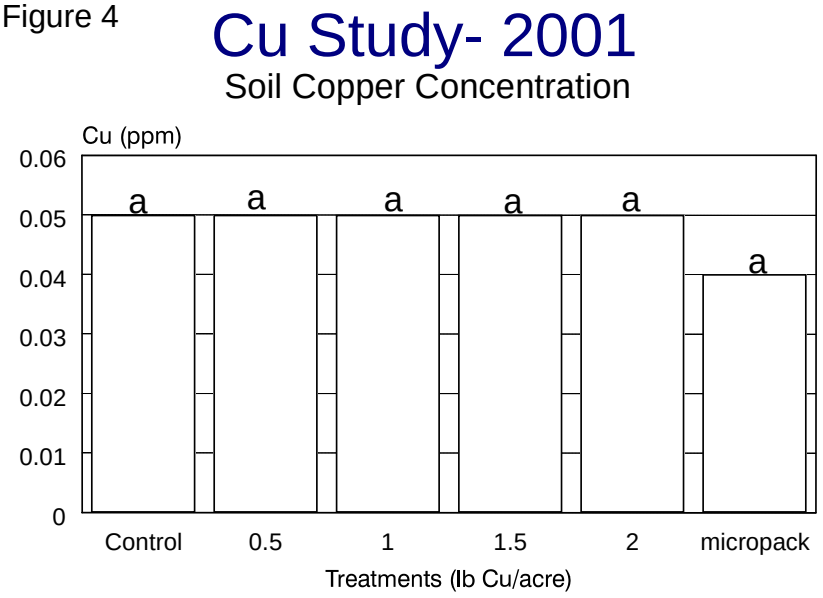
Mean separation by Duncan's Multiple range test, 5% level.

Figure 3



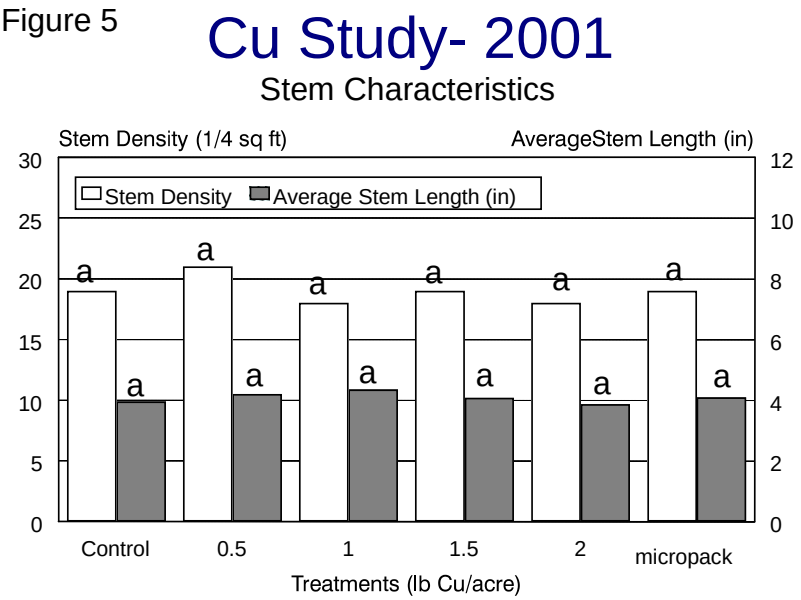
Mean separation by Duncan's Multiple range test, 0.01% level. Significant linear increase in leaf Cu concentration with increasing foliar Cu rate, 0.01% level.

Figure 4



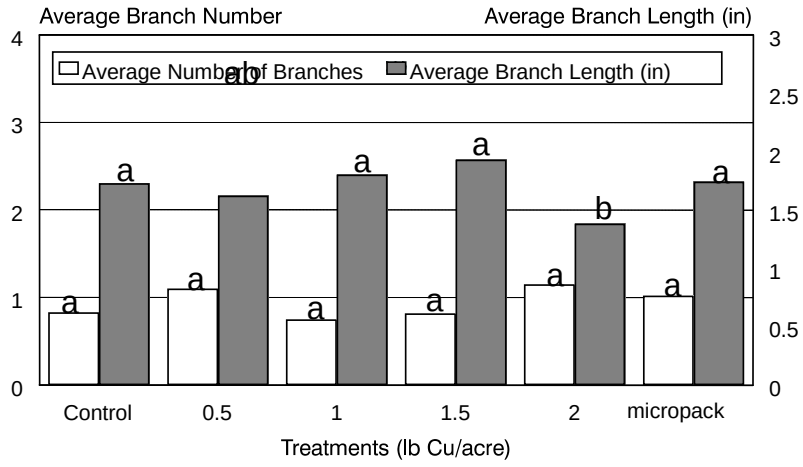
Mean separation by Duncan's Multiple range test, 5% level.

Figure 5



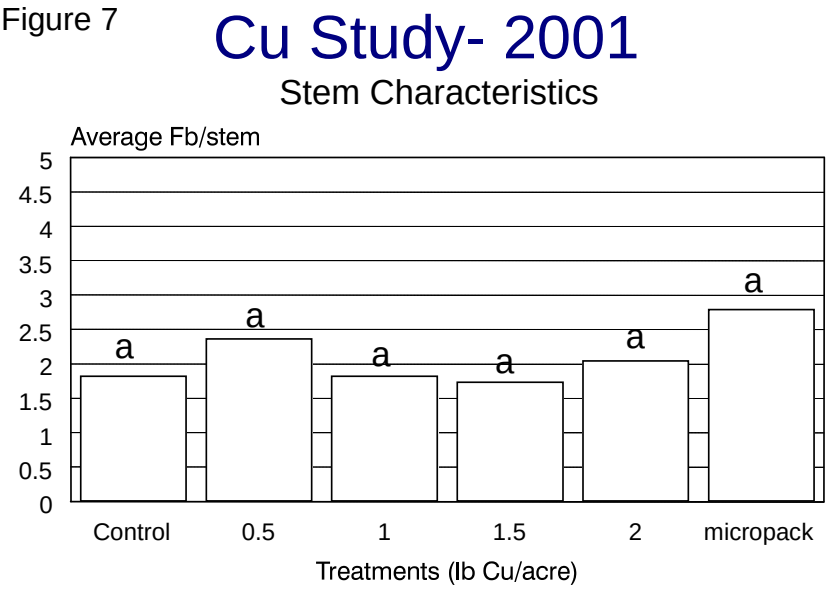
Mean separation by Duncan's Multiple range test, 5% level.

Figure 6



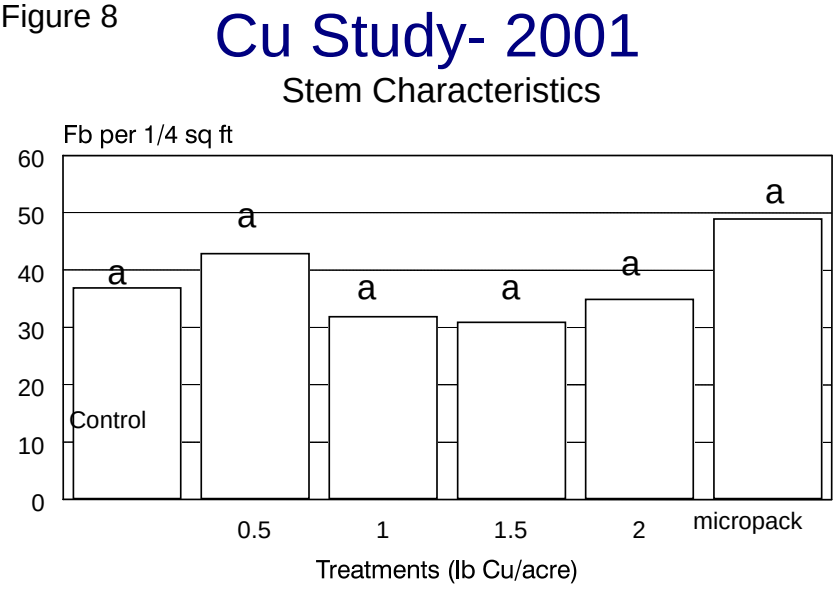
Mean separation by Duncan's Multiple range test, branch number 5% level, average branch length, 0.01% level.

Figure 7



Mean separation by Duncan's Multiple range test, 5% level.

Figure 8

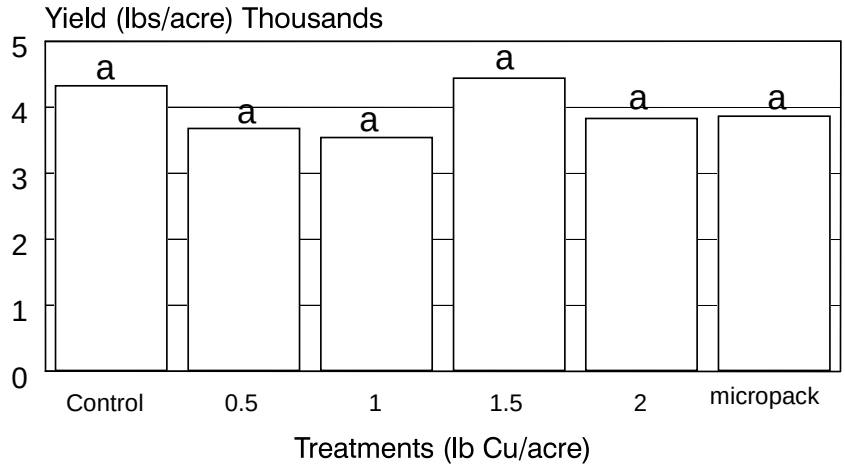


Mean separation by Duncan's Multiple range test, 5% level.

Figure 9

Cu Study- 2001

Yield

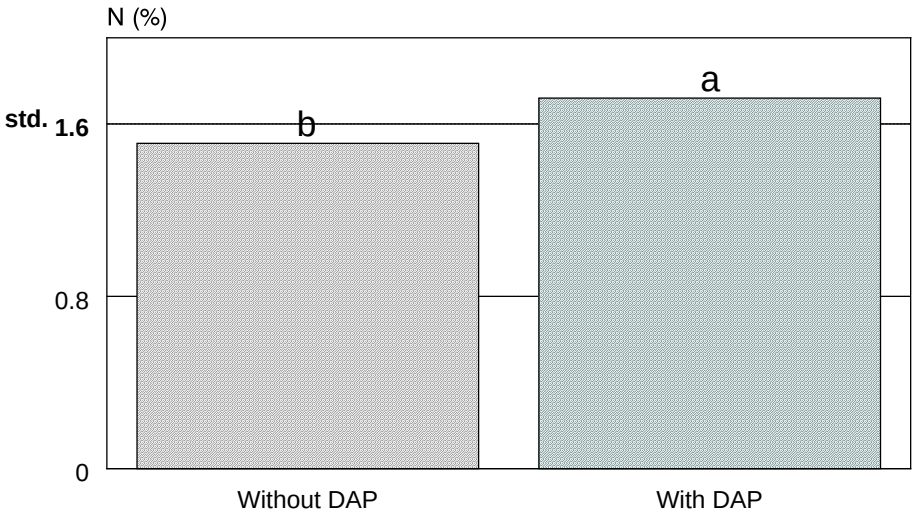


Mean separation by Duncan's Multiple range test, 5% level.

Figure 10

Cu Study- 2003

Leaf Nitrogen Concentration

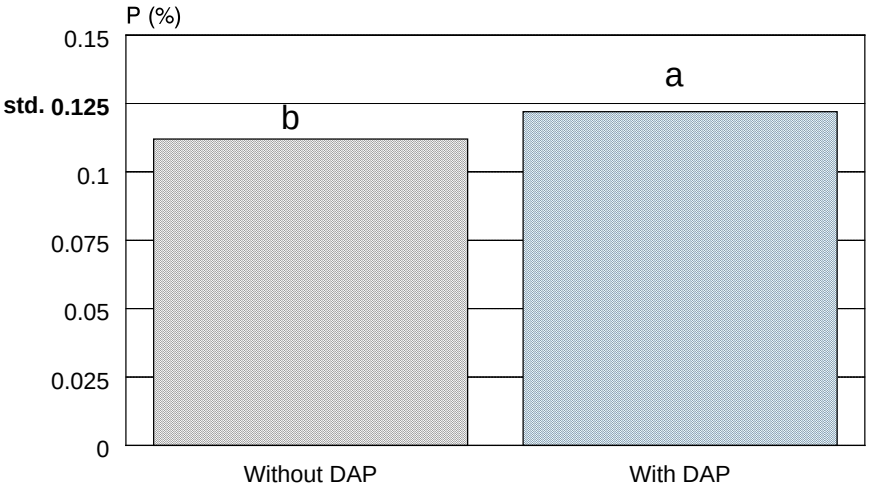


Mean separation by Duncan's Multiple range test, 1% level.

Figure 11

Cu Study- 2003

Leaf Phosphorus Concentration

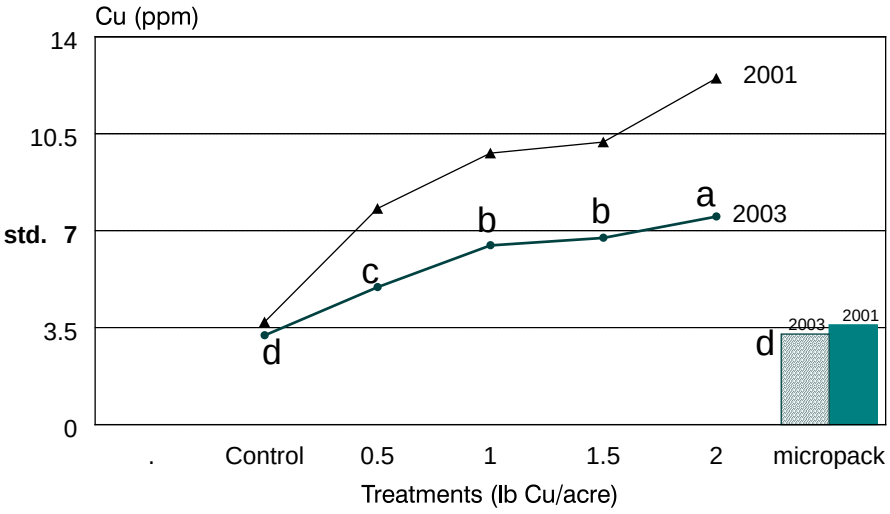


Mean separation by Duncan's Multiple range test, 1% level.

Figure 12

Cu Study- 2001/2003

Leaf Cu Concentration



Mean separation by Duncan's Multiple range test, 0.1% level. .

Figure 13

Cu Study- 2003

Effect of DAP on Leaf Cu Concentration

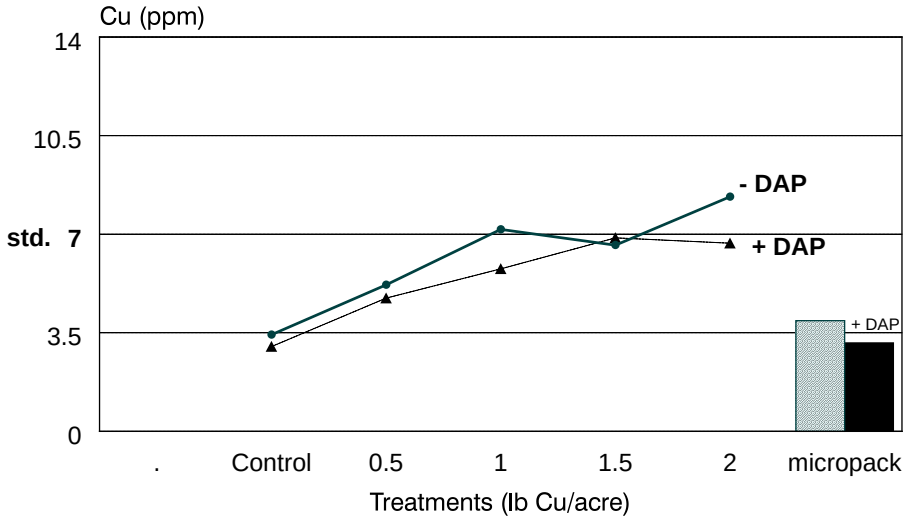
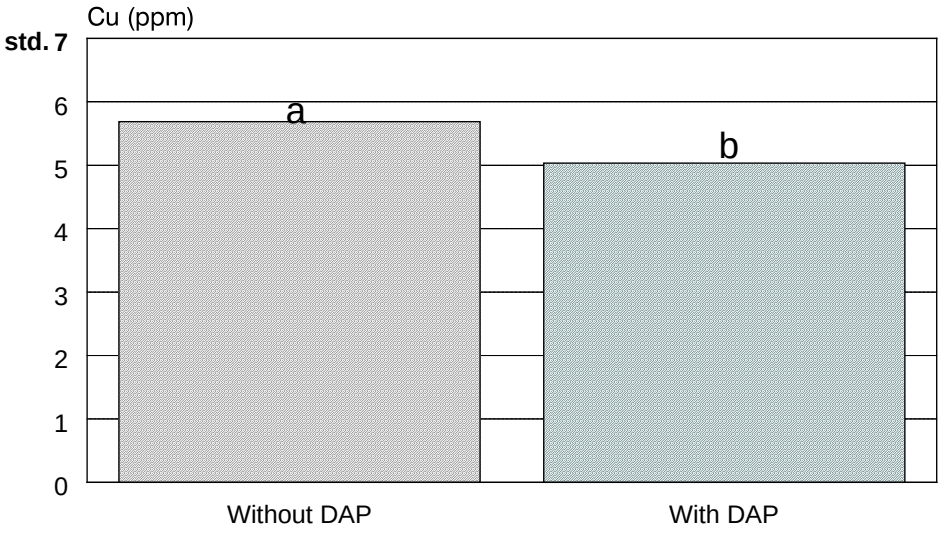


Figure 14

Cu Study- 2003

Effect of DAP on Leaf Cu Concentration



Mean separation by Duncan's Multiple range test, 1% level.

FERTILITY
INVESTIGATORS: John M. Smagula, Professor of Horticulture
Ilse W. Fastook, Scientific Technician

15. TITLE: Effect of Foliar Copper and/or Iron Application on Growth and Yield of Wild Blueberries

OBJECTIVES: Determine the effect of raising foliar copper (Cu) and iron (Fe) concentrations on growth and yield of wild blueberries.

IMPACT OF RESEARCH: The effect of raising leaf Cu and Fe concentrations to above the current standards, either independently or simultaneously will provide information on which growers will base fertility management decisions.

METHODS: A commercial blueberry field that was deficient in Cu and Fe was used in this study. Copper Keylate® (Stoller Enterprises, Inc.) containing 5% Cu was used as a foliar spray in a volume of 67 gal/acre to provide Cu. In a similar volume, the Stoller Enterprises Inc. product Fe Keylate®, containing 5% Fe (5% chelated Iron), was used to provide Fe. Nine 6 ft x 50 ft treatment plots received the following treatments:

1. Control

Prune year application

2. Cu Keylate® at 0.5 lb Cu/acre
3. Fe Keylate® at 0.5 lb Fe/acre
4. Cu Keylate® at 0.5 lb Cu/acre plus Fe Keylate® at 0.5 lb Fe/acre

Double prune year application

5. Cu Keylate® at 0.5 lb Cu/acre plus Fe Keylate® at 0.5 lb Fe/acre (June 7, 2002 + June 19, 2002)

Crop year application

6. Cu Keylate® at 0.5 lb Cu/acre
7. Fe Keylate® at 0.5 lb Fe/acre
8. Cu Keylate® at 0.5 lb Cu/acre plus Fe Keylate® at 0.5 lb Fe/acre

Prune year and crop year application

9. Cu Keylate® at 0.5 lb Cu/acre plus Fe Keylate® at 0.5 lb Fe/acre (prune) + Cu Keylate® at 0.5 lb Cu/acre plus Fe Keylate® at 0.5 lb Fe/acre (crop)

Treatments were randomly assigned to treatment plots in a randomized complete block design with 6 blocks. Foliar sprays were applied on June 7 in the prune year (2002) and June 18 in the crop year (2003). Treatment 5 also received a second prune-year application on June 19, 2002. Composite leaf tissue samples were taken July 8, 2002 and July 8, 2003. Soil samples were taken July 11, 2002. Stem samples from 4 randomly placed 1/4 ft^2 quadrats in each treatment

plot were collected October 31, 2002 for measurement of stem length, branching, and flower bud formation. Yield was determined August 8, 2003.

RESULTS:
Soil pH was about 4.6 in all treatment plots. Soil nutrient concentrations were not affected by the foliar Fe or Cu treatments. Leaf N and P concentrations in control plots were above the satisfactory levels (Fig. 1) and were not affected by the prune year Cu or Fe treatments. Leaf Cu concentrations were below the 7 ppm standard (7ppm) in control plots and were raised by Cu treatments applied in 2002. The treatment containing Cu and Fe resulted in higher leaf Cu concentrations than that containing only Cu (Fig 2). Leaf Cu concentration was not higher in leaves sampled from treatment plots receiving a double application. Leaf Fe concentrations followed a similar trend. Leaf Fe concentrations were deficient (< 50 ppm) in control plots and raised to sufficiency levels in treatment plots receiving Fe treatments. As with the Cu, the Fe concentration was higher in plots receiving a combination of Cu and Fe than for those only receiving the Fe (Fig. 3). The double application of Cu + Fe was not more effective than a single application of Cu + Fe in raising leaf Fe concentrations. The Cu or Fe foliar treatments did not affect other leaf nutrient concentrations. Stem density (Fig. 4), length (Fig. 5), number of branches (Fig. 6) or branch length (Fig. 7) was not affected by treatments at the end of the prune year. Flower bud density (Fig. 8) and average number of flower buds per stem were not meaningfully affected by prune year Cu or Fe treatments (Fig. 9). Crop-year applications of Cu and Fe were effective in raising their respective concentrations (Figs. 10 and 11). Leaf concentrations were higher for Cu (Fig. 10) and Fe (Fig. 11) when Cu and Fe were applied together, compared to either element applied alone. Applications of Cu or Fe in the prune year showed no leaf nutrient carry-over effect in the crop year. Leaf concentrations of Cu and Fe were similar in plots receiving Cu + Fe in the prune and crop year and those receiving Cu + Fe in only the crop year. Berry yield was not affected by any treatment compared to the control (Fig 12).

CONCLUSIONS: Cu and Fe foliar treatments were effective in raising leaf nutrient concentrations of these elements. Combining the Cu and Fe in the same spray was more effective than either spray alone in raising leaf Cu and Fe concentrations. This was true for both prune-year and crop-year applications. No benefits of raising either leaf Cu or Fe concentrations were found with regard to stem characteristics, such as length or branching, or potential yield (flower bud formation). Berry yield was not increased by prune-year, crop-year or prune plus crop-year applications of Cu and Fe. It appears that the standards for Cu and Fe are too high.

RECOMMENDATIONS: No recommendations for using Fe or Cu-containing fertilizer can be made at this time.

Figure 1

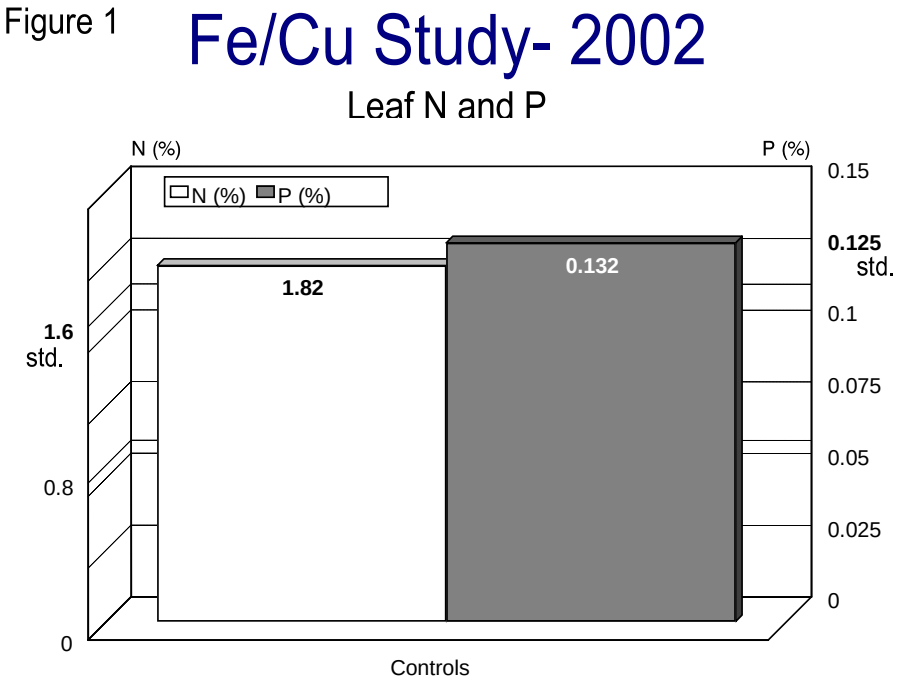
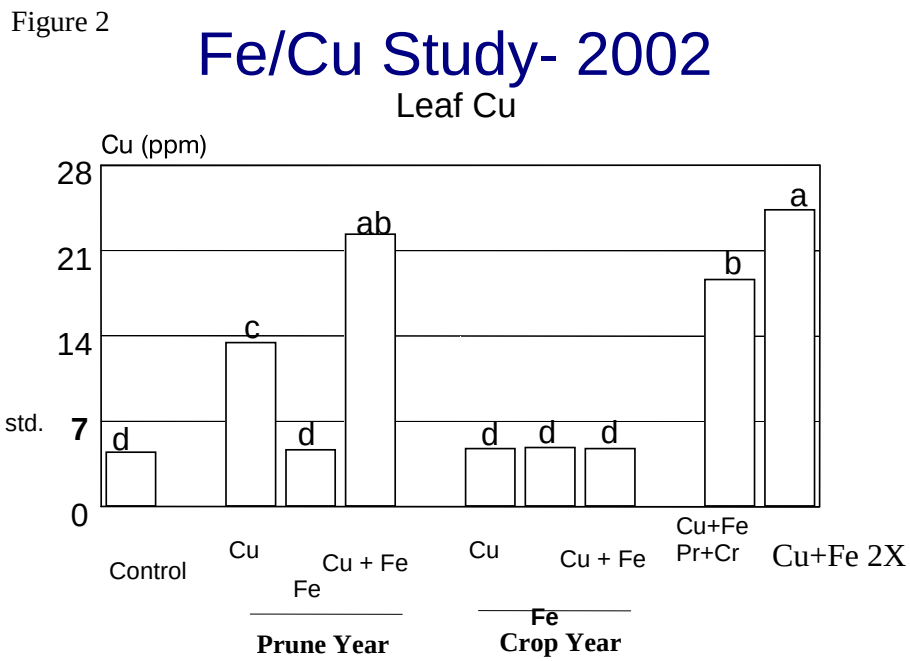


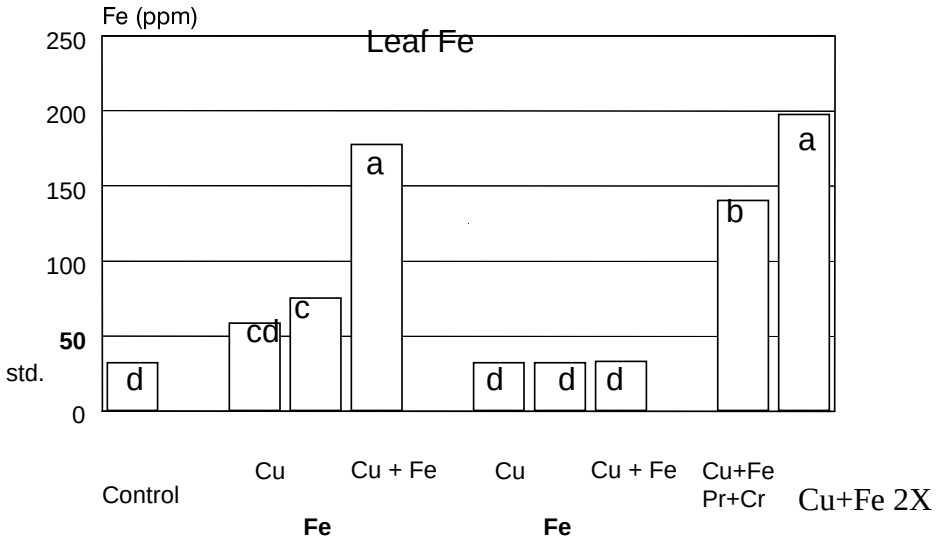
Figure 2



Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, .01% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

Figure 3

Fe/Cu Study- 2002

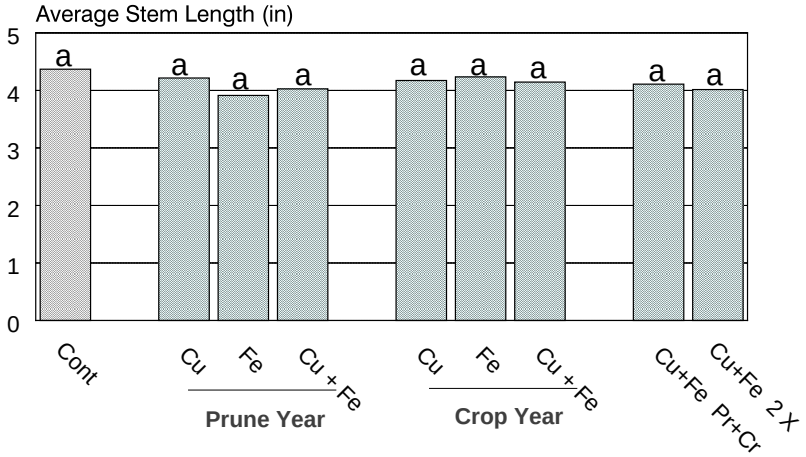


Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, .01% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X = Prune Year double application (Early & Mid June)

Figure 5

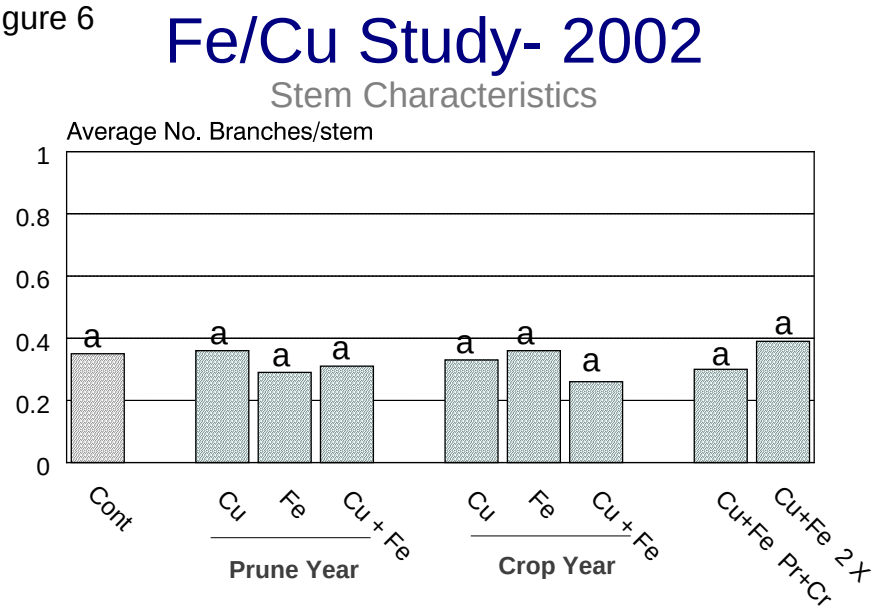
Fe/Cu Study- 2002

Stem Characteristics



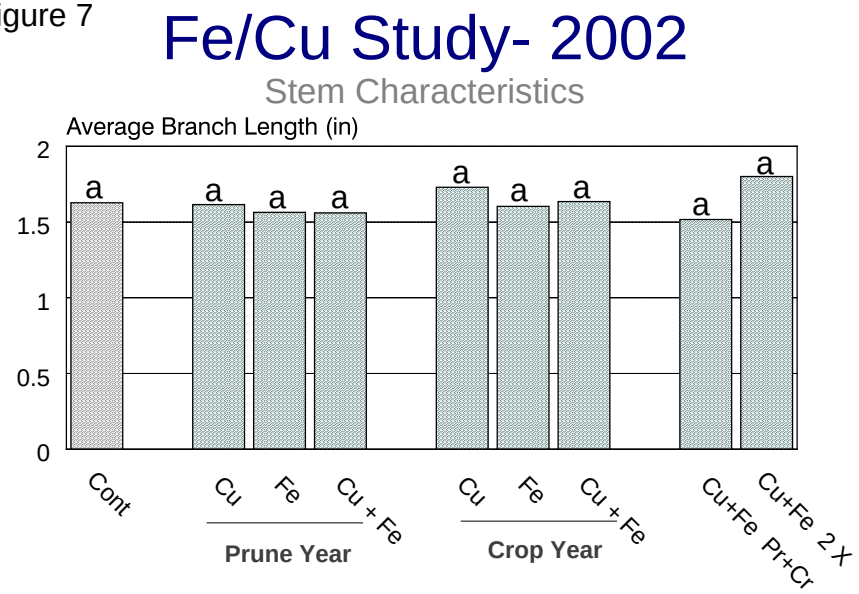
Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, 5% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

Figure 6



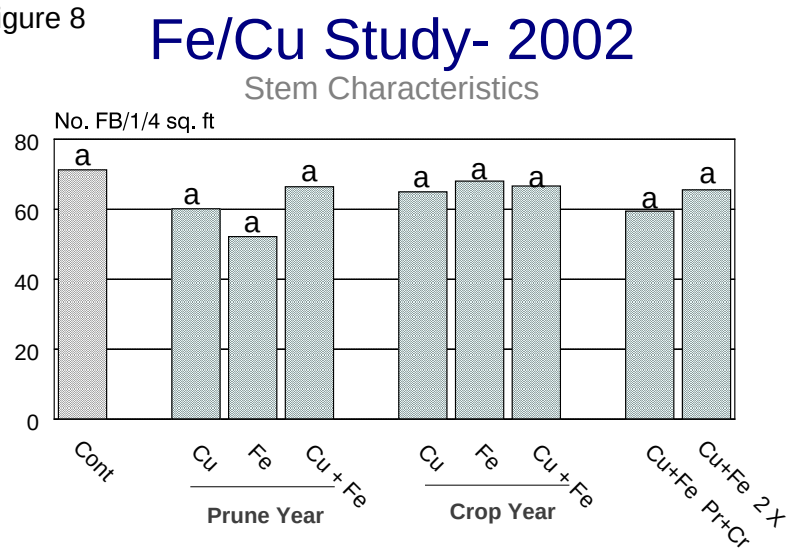
Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, 5% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

Figure 7



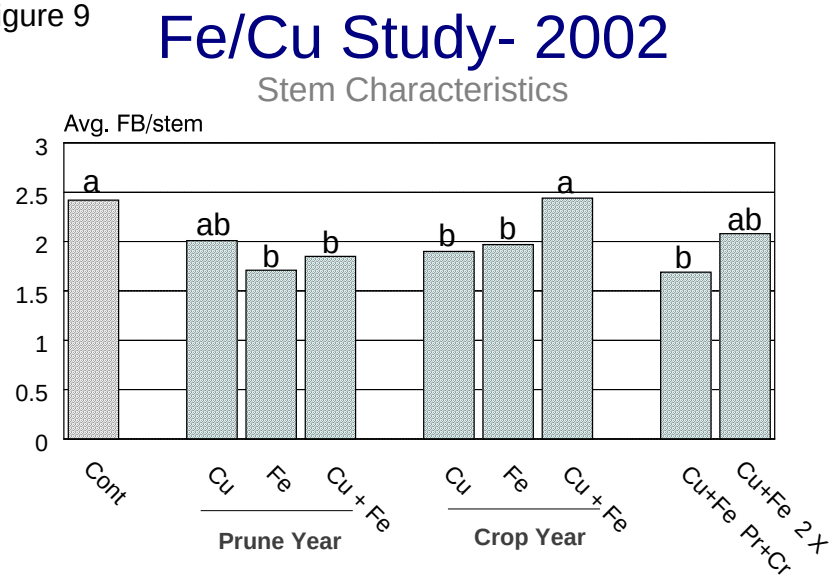
Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, 5% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

Figure 8



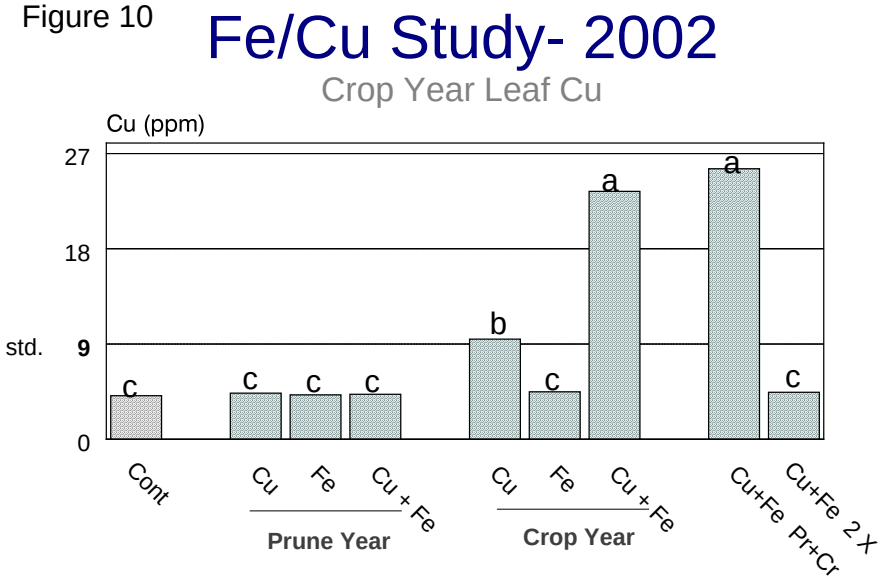
Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, 5% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

Figure 9



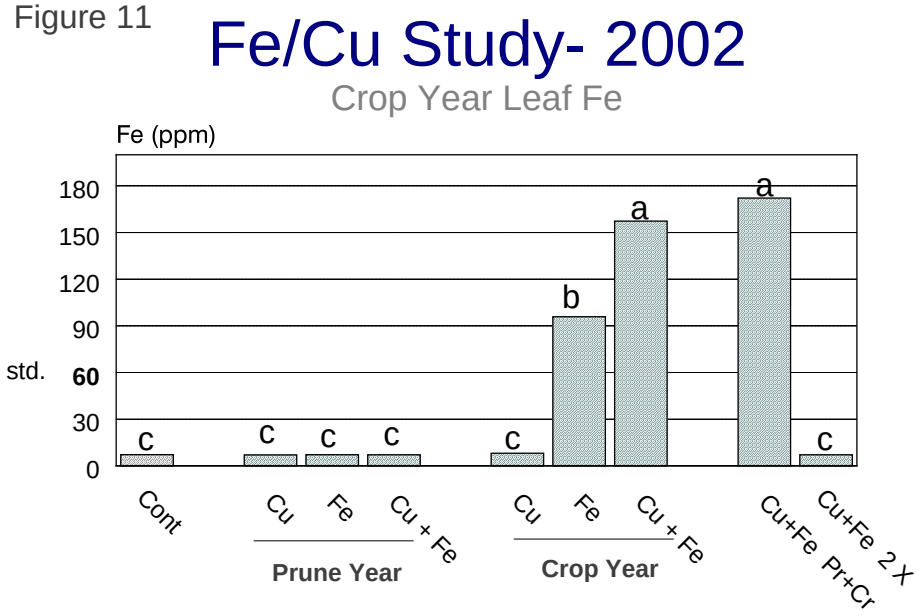
Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, 0.1% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

Figure 10



Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, .01% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

Figure 11

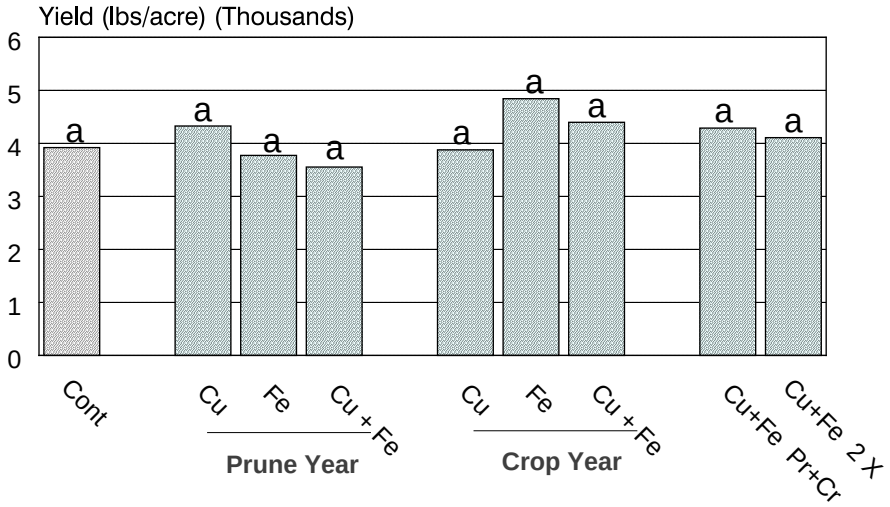


Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, .01% level. Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X = Prune Year double application (Early & Mid June)

Figure 12

Fe/Cu Study- 2002

Berry Yield



Cu and Fe applied at 0.5 lbs/acre. Mean separation by Duncan's Multiple range test, 0.1% level.
Prune Year= 2002; CY= Crop Year= 2003; Pr + Cr= Both Years; 2 X Prune Year double application (Early & Mid June)

FERTILITY

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Ilse W. Fastook, Scientific Technician

16. TITLE: Effect of Soil pH on Nutrient Uptake.

OBJECTIVES: To determine the effect of soil pH adjustment on nutrient uptake, available soil nutrients, plant growth and yield.

Brief Justification:

Many growers have soil pH values at the high end of the recommended pH range for growing wild blueberries yet they are recording high yields. They are reluctant to adjust their soil pH for fear of reducing yields. This study will provide data to support current recommendations for lowering soil pH to 4.6 or result in a reevaluation of these soil test recommendations.

pH Study - Blueberry Hill Farm

METHODS: Four clones were selected at Blueberry Hill Experiment Station Farm in Jonesboro. In each clone, eight 4 ft x 4 ft sections (plots) were identified for establishing four replications of two treatments. The perimeter of each plot was cut down to 6 inches to sever the rhizomes and isolate each plot. In August 1999, the plots were hand raked and the berry weight was not significantly different among potential treatment plots within each clone. Soil samples taken November 1999 from each clone indicated two had a pH of 4.5, one had 4.7 and one had a pH of 4.9. Since one ton of ground limestone will raise pH about 0.2 , treatment plots received an appropriate amount of limestone in May 2000 to adjust the soil pH to about 5.3 (Table 1). Control plots received gypsum ($CaSO_4$) to provide Ca in the amount that the limestone contributed**.**

Table 1
Treatment Summary

Clone	Treatment Number	Starting pH	Limestone $CaCO_3$ (lb/acre)	Gypsum $CaSO_4$ (lb/acre)
1	**1**	**4.7**	**0**	**6,693**
1	**2**	**4.7**	**7,000**	**0**
2	**1**	**4.9**	**0**	**4,784**
2	**2**	**4.9**	**5,000**	**0**
3	**1**	**4.5**	**0**	**8,608**
3	**2**	**4.5**	**9,000**	**0**
4	**1**	**4.5**	**0**	**8,608**
4	**2**	**4.5**	**9,000**	**0**

In this way, paired plots with the same plant material will have substantially different soil pH. Plant and soil nutrients will be monitored by leaf tissue and soil analysis. Soil pH and leaf nutrient concentrations will be related to yield during the crop year. Within each treatment plots stems within randomly placed 1/3 ft^2 quadrats will be cut for stem density (stems/ft^2) and stem

length, branching, and flower bud formation measurements.

RESULTS:

2001 Leaf Tissue Analysis

Treatment with limestone had an effect on a number of nutrient elements in leaf tissue samples taken July 2001 (Table 2**).** The leaf tissue concentrations of Ca, K, B, Cu , Zn and Mn were all lower in the plots receiving limestone ($CaCO_3$) compared to the control. Leaf Mg concentrations were raised by raising the soil pH. Control plot leaf Ca concentration was probably higher due to the greater solubility of $CaSO_4$ than $CaCO_3$.

Table2

Treatment	2001 leaf nutrient concentrations						
	Ca (%)	**K (%)**	**Mg (%)**	**B (ppm)**	**Cu (ppm)**	**Zn (ppm)**	**Mn (ppm)**
Control ($CaSO_4$)	**.721a**	**.481a**	**.208b**	**33a**	**4.2a**	**11.6a**	**1135a**
Limestone ($CaCO_3$)	**.676b**	**.451b**	**.256a**	**25b**	**4.0b**	**10.9b**	**629b**

2002 Leaf Tissue and Soil Analysis

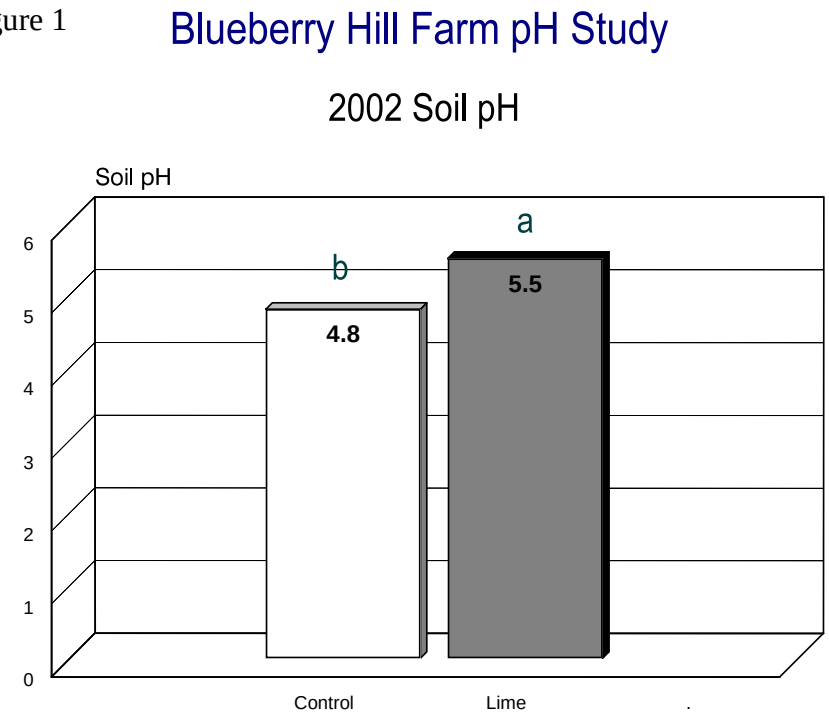
Crop year leaf samples (Table 3) showed different concentrations but similar trends to that found in 2001 prune year leaf samples. Leaf N, P, Zn, and Ca concentrations were not different between the control and limestone-treated plots, but leaf concentration of Mg increased and leaf K, B, Cu, Mn, Al, and Fe concentrations decreased in response to limestone application.

Table3

Treatment	2002 leaf nutrient concentrations						
	K (%)	**Mg (%)**	**B (ppm)**	**Cu (ppm)**	**Mn (ppm)**	**Al (ppm)**	**Fe (ppm)**
Control ($CaSO_4$)	**.398a**	**.150b**	**24a**	**4.42a**	**621a**	**80a**	**40a**
Limestone ($CaCO_3$)	**.380b**	**.168a**	**18b**	**4.19b**	**286b**	**71b**	**35b**

2002 Soil samples showed limestone treated plots had a higher pH than controls (Fig 1.).

Figure 1



Soil concentrations of Ca, Mg, B, Zn, and Mn were higher in the limestone-treated plots that had a higher pH compared to the control (Table 4). Liming resulted in a lower S soil concentration. Soil P, K, Cu, Fe, and Al were unaffected by the change in pH brought about by liming. Yield was not obtained in 2003 due to blossom damage and crop failure when a herbicide for grass control was made to the field using the wrong oil adjuvent.

Table 4

Treatment	2002 soil nutrient concentrations					
	Ca (ppm)	Mg (ppm)	B (ppm)	Zn (ppm)	Mn (ppm)	S (ppm)
Control ($CaSO_4$)	**.398a**	**.150b**	**24a**	**4.42a**	**621a**	**80a**
Limestone ($CaCO_3$)	**.380b**	**.168a**	**18b**	**4.19b**	**286b**	**71b**

pH Study - Aurora

METHODS: Five discrete clones were selected in a commercial blueberry field in Aurora. Two 4 ft x 4 ft treatment plots were established in each clone and the perimeter of each was cut with a spade to isolate each plot. Soil samples indicated that the soil pH under these clones ranged from 5.1 to 5.5 (Table 5). Yield was collected August 2000 from each treatment plot within each clone and no difference was found between those randomly assigned treatment 1 (9,303 lbs/acre) or those assigned treatment 2 (9, 375 lbs/acre). Sulfur (S) was applied in June 2001 to plots assigned treatment 2 to adjust the soil pH down toward pH 4.6. This required from 550 to 990 lb S/acre, depending upon the pH under the specific clone (Table 5). Soil and leaf samples were collected in July 2001 to establish base line data to compare changes as the soil pH changes. Stem samples were taken from each plot in October 2001 from a randomly placed 1/3 ft^2 quadrat for stem density, stem length and branching and flower bud formation measurements. Soil samples were taken July 22, 2002 to determine the effect on soil pH. Yield was collected August 7, 2002. Leaf and soil samples were collected on July 23, 2003. Stem samples were collected November 7, 2002.

Table 5
Treatment Summary

Clone	Treatment Number	Starting pH	Sulfur lb/acre
1	**1**	**5.3**	**0**
1	**2**	**5.3**	**770**
2	**1**	**5.2**	**0**
2	**2**	**5.2**	**660**
3	**1**	**5.5**	**0**
3	**2**	**5.5**	**990**
4	**1**	**5.4**	**0**
4	**2**	**5.4**	**880**
5	**1**	**5.1**	**0**
5	**2**	**5.1**	**550**

RESULTS:

2001 Leaf Tissue and Soil Analysis

Soil samples taken in July 2001 indicated that control and sulfur-treated plots had similar soil pH values of 5.18 and 5.16, respectively. Leaf nutrient concentrations were not significantly different between control and sulfur-treated treatment plots for all nutrients, except manganese (Mn). Leaf nutrients that might be expected to change with soil pH are given in Table 6.

Table 6

Treatment	2001 leaf nutrient concentrations						
	Ca (%)	K (%)	Mg (%)	B (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Control	**.400a**	**.493a**	**.176a**	**28a**	**5.0a**	**15.0a**	**450b**
Sulfur (S)	**.412a**	**.471a**	**.174a**	**26a**	**5.2a**	**15.1a**	**580a**

Soil nutrient concentrations for control and sulfur-treated plots were not different for Ca, K, Mg, P, Al, B, Cu, Fe, Zn or Mn. The concentrations of most elements are presented in Table 7**.**

Table 7

Treatment	2001 soil nutrient concentrations							
	Ca (ppm)	K (ppm)	Mg (ppm)	P (ppm)	B (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Control	**437a**	**96a**	**62a**	**9.4a**	**.17a**	**.11a**	**1.8a**	**12.4a**
Sulfur (S)	**524a**	**106a**	**77a**	**9.4a**	**.17a**	**.13a**	**2.1a**	**16.6a**

2001 Stem Characteristics

Stem density, stem length, and flower buds per stem were not affected by treatments (Table 8).

Table 8

Treatment	2001 Stem Characteristics				
	Density (Stems/ft^2)	Stem Length (in)	Branches (No)	Branch Length (in)	Flower buds/stem
Control	**437a**	**96a**	**62a**	**9.4a**	**.17a**
Sulfur (S)	**524a**	**106a**	**77a**	**9.4a**	**.17a**

2002 Soil and Leaf Tissue Analysis

Soil pH was significantly lower in sulfur-treated plots one year after treatment (Fig.2) but only soil Zn, Mn, and S concentrations were higher in sulfur-treated plots (Table 9). S concentration was 190 ppm in sulfur-treated plots compared to 52 ppm for the controls.

Figure 2

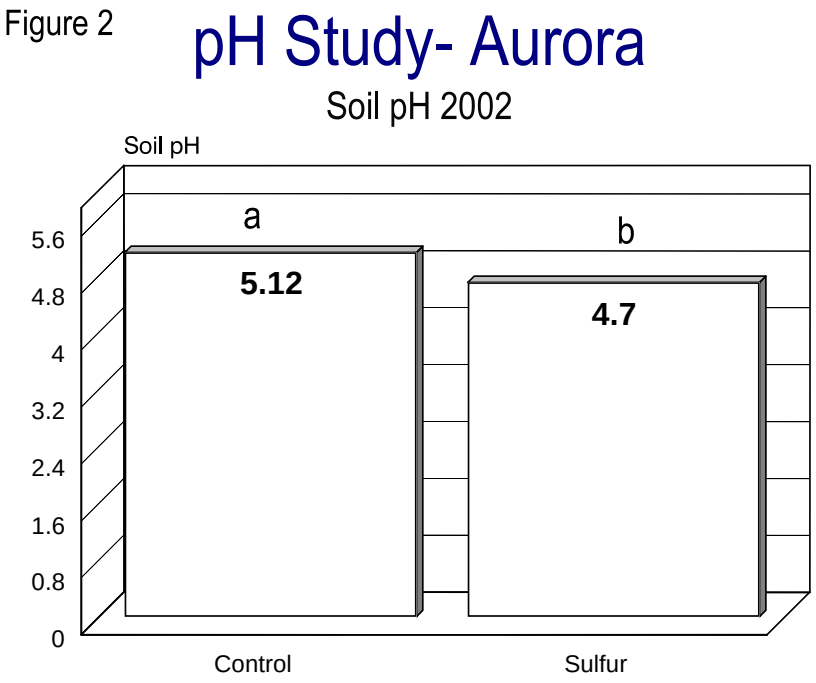


Table 9

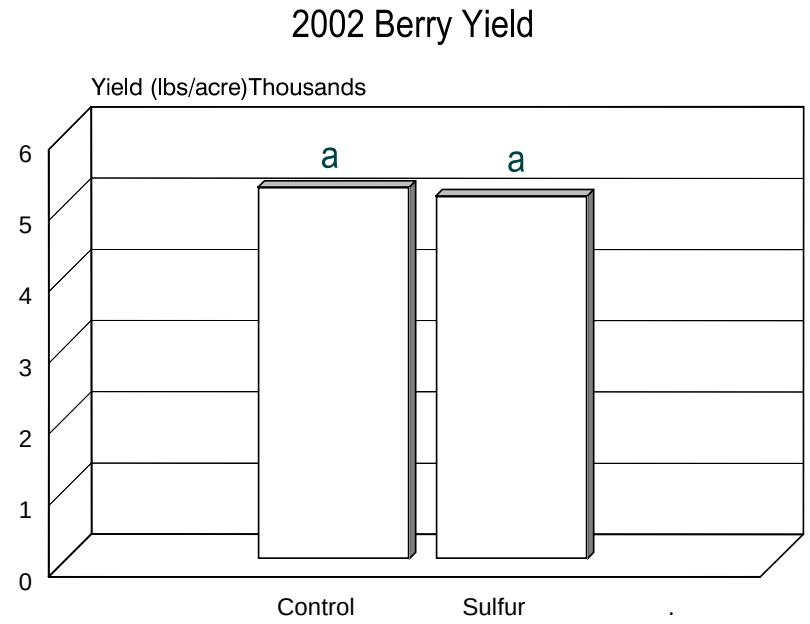
2002 soil nutrient concentrations

Treatment	Ca (ppm)	K (ppm)	Mg (ppm)	P (ppm)	B (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Control	**302a**	**83a**	**34a**	**6.4a**	**.06a**	**.17a**	**1.8a**	**5.8b**
Sulfur (S)	**331a**	**86a**	**37a**	**7.1a**	**.06a**	**.21a**	**2.2a**	**12.8a**

2002 Yield

Blueberry yield collected in August 7, 2002 was not affected by sulfur treatment (Fig. 3).

Figure 3 pH Study- Aurora



2003 Soil and Leaf Tissue Analysis

Soil analysis has not been completed at this time. Leaf tissue levels were similar for control and sulfur-treated plots, except for leaf Mn concentrations (Table 10). Soil Mn concentrations were also higher in treatment plots receiving sulfur (Table 11). Soil pH values for treatment plots in 2003 (Fig. 4) were similar to those in 2002.

Table 10

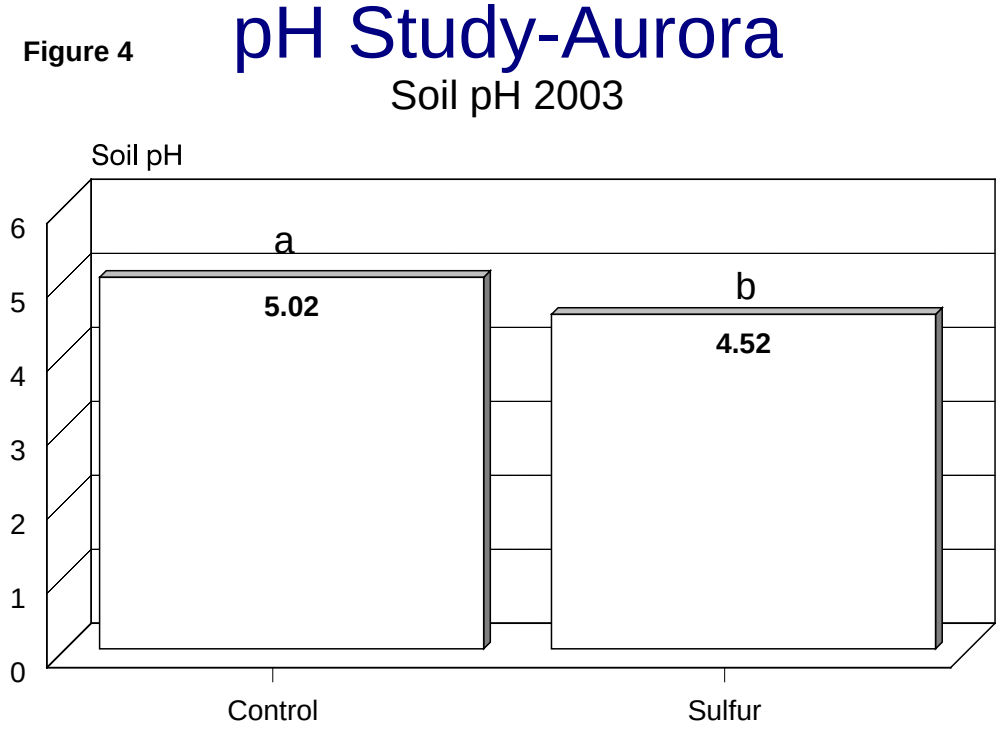
Treatment	2003 leaf nutrient concentrations						
	Ca (%)	K (%)	Mg (%)	B (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Control	**.503a**	**.447a**	**.179a**	**28a**	**4.2a**	**28.2a**	**632b**
Sulfur (S)	**.504a**	**.501a**	**.171a**	**27a**	**4.0a**	**31.8a**	**1098a**

Table 11

2003 soil nutrient concentrations

Treatment	Ca (ppm)	K (ppm)	Mg (ppm)	P (ppm)	B (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Control	**452a**	**88a**	**53a**	**10.4b**	**.08a**	**.14a**	**2.1a**	**14.6b**
Sulfur (S)	**390a**	**83a**	**41a**	**12.1a**	**.07a**	**.16a**	**2.5a**	**21.2a**

Figure 4



CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can be made at this time.

FERTILITY

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Ilse W. Fastook, Scientific Technician

17. TITLE: Effect of Gibberellic Acid (GA_3) and CPPU on Fruit Set and Yield of Wild Blueberry after low temperature flower stress

OBJECTIVES: To determine the effect of gibberellic acid and CPPU on fruit set and yield of wild blueberry

METHODS:

GA_3 Study

Seven distinct clones were identified in a low valley that often experiences frost in a commercial lowbush blueberry field. Within each clone, one of two 0.6 m x 1.2 m treatment plots received GA_3 at 200 $mg \cdot L^{-1}$ with 0.25% X-77 surfactant at about 90% full bloom on May 30 and again June 4, 2003. Foliage was sprayed to the point of drip with the solution. A four-sided shield protected adjacent plots from spray drift. Treatments were replicated four times within each clone in a split plot design with clones as the main plot. Fruit set was determined in each treatment plot on ten tagged stems with three flower buds by counting flower number/stem on June 4 and fruit number/stem just prior to harvest on August 14, 2003. Effect of GA_3 on fruit maturity was determined by classifying berries as green, green/pink, pink/red, red/blue, or blue. The leaves in treatment plots receiving GA_3 turned red, indicating a stress on the plants.

CPPU Study

At the same commercial wild blueberry field another seven clones were selected for this study. CPPU was applied to one of two 0.6 m x 1.2 m treatment plots at 10 mg/L at 7 and 14 days after flowering. Foliage was sprayed to drip. Tagging 10 stems containing 3 flower buds in each plot and counting the numbers of flowers and fruit determined the effect of CPPU on fruit set. Just before harvest, stems were cut and placed in plastic bags for later determination of fruit number, size and weight and the stage of berry maturity. Plots were also harvested on August 14, 2003 to determine berry yield.

Treatments were replicated four times within each clone in a split plot design with clones as the main plot and treatments as subplots

RESULTS:

GA_3 Study

A weather station at the site of the study recorded temperatures below 28 ° F at blossom height on June 3 and 4 (Fig.1). This prompted the second application earlier than the planned application date of two weeks later. Fruit set was not affected by GA_3 treatment (Fig. 2).

Figure 1

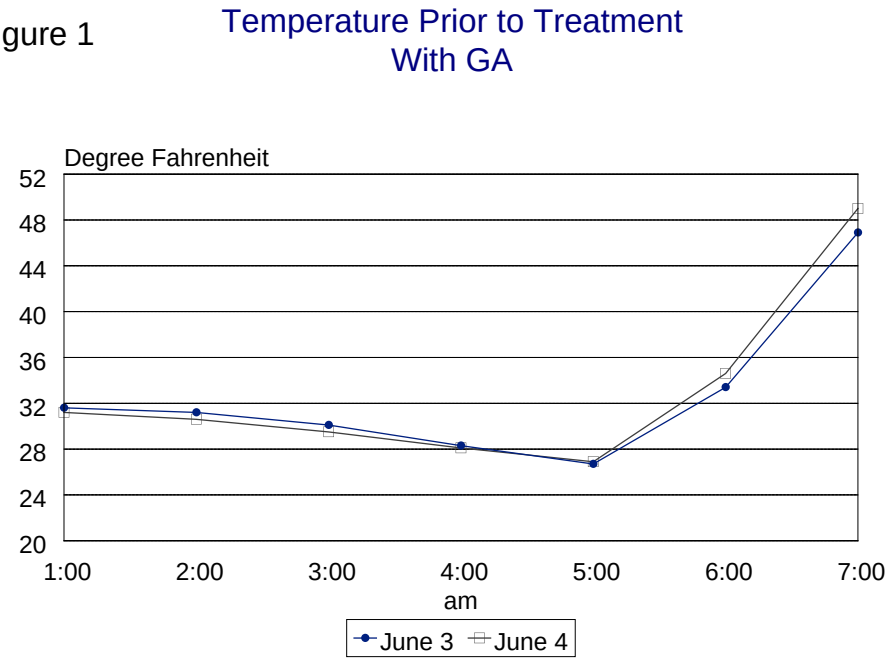
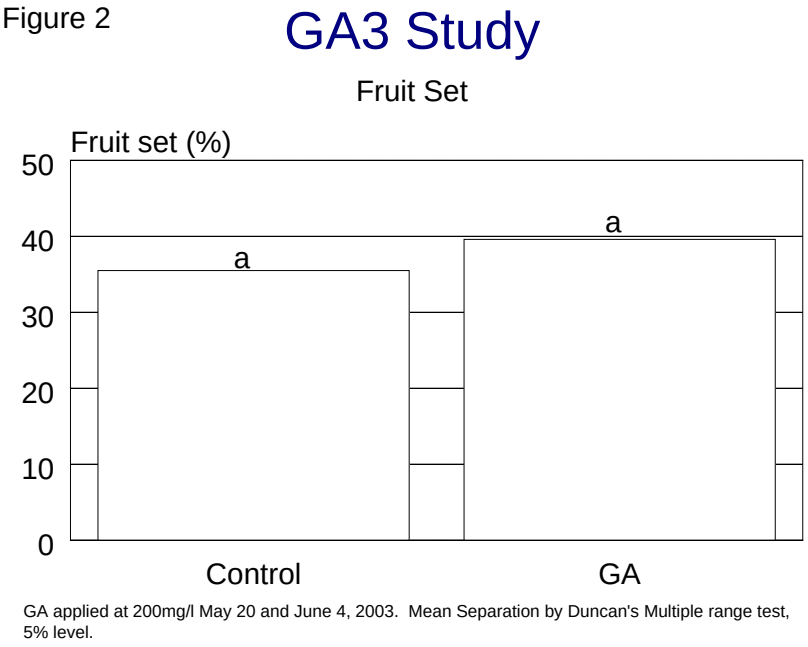


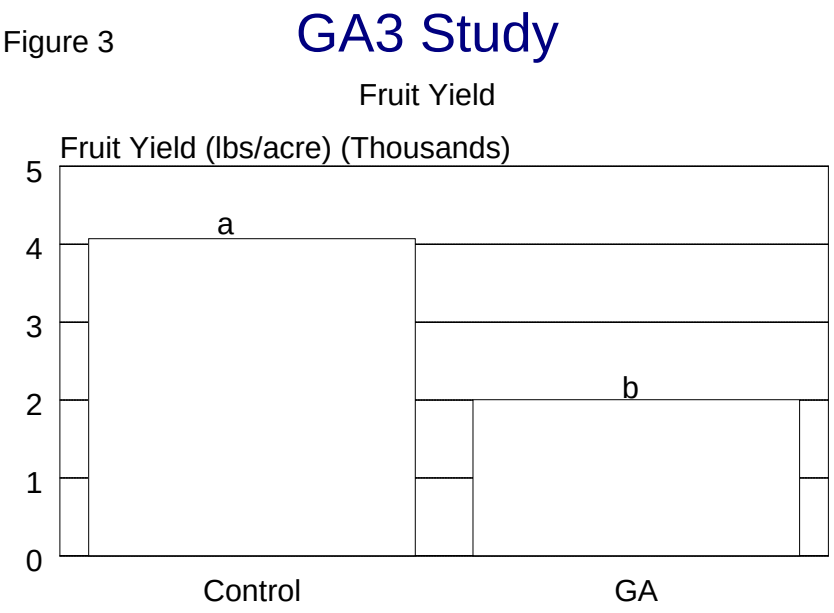
Figure 2



GA applied at 200mg/l May 20 and June 4, 2003. Mean Separation by Duncan's Multiple range test, 5% level.

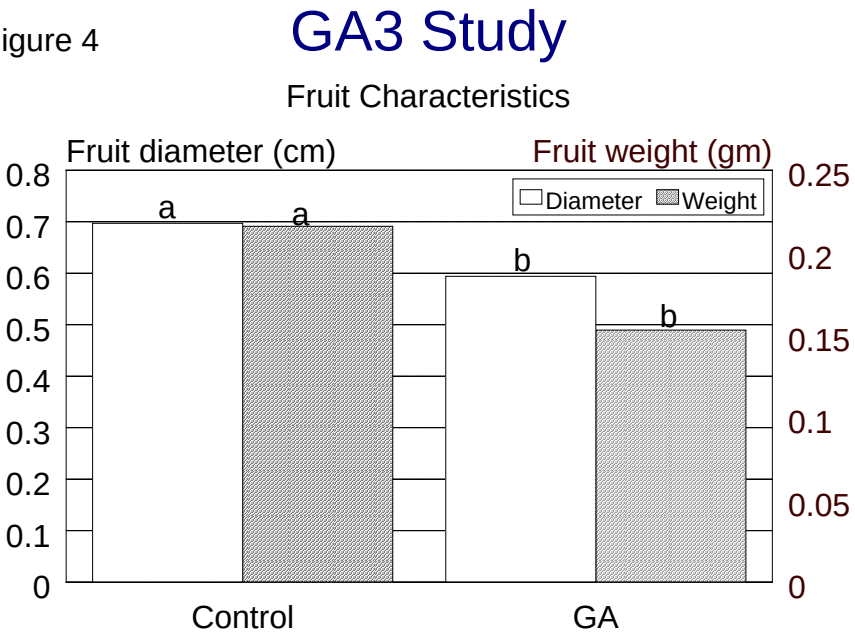
Fruit numbers per three-bud stem were similar, averaging 5.7 and 6.0 for the control and GA_3, respectively; however, berry yield was reduced from 4000 to 2000 lbs/acre (Fig. 3) likely through a decrease in berry diameter and weight (Fig. 4).

Figure 3



GA applied at 200mg/l May 20 and June 4, 2003. Mean Separation by Duncan's Multiple range test, 1% level.

Figure 4

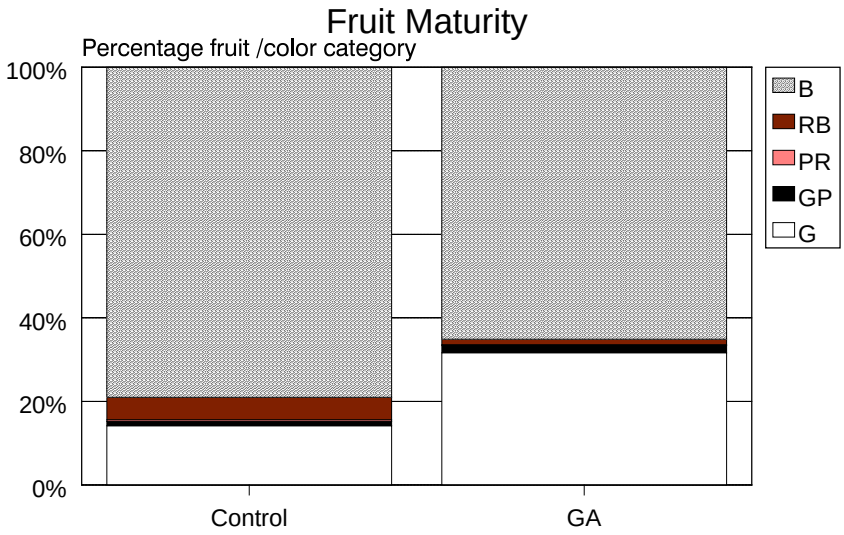


GA applied at 200mg/l May 20 and June 4, 2003. Mean Separation by Duncan's Multiple range test, 6 and 8% level for diameter and weight, respectively.

GA_3 did affect stage of fruit maturity as the percentages of green berries on tagged stems were higher and the percentages of blue berries were lower in GA_3 treatment plots, compared to the controls (Fig. 5). The percentage of green/pink, pink/red, red/blue berries were similar on stems tagged in control and GA_3 treatment plots (Fig.5).

Figure 5

GA3 Study

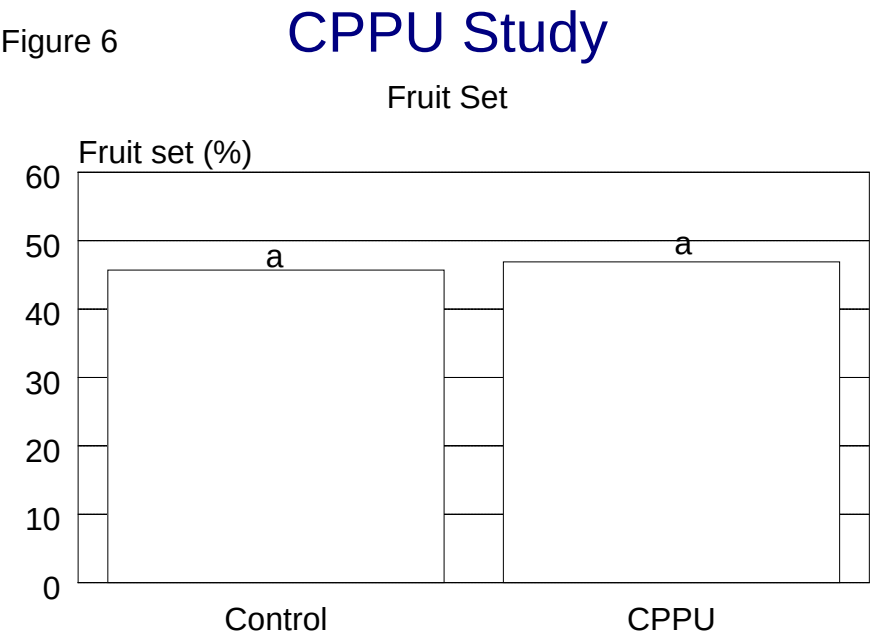


Percentage Blue and Green berries significantly different between treatments at the 6% level.

CPPU Study

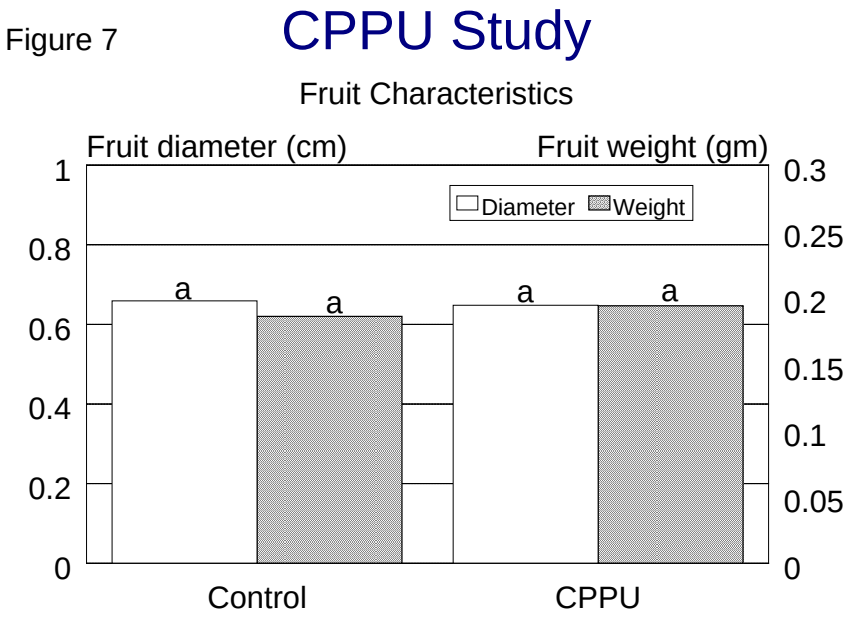
CPPU did not affect percent fruit set (Fig. 6), or average berry diameter and berry weight of the seven clones tested in this study (Fig. 7).

Figure 6



CPPU applied at 10mg/l on June 12 and 20, 2003. Mean Separation by Duncan's Multiple range test, 5% level.

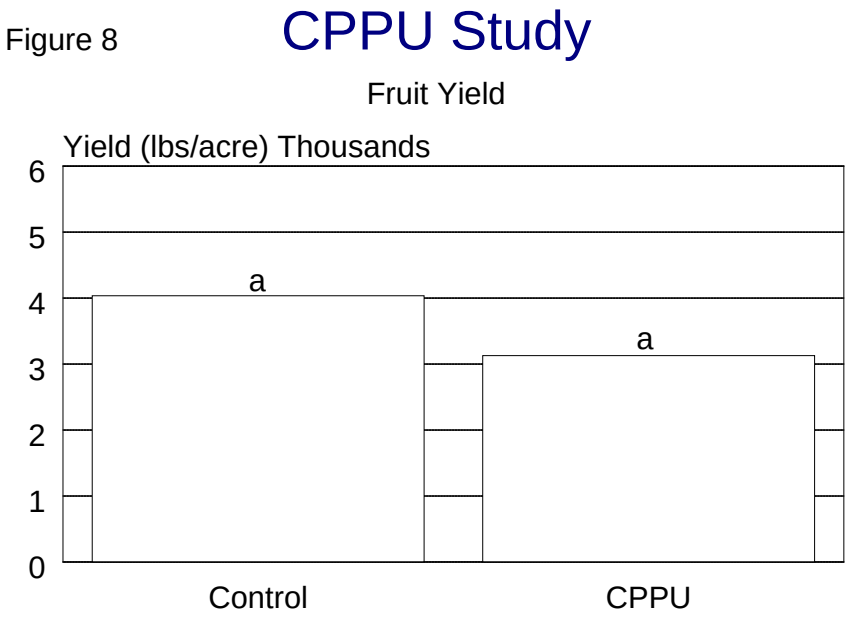
Figure 7



CPPU applied at 10mg/l on June 12 and 20, 2003. Mean Separation by Duncan's Multiple range test, 5% level.

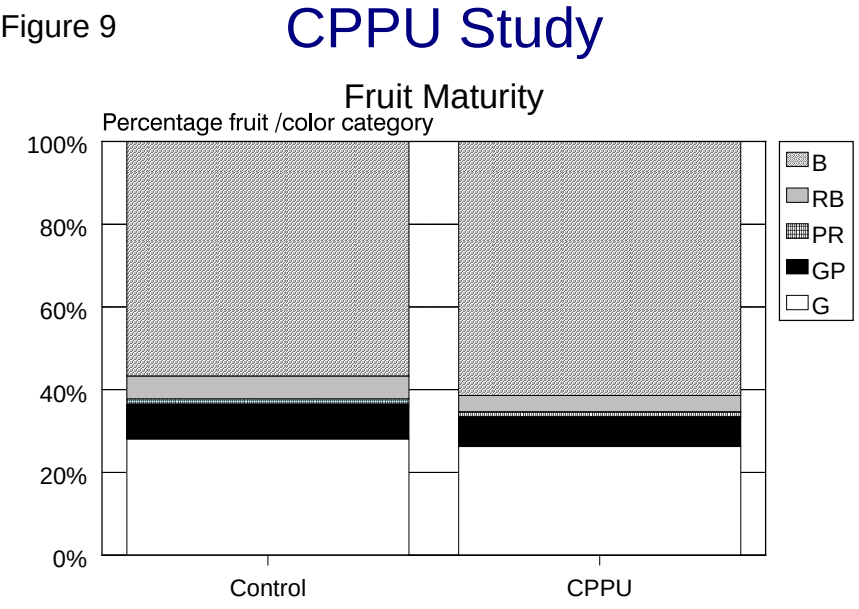
Yield was not affected by CPPU (Fig.8). The average number and percentage of berries of different maturity, as indicated by berry color, was not influenced by CPPU (Fig. 9).

Figure 8



CPPU applied at 10mg/l on June 12 and 20, 2003. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 9



Treatments not significantly different for each color category at the 5% level.

CONCLUSIONS: Under the conditions of this study no benefit was obtained from use of GA_3 or CPPU at the concentrations and timing of sprays on lowbush blueberry fruit set or yield.

RECOMMENDATIONS: We do not recommendations use of these materials at this time.

FERTILITY

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Ilse W. Fastook, Scientific Technician

18. TITLE: Effect of Fertilizer Timing (prune year vs. crop year) on Wild Blueberry Growth and Productivity.

OBJECTIVES: To determine the effect of time of fertilizer application on nutrient uptake, soil nutrient availability, plant growth, and yield.

METHODOLOGY: A commercial wild blueberry field that had a history of low leaf N and phosphorus (P) concentrations was used in this study. Diammonium phosphate (DAP) at 400lbs/acre was applied to 6 ft x 50 ft treatment plots in the spring (preemergent) of the prune year (2003), or will be applied in the spring of the crop year (2004). A foliar application of N (CoRoN™) was also tested to determine if it will hasten the entry of N into the plant during the spring or crop year, compared to the soil applications in those cycles. CoRoN ™ (28% N) is a combination of polymethylene urea coupled with fast-release, low-biuret urea, designed to act as a slow-release foliar fertilizer. CoRoN ™ was applied June 13 of the prune year and June 26, about two weeks later. CoRoN™ will also be applied twice in the Crop year beginning when there is adequate foliage to absorb the spray, sometime in May. Some plots will receive DAP in the spring and crop year and some will receive just foliar sprays in the spring and crop year. A control plot received no fertilization. These 8 treatments (Table 1) were replicated 8 times in a randomized complete block design.

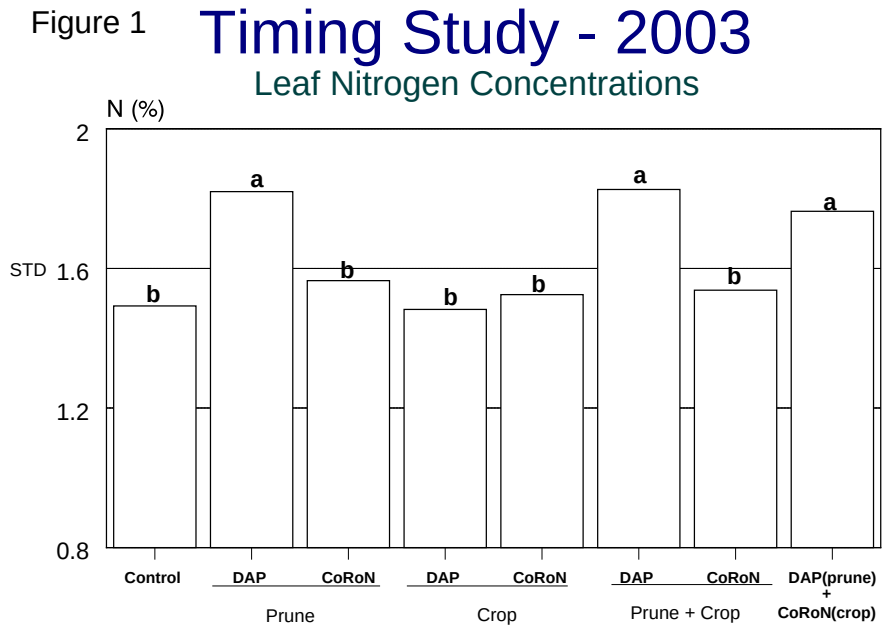
Table 1
Treatment Summary

Treatment 1	**Control**
Treatment 2	**DAP (400 lb /acre), spring of prune year**
Treatment 3	**DAP (400 lb /acre), spring of crop year**
Treatment 4	**DAP (400 lb /acre), spring of prune year +DAP (400 lb /acre), spring of crop year**
Treatment 5	**DAP (400 lb /acre), spring of prune year + Foliar application of N in spring of crop year**
Treatment 6	**Foliar application of N in spring of prune year**
Treatment 7	**Foliar application of N in spring of crop year**
Treatment 8	**Foliar application of N in spring of prune year + Foliar application of N in spring of crop year**

RESULTS:

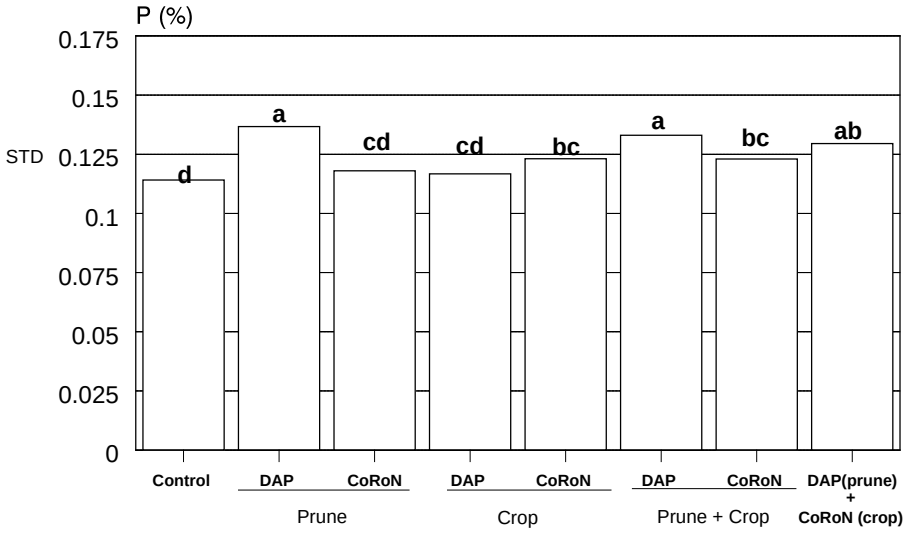
Leaf N concentrations were below the standard (1.6%) in control plots and were raised to sufficiency levels by DAP, but not by CoRoN treatments (Fig. 1). Leaf P concentrations were also at less than sufficient levels in control plots and were raised only by DAP (Fig. 2).

Figure 1



Soil-applied DAP at 80 lb P/acre. CoRoN foliar applied twice at 2.97 lb N/acre. Mean Separation by Duncan's Multiple range test, 0.01% level.

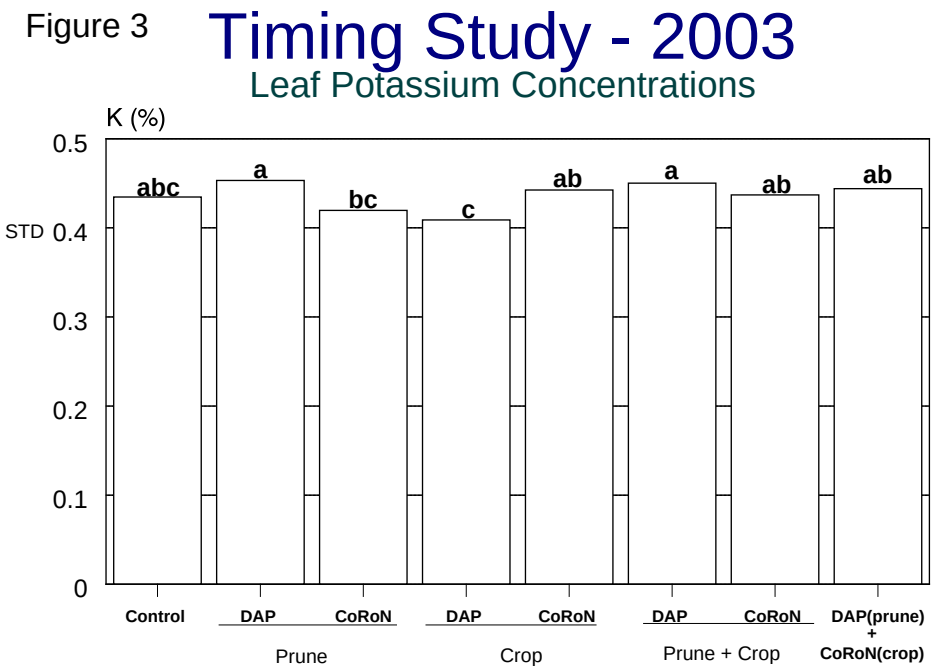
Figure 2



Soil-applied DAP at 80 lb P/acre. CoRoN foliar applied twice at 2.97 lb N/acre. Mean Separation by Duncan's Multiple range test, 0.01% level.

Leaf K levels were not meaningfully affected by treatments (Fig. 3).

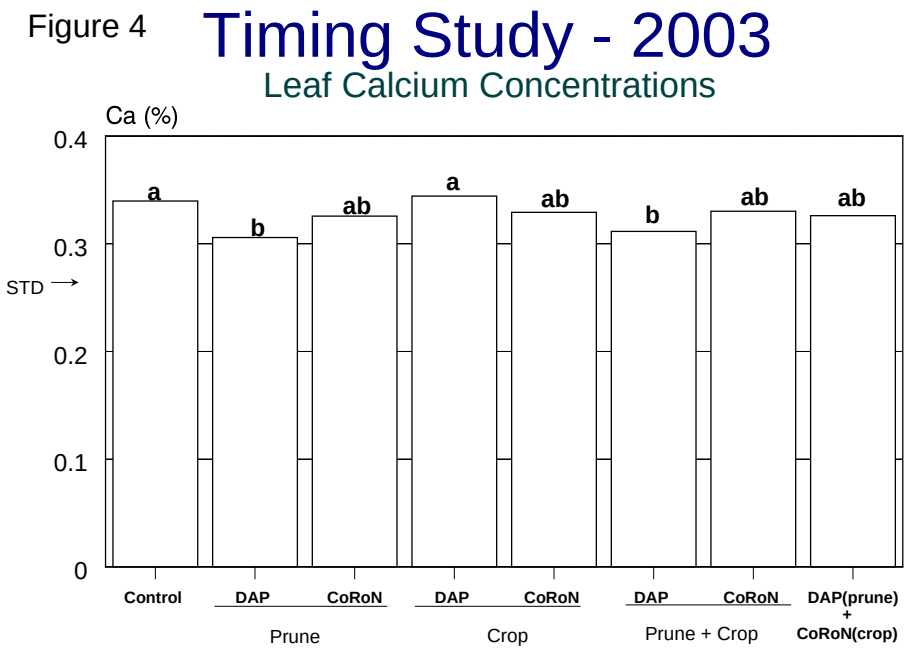
Figure 3



Soil-applied DAP at 80 lb P/acre. CoRoN foliar applied twice at 2.97 lb N/acre. Mean Separation by Duncan's Multiple range test, 5% level.

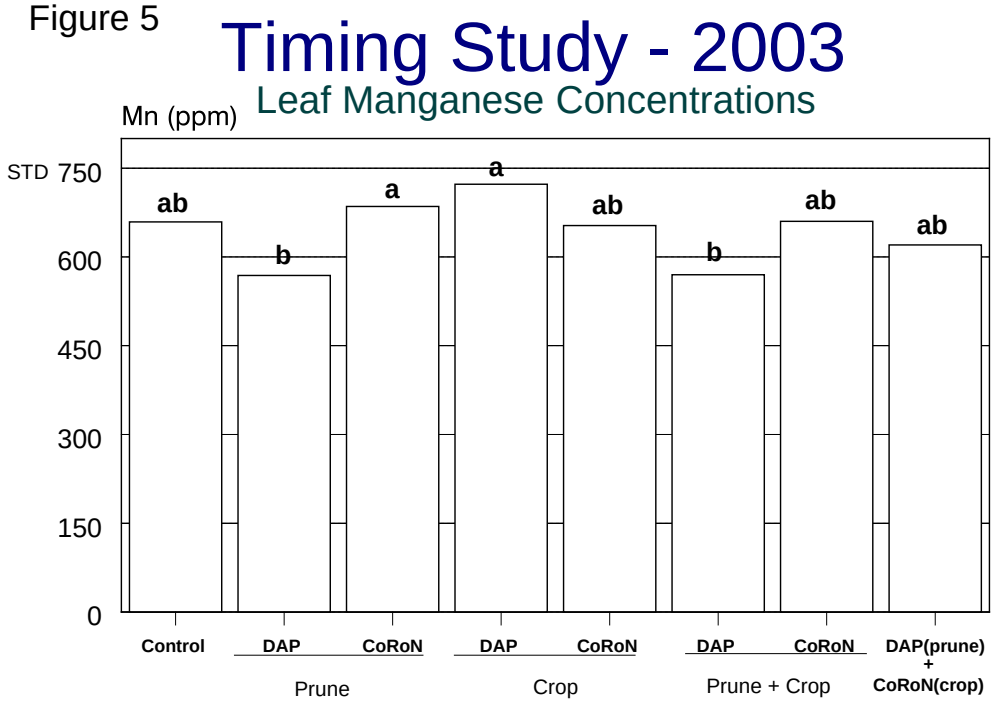
Often we see a lowering of some leaf nutrient concentrations in response to DAP through a dilution effect caused by increased growth and larger leaves stimulated by the N in the DAP. We apparently see this effect with leaf Ca and Mn concentrations (Figs. 4 and 5).

Figure 4



Soil-applied DAP at 80 lb P/acre. CoRoN foliar applied twice at 2.97 lb N/acre. Means Separation by Duncan's Multiple range test, 5% level.

Figure 5



Soil-applied DAP at 80 lb P/acre. CoRoN foliar applied twice at 2.97 lb N/acre. Mean Separation by Duncan's Multiple range test, 5% level.

CONCLUSIONS: Foliar application of N was not effective in raising leaf N concentrations at the rate and timing of applications. This method of applying N to raise leaf N concentrations needs further investigation in a separate study.
No conclusions can be made at this time regarding timing of fertilization.

RECOMMENDATIONS: No recommendations can be made at this time.

WEED MANAGEMENT AND FIELD COVER

INVESTIGATOR: David E. Yarborough, Professor of Horticulture
Kerry F. Lough, Research Assistant

19. TITLE: Assessment of Hexazinone Alternatives for Weed Control in Wild Blueberries and Weed Control and Field Cover Program Base

METHODS: Three experimental trial sites were established in 2003 on the Blueberry Hill Experiment station in Jonesboro, Maine. Experimental design was a randomized complete block with six replications and a plot size of 6 by 40 feet. Treatments consisted of: an untreated control (UTC), hexazinone as Velpar at 1 lb/a, flumioxazin as Chateau applied at 6 oz product/a along with hexazinone at 1 lb/a, flumioxazin at 12 oz/a along with hexazinone at 1 lb/a, and flumioxazin only at 12 oz/a applied on May 13. In a second experiment, treatments consisted of: an untreated control (UTC), hexazinone at 1 lb/a, quinclorac as Drive only at 6 or 12 oz/a applied on May 19. In a third experiment, treatments consisted of: an untreated control (UTC), hexazinone at 1 lb/a, and rimsulfuron as Ultim only at 1 or 2 oz/a applied on May 19. Plots were evaluated for wild blueberry and grass, fern, or broadleaf weed cover on June 26 and August 21 and 22, 2003.

RESULTS: In experiment one, though broadleaf and grass weed cover was reduced by August, there were no significant differences among the flumioxazin and hexazinone treatments and the untreated control (UTC) (Figure 1, 2). Flumioxazin 6 and 12 oz (both with and without hexazinone added) treatments appeared to augment wild blueberry cover (Figure 3), better than the hexazinone treatment alone and the UTC. The 12 oz flumioxazin treatments were superior to the hexazinone treatment for decreasing the fern cover (Figure 4) and had significantly less fern cover than UTC. In the second study hexazinone suppressed grass cover better than either of the rimsulfuron treatments (Figure 5) and had significantly less fern cover than UTC. The rimsulfuron treatments (Figure 6, 7) and the quinclorac treatments of the third experiment (Figure 8, 9) suppressed broadleaf weeds and fern cover equivalent to the hexazinone treatment, though none had significantly less weed cover than UTC. There was no difference in the suppression of grass cover by quinclorac and hexazinone treatments, though there was an early suppression, there was a greater grass cover at a higher rate of quinclorac by the end of the season (Figure 10).

CONCLUSION: Though flumioxazin appears to release blueberry growth and control ferns better than hexazinone, overall there did not appear to be distinct differences in the control of weed cover between hexazinone and flumioxazin, rimsulfuron, and quinclorac treatments. Though not significantly so, hexazinone provided better control of overall weed cover and therefore it does not appear that any of these herbicides have the potential to provide more successful weed suppression than hexazinone, though their potential as alternatives should not be excluded**.**

RECOMMENDATIONS: Evaluate other new herbicides and combinations of registered existing herbicides for suppression of weeds in wild blueberry fields.

Figure 1

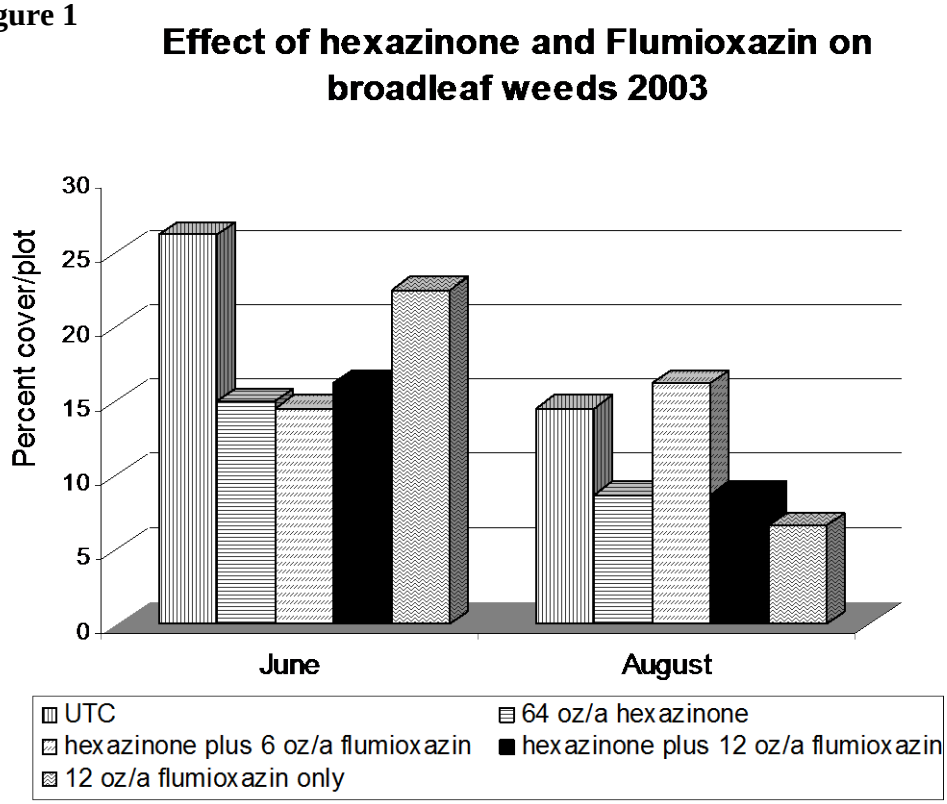


Figure 2

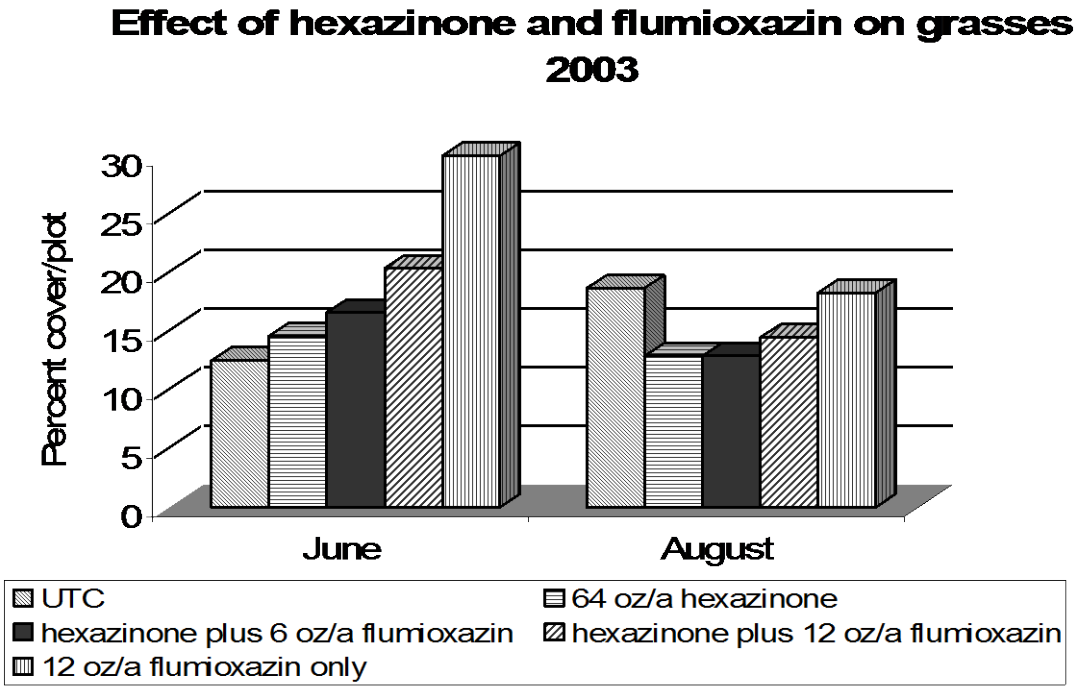


Figure 3.

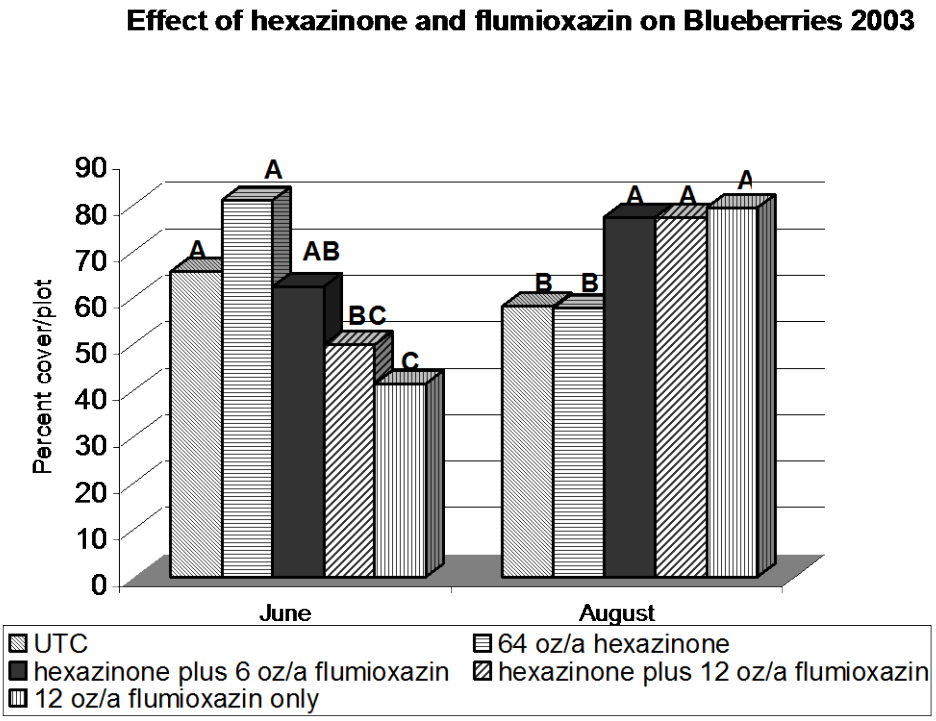


Figure 4

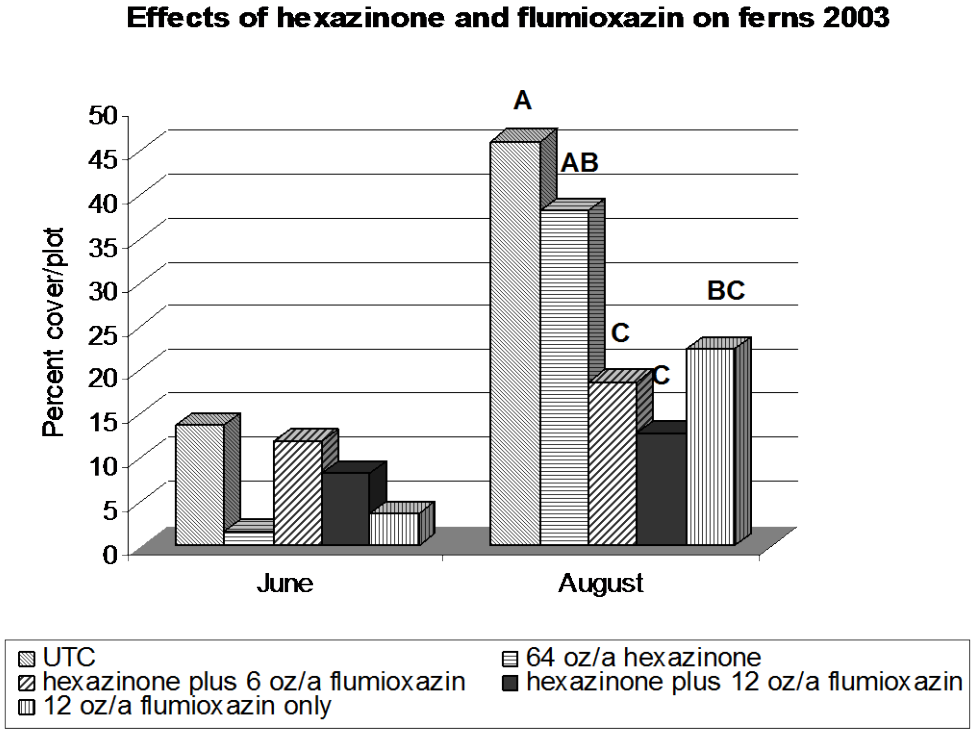


Figure 5

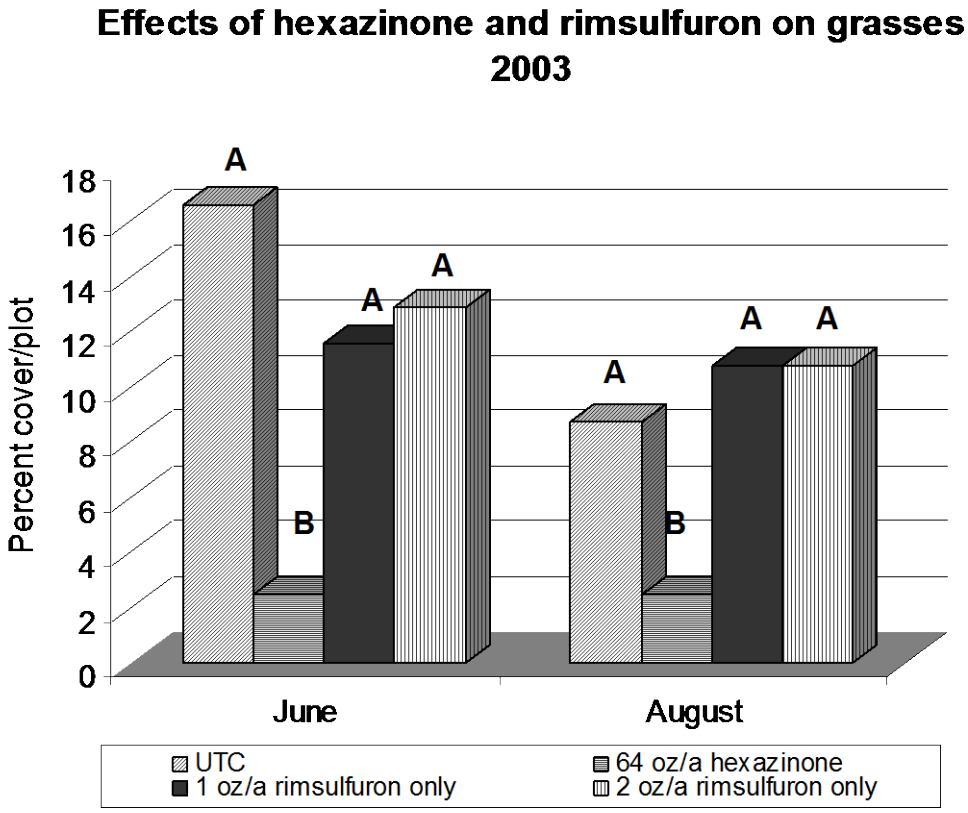


Figure 6

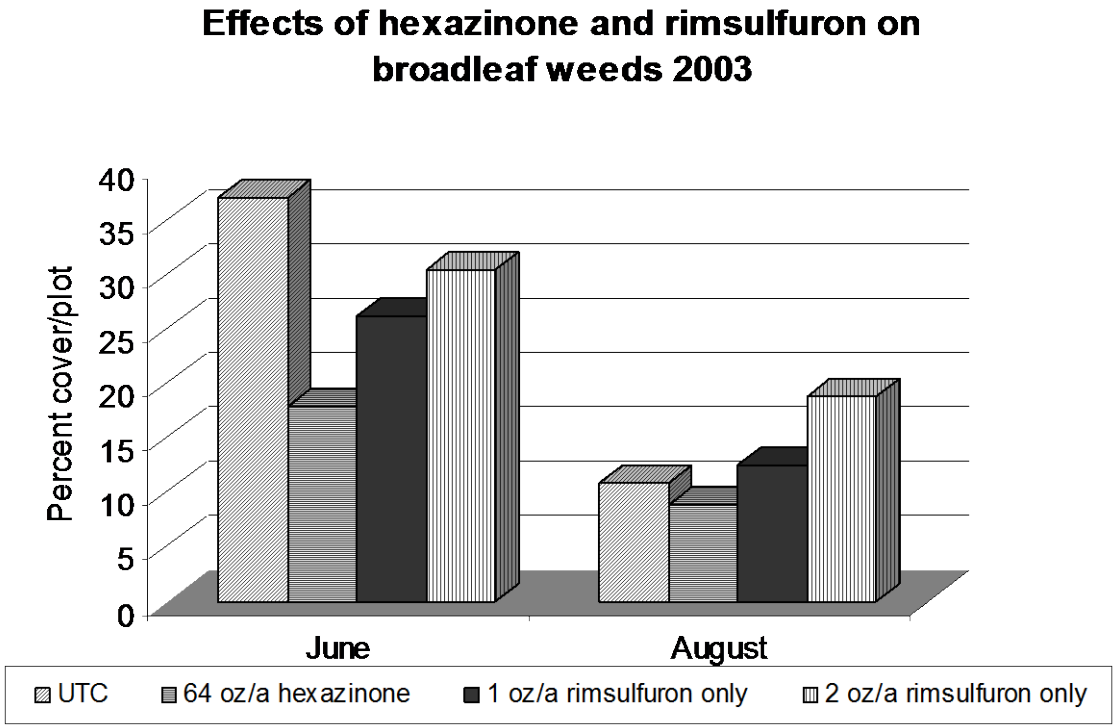


Figure 7

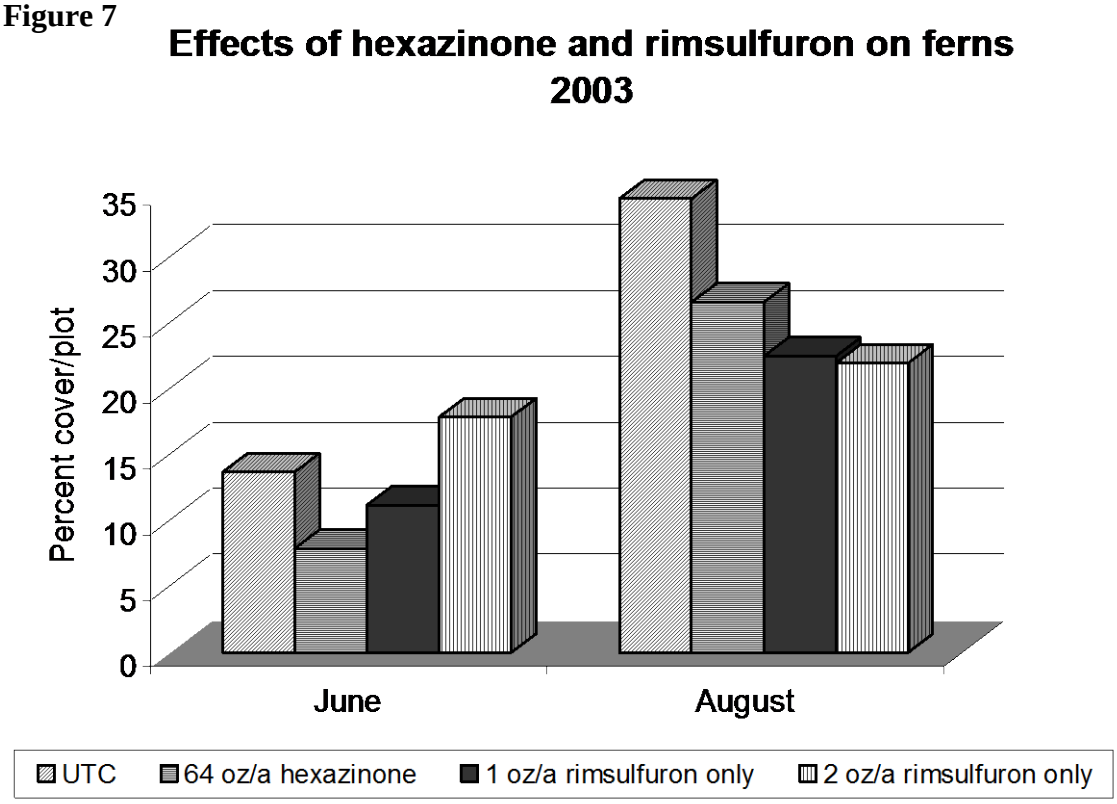


Figure 8

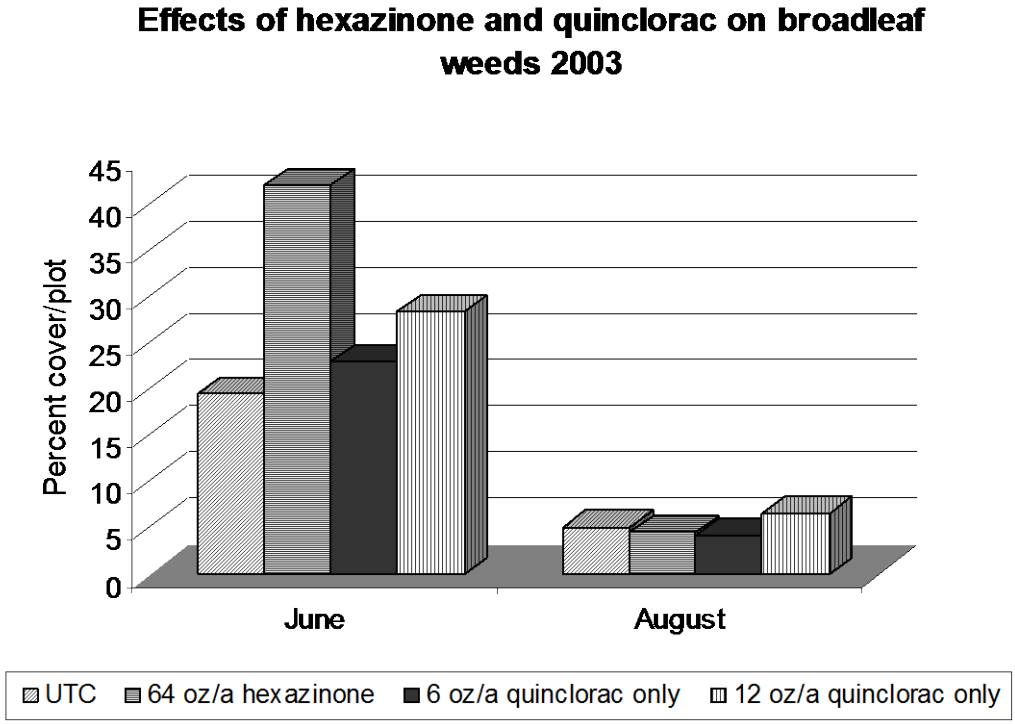


Figure 9

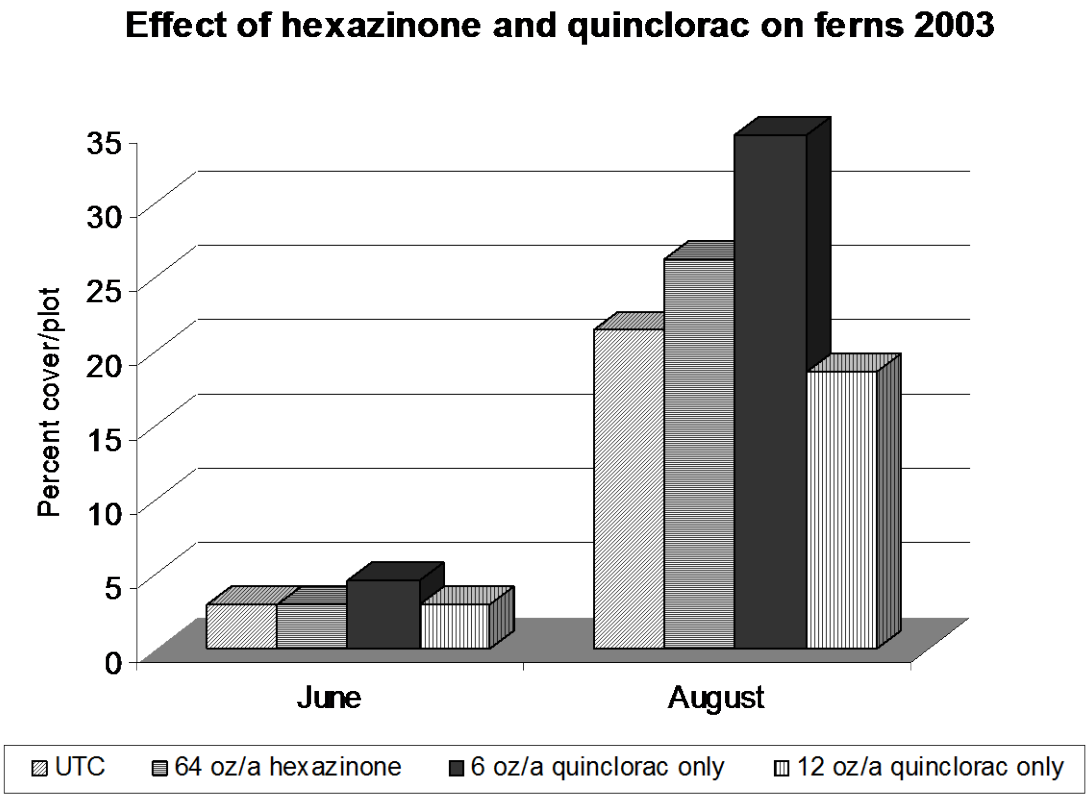
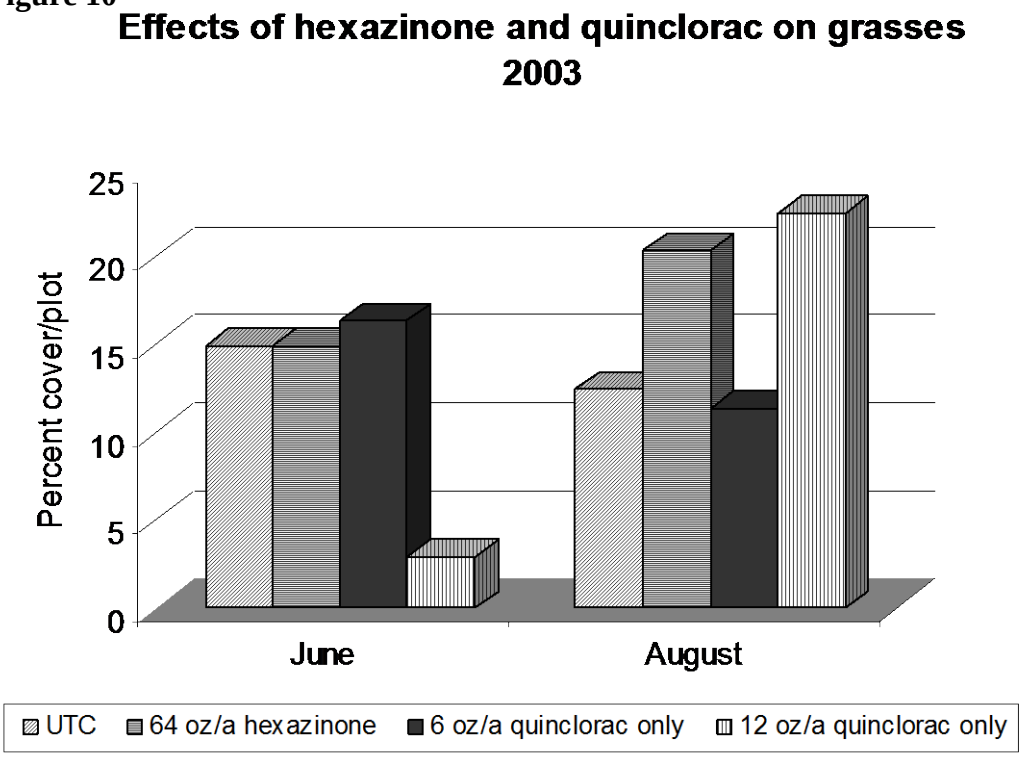


Figure 10



WEED MANAGEMENT AND FIELD COVER

INVESTIGATOR: David E. Yarborough, Professor of Horticulture
Kerry F. Lough, Research Assistant

20. TITLE: Evaluation of Fall Applications of Sulfonylurea Herbicides for Bunchberry Control in Wild Blueberries.

METHODS: Forty-eight meter square plots were established at the Blueberry Hill Farm Experimental Farm, Section U1 in October 2002. Plots were evaluated for blueberry and bunchberry cover. Treatments applied on October 3, 2002 included a control (UTC) for each rate, banvel at 0.25 and 0.5 gal/a; prosulfuron at 0.5 and 1 oz/a; rimsulfuron at 1 and 3 oz/a; triasulfuron at 0.25 and 0.5 oz/a; and halosulfuron at 0.5 and 1 oz/a. Sites were burned one month after treatment application. On August 20, 2003, these plots were evaluated for bunchberry and blueberry cover.

Based on the results from 2003, eighty-eight meter square plots were established at the Blueberry Hill Farm in September 2003 in order to continue the evaluation of sulfonylurea herbicides. The cover of blueberry and bunchberry was recorded prior to herbicide application. Experimental design was a completely randomized block design replicated 8 times with five herbicides at two rates and an untreated check. Treatments applied on September 29, 2003 consisted of a control (UTC), tribenuron methyl as Express at 1 and 2 oz/a, prosulfuron as Peak at 1 and 2 oz/a, rimsulfuron as Matrix at 2 and 4 oz/a, triasulfuron as Amber at 1 and 2 oz/a and halosulfuron as Permit at 1 and 2 oz/a. Sites were burned 1 month after herbicide application.

RESULTS: Results indicate that the sulfonylurea herbicides applied in 2002 had no significant effect on the blueberry or bunchberry cover (Figure 1,2). The exception to this is Banvel at 0.25 and 0.5 gal/a. Blueberry and bunchberry cover were less on the Banvel treated sites than any other site, there was less regeneration a year after treatment. No results will be available for sites tested in 2003 until after evaluation of blueberry and bunchberry cover in 2004.

CONCLUSION: Banvel was not a successful herbicide as it was detrimental in the first year after application to both bunchberry and blueberry cover at the tested rates. Canadian trials have found fall application of a sulfonylurea herbicide to be effective in controlling bunchberry without injury to wild blueberries. By identifying effective materials it is hoped an effective bunchberry treatment will be identified.

RECOMMENDATIONS: Continue study in 2004 with other sulfonylurea herbicides.

Figure 1

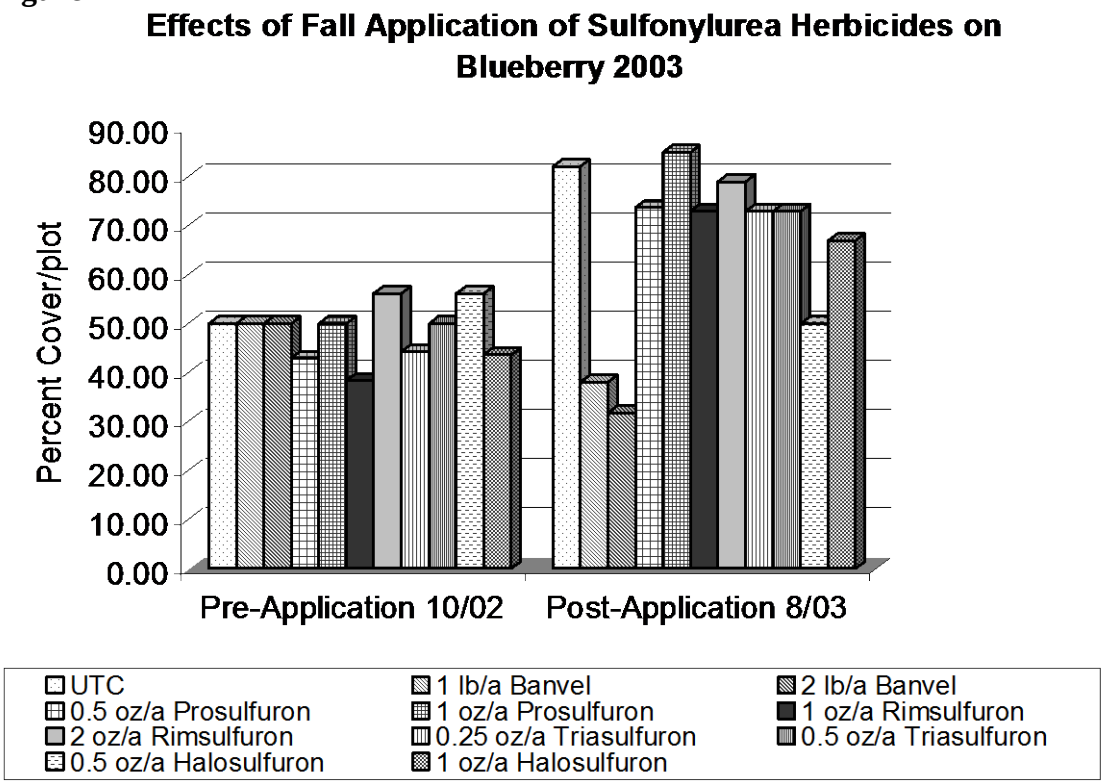
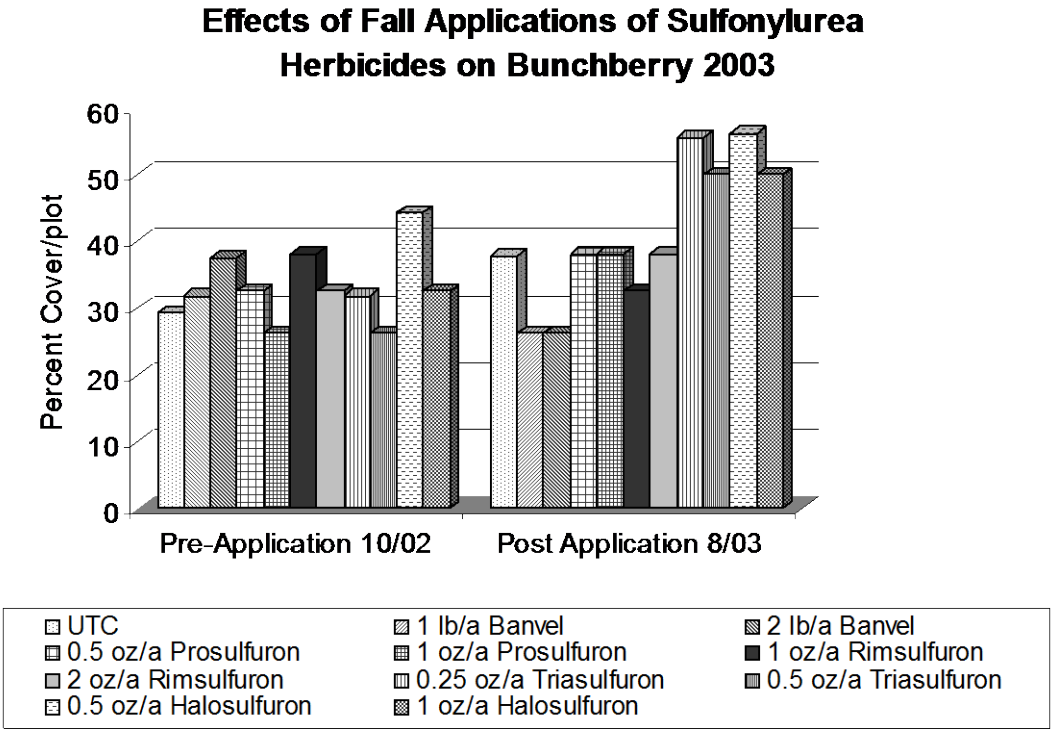


Figure 2



WEED MANAGEMENT AND FIELD COVER

INVESTIGATOR: David E. Yarborough, Professor of Horticulture
Kerry F. Lough, Research Assistant

21. TITLE: Assessment of clean-cut adaptor on hand clippers for weed control in wild blueberries

METHODS: Six treatments were each applied to 10 stems of fern, dogbane, and birch. Treatments consisted of a uncut control, being cut with the clean-cut adaptor, being cut with the clean cut adaptor with concentrated glyphosate in the form of Touchdown 5, being cut with the clean cut adaptor with concentrated glyphosate and 2% (17lbs/100 gal) ammonium sulfate (AMS), being wiped with 20% glyphosate, and being wiped with 20% glyphosate and 2% AMS. Fern and dogbane stems were located at Blueberry Hill Farm while the birch stems were located at Tibbers Flat (TF-4-24) near Columbia Falls. Treatments were applied on June 27 and July 2, 2003. Stems were evaluated September 16, 2003 for survival on a scale of 0-10 with 10 being 100% dead. Phytotoxicity of blueberry plants were also evaluated using a scale of 0-10, with 10 being the most severe.

RESULTS: Results indicate the five treatments reduced the growth and survival of all three species compared to the control (Figure 1-3). For both dogbane and birch, cutting alone did not significantly reduce the survival of the weeds as well as cutting with herbicide, wiping with the herbicide, and cutting or wiping with the herbicide and ammonium sulfate. There were no differences in the survival of either the woody or herbaceous weeds based on the type of application, or if ammonium sulfate was included. Application of the herbicide with the wiper resulted in more phytotoxicity to wild blueberries than with the clean-cut adapter on hand clippers for both the ferns and the dogbane, but not for the birch. A follow-up evaluation is planned for 2004 to determine the continued effectiveness of the treatments.

CONCLUSION: Both the cut and wipe treatments resulted in mortality among dogbane, fern, and birch stems. In order to complete evaluation of each method, these marked stems need to be re-evaluated in the 2004 season for long-term effects.

RECOMMENDATIONS: None at this time.

Figure 1

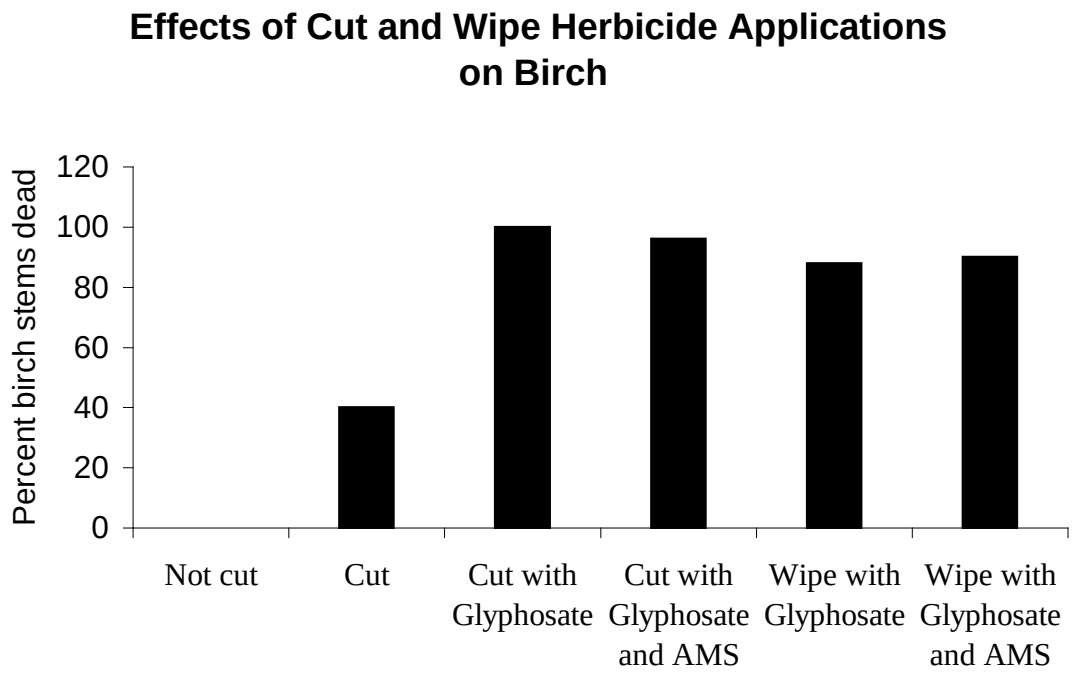


Figure 2

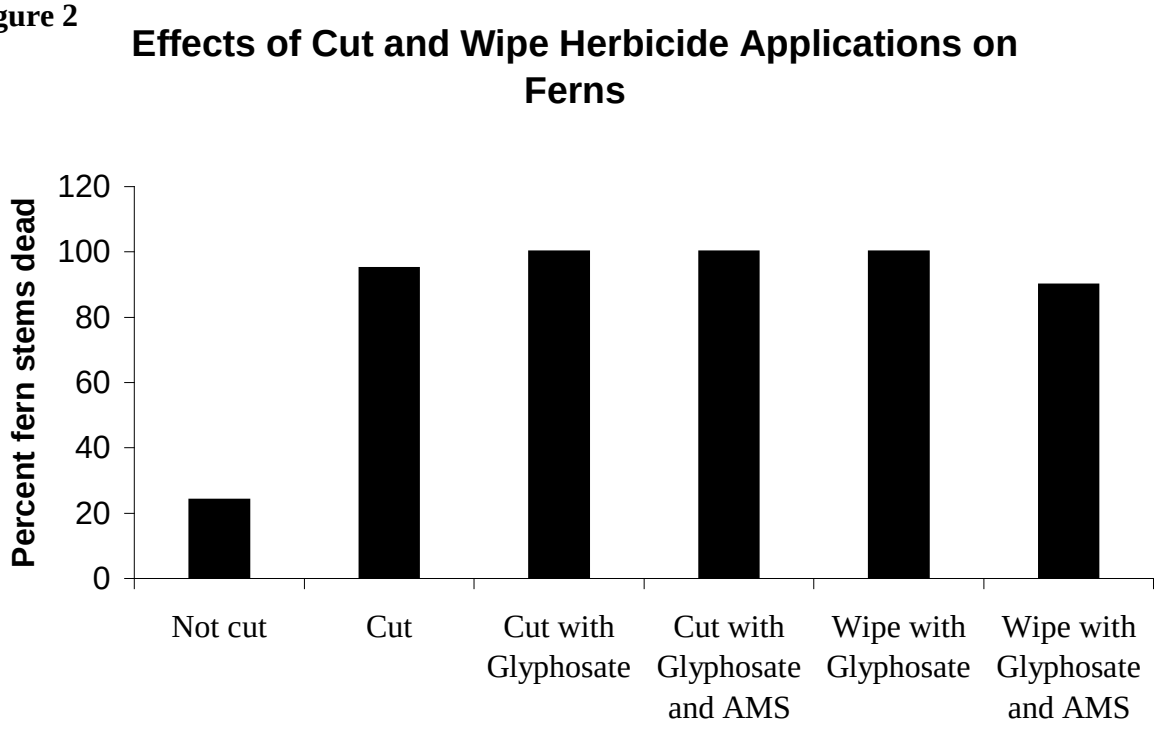


Figure 3

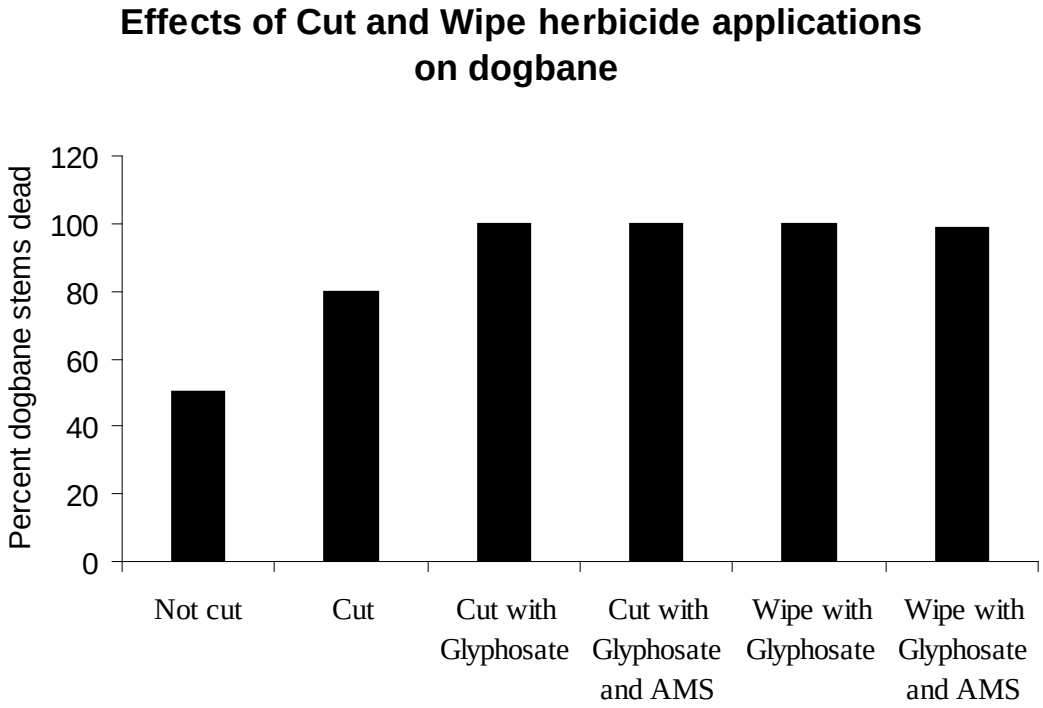
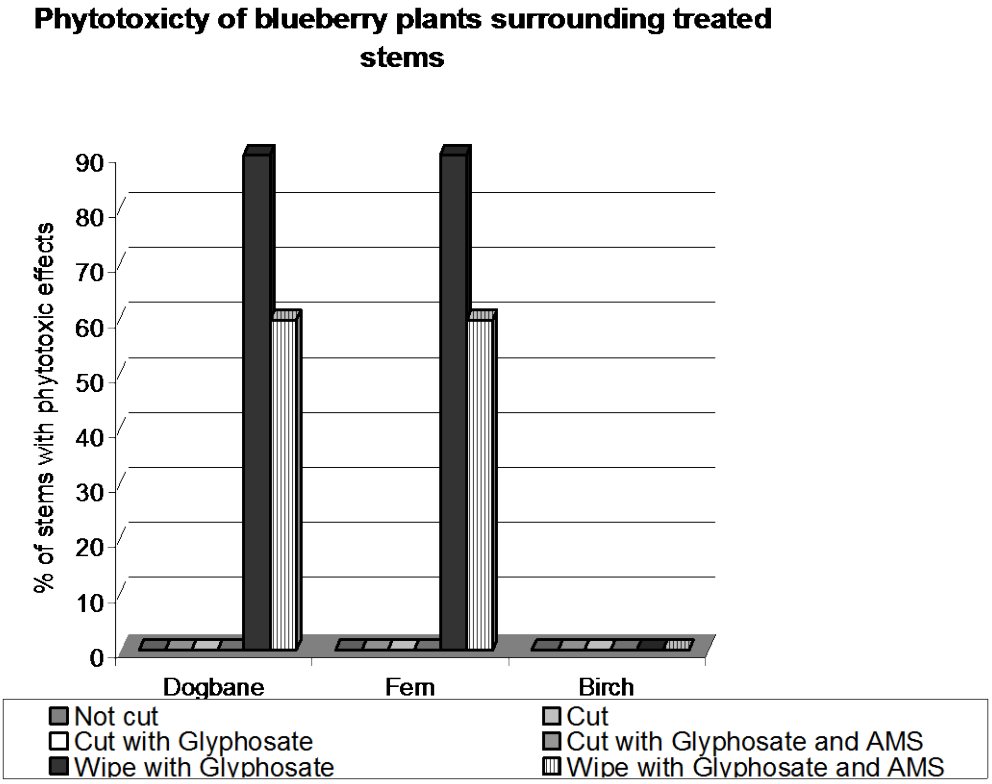


Figure 4



WEED MANAGEMENT AND FIELD COVER
INVESTIGATOR: David E. Yarborough, Professor of Horticulture

22. TITLE: Evaluation and Demonstration of Techniques for Filling in Bare Spots in Wild Blueberry Fields.

METHODS: Tissue culture wild blueberry plants were planted at a 1 foot spacing and mulched with three inches of bark. In 2000, in Aroostook County, one 40' x 40' plot was planted in an old potato field in Caribou and 2 lb/a Velpar and 1000 lb/a sulfur was added because the pH was 5.5. Another Aroostook site was established in Hamlin, in a field owned by Rene LeVasseur that had wild blueberry plants coming in naturally and so provided a good demonstration site. Soil analysis of the Hamlin site showed a pH of 4.7 and a sandy loam texture, both of which are suitable for blueberry growth. A 40' x 120' area in the field was mowed, Velpar applied at 2 lb/a and bark mulch spread at a depth of 3" in an 80' x 40' area. Blueberry plants were put in at 1' spacing over a 40' x 40' area. This site will serve as a demonstration on the feasibility of growing blueberry plants in Aroostook County. For comparison purposes, plants were inter-planted in bare spots among the established clones at Blueberry Hill Farm, and at Guptill Farm by their wild blueberry freezer building in Wesley. In Wesley a 30'x30' plot with plants at a 1'x1' spacing was established by the freezer. In 2002 the Hamlin and Jonesboro locations were treated with 1 lb/a Velpar and the Wesley location received 10 lb/a Pronone. In 2003 the Hamlin location was treated with 1 lb/a Velpar and the Wesley location was weeded by hand in the 1'x1' area of the blueberry plant.

Wild blueberry plant survival and spread from 10, 1-foot square subplots in each area were measured using cover scale ratings taken in the summer of 2001, 2002, and 2003. The rating represents the mean cover plants spread in a one-foot square plot.

RESULTS:

All sites increased in cover in 2003 (Figure 1). Hamlin had the largest increase in blueberry cover (Figure 2); Jonesboro had a smaller increase in cover than last year (Figure 3), while Wesley had a slightly larger increase in cover than in 2002, but still less than Hamlin. Wesley had high weed pressure (Figure 4) and continued high variability because of the Pronone application in 2002, but the surviving plants appear to be doing well (Figure 5).

CONCLUSION: Effective weed control at the Hamilin sight is augmenting increases in blueberry cover, while the Wesley site is continuing to battle high weed density and recovery from the Pronone application.

RECOMMENDATIONS: Continue with the project, maintaining weed control over the next two years, and continue evaluation of cover. Only the Velpar formulation of hexazinone will be used on all sites in the future. I use these sites to demonstrate feasibility of inter-planting tissue culture wild blueberry plants.

Figure 1

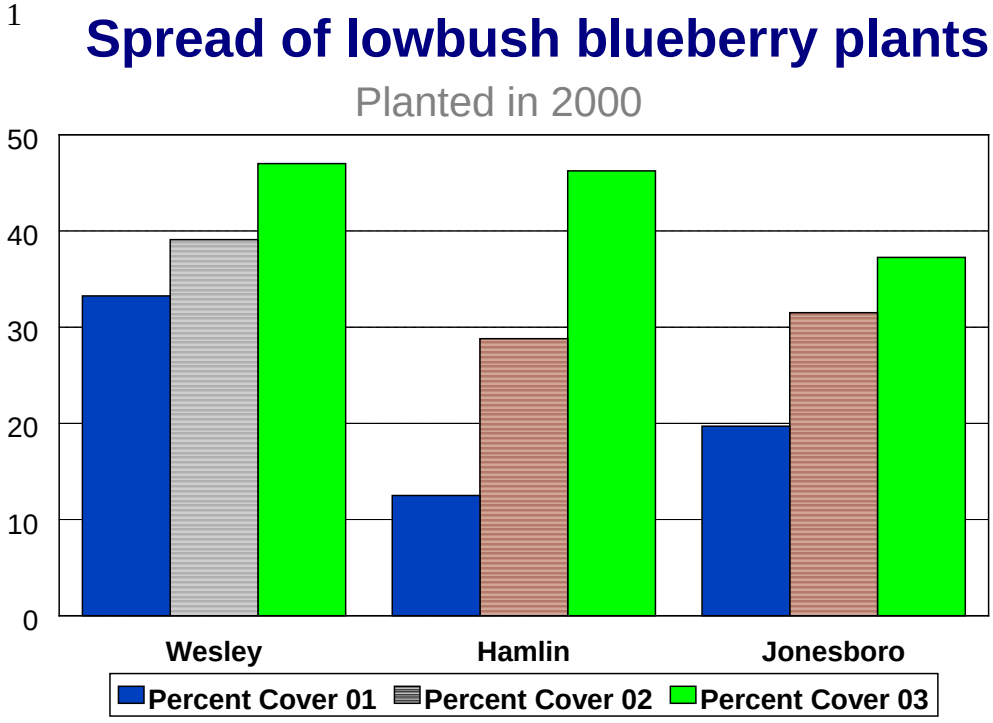

Spread of lowbush blueberry plants
Planted in 2000
50
40
30
20
10
0
Wesley
Hamlin
Jonesboro
Percent Cover 01
Percent Cover 02
Percent Cover 03

Figure 2. Velpar and Sinbar combination released blueberries at Hamlin.

Figure 3. Blueberry spread at Blueberry Hill Farm

Figure 4. Weed pressure at Wesley site.

Figure 5. Blueberry plant at Wesley Site

EXTENSION

INVESTIGATOR: David E. Yarborough, Extension blueberry Specialist

23. TITLE: Wild Blueberry Extension Education Program in 2003

METHODS: Conduct an educational program that will stress the use of best management practices in an integrated crop management program, which will improve the efficiency of culture and minimize the use of unnecessary pesticides and fertilizers. Conduct spring grower meetings and field days to introduce and reinforce the use of best management practices, integrated crop management and sound business management principles. Provide management information through the blueberry newsletters, fact sheets in the wild blueberry grower's guide both in print form and on the web at www.wildblueberries.maine.edu , telephone and correspondence, and conduct field visits as appropriate. Cooperate with County Educators and provide support for blueberry initiatives requested by the County office. Cooperate with the Blueberry Research Advisory Committee, the Wild Blueberry Commission of Maine and the Wild Blueberry Association of North America on blueberry related matters. Cooperate with county (Soil and Water Conservation Districts), state (Department of Agriculture, Board of Pesticides Control) and federal agencies (USDA, IR-4) on blueberry related matters. Needs are determined from Blueberry Advisory Committee long-range plan, Wild Blueberry Newsletter survey, and from individual client contacts. The advisory committee gave priority to grower outreach, IPM, pesticide recommendations for weeds, insects and diseases, food safety and groundwater. Needs identified by the survey include weed management, economics/ marketing, pest management, general information and fertilization. Needs identified by individual grower contact reinforce those previously identified but also added the need for blueberry quality and groundwater concerns.

RESULTS:

Educational Activities:
This year the Blueberry Integrated Crop Management program consisted of field demonstration sessions conducted three times in three counties. Program requirements have been better defined over the past years, new fact sheets have been developed and better examples have been provided, such as weed mapping and explanation of decision making for blight control and perimeter spraying of insecticides for blueberry maggot fly control.

Professional Improvement Activities:
Delivered the following talks at Professional Meetings:

Update on Pesticide Groundwater Survey in Maine. 2003 Annual Meeting Wild Blueberry Research and Extension Workers Meeting, Moncton, New Brunswick, April 10-11, 2003.

Wild Blueberry 2002 Pest Management Update. 2003 Annual Meeting Wild Blueberry Research and Extension Workers Meeting, Moncton, New Brunswick, April 10-11, 2003.

Grower meetings:

South Paris, March 10; Waldoboro, March 12; Ellsworth, March 13; Machias, March 15, 2003.

Blueberry Hill Farm Annual Field Day on July 16, 2003. Sponsored a water management tour for the afternoon portion of the meeting.

ICM sessions:

Wild Blueberry Pest Management Update, Maine Agricultural Trade Show, Augusta, ME, January 16, 2003.

Wild Blueberry Pesticide Applicator Training. Wymans C&D, Deblois, ME, April 15, 2003.

ICM field training sessions: *Knox/Lincoln Counties:* May 6, June 3 and July 1; *Washington County:* May 7, June 4 and July 2; *Hancock County:* May 8, June 5 and July 3, 2003.

Extension Presentations:

Taming the Wild Blueberry for LCH110 Horticultural Science class at UMaine, April 18, 2003.

Growing Wild Blueberries in the Home Garden, Spring Garden Celebration, Mount View High School, Thorndike, ME, May 1, 2003.

Best Management Practices for Wild Blueberries. Addison Town Meeting, June 11, 2003.

Wild Blueberry Production, Bar Harbor Health Summit, August 22, 2003.

Explained Maine wild blueberry production to hundreds of students at the 13th annual Agricultural and Environmental Day at the Farmington Fair on September 15, 2003.

Explained Maine wild blueberry production to hundreds of attendants of the Big E Agricultural Fair in Springfield, MA on September 20-21, 2003.

Equipment Calibration for LCH 25 Turf grass Management class at UMaine, October 1, 2003

Wild Blueberry Production, River Day for 100 plus Elementary school students at Eddington Salmon Club, October 16, 2003.

Publications:

Dalton, T.J., A. Files, and D.E. Yarborough. 2003. An Economic Assessment of the Returns to Irrigation Investment for Wild Blueberries. Acta Horticulturae. 626: 249-257.

Dalton, T.J. and D.E. Yarborough. 2004. The economics of Supplemental Irrigation on Wild Blueberries: A Stochastic Cost Assessment. Small Fruit Review Vol 3 (in press).

Yarborough, D. E. 2004. Factors Contributing to the Increase in Productivity in the Wild Blueberry Industry. Small Fruit Review Vol 3 (in press).
Jensen, K.I.N. and D.E. Yarborough. 2004 An Overview of Weed Management in the Wild Blueberry - Past and present. Small Fruit Review Vol 3 (in press).

Seymour, R.M ., G. Starr, and D. E. Yarborough. 2004. Yield and quality differences of lowbush blueberry (Vaccinium angustifolium) in irrigated and rain-fed conditions. Small Fruit Review Vol 3 (in press).

Television/radio/newspaper Interviews 2003:

The number of sources and multiple contacts are to illustrate that I am regarded as a reliable source in the media and that this interaction gives exposure and credibility to the University of Maine as a good, unbiased source of information.

Associated Press: July 8
Bangor Daily: February 5, June 28, December 1
Boston Globe: November 21, 24
BBC London Radio: July 27
Cooking light Magazine: July 10
Downeast Coastal Press: June 11
Ellsworth American: July 28, August 13
Lewiston Sun Times: March 11, July 8
Maine Public Radio: July 8
Midwestern News Radio: August 12
Mount Desert Islander: January 2
NewsinMaine.com: February 24,
New York Times: January 21, August 4
Portland Press Herald: April 30, December 10
Quoddy Times: November 10, 25
Village Soup: August 27, November 20
WLBZ: July 3
24/7 Book: December 8

Public testimony

Public testimony Maine Board of Pesticides Control, Augusta, ME: January 17, May 2, June 13, December 19, 2003.

Other program activities:

I am the principle investigator for USDA/CSREES *Wild Blueberry Production and Processing Technologies*, which provides funds for all aspects of wild blueberry production. I am responsible for obtaining, compiling and producing the proposals and reports both on paper and providing summaries for the Current Research Information System database on line.

I serve as the liaison for Maine in the IR-4, Minor Use Registration Program and convey project needs for all crops, as well as conduct projects. The objective of the program is to register least toxic alternative pesticides to replace materials that have been canceled so that our growers will be able to keep the minor crop production practices viable in Maine.

Developed educational program for Trade Adjustment Act, federal program to pay growers to compensate for increased imports and decline in field price of wild blueberries. In conjunction with the University of Minnesota, I developed the *Wild Blueberry Technical Assistance Curriculum,* a 126 page resource guide and five Power Point presentations on *World Trade Situation and Outlook, Enterprise Budgets, Production Efficiencies, Improving Quality, and Marketing Opportunities.* These have been produced as a web based course and may be found at http://www.agrisk.umn.edu/taa/Commodities/WildBlueberriesMaine/.

Since 1997, I have petitioned the Board of Pesticides Control each year to request a Section 18 for the use of the fungicide Orbit for the control of mummy berry disease in wild blueberry fields in Maine. I developed the original petition and continue to update it each year.

I report on the wild blueberry crop to the New England Agricultural Statistics Service (NAAS) on a weekly basis during the wild blueberry-growing season. NAAS uses the information to provide updates on the web for the wild blueberry crop for all that are interested.

I am a service provider for the Farms for the Future Program, worked with I Peaked Mountain Farm in Eddington and Ells Farm in Union to improve blueberry production and now am working with The Farm in Rockport and Highland Blueberry Farm in Stockton Springs to improve and diversify their wild blueberry operations.

I have worked the Coastal Land Trust in Camden to develop a management plan to improve production on the Beach Hill reserve.

I serve on the peer review committee for Cooperative Extension, the Department of Plant soil and Environmental Sciences and the joint peer review committees of Renae Moran & Mark Hutton. These review activicties take three weeks a year.

I have served as Secretary/Treasurer of the Northeastern Weed Science Society from 2000-2004.

I am a member of the University of Maine faculty senate representing Cooperative Extension.

Wild Blueberry Fact Sheets - 2003

New
Fact Sheet No. 251 Best Management Practices for Wild Blueberry Production in Maine
Fact Sheet No. 252 Cultural Management for Weeds in Wild Blueberries
Fact Sheet No. 253 Cultural Management for Insects and Diseases in Wild Blueberries
Fact Sheet No. 254 Cultural Management pH

Wild Blueberry Bulletin No. 630 Wild Bee Conservation for Wild Blueberry Fields by Drummond and Stubbs
Growing Lowbush Blueberries from Seed
Home Garden Lowbush Blueberry Planting Guide

Revised
Fact Sheet #227 (UMCE # 2256) Sources of Lowbush Blueberry Plants
Fact Sheet #224 (UMCE # 2040) Commercial Pollinators 2003
Fact Sheet #209 (UMCE #2001) 2003 Insect Control Guide for Wild Blueberries
Fact Sheet #239 (UMCE #2025) 2003 Weed Control Guide for Wild Blueberries
Fact Sheet #219 (UMCE #2000) 2003 Disease Control Guide for Wild Blueberries

CONCLUSION: Growers are participating in IPM programs in the four primary blueberry growing counties, Washington, Hancock, Knox and Lincoln. The skills survey results indicate that growers are learning new skills and making positive changes in their management practices. A high percentage of participating growers indicated they had learned new skills and changed their practices in calibration, reducing the rate of hexazinone used, being able to control blight, identifying and controlling weeds, being able to detect and control insects and the blueberry maggot fly and that they used soil and leaf samples to determine fertilizer rates. Adoption of these management practices will enable growers to improve the efficiency of blueberry culture by reducing unnecessary pesticides and fertilizers.

The hexazinone groundwater survey I have conducted from 1992 through 2003 continues to provide information on the movement of this herbicide into the groundwater. I have sampled test and drilled wells and surface water in blueberry fields over eleven years. This information has been used by the Department of Agriculture in both developing and in updating Best Management Practices and by the Board of Pesticides control in deciding to continue use of hexazinone in Maine. The survey indicates that grower's need the information provided by the meetings, fact sheets and newsletters. It also indicates that many growers are using integrated management techniques. Adoption of best management practices will enable growers to improve the efficiency of blueberry culture by reducing unnecessary pesticides and fertilizers. More efficient management will result in greater returns and a stable, sustainable industry.

RECOMMENDATIONS: Continue to support Extension educational program.

EXTENSION

INVESTIGATOR: David E. Yarborough, Cooperative Extension blueberry specialist

TITLE: 2003 Pesticide Groundwater Survey

METHODS: Surveyed seven drilled wells, two test wells, and seven adjacent surface water samples taken in May, June, July, August and September to test if herbicides and a fungicide is present. The three test wells were put in by the Maine Department of Conservation in 1986 and the others were drilled. One new site with three samples was added in 2003. A sample was taken from the Machias town water, from a well adjacent to the town well, and a stream draining towards the well. Well sites were chosen on the basis of a high probability of finding hexazinone. Residue analysis of the water was performed at the University of Maine Food Science & Human Nutrition Department with a high pressure liquid chromatography which has a detection limit of 0.05 parts per billion (ppb). Tests serve to monitor effectiveness of *Hexazinone Best Management Practices* and to determine if the herbicides hexazinone, terbacil and diuron and the fungicide propiconazole is present in groundwater.

RESULTS: Hexazinone levels in water varied over the season (Figure 1 and 2) and were similar to those found last year. Hexazinone levels ranged from non-detect (ND) to 10.9 ppb (Table 1). The site with highest hexazinone level at 10.9 ppb was the well adjacent to the Machias town well, but levels dropped to under a part per billion by August. The town water supply (42T) also showed an increase to 8.2 ppb in July but dropped to 0.74 to 1.1 ppb later in the year. A review of the management practices on the fields adjacent to the Machias town well indicate low rates and granular applications of hexazinone were made in compliance with best management practices. On the sites with test wells treated with diuron and terbacil, there were three surface water detections of terbacil and one test well detection near the limit late in the season and the adjacent stream had detectable levels in May, August and September. Propiconazole was detected at 0.12 to 0.19 ppb in three wells and in the adjacent surface waters at five locations. Neither of the samples persisted, one was reported at 0.005 which was well below the detection limit of 0.05 ppb. The trend for the data is a decrease in the levels in the spring, followed by a slight increase and a leveling off after applications were made (Figure 3 and 4).

CONCLUSION: These data further substantiate that the current use patterns are not resulting in any increase in hexazinone levels in the groundwater. When alternative herbicides are used, some detections can be expected on sites with sandy soils and shallow water tables. Propiconazole may be found for short durations in well and surface water. All detected levels were well below established EPA health advisory limits (HAL).

RECOMMENDATIONS: Continue to sample wells to ensure best management practices do not result in pesticide detection's above the HAL. Continue to vary management practices to determine how they influence pesticide movement in wild blueberry soils and review and update practices, as new information becomes available. Continue to emphasize best management practices to growers in educational programs and increase awareness of the solubility of hexazinone and potential for well water contamination.

Figure 1 Hexazinone in wells 2003

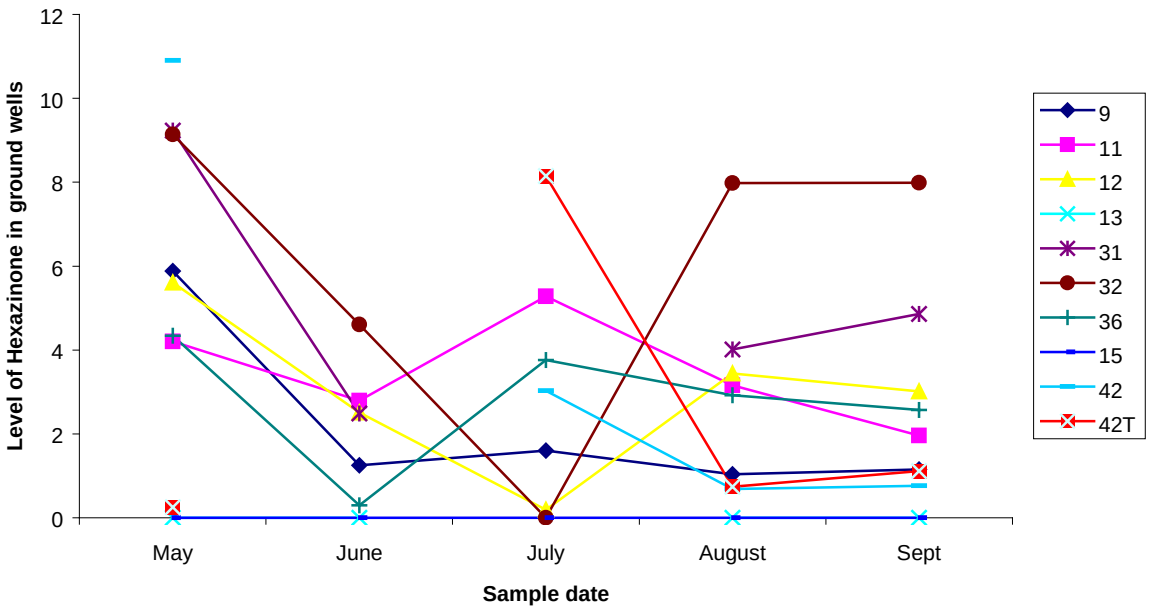


Figure 2 Hexazinone in Surface samples 2003

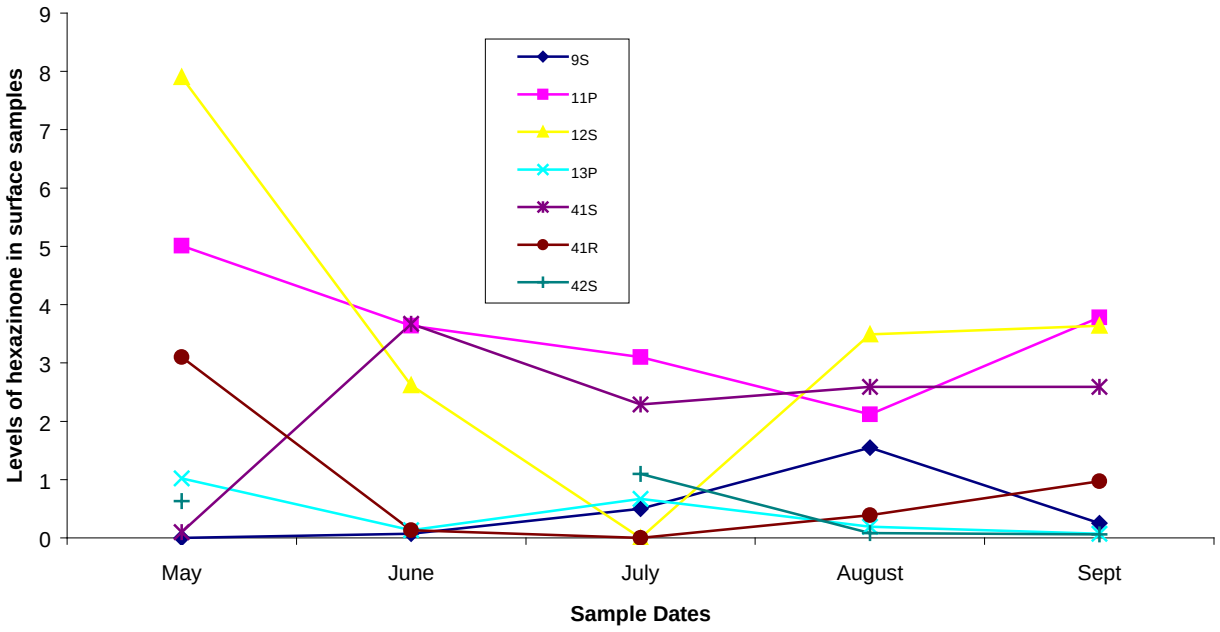


Figure 3 Groundwater Results Trend for Wells 2003

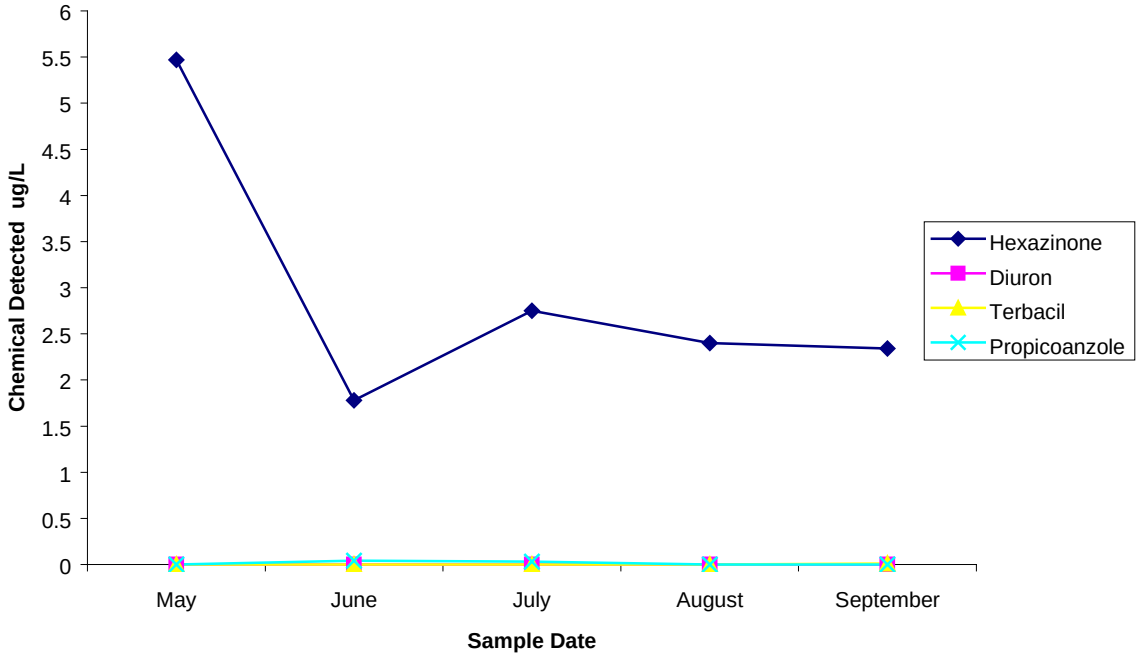


Figure 4 Groundwater Results Trend for Surface Water 2003

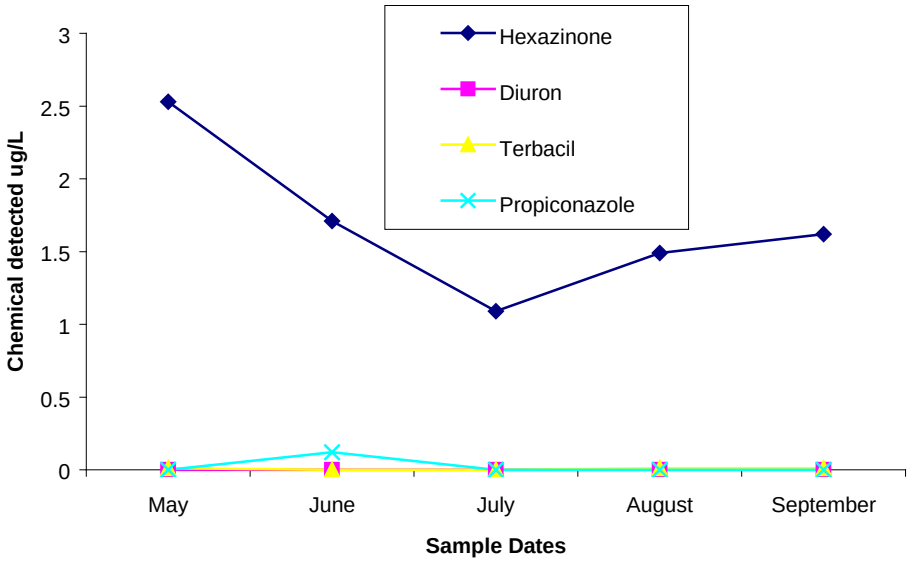


Table 1. 2003 Groundwater Test Result Summary
University of Maine Well Water Survey
Hexazinone/Diuron/Terbacil/Propiconazole in parts per billion

Site well/ Hexazinone (H) /Diuron (D)/ Terbacil (T)/ Propicoanzole (P)	**May**				**June**				**July**				**August**				**September**			
Wells	H	D	T	P	H	D	T	P	H	D	T	P	H	D	T	P	H	D	T	P
9 test	5.88	ND	ND	ND	1.25	ND	ND	0.185	1.6	ND	ND	0.1	1.04	ND	ND	ND	1.15	ND	ND	ND
11 test	4.2	ND	ND	ND	2.79	ND	ND	ND	5.28	ND	ND	ND	3.16	ND	ND	ND	1.96	ND	0.06	ND
12 test	5.61	ND	ND	ND	2.51	ND	ND	ND	0.19	ND	ND	ND	3.44	ND	ND	ND	3.01	ND	ND	ND
13 drill	ND	ND	ND	ND	ND	ND	ND	ND	NA				ND	ND	ND	ND	ND	ND	ND	ND
31 drill	9.23	ND	ND	ND	2.49	ND	ND	0.12	NA				4.01	ND	ND	ND	4.86	ND	ND	ND
32 drill	9.14	ND	ND	ND	4.91	ND	ND	ND	ND	ND	ND	ND	7.98	ND	ND	ND	7.99	ND	ND	ND
36 drill	4.34	ND	ND	ND	0.3	ND	ND	ND	3.76	ND	ND	ND	2.92	ND	ND	ND	2.57	ND	ND	ND
15 drill	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
42 drill	10.9	ND	ND	ND	NA				3.03	ND	ND	0.133	0.69	ND	ND	ND	0.76	ND	ND	ND
42T drill	0.25				NA				8.15	ND	ND	ND	0.74	ND	ND	ND	1.11	ND	ND	ND
Surface																				
9 stream	ND	ND	ND	ND	0.07	ND	ND	0.07	0.5	ND	ND	ND	1.55	ND	ND	ND	0.25	ND	ND	ND
11 pond	5.01	ND	0.08	ND	3.64	ND	ND	0.104	3.1	ND	ND	ND	2.12	ND	0.1	0.005	3.78	ND	0.08	ND
12 stream	7.9	ND	ND	ND	2.62	ND	ND	0.07	ND	ND	ND	ND	3.49	ND	ND	ND	3.64	ND	ND	ND
13 pond	1.02	ND	ND	ND	0.13	ND	ND	0.1	0.67	ND	ND	ND	0.19	ND	ND	ND	0.07	ND	ND	ND
41 spring	0.1	ND	ND	ND	3.67	ND	ND	0.37	2.29	ND	ND	ND	2.59	ND	ND	ND	2.59	ND	ND	ND
41 river	3.1	ND	ND	ND	0.13	ND	ND	ND	ND	ND	ND	ND	0.39	ND	ND	ND	0.97	ND	ND	ND
42 stream	0.63	ND	ND	ND	NA				1.1	ND	ND	ND	0.08	ND	ND	ND	0.06	ND	ND	ND

ND=no detect to 0.05 PPB NA=sample taken lost by lab

EXTENSION

INVESTIGATOR: David E. Yarborough, Extension Blueberry Specialist

25. TITLE: Cultural Weed Management using Sulfur to lower the pH.

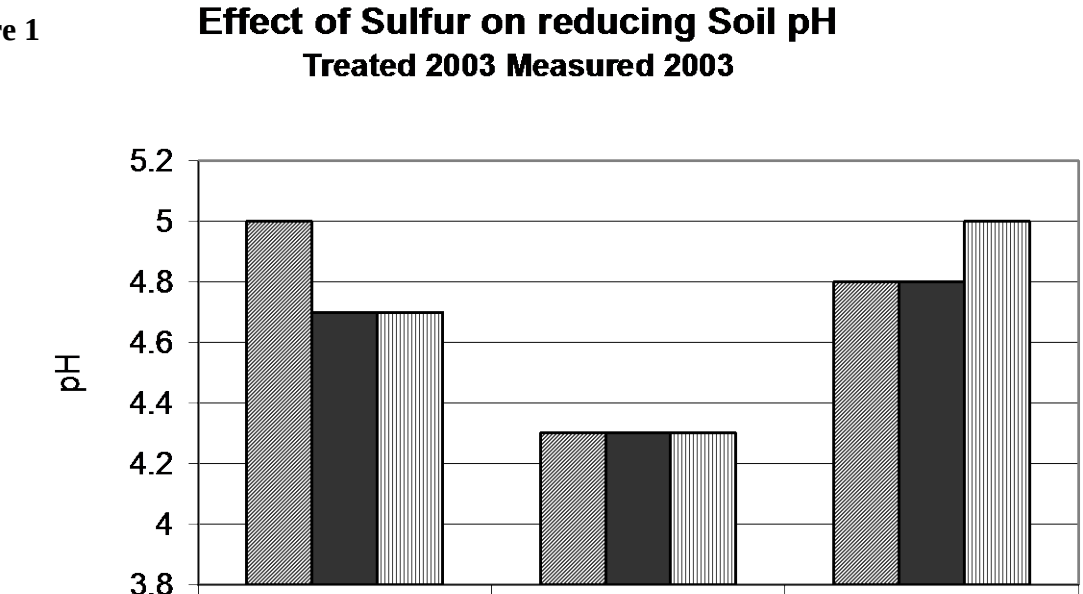
METHODS: Six sites were established in 2000 in Appleton, W. Rockport, Machiasport, Whiting and Wesley (2) and four in 2001 in Union, Jonesboro and Wesley (2) and treated with either 0, 0.5, 1 or 2 lb ai/a Velpar (except for Sinbar on two sites) and treated with sulfur at 0, 500, or 1000 lbs/a. Three new sites were established in 2003 in Eastbrook, Franklin, and Blue Hill that were treated with 0, 0.5, 1 or 2 lbs ai/a Velpar and with 0, 0.5, 1, or 2 lbs/a Sinbar, plots received sulfur at 0, 500 or 1,000 lbs/a. Soil samples are taken in each sulfur plot every year to determine the extent of pH change. The four Velpar plots (or Sinbar plots) by 3 sulfur plots provide 12 combination treatments per site and the new 2003 sites provide 24 treatment combinations per site (4 Velpar and 4 Sinbar by 3 sulfur). All were evaluated in August/September 2003 for weed cover density. Plots will be maintained and pH monitored each year to observe weed population pressure with corresponding change in pH. The Whiting plot was dropped in 2002 because the grower no longer wanted to cooperate.

RESULTS: Soil pH reduction varied by site and year treated with some showing more or less than the 0.5 pH reduction with 500 or 1000lb/a sulfur application (figure 1, 2, 3). In Figure 1 there are no changes seen because this is the first year of sulfur application. There were small increases in pH at several sites (no more than 0.2) in 2003. Although grass, herbaceous, and woody weed cover were reduced with sulfur application, no significant effect was seen (figure 4). Weed cover was reduced with both Velpar and Sinbar applications (figure 5, 6). The only significant reduction was the effect Sinbar had on woody weed cover when comparing 0 lbs/a and 0.5, 1, and 2lbs/a. Sulfur and herbicide interactions did not indicate a significant effect on weed cover.

CONCLUSION: As expected, the pH reduction among sites varied because of variations in factors such as soil CEC differences. Although pH was reduced from 0.5 to 0.7 pH units on some sites, no corresponding reduction in weed cover was seen. It appears there is a trend for a weed suppression effect of the reduced pH but because of the variability, significant effects other than that on woody cover may take more time to occur.

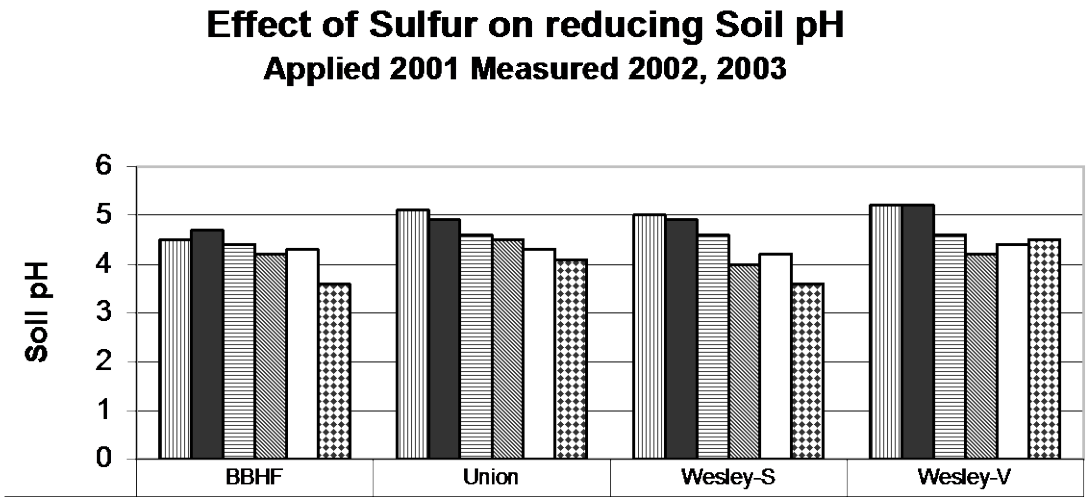
RECOMMENDATIONS: This project should be continued over at least three production cycles in order to document changes in weed composition associated with the decrease in pH.

Figure 1



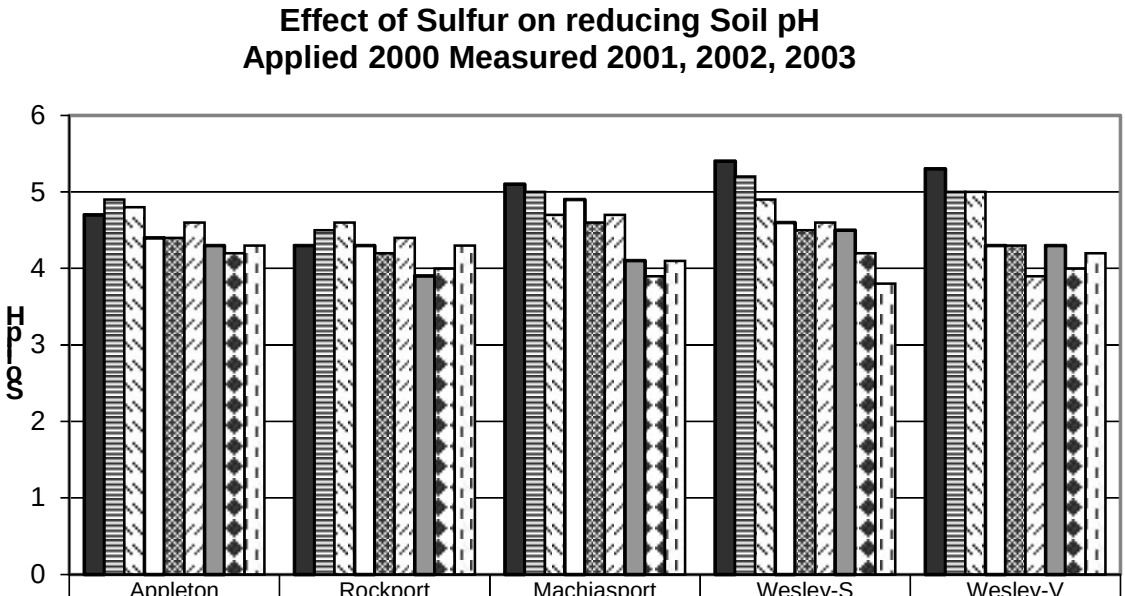
	Blue Hill	Eastbrook	Franklin
0S-03	5	4.3	4.8
500S-03	4.7	4.3	4.8
1000S-03	4.7	4.3	5

Figure 2.



	BBHF	Union	Wesley-S	Wesley-V
0S-02	4.5	5.1	5	5.2
0S-03	4.7	4.9	4.9	5.2
500S-02	4.4	4.6	4.6	4.6
500S-03	4.2	4.5	4	4.2
1000S-02	4.3	4.3	4.2	4.4
1000S-03	3.6	4.1	3.6	4.5

Figure 3.



	Appleton	Rockport	Machiasport	Wesley-S	Wesley-V
0S-01	4.7	4.3	5.1	5.4	5.3
0S-02	4.9	4.5	5	5.2	5
0S-03	4.8	4.6	4.7	4.9	5
500S-01	4.4	4.3	4.9	4.6	4.3
500S-02	4.4	4.2	4.6	4.5	4.3
500S-03	4.6	4.4	4.7	4.6	3.9
1000S-01	4.3	3.9	4.1	4.5	4.3
1000S-02	4.2	4	3.9	4.2	4
1000S-03	4.3	4.3	4.1	3.8	4.2

Figure 4

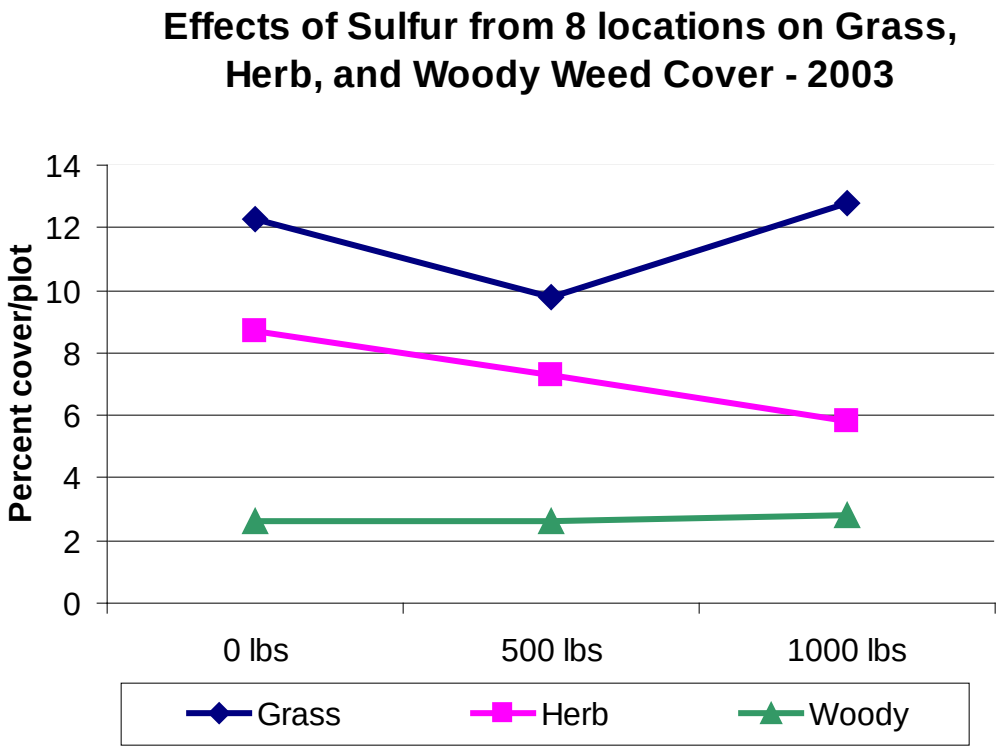


Figure 5

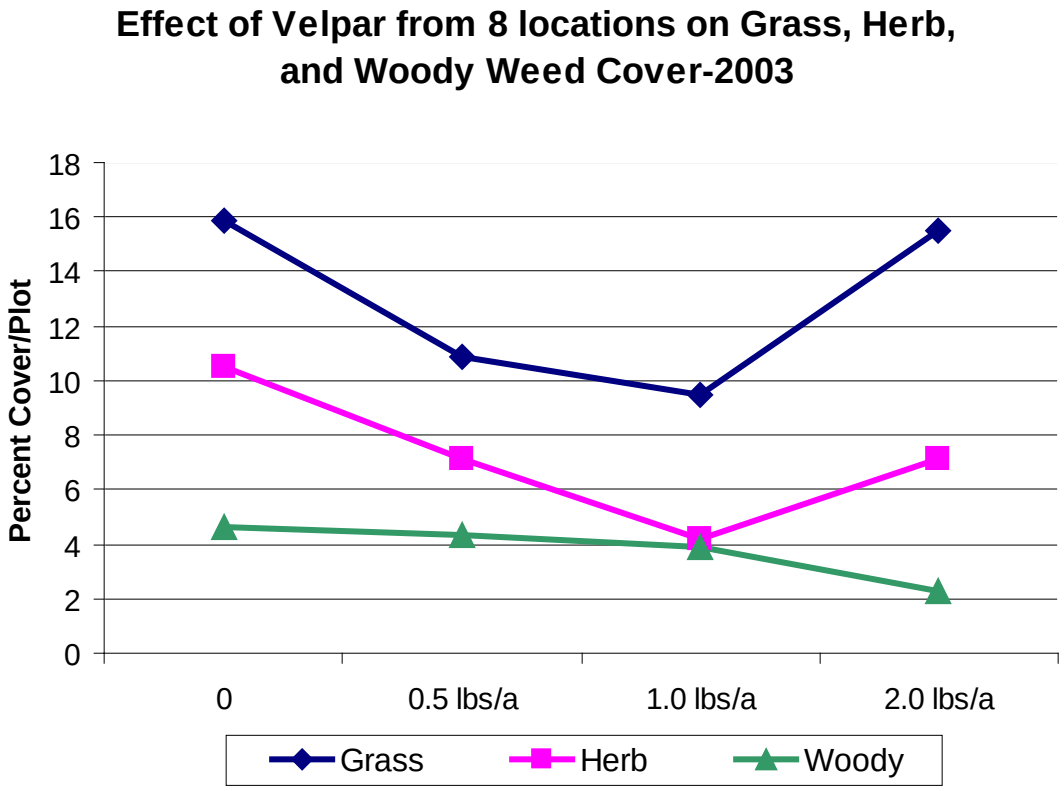
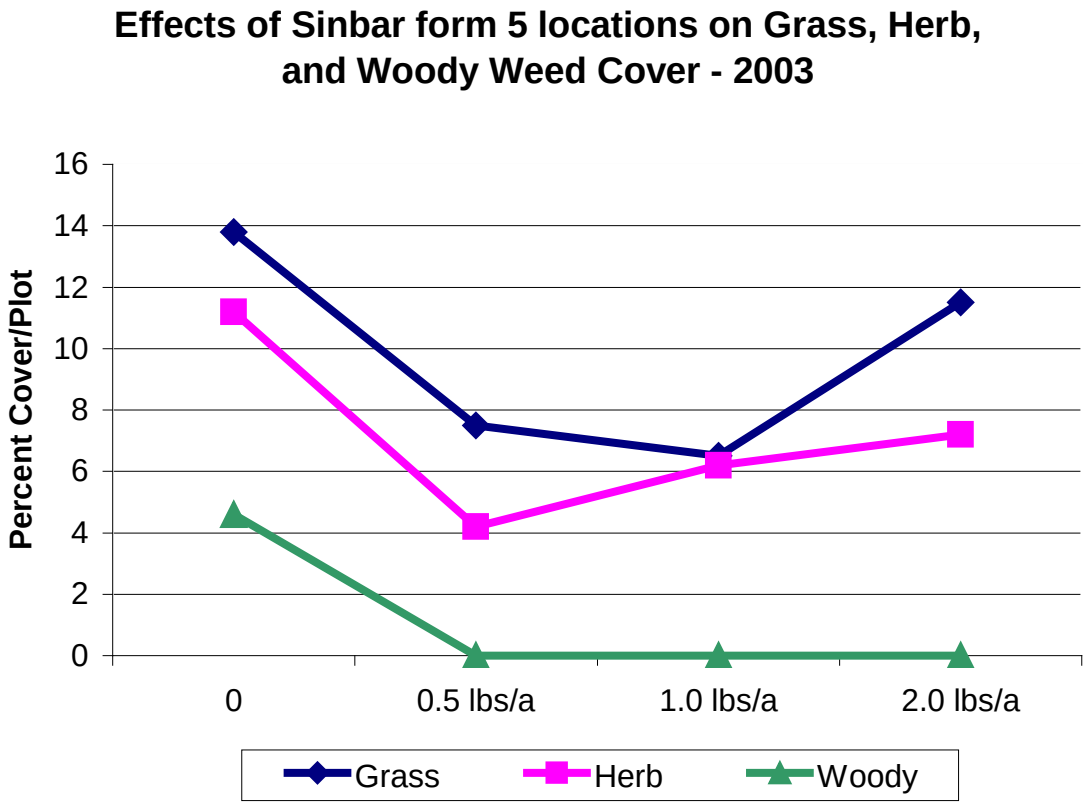


Figure 6


Effects of Sinbar form 5 locations on Grass, Herb, and Woody Weed Cover - 2003
Percent Cover/Plot
16
14
12
10
8
6
4
2
0
0
0.5 lbs/a
1.0 lbs/a
2.0 lbs/a
Grass
Herb
Woody