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2002 Wild Blueberry Project Reports

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2002 Wild Blueberry Project Reports

EXTENSION

FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS Alfred A. Bushway, Professor of Food Science
Rodney J. Bushway, Professor of Food Science
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TITLE: Factors Affecting the Microbial and Pesticide Residues Levels on wild 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, and 1.0% hydrogen peroxide before analysis for phosmet residues. Contact times were 60 and 120 sec. 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 ozone treatments were performed using home-use ozone generators. Two liters of water was ozonated for 10 minutes according to product directions. Berry samples of 350g were then submersed in the ozonated water for 120 seconds. As a preliminary test, 350g of blueberries were ozonated in two liters of distilled water for 10 minutes; however, log reductions were similar to those seen when the distilled water was ozonated for 10 minutes prior to washing.

Ozone/100ppm chlorine or 1% hydrogen peroxide treatments: 350g samples were submersed in 2L of ozonated water for 120 seconds followed by spray treatments with either 100ppm chlorine or 1% hydrogen peroxide. Spray treatments were also allowed a 120 second contact time. All tests and treatments were performed in triplicate and plated in duplicate.

RESULTS: Table 1 and 2 present the data for the effect of treatment and contact time on the mean log reduction for total aerobic plate counts over the three weeks of this study. The data shows that contact time did affect the efficacy of the 100 ppm chlorine and 1% hydrogen peroxide treatments. In each case the log reduction was doubled when contact time went from 60 to 120 sec. Of particular note is the nearly 2-log reduction with 1.0% hydrogen peroxide. There was no synergistic effect of combinations of ozone with chlorine or hydrogen peroxide. In fact, ozone appears to reduce the effectiveness of chlorine and hydrogen peroxide. One must remember that in these experiments home-use ozone generators were used.

TABLE 1
Total Aerobic Plate Counts Mean[c] Log (CFU/g) Reduction

	60 SECOND CONTACT TIME	LOG REDUCTION
CONTROL	3.52 ± 0.40	
OZONE	3.10 ± 0.59	**0.43**
100PPM CHLORINE	2.83 ± 0.08	**0.69**
1% HYDROGEN PEROXIDE	2.66 ± 0.34	**0.86**
DISTILLED WATER	3.17 ± 0.28	**0.36**

TABLE 2

Total Aerobic Plate Counts Mean[c] Log (CFU/g) Reduction

	120 SECOND CONTACT TIME	LOG REDUCTION
CONTROL	3.52 ± 0.40	
OZONE (1)	3.92 ± 1.19	**-0.39**
OZONE (2)	3.53 ± 0.06	**-0.02**
100PPM CHLORINE	2.49 ± 0.33	**1.03**
1% HYDROGEN PEROXIDE	1.58 ± 0.28	**1.94**
DISTILLED WATER	3.25 ± 0.59	**0.27**
OZONE/100PPM CHLORINE	3.11 ± 0.46	**0.40**
OZONE/1% HYDROGEN PEROXIDE	2.84 ± 0.31	**0.67**

Negative values for log reductions indicate an increase in microbial load as compared to the control or non-treated sample. Sampling probably accounts for these differences. Only a few samples were positive for coliforms and no *E. coli* were detected in any of the samples (detection limit of 3 cells/g).

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. This research is being proposed for the next year.

FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Mary Ellen Camire, Professor of Food Science
Kathy Davis-Dentici, Scientific Technician
Michael Dougherty, Research Associate
Kathleen Buzzard, Graduate Student

TITLE: Effect of Blueberry Products on Oxidation in Meat Based Food Systems

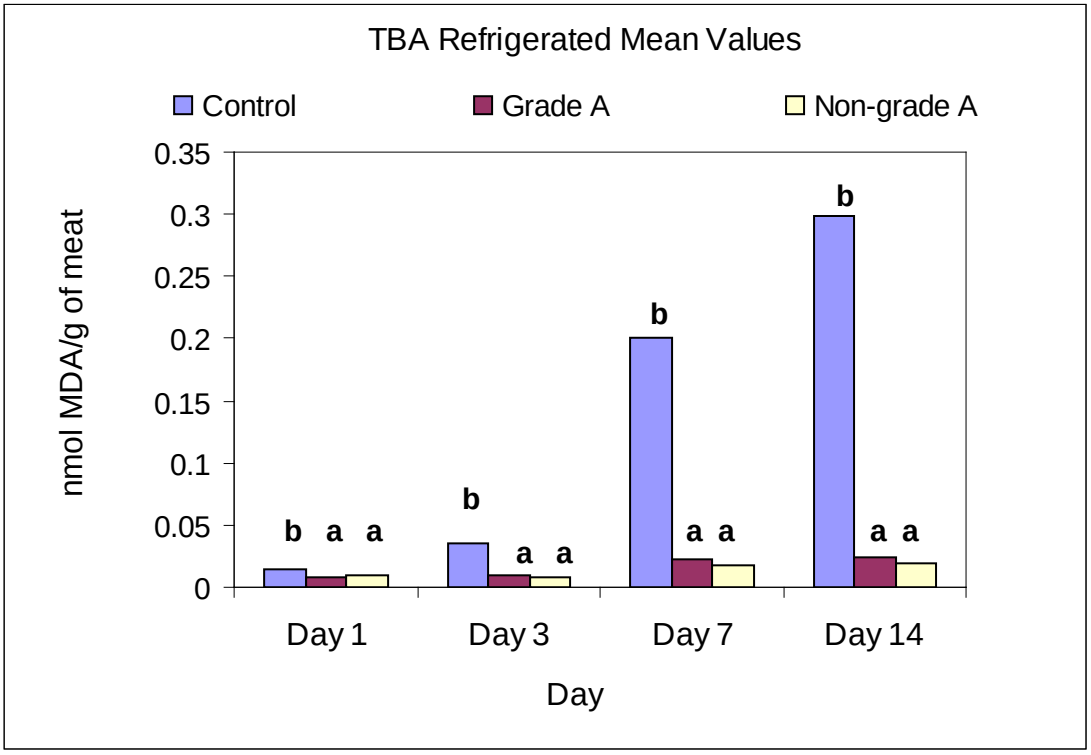
METHODS: Ground turkey patties were processed from 93% lean ground turkey with 3.5%% (w/w) lowbush blueberry puree, which had been prepared from off grade or sorter rejects. Untreated turkey patties were prepared to serve as the negative control. Patties were broiled to an internal temperature of 75 C. Precooked turkey patties were stored under refrigeration (4-5 C), and evaluated for oxidation using two chemical methods [Thiobarbaturic acid (TBA) reactive substances and hexanal production) at 0, 3, 7, 10 and 14 days of storage. The experiment was replicated once. Additional samples were stored frozen for up to 180 days in Experiment 1 and for 90 days in Experiment 2. A colorimetric method was used for TBA analyses and a gas chromatograph equipped with a headspace analyzer was used to determine hexanal concentrations. A consumer panel was used to evaluate the cooked patties from Experiment 2 for preference on day 3 of refrigerated storage and day 30 and 90 of frozen storage.

RESULTS: For both Experiment 1 and 2, the blueberry purees significantly decreased ($p \leq 0.05$) TBA values in the refrigerated turkey patties (Figure 1 & 2). The effects of the purees were more pronounced in the refrigerated turkey patties than the frozen turkey patties. The control patties over the fourteen days of refrigerated storage consistently had higher TBA values than patties containing both blueberry purees. TBA values during frozen storage fluctuated among treatments. Other researchers have reported similar results with frozen food products. Gas chromatography results for Experiment 1 and 2 showed that both blueberry purees significantly lowered ($p \leq 0.05$) hexanal production in the turkey patties during refrigerated storage (Figure 3 & 4). An overall trend was found between treatment and hexanal content. On all of the refrigerated days tested, hexanal content was higher in the control patties than either puree treatments. The frozen storage treatments also showed similar results with the control having higher hexanal concentrations than either purees except on day 150. Results from the consumer panel were variable. Fresh ground turkey patties were always presented as one of the treatments along with the precooked control and the two blueberry puree samples. Panelists commented on the dark color of the turkey patties with blueberry puree as well as the gritty texture associated with the seeds in the puree. It was determined that there is a potential market for turkey patties containing blueberry puree based on these acceptability scores. However, plain ground turkey patties are a novelty food item. Some panelists did note that they purchased ground beef for burgers not turkey. Advertising the potential health benefits of the blueberry purees could be a good marketing tool.

RECOMMENDATIONS: There is potential for incorporating blueberry products into meat-based systems. Using a juice concentrate in the formulations may solve the problem with the

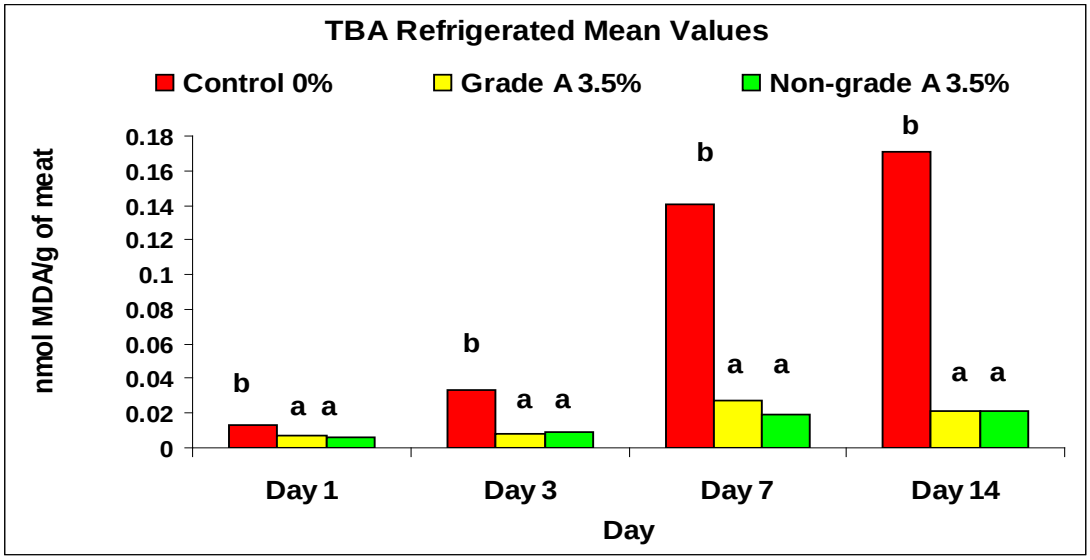
seeds in the puree. Experiments are currently underway to determine the feasibility of using juice concentrate in both beef and turkey patties. Because of the higher anthocyanin and phenolic content of the juice concentrate, less may be required for retarding lipid oxidation and warmed over flavor development. This may also lead to improved color in the precooked patties.

Figure 1. TBA Concentrations in Refrigerated Turkey Patties



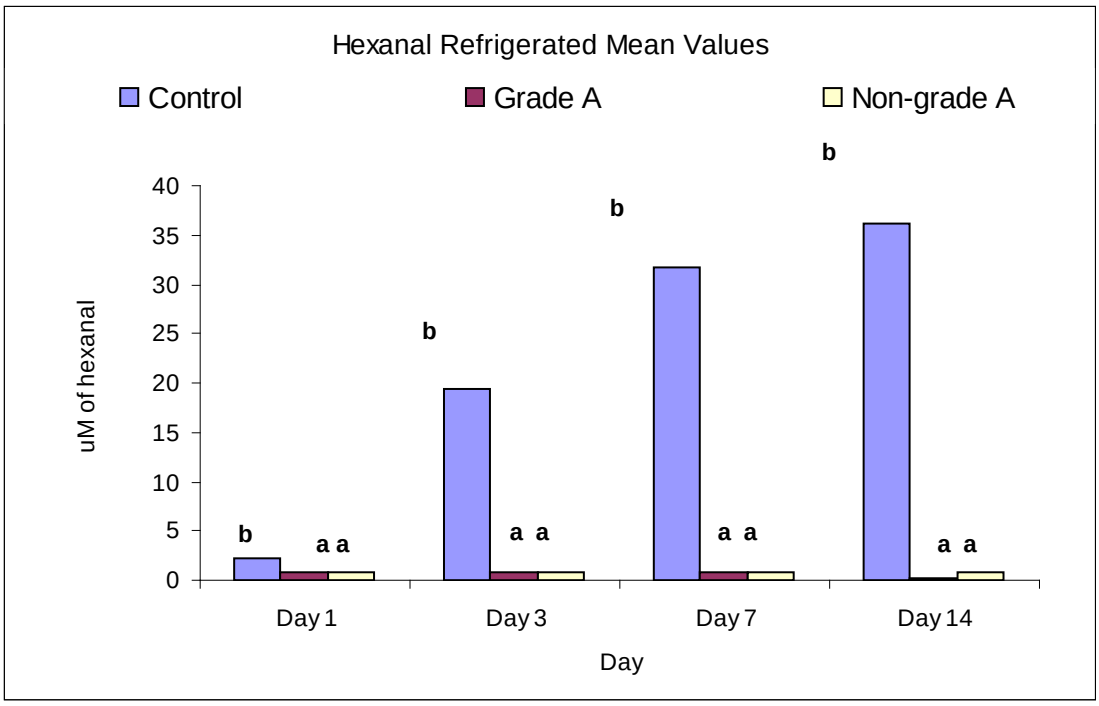
*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Figure 2. TBA Concentrations in Refrigerated Turkey Patties



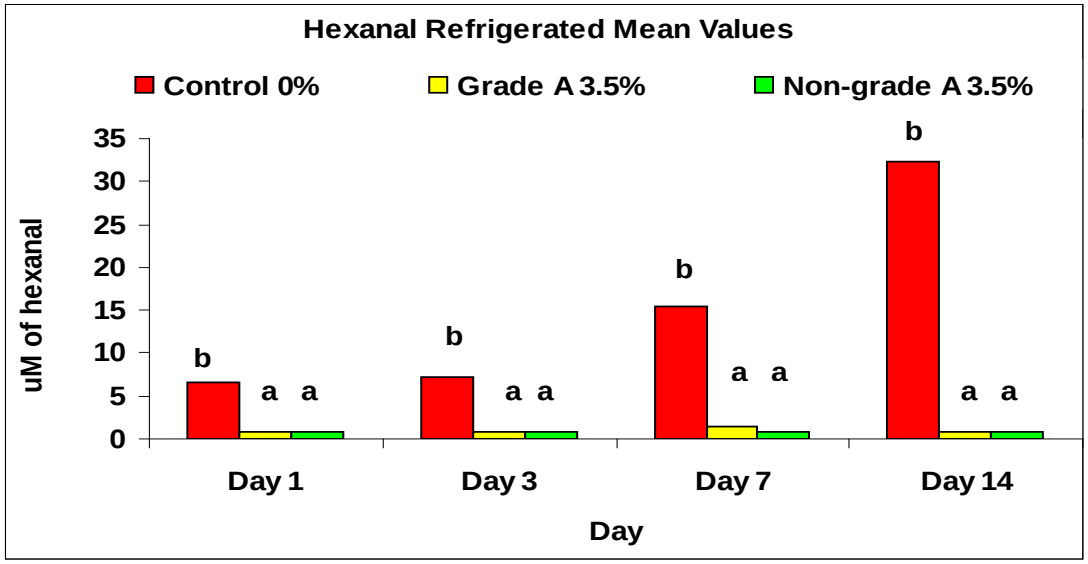
*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Figure 3. Hexanal Concentrations in Refrigerated Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean scores were determined by triplicate replications.

Figure 4. Hexanal Concentrations in Refrigerated Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
L. Brian Perkins, Research Chemist

TITLE: Determination of Pesticide Residue Levels in Fresh and Processed Wild Blueberries.

METHODS: Blueberry samples (6 pounds each) were collected by processors and brought to the University of Maine Food Safety Laboratory in September and October of 2000. Samples were stored frozen until they were analyzed during December, 2000 and January, 2001. Pesticide residues in the blueberries were assayed using high pressure liquid chromatography (HPLC), gas chromatograph-atomic emission detector (GC-AED) and enzyme-linked immunsorbent assay (ELISA) methods developed in the Food Safety Laboratory.

RESULTS: Seventy-five samples were analyzed from the 2000 wild blueberry crop (table 1). Twenty-five (33%) of the 75 samples were positive for phosmet (Imidan®)(0.011 to 0.788 ppm); two (2.7%) were positive for azinphos-methyl (Guthion®) (0.037 to 0.073 ppm)); no sample contained carbendazim, methoxychlor, hexazinone (Velpar®), captan(Captan®) or propiconazole (Orbit®). All of the residues found were well below the EPA tolerance levels.

CONCLUSION: When the residual tolerances of these pesticides is considered, the levels found on the 2000 Maine wild blueberry crop is very low. The number of samples positive for phosmet and azinphos-methyl were similar to previous years. This is the first year the any sample was positive for propiconazole. This may be due to the fact that propiconazole use is relatively new to the industry.

RECOMMENDATIONS: The continued collection of data will enable us to maintain a data base for residual pesticides which is invaluable to the wild blueberry industry.

FUTURE WORK: Development of gas chromatograph/multispectral/atomic emission detector (GC/MS/AED) methods for a number of pesticides that are now used more commonly by the industry. Development of liquid chromatograph with tandem mass spectraldetectors (LC/MS/MS) methods to assay agrochemical metabolites and new polar metabolites, such as the sulfonylureas

FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATOR: Dr. Darrell Donahue, Chemical and Biological Engineering-UMaine

COLLABORATOR: Dr. Frank Drummond and Judy Collins, Biological Sciences-UMaine

TITLE: Infestation Detection using NIRS

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, 2002, 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 sciences laboratory. Blueberry maggot adults were reared from pupae collected in 2001 (See Bio. Study 1 of 1999 report). 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 than 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 moved to the biological engineering laboratory and 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, usually due to the maggot crawling out, were put aside if they were not usable. Other usable blueberries were assigned names according to their origin (e.g., "Jonesboro") and the batch number. Each batch was separated in two to five subsets of 96 berries each and designated with a letter (A, B, C, D, and E). All berries from each set were scanned on the same day and under the same conditions. These berries were then counted and recorded on the data sheet. Each of the scannable berries 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 or over 11 mm were not used. Each berry was sized and placed in an individually labeled tray, which depicted the date, quart number, and berry number. Once these steps were completed the berry was held until it was scanned using one of the three NIRS systems. Figure 2 gives a schematic of the basic overall berry scan procedure 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 15 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.). See Figure 2 below for more details of the set up. 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 and one using the bifurcated cable.

At USDA-ARS-Michigan (MSU), scanning set up and equipment was different. The MSU equipment uses a model SU320-1.7RT-D sensor/detector (Sensors Unlimited, Princeton, NJ) in the 900 – 1400 nm range. The receiving fibers are mounted at 45 degree angles from the excitation light source and approximately between 3 and 5 mm from the berry surface. At USDA-ARS-Kansas (KSU), uses two detectors (a silicon detector at 400-950 nm and an InGaAS detector for 950-1700 nm). The KSU receiving fiber was at 360 degrees (right beside) the excitation light and approximately 12 mm from the berry surface. A different setup with 10 mm distance to the surface of the berry was also tested. In collaboration with Dr. David Slaughter, professor at University of California, Davis, California, (UC-Davis) berries were sized, shipped and scanned using a NIRSystems model 6500 (FOSS NIRSystems, Silver Spring, MD) in reflectance mode for the 400 to 2500 nm wavelength range (a silicon detector for 400-1100 nm and a lead sulfide detector for 1100-2500 nm region). See Figure 2 for a graphical representation of these set ups.

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 (ground truth). 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 whether a maggot is 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. These 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 discriminant model. The observed anomalies in the raw spectra were compared later with outlier spectra identified by Partial Least Squares (PLS).

Spectral data were averaged based on berry type (wild or cultivated), experimental date, position of scan (stem or calyx) and instrument used. Averaged spectra from infested and non-infested blueberries were subtracted in order to examine the difference spectra for potential wavelength areas that would indicate differences that can be attributed to the presence of infestation in the blueberries. Modeling experiments with averaged spectra were carried out by extracting all spectra of infested and non-infested berries scanned on the same day. Next, non-infested berries were divided in two groups and averaged and the same number spectra of infested berries were averaged resulting in three spectra for each scan date. Subtractions between the two non-infested averaged spectra and a non-infested and infested averaged spectrum were made (see Figure 3).

PLS analysis was carried out on most of the data from 2002 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) data. This involves regression of the independent variations contained in the spectra against the constituent concentrations. All independent variations are captured in separate factors called also 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 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). Samples were considered infested if predicted values were greater than a rejection threshold, and all others were considered non-infested. The threshold was calculated as mean of the assigned arbitrary values for each data set. For some unbalanced data sets this method proved to be not successful so the average of the two constituent values was used instead.

Different types of preprocessing were examined to determine the best approach for successful prediction by PLS. Spectral data sets scanned on different days with the same instrument and settings were combined after averaging all replicates. PLS was performed on these large data sets and on individual data sets consisting of berries from the same batch, scanned on the same day with the same instrument. Classification was tested after calculating the average spectrum of all the spectra and then subtracting the result from each spectrum (mean centering) or scaling by the standard deviation for each wavelength also called auto scaling and selection of wavelength bands. These methods are often used in spectroscopic data analysis as they further enhance the calibration model.

Cross validation was used in the analyses 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 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 how successful the prediction is. 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 = $SECV^2$xNumber of samples (see Figure 3). Cross validation was performed for all models removing consecutively one sample or all replicates of the same sample from the data.

After calculating the PLS model and cross validation the spectral and constituent value, outliers were identified based on the residual plots, removed from the data sets and the model was recalculated. Constituent concentrations residuals represent the prediction error for each sample which is the difference between the actual and predicted concentration. Spectra residuals are the difference 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 (Figure 4). For any given wavelength, the absolute value of the beta coefficient or loadings indicate how important that wavelength was for prediction; a beta coefficient of 0 indications no importance to prediction.

RESULTS:

1. Artificial laboratory infestation and preparation

The laboratory experiment to artificially inoculate berries with maggot larvae was very successful this season. Approximately 58 % maggot infestation rate was achieved. 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 and be optimized and yield high portions of infested berries. Therefore, research by Drummond should continue in this area.

2. NIRS: data processing, modeling and analysis

Data processing. The results from subtractions of averaged spectra based on infestation, scan date and instrumental setup showed differences between averaged spectra of infested and non-infested berries in almost the whole wavelength bandwidth of the UMaine and KSU instrument (see Figure 5). By examining raw spectra differences were found between infested and non-infested blueberries. The regions where the two resulting spectra differed were 700-800 nm for the UMaine spectra and 1400 - 1600 for the KSU spectra. These differences are potentially interesting for identification of the position of the berry by NIR spectroscopy.

Modeling and analysis. Wavelength region selection. Models on single and combined data sets were used to test for prediction improvement by wavelength region selection (see Tables 1 and 2). After using different wavelength bands in models of single data sets from UMaine, the prediction did not improve compared to using the whole spectra and the total correct classification was lower, 54.2% compared to 61.8% for the whole spectrum. The best prediction when using UMaine data was for the wavelength region 950 – 1100 nm, while the models on other selected wavelength bands were less efficient with correct classification, see Table 1.

In the combined KSU data set the region of 1400 to 1600 nm was selected based on results from subtractions of averaged spectra and calibration coefficients from previous PLS models. Relatively good total correct classification of 70.4 % was obtained for this model although it is lower than the classification for the whole spectrum at 81.3 % (see Table 2). This can be expected since this is the wavelength range for proteins and amino groups overtones which are the major distinctive compounds of fly larvae (maggots).

These results indicate that the differences between spectra of non-infested and infested berries as identified by PLS are most likely to be found in the longer wavelength bands of the spectra. However, best prediction results are achieved when modeling the greater part of the measured wavelength range rather than single wavelengths or wavelength bands.

PLS models, single data sets. PLS models were calculated on single data sets and results for a portion of them are presented in Table 3. Outliers were removed before recalculating the models and mean centering was used as preprocessing which enhanced successful classification in most of the cases. The suggested number of factors based on PRESS value reduction for most of the data set was between 5 and 6 indicative of different physical or chemical properties of the berries. Although these model factors cannot be attributed to specific properties of the samples at this stage of the project, it can be noted that the factors or their combinations are correlated to infestation presence or absence. For most of the models, the percent correct classification for data set scanned at KSU, UMaine and UC-Davis was higher than for the ones scanned at MSU. Correct classification after modeling spectra scanned at UC-Davis was lower compared to UMaine data, but this can be attributed to the fact that there was only one data set scanned at UC-Davis with much smaller number of samples.

Overall the best prediction was achieved when modeling the whole spectra of berry set Jonesboro 1C at 77.0 % with the KSU instrumental set up, even though it was an unbalanced data set with much higher number of non-infested berries than infested. Generally prediction of infestation was better for data sets with larger number of samples. For achieving good classification results using PLS, a much larger number of samples is required to maximize the accuracy of the calibration model and enhance prediction. The contribution to correct classification of both non-infested and infested samples varied with each data set. From the 2002 data sets, it cannot be determined whether infested or non-infested samples are predicted better by the model.

PLS models, combined data sets. By using large combined data sets for PLS models on blueberries scanned with different spectrometers, we were able to achieve improved classification (see Table 2). Two preprocessing techniques, mean centering and variance scaling, were tested and the results were compared. For the combined data set of spectra scanned at KSU the classification improved from 61.7% using a single data set to 79.5 % for the combined data set. These results improved additionally to 81.3% classification after removing outlier samples and mean centering and variance scaling the data (see Table 2). For the remaining models mean centering and variance scaling led to increase in prediction percentage. The best prediction results were obtained after mean centering, and variance scaling of the combined sets of spectra scanned at KSU at 81.3 %. Based on correct classification ranking KSU data was best followed by UMaine data at 76.6 %, MSU data at 62.0 % and then UC-Davis data at 61.1 % (see Tables 2 and 3).

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, these values within each model can be compared being estimates of the error of prediction. Therefore, they were used for identifying the number of factors giving the best prediction as well as results from applying preprocessing within the same data sets or between data sets with similar size.

The optimum number of significant PLS factors was found to be 11 for UMaine data, between 7 and 10 for KSU data, 6 for MSU data and 4 for UC-Davis data as identified by PRESS/SECV reduction calculated by the PLS models. This is expected since the spectra in different wavelengths would contain different information as well as there is additional variation due to instrumental set up, light intensity, detector distance and position, etc.

The threshold values were calculated as an average value from the infestation arbitrary values (constituents) of all spectra in the set. In these experiments the infested samples were predicted more successfully than non-infested samples and therefore they had a larger contribution for the total correct classification.

Overall results indicate that the instrument and setup at KSU operating in the wavelength region 550 – 1690 nm provided data best correlated to presence or absence of infestation. PLS model results in the longer wavelength region of the spectra (1400 – 1600 nm) provided relatively high correct classification implying that these spectral bands are most sensitive to maggot infestation in blueberries. Analysis efforts in the future will be focused on differences found in these wavelengths.

RECOMMENDATIONS: Continue the study using NIRS during the 2003 and 2004 field seasons. The laboratory inoculation/infestation method (lead by Drummond) of assuring a high percentage of maggot-infested berries will be used as a primary source of berries for these studies. Drummond will work to optimize the parameters associated with this portion of the study.

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-ARS laboratories in Manhattan, Kansas (Dr. Floyd Dowell), and East Lansing, Michigan (Drs. Guyer and Lu). Future work will include further refining of the PLS models and applying of methods for signal correction and noise reduction on the spectral data as well as other appropriate techniques. Attempts will be made to correlate PLS factors to specific physical and chemical properties of blueberries by chromatographic methods and further multivariate analysis. Having achieved good rate of artificial infestation more balanced data will be collected in the new harvest seasons allowing us to validate the refined prediction models as well as investigate any variations in the blueberries from season to season.

Table 1. PLS results of models on selections of different wavelength ranges of spectra from berry set Jonesboro 1 A and UMaine instrument. Outliers were removed before the calculation of the model

Wavelength range	650 - 1100 nm (whole spectrum)	650 - 750 nm	700 - 800 nm	950 - 1100 nm
PLS model parameters	Mean centered, 6 factors, cross validated			
Number spectra from non-infested berries (1)	99	99	99	99
Number spectra from infested berries (2)	189	189	186	189
Total number of spectra	288	288	285	288
Correct classification of non-infested, %	57.6	60.6	40.4	53.5
Correct classification of infested, %	64.0	40.2	52.2	54.5
Total misclassification, %	38.2	52.8	51.9	45.8
Total correct classification, %	61.8	47.2	48.1	54.2

Table 2. PLS results on data of combined spectra preprocessed using mean centering (MC) and variance scaling (VS) techniques. All models were cross validated and recalculated after outliers' exclusion

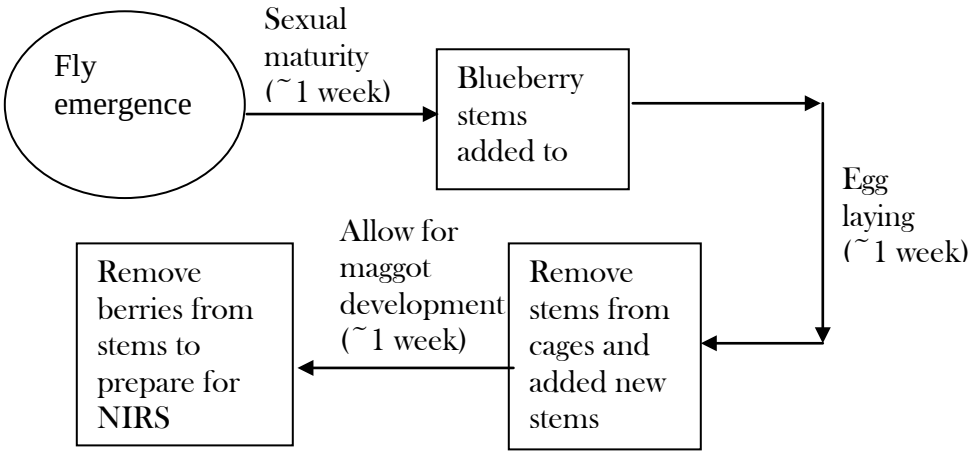
Place, instrument and settings	UMaine Reflectance chamber set up			USDA-KSU All spectra 10 mm from detector, stem end facing				USDA-MSU All spectra 5 mm from detector, averaged		
Sample sets	Jonesboro1 A, B, C & Jonesboro 2 B			Jonesboro 2 A, D Jonesboro 3 C, D				Jonesboro 2 C Test batch		
PLS model parameters	650 - 1100 nm (whole spectrum)			550 - 1690 nm (whole spectrum)			1400 - 1600 nm	900 - 1400 nm (whole spectrum)		
Number of PLS factors	11	11	11	10	8	7	7	6	6	6
Data pre-processing	none	MC	MC VS	none	MC	MC VS	MC VS	none	MC	MC VS
Total number of spectra (non-infested, infested)	406 (234, 172)			287 (128, 159)			284 (128, 156)	134 (47, 87)		
Correct classification	72.7	72.2	72.2	75.8	76.6	75.8	73.4	66.0	57.5	57.5

Place, instrument and settings	UMaine Reflectance chamber set up			USDA-KSU All spectra 10 mm from detector, stem end facing			USDA-MSU All spectra 5 mm from detector, averaged			
of non-infested, %										
Correct classification of infested, %	78.5	82.6	82.6	83.0	84.9	85.5	68.0	43.7	58.6	64.4
Total correct classification, %	75.1	76.6	76.6	79.8	81.3	81.3	70.4	51.5	58.2	61.9
SECV	0.43	0.42	0.42	0.39	0.38	0.37	0.43	0.57	0.49	0.48

Table 3. PLS results of models on single data sets with samples from Jonesboro, Maine, scanned at KSU, MSU, UMaine and UC- Davis. Outliers were removed before the calculation of the model and all models were cross validated and mean centered

Place, instrument and settings	KSU	MSU	UMaine					UC Davis
Sample sets	2 A	2 C	1 A	1 C	2 B	3 A	3 B	5 E
Number of factors	6	6	6	6	5	5	6	4
Number spectra from non-infested berries	30	20	99	219	78	162	172	33
Number spectra from infested berries	47	56	189	60	241	189	156	57
Total number of spectra	77	76	288	269	319	351	328	90
Correct classification of non-infested, %	66.7	50.0	57.6	92.2	0.0	62.4	83.7	63.6
Correct classification of infested, %	61.7	48.2	64.0	25.0	97.1	61.4	60.9	59.7
Total misclassification, %	36.4	51.3	38.2	23.1	26.7	38.2	27.1	38.9
Total correct classification, %	63.6	48.7	61.8	77.0	73.4	61.8	72.9	61.1

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



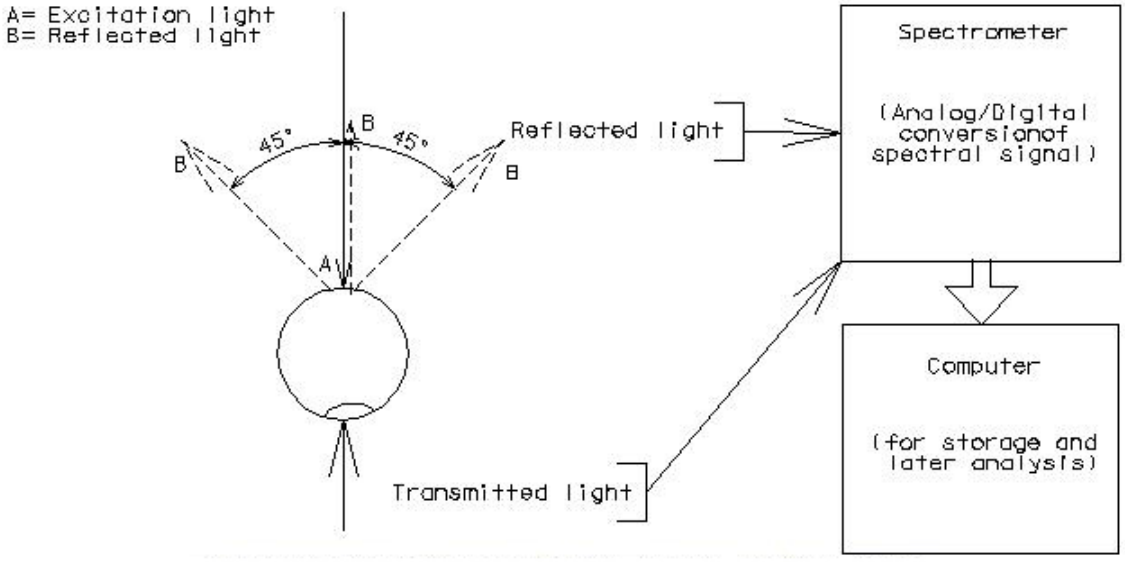
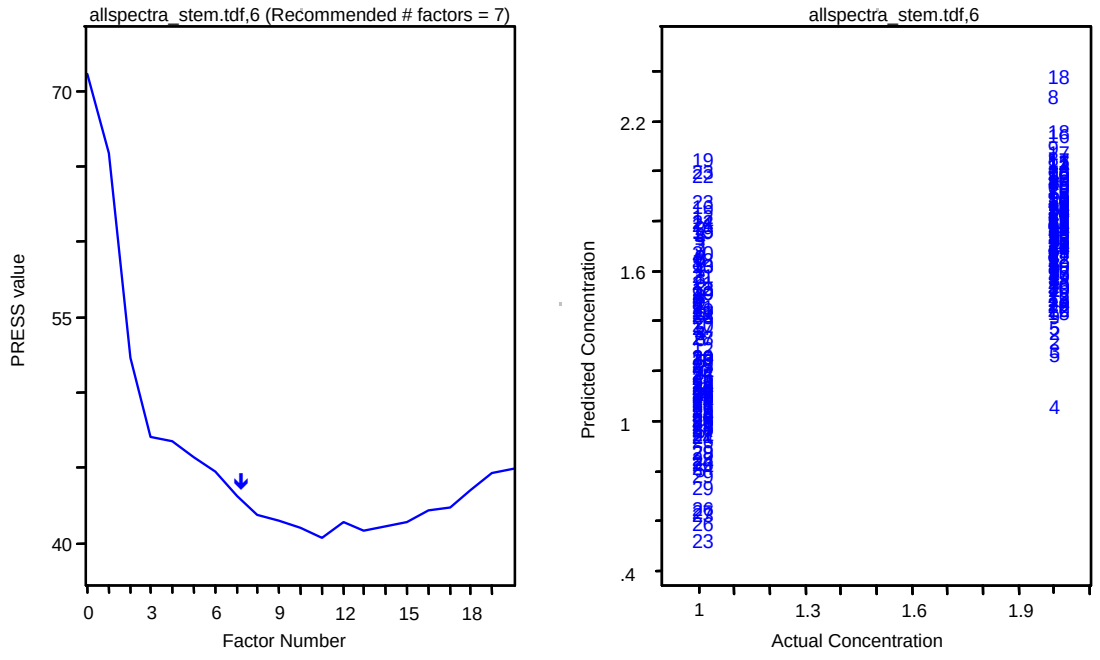


Figure 2. Experimental set ups used in 2002; UMaine reflectance and MSU reflectance was collected at 45 degree angle from the excitation light, KSU reflectance was collected at 360 degree angle from excitation light, UC-Davis was collected in transmission at 180 degree angle from excitation light.



(a) (b)

Figure 3. PRESS (a) and Actual vs. Predicted (b) plots from PLS model on a combined data set from KSU. Mean centering, variance scaling and 11 factors were used for the model which yielded correct prediction for 81.3% of the samples

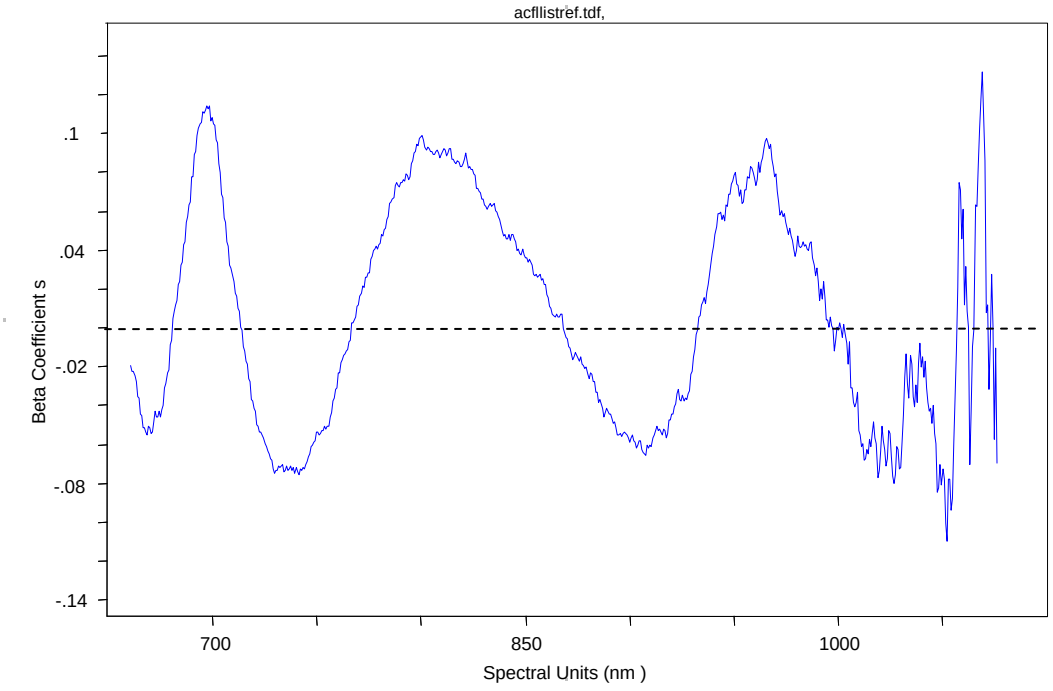


Figure 4. Beta (calibration) coefficients from the PLS model of berry set Jonesboro

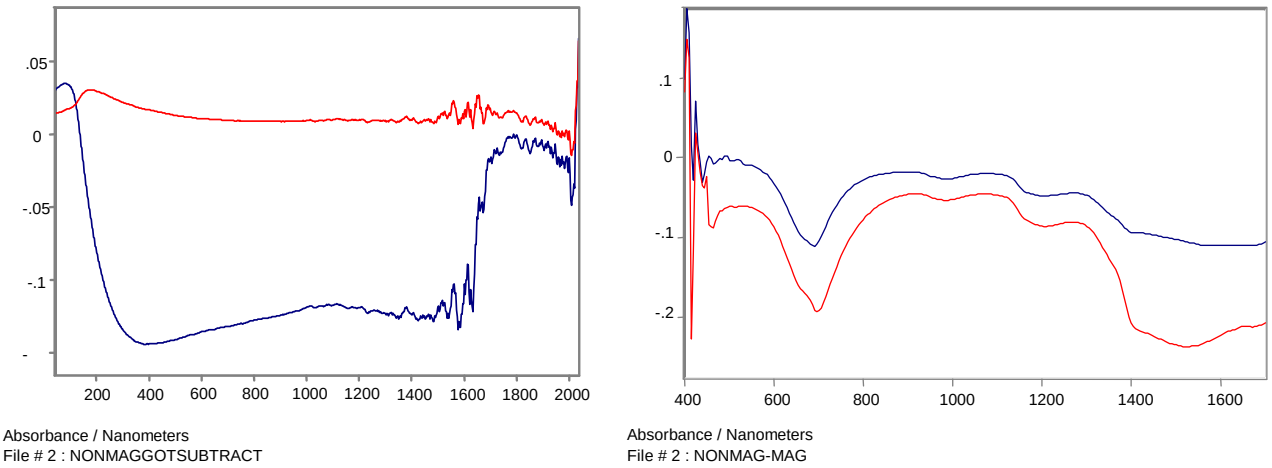


Figure 5. Spectral subtractions of averaged spectra scanned using UMaine (a) and KSU (b) set ups

F00D SCIENCE AND HUMAN NUTRITION

INVESTIGATOR: D.J. Klimis-Zacas, Associate Professor of Clinical Nutrition

TITLE: Investigation Of The Mechanism By Which Blueberry Fractions Maintain Arterial Integrity.

METHODOLOGY: Weanling Sprague-Dawley rats (twelve in each group) will be placed on the following diets for 15 weeks. 1) Control diet 2) Control diet and blueberries 3) Control diet (for 15 weeks) adding blueberries for eight weeks (reversal diet). Rat weights and food intakes will be measured throughout the experiment and rats will be fed the above diets for 15 weeks and subsequently sacrificed. Blood and arteries will be removed and arterial rings prepared. From each aorta harvested four rings will be prepared. Two will be intact and two denuded. Denudation removes the endothelial layer and all factors that aid in vasorelaxation. This will aid us in pinpointing where the effect of whole blueberries occurs (in the endothelium or in the smooth muscle cell). Arterial rings will be placed in tissue baths and tension applied on them. Vascular reactivity will be tested with both mechanical and agonist stimulation. The myogenic response to stretching of the vascular wall will be determined by application of graded preload tension on the aortic rings. Tension will be 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 will be assessed. Vasodilation will be studied after preconstriction of the aortic rings with 1 □M phenylephrine. Concentration-response curves will be 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, will be 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. Nitric acid concentration will be monitored by an amperometric microelectrode (World Precision Instruments).

RESULTS: Weanling male 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 influence the contractile machinery of the rat aorta in response to an (alpha-1 adrenergic receptor and that they act on the smooth muscle cell.

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 by 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 pintpoint 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 one more year to validate data.

INVESTIGATOR: Richard A. Cook, Associate Professor of Human Nutrition.

TITLE: Antioxidant Assessment in the Elderly.

METHODS: Study #1. Twenty-four women age 60-90 residing in Western Maine were randomly assigned to an experimental (wild-blueberry consuming) group (12 subjects each) or a control (non-blueberry-consuming) group (12 subjects each). At baseline a Tufts Elderly Health and Nutrition Food Frequency Questionnaire was administered to determine usual food intake antioxidant potential. A total of 24 ml of blood was taken from all subjects at the beginning and at the end of the experimental period. The experimental groups consumed one cup of wild blueberries each day for a period of 30 days along with a normal diet. One-half of the blueberries were to be eaten with breakfast and the other half after dinner. The blueberries were not to be heated. Subjects in the control group were instructed not to eat any blueberries during the thirty-day period and to follow a normal diet. Usual intake levels were determined for: vitamins A, C, D, and E; beta-carotene; alpha-carotene; cryptoxanthin; lycopene; and lutein. Blood levels were determined for Oxygen Radial Absorbance Capacity (ORAC) without interfering protein, Ferric Reducing Antioxidant Potential (FRAP), and Uric Acid. **Study #2**. Seven adult females in the Central Maine area between the ages of 35 and 60, with no interfering physiological or biochemical parameters, were selected for a bioavailability study of polyphenolic and other antioxidant compounds found in lowbush, wild blueberries. Each individual acted as both an experimental and control subject in a crossover design. Half the subjects consumed one-half cup wild blueberries two times per day for two weeks and half of the subjects consumed no blueberries, or interfering antioxidant supplements, over the same time period. Subjects then fasted for 12 hours overnight. Serial blood and urine specimens were then collected. Urine was voided at baseline and then collected at the two-hour and four-hour intervals. Eighteen milliliters of blood were collected at baseline and then at 2, 3, and 4-hour intervals. At baseline subjects consumed about 24 ounces of a drink containing blueberries (11 g freeze-dried powder in a high energy liquid) or a similar drink minus the blueberries. After the first sample collections, subjects waited two weeks without any blueberry consumption. Then subjects who didn't eat blueberries previously, consumed blueberries for the next two weeks as described previously. Subjects again fasted overnight and had final blood and urine collections per the protocols previously described. Blood and urine measurements included: Plasma (blood) Antioxidant Capacity (lipophilic and hydrophilic); Measurements of Oxidative Stress (glutathione peroxidase; lipid peroxidation – red blood cells); Urine Anti-Adhesive Factor (UTI); Urine Antioxidants; Absorption of Polyphenolics and Metabolites (anthocyanins major focus); and Platelet Aggregation.

RESULTS: Study #1: There were no significant differences in dietary antioxidant levels or blood antioxidant capacities at baseline. Serum ORAC was significantly increased in the blueberry-consuming group (+234.5 mM trolox equiv., p=.048) with no significant changes in the control group (p=.566). FRAP also increased in the experimental group (+27.9 mM trolox equiv., p=.036) but not in the control group (p=.708). Absence of increases in plasma uric acid levels among both groups showed no antioxidant interference from this parameter, as an additional verification of the antioxidant increase coming from the blueberries. **Study #2:** All blood and urine samples have been collected and biochemical analyses are in progress.

CONCLUSION: Data from study #1 suggest that regular consumption of wild (low bush) blueberries may increase blood antioxidant capacity or help prevent seasonal blood antioxidant losses. Study #2: Information on the bioavailability of some antioxidant components of wild blueberries may help determine more specifically why this fruit exhibits such a powerful antioxidant capacity for human consumption.

RECOMMENDATIONS: More research is needed on the antioxidant potential of wild blueberries under different physiological conditions (e.g. level of intake, length of consumption, age, gender, etc.) and specific metabolites expressing high and/or prolonged effects need to be identified.

IRRIGATION

INVESTIGATOR: David E. Yarborough, Professor of Horticulture, University of Maine

COOPERATOR: Gordon Starr, Soil Scientist/Hydrologist, USDA-ARS, Orono, ME

TITLE: Irrigation Water Use in Wild Blueberry Production

METHODS: Weighing lysimeters and devices for measuring soil water tension, soil water content, and meteorological variables were installed in 2002 for studying crop water use at Blueberry Hill farm in Jonesboro, ME and these have been complemented by lysimeters two additional sites. The sites were chosen to give a range of climate to evaluate fog and temperature effects on water use of lowbush blueberries. A site belonging to collaborator Sanford Kelley located in Jonesport, ME was less than a mile from the Atlantic ocean. An inland site owned by collaborator Jasper Wyman and Son in Deblois, ME was typical of the Blueberry Barrens area of Washington County, ME

RESULTS: Diminishing supplies and competing interests for surface and ground water have resulted in severe irrigation water supply shortages for the Wild Blueberry Industry. Grower experience indicates that the blueberry crop requires somewhere near one inch per week of water and that fog aids production by supplying water. Initial results for this study suggest that water was being supplied to the crop at night through direct condensation on the plants and adsorption into the soil. This effect was more prevalent at the sites near the coast.

CONCLUSION: initial results suggest that water demand of wild blueberries will be greater at inland locations where temperature is greater, humidity is less, and coastal fog is less prevalent.

RECOMMENDATIONS: Several years of additional data are needed to quantify water use of the crop over time and throughout the two year cropping cycle. Continue study.

ENTOMOLOGY

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

TITLE: Control Tactics for Blueberry Pest Insects, 2002

1. Field evaluation of insecticides for control of secondary pest insects.

METHODS: Two trials were conducted, one each against blueberry spanworm and blueberry thrips. The test against blueberry spanworm was applied as a foliar spray to fruit-bearing fields. Effectiveness was measured by taking pre- and post-treatment sweep-net samples. In the thrips trials, Admire® was applied as a spray to the soil prior to stem emergence; Malathion® was applied as a foliar spray. Efficacy was determined by counting the number of infested stems after treatment as evidenced by leaf curling.
RESULTS/CONCLUSIONS: Imidan®, SpinTor®, and Intrepid® all provided excellent seasonal control of blueberry spanworm larvae. The lower rate of Calypso®, Proclaim®, and both rates of Confirm® all reduced spanworm populations; although, the reduction was not statistically significant ($P < 0.05$, ANCOVA with prespray counts as the covariate) (Table 1).

The pre-emergence application of Admire® resulted in only a 26% reduction in the average % stems with thrips curls in each sq ft sample; the difference was not significant (ANOVA, $P = 0.4139$)(Table 2). A reduction of 38% was observed following a similar application in 2000. Only a 12% reduction was observed with Malathion®. There was also no significant difference in the average number of stems per sample (ANOVA, $P = 0.1789$).

2. Aerial application of Spinosad fruit fly bait to control blueberry maggot fly (BMF).

METHODS: Ten, baited, yellow Pherocon® AM traps were placed in each of five fruit-bearing fields in Washington Co. The traps were set 100-200 ft apart and 10-15 ft into the field along a wooded edge. All traps were checked at intervals beginning on 1 July and continuing until 30 July and were replaced on 12 and 22 July. Spinosad® Fruit fly Bait was applied, by air, to all five sites. The material was applied at ½ the recommended rate because of the nozzle type used on the aircraft. The applications were made when trap captures indicated the presence of a suitable BMF population. A second application was made to four of the fields on 20 July. On the second application date, one field was treated with Imidan® 70 WP. A portion of each field was left untreated as a control. The number of traps in the treated vs. untreated portions of the field varied depending on the topography. Efficacy was evaluated on the number of BMF captured on the AM traps before and after the applications and on the number of maggots found in the fruit at harvest.

RESULTS/CONCLUSIONS: The perimeter application of a low rate of Spinosad® Fruit Fly Bait resulted in a reduction in the number of BMF captured on AM traps from the treated compared to the check transects (Fig.1) ($P = 0.0641$, Repeated Measures ANOVA). Significantly more maggots were found in berries collected from untreated check areas (5.5 ± 1.3 maggots/qt) compared to Imidan treated areas (1.5 ± 0.6 maggots/qt)(Fig. 2)($P = 0.008$, Repeated

Measures ANOVA).

RECOMMENDATIONS: Additional trials should be conducted with Spinosad® Fruit Fly Bait. Results appear promising despite our inability to apply the material at the recommended rate in 2002. Confirm® and SpinTor® will be added to the list of products recommended for blueberry spanworm control in 2003. A new Bt product (Deliver®) is also now available for spanworm control, and Dipel® and Biobit® will continue to be recommended. Javelin is no longer registered. SpinTor® will also be recommended for flea beetle control. Both of these products have proven very effective in efficacy trials. Diazinon® will continue to be available for thrips control until 2004.

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

Table 1. Field control of blueberry spanworm larvae.

Material	Amt. form./ acre	Larvae/10 sweeps Prespray	Post spray 10 May	13 May	15 May	16 May	20 May	23 May	Seasonal density
Imidan 70 WP	21.3 oz	12.7	0.3	0.3	0.3	0.3	0.3		2.5 a
SpinTor 2 SC	5.7 oz	14.0	1.7	1.7	0.3	0.7	2.7		2.7 a
Calypso 480 SC	1.5 oz	13.3	3.7	3.7	1.0	2.3	1.0		3.6 ab
Calypso 480 SC	3.0 oz	12.7	8.3	2.0	0.3	5.0	3.3		5.1 ab
Proclaim 5 SG	3.2 oz								
+ Kinetic nonionic s/s	1.5 oz	13.3	3.0	2.3	0.7	2.7	1.3		3.4 ab
Confirm 2 F	8.0 oz								
+ Latron B-1956	1.5 oz	15.3	5.7	2.7	1.0	1.3	1.7		3.9 ab
Confirm 2 F	16.0 oz								
+ Latron B-1956	1.5 oz	14.7	4.0	1.7	2.0	1.7	1.7		3.7 ab
Intrepid 2 F	16.0 oz								
+ Latron B-1956	1.5 oz	13.3	3.7	2.0	1.0	0.7	1.0		3.0 a
No insecticide		12.0	7.7	9.3	6.0	5.0	3.7		6.9 b

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 ($P < 0.05$; ANCOVA with prespray counts as the covariate). Data were transformed by $Log_{10}(X + 1)$ prior to analysis. Mean comparisons were Bonferroni corrected; $\alpha = 0.0014$.

Table 2. Field control of blueberry thrips.

Material	Amt. form./acre	Avg. no. stems/sq ft	Avg. % stems with curls/sq ft
Admire 2F (pre-emergence)	16 oz	52.9 a	58.3 a
Malathion 5 EC	16 oz	67.8 a	69.0 a
No insecticide	-	67.4 a	78.4 a

Means followed by the same letter are not significantly different ($P < 0.05$, SNK). Data for avg. no. stems/sq ft was transformed by $\log_{10}(X + 0.1)$ prior to analysis; avg. % stems with curls/sq ft were transformed by arcsine.

2. AERIAL APPLICATION OF SPINOSAD FRUIT FLY BAIT TO CONTROL BLUEBERRY MAGGOT FLY (BMF).

Fig. 1. Effect of treatment on BMF captures.

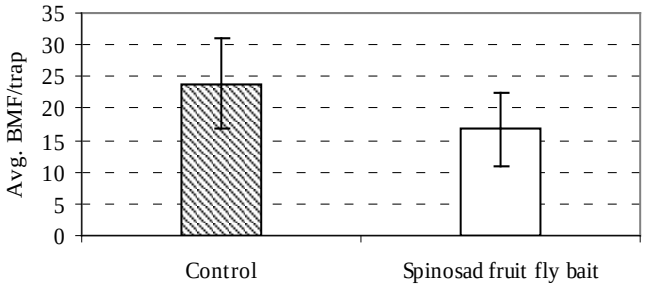
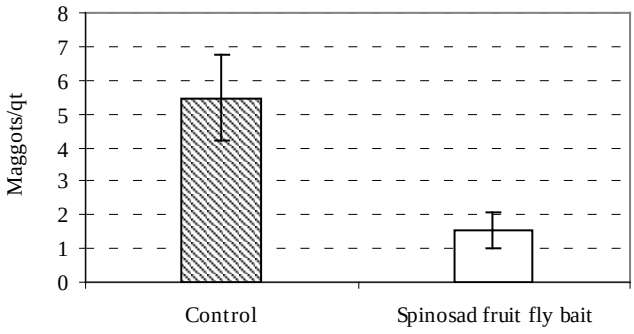


Fig. 2. Effect of treatment on maggots/qt.



ENTOMOLOGY

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

TITLE: IPM strategies.

1. Evaluation of insecticide-treated spheres for blueberry maggot fly (BMF) control.

METHODS: Green, plastic spheres (Great Lakes IPM, Vestaburg, MI) were sanded then painted with latex gloss acrylic enamel paint mixed with 4% v/v imidacloprid (Provado® 1.6 F). The spheres were placed in three fruit-bearing blueberry fields in Washington Co. The spheres were hung from metal poles, 1 to 6 inches above the blueberry canopy and 10-ft apart in a square or rectangular pattern with at least one side of the square along a field edge close to a wooded area from which BMF were most likely to colonize. Ammonium superchargers (Great Lakes IPM) were hung from each pole as attractant bait. A molded wax and sugar "cap" feeding attractant (Bradley Chandler, University of Massachusetts) was firmly attached to the top of each sphere, then charged by dousing it with water. At least 50% of each field was left unprotected as a check. Blueberry maggot fly numbers were monitored with baited yellow Pherocon® AM traps placed inside and outside the protective barrier formed by the spheres. At two of the sites, three AM traps were placed in the center (Middle) and one to each side immediately adjacent to and inside the barrier formed by the spheres (Edge). Eight additional traps were placed in a similar pattern in the adjacent untreated check. At the third site, we only placed the three center traps in the treated and check areas. Efficacy was evaluated based on the number of maggots found in the fruit at harvest.

RESULTS/CONCLUSIONS: A nested ANOVA with "trap within treatment" as the error factor was completed for the seasonal density of BMF over all sites (Table 1). There were no significant differences between the treatments when edge traps were compared with edge traps ($P = 0.2047$) and middle traps were compared to middle traps ($P = 0.1886$); although, in both cases, the trend was for trap capture to be in the sphere-treated plots. There was a significant difference at the $P < 0.10$ level when BMF counts from edge and middle traps were combined and compared between the treatments ($P = 0.0873$). However, there was not a significant reduction in numbers of maggots found in the fruit at harvest ($P = 0.4152$, ANOVA). More maggots were found in fruit from the treated area.

RECOMMENDATIONS: Perimeter treatments of baited spheres did reduce BMF numbers but not maggot infestation. It may be that deployment of traps about the field perimeter is not enough to provide adequate control. In 2003, we plan to investigate perimeter deployment of traps along with trap deployment within a field. At this point we can not recommend insecticide-treated spheres for control of BMF; although, the technology does have some promise.

2. Perimeter application of Imidan 70 WP to control BMF.

METHODS: Baited, yellow Pherocon® AM traps were placed in three fields in Washington Co. The traps were distributed in transects. There were four transects per field. For each transect, one trap was set 10 ft into the field from the edge. Subsequent traps were set 50, 100, and 150 ft along a line running into the field. The traps were checked at intervals beginning on 1 July and continuing until 30 July.

Imidan 70 WP was applied by air to all three sites at a rate of 1 lb/acre. The applications were made when trap captures indicated the presence of a suitable BMF population. Each application was made in a swath along the edge of the field and in such a way as to incorporate two of the four trapping transects in the treated area. Efficacy was evaluated based on the number of maggots found in the fruit at harvest.

RESULTS/CONCLUSIONS: There was no significant difference in BMF captures between treated and untreated check transects prior to the application. The perimeter application of Imidan 70 WP did result in a significant reduction in the number of BMF captured on AM traps from the treated compared to the check transects (Fig. 1)($P = 0.0323$, Repeated Measures ANOVA). After application of Imidan 70 WP, the average number of BMF in the check transects increased from 4.6 to 6.9 BMF/trap. There was a decrease on treated traps from 2.5 to 1.9 BMF/trap. There was also a significant interaction between distance from the field edge and trap catch (Fig. 2)($P = 0.0016$). Significantly more flies were captured in the check areas at all distances. There was no interaction between treatment*distance and trap catch ($P = 0.7975$).

Significantly more maggots ($P < 0.10$) were found in berries collected from untreated check areas (5.4 ± 2.3 maggots/qt) compared to Imidan treated areas (2.8 ± 1.0 maggots/qt)(Fig. 3)($P = 0.0961$, Repeated Measures ANOVA). There was also a significant treatment*distance interaction (Fig. 4)($P = 0.0290$). More maggots were found in berries collected near the field edge in the untreated check areas.

RECOMMENDATIONS: A perimeter treatments with Imidan is a viable control tactic for BMF. Several years of experiments have shown it to be effective. We will continue to look at its feasibility and try to improve this tactic by investigating the use of attractants mixed in with the insecticide application.

3. Economic threshold of blueberry spanworm larvae in pruned fields.

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 larvae was placed in each plot (0, 10, 20, 40, or 60 larvae per plot). Block #1 was set on 16 May using 1^{st} and 2nd instar spanworm larvae collected from an infested field. Blocks 2, 3, and 4 were set on 22 May with 1^{st} to 3^{rd} instar larvae. Blocks 5 and 6 were set on 29 and 30 May, respectively with 3^{rd} to 5^{th} 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, the mesh cages were removed and the percentage of blueberry cover within each plot was estimated, converted to % defoliation, and compared with the initial larval density. A second sample was taken on 17 July.

RESULTS/CONCLUSIONS: Table 3 summarizes the % blueberry leaf cover and the resulting % defoliation at each initial spanworm larval density for both sample dates. Figure 5 shows the relationship between average % defoliation and initial spanworm larval density following the first sample on 13 June. There was a significant linear (P = 0.0204) and quadratic (P = 0.0188) trend. Defoliation increased with increasing larval density. No such trends were observed on the second sample date on 17 July (linear, P = 0.1492; quadratic, P = 0.1214)(Fig. 6); although, defoliation was slightly higher at the higher densities. An Analysis of Variance revealed no significant difference between the blocks on 13 June (P = 0.5648). There was a difference on 17 July (P = 0.0193). Therefore, while it appears that increasing spanworm larval density resulted in increased defoliation of young, newly emerging sprouts in May, by mid-July the blueberry plants appeared to have recovered in terms of vegetative cover. Densities of 40 and 60-larvae/4 ft^2 resulted in close to 100 defoliation.

RECOMMENDATIONS: In the spring, 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. An analysis of fruit-bud production will determine whether the plants did recover from the defoliation or whether an accompanying yield loss will result.

4. Economic threshold of blueberry flea beetle larvae in pruned fields.

METHODS: In May 2002, three replications (blocks) were established in a pruned 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. In each block, one of four different densities of larvae was placed in each plot (0, 10, 30, or 60 larvae per plot). Both blocks were set on 7 June 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, the mesh cages were removed and the percentage of blueberry cover within each plot was estimated, converted to % defoliation, and compared with the initial larval density.

RESULTS/CONCLUSIONS: Table 4 summarizes the % blueberry leaf cover and the resulting % defoliation at each initial flea beetle larval density. Figure 7 shows the relationship between average % defoliation and initial spanworm larval density. Although there was some increase in defoliation at initial densities of 10, 30, and 60 larvae, there was no significant linear or quadratic trend (Regression analysis, P = 0.5976 and 0.3603, respectively).

The larvae that were placed on the plots were late instar. It is possible that using earlier instar larvae would have resulted in increased defoliation at high initial larval densities. More importantly, there was a high level of variation in defoliation at each density. This suggests that three replicates were too few for this experiment.

RECOMMENDATIONS: In the spring, 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. The trend in defoliation suggests that even ten flea beetle larvae in a 4 ft^2 plot will result in a high level of defoliation of emerging sprouts and warrants further study.

1. EVALUATION OF INSECTICIDE-TREATED SPHERES FOR BMF CONTROL

Table 1. Seasonal density of BMF.

	AM trap location		
Treatment	Edge	Middle	All
Treated (within sphere barrier)	1.7 (1.3)	1.3 (0.9)	1.5 (1.1)
Open check	3.7 (4.7)	2.3 (1.9)	3.0 (3.4)

Table 2. Average maggots/quart found in fruit at harvest.

	Maggots/quart (SD)	
Field	Treated	Check
Site 1	6.0 (4.5)	5.0 (2.6)
Site 2	0.0 (0.0)	0.0 (0.0)
Site 3	5.8 (5.9)	2.5 (3.3)
All fields, combined	3.9 (4.8)	2.5 (2.1)

2. PERIMETER APPLICATION OF IMIDAN 70 WP TO CONTROL BMF.

Fig. 1. Effect of treatment on BMF captures.

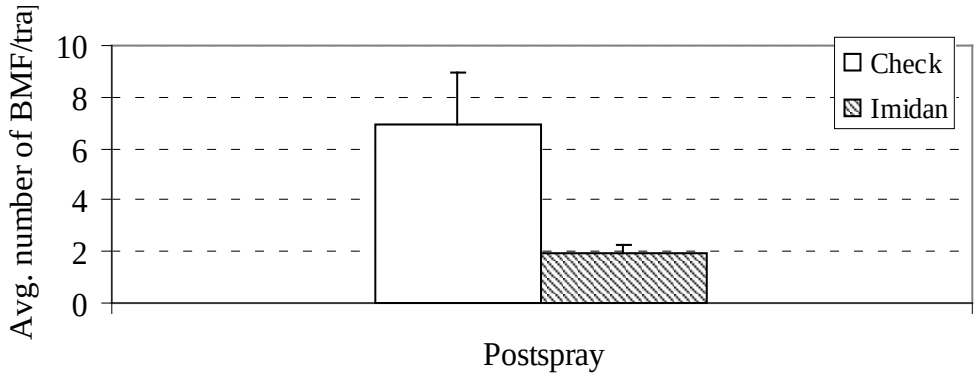


Fig. 2. Effect of distance on BMF captures.

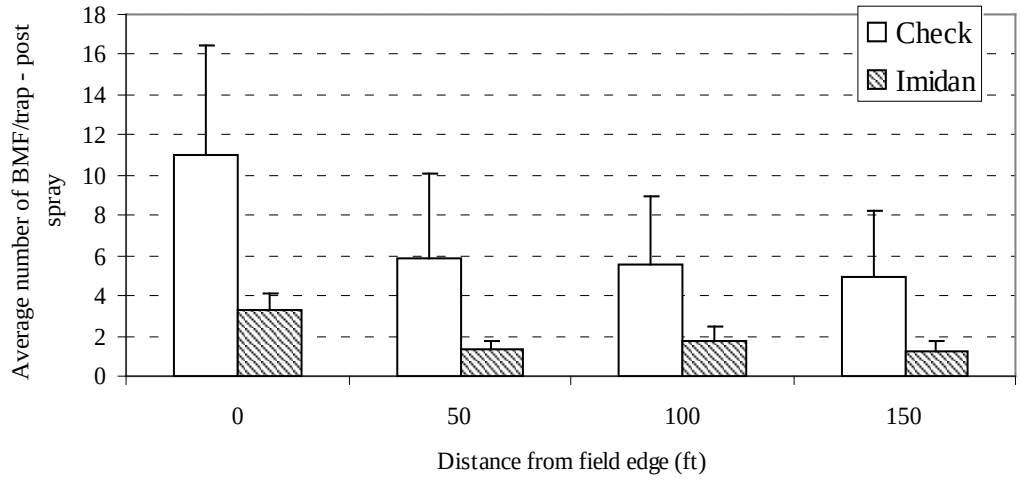


Fig. 3. Effect of treatment on maggots/qt.

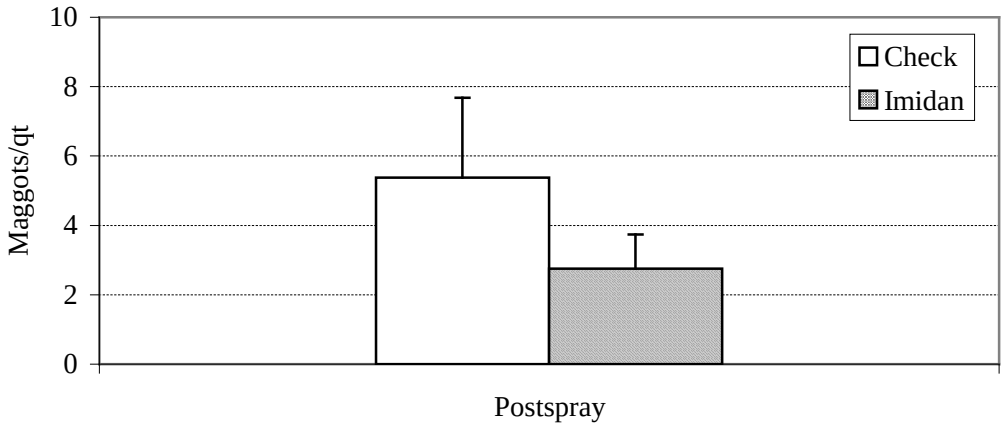
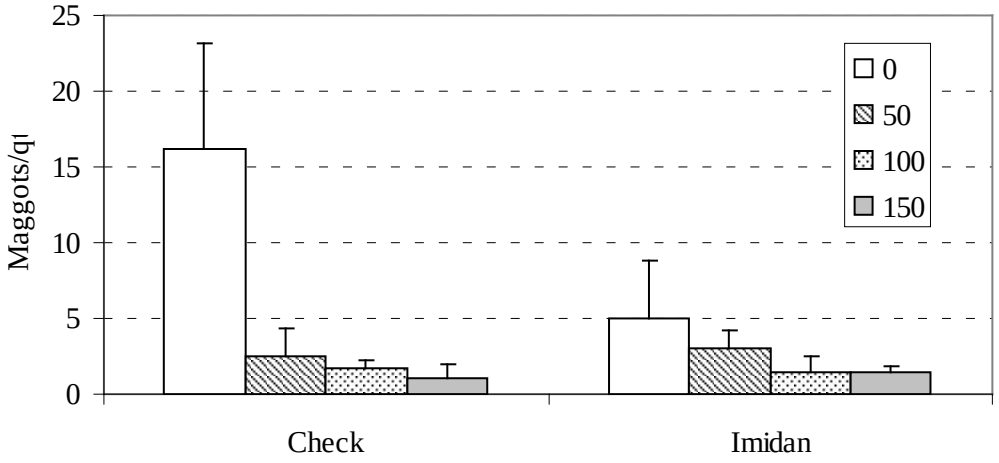


Fig. 4. Effect of treatment*distance on maggots/qt.



3. ECONOMIC THRESHOLD OF BLUEBERRY SPANWORM LARVAE IN PRUNED FIELDS.

Fig. 5. Relationship between spanworm larval density and % defoliation, 13 June sample.

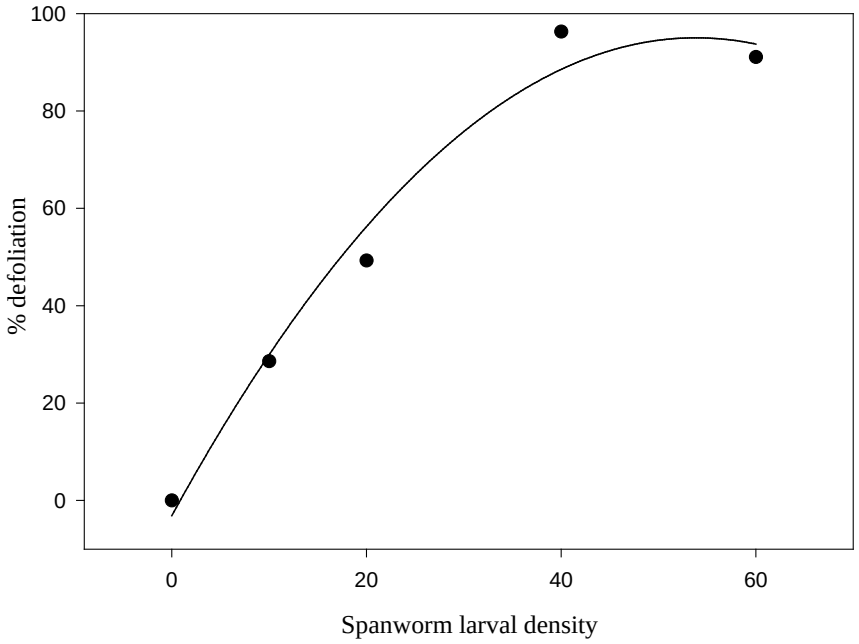


Fig. 6. Relationship between spanworm larval density and % defoliation, 17 July.

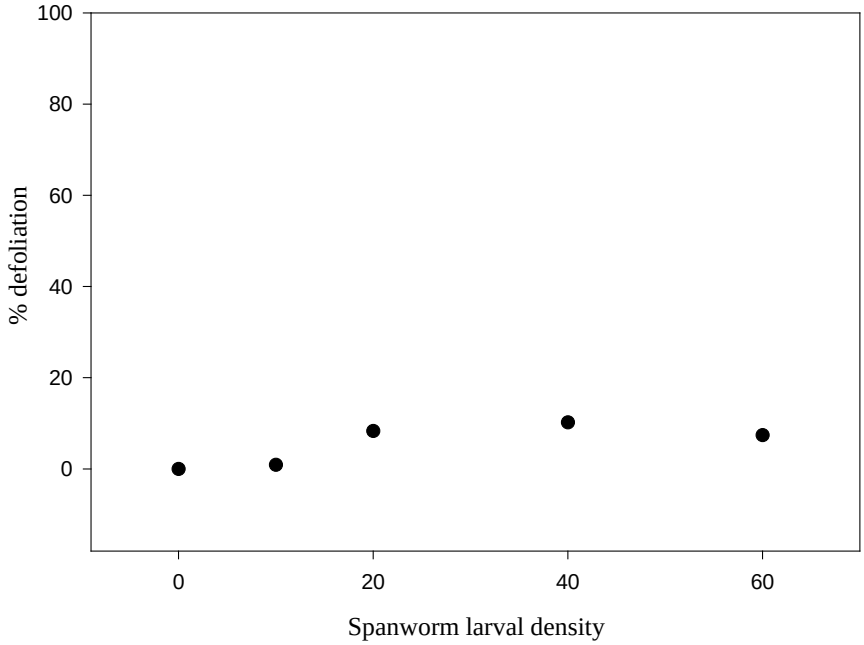


Table 3. Percent of blueberry leaf cover and % defoliation as a result of spanworm larval densities.

Initial spanworm Larval density	% cover [1]	13 June % defoliation [2]	17 July % defoliation
0	28.0 (7.2)	0.0	0.0
10	20.0 (11.9)	28.6	0.9
20	14.2 (6.6)	49.3	8.3
40	1.0 (1.1)	96.4	10.2
60	2.5 (3.5)	91.1	7.4

[1] Mean % cover ± Standard error.

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

4. ECONOMIC THRESHOLD OF BLUEBERRY FLEA BEETLE LARVAE IN PRUNED FIELDS.

Fig. 7. Relationship between % defoliation and initial larval density.

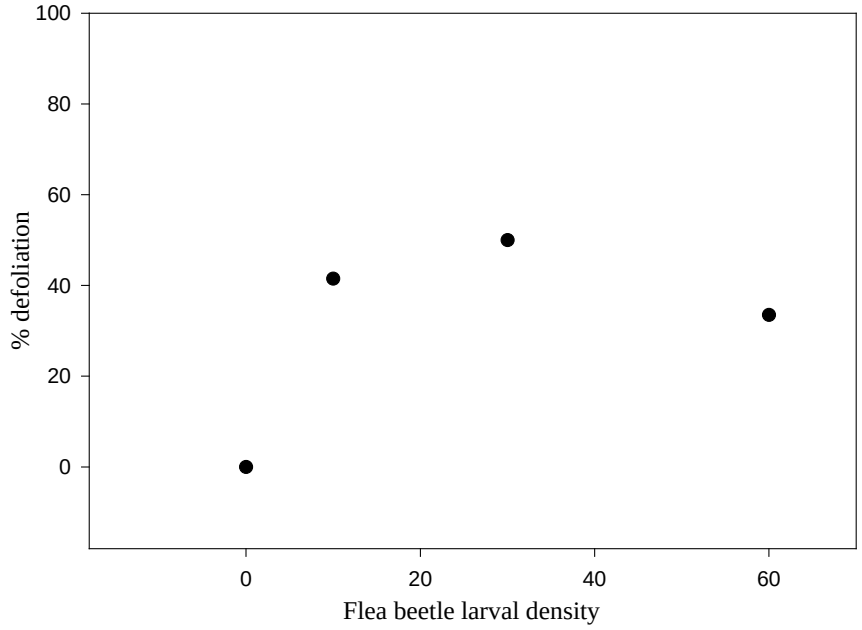


Table 4. Percent of blueberry leaf cover and % defoliation as a result of flea beetle larval densities.

Initial flea beetle Larval density	% cover [1]	% defoliation [2]
0	20.0 (5.7)	0.0
10	11.7 (4.3)	41.5
30	10.0 (4.9)	50.0
60	13.3 (3.3)	33.5

[1] Mean % cover ± Standard error.

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

ENTOMOLOGY

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

TITLE: Pest Biology

1. Vertical distribution of blueberry maggot flies (BMF) within the forest perimeter around wild blueberry fields.

METHODS: Baited, yellow Pherocon® AM traps were hung from trees adjacent to five, fruit-bearing, wild blueberry fields. At each site, the traps were hung 5, 10, 15, and 20 ft above the ground. An additional trap was hung 6-10 inches above the ground from a separate pole. The trees used for the study were 10- 20 ft into the woods from the edge of the field. Any captured BMF were collected and inspected in the laboratory to determine gender and oviposition status.

RESULTS/CONCLUSIONS: Trap catches indicated that adult BMF move up into trees adjacent to blueberry fields (Fig. 1). The reason for this movement is unknown but would be a result of either foraging for food or for mates. It is interesting that, except for a few instances, numbers of female flies dominate (Fig. 2). This suggests that foraging for food may be a more plausible explanation than foraging for mates. Figure 2 shows that in the trees surrounding most fields, with one exception, while BMF venture up into the canopy they concentrate at the lower altitudes. This pattern of occupying the lower vertical strata is characteristic of most of the season except towards the end of July, the period that reflects peak fly emergence (Fig. 3).

RECOMMENDATION: There is probably not much significance to the fact that BMF are moving vertically into the trees UNLESS one is trying to implement a strategy of perimeter treatments to control BMF. If the surrounding forest edge is close to the blueberry field, then flies colonizing the field from the tops of trees may fly over the treated perimeter without coming into contact with the insecticide. This aspect of perimeter treatments needs further investigation.

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

METHODS: On 25 June, emergence traps were placed in, and adjacent to, three wild blueberry fields in Washington Co. Fifteen traps were set at each of two sites. Ten traps were placed along the field edge; five were in the fruit-bearing section of the field and five in a nearby pruned section. The remaining five traps were placed in an adjacent wooded area with unmanaged blueberries in the under story. At a third site, four traps were placed in each type of habitat for a total of 12 traps. A baited Pherocon® AM trap was placed in each area to monitor for the presence of BMF.

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RESULTS/CONCLUSIONS: A large number of flies were captured on AM traps at all sites and habitats. It is interesting to note that more flies were caught on AM traps in the woods and fruit-bearing habitats compared to the prune-field habitat (Table 1). However, emergence trap captures suggest that both the woods and pruned habitat have 5 to 6 times the density of flies emerging from the soil compared to the fruit-bearing habitat (Fig. 4).

In our 2001 study, captures in the fruit-bearing habitat lagged slightly behind those in pruned fields and wooded areas (Fig. 5). This was not the case in 2002. Consistently more flies were captured in fruit-bearing areas (Fig. 6). It is hypothesized that in 2001, BMF activity, as reflected by trap capture, occurred over most of the growing season. In 2002, fly activity occurred during the first week of the growing season, but slowed to a minimal rate in week two before increasing again in weeks three and four in the fruit-bearing and woods habitats but not in the pruned habitat. An analysis of the temperature records during these periods revealed that cool temperatures characterized the period of increased activity during week three.

RECOMMENDATIONS: We hypothesize that the reason AM trap capture is so low in pruned fields relative to the other habitats is that flies leave pruned fields soon after emergence in search of food, mating sites, and oviposition sites. This is an important finding because it suggests that management of BMF by treating pruned fields with an insecticide is a risky strategy since the residence time of flies in the field may be relatively short. Only a continuous coverage of insecticide during fly emergence would be effective in killing a high proportion of flies if they leave pruned fields soon after emerging. More research needs to be conducted on fly dispersal after emergence to verify our hypothesis.

3. <u>The effect of blueberry clone on spanworm larval density</u>.

METHODS: Blueberry clones were sampled for blueberry spanworm larvae on each of three dates (6 May, 22 May and 4 June. Seventy-five clones were sampled on 6 May, 20 on 22 May, and 40 on 4 June. The clones were characterized into types according to stem, leaf and flower pigmentation. In addition, the phenological state of the clone was recorded as tight bud (TB), swollen bud (SB), tight cluster (TC), loose cluster (LC), bloom (B), or some combination of stages, i.e. tight to loose cluster.

RESULTS/CONCLUSIONS: In 2001, we found a significant relationship between spanworm density and blueberry-clone bloom phenology (Fig. 7). Results from 2001 also showed that clone type as characterized by stem color appeared to have no significant effect on spanworm larval density (Fig. 8). Bloom phenology appeared to have a significant effect on larval density in 2002 as well (Fig. 9, ANOVA, $P = 0.02$). Larval density was greater on the phenologically younger clones and decreased the more mature (closer to full bloom) the clone. However, since the sampling in 2002 (unlike 2001) occurred over a one month period (6 May to 4 June) we investigated the distribution of bloom phenology at each of the three dates and compared it to the distribution of spanworm density on the various phenological bloom classes. A nonparametric multinomial test comparing the two distributions at each date suggests that larval density

is associated with bloom phenology because it is not found in the same proportion as the phenology of the clones but rather with the earliness of the clones (P = 0.00001, P = 0.00001, and P = 0.10 for 6 May, 22 May, and 4 June, respectively). This suggests that spanworm larvae occur in numbers related to the earliest blooming plants despite hatching from eggs that are randomly laid throughout the field. As phenology of bloom progresses, these insects tend to favor the earlier stage plants.

RECOMMENDATIONS: We will repeat this study again in 2003. If there is a high level of association between bloom phenology and spanworm density, it would lead to a more efficient means of sampling spanworm by concentrating on the earlier clones.

4. Growth and development of blueberry spanworm in the laboratory.

METHODS: Blueberry spanworm eggs were collected in the summer of 2001 and stored for the winter. In late February or early April, eggs were removed from the refrigerator and reared at room temperature (18-20^{o}C) in the laboratory. Emerging larvae were placed in individual plastic diet cups with fresh blueberry buds and foliage taken from plants cut in the spring at Blueberry Hill Farm. Larval instar as determined by head capsule size was recorded daily for each larva.

RESULTS/CONCLUSIONS: The average number of days required for each immature life stage to complete its development is shown in Table 2. A temperature dependent model of egg hatch based on data from 1999-2002 is shown in Fig. 10.

RECOMMENDATIONS: The non-linear model resulting from this research will form the basis of an early warning detection forecast system for blueberry spanworm to be validated in 2003. The ability to predict the onset of emergence of blueberry spanworm from wintering eggs and understanding patterns of larval growth and development will help growers make more informed crop-management decisions.

1. VERTICAL DISTRIBUTION OF BLUEBERRY MAGGOT FLIES.

Fig. 1. Average male and female BMF collected, by height (ft) for individual fields and all fields, combined, on all dates.

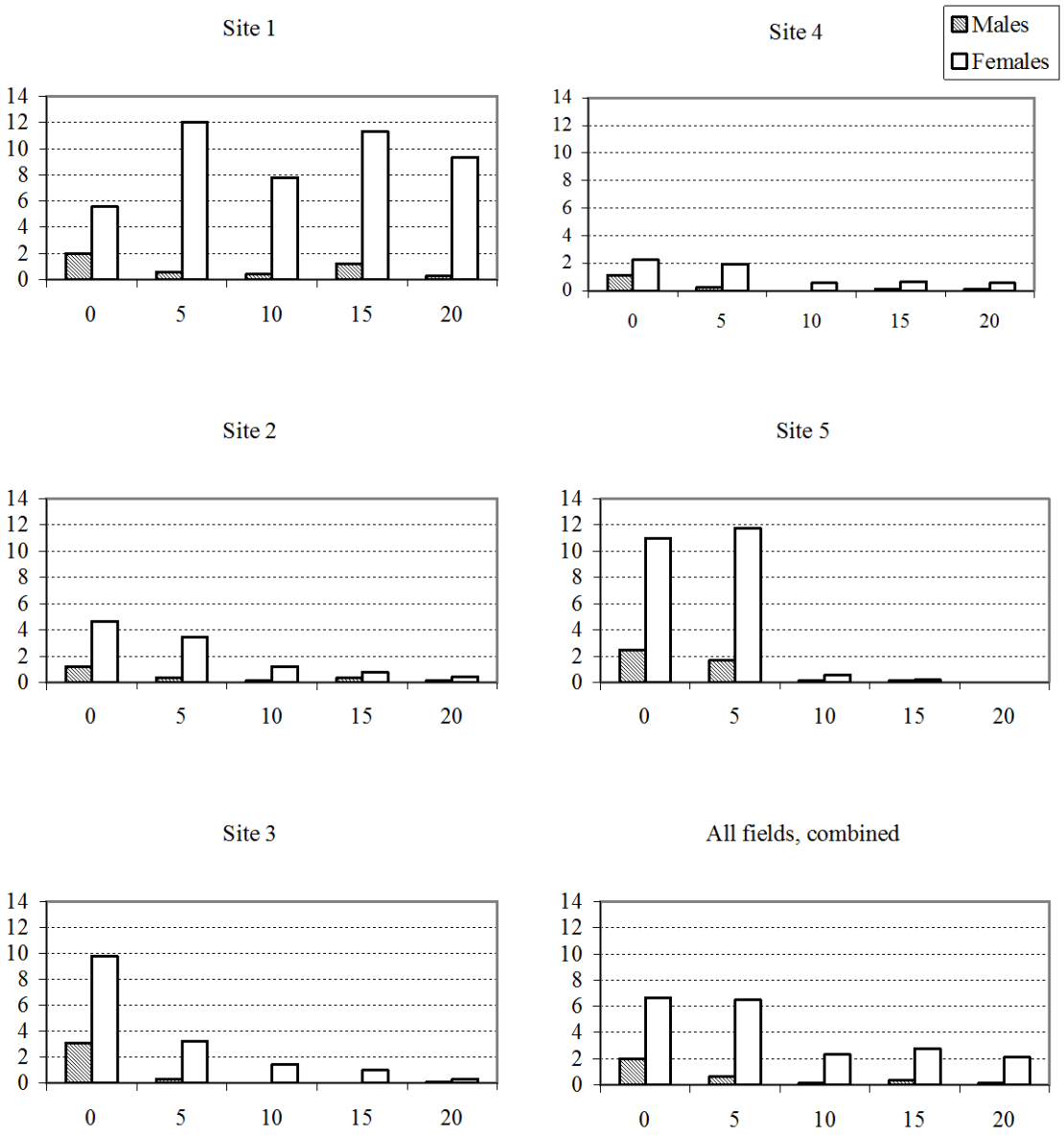


Fig. 2. Percent of BMF males and females collected at each height (ft) by date, for all fields, combined.

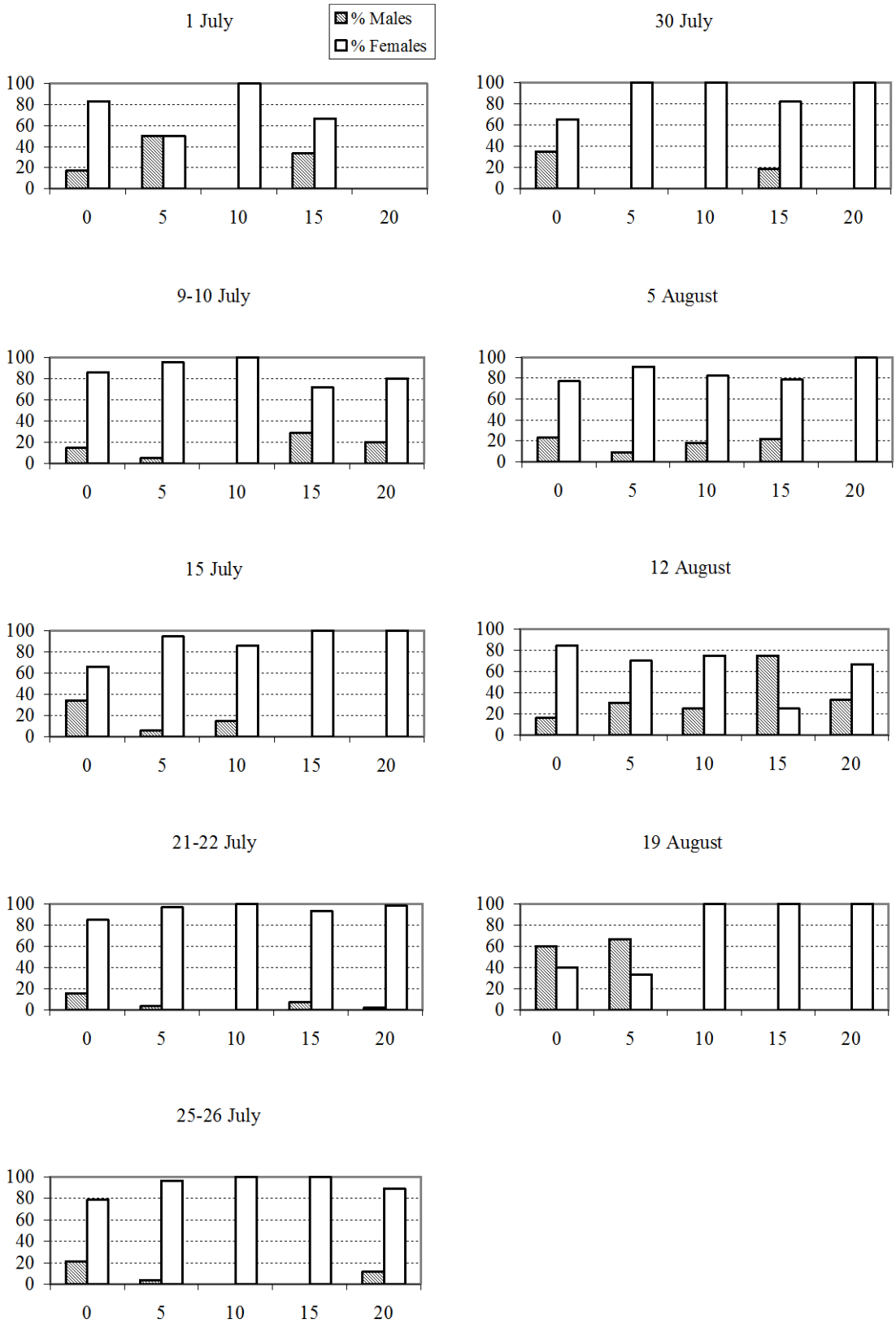
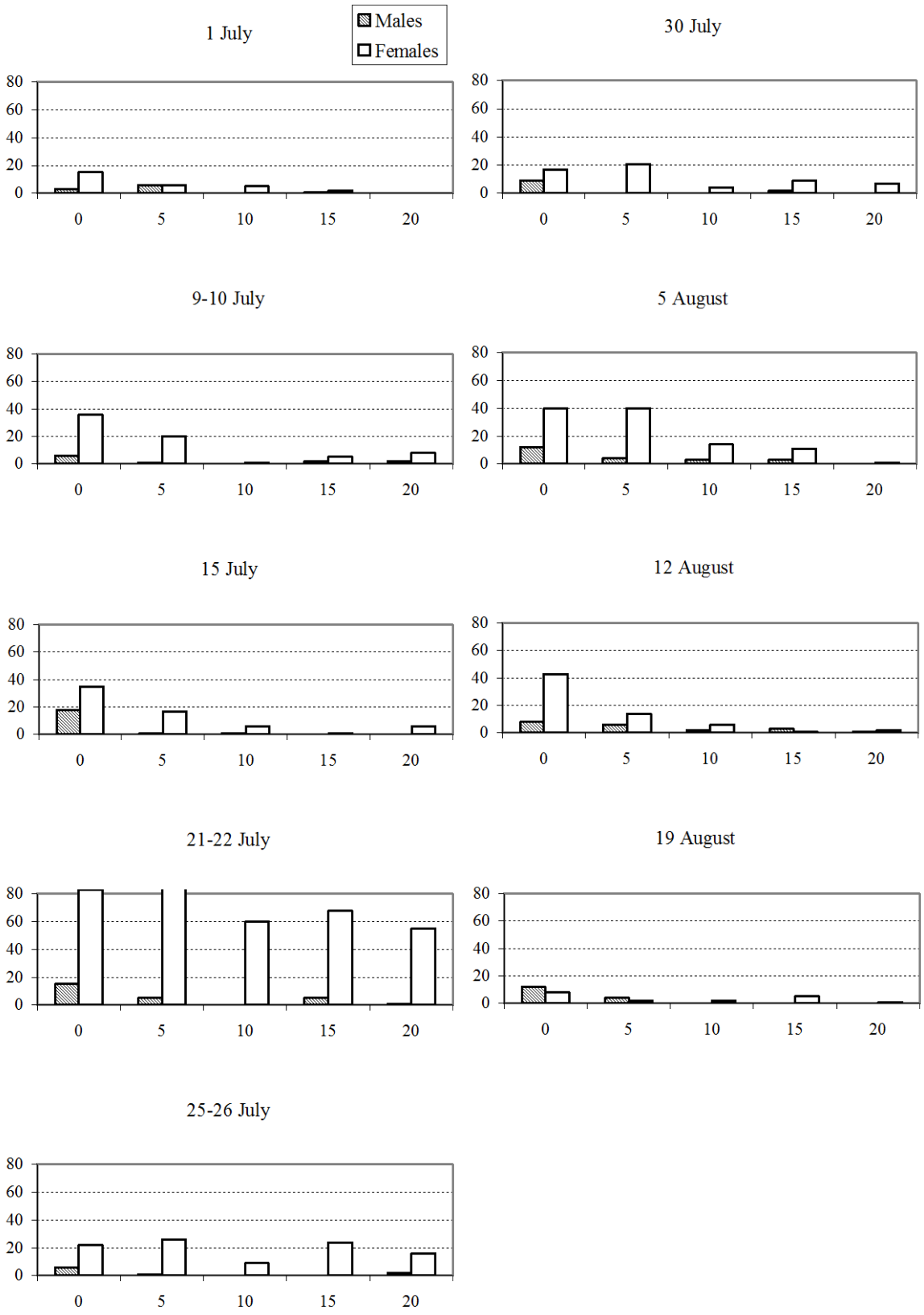


Fig. 3. Total number of male and female BMF collected at each height (ft) by date, for all fields, combined.



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

Table 1. Seasonal density of blueberry maggot flies.

AM trap location	Average BMF/trap	BMF/trap Seasonal density
Fruit-bearing habitat	29.5	28.0
Pruned habitat	8.3	7.3
Wooded habitat	19.9	18.2

"Average BMF/trap" is the total number of flies captured over the trial at all sites divided by the number of traps. Seasonal densities are for all sites, combined, and are trapezoidal integrals of densities over the season divided by the duration (in days) of the experiment.

Fig. 4. Emergence trap captures of BMF, 2001-2002.

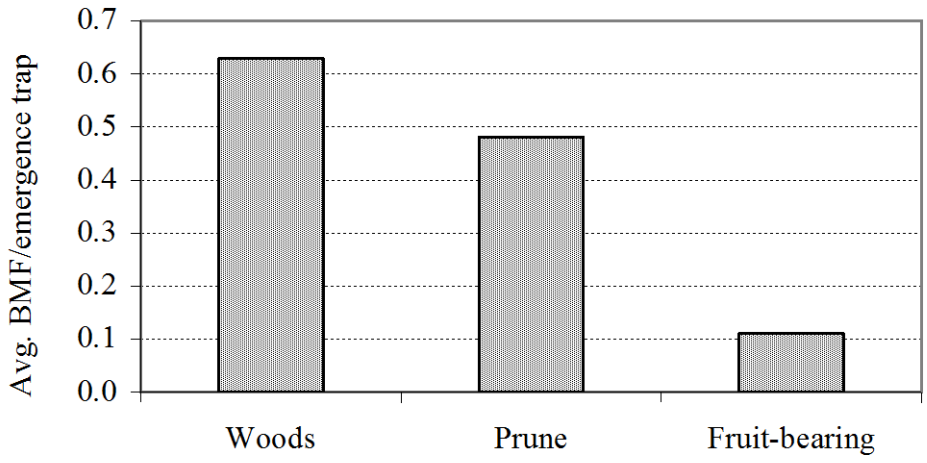


Fig. 5. Seasonal emergence of BMF, 2001

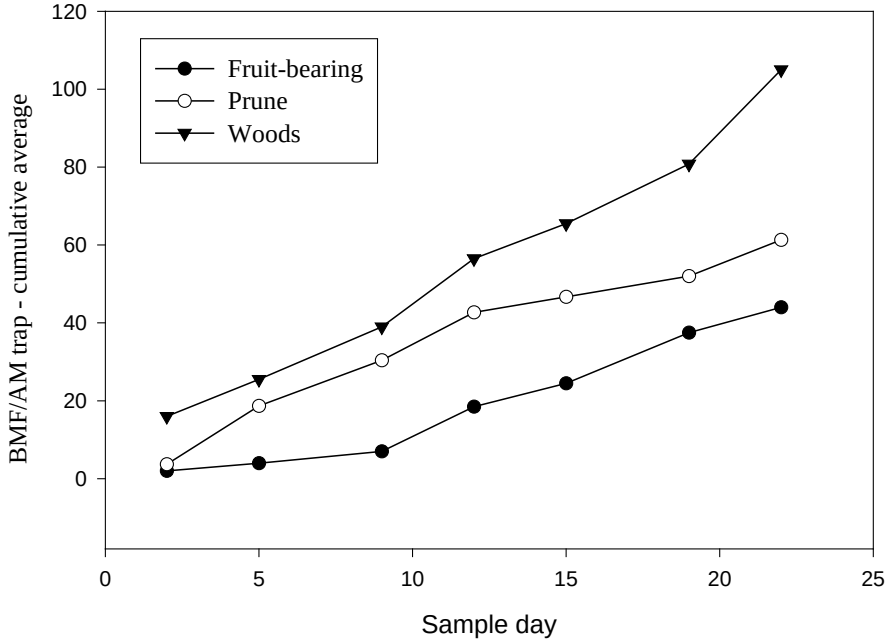
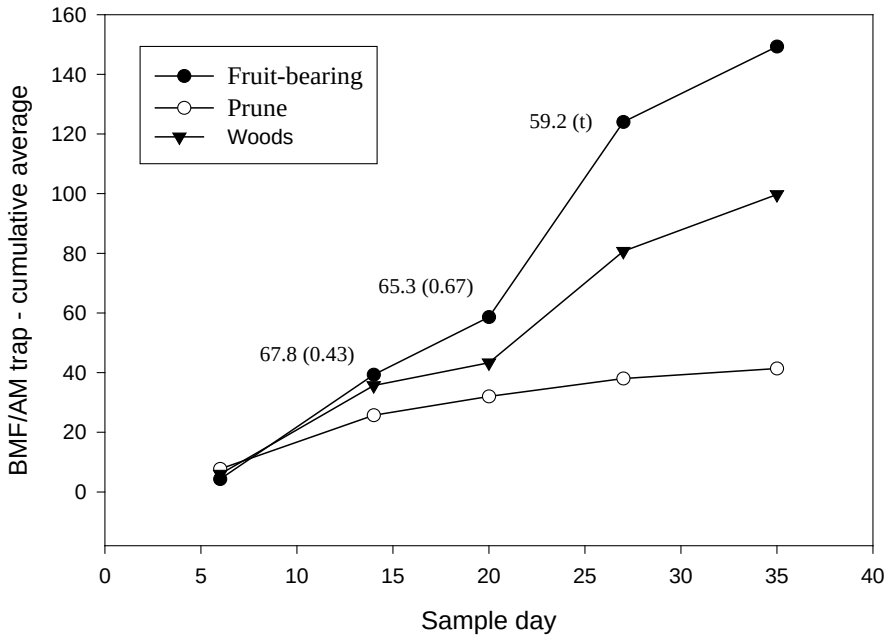


Fig. 6. Seasonal emergence of BMF, 2002.



3. EFFECT OF BLUEBERRY CLONE ON SPANWORM LARVAL DENSITY.

Fig. 7. Effect of bloom phenology on larval density, 2001.

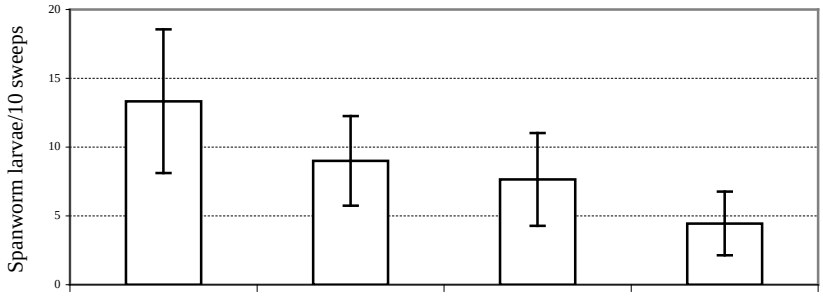


Fig. 8. Effect of clone type on larval density, 2001.

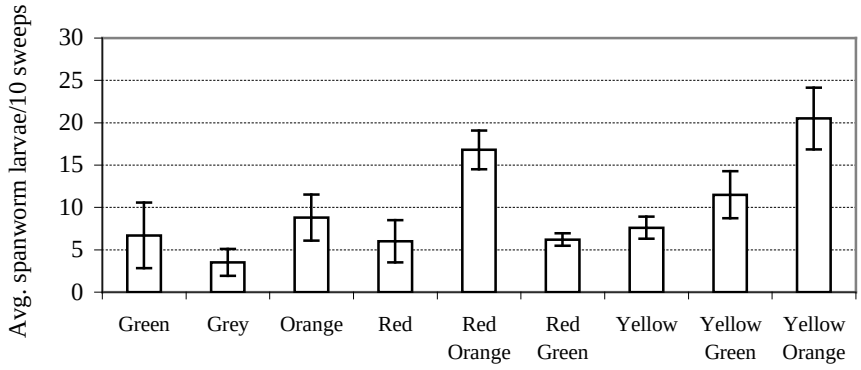
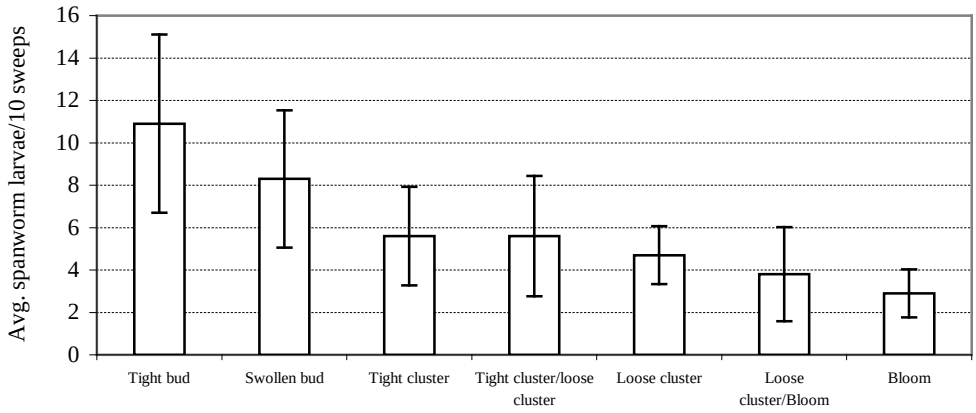


Fig. 9. Effect of bloom phenology on larval density, 2002.

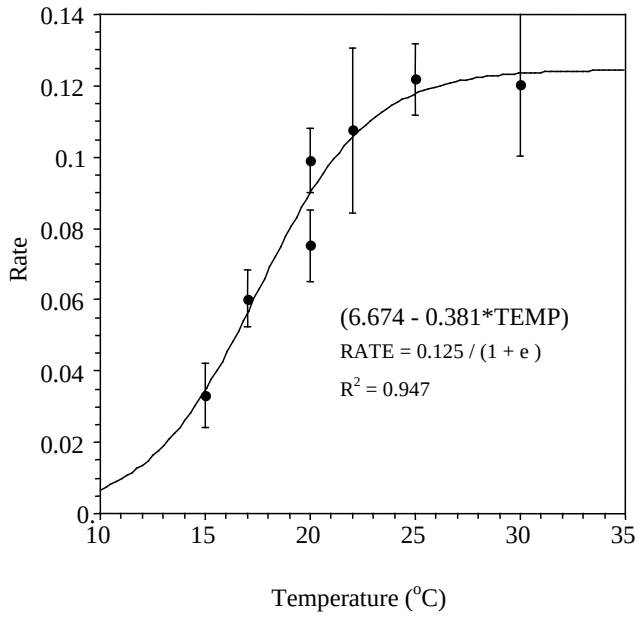


4. GROWTH AND DEVELOPMENT OF BLUEBERRY SPANWORM IN THE LABORATORY.

Table 2. Development of blueberry spanworm.

Developmental Stage	Avg. days to develop (SE)
Egg	8.8 (1.7)
1st instar	3.9 (0.9)
2nd instar	3.8 (0.7)
3rd instar	3.3 (0.7)
4th instar	4.3 (0.5)
5th instar	4.4 (1.0)
Pupa	13.0 (1.2)

Fig. 10. Median spanworm egg hatch rate modeled as a function of incubation temperature.



INVESTIGATORS: C. S. Stubbs, Department of Biological Sciences
F.A. Drummond, Department of Biological Sciences

TITLE: Wild Blueberry Pollination Research

OBJECTIVE: To assess whether commercial *Bombus impatiens* will produce Queens that can overwinter in Maine blueberry growing areas.

METHODOLOGY: Year 1 (2002) of this study was conducted at the Jonesboro, Blueberry Hill Farm and a farm in Winterport. The quads of the commercial bumble bee, *Bombus impatiens*, arrived considerably before the onset of blueberry bloom, May 9 and 10. Thus, all quads initially went to the farm in Winterport, which had ample dandelion, shadbush, cherry, willow and other flowering plants for the bees to forage on. Then on 29 May there was adequate blueberry bloom at blueberry Hill so two of the quads were moved and 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 a numbered tag affixed to her upper thorax with glue. The Queen was then monitored to make certain she successfully recovered from the chilling.
The following spring (2003) we will determine whether the marked Queens have successfully overwintered through searching for them with plot counts, sweep-net sampling, and transects both in the wild blueberry bloom and also in any nearby alternate forage.

RESULTS: The first new Queen was captured and marked on May 16. Overall, a total of 21 new Queens were tagged (3 at Jonesboro and 18 at Winterport). The final new Queen was marked in Jonesboro on June 18 and on July 25 in Winterport. Several new queens escaped without getting marked and tagged. Thus total Queen production may be somewhat higher than recorded.

There was great variability among the colonies in new Queen production ranging from 0 to 8 Queens produced per colony. Three possible factors contributing to the greater Queen production in Winterport are: 1) one of the quads that went to Jonesboro arrived a day later and had been damaged in shipment so that some bees probably have been lost prior to arrival in Maine. This damage reduced the worker foraging force for that quad. 2) Some bees may have been lost when the two quads were shut up and transported to Jonesboro, which again would reduce the worker force. 3) There was more and better alternate forage after blueberry bloom in Winterport than in Jonesboro.

RECOMMENDATIONS: This is Year 1 of a two-year study. The study requires replication because *B. impatiens* Queens perhaps only successfully overwinter during mild winters. Therefore, it is necessary to repeat this experiment for a series of replicate cycles in case the winter is mild. In the spring of 2003 and then again in 2004 we will determine if the Queens survived successfully. If they do, then the pollination benefits from purchasing quads will actually be much greater over time than the initial investment expense.

INVESTIGATORS: S.L. Annis, Biological Sciences
C.S. Stubbs, Biological Sciences
COOPERATORS: D.E. Yarborough, PSE
J.M. Smagula, PSE

TITLE: Stem Blight and Leaf Spot Diseases in Lowbush Blueberry Fields, 2002

METHODS : *Disease Survey Year 4 and Effects of Disease on Yield.* Six fields previously investigated were used to follow the persistence and incidence of disease through the cropping cycle. In late July through mid August 2001, twenty 0.25m^2 plots equally distributed along a W transect (5 per section) were established in 6 nonbearing fields. All living stems with symptoms of disease were tagged in each plot. In May 2002, prior to full bloom, stems in these plots were reexamined and any additional stems showing symptoms were tagged. In addition, a maximum of 3 healthy stems per plot were also tagged. In the spring and in late July, flowers and fruits, respectively, were counted on the tagged stems. The adjusted fruit set (number of fruit / number of flowers) per stem was calculated. All tagged stems were collected and photographed to document disease symptoms. Stems were then surface sterilized in 10% bleach and plated out on water agar for identification of fungi.

In late July - early August 2002, 20 additional 0.25m^2 plots were established along the W transect of each field. All stems showing disease symptoms were collected from these plots and the total number of stems per plot was determined for 4 plots per field. Incidence of leaf spot disease (percentage of stems with leaf spot) was estimated in the plots, and 2 stems with leaf spot were collected per plot. All stems were rated for generalized location of disease symptoms, such as tip, middle or bottom of the stem or stem death. For each field, the stems from 6 plots were diagnosed by location and types of symptoms. The leaves from 6 plots and the diagnosed stems were surface sterilized in 10% bleach and plated on malt yeast extract agar and/or water agar. Identification of fungi from these samples will be completed in 2003.

Fungicide trial 1. Effects of fungicide treatments during late bloom on stem and leaf spot diseases, leaf retention, and blueberry yield.

Plots (12’ x 50’) were established in two fields (Montegail, Township 19, and Spring Pond, Deblois) under normal management practices to examine the effect of late sprays of fungicide on disease. Eight blocks with 3 treatments, Bravo (4 pints/acre), Orbit (6 ounces/acre), or no fungicides were sprayed by Dave Yarborough on June 4th during late bloom. In early August, two 6”x 36”sampling areas per plot were raked and berry weights measured per sampling area. Leaf spot disease was estimated using a rank scale for severity of 1- 4, 1 indicates few spots, 4 indicates numerous spots, and percentage of stems with leaf spot for incidence in the same sampling areas as above. Finally, all diseased stems from these sampling areas were collected. In the laboratory, stems were rated for generalized location of disease symptoms, such as tip, middle or bottom of the stem or stem death. In October, the Spring Pond plots were rated for leaf retention using a ranking scale of 1- 4 with 1 indicating few leaves retained to 4 indicating most leaves retained.

Fungicide trial 2. Effects of different fungicide treatments on mummy berry blight, leaf spot diseases and blueberry yield.

Plots (6' x 25') were established in two fields (Montegail, Township 19, and Spring Pond, Deblois) under normal management practices except no fungicides had been sprayed by the growers. Seven plots, replicated in 4 blocks, were randomly assigned to controls or 6 different fungicide treatments that varied by fungicide, and spray date (Table 1). On June 6 and 7th, 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 were recorded.

Effects of DAP fertilizer on the incidence of stem blight and leaf spots diseases

We used the fertility trials established by J. Smagula at Sunkhaze Medow blueberry farm in T-31 to examine the effects of fertilizer (DAP) treatment on stem and leaf diseases. We sampled the control and DAP only treatments of Dr. Smagula's fertility experiment. Please see J. Smagula's report for his fertilizer application and yield assessment methods.

Just prior to harvest on August 1, 2002, four 6"x36"sample areas were examined within each of 7 replicated DAP and control. All diseased stems were collected from each sample area and returned to the laboratory for diagnoses of disease location. To estimate stem density, the total number of healthy stems was counted in one sample area per plot. Incidence of leaf spot disease was also estimated as the percentage of stems with leaf spot for one sample area in each plot.

Data analysis. Data were not normally distributed. Wilcoxon paired signed-rank comparisons and Dunn's multiple comparison tests for non-parametric data were used to determine the significant effects of treatments and differences between treatments, respectively. Correlations used Spearman's rank correlation coefficient. All analyses was performed using the SAS program.

RESULTS: *Disease Survey Year 4 and Effects of Disease on Yield*

Diseased stems and spotted leaves were found in all 6 fields surveyed. The incidence of stem disease in bearing fields was higher in 2002 than in 2001, but not as high as in 2000 or 1999 (Figure 1). Average percentage of diseased stems was greater during bearing years than nonbearing years for 5 fields followed over two crop cycles (Figure 2). A sixth field was examined from 2000 on, but not included in the previous analysis. In surveys of other fields in the previous 3 years, bearing fields have had higher incidence of stem disease than nonbearing fields. There were lower levels of stem disease on average in the fields in the second crop cycle than the first. This may be due to the dry, warm weather conditions during the spring of 2001. There were higher levels of incidence of disease for all stem locations in the bearing year than the previous non-bearing year (Figure 3). When the fields were nonbearing (2001), dead stems were the most frequent stem symptom, and in the same fields during the bearing year (2002), dead stems and stem with diseased tips were the most frequent (Figure 3).

The effects of stem diseases on adjusted fruit set varied among the 6 fields. In 4 of the 6 fields, the adjusted fruit set was significantly lower in the diseased stems tagged in the fall of 2001 than for the diseased stems tagged in the spring of 2002. Disease initiated in the non-bearing year may have a greater effect upon yield than that initiated in the bearing year. Two fields had significant effects of disease on adjusted fruit set compared to the controls. In field 21,

stems with disease at their tips had significantly less adjusted fruit set than control stems, however control stems had significantly less fruit set than stems with disease at their bases (Figure 4). In field 35, stems with disease at their tips, in the middle of the stem or at the base of the stem had significantly less fruit set than the control stems (Figure 5). Different types of symptoms were described from the same location on the stem (i.e. tip, middle or bottom of the stem) for the various fields, which may produce the observed variation in effect of disease on yield. The effect of stem diseases on fruit set may also be affected by variation in the aggressiveness of strains of pathogenic fungi found in a particular field.

The incidence of leaf spot in bearing fields did not vary significantly over the 4 years of study (Figure 6) suggesting that weather conditions may not have as strong an effect on leaf spot as on stem disease. The average incidence of leaf spot in the bearing years (2000 and 2002) was significantly higher than that in nonbearing years (1999 and 2001) for the 5 fields examined over 4 years (Figure 7). Similar levels of leaf spot were found in the two crop cycles which is in contrast to the variation between crop cycles found in levels of stem disease.

Fungicide trial 1. Effects of fungicide treatments during late bloom on stem and leaf spot diseases, leaf retention, and blueberry yield.

There was no significant differences among treatments and the control for the number of diseased stems per plot, but fungicide treated plots had significantly less severity and incidence of leaf spot than the control plots (Table 2). Treatments with Bravo had significantly lower incidence and severity of leaf spot than Orbit treatments. The incidence of leaf spot was strongly correlated to the leaf spot severity rating for both fields (Spearman Correlation coefficients of 0.85 for Township 19 field and 0.9 for Deblois field, $P < 0.01$). In the Deblois field, Bravo treated plots had a significantly higher leaf retention ranking than either the Orbit treatment or the control (Table 2). The leaf retention ranking was weakly inversely correlated to the level of leaf spot incidence and severity for the Deblois field (Spearman Correlation coefficients of -0.26 for leaf spot incidence and -0.25 for leaf spot severity, $P < 0.1$). However, there were no significant effects of fungicide treatment on yield (berry weight) for either field (Table 2).

Fungicide trial 2. Effects of different fungicide treatments on mummy berry blight, leaf spot diseases and blueberry yield.

The incidence of mummy berry blight was 3 times higher in the control plots in the Township 19 field than those in the Deblois field (Table 3). For the Township 19 field, fungicide treatments 3 and 7 (see Table 1) had significantly lower mummy berry incidence than the control plots (Table 3). In the Township 19 field, the yield was weakly inversely correlated to the incidence of mummy berry blight per plot (Spearman Correlation coefficient of -0.45, $P < 0.02$). In the Township 19 field, fungicide treatment 3 also caused significantly lower levels of leaf spot incidence and severity compared to the control plots. For the Deblois field, fungicide treatment 3 also had significantly less incidence of mummy berry blight than compared to the controls, but this treatment did not have significantly different levels of leaf spot incidence and severity compared to the control plots. In the Deblois field, only fungicide treatment 2 had both significantly less incidence and severity of leaf spot disease than the controls. In both fields, the incidence of leaf spot was strongly correlated to the severity of leaf spot (Spearman Correlation coefficients of 0.94 for Township 19 field and 0.95 for Deblois field, $P < 0.01$). In both fields, there was no significant effect of fungicide treatment on blueberry yield (berry weight).

Effects of DAP fertilizer on the incidence of stem blight and leaf spots diseases

There was significantly more diseased stems and healthy stems in DAP treated plots than control plots (Table 4). However, there was no significant difference in the percentage of diseased stem between the two treatments. There was also no significant effect of fertilizer on the level of leaf spot incidence, which was highly variable.

Stem and Leaf Disease Sample Identifications from 1999, 2000, 2001

To date (1999-2001) more than 200 fungi have been identified. Some of these fungi are known plant pathogens, and at least 18 of these genera are known to produce disease on blueberries or other members of the Ericaceae.

Twenty-three of the 25 fungi identified at the highest frequencies from infected stems in 1999 were also identified in infected stems in 2000 and/or 2001 (Figure 8). Many of these fungi were found in all fields in all years and may be secondary pathogens of dead plant tissue. However, many of these fungi are known pathogens of Ericaceae. Only 11 of the 24 fungi most frequently identified from infected leaves in 1999 were also identified from leaves in 2000 and/or 2001 (Figure 9).

CONCLUSIONS : Stem and leaf blight diseases are common in lowbush blueberry fields with a higher incidence in the bearing years than non-bearing years. The higher incidence of stem disease in 2002 compared to 2001 suggests that weather conditions play an important role in determining the severity of stem disease in the wild blueberry agroecosystem. However, the similar levels of leaf spot disease in bearing fields over the last 4 years and in the 5 fields examined over two crop cycles suggest that weather in the spring may not be as important for leaf spot disease development. The effects of disease on yield, as measured by adjusted fruit set, vary by field and are probably affect by individual field conditions and the particular combination of diseases in each field. Disease initiating in the nonbearing year may result in killing of stems or as sources of inoculum in the bearing year. In fungicide trial 1, treatment during late bloom with Orbit or Bravo decreased leaf spot disease severity and incidence. However, Bravo had the larger effect, but neither fungicide affected stem disease incidence or yield (berry weight). In fungicide trial 2, only fungicide treatment 3 (see Table1) produced a significant decrease in mummy berry blight in both fields. There were no consistent effects of any of the fungicide treatments on leaf spot disease or yield. There were no significant effects of fertilizer treatment (DAP) on stem or leaf spot diseases. Many potential pathogens of blueberry that have been isolated from diseased stems and leaves and it appears that a complex of fungi are causing stem and leaf diseases. Variation in aggressiveness of different strains of the same fungus may also account for the differences in effects of disease on yield seen between the fields.

RECOMMENDATIONS: Bravo appears to hold promise for control of mummy berry disease and leaf spot disease, and BAS510, a reduced risk fungicide was effective on mummy berry. However further studies are needed to determine their effectiveness and different timing of treatments need to be performed. Recommendations for control of stem disease cannot be made at this time. It is recommended that the impact of disease on yield be continued in a subset of the previously surveyed fields. Disease onset would be tracked in the prune year of the crop cycle through the crop year because our previous findings suggest this will give a better indication of the effects of stem and leaf spot diseases on yield. The aggressiveness of different strains of

disease causing fungi and the susceptibility of different clones of wild blueberry needs to be examined. The effects of using fungicides in the nonbearing year to control subsequent disease in the bearing year should be investigated in 2003.

Table 1. Fungicide trial 2. Fungicide treatment and dates applied to Township 19 and Deblois fields in 2002

Treatment[1] /Date	May 2	May 9	May 20	June 13	June 27
1 Control	0	0	0	0	0
2	Orbit	Orbit	Orbit	Bravo	Abound
3	Bravo	Bravo	Orbit	Bravo	Switch
4	Switch	Switch	Orbit	Bravo	0
5	Abound	Abound	Abound	0	0
6	Bas 510	Bas 510	Bas 510	Bas 510	0
7	Bas 516	Bas 516	Bas 516	Bas 516	0

[1]Chemical rates: Orbit 6 ounces/a, Bravo 4 pints/a, Switch 9 ounces/a, Abound 15.4 ounces/a, BAS 510 0.35 pounds/a, BAS 516 0.55 pounds/a.

Table 2. Effect of late bloom fungicide treatments on stem and leaf diseases, leaf retention and yield in two lowbush blueberry fields, 2002

Field	Treatment	# diseased stems /plot	% stems with leaf spot	Leaf spot severity rating	Leaf retention rating	Yield (g berry weight /ft^2)
Township 19	Control	14.5 a	71.9 a	2.6 a	n.d.	132.4 a
	Orbit	17.3 a	42.8 b	1.9 b	n.d.	114.9 a
	Bravo	18.2 a	21.2 c	1.1 c	n.d.	127.1 a
Deblois	Control	11.6 a	76.3 a	2.3 a	2.8 a	134.4 a
	Orbit	12.5 a	55.6 b	1.9 b	2.8 a	148.4 a
	Bravo	12.8 a	33.5 c	1.4 c	3.3 b	128.4 a

Table 3. Effect of different fungicide treatments on mummy berry blight and leaf diseases and yield in two lowbush blueberry fields, 2002

Field	Treatment	% stems with mummy berry blight	% stems with leaf spot	Leaf spot severity rating	Yield (g berry weight/ ft^2)
Township 19	Control	65.7 a	62.8 ab	2.42 a	191.7 a
	2	55.3 a	25.4 ac	1.4 ab	152.5 a
	3	27.6 b	14 c	1 b	181.1 a
	4	60.7 a	19.8 ac	1.4 ab	138.4 a
	5	49.5 ab	85 b	2.6 a	142.6 a
	6	48 ab	17.6 ac	1.4 ab	234.8 a
	7	30.7 bc	23.5 ac	1.6 ab	189.9 a
Deblois	Control	20.1 a	72.6 a	2.5 a	123.2 a
	2	9.5 ab	23.9 b	1 b	70.5 a
	3	4 b	22 ab	1.4 ab	94.6 a
	4	10.8 a	18.6 b	1.4 ab	84.8 a
	5	13.8 ab	51.4 ab	2.1 ab	95 a
	6	9 ab	15.9 b	1.2 ab	144.2 a
	7	6.9 ab	24.5 ab	1.2 b	132.9 a

Table 4. Effect of DAP fertilizer on diseased stems and leaf spot in a lowbush blueberry field, 2002

Treatment	Total # diseased stems/plot	Total # of healthy stems/plot	% of diseased stems/plot	% of stems with leaf spot/plot
Control	6.8 a	49.8 a	13.1 a	58.6 a
DAP	9.8 b	65.4 b	14.8 a	28.8 a

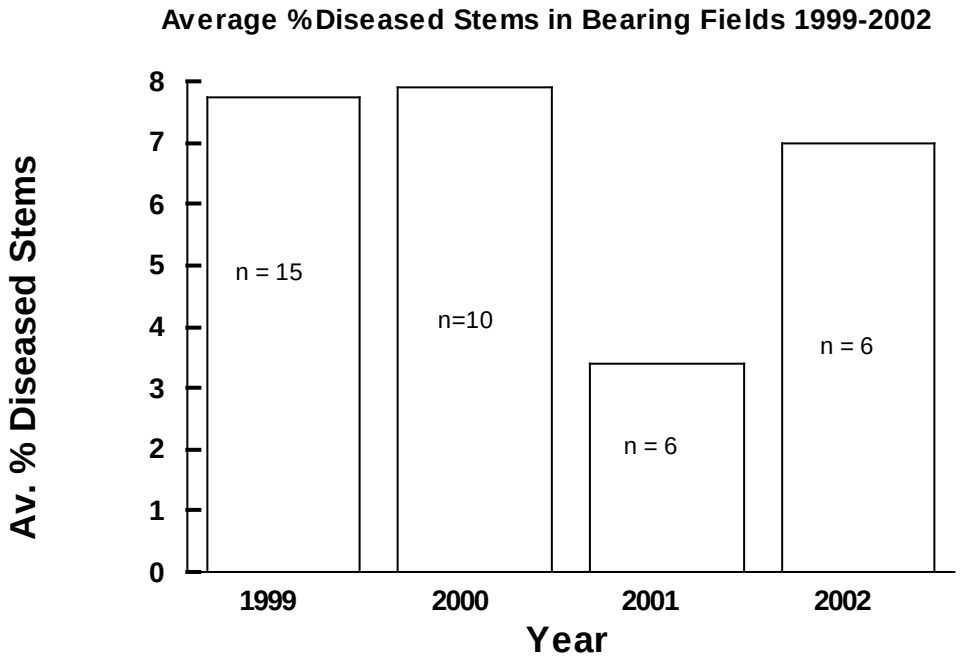


Figure 1. Average % diseased stems per plot in bearing fields, 1999-2002.

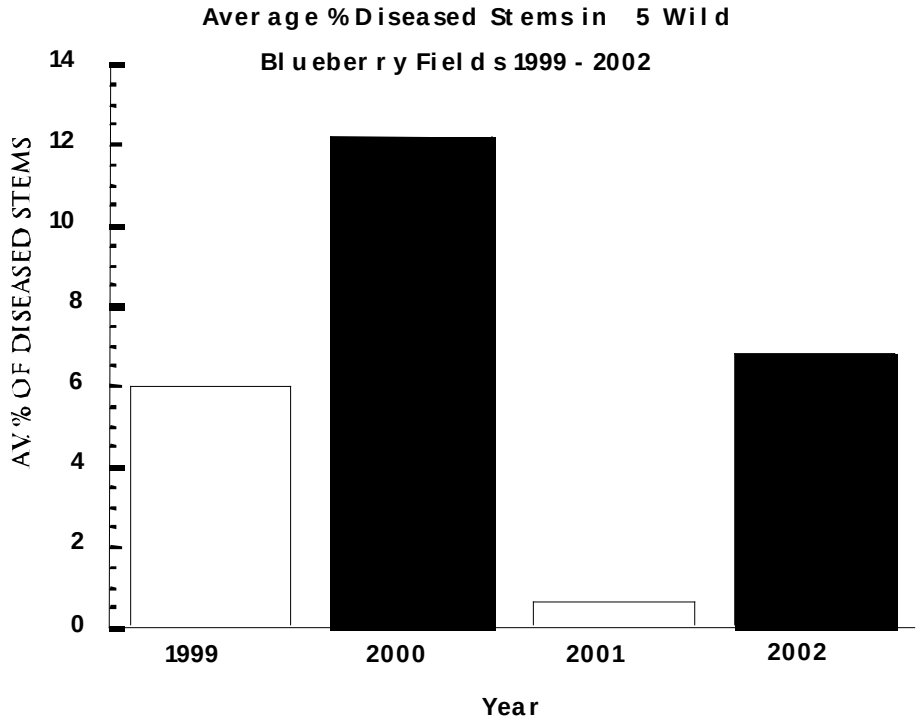


Figure 2. Average % of diseased stems per plot in 5 wild blueberry fields over two crop cycles. Black bars indicate bearing years and white bars indicate nonbearing years.

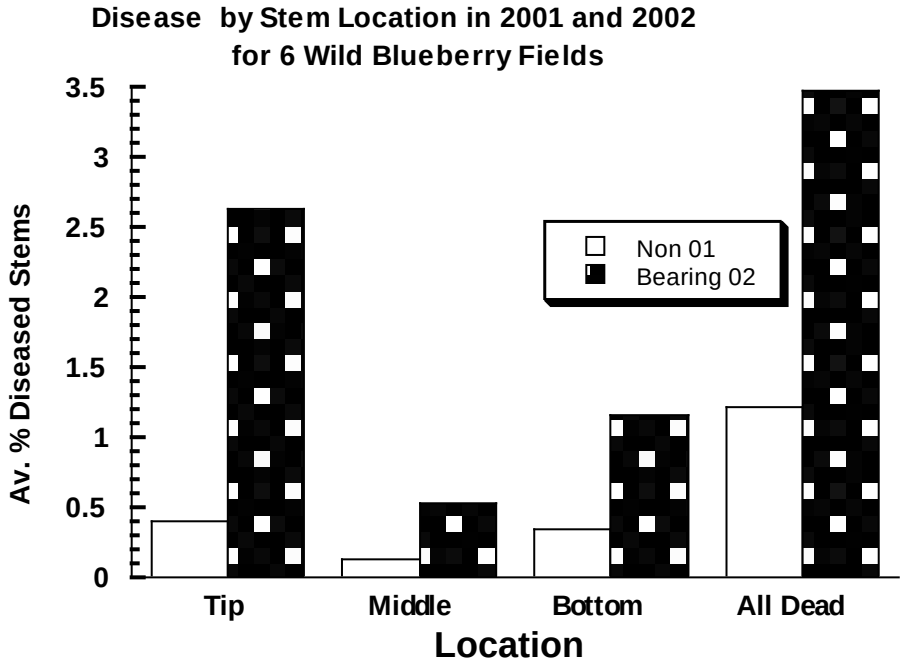


Figure 3. Average % diseased stems per plot by stem location in 2001 and 2002.

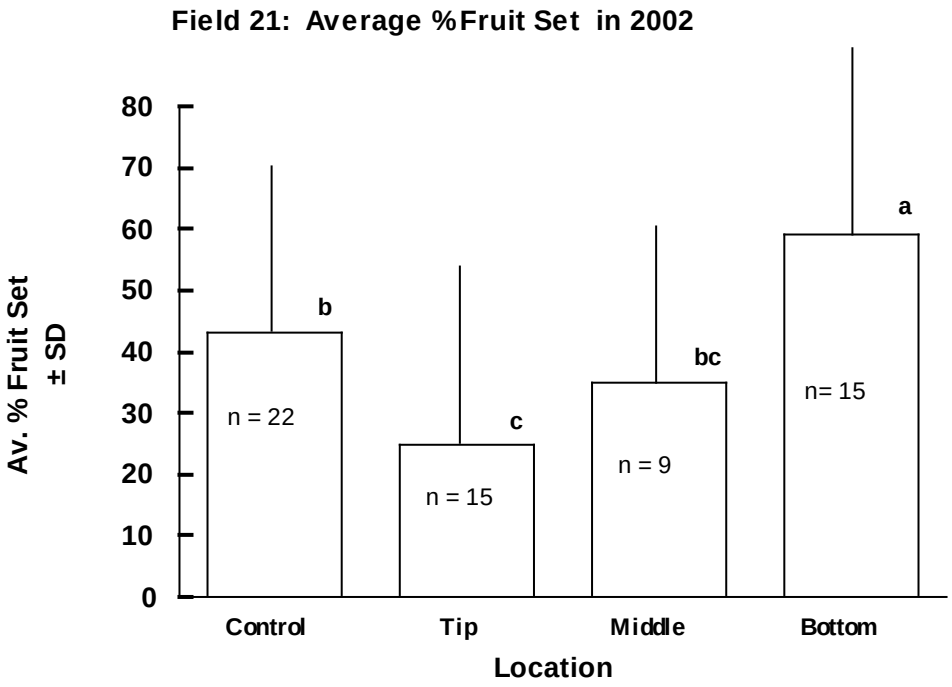


Figure 4. Average adjusted fruit set in healthy (control) and diseased stems by location for field 21 in 2002. N= number of stems per treatment.

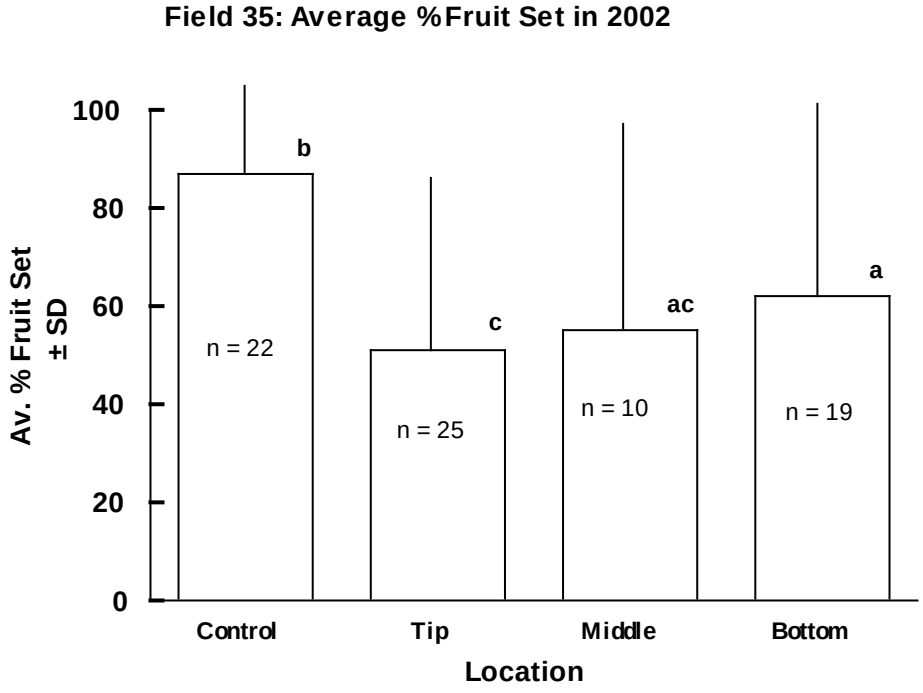


Figure 5. Average adjusted fruit set for healthy (control) and diseased stems by location for field 35 in 2002. N= number of stems per treatment.

Figure 6. Average % of stems with leaf spot per plot in bearing fields 1999-2002. N= number of fields sampled.

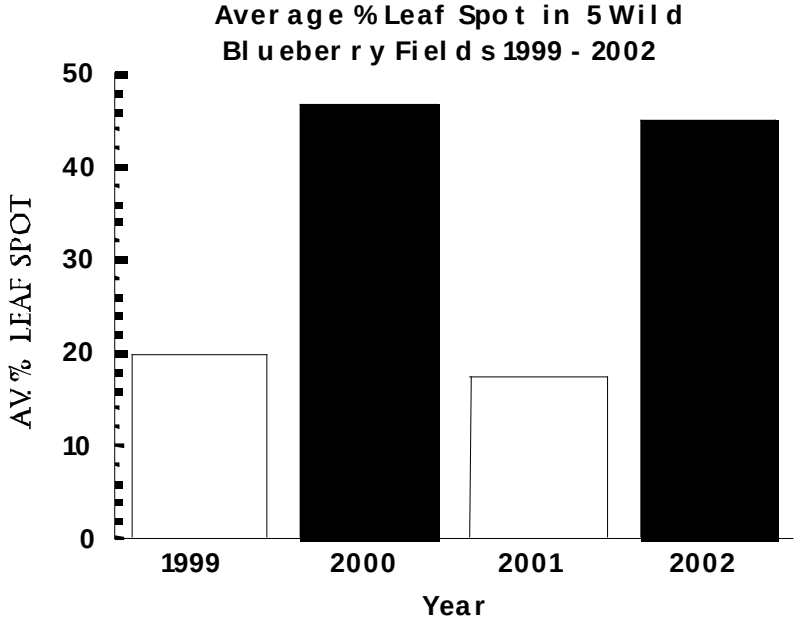
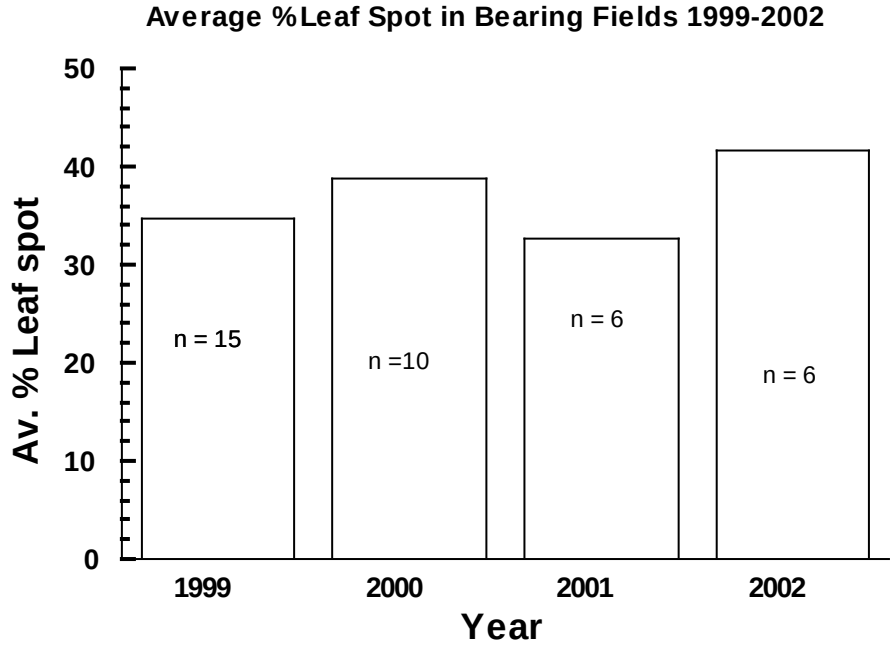


Figure 7. Average % of diseased stems per plot in 5 wild blueberry fields over 2 crop cycles. Black bars indicate bearing years and white bars indicate nonbearing years.



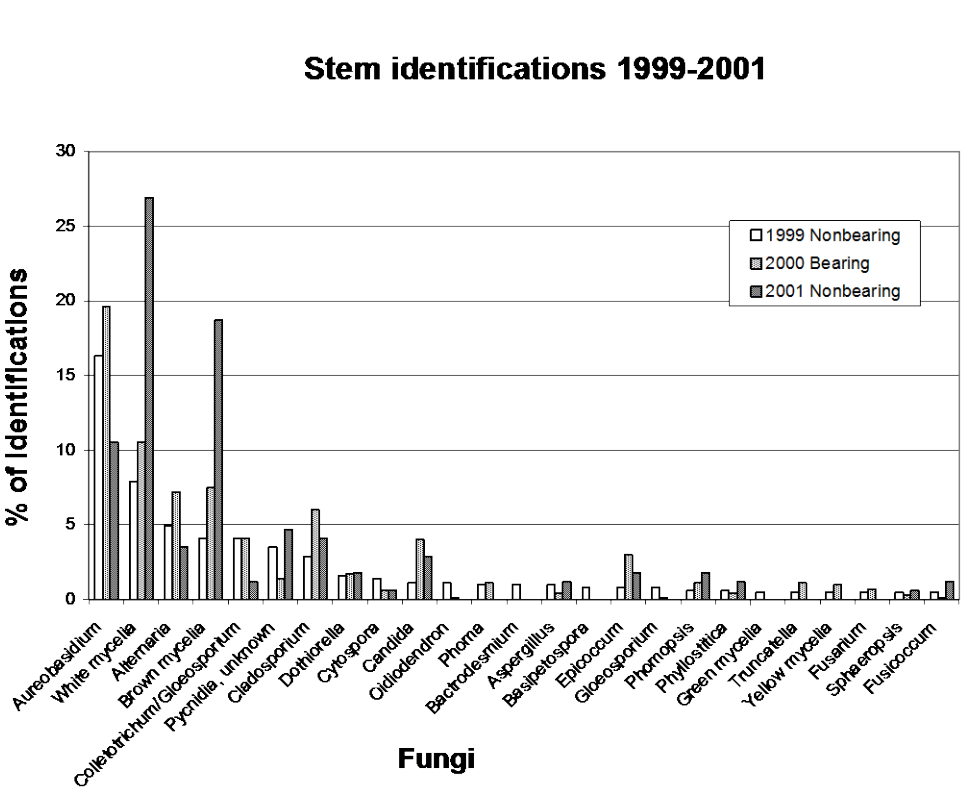


Figure 8. Fungi with the highest frequency of identifications from diseased stems in 1999 (white bars) and their persistence, as measured by frequency of identification, in fields over 2000 (gray bars) and 2001 (darkest bars).

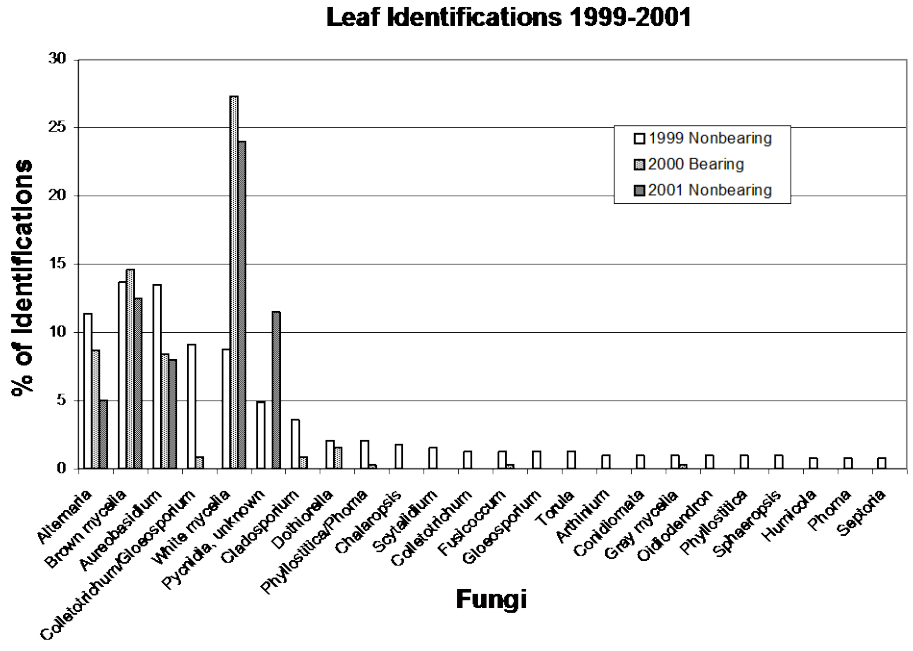


Figure 9. Fungi with the highest frequency of identifications from diseased leaves in 1999 (white bars) and their persistence, as measured by frequency of identification, in fields over 2000 (gray bars) and 2001 (darkest bars).

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Karen Loennecker, Scientific Technician

TITLE: Effect of Foliar-applied Iron Chelate Concentration on Leaf Iron Concentration, Wild Blueberry Growth and Yield.

OBJECTIVES: To evaluate the effect of foliar-applied fertilizer containing different concentrations of iron (Fe) on leaf Fe concentration, growth, and yield of wild blueberry.

METHODS: A field that had a previous history of leaf Fe concentrations below 50 ppm was used in this study. Nitrogen (N) and phosphorus (P) needs were to be satisfied by diammonium phosphate (DAP, 18-46-0)) fertilizer application by the owner of the field. Fe Keylate (Stoller Enterprises Inc.) which contains 5% Fe (5% chelated Fe) was used as the source of Fe. Ammonium sulfate at 2.8 lbs/acre was added to the solution to enhance uptake of the Fe chelate. Five 6 ft x 50 ft treatment plots received the following foliar sprays applied in water at 67 gal/acre on June 14, 2001:

1. Control - no fertilization
2. Fe Keylate at 0.5 lb Fe/acre
3. Fe Keylate at 1.0 lb Fe/acre
4. Fe Keylate at 1.5 lb Fe/acre
5. Fe Keylate at 2.0 lb Fe/acre

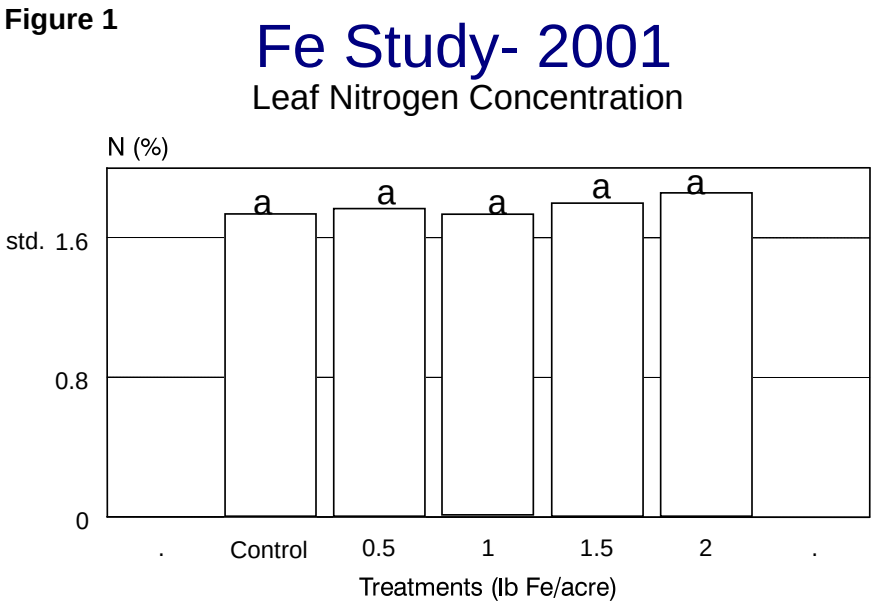
Treatments were replicated 6 times in a randomized complete block design. Composite leaf samples were taken randomly across each treatment plot on July 6, 2001. Stem height and flower bud formation were measured on stems cut at ground level in four, $1/4ft^2$ quadrats/treatment plot November 6, 2001. Yield was determined on August 9, 2002 by harvesting with a metal rake a strip 16.9 inches wide the length of the plots and recording the berry weight.

RESULTS: Leaf N concentrations were above the standard (1.6%) and were not affected by the Fe treatments (Fig. 1). Leaf P concentrations were below or near the standard (0.125%) and not affected by treatments (Fig. 2). Leaf Fe concentrations increased linearly with increasing rate of Fe applied to the foliage (Fig. 3). The concentration of Fe in leaf tissue was raised to above the standard 50 ppm with the lowest rate, 0.5 lb Fe/acre. Soil Fe concentration was not affected by the foliar application of Fe (Fig. 4). Stem density (stems/sq. ft.) and average stem length (Fig. 5) were not influenced by Fe treatments, compared to controls. Branching and branch length were also not affected by Fe treatments (Fig. 6). Flower bud density (flower buds per 1/4 sq ft) and average number of flower buds per stem were not influenced by Fe treatments (Fig. 7), nor was berry yield (Fig. 8).

CONCLUSIONS: The results of this study suggest that the standard for satisfactory leaf Fe concentration may too high. Raising leaf Fe concentration above 35 ppm, in this particular field, produced no growth or yield benefits. No conclusions can be made at this time since another study testing the standard at another site has not been completed.

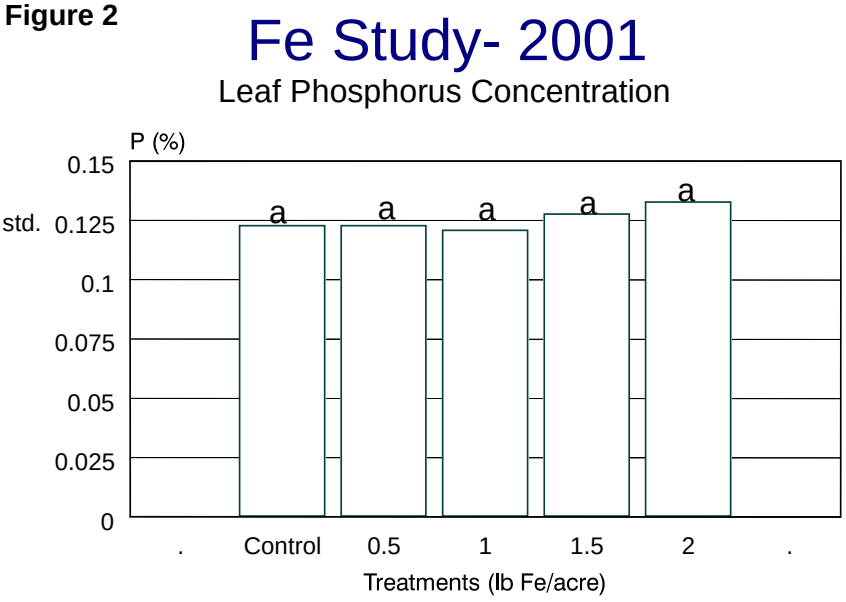
RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1



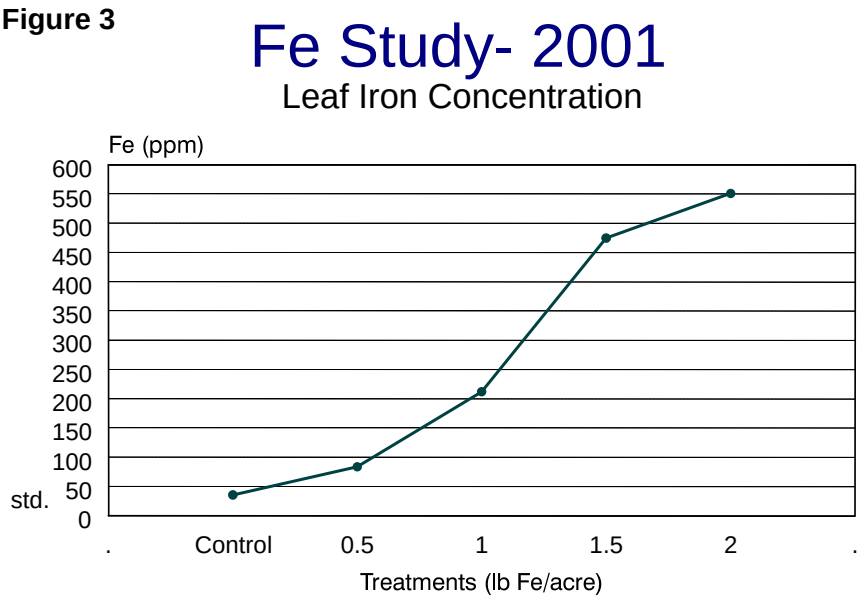
Mean separation by Duncan's Multiple range test, 0.5% level.

Figure 2



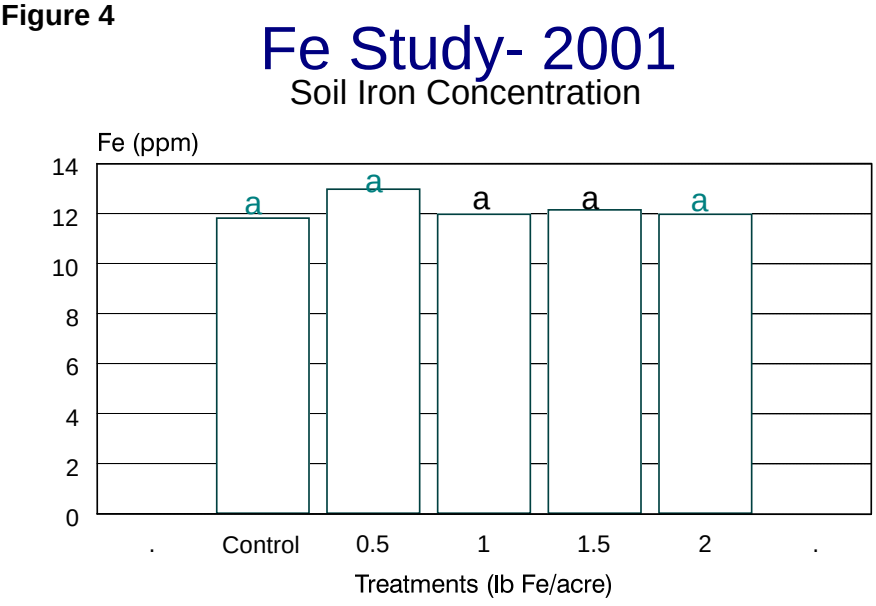
Mean separation by Duncan's Multiple range test, 0.5% level.

Figure 3



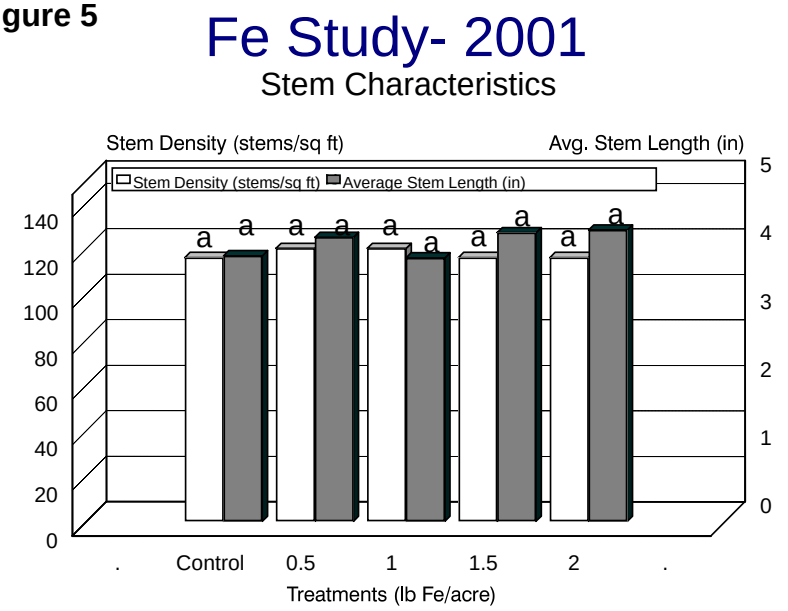
Significant linear increase in leaf Fe concentration with increasing foliar Fe rate, 0.01% level.

Figure 4



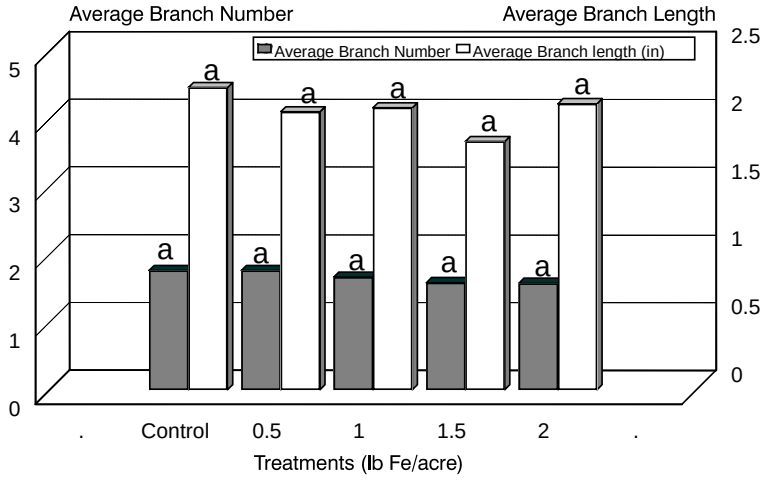
Mean separation by Duncan's Multiple range test, 5% level.

Figure 5



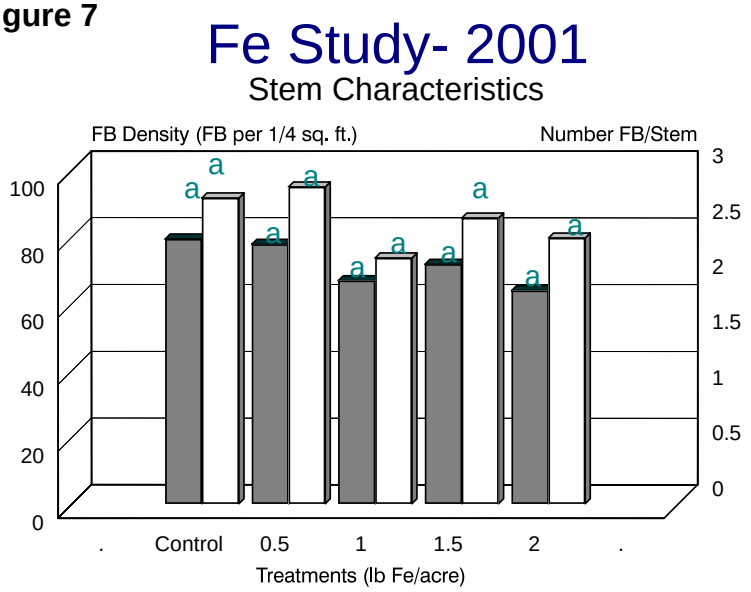
Mean separation by Duncan's Multiple range test, 5% level.

Figure 6



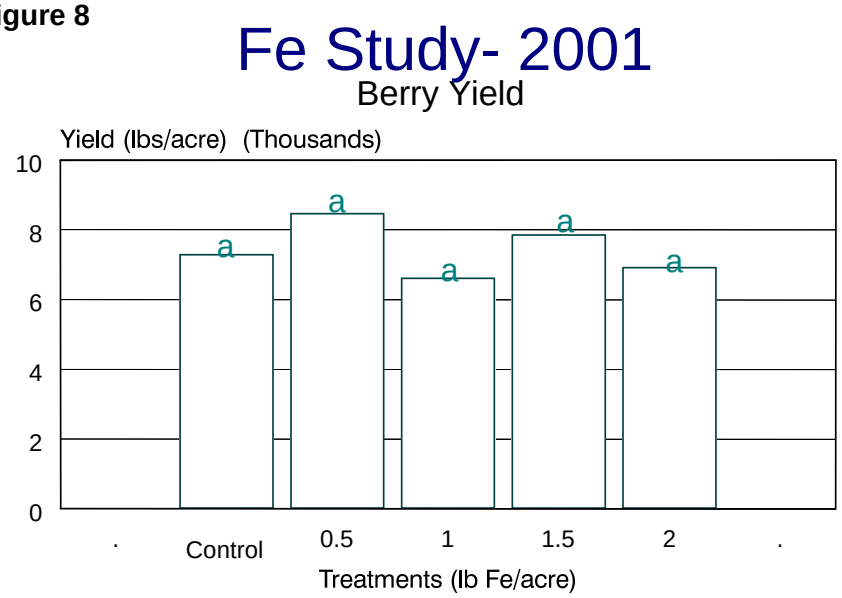
Mean separation by Duncan's Multiple range test, 5% level.

Figure 7



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

Figure 8



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

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Karen Loenneker, Scientific Technician

TITLE: Effect of Boron Application Methods on Boron Uptake in Wild Blueberries.

OBJECTIVES: Compare the uptake of boron (B) into leaf tissues from soil and leaf applications.

Brief Justification:

B availability may be limited in the acid, podsol soils in which most of Maine's wild blueberries are grown. In 1984, a comparison of six grower-classified "good" and six "poor" fields indicated that they had equal numbers of flower buds per stem but that higher levels of B and calcium (Ca) were found in the leaf tissue of the "good" fields. A survey of leaf nutrient concentrations in commercial wild blueberry fields conducted in 1987 and 1988 indicated that 39 out of 75 fields had B concentrations below the standard of 24 ppm, established by Trevett in 1972. Insufficient B concentration in flowers has been associated with low fruit set due to inadequate pollen tube growth through the style into the ovary where fertilization occurs and seed development begins. Larger berries may be produced due to more seed development within the fruit. When wild blueberry plants are unable to obtain adequate amounts of B, applying B through soil fertilization or foliar leaf application could improve fruit set and stimulate greater numbers of berries to develop. There is little information comparing the effectiveness of soil and foliar B application in correcting B deficiency of the wild blueberry.
In a 1999 study, treatments of soil-applied borate (Granubor®) or foliar-applied borate (Solubor®) with or without 400 lb/acre diammonium phosphate (DAP, 18-46-0) to satisfy nitrogen (N) and phosphorus (P) needs were applied to 5 ft x 25 ft treatment plots. Composite leaf tissue samples indicated that leaf B concentrations were not raised to the anticipated 50 ppm level when Solubor® was applied at .66 lb B/acre, as had been observed in a 1997 study. Therefore, the same treatments of Granubor® or Solubor® with or without DAP (Table 1) were applied in a new study in 2001 at the same location.

METHODS: Soil-applied Granubor® (14.3% B from sodium tetraborate pentahydrate and disodium octaborate tetrahydrate) and foliar-applied Solubor® (20.5% B from disodium octaborate tetrahydrate) was applied with or without DAP to 5 ft x 50 ft treatment plots, replicated 7 times in a randomized complete block design (RCB). These treatments were compared to a control that received no fertilization and to an application of DAP without B (Table 1). Leaf tissue and soil samples were taken on July 11, 2001 for determination of leaf and soil nutrient concentrations. Stem samples were taken November 1, 2001 for determining treatment effects on stem characteristics (stem length, branching) and potential yield (flower bud formation). In May 2002, treatment plots were split into two 25 ft sections and in each sub plot 20 stem having 4 flower buds were tagged and the number of flowers per stem were recorded. On June 4, 2002, just after full bloom, one sub plot of each treatment was randomly selected to receive a foliar application of Solubor® at .66 lb B/acre. Leaf samples were taken July 2, 2002 to determine leaf B concentrations. Tagged stems were collected August 1, 2002 and the number of berries was recorded to determine fruit set. The effect of treatments on ripening was determined by counting the number of green, green pink, pink red, red blue and blue berries for

each tagged stem. Blueberry yield was measured by harvesting a rake-width down the center of each treatment plot in August 6, 2002.

Table 1 Treatment Summary	
Treatment 1	Control
Treatment 2	Soil Granubor® (2 lbs B/acre)
Treatment 3	Soil (2 lbs B/acre) + DAP (400 lbs/acre)
Treatment 4	Foliar Solubor® (0.66 lbs B/acre)
Treatment 5	Foliar (0.66 lbs B/acre) +DAP (400 lbs/acre)
Treatment 6	DAP (400 lbs/acre)

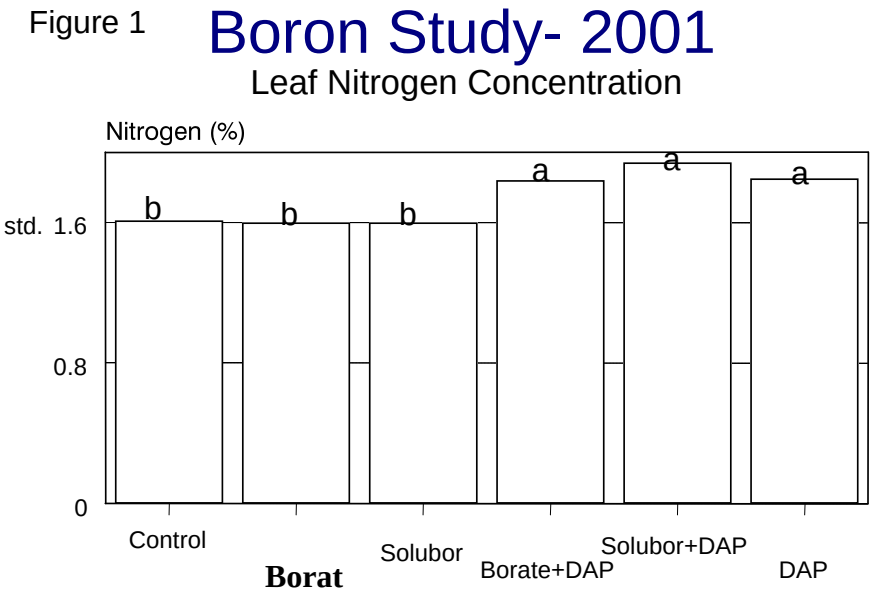
RESULTS: Leaf N concentrations were at the 1.6% sufficiency level in control plots and plots receiving only B from Granubor® or Solubor® (Fig. 1). DAP when applied alone or with a source of B raised leaf N concentration to above the 1.6% level. Leaf P concentration were well below the standard (0.125%) in control plots and were raised to sufficiency levels when DAP was applied, with or without B (Fig. 2). B concentrations in leaves were below the 24 ppm standard in control plots and were raised to sufficiency levels with soil-applied B (Granubor®) or foliar-applied B (Solubor®) (Fig. 3). When applied to plots that also received DAP, leaf B concentration decreased, possibly due to a dilution effect caused by growth simulation by the N in the DAP. The concentration of B in leaves treated with Solubor® plus DAP was not significantly different from the control but did average above the 24 ppm standard. Soil P concentrations were raised by DAP with or without boron, compared to the other treatments (Fig.4). Soil B concentrations were increased by soil-applied B (Granubor®) but not the foliar-applied B (Solubor®) (Fig. 5). Stem density was not affected by any treatment (Fig. 6), but average stem length was increased in treatment plots receiving DAP (Fig. 7), compared to those not receiving DAP. There was no effect of treatments on branching or branch length (Fig. 8). Number of flower buds per stem (Fig. 9) and Number of flower buds per unit area (Fig. 10) were increased by DAP but B treatments did not enhance this effect; there was no difference between DAP and DAP plus Granubor® or DAP plus Solubor®. Crop-year application of B raised the average Leaf B from 34 ppm in sub plots not receiving the treatment to 52 ppm, but fruit set was not influenced. The split plots without Solubor® had an average fruit set of 30% and those with Solubor® had an average fruit set of 29%. Fruit set was the same in all treatment plots (Fig. 11), resulting in an average of 5 or 6 fruit per stem (Fig 12). There was no difference in the numbers of blue, red blue, pink red, or green pink fruit per stem, but the numbers of green fruit were higher in DAP and Solubor plus DAP treatment plots compared to the control (Fig. 13). Fruit yield, was higher in treatment plots receiving DAP, presumably due to longer stems with more flower buds (Fig 14).

CONCLUSIONS: Both soil-applied B or foliar-applied B raised the leaf B concentration levels above the 24 ppm standard suggested by Trevett in 1972, but this had no effect on growth or

yield. N and P in DAP corrected deficiencies of these nutrients and increased growth and flower bud formation leading to higher yields. The addition of B to the DAP treatment had no effect on flower bud formation or fruit set and yield. These data suggest that the standard for B (24 ppm) is too high.

RECOMMENDATIONS: No recommendation for B application can be made.

Figure 1

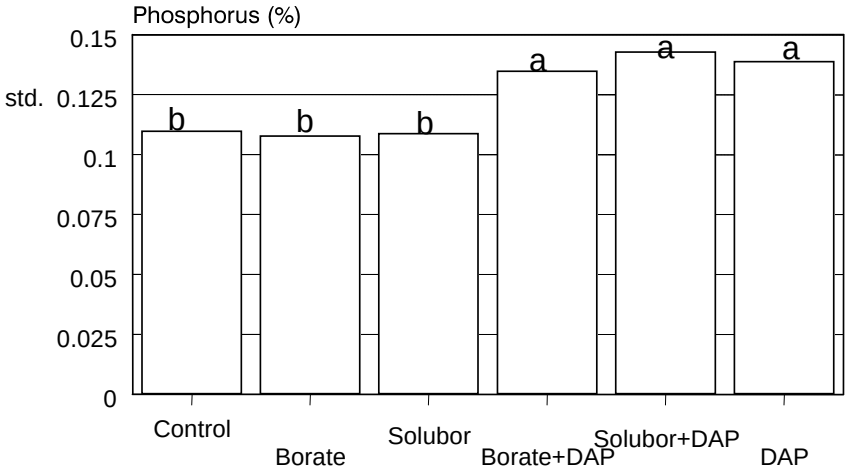


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level.

Figure 2

Boron Study- 2001

Leaf Phosphorus Concentration

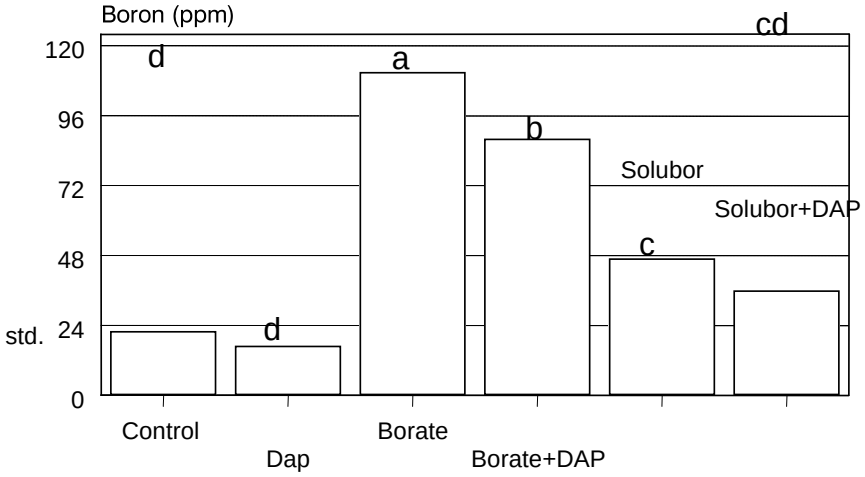


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level.

Figure 3

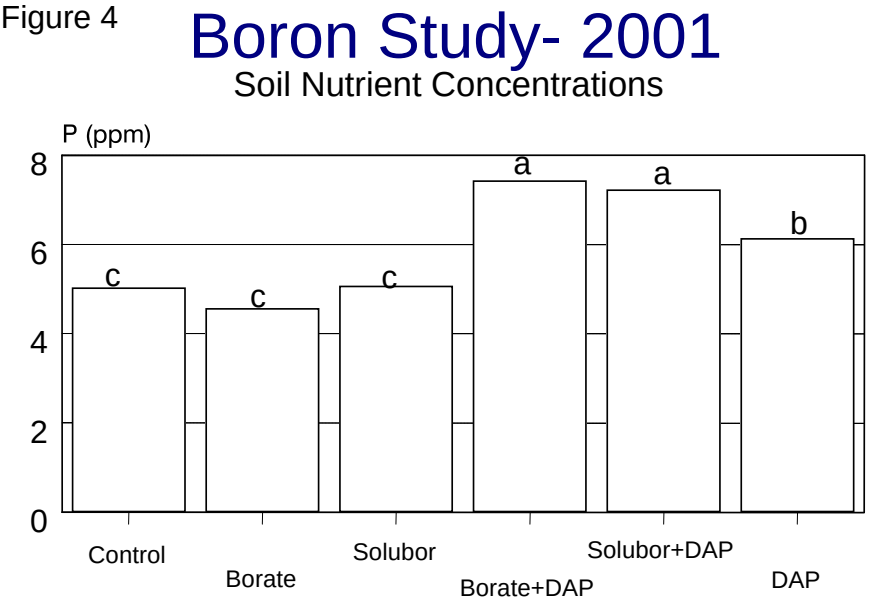
Boron Study- 2001

Leaf Boron Concentration



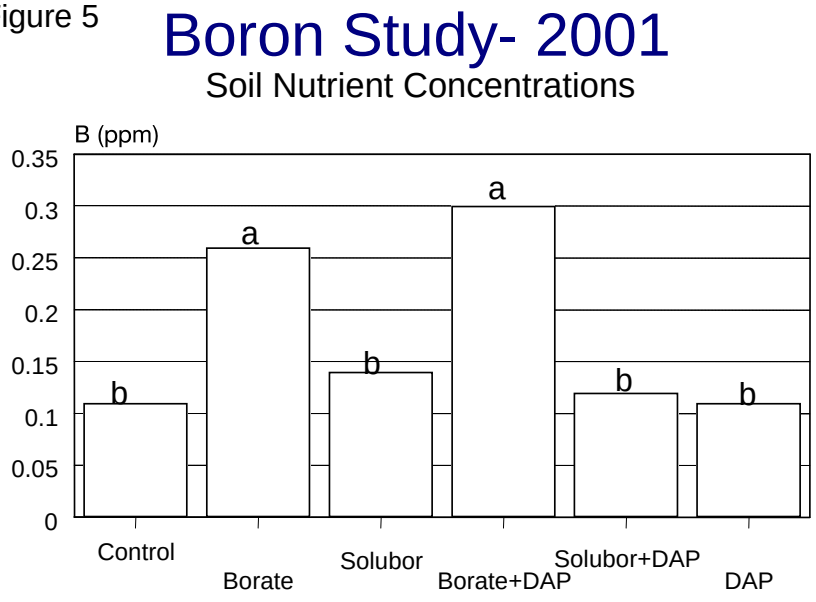
Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level.

Figure 4



Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level.

Figure 5

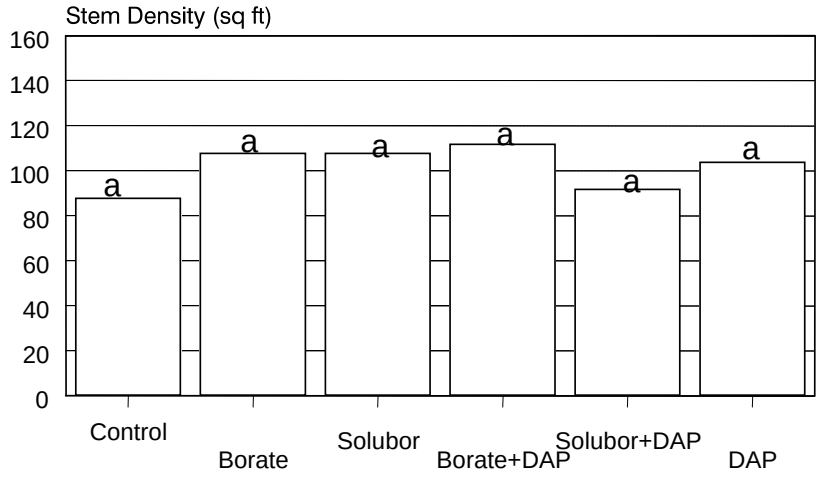


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level.

Figure 6

Boron Study- 2001

Stem Characteristics

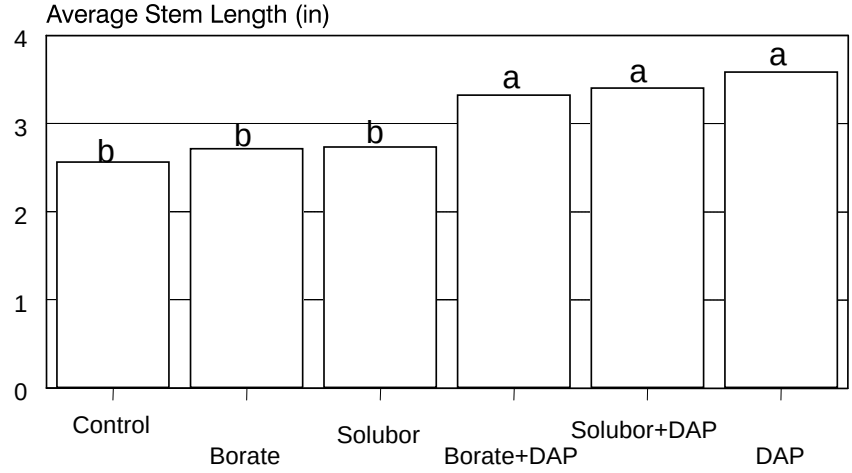


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 5% level.

Figure 7

Boron Study- 2001

Stem Characteristics

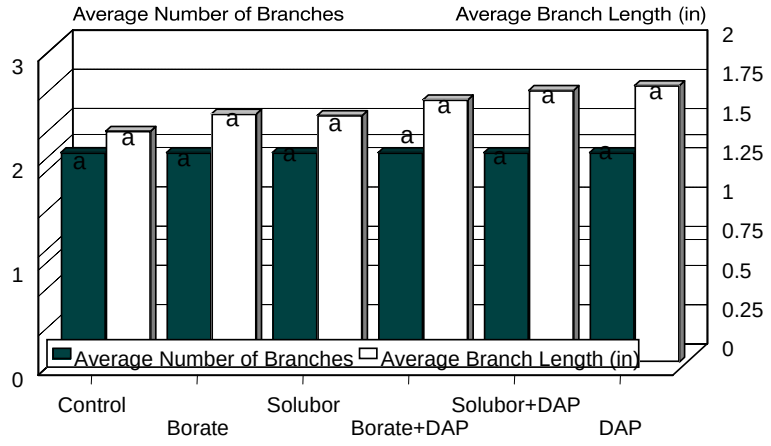


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level.

Figure 8

Boron Study- 2001

Stem Characteristics

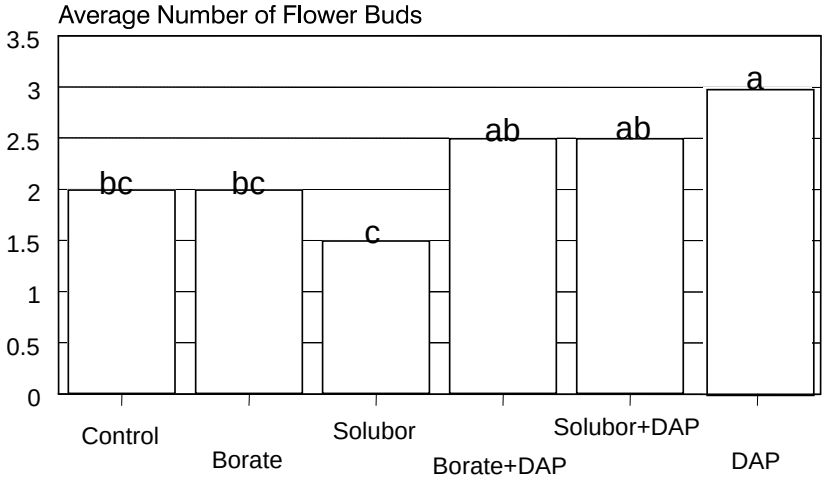


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 5% level.

Figure 9

Boron Study- 2001

Stem Characteristics

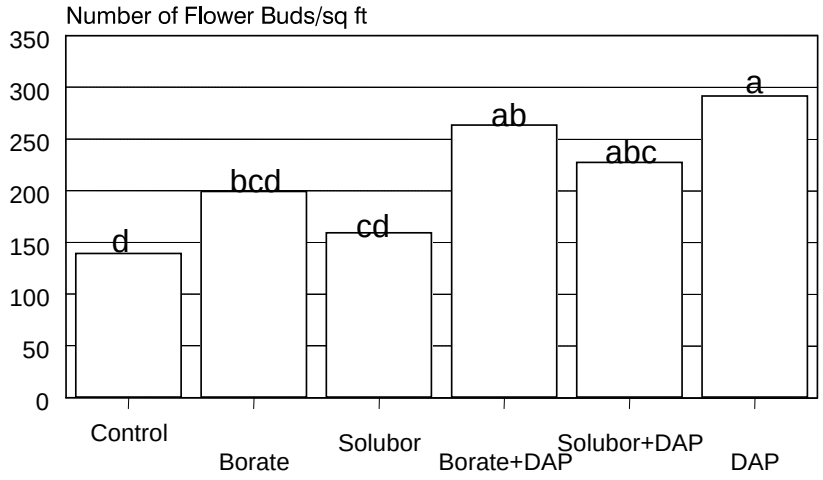


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.2% level.

Figure 10

Boron Study- 2001

Stem Characteristics

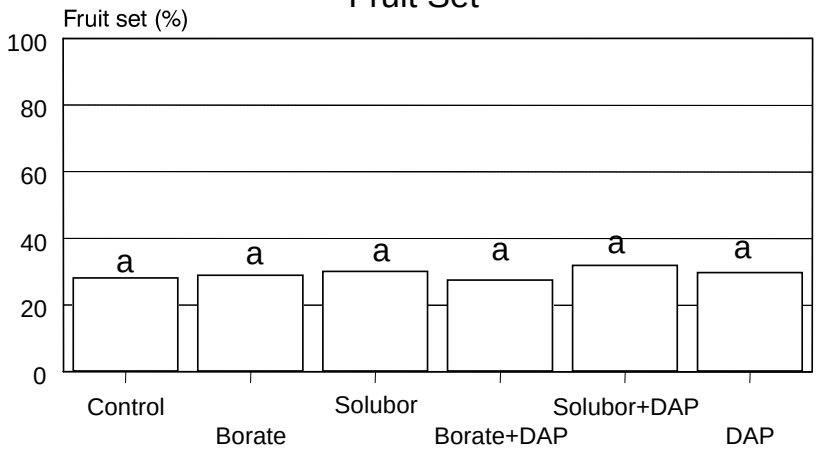


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.02% level.

Figure 11

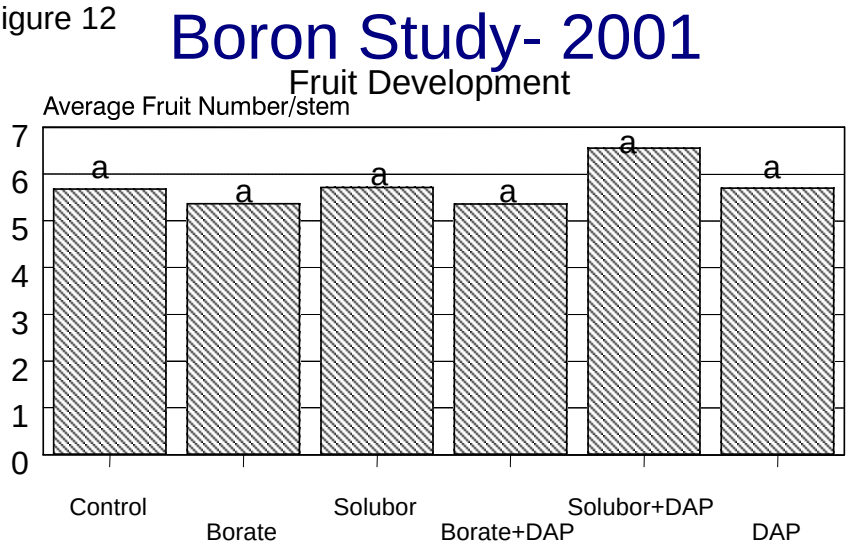
Boron Study- 2001

Fruit Set



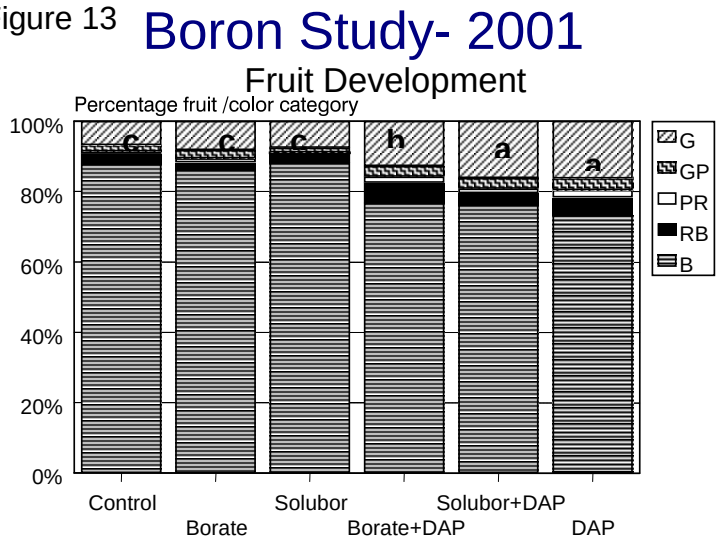
Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level. Means are averages of both sub plots. Sub plot 2 received Solubor the crop year at full bloom.

Figure 12



Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean Separation by Duncan's Multiple range test, 0.01% level. Means are averages of both sub plots. Sub plot 2 received Solubor the crop year at full bloom.

Figure 13

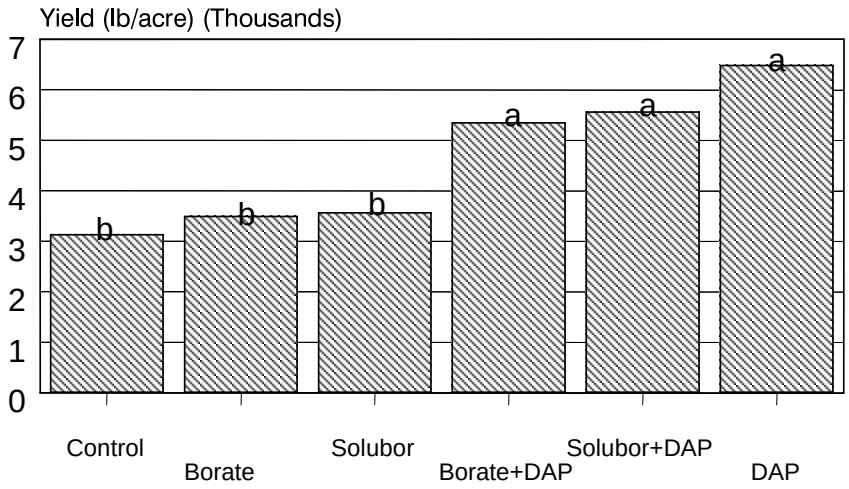


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean Separation by Duncan's Multiple range test, 0.01% level. Means are averages of both sub plots. Sub plot 2 received Solubor the crop year at full

Figure 14

Boron Study- 2001

Yield



Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre.
Mean Separation by Duncan's Multiple range test, 0.01% level.

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Karen Loennecker, Scientific Technician

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: To compare prune year and crop year fertilization an effective method of applying N and P in the crop year is essential. This 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 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.

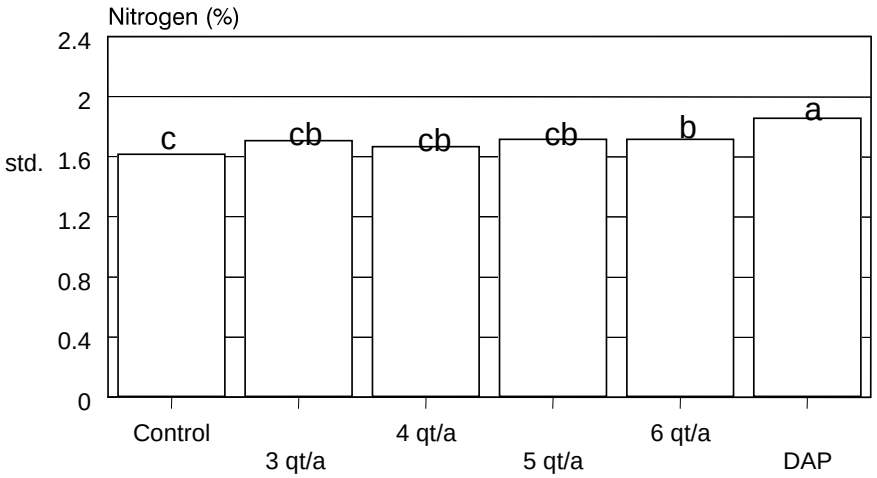
RESULTS: Soil pH ranged from 5.0 to 5.1 among treatment plots. The June foliar sprays were not effective in raising leaf N concentrations, compared to the control (Fig.1). Preemergent DAP application did raise the leaf N concentration. DAP also raised leaf P concentrations to above the standard (Fig.2). Stem density varied among plots (Fig.3) but not meaningfully. 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.

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.

Figure 1 N Foliar Rate Study- 2002

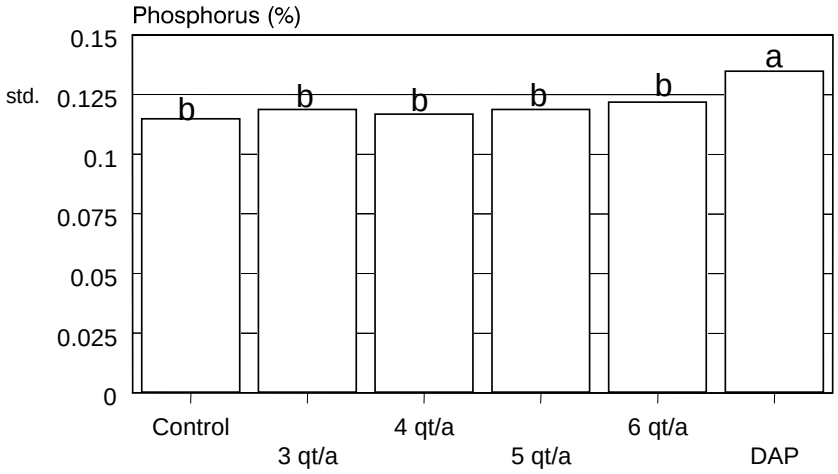
Leaf Nitrogen Concentration



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.

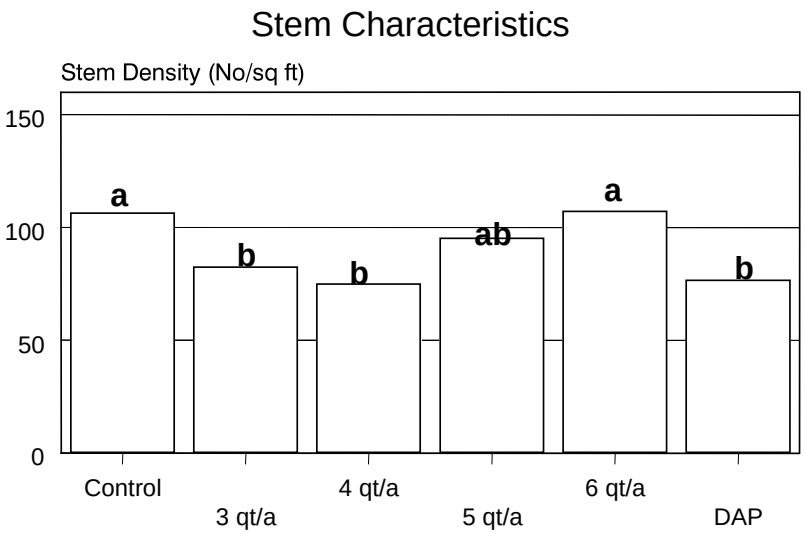
Figure 2 N Foliar Rate Study- 2002

Leaf Phosphorus Concentration



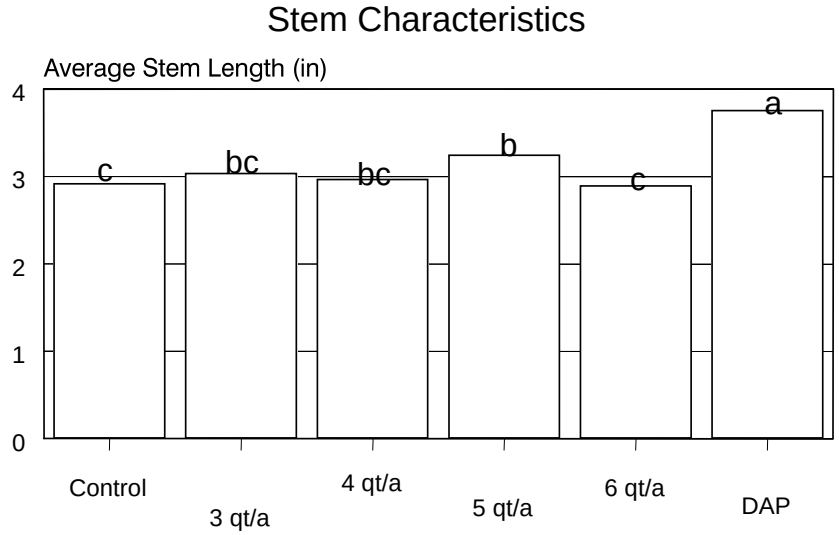
Foliar spray of 28-0-0 (1 qt/acre = .58 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 3 N Foliar Rate Study- 2002



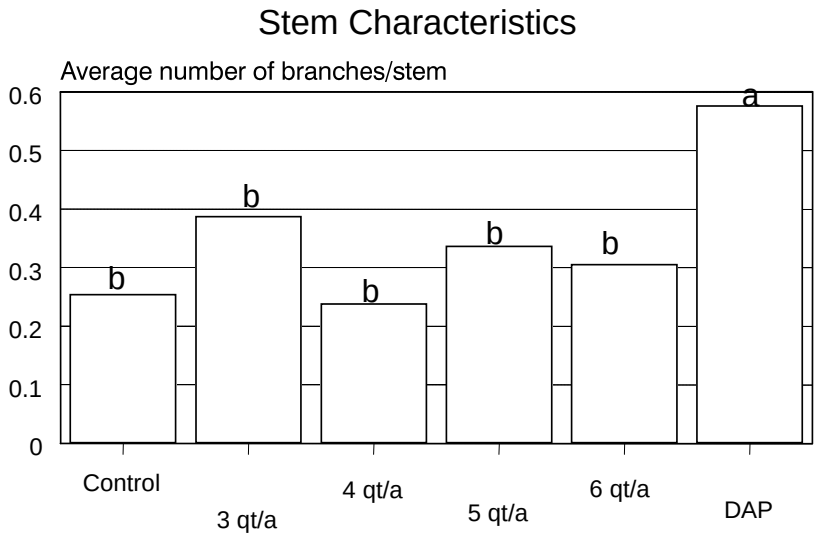
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .1% level.

Figure 4 N Foliar Rate Study- 2002



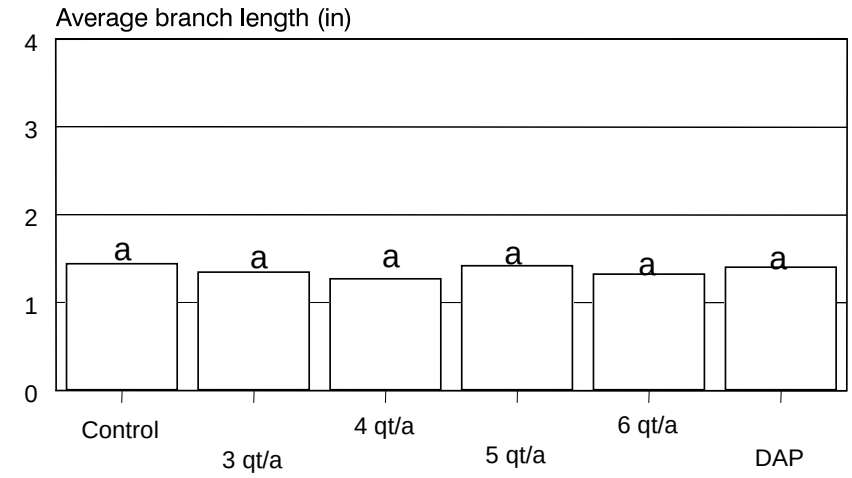
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

Figure 5 N Foliar Rate Study- 2002



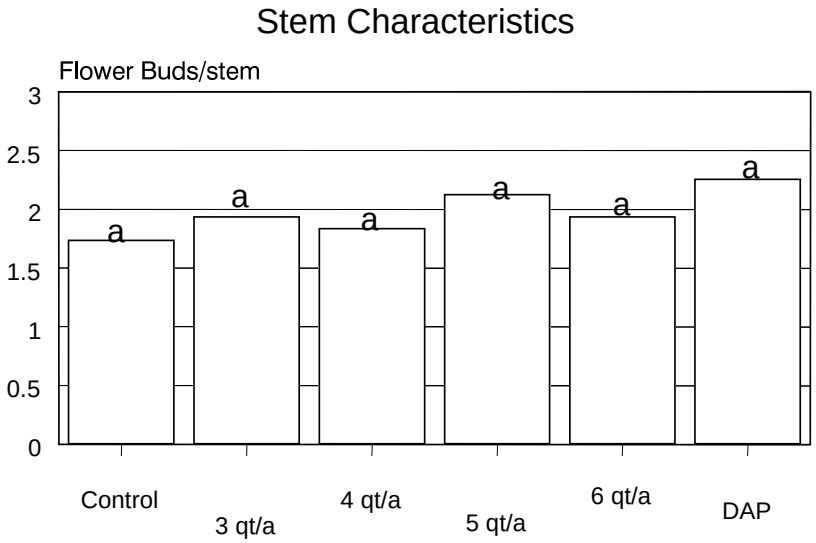
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 6 N Foliar Rate Study- 2002



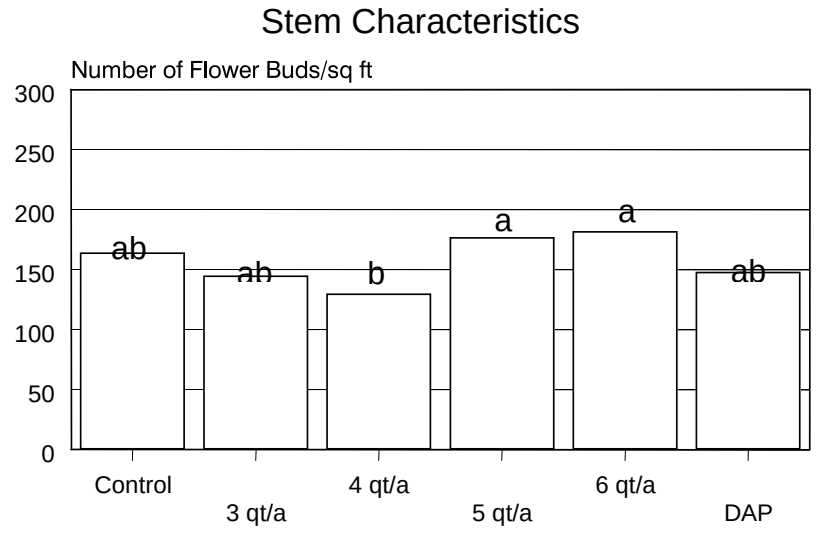
Foliar spray of 28-0-0 applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, 5% level.

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.

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Karen Loennecker, Scientific Technician

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. This study was delayed a year so that an effective method of raising P by foliar spray could be tested. A rate study to determine the most appropriate rate for a foliar 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.

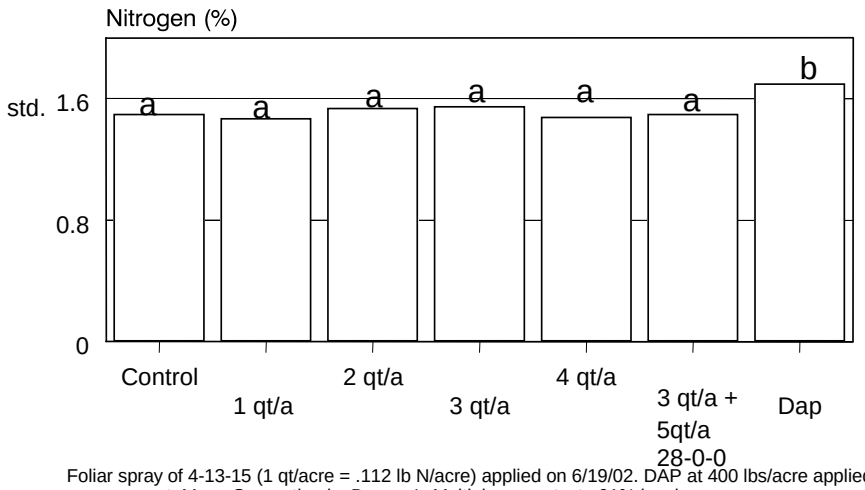
METHODS: A commercial blueberry field in Franklin, ME which had low N and P concentrations in 2000 leaf samples was used in this study. A commercial product manufactured by Plant Food Company, Inc. Cranbury, NJ, with a 4-13-15 analysis plus 10% sulfur was applied at 1,2, 3, or 4 qts/acre and compared 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 will be collected in August 2003.

RESULTS: Soil pH ranged from 4.95 to 5.50 among treatments. Soil organic matter (LOI) ranged from 6.7 to 8.8 among treatments. 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).

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.

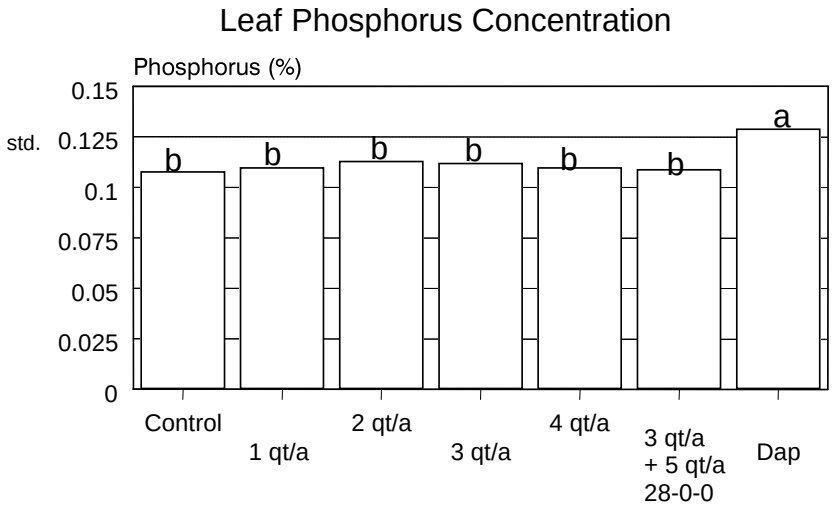
RECOMMENDATIONS: No recommendations can be made at this time.

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.

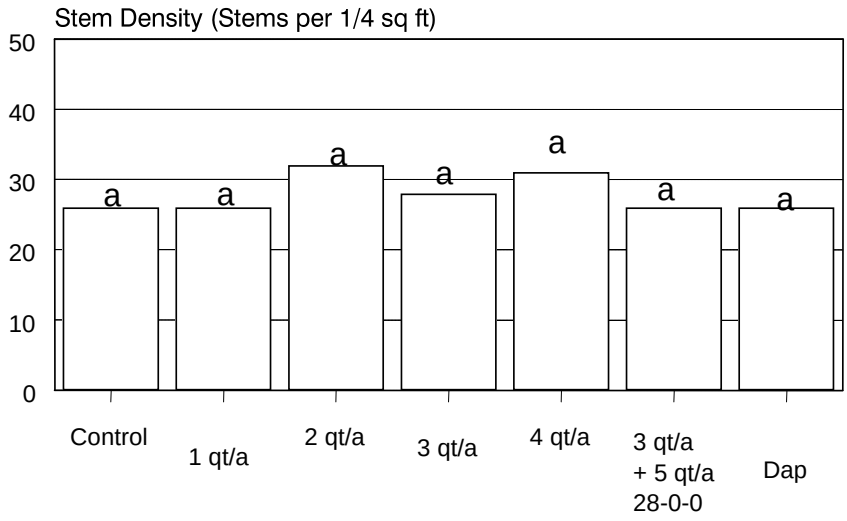
Figure 2 P Foliar Rate Study- 2002



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

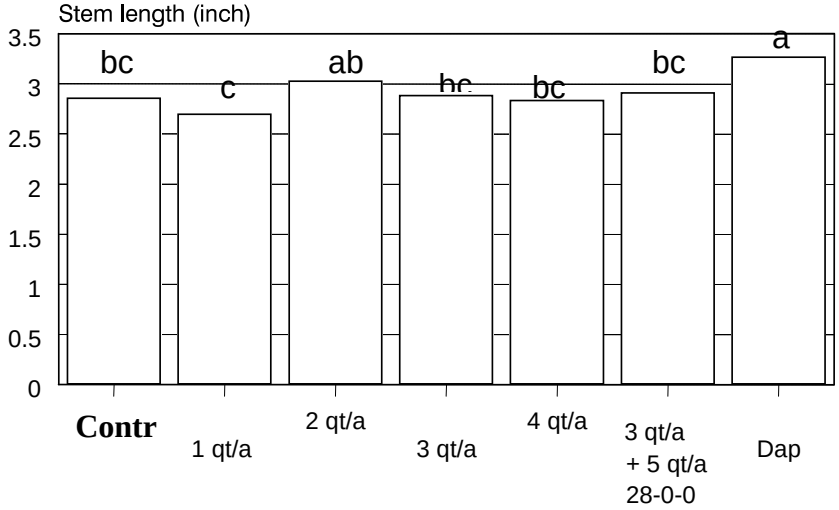
Stem Characteristics



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.

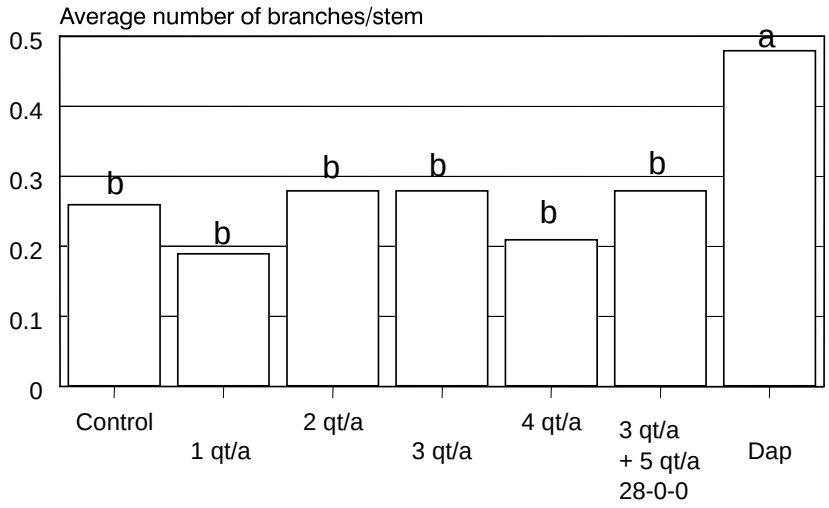
Figure 4 P Foliar Rate Study- 2002

Stem Characteristics



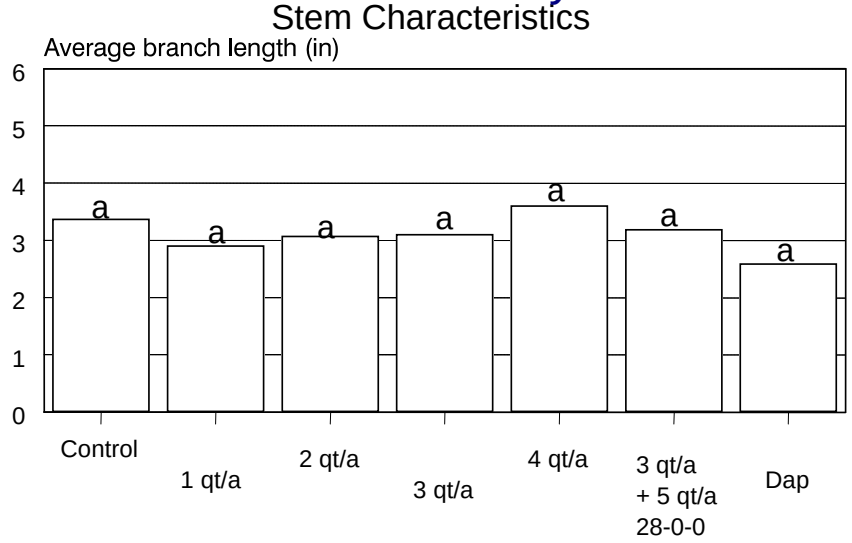
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

Figure 5 P Foliar Rate Study- 2002



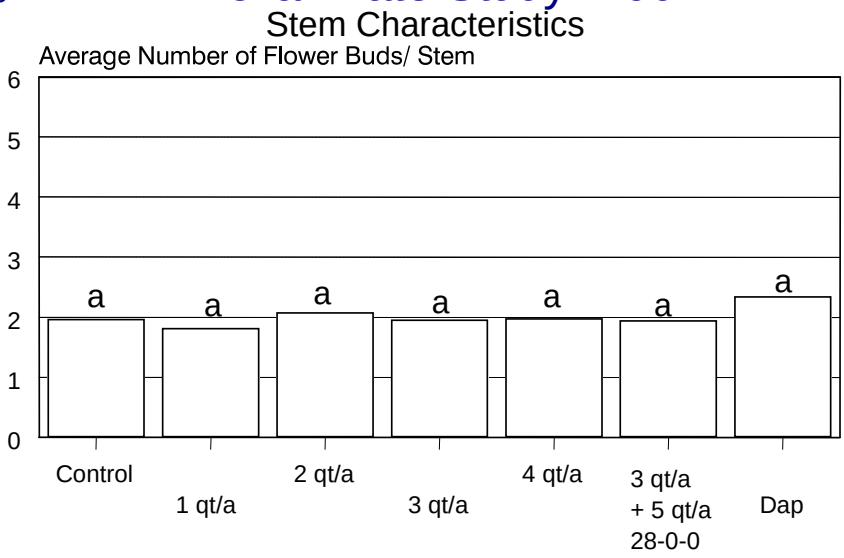
Foliar spray of 4-13-15 (1 qt/acre = .112 lb N/acre) applied on 6/19/02. DAP at 400 lbs/acre applied preemergent. Mean Separation by Duncan's Multiple range test, .01% level.

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.

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Karen Loennecker, Scientific Technician

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 November 6, 2001 for measurement of stem length and flower bud formation. Yield was determined August 9, 2002 by hand raking a strip 16.9 inches wide the length of each plot.

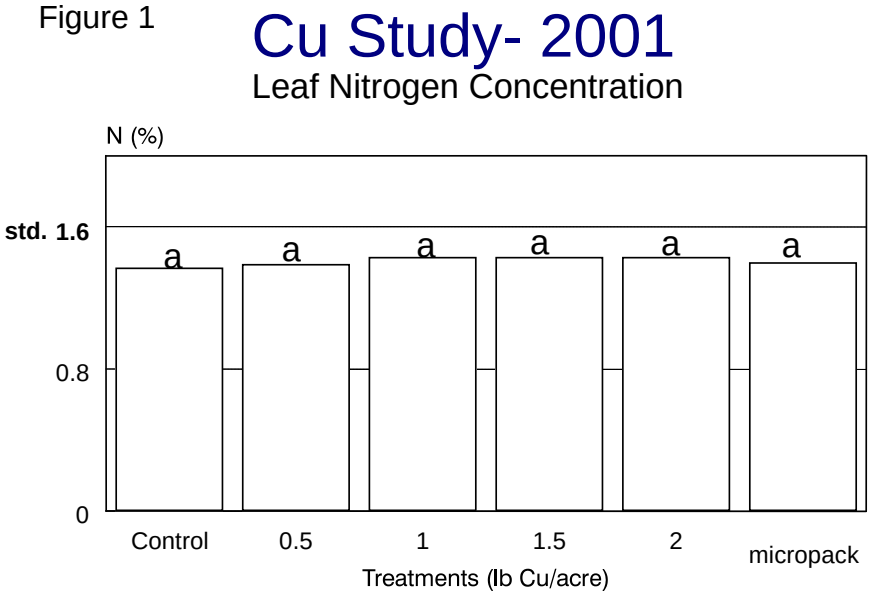
RESULTS: Leaf N concentrations were below the standard (1.6%) and were not affected by any treatment (Fig. 1). Leaf P concentration was also below the standard (0.125%) (Fig. 2) and was unaffected by treatments. Leaf Cu concentrations increased linearly with increasing

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.

CONCLUSIONS: Cu Keylate was effective in raising leaf Cu levels to a sufficiency level. The deficiency of N and P, however, may have compromised the test of the Cu standard. Micromate provided inadequate amounts of Cu to raise leaf Cu concentrations above the levels found in the controls.

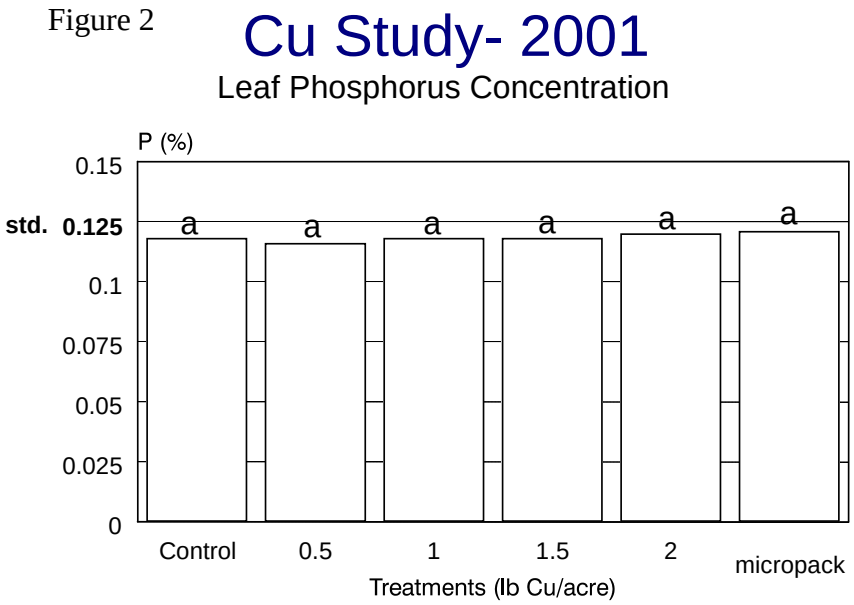
RECOMMENDATIONS: No recommendations for Cu fertilization can be made to growers at this time. This experiment should be continued at this site with a split-plot design, in which DAP, at 400 lbs/acre, Cu Keylate and Micromate, at the rates used in 2001, would be applied to a 25foot section of the plots. This will evaluate the effect of raising leaf Cu concentrations when N and P are not limiting and also determine carry-over effects of the 2001 Cu treatments.

Figure 1



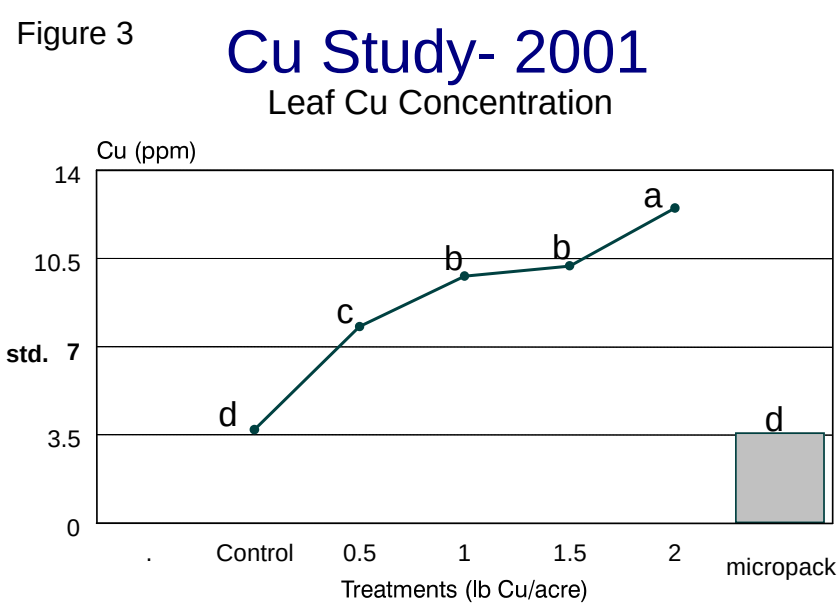
Mean separation by Duncan's Multiple range test, 5% level.

Figure 2



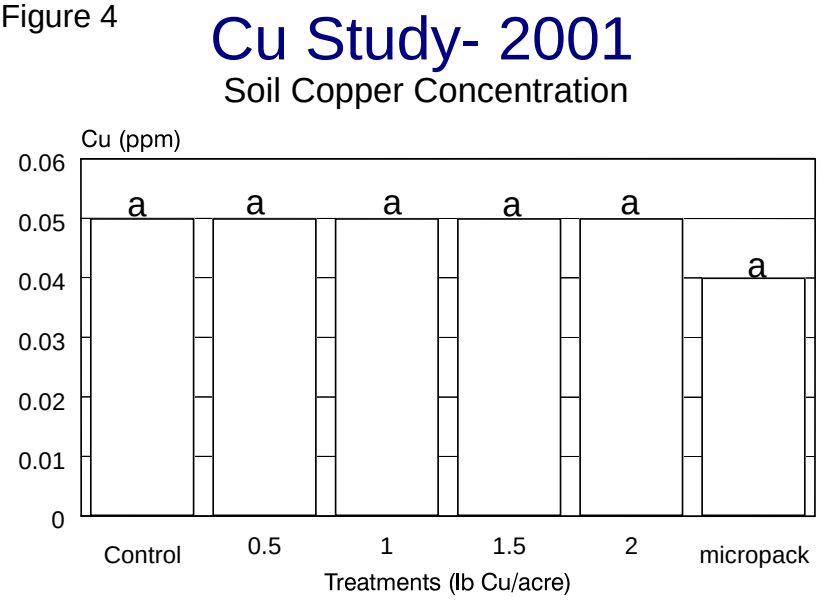
Mean separation by Duncan's Multiple range test, 5% level.

Figure 3



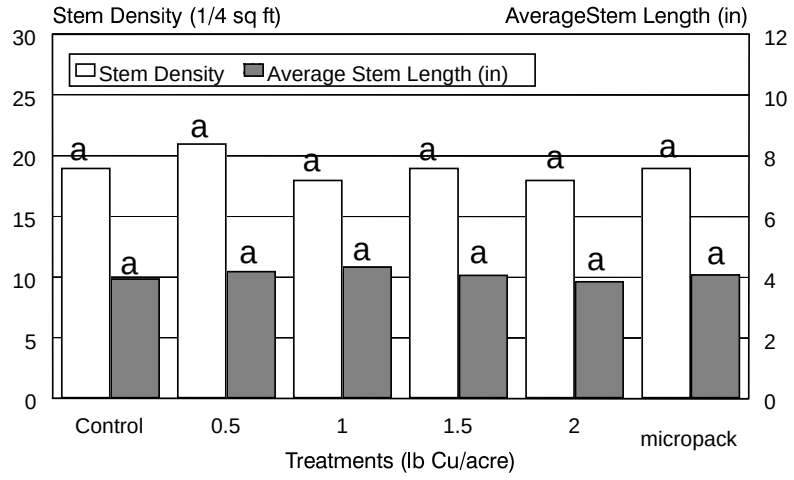
Mean separation by Duncan's Multiple range test, 0.01% level. Significant linear increase in leaf Cu concentration with increasing foliar Cu rate, 0.01% level.

Figure 4



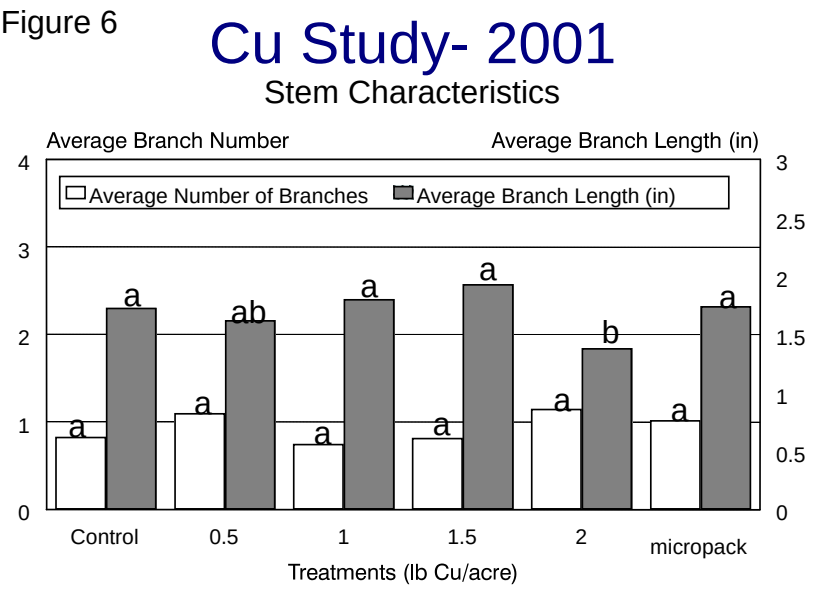
Mean separation by Duncan's Multiple range test, 5% level.

Figure 5



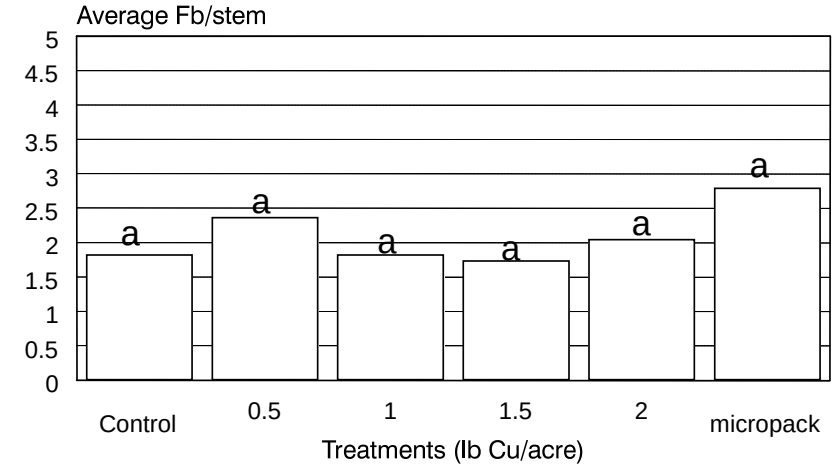
Mean separation by Duncan's Multiple range test, 5% level.

Figure 6



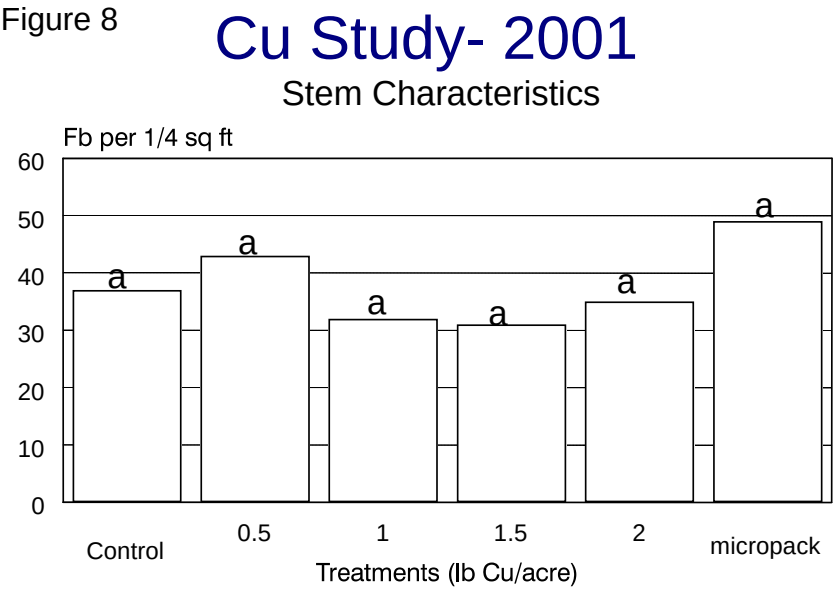
Mean separation by Duncan's Multiple range test, branch number 5% level, average branch length, 0.01% level.

Figure 7



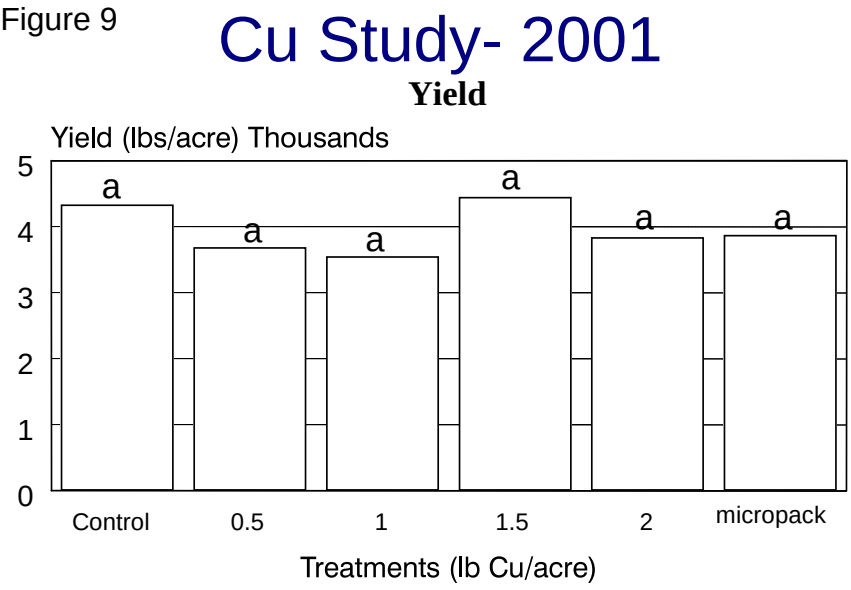
Mean separation by Duncan's Multiple range test, 5% level.

Figure 8



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

Figure 9



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

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Karen Loennecker, Scientific Technician

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: One location that was deficient in Cu and Fe will be 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 will receive 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. Composite leaf tissue samples were taken in July 8, 2002. 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 will be determined in August 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.

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.

RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1

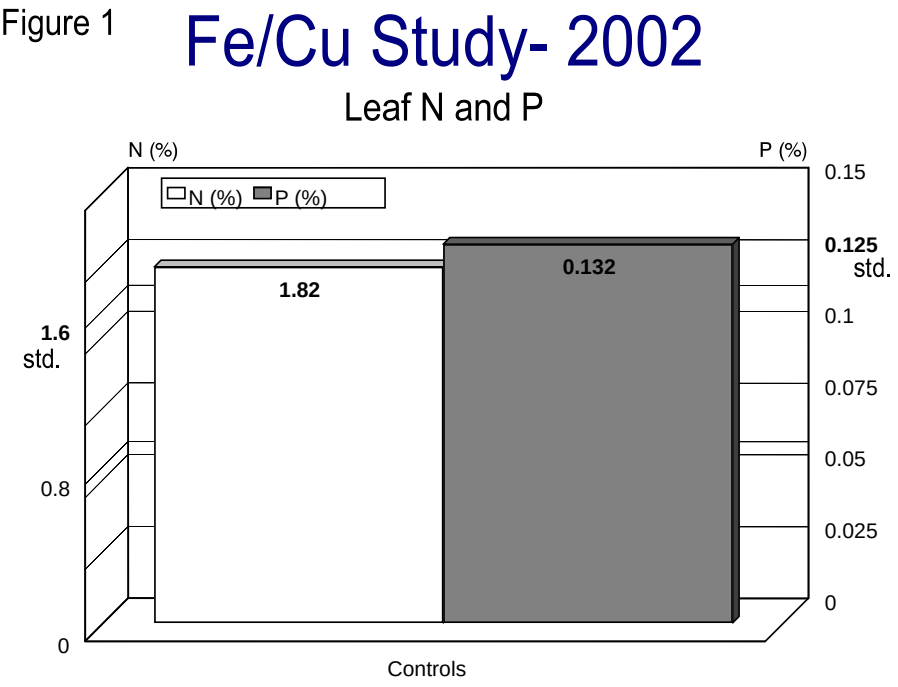
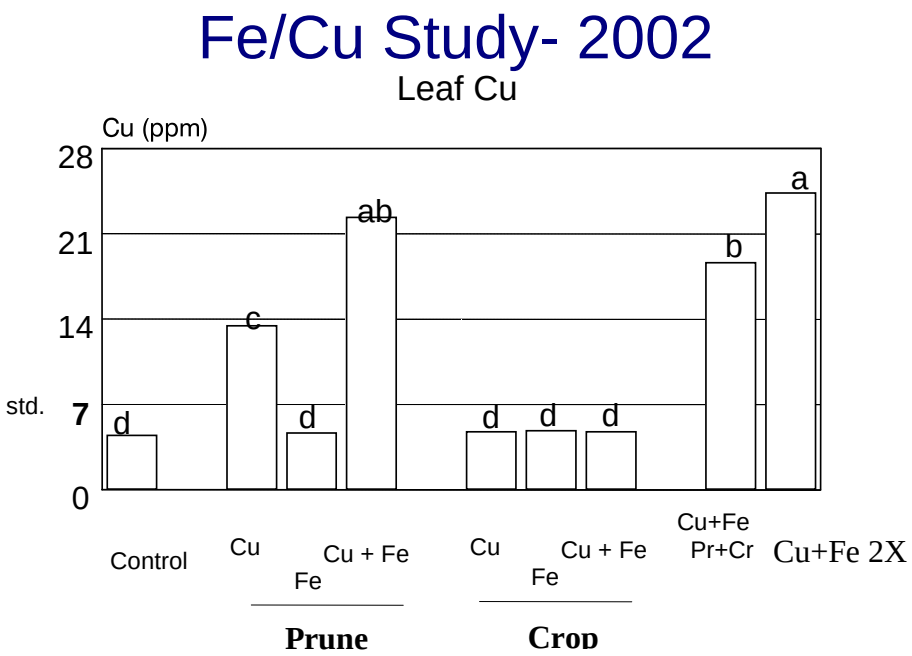
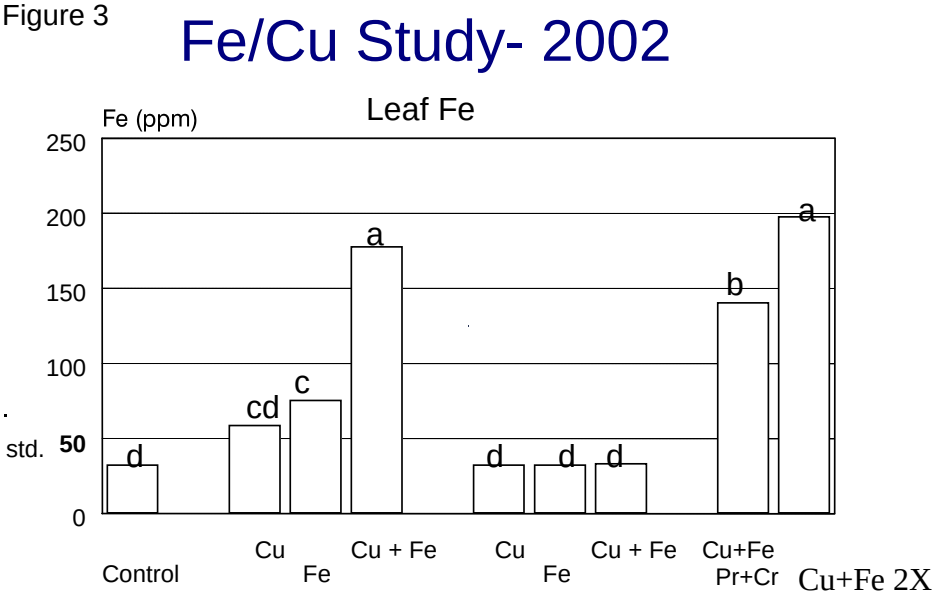


Figure 2



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

Figure 3



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)

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Karen Loennecker, Scientific Technician

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. Yield will be collected in August, 2003 by hand raking the entire plot.

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
2001 leaf nutrient concentrations

Treatment	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

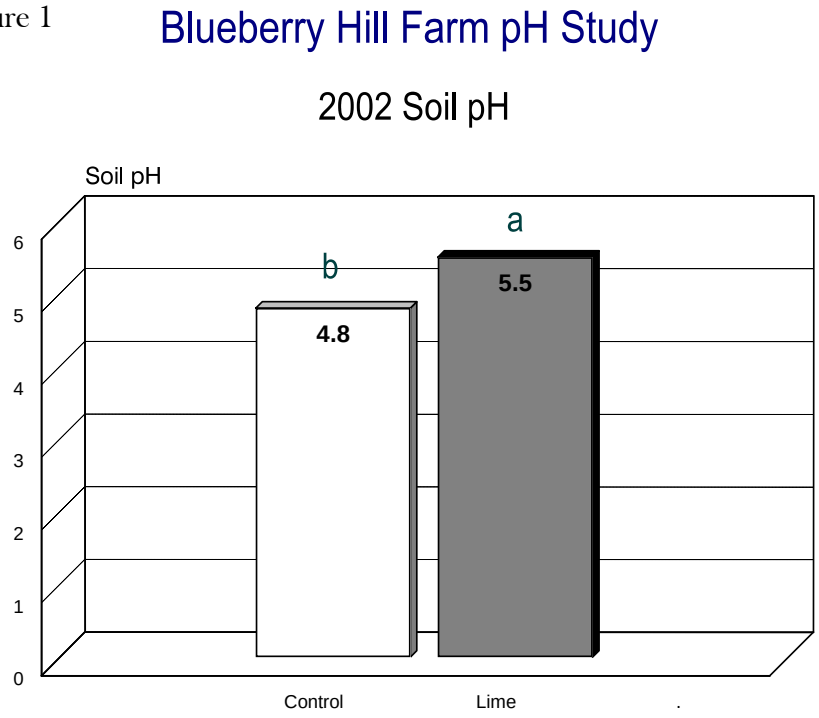
Crop year leaf samples (Table 3) showed different concentrations but similar trends to that found in 2001 prune year leaf samples. Leaf N, P, Zn, and Ca concentrations were not different between the control and limestone-treated plots, but leaf concentration of Mg increased and leaf K, B, Cu, Mn, Al,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

Table3
2002 leaf nutrient concentrations

Treatment	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.

Table 4
2002 soil nutrient concentrations

Treatment	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

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.

Treatment	Table 6 2001 leaf nutrient concentrations						
	Ca (%)	K (%)	Mg (%)	B (ppm)	Cu (ppm)	Zn (ppm)	Mn (ppm)
Control	.400a	.493a	.176a	28a	5.0a	15.0a	450a
Sulfur (S)	.412a	.471a	.174a	26a	5.2a	15.1a	580b

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.

Treatment	Table 7 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).

Treatment	Table 8 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

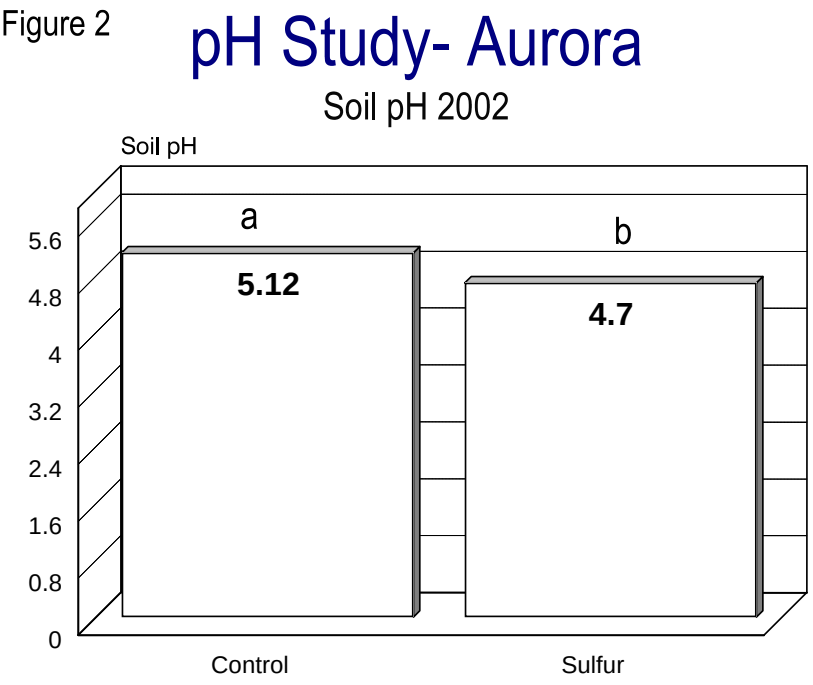


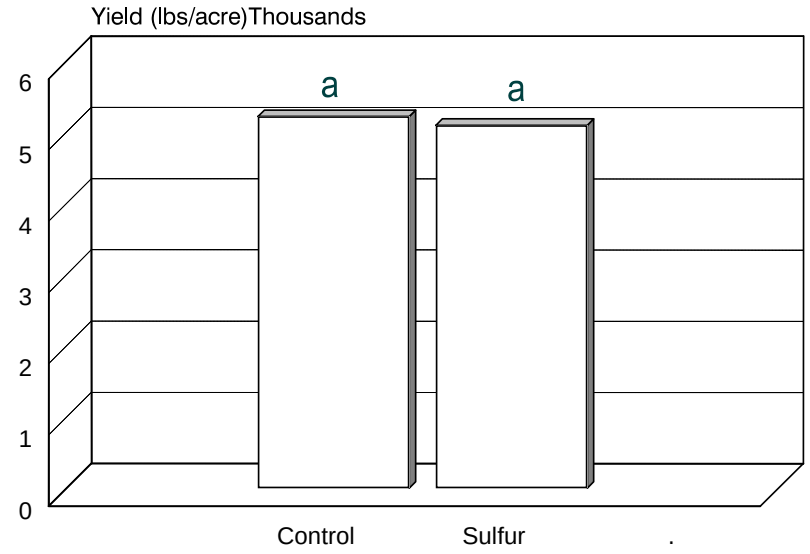
Table 9
2002 soil nutrient concentrations

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 2002 Berry Yield



CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can be made at this time.

WEED MANAGEMENT AND FIELD COVER

INVESTIGATOR: David E. Yarborough, Professor of Horticulture

TITLE: Assessment of Hexazinone Alternatives for Weed Control in Wild Blueberries.

METHODS: Four experimental trial sites were established in 2002 on the Blueberry Hill Experiment station in Jonesboro, Maine. Experimental design was a randomized complete block with six replications, plot size was 1 by 15 meters. Treatments were: azafenidin at applied at 0, 10 or 20 oz product /a or hexazinone as Velpar® at 1.3 lbs product/a on April 16; rimsulfuron applied at 0, 1 or 2 oz product /a or Velpar® at 1.3 lbs product/a on April 16; flumioxazin applied at 0, 6 or 12 oz product /a or Velpar® at 1.3 lbs product/a on April 17; and pendimethalin at 0, 4.8 or 9.6 pt product /a or Velpar® at 1.3 lbs product/a on April 18. Plots were evaluated for wild blueberry and grass or broadleaf weed cover on July 17 and September 4, 2002.

RESULTS: Almost three inches of rain occurred after the treatments, so I expect that there was sufficient rainfall to activate the herbicides (Figure 1). The 20 oz/a Azafenidin treatment appeared as good for the broad leaf weeds (Figure 2) and was better than the standard Velpar treatment for the grasses (Figure 3). The Rimsulfuron treatment (Figure 4, 5) and Pendamethalin treatment (Figure 6, 7) had suppression equal to the Velpar for the grasses but not on broadleaf weeds. The Flumioxazin had a suppression of grasses (Figure 8) but had an increase in broadleaf weeds at the high rate (Figure 9).

CONCLUSION: Although the azafenidin treatment appeared as good or better than the standard Velpar treatment we will not continue to evaluate it. DuPont has announced that it will not support this herbicide for use in fruit crops, it is not clear why, but it is clear that this will no longer be an option for use in blueberries. It does not appear that any of these herbicides have the potential to provide as good as weed suppression as hexazinone**.**

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

Figure 1.

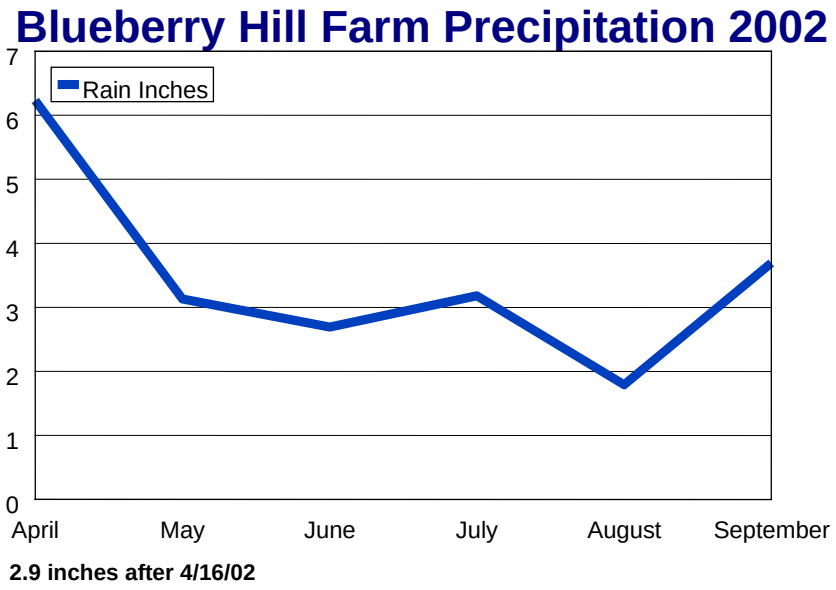


Figure 2.

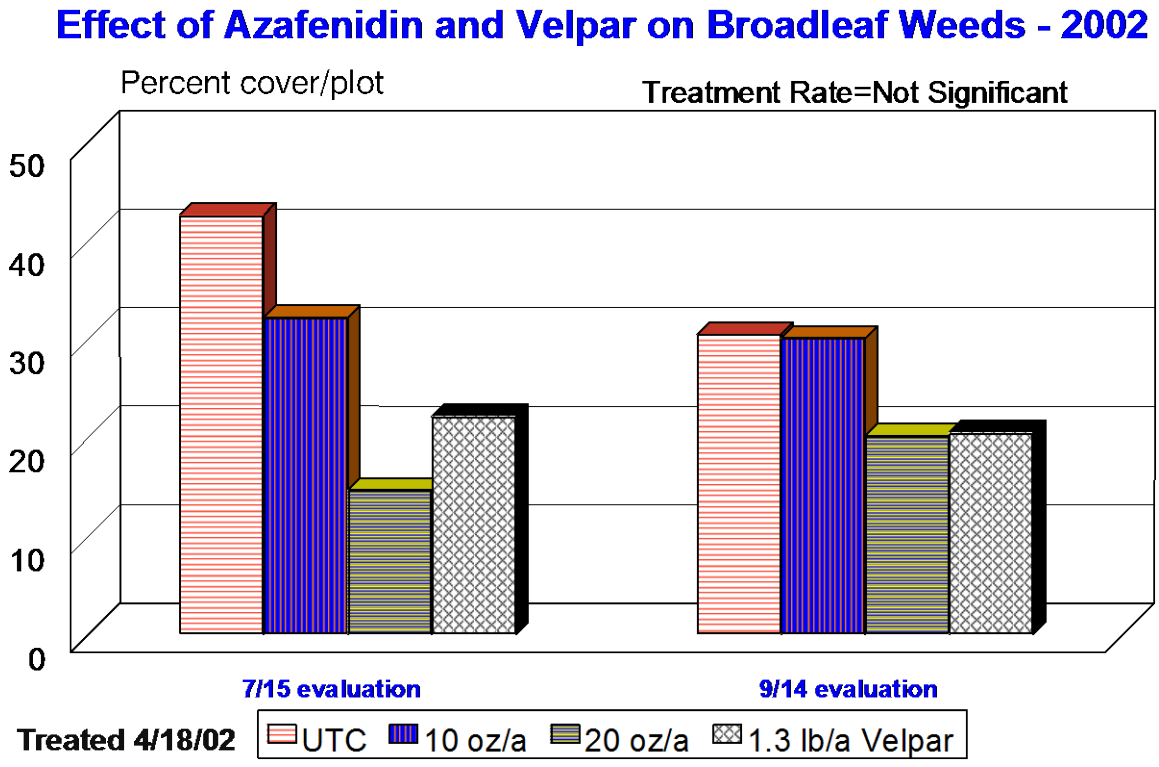


Figure 3.

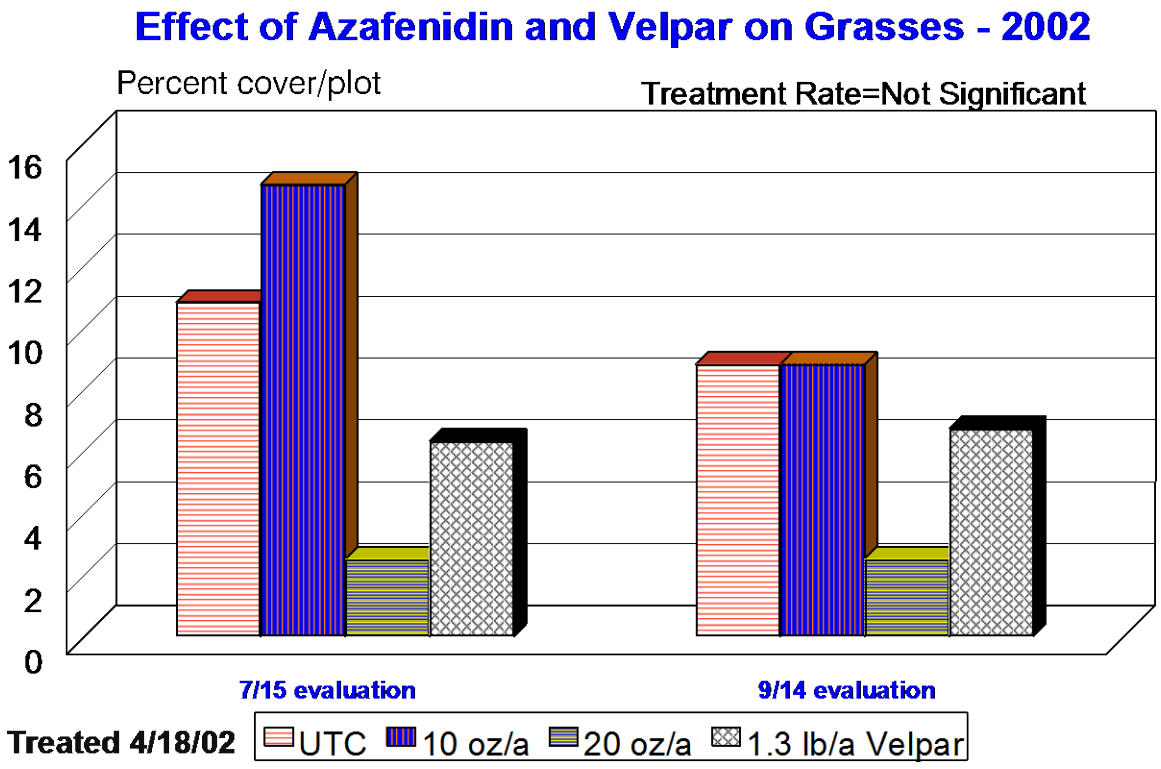


Figure 4.

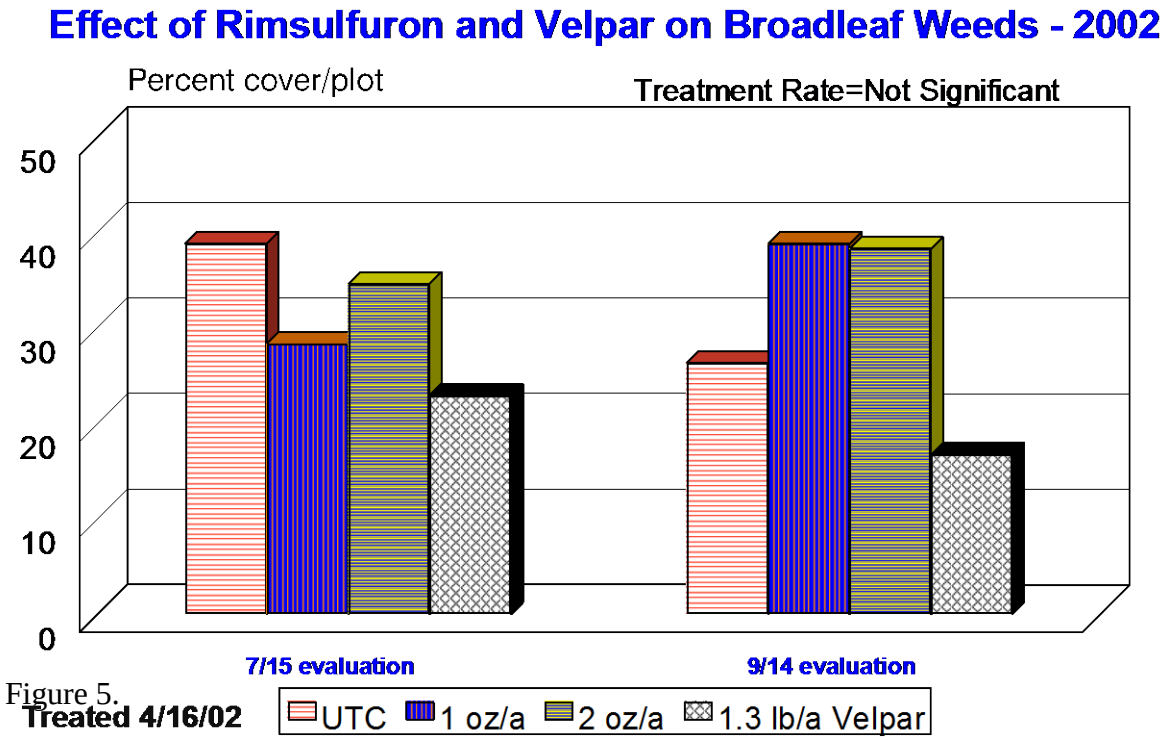


Figure 5.

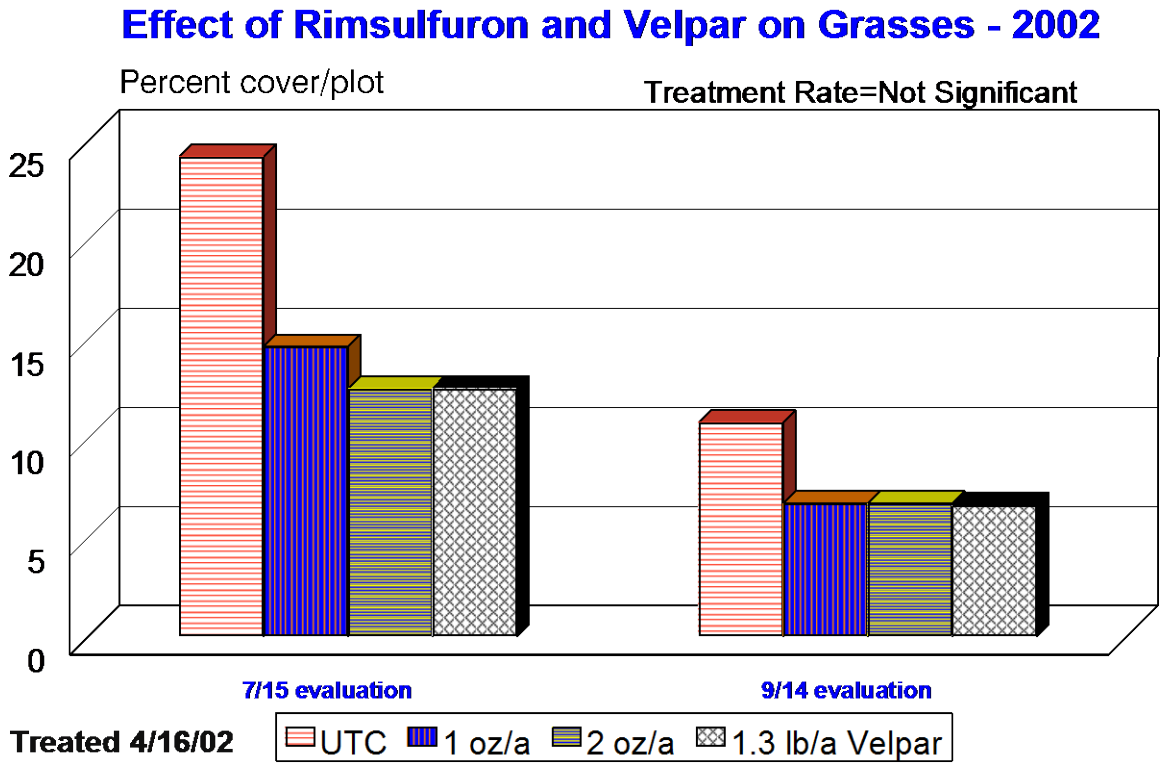


Figure 6.

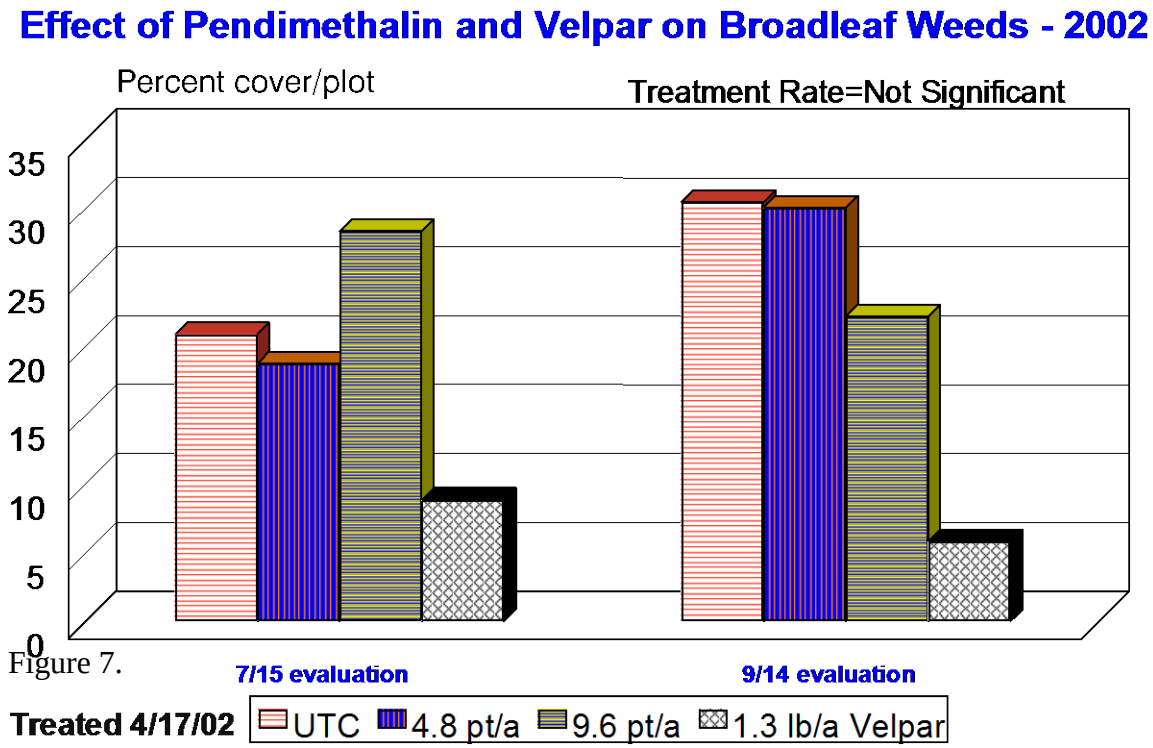


Figure 7.

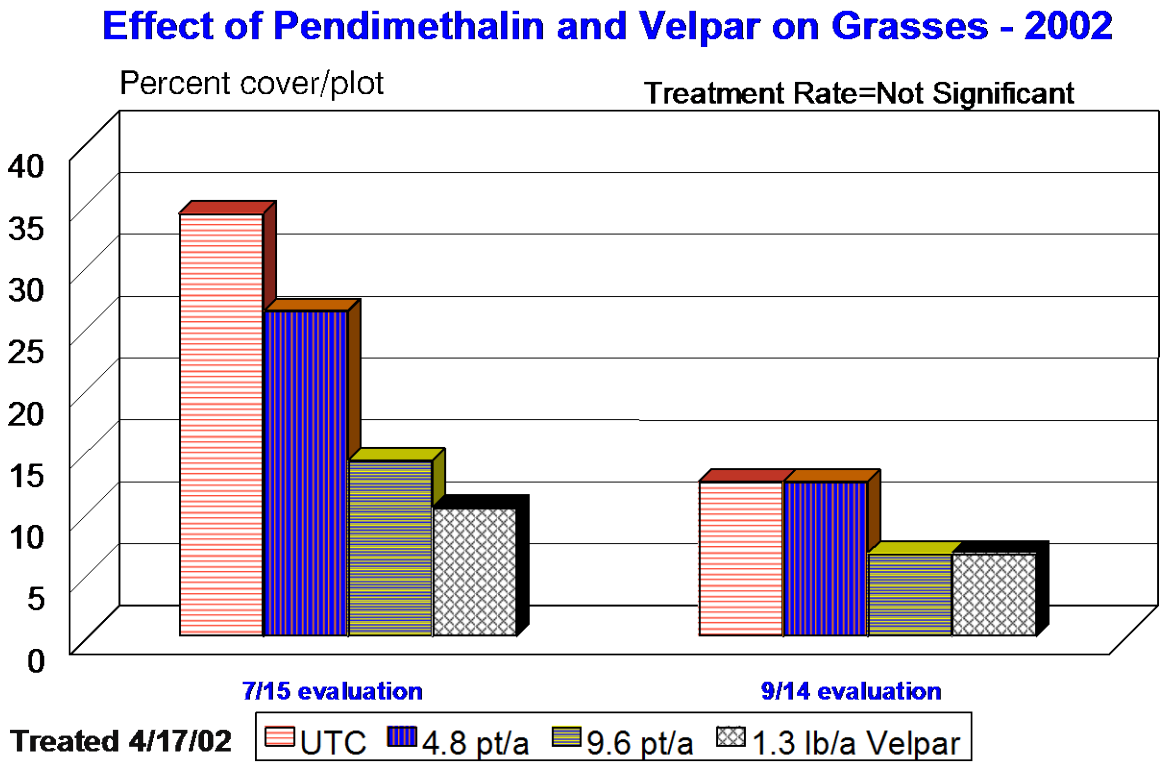


Figure 8.

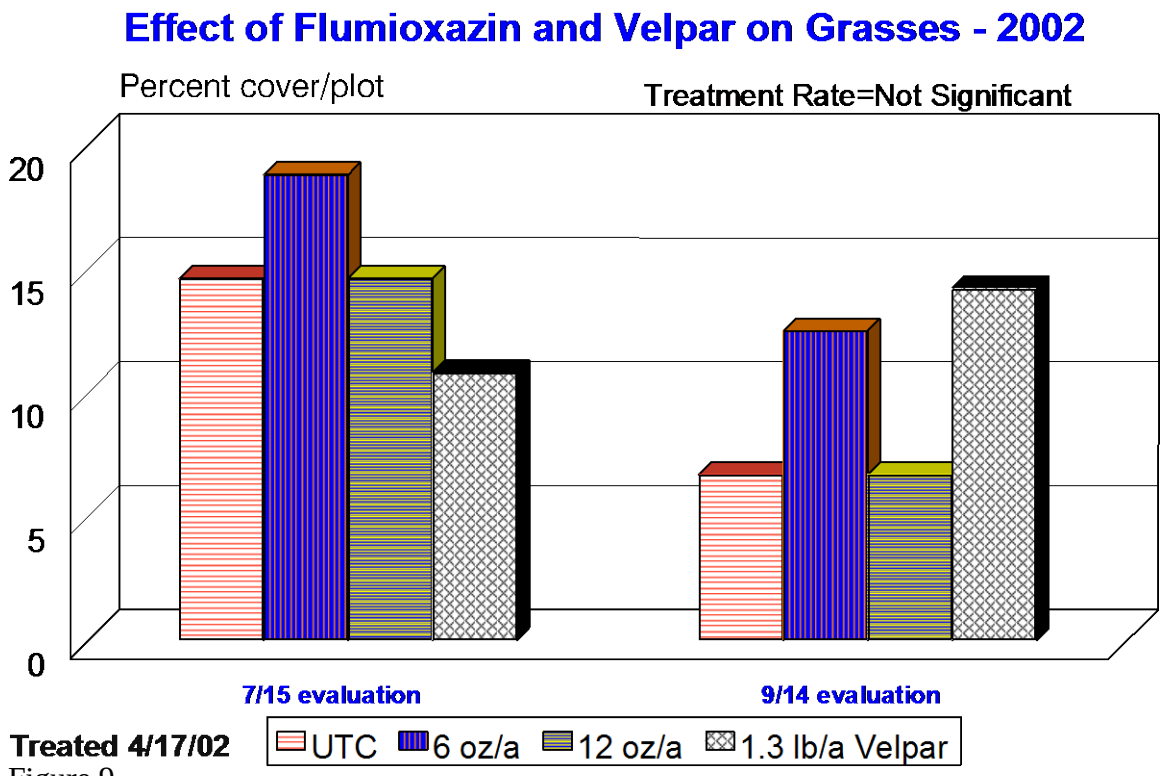
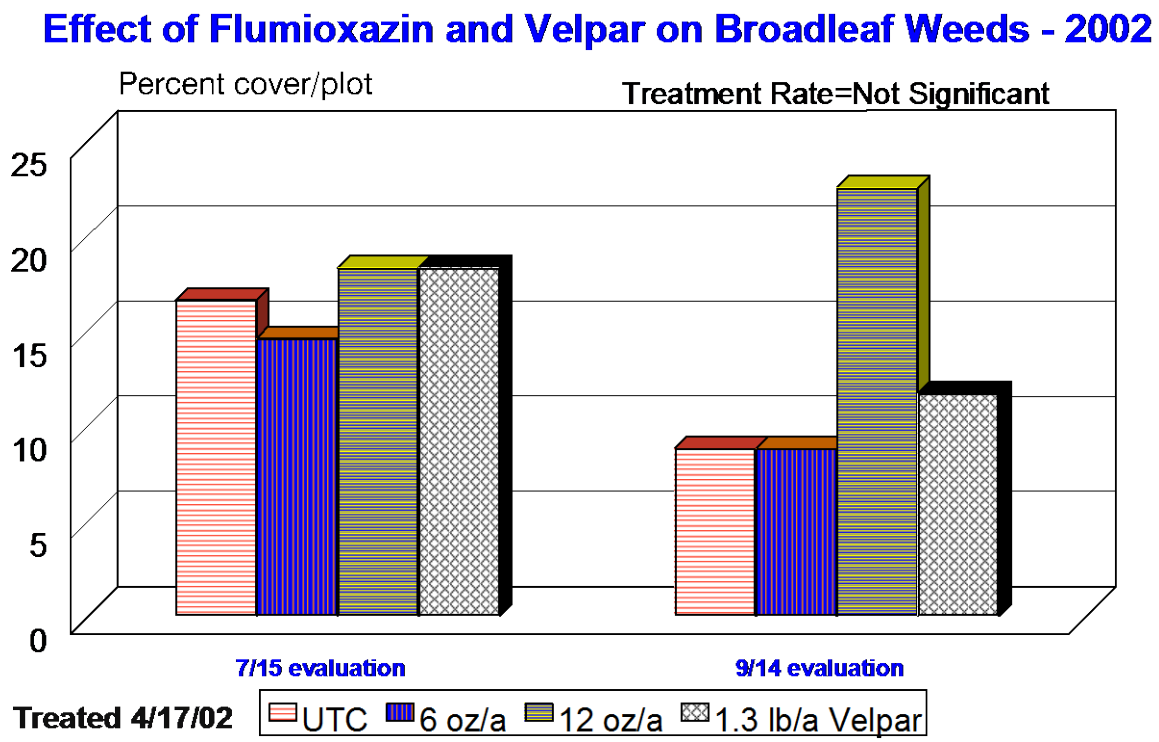


Figure 9.


Effect of Flumioxazin and Velpar on Broadleaf Weeds - 2002
Percent cover/plot
Treatment Rate=Not Significant
25
20
15
10
5
0
7/15 evaluation
9/14 evaluation
Treated 4/17/02
UTC
6 oz/a
12 oz/a
1.3 lb/a Velpar

WEED MANAGEMENT AND FIELD COVER

INVESTIGATOR: David E. Yarborough, Professor of Horticulture

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

METHODS: Forty-eight meter square plots were established and the cover of blueberry and bunchberry was recorded at Blueberry Hill Farm Experimental Farm, Section U1 on October 3, 2002. Experimental design was a randomized complete block with five herbicides at two rates and an untreated check, replicated four times. Treatments applied on October 3, 2002 consisted of a control 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.

RESULTS: No results available until after evaluation of blueberry and bunchberry cover in 2003.

CONCLUSION: Canadian trials have found fall application of a sulfonyl urea 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 2003 with other sulfonlyurea herbicides.

WEED MANAGEMENT AND FIELD COVER

INVESTIGATOR: David E. Yarborough, Professor of Horticulture

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 a 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. 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.

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

RESULTS: All sites increased in cover in 2002 (Figure 1). Hamlin and Jonesboro sites had a significant increase in blueberry cover, the Wesley site, which had the largest increase last year had the smallest increase, this was because the Pronone treatment killed several of the plants (Figure 2). In Wesley the weed control was also very poor which also would have reduced the blueberry spread (Figure 3). In contrast to last year the weed control in Hamlin was excellent (Figure 4) and the greatest spread could be seen at that site (Figure 1).

CONCLUSION: The lack of spread in Wesley may be attributed to the Pronone injury and weed pressure observed at the site. The soil type was not appropriate for Pronone and many of the plants were killed.

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

Figure 1.

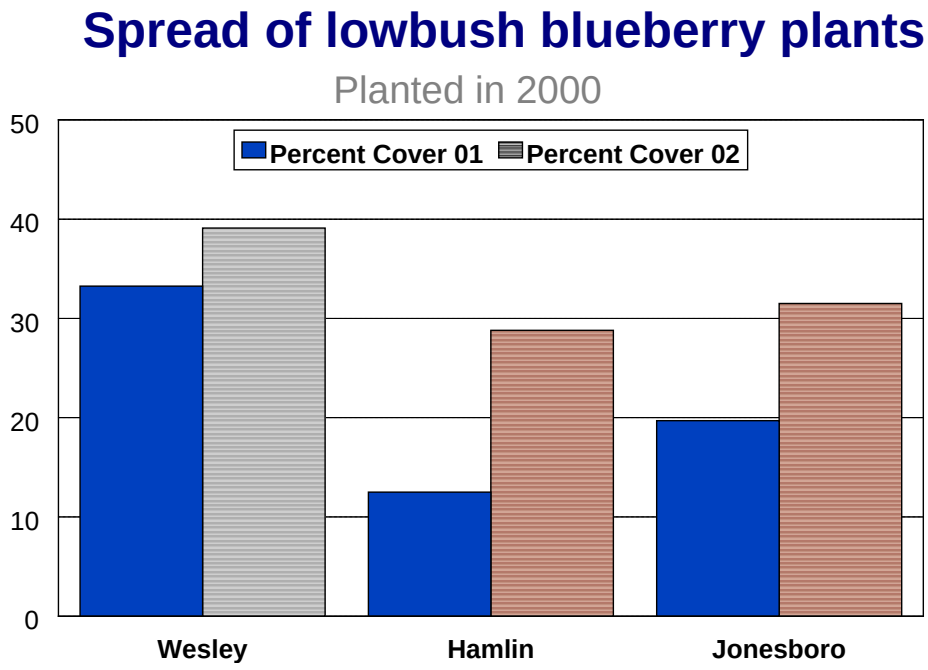


Figure 2. Blueberry plant killed by Pronone application.

Figure 3. Weed pressure at Wesley site.

Figure 4. Excellent weed control at Hamlin site.

EXTENSION

INVESTIGATOR: David E. Yarborough, Extension blueberry Specialist

TITLE: Wild Blueberry Extension Education Program in 2002

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.

Professional Improvement Activities:
Delivered or cooperated in the following talks at Professional Meetings:

Yarborough, D. E. 2002. Comparison of the sprout-less weeder with cutting and wiping for hardwood control in wild blueberry fields at Northeastern Weed Science Society Meeting in Philadelphia, PA on January 7-10, 2002 and at Wild Blueberry Research and Extension Workers Meeting in Portland, ME on March 21, 2002.

Dalton, T.J., A. Files, and D.E. Yarborough. 2002. An Economic Assessment of the Returns to Irrigation Investment for Wild Blueberries. 26th International Horticultural Congress. Toronto, Ontario, Canada. August 11-17, 2002.

Dalton, T.J.and D.E. Yarborough. 2002. The economics of Supplemental Irrigation on Wild Blueberries: A Stochastic Cost Assessment. 9th North American Blueberry Research and Extension Workers Meeting. Halifax, Nova Scotia, Canada. August 18-21, 2002.

Yarborough, D. E. Factors Contributing to the Increase in Productivity in the Wild Blueberry Industry. 9th North American Blueberry Research and Extension Workers Meeting. Halifax, Nova Scotia, Canada. August 18-21, 2002.

Jensen, K.I.N. and D.E. Yarborough. An Overview of Weed Management in the Wild Blueberry - Past and present. 9th North American Blueberry Research and Extension Workers Meeting. Halifax, Nova Scotia, Canada. August 18-21, 2002.

Seymour, R.M ., G. Starr, and D. E. Yarborough. 2002. Yield and quality differences of lowbush blueberry (Vaccinium angustifolium) in irrigated and rain-fed conditions. 9th North American Blueberry Research and Extension Workers Meeting. Halifax, Nova Scotia, Canada. August 18-21, 2002.

Starr, G., R.M. Seymour, F. Olday and D. E. Yarborough. Determination of evapotranspiration and drainage in lowbush blueberries (Vaccinium angustifolium) using weighing lysimeters. 9th North American Blueberry Research and Extension Workers Meeting. Halifax, Nova Scotia, Canada. August 18-21, 2002.

Spring grower meetings:
South Paris, March 25; Union, March 28; Ellsworth, March 27; Machias, March 30, 2002.

ICM sessions:
Blueberry Pest Management at Augusta Agricultural Trade Show, January 10, 2002.
Equipment Calibration and Experimental Design at Category 10 Pesticide Applicator Training Session at the In-Service Training in Portsmouth, NH on January 31, 2002.
ICM field training sessions: Knox/Lincoln Counties April 30, May 27 and 25 & June 26; Washington County May 1, 29 & June 26; Hancock County May 2, 30 June 27.
IPM Cranberry Tag Team Meeting Presentation on weed management, Columbia Falls, June 12, 2002.
Minimizing Off-Target Deposition of Pesticide Applications at Cherryfield Foods Training Session on April 23, 2002.

Extension Presentations:
Taming the Wild Blueberry at the Rehab Center in Brewer on February 20, 2002.
Taming the Wild Blueberry for LCH110 Horticultural Science class at UMaine, March 29, 2002.
Wild Blueberry Production for landowners abutting blueberry fields at the Union Town Hall on April 17, 2002.

Weed Management Principles for Kennebec County Master Gardner Program in Augusta, ME on May 7, 2002.

Wild Blueberries for Blue Hill Heritage Trust Walk and Talk on Caterpillar Hill on August 7, 2002.

Wild Blueberry Production Practices at SHARE UMM Velpar forum, in Machias on September 26, 2002.

Equipment Calibration for LCH 25 Turfgrass Management class at UMaine, October 2, 2002.

Television/radio/newspaper Interviews 2002:

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.

Bangor Daily: September 19, October 4
Boston Globe: May 30, June 10
CBC Radio: August 26
Channel 7 news: February 19
Ellsworth American: April 4
Maine Public Radio: July 24
Maine Times: March 27
Nature Conservancy: February 26
NewsinMaine.com: December 20
Portland Press Herald: July 17, August 27
Quoddy Times: July 30
Rural Delivery Magazine: January 16
Time -Warner: August 23
WZON radio: July 24
Yankee Magazine: February 26

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.

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 update it each year.

I have been cooperating with the U.S. Environmental Protection Agency in their assessment of hexazinone dietary risk to determine if more restrictions are needed for the Velpar used in wild blueberry production in Maine. I have been providing use information and a review of their assessment. The EPA findings indicated that '…no harm to any population subgroup will result from aggregate exposure to hexazinone…'. The tolerance in fruit was increased from 0.2 to 0.6 ppm because this was the lowest level that quantification was accurate. This has no effect because we do not find any hexazinone residue in the fruit.

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 interested.

I met with legislators at UMaine day in Augusta on March 7 to discuss wild blueberry culture.

Explained Maine wild blueberry production to hundreds of attendants of the Big E Agricultural Fair in Springfield, MA on September 29-30, 2002.

Provided a tour of wild blueberry fields to a group of growers from Quebec on November 4, 2002.

Met with specialists and researchers from the Maritime Provinces to discuss minor use need priorities for wild blueberry production, Nova Scotia Agricultural College, Truro, NS on November 14, 2002.

Public testimony Maine Board of Pesticides Control, Augusta, ME - January 4, 2002, February 15, 2002, March 3, 2002.

Gave testimony in a deposition on the Guptill Pronone Injury lawsuit on July 23-24 and September 23-24, 2002 at UMaine in Orono.

Manuscripts or Proposals reviewed:
Reviewed 'The Berries Book' by Gail Gibbons a writer and Illustrator of children's books, published in 2002.

Reviewed 'Blueberryland -Taming the Maine Wild Lowbush Blueberry' by Walter Staples a New Hampshire author, due for publication in 2003.

Reviewed a proposal for 'Innovative protocols for the development of a sustainable wild berry operation for Alaska' for the USDA Small Business Innovation Research program in 2002.

Reviewed 'An evaluation of turfgrass species and varieties' by Alan Langille and Annamarie

Pennucci for a MAFES Miscellaneous Report in 2002.

Wild Blueberry Fact Sheets - 2002

New
Fact Sheet #303 (UMCE # 2182) Minimizing Off-Target Deposition of Pesticide Applications
Fact Sheet #216 (UMCE # 2003) Flower Primordia Development Stage with Temperature Tolerance

Revised
Fact Sheet #629 (UMCE # 2079) Honey Bees and Blueberry Pollination
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
Fact Sheet #241- 248 Weeds 1-8. 2002 Revised with color photos

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 2002 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 nine 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 growers 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 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: 2002 Pesticide Groundwater Survey

METHODS: Surveyed five drilled wells, three test wells, one dug well and six adjacent surface water samples taken April, May, June, July, August and September to test if herbicides and a fungicide is present. Three wells were put in by the Maine Department of Conservation in 1986 and the others were drilled. Two sites, a spring adjacent to wild blueberry field one on the Narraguagus river were added in 2002. 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 fungicide propiconazole is present in groundwater.

RESULTS: Hexazinone levels in water were similar compared to last year. Hexazinone levels ranged from non-detect (ND) to 21.5 ppb (Table 1). The site with with highest hexazinone level has a soil that is shallow to bedrock and levels varied from 8.2 ppb to 21.5ppb over the season. On the sites with test wells treated with diuron and terbacil, there were three surface water detections of terbacil and one test well detection early in the season but for all sites the detection was not present in the next sample taken. Propiconazole was detected once, in the adjacent surface waters at two locations, but not in the test or drilled wells. Neither of the samples persisted and one was at the detection limit of 0.05 ppb. Propiconazole detections in test wells last year may have been due to surface contamination during sampling, this year I took extra cautions to prevent this contamination and no detections were found in any test well.
This year's survey of herbicide use indicated a significant reduction in hexazinone rate (to an average of 0.4 lb/a) and an increase in the trend of rotating to other herbicides (14%) or not using herbicides for a cycle (14%) (Figure 1).

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 surface water. All detected levels were well below established EPA health advisory limits (HAL).

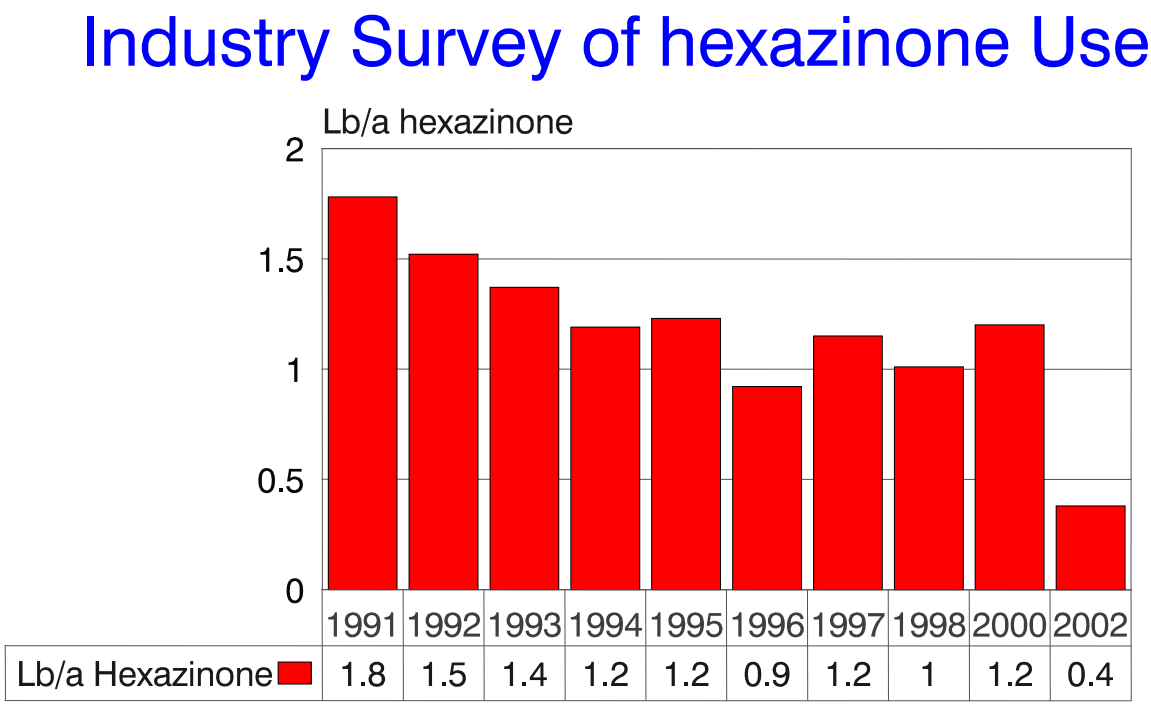
RECOMMENDATIONS: Continue to sample wells to ensure best management practices do not result in pesticide detections above the HAL. Continue to vary management practices to determine how they influence pesticide movement in wild blueberry soils and review and update practices, as new information becomes 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.

Table 1. 2002 Groundwater Test Result Summary
University of Maine Well Water Survey
Hexazinone/Diuron/Terbacil/Propiconazole in parts per billion

SiteWell /hexazinone/ diuron/terbacil/ propicoanzole	April	May	June	July	September
Wells					
9 test	3.0/ND/ND.ND	3.5/ND/ ND/ND	1.9/ND/ND/ND	NA	1.7/ND/ ND/ND
11 test	6.6/ND/0.05/ND	4.7/ND/ ND/ND	0.76/ND/ND/ ND	NA/ND/ND/ND	2.7/ND/ ND/ND
12 test	6.9/ND/ ND/ND	5.3/ND/ ND/ND	4.6/ND/ND/ND	NA/ND/ND/ND	4.7/ND/ ND/ND
13 drill	3.5/ND/ ND/ND	3.7/ND/ ND/ND	ND/ND/ND/ND	NA/ND/ND/ND	2.2/ND/ ND/ND
31 drill	7.0/ND/ ND/ND	4.0/ND/ ND/ND	1.2/ND/ND/ND	NA/ND/ND/ND	4.2/ND/ ND/ND
32 drill	19.7/ND ND/ND	10.7/ND/ ND/ND	8.2/ND/ND/ND	21.5/ND/ND/ND	9.3/ND/ ND/ND
36 drill	3.6/ND/ ND/ND	2.0/ND/ ND/ND	1.7/ND/ND/ND	3.6/ND/ ND/ND	8.9/ND/ ND/ND
15 drill	ND/ND/ ND/ND	0.33/ND/ ND/ND	ND/ND/ND/ND	ND/ND/ ND/ND	3.6/ND/ ND/ND
Surface					
9 stream	0.1/ND/ ND/ND	0.3/ND/ ND/ND	0.1/ND/ND/ND	NA	0.2/ND/ ND/ND
11 pond	2.1/ND/0.07/ND	5.2/ND/ ND/ND	2.5/ND/ND/0.05	2.6/ND/ ND/ND	0.3/ND/ 0.6/ND
12 stream	6.2/ND/0.3/ND	4.1/ND/ ND/ND	2.5/ND/ND/ND	3.8/ND/ ND/ND	4.8/ND/ ND/ND
13 pond	ND/ND/ ND/ND	ND/ND/ 0.1/0.7	ND/ND/ND/ND	ND/ND/ ND/ND	0.1/ND/ ND/ND
41 spring	3.7/ND/ ND/ND	3.9/ND/ ND/ND	3.0/ND/ND/ND		
41 river	0.5/ND/ ND/ND	0.3/ND/ ND/ND	0.2/ND/ND/ND	3.6/ND/ND/ND	2.6/ND/ND/ ND
				ND/ND/ND/ND	0.4/ND/ND/ ND
HAL(ppb)	**Hexazinone 400**		**Diuron 10**	**Terbacil 90**	Propiconazole **50**

ND=no detect To 0.05 PPB NA = Sample not taken or analyzed

Figure 1.



2002 Acres Liquid 60% Granular 12% Terbacil/Diuron14%, None 14%

EXTENSION

INVESTIGATOR: David E. Yarborough, Extension Blueberry Specialist

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 more in 2001 in Union, Jonesboro and Wesley(2) and treated with either 0, 0.5, 1 or 2 lb ai/a Velpar7 (except for Sinbar7 on two sites) and with 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. Four Velpar7 plots by 3 sulfur plots provides 12 combination treatments per site which were evaluated in June 2002 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, with some showing more or less than the 0.5 pH reduction with 500 lb/a sulfur (figure 1, 2). Weed cover was reduced with Velpar or Sinbar applications (figure 4). Although grass and herbaceous weed cover were reduced with sulfur application, no significant effect was seen for the sulfur from the five sites treated in 2001 (figure 3).

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 1 pH unit on some sites, no corresponding reduction in weed cover was seen. It appears there is a trend for the weed suppression effect of the reduced pH but because of the variability no significant effect was seen, this may take longer 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.

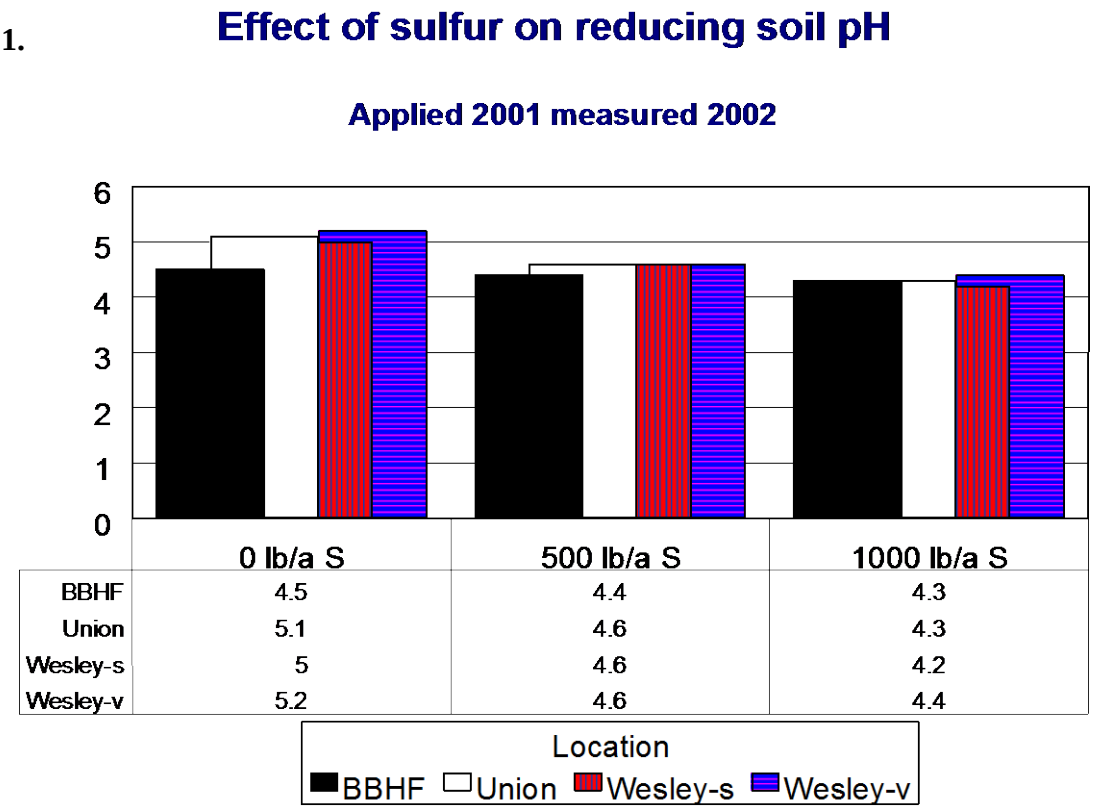


Figure 2.

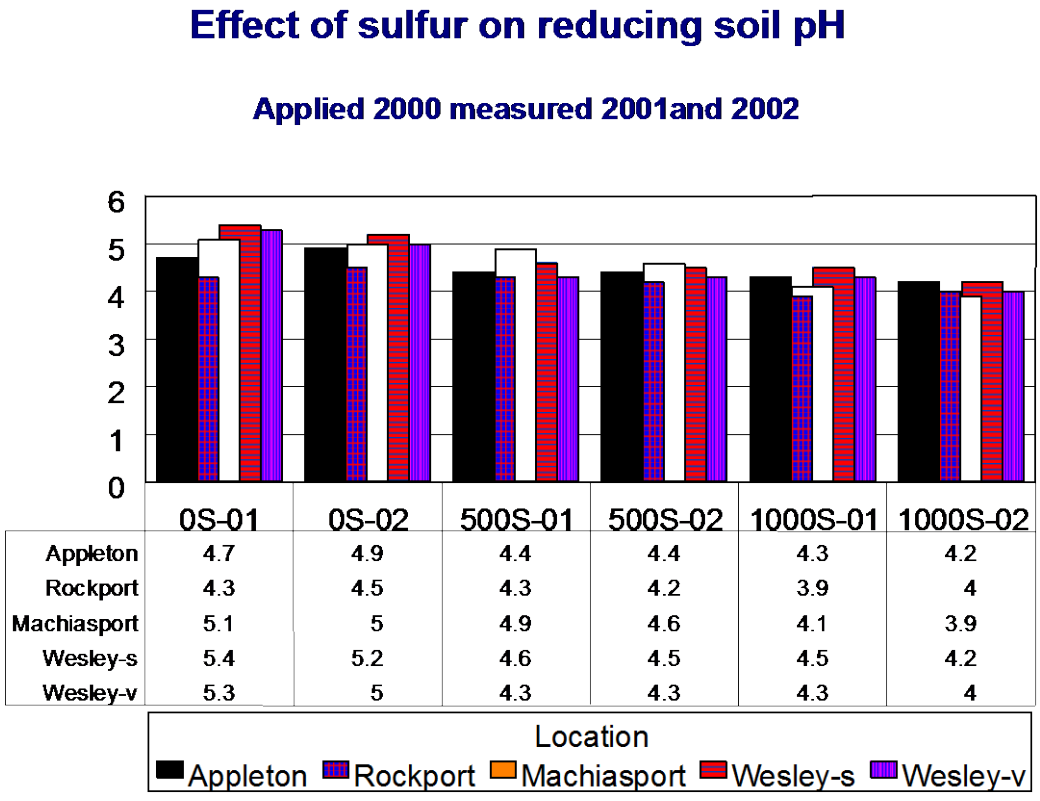
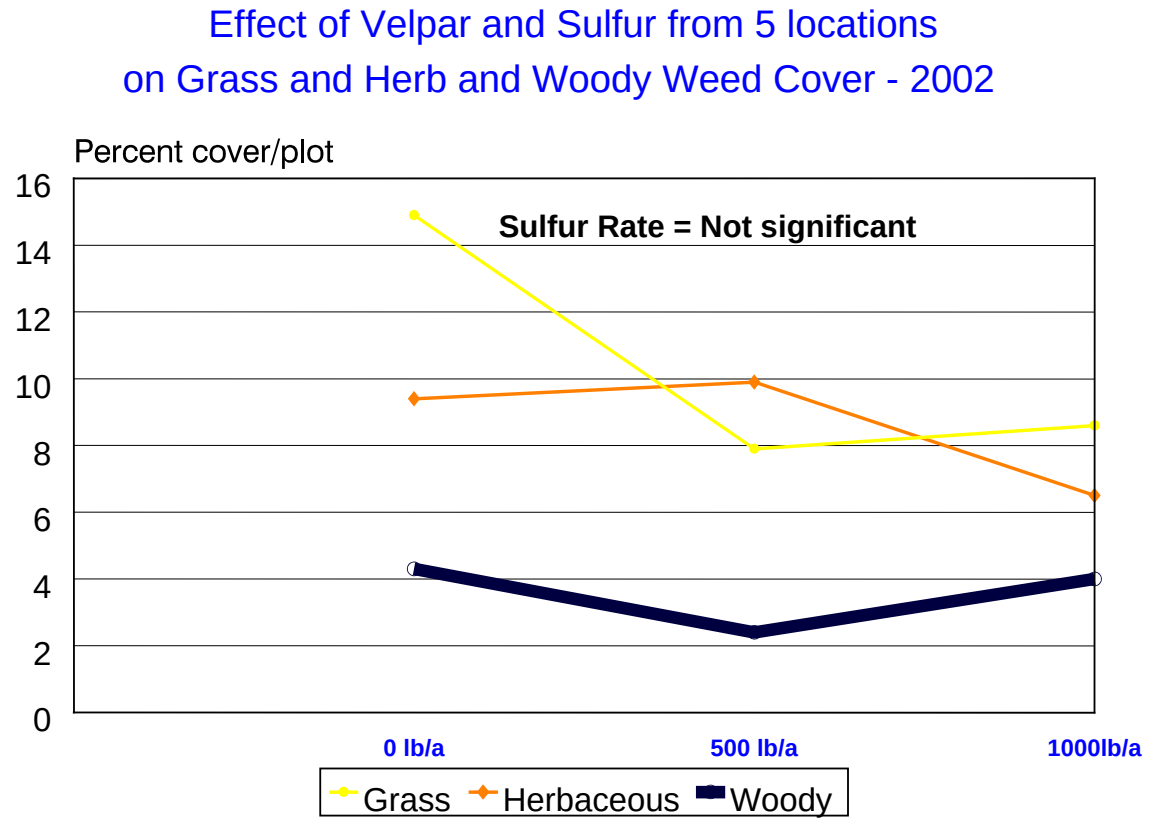


Figure 3.



Sulfur applied in 2000

Figure 4.