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Winter 2001

2000 Wild Blueberry Project Reports

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FOOD SCIENCE AND HUMAN NUTRITION

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

1. 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 1999. Samples were stored frozen until they were analyzed During December,1999 and January, 2000. Pesticide residues in the blueberries were assayed using HPLC, GC-AED and ELISA methods developed in the Food Safety Laboratory.

RESULTS: Sixty-nine samples were analyzed from the 1999 wild blueberry crop (table 1). Twenty-two (32%) of the 69 samples were positive for phosmet (0.006 to 2.6 ppm); twenty (29%) were positive for azinphos-methly (0.01 to 1.2 ppm)); thirty (77%) contained carbendazim (0.025 ppm to 0.87 ppm); one contained methoxychlor (0.08ppm); and one showed reisidual propiconazole (0.10 ppm). 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 1999 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 ropiconazole use is relatively new to the industdry.

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 LC/MS/MS methods to assay agrochemical metabolites and new polar metabolites, such as the sulfonylureas.

1999 Blueberry Pesticide Results (02/02/00)							
Sample	Phosmet (ppm)	Guthion (ppm)	Methoxychlor (ppm)	Carbendazim (ppm)	Hexazinone (ppm)	Propiconizol (ppm)	Captan (ppm)
Detection limit	0.001	0.001	0.005	0.02	0.02	0.005	0.005
1	ND	ND	ND	ND	ND	ND	ND
2	ND	ND	ND	ND	ND	ND	ND
3	ND	0.079	ND	ND	ND	ND	ND
4	0.116	ND	ND	ND	ND	ND	ND
5	ND	ND	ND	ND	ND	ND	ND
6	0.023	ND	ND	ND	ND	ND	ND
7	2.558	ND	ND	ND	ND	ND	ND
8	ND	ND	ND	ND	ND	ND	ND
9	ND	ND	ND	0.103	ND	ND	ND
10	ND	0.055	ND	ND	ND	ND	ND
11	ND	0.091	ND	ND	ND	ND	ND
12	0.02	0.072	ND	ND	ND	ND	ND
13	ND	ND	ND	0.247	ND	ND	ND
14	ND	ND	ND	ND	ND	ND	ND
15	ND	ND	ND	0.563	ND	ND	ND
16	0.007	ND	ND	0.163	ND	ND	ND
17	0.028	ND	0.08	0.185	ND	ND	ND
18	ND	0.051	ND	ND	ND	ND	ND
19	ND	1.206	ND	0.047	ND	ND	ND
20	ND	0.108	ND	0.037	ND	ND	ND
21	ND	0.025	ND	ND	ND	ND	ND
22	ND	0.025	ND	0.157	ND	ND	ND
23	0.172	ND	ND	0.275	ND	ND	ND
24	ND	0.026	ND	0.456	ND	ND	ND
25	ND	0.045	ND	0.09	ND	ND	ND

26	ND	ND	ND	ND	ND	ND	ND
27	ND	0.088	ND	ND	ND	ND	ND
28	0.115	ND	ND	0.228	ND	ND	ND
29	0.023	ND	ND	0.117	ND	ND	ND
30	0.038	ND	ND	0.305	ND	ND	ND
31	ND	0.014	ND	0.064	ND	ND	ND
32	ND	ND	ND	ND	ND	ND	ND
33	0.024	0.01	ND	ND	ND	ND	ND
Sample	Phosmet (ppm)	Guthion (ppm)	Methoxychlor (ppm)	Carbendazim (ppm)	Hexazinone (ppm)	Propiconizol (ppm)	Captan (ppm)
34	ND	ND	ND	ND	ND	ND	ND
35	ND	ND	ND	ND	ND	ND	ND
36	ND	0.021	ND	ND	ND	ND	ND
37	ND	ND	ND	ND	ND	ND	ND
38	0.303	ND	ND	ND	ND	ND	ND
39	0.006	ND	ND	0.212	ND	ND	ND
40	ND	ND	ND	0.212	ND	ND	ND
41	ND	ND	ND	ND	ND	ND	ND
42	ND	ND	ND	0.272	ND	ND	ND
43	ND	ND	ND	0.187	ND	ND	ND
44	0.006	ND	ND	0.129	ND	ND	ND
45	0.013	ND	ND	0.23	ND	ND	ND
46	ND	ND	ND	ND	ND	ND	ND
47	0.006	ND	ND	0.206	ND	ND	ND
48	ND	ND	ND	ND	ND	ND	ND
49	ND	ND	ND	0.083	ND	ND	ND
50	ND	ND	ND	0.039	ND	ND	ND
51	ND	ND	ND	ND	ND	ND	ND
52	ND	ND	ND	0.29	ND	ND	ND
53	0.008	ND	ND	0.117	ND	ND	ND
54	0.006	ND	ND	0.099	ND	ND	ND

55	ND	0.032	ND	0.872	ND	ND	ND
56	ND	ND	ND	ND	ND	ND	ND
57	0.032	ND	ND	ND	ND	ND	ND
58	ND	ND	ND	0.025	ND	ND	ND
59	ND	ND	ND	ND	ND	ND	ND
60	ND	0.278	ND	ND	ND	0.104	ND
61	0.029	ND	ND	ND	ND	ND	ND
62	ND	ND	ND	0.572	ND	ND	ND
63	ND	ND	ND	ND	ND	ND	ND
64	0.053	0.054	ND	ND	ND	ND	ND
65	ND	ND	ND	ND	ND	ND	ND
66	ND	ND	ND	ND	ND	ND	ND
67	ND	ND	ND	ND	ND	ND	ND
68	ND	0.043	ND	ND	ND	ND	ND
69	0.038	0.081	ND	ND	ND	ND	ND
Pesticide	Phosmet (ppm)	Guthion (ppm)	Methoxychlor (ppm)	Carbendazim (ppm)	Hexazinone (ppm)	Propiconizol (ppm)	Captan (ppm)
Tolerance	10	5	14	7	0.2	1	25

FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Russell Hazen, Graduate Research Assistant

2. TITLE: Factors Affecting the Microbiological Quality of IQF Blueberries

METHODS: Incoming field samples from the 2000 harvest season were analyzed for *Listeria* spa. using the Gene-Trak® *Listeria* DLP Assay from Gene-Track Systems. A total of 172 field samples were analyzed. In a second experiment, the effects of chlorine spray and freezing on the microbiological quality of Maine wild blueberries was examined. Blueberry samples were collected as they entered a blueberry processing plant in Washington County, Maine, and transported on ice to the Department of Food Science and Human Nutrition. Sub-samples of 350 g were spread within a 30-cm by 30-cm (12") square on a sterile wire screen. Samples were sprayed with 500 ml of either sterile water or 100 ppm chlorine solution and allowed one of four contact times (30, 60, 120 or 300 sec) prior to freezing. Samples of 50 g were taken initially and after each processing step. Microbiological analyses of total aerobes and yeast 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).

RESULTS: One hundred and seventy-two field samples have been analyzed for *Listeria* spa. Only **two** samples have tested positive for a *Listeria* spa. However, in conducting these analyses problems were observed. These problems could result from a physical problem with the testing protocol, which may have included (1) enrichment protocol may not have been selective enough (2) resilient background flora.

Results from the chlorination study demonstrated that all treatments resulted in statistically significant ($P<0.05$) reductions in total aerobes, when compared to initial values of 4.02 ± 0.15 log (Table 1). As well as in yeast when compared to initial values of 4.19 ± 0.08 log (Table 2). However, no statistically significant differences in log reductions among samples receiving either sterile or chlorinated water washes were detected for either aerobes or yeast. Chlorine did initially appear to have an effect, but this was later determined to be not statistically significant. Increasing the contact time was also determined to be statistically insignificant with no differences among treatments (Fig 1 and 2). Freezing was determined to be a statistically significant ($P<0.05$) means of reducing the total aerobes and yeast commonly found on wild blueberries (Fig 3 and 4). However, the total reduction in aerobes and yeast after treatment and subsequent freezing still did not yield a reduction much greater than 2 logs and in some resulted in a reduction of less than 1 log. Therefore, the steps in IQF processing of blueberries may not be considered a reliable means of ensuring the microbial safety of this product, but are a useful means of reducing microbial load, and prolonging the quality of IQF processed blueberries (Fig 5 and 6).

RECOMMENDATIONS: An inoculation study examining the growth of *L. monocytogenes* on/in blueberry samples will be performed in the next several months. This study will develop a

much-needed database on the likely hood for potential *Listeria* related problems in the Maine Wild Blueberry industry. This study could indicate the prevalence of *Listeria* contamination, and determine if monitoring of wild lowbush blueberries is even necessary. The chlorination study appears to indicate that chlorination may be an unnecessary expense. Chlorination and freezing produced a mean log reduction of 1.85 while sterile water and freezing only resulted in a reduction of 1.28 logs. This difference was not significant statistically, but it may be important to processors wishing to gain this additional reduction. The industry may wish to consider other means for microbial reduction of IQF blueberries. These could include but are not limited ozone, organic acids, chlorine dioxide and light-pulse technology.

Table 1. Difference in Total Aerobes (log CFU/g)[a] Initially and After Spray Treatments

	Mean[b] Log CFU/g	Standard Deviation	Significant Difference [c]
Initial Aerobes	4.02	0.15	a
Spray + 30 Sec	3.66	0.06	b
Spray + 60 Sec	3.85	0.11	b
Spray + 120 Sec	3.80	0.10	b
Spray + 300 Sec	3.78	0.11	b
Cl Spray + 30 Sec	3.89	0.06	b
Cl Spray + 60 Sec	3.74	0.14	b
Cl Spray + 120 Sec	3.82	0.05	b
Cl Spray + 300 Sec	3.70	0.02	b
[a]all values obtained from analysis were converted to CFU/g of			
[b]Mean value of four samples			
[c] Values not followed by the same letter were determined to be significantly different using Tukey's HSD Multiple comparisons			

Table 2. Difference in Initial Yeast (log CFU/g)[a] and Yeast After Spray Treatments

	Mean[b] Log CFU/g	Standard Deviation	Significant Difference [c]
Initial Aerobes	4.19	0.08	a
Spray + 30 Sec	3.75	0.03	b
Spray + 60 Sec	3.84	0.08	b
Spray + 120 Sec	3.70	0.11	b
Spray + 300 Sec	3.76	0.14	b
Cl Spray + 30 Sec	3.90	0.18	b
Cl Spray + 60 Sec	3.87	0.10	b
Cl Spray + 120 Sec	3.83	0.15	b
Cl Spray + 300 Sec	3.85	0.16	b
[a]all values obtained from analysis were converted to CFU/g of blueberries			
[b]Mean value of four samples			
[c] Values not followed by the same letter were determined to be significantly different			

Figure 1. Mean Reduction in Aerobes (CFU/g) from Sterile Water Spray and Cl Water Spray

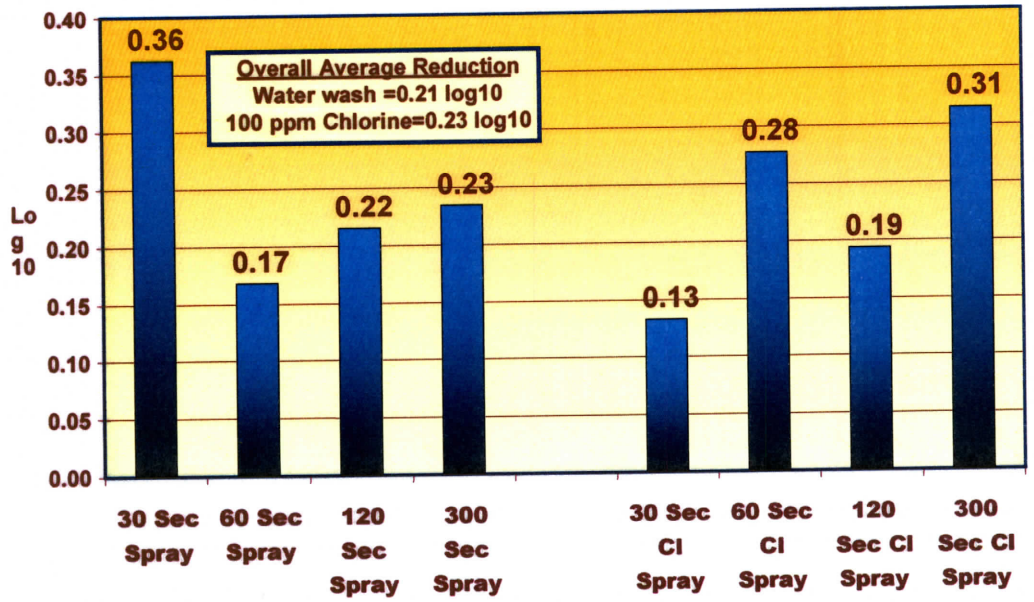


Figure 2. Mean Reduction in Yeast/g from Sterile Water Spray and Cl Water Spray

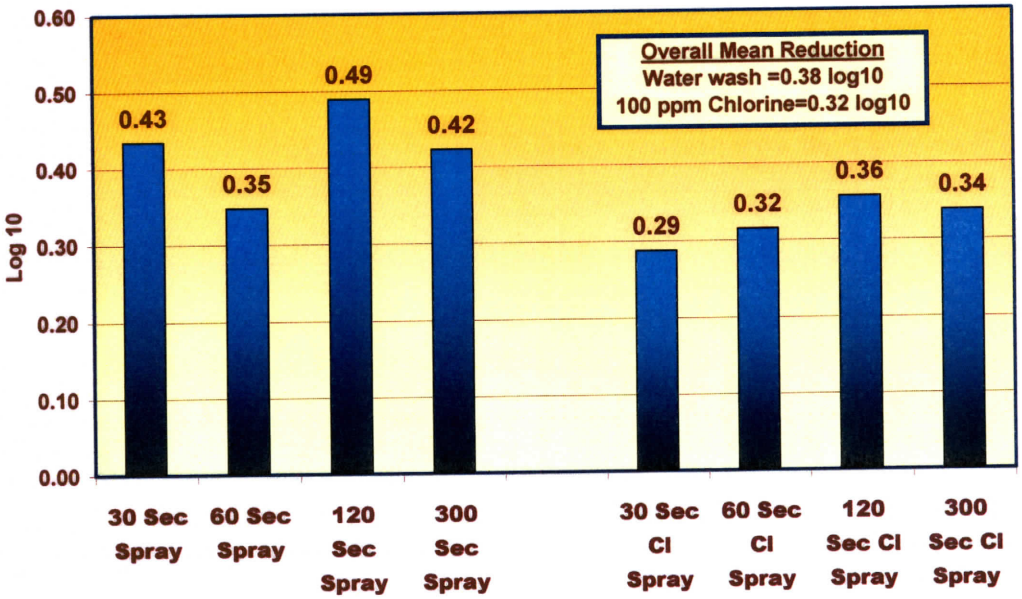


Figure 3. Mean Reduction in Total Aerobes (CFU/g) from Freezing

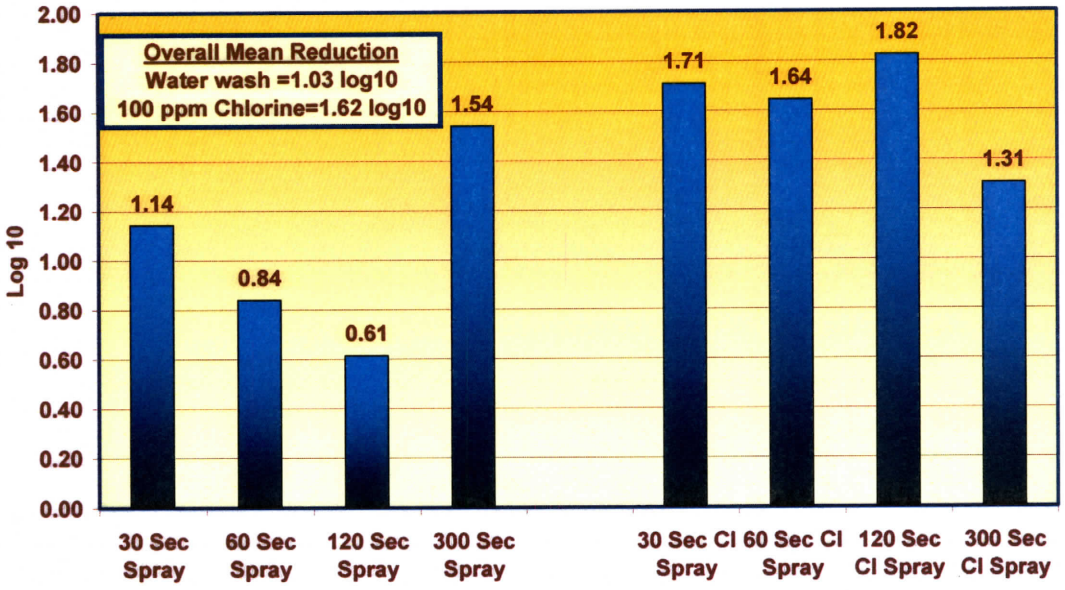


Figure 4. Mean Reduction in Yeast/g from Freezing

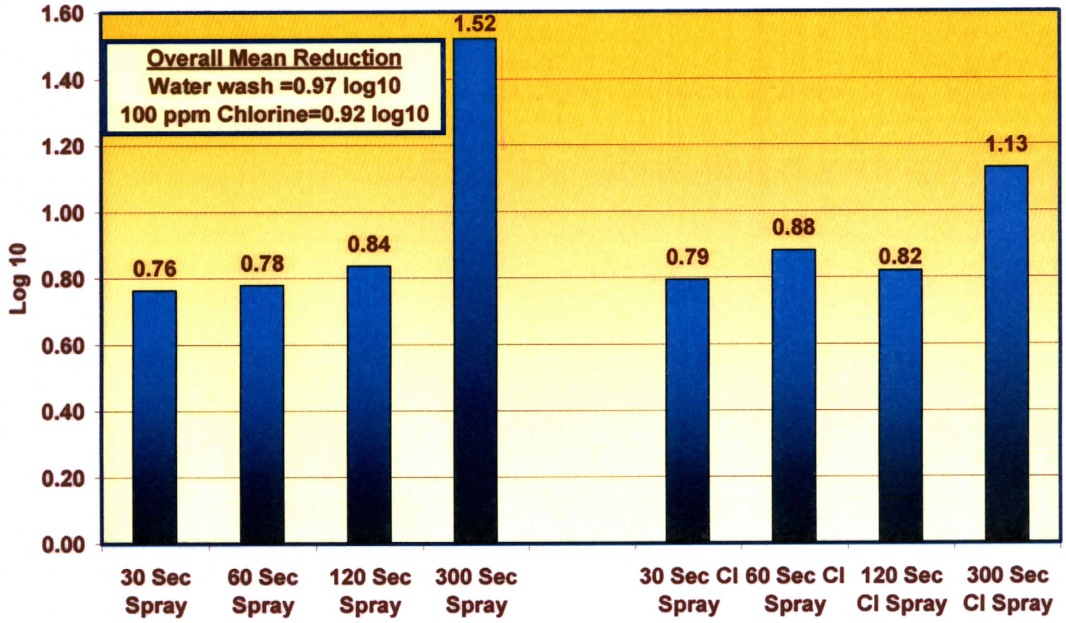


Figure 5. Mean Reduction in Aerobes (CFU/g) from Spray Treatment and Subsequent Freezing

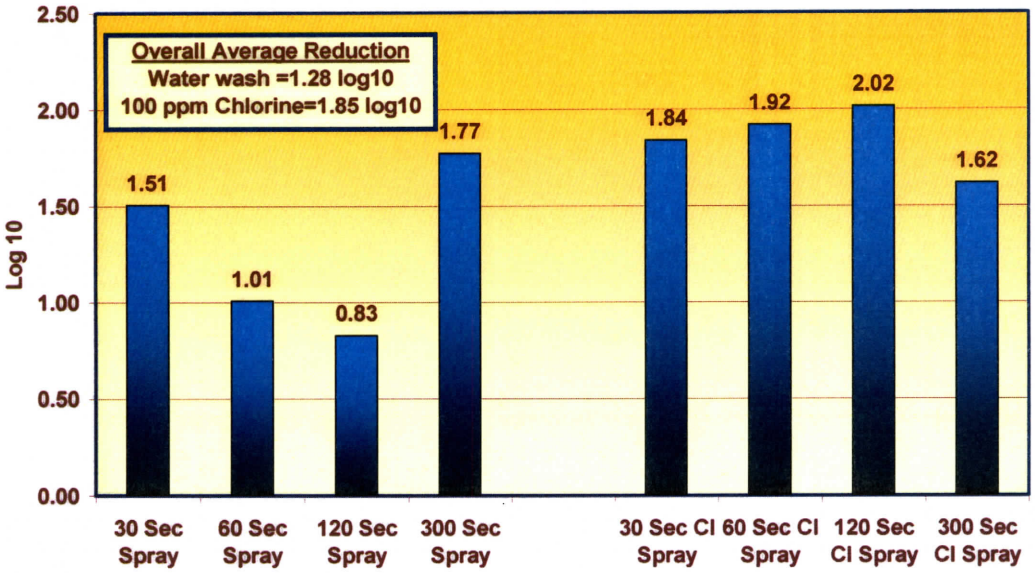
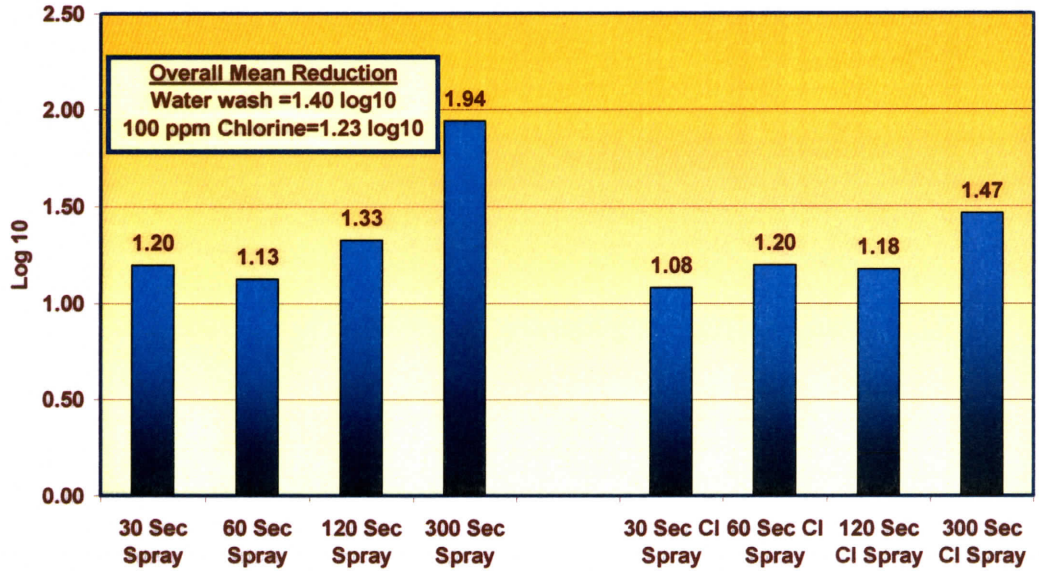


Figure 6. Mean Reduction in Yeast/g from Spray Treatment and Subsequent Freezing



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, Scientific Technician
Kathleen Buzzard, Undergraduate Student

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

METHODS: Ground beef patties were processed from 90% lean beef with varying concentrations of blueberry puree (3.5%, 1.75% and 0.875%, w/w). Untreated beef patties were prepared to serve as the negative control. Patties were broiled to an internal temperature of 75E C (167EF). Precooked beef patties were stored under refrigeration (4-5EC (39-40EF)), and evaluated for oxidation using two chemical methods [Thiobarbaturic acid (TBA) reactive substances and hexanal production) at 0, 4, and 7 days of storage. A colorimetric method was used for TBA analyses and a gas chromatograph equipped with a headspace analyzer was used to determine hexanal concentrations. Carcinogenic compounds (polycyclic aromatic hydrocarbons -PAH) were determined by High Performance Liquid Chromatography (HPLC).

RESULTS: TBA values were significantly ($P<0.05$) different between the control and 3.5% blueberry puree cooked ground beef patties at days 3 and 10 of refrigerated storage (Fig 1). After 10 days of refrigerated storage, the TBA value for the control samples was 4.5-mg malonaldehyde/ kg of burger. For the 3.5% blueberry puree beef patties, only 0.8-mg malonaldehyde/ kg of burger was detected. Hexanal concentration was significantly ($P<0.05$) higher in the control samples immediately after broiling, and remained higher throughout the 10 day refrigerated storage study (Fig 2). Hexanal concentration for the control beef patties was 90 uM after 10 days of frozen storage, and only 4uM for the patties formulated with 3.5% blueberry puree.

Data from the effect of blueberry puree concentration has shown that as puree concentration increased levels of hexanal decreased. At day 0, control patties contained 14 uM of hexanal with the level increasing to 37 uM after 9 days of refrigerated storage. Patties containing 0.875, 1.75 or 3.5% puree contained between 9-11 uM hexanal at day 0. At day 7, the hexanal concentration for patties with 1.75 or 3.5% puree remained unchanged. Hexanal concentration for patties containing 0.875% puree increased to 18 uM. These results indicate that there is a typical dose response between the concentration of puree and hexanal production. At day 7 of refrigerated storage, mgof malonaldehyde/kg of meat were 6.67, 6.42, 3.23 and 1.96 for patties with 0, 0.875, 1.75and 3.5 blueberry puree, respectively.

RECOMMENDATIONS: This study will continue during the remainder of this year. A comparison will be made with puree prepared from highbush blueberries. Beef patties prepared with 3.5% (w/w) lowbush blueberry puree will serve as the positive control and untreated patties will be the negative control. Evaluations will be performed at days 1,4 and 8 of refrigerated

storage (4-5EC (39-41EF)) and at days 1, 30, 60, 90 and 120 of frozen storage. In addition to the chemical analyses, a trained panel will be used to evaluate differences among treatments. Based on the preliminary results from this study, research with ground cooked poultry products is recommended. Cooked processed poultry products because of the unsaturated fatty acids are more susceptible to the development of warmed over flavors (oxidative changes) then is red meat. As constituent fractions from lowbush blueberries are produced, they should be screened for inhibition of oxidation in meat based systems.

FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Darrell W. Donahue, Associate Professor, Biosystems Science and Engineering
Angela Ferran, Graduate Student
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Judy Collins, Research Scientist, Biosystems Science and Engineering

4. TITLE: Separation of Maggot Infested Wild Blueberries in the IQF Processing Line.

OBJECTIVE: Exploratory research examining near infrared radiation (NIR) and cold water tolerance for a method to separate maggot infested wild blueberries in an IQF processing line.

METHODS: Field and sample preparation. After fruit set in July, 2000, the research team identified plots at the Blueberry Hill Research Farm that would not be sprayed in order to have control plots and areas for harvesting of blueberries for testing for maggot infestation.

Laboratory inoculation 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 1999 (See Bio. Study 1 of 1999 report). As they emerged, adults were placed in ovipostion cages in the laboratory (Figure 1). Each cage consisted of a 4.92 L (5.19 qts) Rubbermaid®, square, Servin'Saver, plastic container or an 8.3 L (8.7 qts) 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 (3.94" x .39") 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 (73.4-77EF). 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 that were taken from the cages and placed in a cool laboratory setting (approximately 22EC (72EF)) 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. At the appropriate time the blueberries were moved to the biological engineering laboratory and prepared for near infrared scanning as described below.

Near infrared spectroscopy and analysis. The berries that were damaged during maturation, usually due to the maggot crawling out, were put aside if they were unable to be scanned. 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 NIR process was sizing and massing weighing 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 millimeters. Berries that were under 6 (0.23") or over 11 mm (0.43") were not used. Once the size of the berry was recorded it was then weighed. Each berry was sized and weighed and then placed in a labeled tray, which depicted the date, quart number and berry number of each of the berries encased. Once these steps were completed the berry was held until it could be scanned using a prototype spectroscopy machine developed by the principle investigator in conjunction with Ocean Optics, Inc. (Dunedin, FL). A wide-spectrum halogen light source was focused onto the individual berry via a fiber optic cable. A culminating lens mounted below the sample (berry) allowed collection of light transmitted through the berry with the transmitted light then directed to an A/D converter via another fiber optic cable. After digital conversion, the sample data between 350 and 950 nanometers (nm) was graphed via the associated software program (OOIBase32, Ocean Optics, Inc.). Before each sample set, two reference spectra (complete light and dark) were taken and saved. During the exploratory phase of this project several scans were done on each individual berry and each berry was scanned either two, three or four times each, see Figure 1. Once the program is set up and the numbering scheme recorded, the berry is placed on the lens transversely so that the light passed through the berry transverse to the stem-calyx axis. The two primary scans were made transverse to in parallel to the stem-calyx axis (labeled (a) and (c) respectively on Figure 1). If doing three scans per berry, in addition to the two primary scans, a scan is done at a 45E angle to the vertical (stem-calyx axis), labeled (b) on Figure 1. With the fourth scan the stem of the berry will be transverse, in the opposite direction (a 135E angle, opposite berry side) of the first scan (labeled (d) on Figure 1). After completing the scan sets for the berry it is replaced in its respective spot in the tray to await ground truth with a microscope.

After scanning the berries, they were dissected to determine if a maggot was present (ground truth). The berry is placed in an aluminum plate and examined under a light microscope (Olympus Model H011, Olympus, Inc., Japan) at 10X magnification and it is recorded whether a maggot is present. Following dissection, berries are placed on a tray, labeled with their respective quart number and placed in a standard drying oven at 40EC (104EF) for 6-8 hours. After this period they are removed and weighed to determine final dry matter content. This information is then recorded on the spreadsheet with the previous information collected. At this point the berries can be discarded and the process is repeated for other berries.

For preliminary data analysis of the scan information, the following protocol was used as suggested by Pearson (pers comm., 2000). All the transmittance scan data (whether there were 2,3,4 scans) for a berry were brought into a spreadsheet. The transmittance scans were averaged at each wavelength (350-950 nm) to produce an average transmittance value. This average transmittance value was calculated and then each value was divided by the overall average transmittance scan value to normalize the data. From these data, a plot of normalized

transmittance versus wavelength was created an example plot is given in Figure 2.

Cold water tolerance. Four times during the 2000 field season wild blueberries were harvested from the field and three, one-quart subsamples were collected to perform a sample maggot count, see Table 1 for these results. The normal boiling and dissection (Dixon and Knowlton 1994) was used at the Biological Engineering Laboratory at the University of Maine as a baseline test to determine the average number of maggots in a given sample of berries from the field.For three of the four harvest samples during the 2000 harvest season quart samples were evaluated to determine cold water tolerance. The protocol was to create a 1-2EC (34-35EF) water bath in an insulated cooler system. One quart of berries was floated in the water bath for approximately 30 minutes, stirring occasionally. After the float time was allowed, the floating berries and other materials were skimmed off to make one sample (called floaters) and materials that sank (submerged) were separated into the another sample (called sinkers). The water that was left behind was drained through a sieve so that any maggots suspended in the water would be trapped on the sieve. The sieve was then looked at under a stereoscope for maggots. The other two samples (floaters and sinkers) were subjected to the boiling and dissection method (Dixon and Knowlton 1994) to determine maggot counts. Eight samples (from three different harvest times) were evaluated. One harvest (on 08/10/00) yielded a low maggot count and therefore no floatation tests were performed.

RESULTS/CONCLUSIONS: The laboratory experiment to artificially inoculate berries with maggot larvae was very successful. In most cases the resultant inoculation level was approximately 30 percent of berries with a maggot. In order to guarantee high maggot counts to evaluate different NIR methods of separation, these laboratory cages have yielded positive results and will be continued in future field seasons.

Near-infrared spectroscopy and analysis. The evaluation of spectra between 350 and 950 nm is inconclusive at this time. On individual berries there are some differences seen in the normalized transmittance data. However, when composite graphs are created by combining scans by type (maggot and size) there is little evidence of differences (see Figures 3 and 4). Discussing this result with other researchers using NIR techniques, it could be that combining (averaging) transmittance scans masks the individual differences. It was also suggested that having a spectrometer that allows more resolution in narrower bandwidths (for example 600-1100 nm and 1700-2000 nm) would be more telling.

At a meeting of other researchers who viewed the results of this work, they mentioned the lack of a “blue hue” (blue color) peak in the 450 nm wavelength range (see Figures 2, 3 and 4). The research team will follow up on this suggestion and question to see if there are reasons for the lack of this blue hue peak (Slaughter, pers. comm., 2000). Another researcher suggested the development of a neural network capable of evaluating individual transmittance spectra for an analysis tool.

Cold water tolerance. Maggots were found in both berry samples (floaters and sinkers) as well as found in the remaining cooler water, see Table 2 for results. These data present mixed results concerning cold water tolerance. The data show that maggots are found both in the sinker

berries and water (suspended). These data indicate that in general the maggots are not staying in berries that float. There are two possible reasons for this; maggots are crawling out of the berries looking for a different "warmer" environment or the berries that have maggots are damaged and sink or partially sink (become suspended). It is likely that damaged berries will either become suspended or sink because they take on water through damage portals and therefore is a plausible explanation for the 2000 results. These results are in direct contrast with results from the 1999 tests where maggots were found only in the floaters.

RECOMMENDATIONS: Continue the study using NIR during the 2001 through 2003 field seasons. The principal investigator will adapt the prototype NIR spectrometer to look closer at the more promising wavelengths of 600-1100 nm and 1200-2100 nm. The laboratory inoculation method (Drummond et al.) of assuring a high percentage of maggot infested berries will be used as a primary source of berries. Contact with the Blueberry Hill Research Farm and other grower farms will continue so that if they have a high maggot concentration during harvest, field samples can be used in the analysis to supplement the laboratory sampling.

Unless a better method to sort out the results of the cold water tolerance evaluation is found it is recommended to go no further with that study. The research team cannot set up a test that mimics the cold water floatation of Guptill Farms.

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Dixon, P.L. and Knowlton, A.D. 1994. Post-harvest recovery of Rhagoletis mendax Curran (Diptera: Tephritidae) from lowbush blueberry fruit. The Canadian Entomologist 126: 121-123.

Pearson, T. 2000. Personal communications. Research scientist, USDA-ARS Western Regional Research Center, Albany, California. July-September.

Slaughter, D. C. 2000. Personal communications. Professor, Biological and Agricultural Engineering, University of California-Davis, Davis, California. October, November.

Table 1. Date, location, quantity harvested, and laboratory test on maggot counts. All laboratory tests were performed using blueberry boil dissection methods

Date	Farm location	Quantity harvested (quarts)	Sample location	Maggot count [1]
08/04/00	Blueberry Hill Farm, Jonesboro	15 (approximate)	Field	1
08/10/00	Blueberry Hill Farm, Jonesboro	20 (approximate)	Field	1, 0, 2
08/17/00	Beddington Ridge Farm (Ron Varin)	25	Field	7, 6, 10
08/24/00	Blueberry Hill Farm, Jonesboro	15 (approximate)	Field plot	4, 1, 0

[1] Maggot counts per quart as determined by Dixon and Knowlton (1994) boil and dissection method, each number represents maggots found in a one quart sample.

Table 2. Cold water tolerance by date, position, and maggot count

Date – Trial	Water temperature C (F)	Estimated maggot count[1] (average)	Float count	Sink count	Water
08/04/00 – 1	1.1 (34)	1/quart	0	0	0
" – 2	1.1 (34)	"	0	0	0
" – 3	2.2 (36)	"	0	1	0
08/10/00		1/quart	NP[2]	NP	NP
08/17/00 – 1	2.2 (36)	7/quart	0*	6*	2*
" – 2	1.7 (35)	"	1*	5*	1*
" – 3	1.1 (34)	"	0*	4*	2*
08/24/00 – 1	2.2 (36)	1/quart	0	0	0
" – 2	1.1 (34)	"	1	1	1

[1] based on prior boil/dissection maggot counts (see Table 1)
[2] tests were not performed (NP)
* value based on average of three replicates

Figure 1. Blueberry scanning positions for the NIR system.

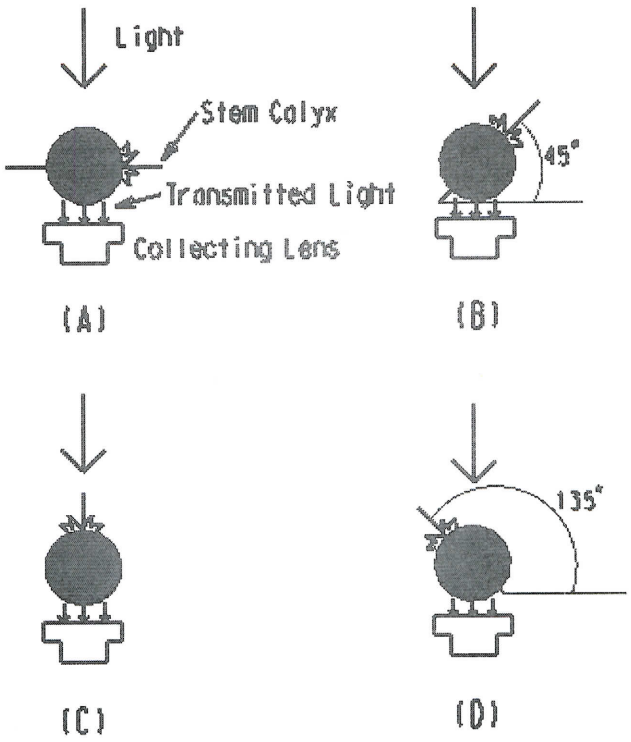


Figure 2. Normalized transmittance versus wavelength for a small blueberry with a maggot

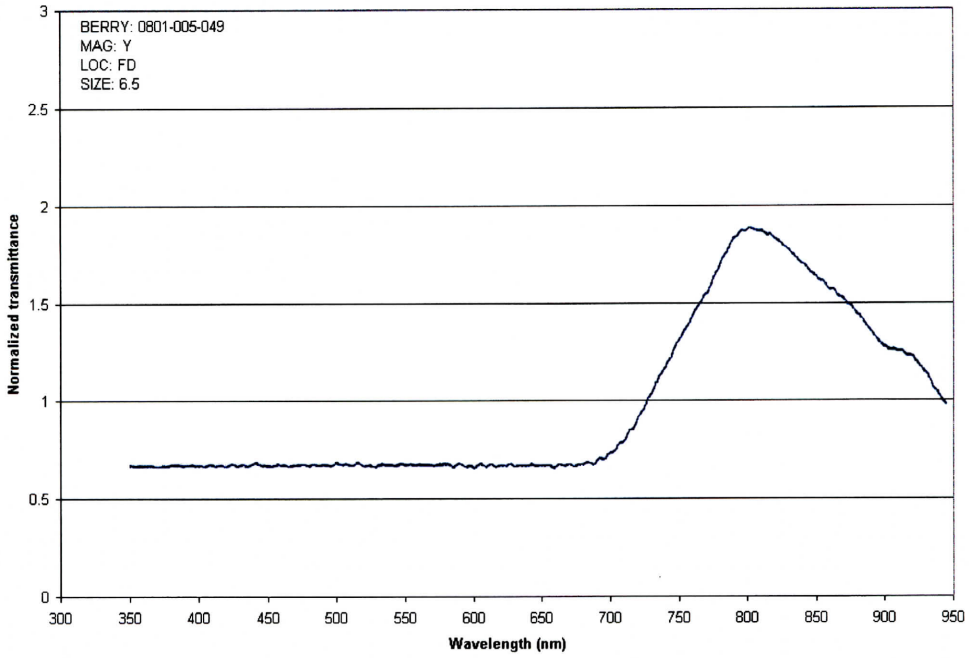


Figure 3. Composite graph of normalized transmittance versus wavelength for one quart of blueberries, composites are separated by berry diameter and maggot presence

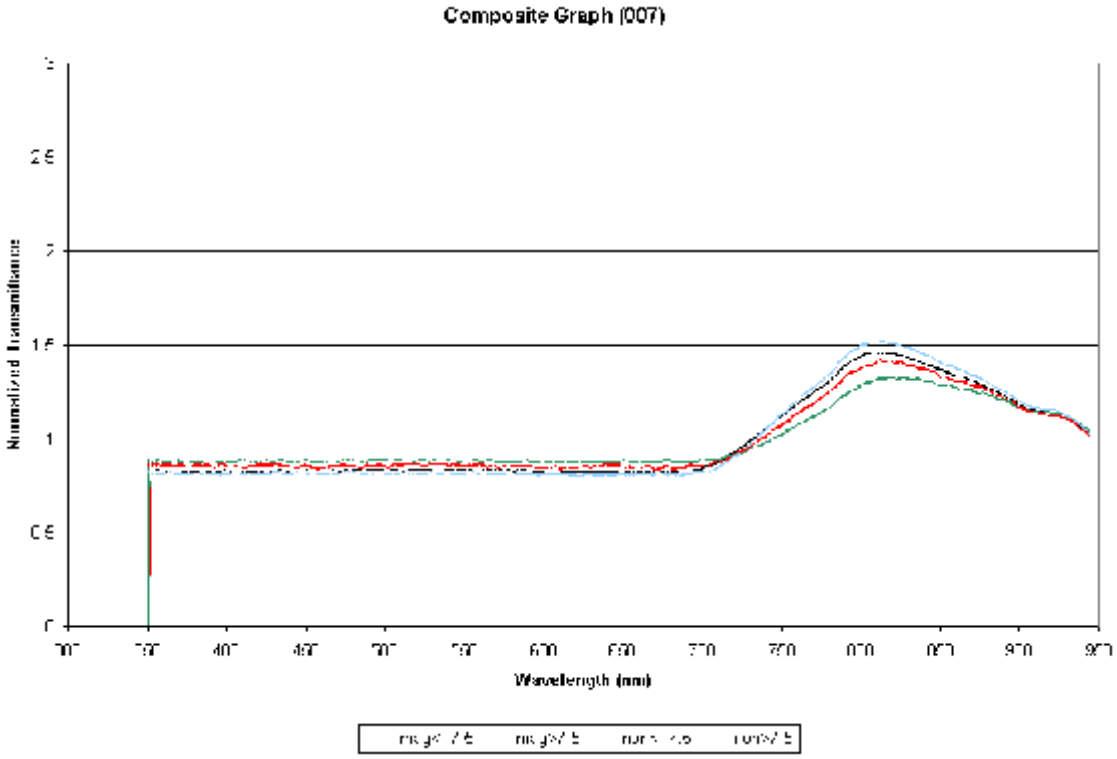
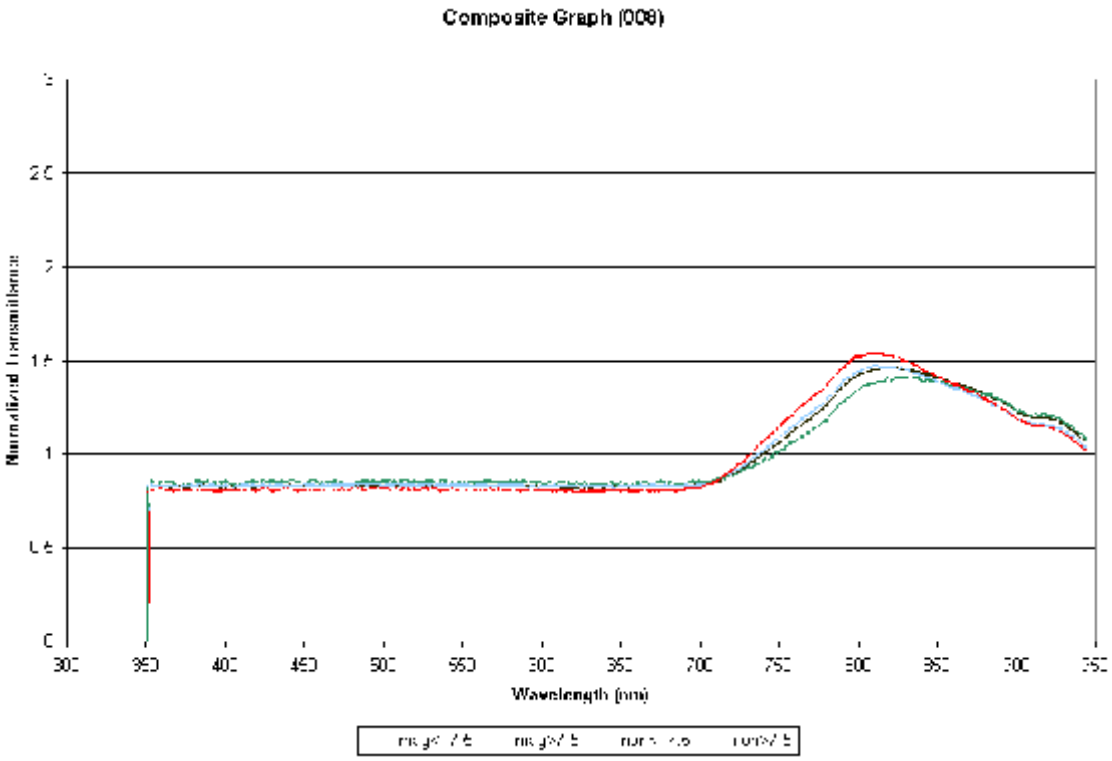


Figure 4. Composite graph of normalized transmittance versus wavelength for one quart of blueberries, composites are separated by berry diameter and maggot presence



IRRIGATION

INVESTIGATORS: Rose Mary Seymour, Assistant Professor Bio-Resource Engineering

1. TITLE: Water Use of Wild Blueberries

OBJECTIVES: (1) Determine accurate crop coefficients for pan evaporation and Penman potential ET for Maine lowbush blueberries, (2) measure plant growth stage indicators to correlate with water use, and (3) determine yield impacts of water stress at various growth stages of plants.

METHODS: Field plots with various limitations on water availability will be established and soil moisture, plant growth and development and plant above ground biomass will be measured for all treatments through the growing season.

To ensure a certain amount of water stress even in wet climatic years rain-out shelters will be used. For the plots using the rain-out shelters, areas for taking yield, plant growth and harvest quality samples will be delineated under the shelters. Each of these areas will have sheet steel driven 15 cm (6") into the soil around their perimeter to isolate the plants within these sample areas. All blueberry plots will be managed similarly in all respects except soil moisture. Water management treatments will be as follows:

A) Rainfed only
B) Irrigation applied at 50% plant available water (PAW)
C) Rain-out shelter covering plot for rainfall or irrigation amounts greater than 0.5 inch per week.

There will be 6 replications of each treatment for each year of the biennial growth cycle. Thus, with the 3 treatments given above there will be 36 plots to monitor after the first year of the study. In the initial crop year, there were only 18 plots. The research plots will be laid out in a random block design with 2 main blocks. The 18 plots in the first year will be the one main block and the 18 plots initiated in the second year will be the second block.

Data collected for the study will include daily soil moisture changes, daily weather parameters, daily pan evaporation and weekly above ground biomass. The occurrence and timing of critical plant growth stages will also be documented. Yield samples will be taken for all treatments. Yield data will be used to determine yield losses due to limited irrigation treatments. Other plant characteristics throughout the growth and development of the plants will be used to evaluate developmental deficiencies caused by water stress.

From the data collected, potential ET, pan evaporation, growing degree days, actual crop water use and water stress index for all treatments will be calculated. Actual crop water use, growing degree days, potential ET and pan evaporation will be used to determine crop coefficients. The coefficients will be related back to biomass changes, plant growth stage, and growing degree days.

STATUS OF PROJECT TO DATE:

1- Irrigation System

The irrigation system was put in place and used a few times in August. Coefficients of uniformity of irrigation provided by the system were evaluated for the plots that would be irrigated. The coefficients ranged from 67 to 88 %.

2- Shelters

Shelters were built in June to keep excess rain out in the limited water treatments. The shelters were built from boards enclosed in plastic where the plastic could be raised when shelter from rain was not needed. The shelters were not portable. Sample areas beneath the shelters were isolated in 2.4 m X 1.2 m (8' X4') boxes of 6 mm (¼") steel hammered into the ground 15 cm (6") to prevent the plants from receiving water outside the shelter through rhizomes or roots. The shelters were used only once before September, but since September excess rain has required their use on several occasions. The shelters would only be used after 1.3 cm (0.5") of rain had fallen in a week. There were two weeks in the summer where plots received less than the 1.3 cm minimum. When the rain in a weeks time was less than 1.3 cm, the shelter plots and the irrigation plots were irrigated.

Thermometers to read inside and outside the shelters were set up for each shelter. From this growing degree days inside and outside the shelters can be calculated. Temperature data from the shelters will be analyzed to see if shelters could make a significant difference in growing degree days. This analysis is in process.

3-Weather data

The weather station was in horrible disrepair. Every piece of the station had to be replaced or returned to the company for work. The wind, temperature and humidity sensors are working now, but the rain gauge and pyranometer (for measuring solar radiation) still need to be replaced. Temperature and rainfall data that was collected at the farm headquarters were used to determine rainfall amounts and growing degree days. The rainfall amounts were important for determining when to close the shelters and when to irrigate. Growing degree days (sometimes called heat units) were calculated to correlate with growth and development of the plants and crop coefficients. ET was not calculated because weather data was incomplete, but I plan to acquire NOAA weather data and I should be able to use it to get an estimate of ET over the season.

4- Plant Monitoring

Plant monitoring began in July. Plant samples were taken approximately once every two weeks. Measurements of stem lengths, plant stem numbers, plant dry biomass and once frost had occurred, plant bud counts were taken for all plots. This data is in the process of being analyzed to determine any differences among treatments and the variability among the plots. From observations, it is expected that there may be some difference in the water limited plots from the rainfed and irrigated, but no differences between the rainfed and irrigated. Variability from plot to plot seems to be great.

5- Soil Moisture Monitoring

The equipment for soil moisture monitoring did not arrive until the first of September, so soil moisture monitoring was not carried out this year except for determining if irrigation was needed. If there was concern that irrigation was needed, I would take soil samples and evaluate moisture content by hand to make an assessment on whether or not to irrigate. Soil samples were taken to determine the available water in the soil profile for the study site. Available water determination was tested in the laboratory, and that data is being analyzed at this time to indicate water available values and variability among the plots.

6- Crop Coefficient Determination

Without soil moisture data and complete weather data, the crop coefficients cannot be determined, so this process will begin next Spring as the new soil moisture monitoring equipment goes into the field.

CONCLUSION: Full implementation of weather equipment and shelter construction will be finished this winter with initiation of results beginning this spring.

ENTOMOLOGY

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

1. TITLE: Control Tactics for Blueberry Pest Insects, 2000

A. METHODS: Evaluation of insecticides for control of secondary pest insects.

No laboratory bioassays or field trials were completed against secondary pest insects because of a lack of suitable populations.

B. METHODS: Control of blueberry maggot with ground application of insecticides.

The efficacy of three materials (SpinTor, Azadirachtin, and Imidan) was evaluated following ground applications with an air-blast sprayer. Efficacy was evaluated based on the seasonal density of adults as measured with baited, yellow, sticky traps and on the number of maggots in the fruit at harvest.

RESULTS: Analysis of the sticky-trap data indicated that there were no significant differences in the cumulative number of flies/trap over the season between plots treated with the three materials. There were also no significant differences in the number maggots per quart of berries at harvest; although, all treatments had fewer maggots than the untreated controls (Table 1).

C. METHODS: Control of blueberry maggot with perimeter application of Imidan 70 WP.

Imidan 70 WP was applied with an airblast sprayer in an 80-ft swath along one edge of three different blueberry fields. Efficacy was evaluated based on the number of adult flies captured on baited, yellow, sticky traps before and after application.

RESULTS:

A perimeter application of Imidan 70 WP resulted in a significant reduction in the number of maggot flies captured in treated vs. untreated areas. After application, the average number of flies in the control area increased from 3.6 flies/trap to 9.9 flies/trap which is just slightly below the recommended cumulative action threshold of 10 flies/trap. There was a decrease in treated areas from 3.0 flies/trap to 1.8 flies/trap (Fig. 1). Also, there was a significant interaction between distance from the field edge and trap catch. In untreated areas, the further from the field edge, the fewer flies were trapped.

CONCLUSIONS: Research in 1998 and 1999 focused on within-field movement of blueberry maggot flies and colonization patterns of blueberry maggot flies into wild blueberry fields. Work in 1999 suggested that most of the maggot fly population in a field is aggregated within the first 100 ft into the field indicating the potential for effective use of perimeter applications designed to prevent movement of adults into a field from surrounding areas. Results obtained from this study lend support to this idea.

D. METHODS: Control of blueberry maggot with baited biodegradable decoy spheres impregnated with imidacloprid.

Biodegradable, green spheres impregnated with granulated sugar and imidacloprid as a poison were placed in four fields. The spheres were placed 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 blueberry maggot flies are most likely to colonize. At least 50% of each field was left unprotected as a control. Efficacy was evaluated based on the seasonal density of adults as measured with baited, yellow, sticky traps and on the number of maggots found in the fruit at harvest.

RESULTS: Analysis revealed no differences between numbers of adults captured on sticky traps in treated, untreated, and edge areas of fields or in the number of maggots found in the fruit at harvest (Table 2).

CONCLUSIONS: Although good results have been obtained against apple maggot and against blueberry maggot in highbush plantings using these spheres, it appears that they are not well suited to use in wild blueberry fields unless they can be protected from birds and mammals. Most of the spheres were consumed by animals at three of the four sites. This resulted in large gaps in the protective barrier which could allow flies to enter the field unimpeded.

E. METHODS: Control of blueberry maggot with aerial application of Imidan 70 WP.

Imidan 70 WP was applied by helicopter at a rate of 9.6 oz/acre (actual mix was 16 oz of Imidan in 5 pts of water) or fixed-wing aircraft (11.2 oz/acre in 5 pts of water) to various commercial blueberry fields. Efficacy was evaluated based on the seasonal density of adults captured on baited, yellow, sticky traps and on the number of maggots found in the fruit at harvest.

RESULTS: Helicopter trial: The number of blueberry maggot flies captured on yellow sticky traps remained below action thresholds until mid-July then rose dramatically. Immediately after application on 21 July, the number of flies captured in treated areas was significantly less than in the control areas for Site 2 and for both sites combined (Table 3). There was no significant difference in numbers of maggots found in the fruit.

Fixed-wing trial: Prior to the application of Imidan, there was no significant difference in the number of flies captured between the treated and untreated areas. After application, significantly more flies were captured in untreated areas. Maggot pressure in fruit was very low (< 1 maggot/qt in all areas (Table 4)

F. METHODS: Exclusion of blueberry maggot adults from field plots using mesh fencing.

Three-sided, u-shaped, plots were set in three, crop-year wild blueberry fields. Each plot measured 70 x 150 x 70 ft and was enclosed with black fiberglass window screening, 4-ft high, and attached to wooden stakes. Effectiveness of the barriers was evaluated based on the seasonal density of adults captured on baited, yellow, sticky traps and on the number of maggots found in fruit at harvest.

RESULTS: Consistently fewer flies were captured on sticky traps, on average, inside then outside the enclosures. The differences were not statistically significant at any one site; however, there was a significant difference for all sites combined (Table 5). However, only a 23% reduction resulted from using the screen barriers. There were no significant differences in the number of maggots found in the fruit at harvest.

CONCLUSIONS: Enclosing small field plots with window screening resulted in significant reductions in the total number of flies captured on yellow sticky traps in both 1998 and 1999. There was also a significant reduction in numbers of maggots found in processed fruit in 1999. 2000 was the first year in which larger scale field tests were conducted. Although trends did suggest that there was less maggot infestation within the barriers compared to outside the barriers, this method of blueberry maggot control is probably not economically feasible in production level pest management. The window screening used in the trials is prohibitively expensive. Unless a lower priced alternative can be found, this method cannot be recommended for blueberry maggot control at this time.

G. METHODS: Persistence of *Beauveria bassiana* (Mycotrol ES) in the soil.

Mycotrol ES was applied as a soil drench in 10, pruned-year, wild blueberry fields. Soil samples were collected immediately after application and at one and three months to monitor residual levels of *B. bassiana* at different soil depths.

RESULTS: More *B. bassiana* was recovered close to the soil surface and less was recovered in deeper samples on the first sample date (Fig. 2.) There was also a decrease over time with more *B. bassiana* being recovered immediately after application and less on subsequent dates. The mean half-life of *B. bassiana* in nine fields was about 22 days. Half-life in 1998 and 1999 was much longer; 45 and 41 days, respectively.

There was no apparent correlation between levels of *B. bassiana* and various soil characteristics including soil pH, % organic matter, or levels of calcium, phosphorous, or potassium. There was a slight negative correlation between the level of magnesium and the percent *B. bassiana* remaining in the soil in the August sample at the 0-2 cm depth ($P = 0.10$; Pearson correlation).

CONCLUSIONS: Field studies involving the release of late instar flea beetle and spanworm larvae onto soil previously sprayed with Mycotrol still need to be conducted to evaluate the potential for mortality for mortality of these insects pupating in or on the soil surface.

RECOMMENDATIONS: For the most part, it is too early to recommend new control tactics based upon the 2000 control trials. However, we can recommend that Imidan 70 WP can be substituted aerially for Imidan 2.5 EC. Perimeter sprays of Imidan and use of baited traps deployed along the field perimeter will be retested in 2001. SpinTor and Azadirachtin will also be further evaluated in 2001 for blueberry maggot control.

Table 1. Control of blueberry maggot with ground application of insecticides.

Material	Amt.form./ acre quart	Avg. maggots/	Cumulative flies/trap	
SpinTor 2 SC	8 oz	0.3 a	7.3 a	
Azadirachtin 4.5 WG/WDG	21 oz	0.5 a	15.0 a	
Imidan 70 WP	21.3 oz	0.2 a	8.0 a	
No insecticide	-	1.0 a	10.5 a	

Fig. 1. Perimeter application of Imidan to control blueberry maggot.

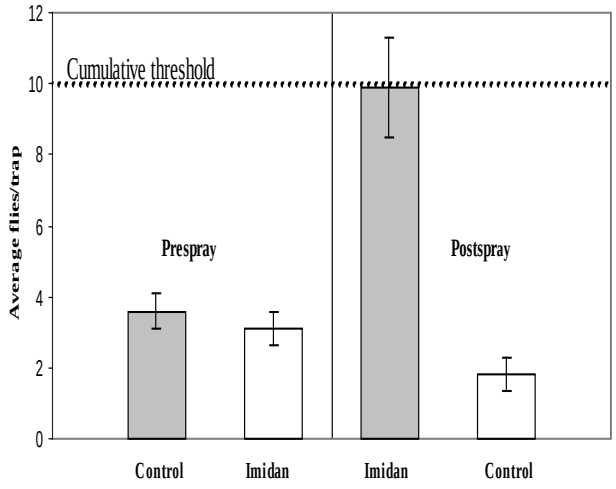


Table 2. Control of blueberry maggot with baited biodegradable decoy spheres impregnated with imidacloprid.

Site	Cumulative flies/trap Treated	Untreated	Edge	Maggots/qt Treated	Untreated
Union I	1.3	6.3	5.4	0.8	0.6
Union II	7.5	10.8	6.7	0.4	0.2
Palermo	25.0	13.0	34.0	0.6	0.4
Harrington	3.0	3.8	4.6	-	-
All sites (mean)	9.2 a	8.5 a	12.7 a	0.6 a	0.4 a

Table 3. Control of blueberry maggot with helicopter application of Imidan 70 WP.

Field	Average flies/ trap on 22 July	Average maggots/qt *
Site 1		
Field A	6.6 a	0.5 a
Field B	8.5 a	1.8 a
No insecticide	13.5 a	2.0 a
Site 2		
Field C	8.0 a	4.5 a
No insecticide	22.0 b	3.5 a
Treated (Both sites combined)	7.4 a	2.2 a
No insecticide	17.8 b	2.8 a

Table 4. Control of blueberry maggot with fixed-wing application of Imidan 70 WP.

Treatment	Average flies/trap Prespray	Postspray	Average maggots/qt *
Early treatment sites	0.73 a	0.22 a	0.17 a
Late treatment sites (control)	0.80 a	5.10 b	0.88 a

Prespray fly counts are for prior to the 14 July “early treatment”. Postspray does not include any fly counts collected after the 20 July “late treatment”.

Table 5. Exclusion of blueberry maggot adults from field plots using mesh fencing.

Treatment	Cumulative lies/trap	Maggots/qt (SD)
All Sites Combined		
Enclosed	56.5 a	1.5 (1.9) a
Open	75.8 b	2.7 (2.6) a
Jonesboro		
Enclosed	68.5 a	1.0 (1.4) a
Open	82.0 a	2.5 (0.7) a
Township 19		
Enclosed	15.0 a	1.0 (0.0) a
Open	28.5 a	0.5 (0.7) a
Columbia		
Enclosed	86.0 a	2.5 (3.5) a
Open	117.0 a	5.0 (4.2) a

ENTOMOLOGY

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

2. TITLE: IPM Strategies

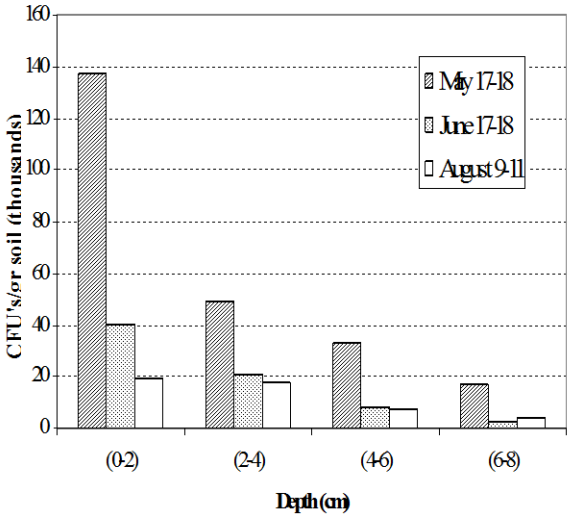
A. METHODS: Impact of IPM monitoring on wild blueberry yield.

The objective of this study was to determine if walking through fields during monitoring practices such as sweep-net sampling and yellow sticky-trap sampling has a negative impact on yield. There were three replications of each of seven treatments as outlined below.

1. Walk through plots at early bud break
2. Walk through plots at early bloom
3. Walk through while sweeping at early bud break
4. Walk through while sweeping at early bloom
5. Walk through 2X to simulate setting out and picking up yellow sticky traps
6. Walk through weekly to simulate blueberry maggot trap monitoring
7. Control - no treatment

Plot size was 5 x 30 ft. On 17 August, a commercial blueberry rake was used to harvest a 14-inch swath down the midline of each plot. The berries were brought into the laboratory and weighed immediately.

Fig 2. Persistance of *B bassiana* in the soil following spring treatment with Mycotrol ES.



RESULTS: Statistical analysis revealed no significant difference between the control and any treatment (Fig. 1).

CONCLUSIONS: Walking over the same area repeatedly might cause a reduction in yield, but our study suggests that the loss of yield is less than the variation in yield between clones. Any effect that IPM monitoring may cause can be minimized by taking a slightly different path through the field each time sampling is performed.

B. METHODS: Monitoring populations of thrips in wild blueberry fields.

The objective of this study was to test the usefulness of using blue sticky cards to time insecticide sprays compared to the existing method of waiting until 1/4 and ½ inch vegetative growth is observed on pruned plants. On 3 May, two blue sticky cards were placed in a pruned blueberry field which had been infested with thrips in 1998. Each card measured 3 x 5 inches and was hung just above the ground from a wooden lathe. Both cards were replaced at weekly intervals. The number of thrips on each card was counted in the laboratory. At weekly intervals beginning on 12 June, 20 leaf curls were collected and brought into the laboratory. The curls were examined and the number of live thrips per curl was recorded.

RESULTS: Peak captures of blueberry thrips on blue sticky cards were recorded on 26 July. The highest numbers of thrips in curls occurred on 19 July. First thrips on cards and first curls were both observed on 14 June.

CONCLUSIONS: In 1999 there was a lag between the first appearance of thrips on cards and leaf curls. In order to be effective, insecticide applications to control thrips need to be made prior to the appearance of curls in the field. This project will be repeated next year, but thrips cards will be checked every 2 or 3 days rather than weekly.

C. METHODS: Economic threshold for blueberry flea beetle.

In May 1999, four sites were selected in a pruned-year field at Blueberry Hill Farm. Four, 2 x 2 ft plots were set at each site. Each series of four plots was set within the same wild blueberry clone. On 19 May, mid-instar flea beetle larvae were collected from an infested field. At each site, one of four different densities of larvae was placed in each plot (0, 50, 100, or 150 larvae per plot). 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.

In October following leaf drop, 50 stems within each plot were cut and brought into the laboratory. A record was made of the number of flower buds per stem and the mean flower buds per plot at each density. A regression analysis was conducted on flower buds vs. initial larval density.

In June 2000, the number of flowers per bud was determined for 25 to 30 additional stems from each plot and a second regression analysis was conducted on flowers vs. initial larval density.

RESULTS: The analyses of data collected in 1999 revealed no significant regression between initial larval density and number of fruit buds per stem (Fig. 2). Similar results were obtained for

flowers per stem in 2000 (Fig. 3).

CONCLUSIONS: It appears that pruned-year fields are not sensitive to blueberry flea beetle feeding. Economic thresholds may be in excess of 150 larvae per 4 sq ft plot of blueberries; although, this experiment needs to be repeated for confirmation.

D. METHODS: Validation of a predictive model for emergence of blueberry maggot adults.

In August 1999, blueberries collected from a maggot infested field were distributed in a 1 to 2-inch deep layer in 10 screened boxes suspended over blueberry plants in a pruned field at Blueberry Hill Farm, Jonesboro. Five additional boxes were set at Blueberry Hill in Winterport. The boxes were covered with mesh cages to prevent predation by mice or birds. The maggots were allowed to develop and move into the soil to pupate; the mesh cages were then removed. On 25 June at Jonesboro and 23 June at Winterport, emergence traps were placed over each pupation site. The traps were monitored daily and any blueberry maggot adults were collected and stored in 70% ETOH for later gender identification.

On 27 March, two HOBO® temperature data loggers were buried at each site to monitor soil temperatures every two hours throughout the trials. The temperature data was downloaded at the end of the season and used to determine the daily percent development of blueberry maggot pupae towards emergence of adult flies. One logger was 1-inch deep; the second was 2-inches deep. This data was then compared with the predictive model for emergence of blueberry maggot adults constructed from laboratory data on emergence under constant controlled temperatures collected in 1997.

RESULTS: Figures 4 and 5 show the observed and predicted emergence of blueberry maggot flies for both the Winterport and Jonesboro sites, respectively. The predictions for both sites were excellent. There were no differences in soil temperature at one and two inches at Jonesboro. In Winterport, the one inch soil temperatures resulted in a slightly better prediction than that based upon the two inch depth monitoring. Mean emergence at both sites was predicted on the day it was observed in the field. Winterport emergence (both observed and predicted) was six days ahead of the mean emergence predicted and observed for Jonesboro. Both models predicted the onset of emergence a few days prematurely. The tail-end of the observed emergence in Winterport was predicted well using the one inch soil temperatures, but at Jonesboro, the model predictions lagged behind observed emergence by a few days. Emergence is initially dominated by female flies with males emerging later in the season.

CONCLUSIONS: This study over the past three years has shown that blueberry maggot fly emergence can be reliably predicted if soil temperatures are monitored beginning on 1 April. The one inch depth results in better predictions than the two inch depth. The blueberry maggot fly predictor is now available to growers as a "user-friendly" software application (BluePest) for personal computers that run the Windows operating system.

RECOMMENDATIONS:

We recommend that growers monitor soil temperature at a one inch soil depth and use the

BluePest software to predict the emergence of blueberry maggot flies as an early warning system.

Fig 1. Impact of IPM monitoring on yields.

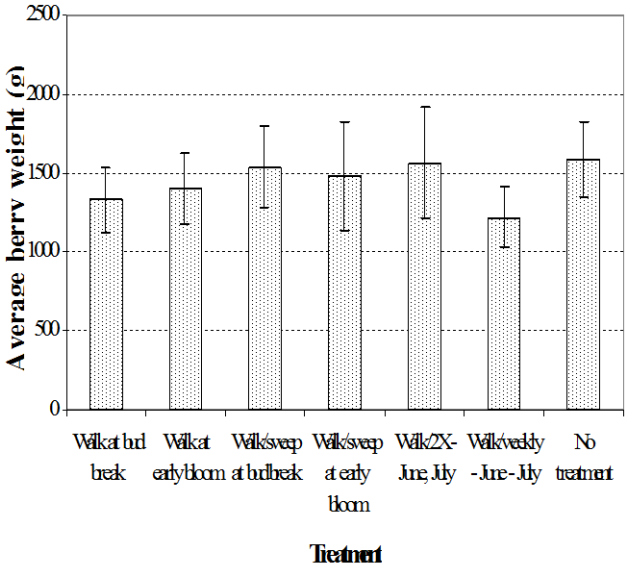
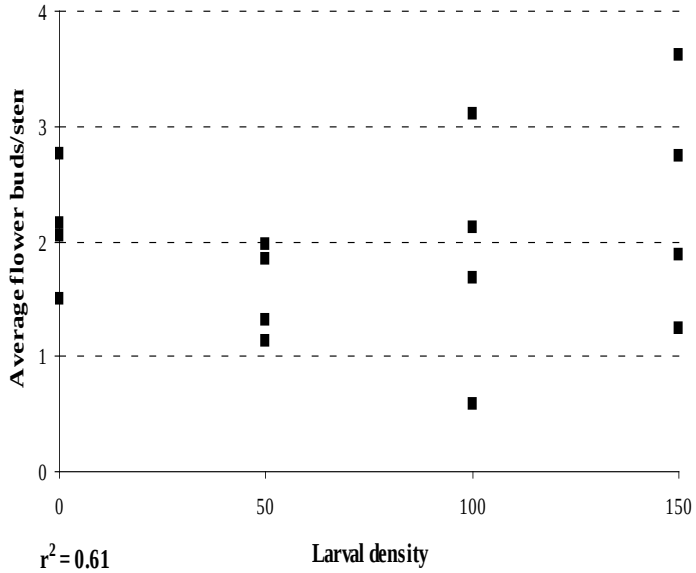


Fig. 2. Economic threshold for blueberry flea beetle, larval density vs. fruit buds/stem (1999).



$r^2 = 0.61$

$P = 0.6328$

Fig. 3. Economic threshold for blueberry flea beetle, larval density vs. flowers/stem (2000).

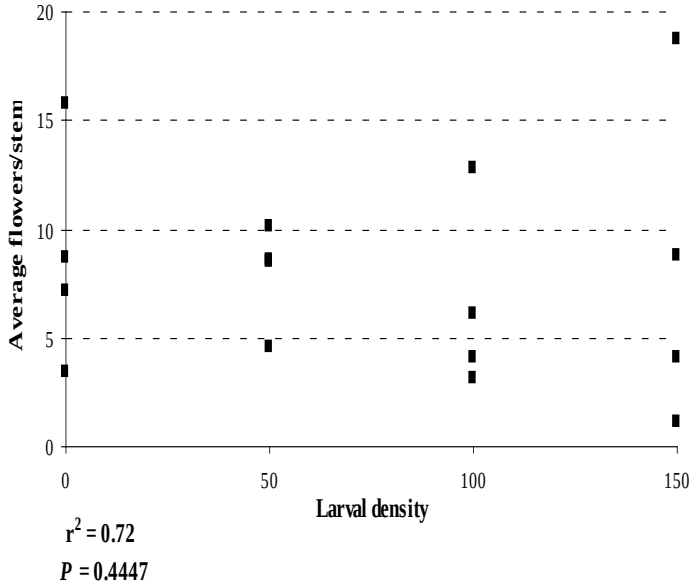


Fig. 4. Validation of a predictive model, Winterport emergence data.

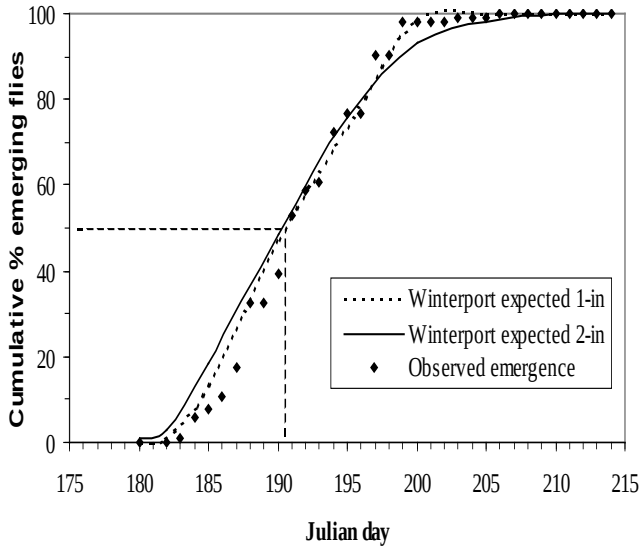
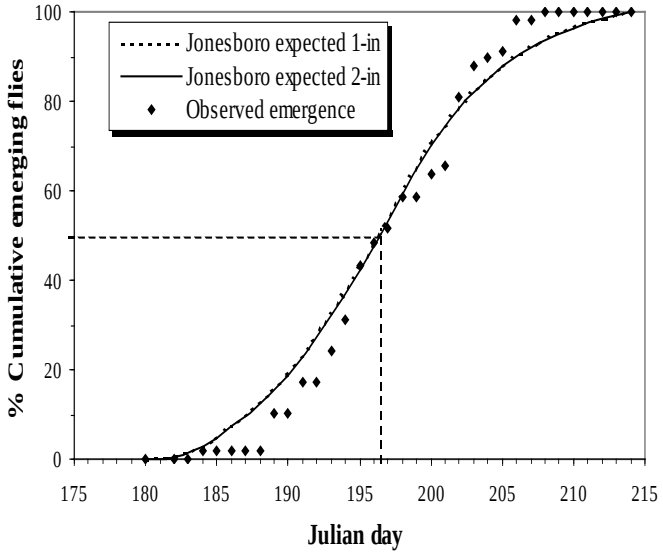


Fig. 5. Validation of a predictive model, Jonesboro emergence data.



ENTOMOLOGY

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

3. TITLE: Biology and Ecology of Blueberry Pest Insects

A. METHODS: Vertical distribution of blueberry maggot flies within the forest perimeter around wild blueberry fields.

Baited, yellow, sticky traps were hung from trees adjacent to crop-year, wild blueberry fields. There were three sites, with one vertical transect 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. At each site, the tree used for the study was 10 to 20 ft into the woods from the edge of the field.

RESULTS: Most flies were captured at the 6-10 inch height; however, traps at all other heights also captured flies (Table 1).

CONCLUSIONS: Results from a trial in 1998 indicated that blueberry maggot flies within a field remain relatively close to the crop canopy. The majority of the flies captured were at the canopy level suggesting that flies generally stay low to the ground when migrating into fields. This is apparently not the case for flies located in the wooded areas immediately adjacent to fields. These results may have particular significance in regards to field perimeter barriers. If the forest edge abuts the blueberry field and flies are active high in the trees, than flies colonizing a field from these heights might have a high likelihood of flying over the barrier if it is close to the forest edge.

B. METHODS: Blueberry maggot fly emergence in pruned fields and wooded field edges.

Emergence traps were placed in three, pruned, wild blueberry fields. Eight traps were set at each site, four within the field and four in nearby wooded areas with unmanaged blueberries. A baited, yellow, sticky trap was placed in each unmanaged area to monitor for the presence of flies.

RESULTS: The focus of this study was to determine if wooded areas with unmanaged wild blueberries are an important source of infestation. Only a small number of flies were captured using this method. Two flies were captured in emergence traps placed over blueberries in wooded areas, one at each of two sites. Six flies were taken in traps placed within pruned fields.

CONCLUSIONS: Despite the low numbers of flies collected in the emergence traps, this study does confirm the presence of blueberry maggot pupae in the soil of pruned fields and in wooded areas adjacent to fields. The low number of flies caught makes it difficult to evaluate the significance of wooded areas as breeding grounds for blueberry maggot flies.

C. METHODS: Colonization of blueberry fields by blueberry maggot flies.

Baited, yellow, sticky traps were placed in three fields. The traps were distributed in linear transects. For each transect, one trap was set in the woods 10-20 ft outside the field edge. The next trap was at the field edge; subsequent traps were set 10, 20, 50, 100, 200, 300, and 500 ft along a line running into the field. The traps were checked at three or four day intervals.

RESULTS: Blueberry maggot fly captures were very low at Sites A and B. Populations were higher at Site C and supported previous observations that most of the maggot fly population in a field is aggregated within the first 100 ft into the field (Fig. 1). At Site C, the cumulative action threshold of 10 flies/trap was exceeded at all distances between the woods and 50 ft into the field. There was a drop in the number of flies captured between the 50 and 100 ft distances. A total of 519 flies were captured over the season. Of that number, 422 (81.3%) were females. Of all the females captured, 210 or 40.5% were found to have some or many eggs.

CONCLUSIONS: Females flies with potential to lay eggs did not occur in the field until the third sample date on 11 July (Fig. 2). On the first two sample dates (3 & 6 July), none of the captured females had eggs. This is significant because it suggests that growers have a 7-10 day lag-time between the date that flies are first captured and the date that the first damage can occur.

D. METHODS: Within-field movement of blueberry maggot flies.

In late July, 100 baited, yellow, sticky traps were distributed in a 10 x 10 grid with 20 ft between each row and column of traps. On three dates, adults flies which had been reared in the laboratory were marked with flourescent dye and released into the field. The traps were checked daily and any captured flies were collected and examined for dye.

RESULTS: Of 105 flies released, only nine were recaptured (8.6%). Flies moved an average of 17.5 ft/day. The distance traveled by these flies ranged from 8.5 to 31.6 ft/day. Figure 3 shows the distribution of distances that flies move per day for flies collected in 1998, 1999, and 2000.

RECOMMENDATIONS: Research in 1998, 1999, and 2000 focused on the within-field movement and colonization patterns of blueberry maggot flies into wild blueberry fields. These studies are central to our IPM project on within-field management of blueberry maggot fly. Basic biology data from these studies will form the basis for spray tactics such as strip spraying and field perimeter treatments. Additional work will help us to understand the importance and effects of fly sexual maturity, age, and weather conditions on fly movement.

Growth and development of blueberry spanworm and flea beetle in the laboratory.

No spanworm were successfully reared to adults in 2000. Emerging larvae were apparently infected with a granulosis virus which resulted in very high mortality. Attempts to rear blueberry flea beetle were also unsuccessful. We did collect ca. 600 flea beetle eggs for additional studies this winter.

CONCLUSIONS AND RECOMMENDATIONS

Some success has been made towards establishing the conditions needed to maintain

blueberry spanworm in the laboratory. However, efforts to rear blueberry flea beetle in the laboratory have not been successful. Additional investigation needs to be made into conditions required for the survival of both these insects so that laboratory colonies can be established for future insecticide bioassays. The development of laboratory rearing techniques for blueberry spanworm and blueberry flea beetle will allow more efficient evaluation of novel and new control materials for potential use against these pests through laboratory bioassays. In addition, a preliminary simulation model has been constructed for the egg and first and second instar larval stages of blueberry spanworm in the laboratory. Studies are needed to add data to the late larval instars.

Table 1. Vertical distribution of blueberry maggot flies within the forest perimeter around wild blueberry fields.

Average flies captured/sample date			
Trap	Within field	Wooded perimeter	
1998. height		(2000)	
6-10 inches		2.1	2.9
5 ft		0.01.1	
8 ft		0.0-	
10 ft	-1.1		
15 ft	-1.0		
20 ft	-1.4		

Fig. 1. Colonization of blueberry fields by blueberry maggot flies, average cumulative fly captures.

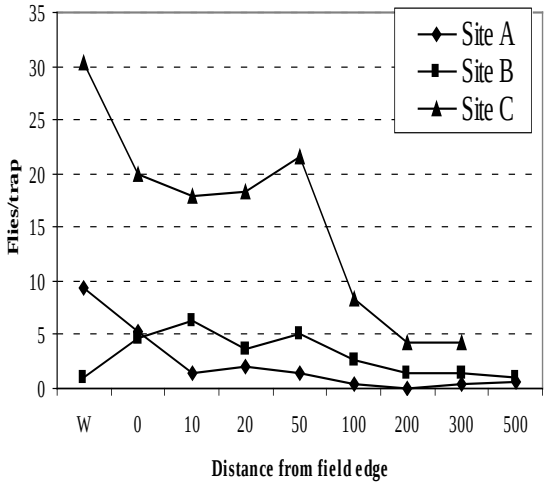


Fig. 2 Colonization of blueberry fields by blueberry maggot flies, sex ratio and reproductive maturity of blueberry maggot flies captured over all distances.

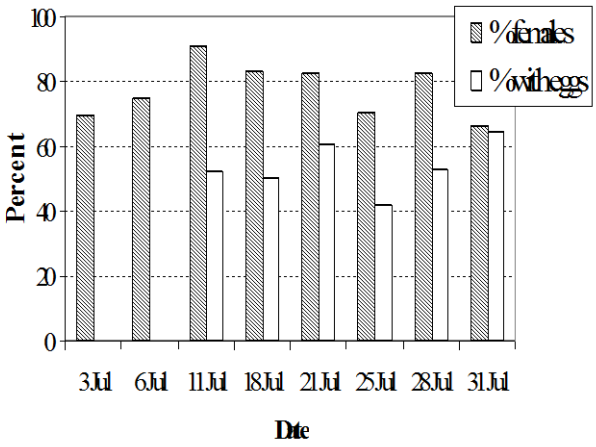
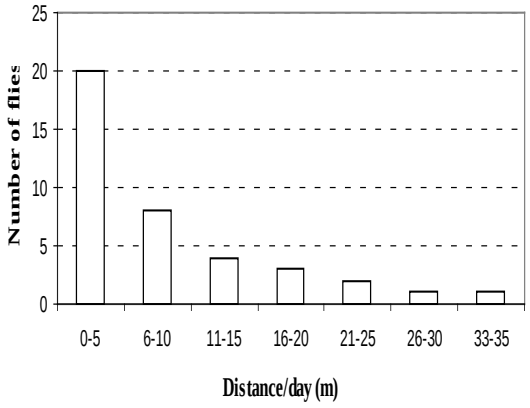


Fig. 3. Within-field movement of blueberry maggot flies, daily movement distance.



DISEASE CONTROL

INVESTIGATORS: S.L. Annis, Assistant Professor of Biological Sciences and
C.S. Stubbs, Post-doctoral researcher in Biological Sciences

1. TITLE: Survey of Stem Blight and Leaf Spot Diseases in Lowbush Blueberry Fields

METHODS: Thirty-one blueberry fields, 16 non-bearing and 15 bearing fields, chosen from 4 geographic areas of Maine were sampled for stem blight and leaf spot diseases in the summer of 1999. Twenty plots of 0.25m^2 were equally spaced along a W transect of each field. All stems showing disease symptoms were collected and 5 stems showing leaf spot symptoms were collected. Total number of stems per plot were determined for 4 plots per field. Three soil cores were taken to determine the depth of the organic layer. All stems were rated for generalized disease symptoms, such as tip dieback, stem lesions, and stem death. From each field, stem samples and leaf samples from 6 randomly chosen plots for each were sorted by symptoms and surface sterilized in 10% bleach and plated on malt yeast extract agar and water agar. Fungi isolated from the stems and leaves were identified to genus. Information on cultural practices, including fungicide and other treatments of fields was obtained from growers. Statistical analyses were performed on the data and will be continued.

RESULTS: Diseased stems and spotted leaves were found in all fields that were surveyed. The percentage of diseased stems in blueberry fields ranged from 3 to 13.5% with an average of 4.8%. Bearing fields had a significantly higher percentage of diseased stems than non-bearing fields (Figure 1). There was significantly more disease found on stem tips than other locations on the stem in the bearing fields (Figure 2). However, in the non-bearing fields, there was no significant difference in the location of disease symptoms on the stems (Figure 2). The estimate of incidence of all leaf spots in sampled plots in bearing fields was 46%. This was significantly higher than the 28% incidence of leaf spot in sampled plots in non-bearing fields. Based on one year's survey data, no management practice seemed to significantly affect disease incidence. In part, this could be accounted for by the large amount variation in management practices found. There was a trend indicating higher disease incidence in mowed fields than in burned fields or fields that were partially burned and partially mowed (Figure 3). The effects of management practices on disease incidence are again being investigated in 2000 in order to clarify their role in disease. From the 31 fields surveyed in 1999, we have identified 115 different types of fungi from diseased leaves and stems; the majority have been identified to genera (Table 1). The most commonly found fungi on stems and leaves are shown in Table 2; the majority of these fungi are known plant pathogens. However, the most common fungus found on both stems and leaves was *Aureobasidium*, a yeast that grows on plant surfaces, that may be weakly pathogenic. At least 18 of these genera are known to produce disease on blueberries or other members of the Ericaceae.

CONCLUSION: Stem and leaf blight diseases are common in lowbush blueberry fields and appears to have higher incidence in bearing fields than non-bearing fields. Many potential pathogens of blueberry that have been isolated from diseased stems and leaves and it appears that a complex of fungi may be causing stem and leaf diseases.

RECOMMENDATION: Recommendations for disease control cannot be made at this time. It is recommended that the disease survey be replicated in a subset of the surveyed fields in order to confirm the levels of disease incidence and persistence of potential fungal pathogens identified in fields.

Table 1. Fungi identified on lowbush blueberry stems and leaves

Acarosporium	*Colletotrichum*	*Heteroconium*	*Phomopsis*
Acremoniella	*Colletotrichum/Gloeosporium*	*Humicola*	*Phyllosticta*
Acrospeira	conidiomata, yellow	*Hyalodendron*	*Phymatotrichum*
Alternaria	*Coniochaeta*	Leptothyrium	Pithomyces
Ampulliferina	*Coniothyrium*	*Libertella*	*Pleospora*
Aristatoma	*Curvularia*	*Marroshina*	pycnidia, uk
Arthrinium	*Cylindrocarpon*	*Monilinia*	*Rhinocladiella*
Ascomycete, uk	*Cylindrosporium*	mycelia sterilia, blackish	*Rhynchosporium*
Aspergillus	*Cytospora*	mycelia sterilia, brown	*Sclerotium*
Aureobasidium	*Cytosporella*	mycelia sterilia, dark green	*Septocylindrium*
Bacteria	*Dendrodochium*	mycelia sterilia, gray	*Septogloeum*
Bactrodesmium	*Dendrographium*	mycelia sterilia, green-gray	*Septonema*
Basipetospora	*Diplococcum*	mycelia sterilia, olive	*Sphaceloma*
Bispora	*Diplodia*	mycelia sterilia, red-orange	*Sphaeronaema*
Botryoderma	*Dothichiza*	mycelia sterilia, white	*Sphaeropsis*
Botryodiplodia	*Dothiorella*	mycelia sterilia, yellow	sporodochia, uk
Botrytis	*Dothistroma*	*Nigrospora*	Sporonema
Brachysporium	*Epicoccum*	*Oidiodendron*	*Stachylidum*
Briosia	*Fusarium*	*Oidium*	*Stagnospora*
Candida	*Geotrichium*	*Paecilomyces*	*Steganosporium*
Catenophora		*Papularia*	*Stigmella*
Catinula	*Gilmaniella*	*Papulospora*	*Strasseria*
Chaetomella	*Gliocladium*	*Penicillium*	*Taeniolella*
Chaetomium	*Gloeosporium*	*Periconia*	*Torula*
Chaetophoma	*Hainesia*	*Pestalotia*	*Trichocladium*
Chalara	*Helicomyces*	*Phlyctaena*	*Trichoderma*
Chalaropsis	*Hendersonula*	*Phoma*	*Truncatella*
Chrysosporium		*Phoma or Phyllosticta*	*Ulocladium*

Cladosporium			*Wallemia*
			Xylohypha

Table 2. Most common fungi occurring on lowbush blueberry stems and leaves

Fungus	Stems	Leaves
Alternaria	**5.3**	**12.5**
Aureobasidium	**23.3**	**15.5**
Candida	**1.1**	
Chalaropsis		**2.5**
Cladosporium	**2.4**	**3.8**
Colletotrichum /Gloeosporium	**5.3**	**8.3**
Cytospora	**1.4**	
Dothiorella	**1.7**	**1.7**
Gloeosporium	**1.2**	
mycelia sterilia, brown	**6.5**	**11.3**
mycelia sterilia, white	**10.7**	**8.6**
Oidodendron	**1.1**	
Phoma	**1.6**	
pycnidia, unknown	**3.3**	**3.3**
Sphaeropsis		**1.6**
Torula		**3.1**

Figure 1. Disease Incidence: Stem Blight of Lowbush Blueberry

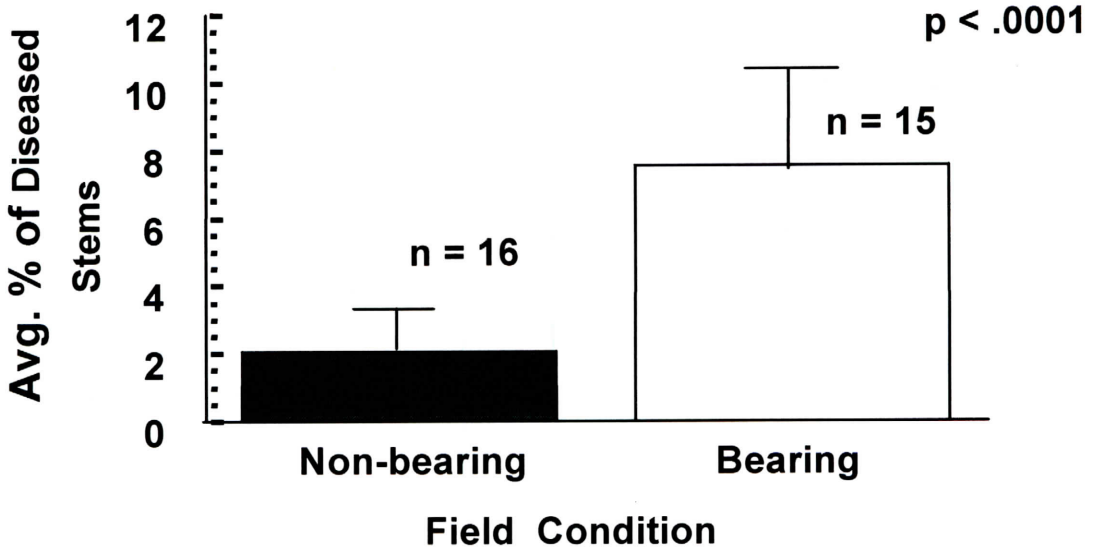


Figure 2. Location of disease on stems for bearing and non-bearing fields

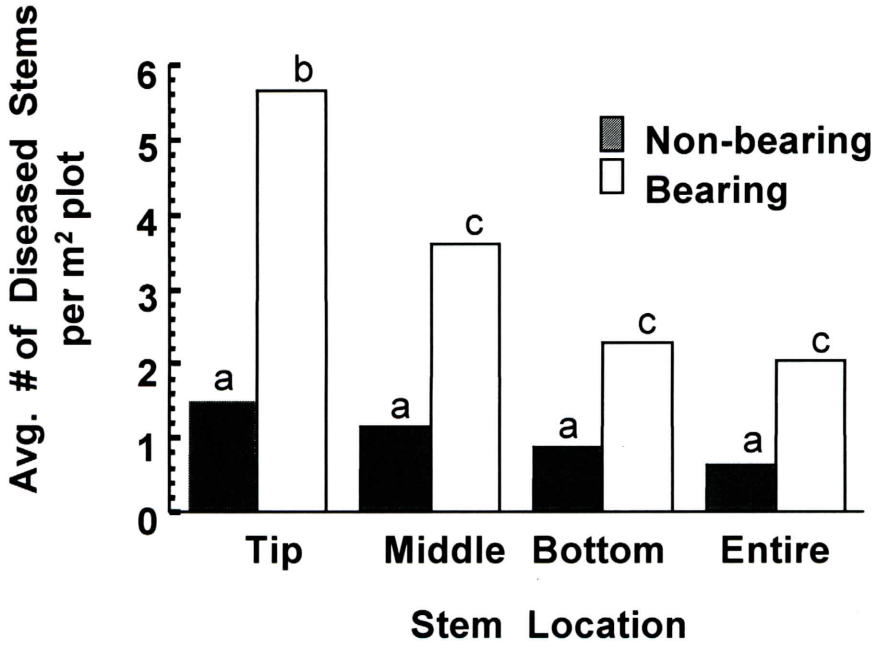
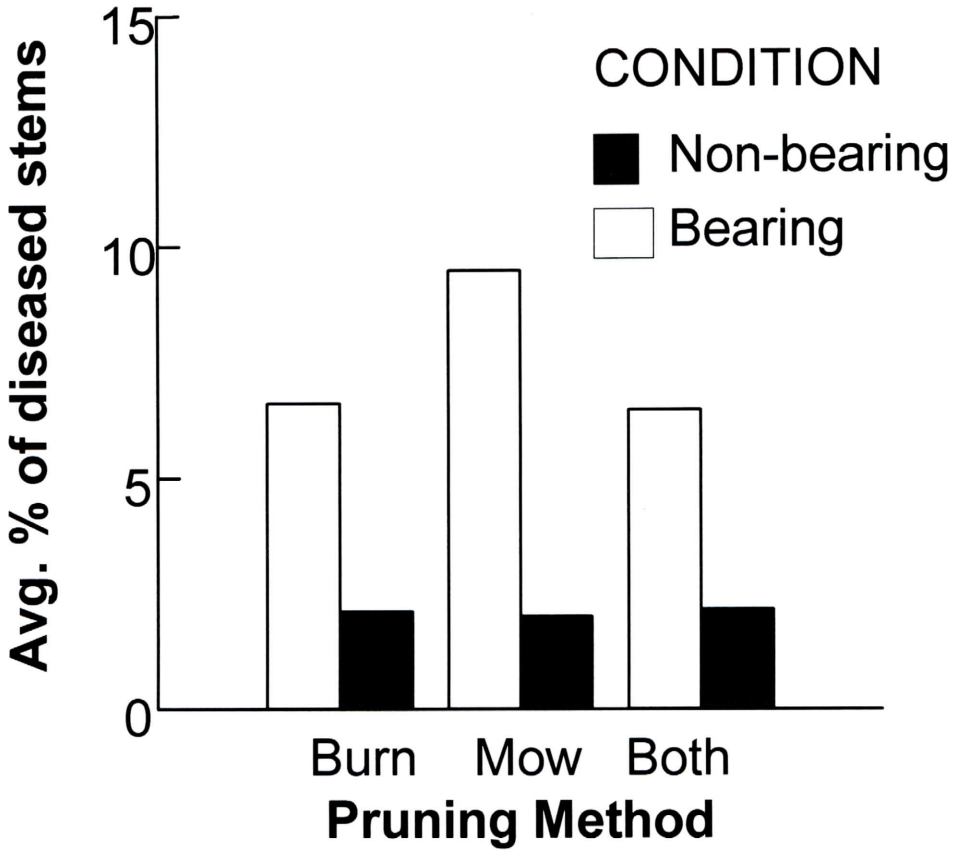


Figure 3. Percentage of diseased stems by pruning and field condition



PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Adam Nielsen, Research Assistant
Stephenson NgaNga, Research Assistant
Tarsha Rideout, Research Assistant

1. TITLE: Phosphorus/Nitrogen Fertilizer Ratio.

OBJECTIVES: To evaluate the growth and yield response of lowbush blueberries to fertilizers containing different phosphorus to nitrogen ratios.

METHODS: Three fields previously used in the phosphorus dose/response study were used in this study. Since the control plots had a known history of leaf nutrient concentrations (low leaf phosphorus) and a consistent yield, they were enlarged to include four, 5 ft x 20 ft treatment plots for the following treatments:

1. Control - no fertilization
2. Phosphorus (60 lb P/acre, using triple superphosphate (TSP)).
3. Phosphorus + nitrogen (60 lb P/acre + 28.8 lb N/acre, using monoammonium phosphate (MAP)).
4. Phosphorus + nitrogen (60 lb P/acre + 54 lb N/acre, using diammonium phosphate (DAP)).

TREATMENT SUMMARY TABLE			
	TRIPLE SUPER PHOSPHATE	MAP (11-52-0)	DAP (18-46-0)
ACTUAL P (LB/ACRE)	60	60	60
ACTUAL N (LB/ACRE)	0	28.8	54
RATIO P/N	1/0	2.1/1	1.11/1

Treatments were replicated 12 times at each of the three locations. Nutrient uptake in response to treatments applied May 1995 and 1997 were evaluated by analyzing composite leaf samples taken from 30 stems randomly selected across each treatment plot in July 1995 and 1997. Growth characteristics (including stem height and flower bud formation) were assessed on stems cut at ground level in four 1/4 ft^2 quadrats/treatment plot in October 1995 and 1997. Yield was determined in August 1996, 1998, and 2000 by hand harvesting the plots, winnowing the berries and recording the weight.

RESULTS:

1995 Leaf Tissue Nutrient Concentrations

Leaf P concentrations in control plots at the three locations averaged 0.100%, considerably less than the 0.125% standard reported by Professor Trevett in 1972 (Fig. 1). All fertilizers raised the leaf P concentrations compared to the controls. We also noted that there

was no difference between TSP, MAP, or DAP in raising the leaf phosphorus concentration when the three locations were averaged. There were differences among locations and they are illustrated in Figures 2, 3 and 4. Controls had phosphorus concentrations of 0.108, 0.102 and 0.091% for Location 1, 2, and 3, respectively. The ratio of leaf P concentrations from plots receiving DAP to the control plots was 1.16 for locations 1 and 2, but for location 3 it was 1.24. In other words, the response to DAP was greater at location 3 where concentrations were raised .022%, compared to 0.017 and 0.016%, at locations 1 and 2, respectively.

N concentrations were higher in leaf tissue samples from MAP and DAP treatment plots which received N along with P (Fig. 5). N concentrations in leaves from control plots were much below the 1.6% standard. DAP raised N concentrations more than MAP, but neither source brought the concentration up to the 1.6% standard. TSP had no effect on leaf N concentrations.

While leaf P and N concentrations rose in response to fertilizer treatments, Mg, B and Cu leaf tissue concentrations declined in response to fertilizers containing N (Figs. 6, 7, and 8). This relationship has been previously noted and may not be very important since concentrations of Mg and Cu did not decrease to deficiency levels. The standards reported by Professor Trevett in 1972 for Mg and Cu are 0.13% and 7 ppm, respectively. B was deficient (<24 ppm) at all locations and leaf B concentrations were lowered by N-containing fertilizers. Leaf Ca concentrations were also lower at one of the locations. The decrease in leaf Mg, B and Cu concentrations may be due to competitive uptake between N and these nutrients or a dilution effect resulting from increased growth due to the N component of the fertilizer.

1995 Soil Nutrient Concentrations

Soil P concentrations averaged across locations showed a similar pattern to that found for leaf P concentrations among treatment plots; all fertilizers raised soil P concentrations, compared to the controls (Fig. 9). However, MAP or DAP did not raise soil P concentrations higher than TSP, according to logical contrasts to statistically compare among the fertilizer treatments (Table 1).

1995 Stem Characteristics and 1996 Yield

The effect of fertilizer treatments on stem density and height and flower bud formation was determined through measurements on stems sampled from four 1/4 ft^2 quadrats per treatment plot. The density of stems was increased by MAP and DAP, but not by TSP, compared to the control (Table 2). Stem length, flower buds per stem, and flower bud density were also increased by both MAP and DAP, but not TSP. Averaged across all three locations, fertilization with DAP resulted in the tallest stems and the most flower buds per stem. Fruit yield was higher for DAP compared to control plots (Fig. 10).

1997 Leaf Tissue Nutrient Concentrations

The 1997 leaf P concentrations, averaged across locations, indicated that plants responded to the treatments as they did in 1995; P concentrations of leaves in control plots (0.97%) were well below the standard (0.125%) and were significantly raised by TSP (0.125%), MAP (0.128%), and DAP (0.129%) (Fig. 1). The responses to treatments at individual fields (Figs. 2, 3 and 4) indicated that while leaf P concentrations of control plots differed somewhat, the general response to TSP, MAP, and DAP was similar.

Nitrogen was raised to concentrations above the standard (1.6%) by treatments

contributing N (MAP and DAP) (Fig. 5).

Leaf Mg and B concentrations did not decrease in leaf samples from treatment plots receiving MAP or DAP as was the case in 1995. Leaf Cu concentrations did, however, follow the same trend as in 1995 and were lower in treatment plots receiving MAP or DAP.

1997 Soil Nutrient Concentrations

Analysis of soil samples taken in July 1997 indicated that, as in 1995 soil samples, all fertilizers raised soil P concentrations, compared to the controls (Fig. 9). Soil P concentrations in plots receiving DAP, were slightly higher than those receiving TSP but not different from those receiving MAP. In general, the soil P concentrations were about half that found in 1995, including the control. For this we have no explanation.

1997 Stem Characteristics and 1998 Yield

Stem density (Table 3), randomly sampled in the fall 1997 from each treatment plot using four ¼ ft^2 quadrats, was remarkably similar to the 1995 data (Table 2). Stem length was increased by N-containing fertilizer treatments but not by TSP. DAP treatments resulted in taller stems than MAP, presumably due to its higher concentration of N. The number of flower buds per stem also showed this trend. Flower bud density (flower buds per unit area) was not statistically different between MAP and DAP treatments but both were higher than the TSP treatments and the controls. Averaged across all three locations, fertilization with DAP resulted in taller stems with more flower buds per stem and the highest yield, although MAP also increased yield compared to the controls (Fig. 10). TSP, while elevating soil P and leaf P concentrations, did not result in an increase in growth, flower bud formation or yield compared to the controls.

1999 Leaf Tissue Nutrient Concentrations

Plots at location 1 were abandoned due to circumstances beyond our control. Averaged across the two locations, the leaf P concentrations were greater in plots receiving TSP, MAP, or DAP, compared to the control as was the case in 1995 and 1997(Fig 1). It appears that in 1999 differences in leaf P concentration are beginning to appear among the P containing fertilizers. However, there was a significant interaction between treatment and location for the leaf P concentration response to treatments. This means that one field responded differently from the other and is apparent when responses at location 2 (Fig. 3) and location 3 (Fig. 4) are compared. The difference in the average is due only to the response at field 3. Leaf P concentration in control plots at both locations are below the standard suggested by Trevett (0.125%). At location 2 (Fig. 3), TSP has been as effective as MAP or DAP at raising leaf P concentrations but this is not the case at location 3 (Fig. 4), where MAP and DAP have been somewhat more effective than TSP. Could it be the inherent difference in soil N availability between the two fields?

The leaf N concentrations averaged across 3 locations in 1995 and 1997 and 2 locations in 1999 increased when MAP or DAP was applied (Fig 5). However, there is a difference between location 2 and 3 in control plot leaf N concentrations; higher levels were found in location 2 that in location 3 (Figs 5b and 5c). The leaf N concentrations were raised in location 3 to the 1.6% standard only in 1999, when plots received DAP (Fig. 5c). At location 2 (Fig. 5b) this level of leaf N concentration was reached in 1995 when DAP was applied. In 1999, however, when control plots had leaf N levels above the 1.6% standard leaf N concentrations was raised by MAP and DAP but not TSP. These differences in N availability at these two fields

could explain the difference in response to treatments with regard to P uptake. Available N seems to be important in absorption and translocation of P from the soil into the leaves.

At both locations in 1999, leaf Mg concentrations were highest in plots treated with TSP (Fig.6). The lower leaf Mg concentrations in other plots were not, however, below the satisfactory concentration (0.13%). Leaf boron concentrations also showed a similar trend in 1999 (Fig. 7). Copper concentrations in leaf tissue were reduced by MAP and DAP but not TSP(Fig. 8), suggesting that this is a dilution effect resulting from N-stimulated growth.

1999 Soil Nutrient Concentrations

Soil samples taken in 1999 indicated soil P concentrations for control plots were similar to the levels found in 1997 samples. Soil P concentrations in plots receiving TSP, MAP or DAP showed a similar pattern to that observed in 1997, but concentrations were higher than in 1997. Soil pH was reduced by MAP or DAP (Fig 9b). This is expected as the ammonium form of nitrogen fertilizer found in MAP and DAP is oxidized in the soil, and the nitrate form is produced. Ammonia is a base and oxidizing it produces acids that lower soil pH. The organic matter content of the soil sample and the cation exchange capacity was significantly higher in soil from plots receiving DAP (Fig. 9c). This may be related to increased growth and a greater amount of leaf litter produced in these plots.

1999 Stem Characteristics and 2000 Yield

Stem characteristics of samples collected from treatment plots from two locations suggest that MAP and DAP fertilization has not affected stem density, but has resulted in taller stems with more flower buds (Table 4). While the yield averaged across both locations suggests plots fertilized with DAP had the greatest yields, there was a difference between the two locations. At location 3, the yield was greatest for plots receiving DAP **(**Fig. 11), but at location 2 the yield was greatest for plots receiving MAP, rather than DAP (Fig. 12). This could be related to the difference in N needs between the two fields; location 2 needed less N and thus did better with MAP. This is consistent with our current fertilizer recommendations.

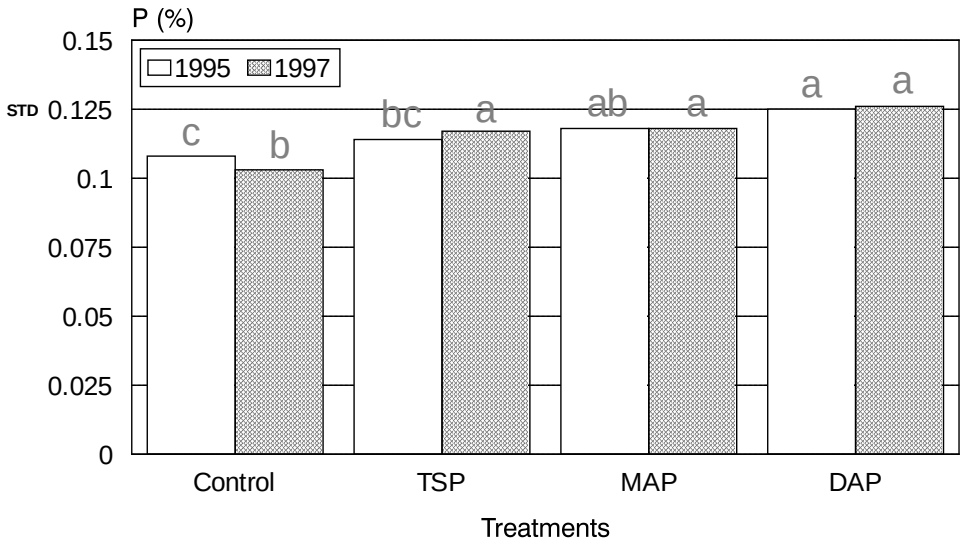
CONCLUSIONS: For P deficient lowbush blueberry fields, MAP and DAP resulted in better growth and yield than TSP. Fields respond differently to MAP and DAP, depending on the natural N status of the field.

RECOMMENDATIONS: For lowbush blueberry fields in which leaf tissue analysis indicates adequate N concentration (at or above 1.6%), MAP should be applied to overcome P deficiency. When both a N and P deficiency exists, DAP would be preferred.

Figure 2

P/N Ratio Study

Phosphorus leaf concentrations at location 1

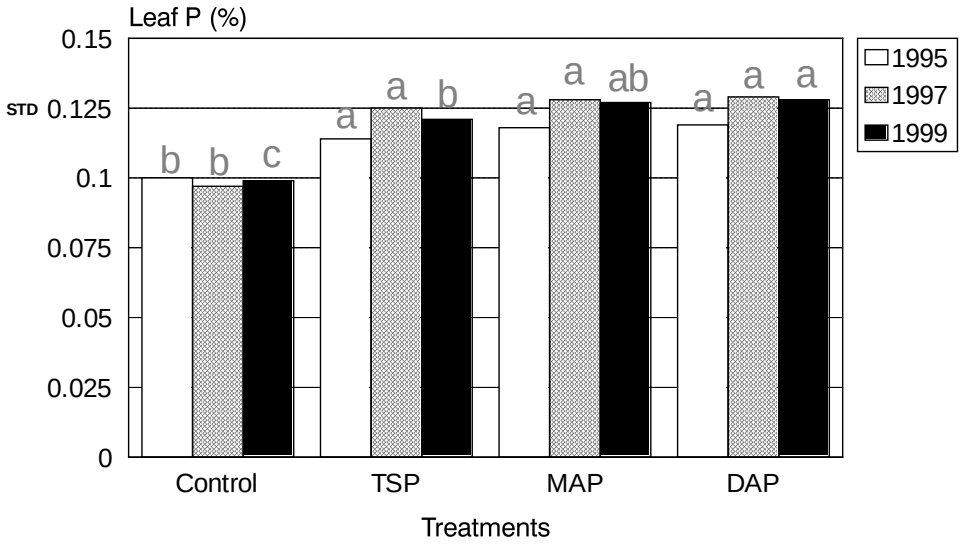


Means within years not having a letter in common are significantly different at the 1% level. This location was eliminated from the study in 1999.

Figure 1

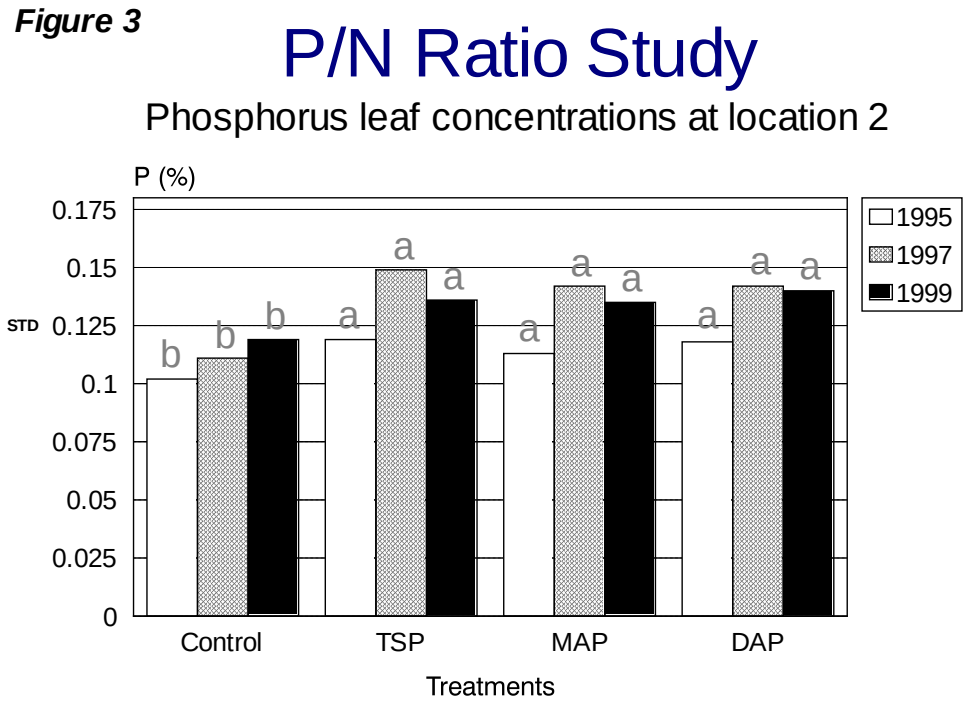
P/N Ratio Study

Phosphorus leaf concentrations*



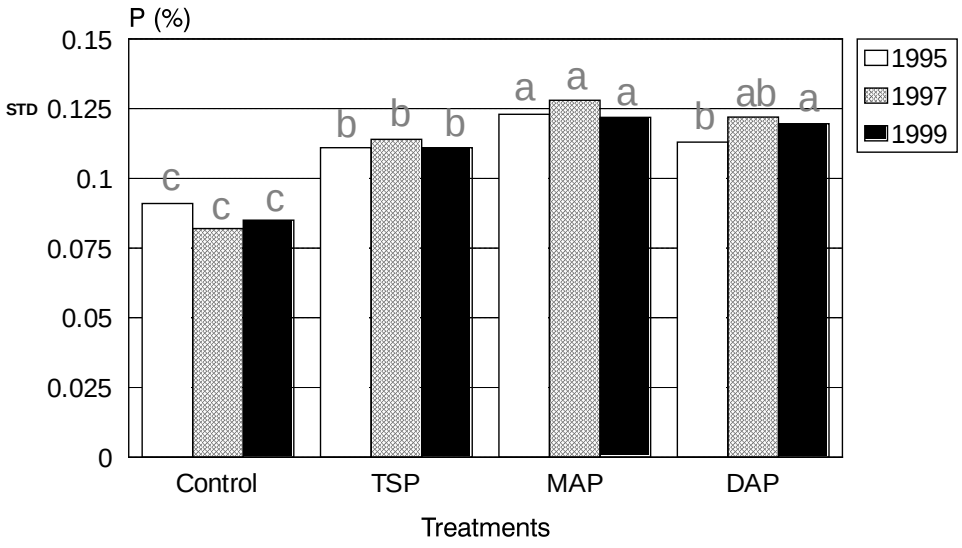
*Values are average of three locations in 1995 and 1997 and two locations in 1999. Treatment means within years not having a letter in common are significantly different at the 1% level.

Figure 3



Means within years not having a letter in common are significantly different at the 1% level.

Figure 4

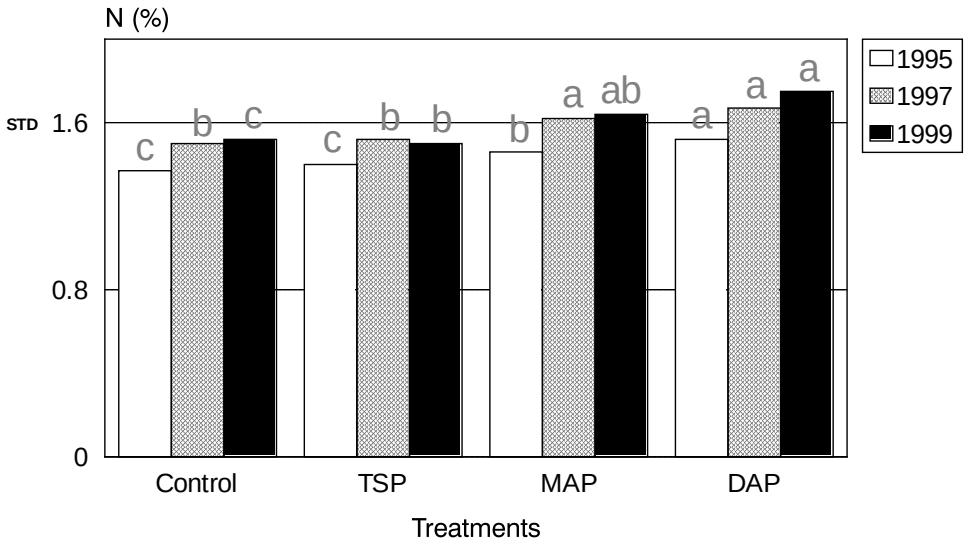


Means within years not having a letter in common are significantly different at the 1% level.

Figure 5

P/N Ratio Study

Nitrogen leaf concentrations*

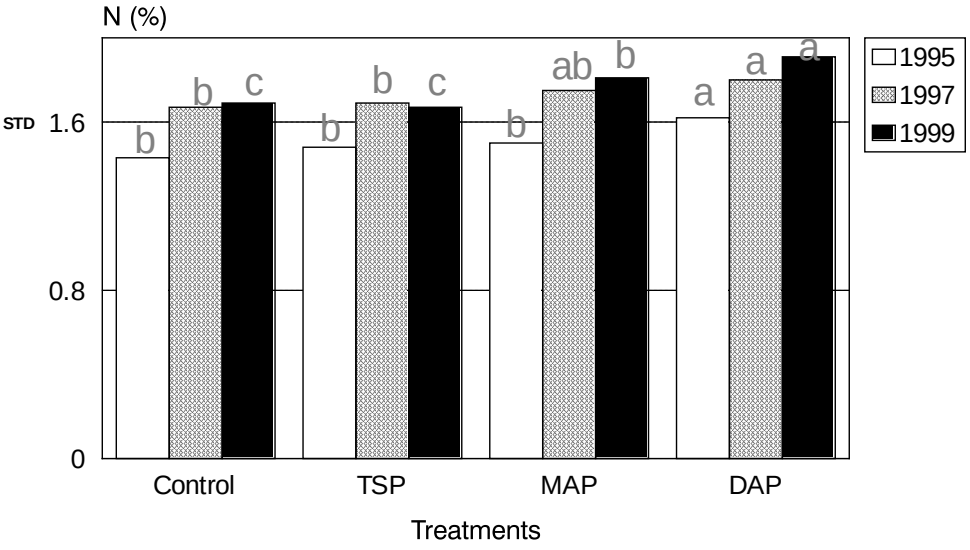


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means within years not having a letter in common are significantly different at the 1% level.

Figure 5b

P/N Ratio Study

Nitrogen leaf concentrations at location 2*

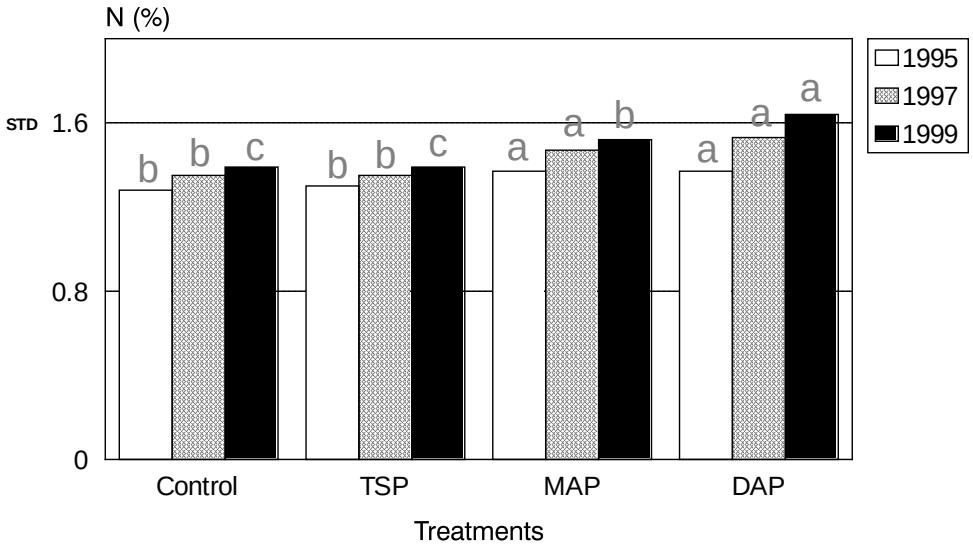


* Means within years not having a letter in common are significantly different at the 1% level.

Figure 5c

P/N Ratio Study

Nitrogen leaf concentrations at location 3*

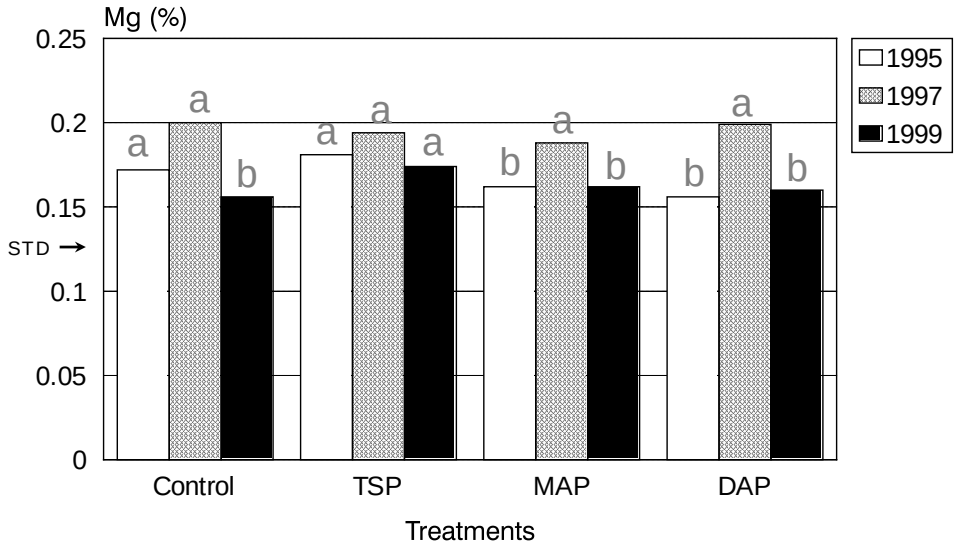


* Means within years not having a letter in common are significantly different at the 1% level.

Figure 6

P/N Ratio Study

Magnesium leaf concentrations*

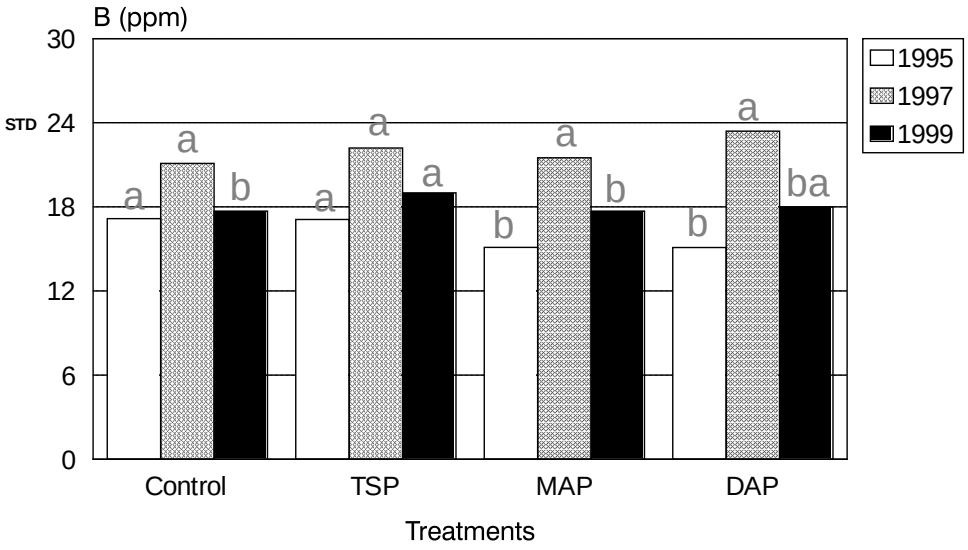


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means not having a letter in common are significantly different at the 1% level.

Figure 7

P/N Ratio Study

Boron leaf concentrations*

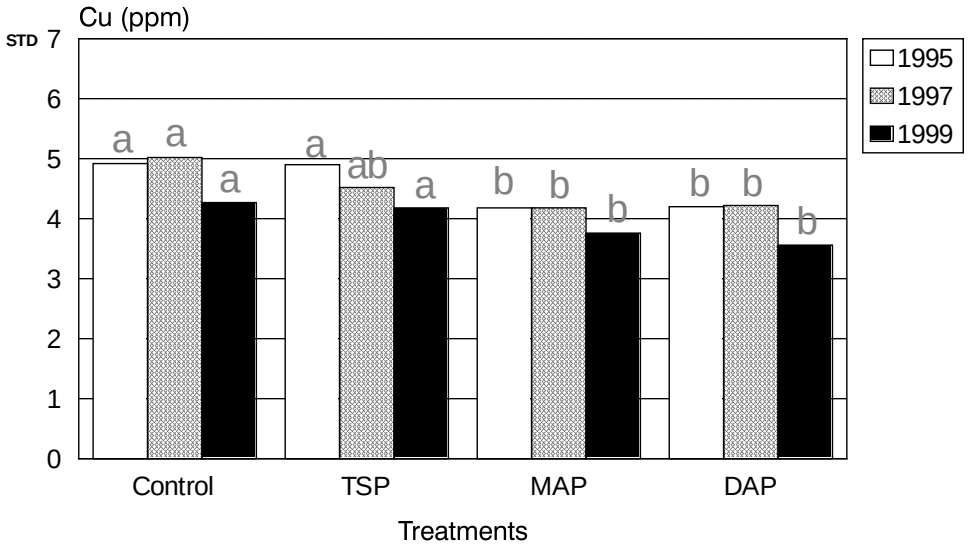


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means not having a letter in common are significantly different at the 1% level (1995), 5 % level(1997), and 5.6% level (1999).

Figure 8

P/N Ratio Study

Copper leaf concentrations*

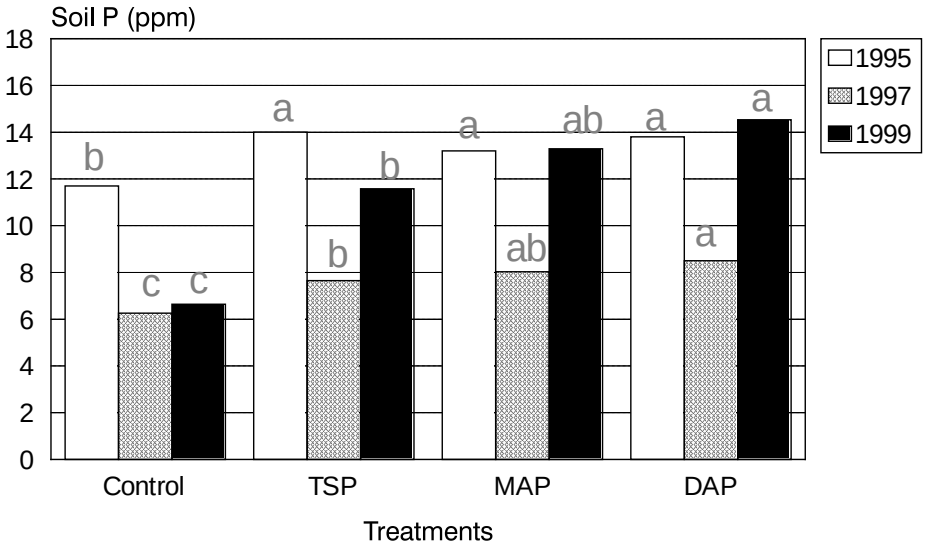


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means not having a letter in common are significantly different at the 1% level.

Figure 9

P/N Ratio Study

Soil phosphorus concentrations*

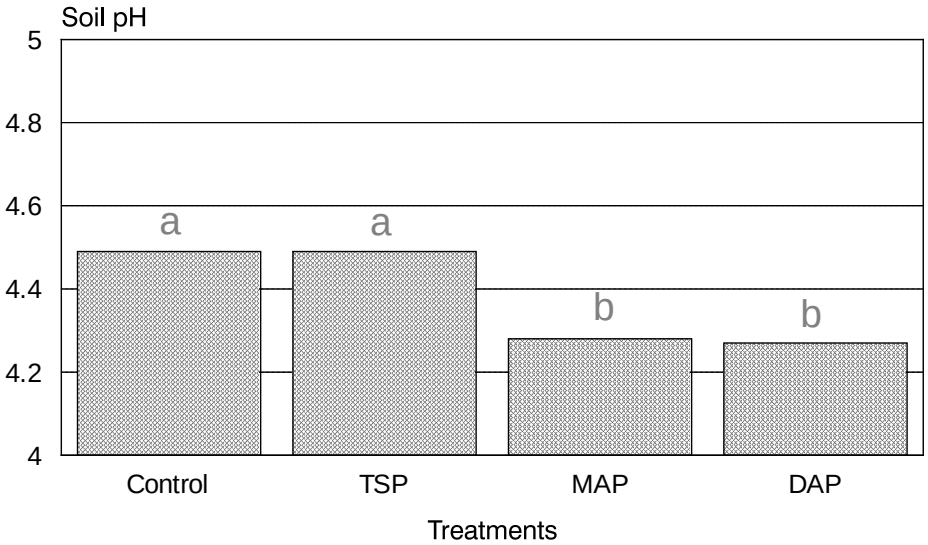


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Treatment means for soils within years not having a letter in common are significantly different at the 1% level.

Figure 9b

P/N Ratio Study

1999 Soil pH*

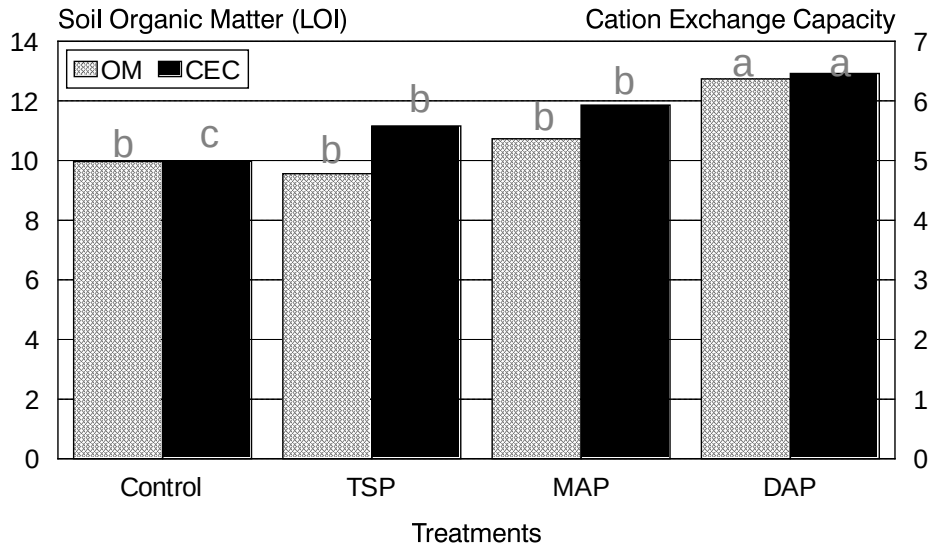


*Values are average of two locations. Treatment means for soil pH not having a letter in common are significantly different at the .02% level.

Figure 9c

P/N Ratio Study

1999 Soil Organic Matter and CEC*

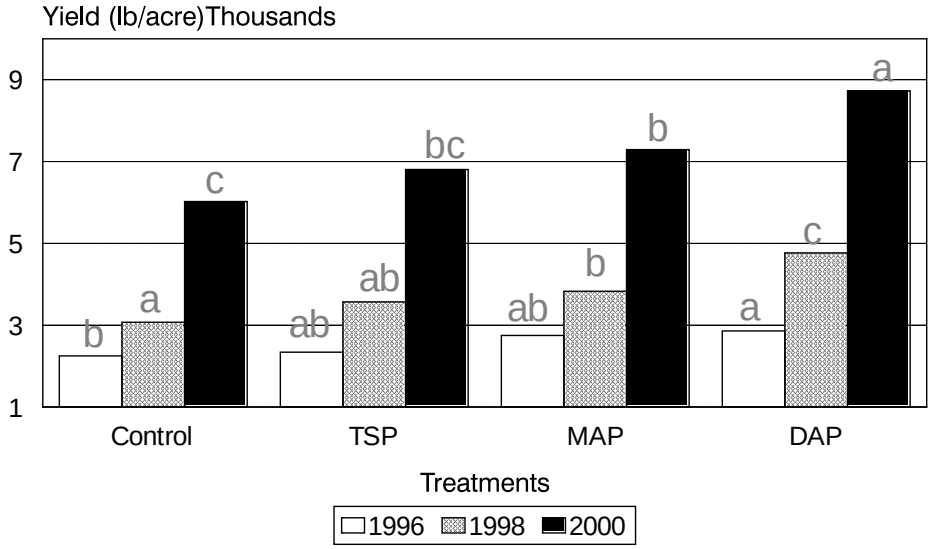


*Values are average of two locations. Treatment means for soil OM and CED not having a letter in common are significantly different at the .01% level.

Figure 10

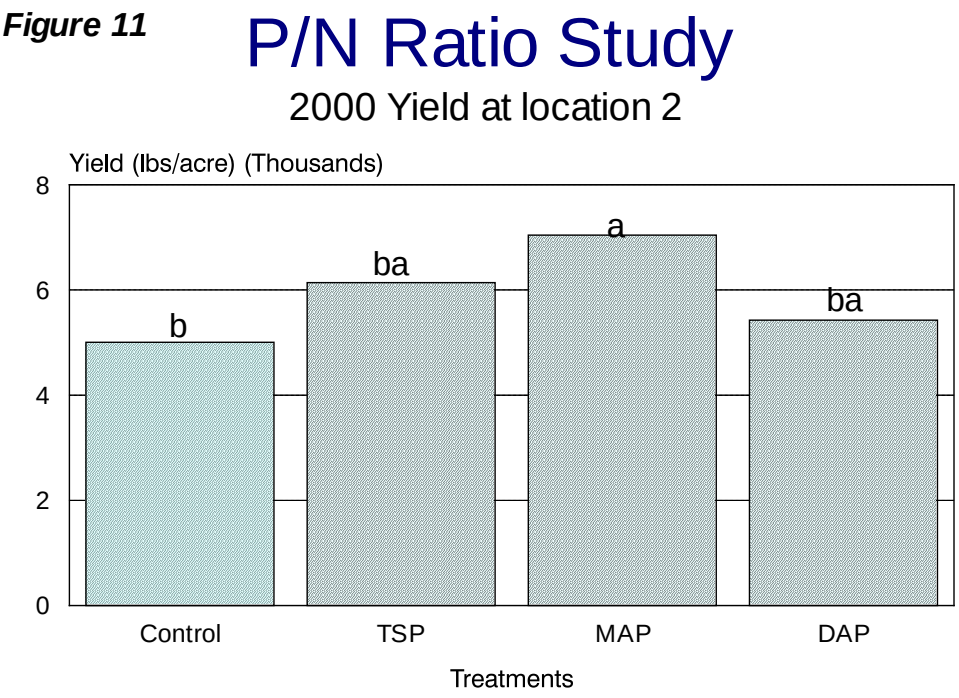
P/N Ratio Study

1996,1998, and 2000 Yield*



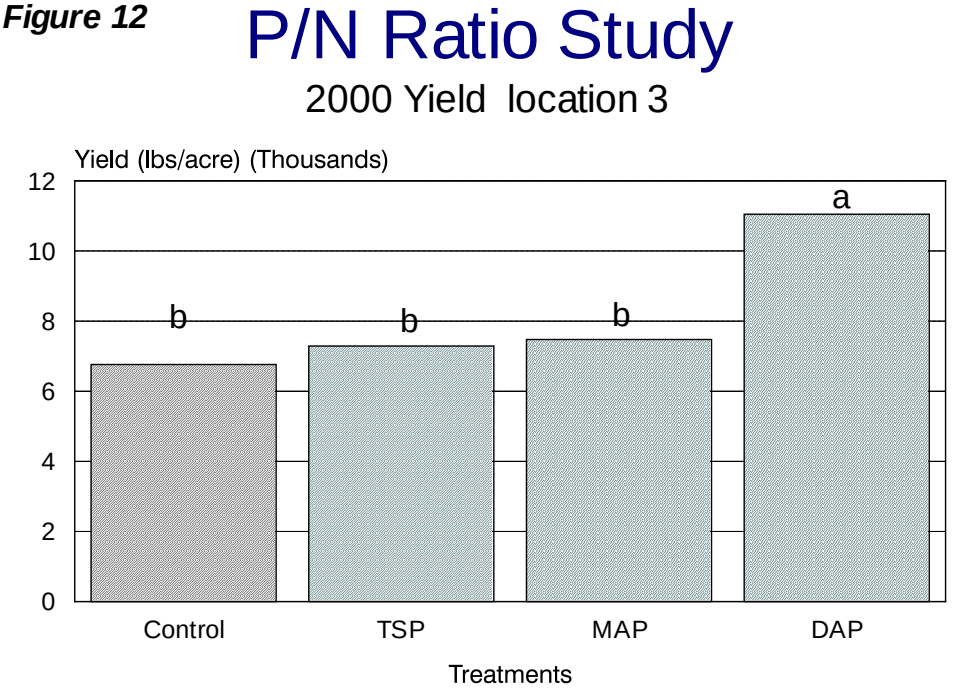
*Values are average of three locations in 1995 and 1997 and two locations in 1999. Treatment means within years not having a letter in common are significantly different at the 1% level. Yields adjusted for bare areas.

Figure 11



Treatments significantly different at 10 % level.

Figure 12



Treatments significantly different at 10 % level.

Table 1

P/N Ratio Study

Soil phosphorus concentrations,1995

Treatments	P (%)
Control	11.7
TSP	14
MAP	13.2
DAP	13.8
Contrasts	SIGN LEVEL
Fert vs Control	1%
N+P vs P	ns
MAP vs DAP	ns

Table 2

P/N Ratio Study

Stem characteristics, 1995

Treatment	Stems per 1/4 sq ft	Stem length (in)	Flower buds per stem	Flower buds per 1/4 sq ft
Control	21 b	2.9 c	1.8 c	37 b
TSP	22 ba	3.0 c	1.9 cb	41 b
MAP	24 a	3.3 b	2.1 b	50 a
DAP	24 a	3.5 a	2.4 a	55 a

Means of all locations within columns followed by different letters significantly different at the 5% level.

Table 3

P/N Ratio Study

Stem characteristics, 1997

Treatment	Stems per 1/4 sq ft	Stem length (in)	Flower buds per stem	Flower buds per 1/4 sq ft
Control	21 b	3.2 c	2.1 c	41 b
TSP	23 ba	3.2 c	2.0 c	42 b
MAP	24 a	3.8 b	2.6 b	57 a
DAP	24 a	4.0 a	2.9 a	63 a

Means of all locations within columns followed by different letters significantly different at the 5% level.

Table 4

P/N Ratio Study

Stem characteristics, 1999

Treatment	Stems per 1/4 sq ft	Stem length (in)	Flower buds per stem	Flower buds per 1/4 sq ft
Control	27 a	2.9 b	1.67 b	42 b
TSP	27 a	2.8 b	1.69 b	41 b
MAP	27 a	3.4 a	2.25 a	52 a
DAP	27 a	3.6 a	2.28 a	52 a

Means of all locations within columns followed by different letters significantly different at the 5% level.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Adam Nielsen, Research Assistant
Stephenson NgaNga, Research Assistant
Tarsha Rideout, Research Assistant

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

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

Boron availability may be limited in the acid podsol soils in which most of Maine's lowbush 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 boron and calcium were found in the leaf tissue of the "good" fields. A survey of leaf nutrient concentrations in commercial lowbush blueberry fields conducted in 1987 and 1988 indicated that 39 out of 75 fields had boron concentrations below the standard of 24 ppm, established by Trevett in 1972.

Insufficient boron concentration in flowers has been associated with low fruit set due to inadequate pollen growth through the style into the ovary, where fertilization occurs and seed development begins. Berries increase in size as more seeds develop. Remedying boron deficiency by supplementation through soil or leaves could improve fruit set and increase fruit production. There is little information comparing the effectiveness of soil and foliar boron application in correcting boron deficiency of the lowbush blueberry.

METHODOLOGY: *Boron application study I (1997)*

One commercial lowbush blueberry field was used in this study. Treatment plots measuring 5 ft x 25 ft received the following treatment combinations of soil borate, foliar Solubor®, DAP (80 lbs P), or Zn (3 lb/acre):

Soil Treatments	
T1 =Control + DAP + Zn	T9 =Control
T2 =1.0 lb B/a Borate + DAP + Zn	T10 =1.0 lb B/a Borate
T3 =2.0 lb B/a Borate + DAP + Zn	T11 =2.0 lb B/a Borate
T4 =3.0 lb B/a Borate + DAP + Zn	T12 =3.0 lb B/a BorateFoliar Treatments
T6 =0.22 lb B/a Solubor® + DAP + Zn	T14 =0.22 lb B/a Solubor®
T7 =0.44 lb B/a Solubor® + DAP + Zn	T15 =0.44 lb B/a Solubor®
T8 =0.66 lb B/a Solubor® + DAP + Zn	T16 =0.66 lb B/a Solubor®

These treatments were randomly assigned to treatment plots in a randomized complete block with 8 blocks. Preemergence soil application of boron was made May 28, 1997 and foliar

application on June 17, 1997. To test if response to boron treatment could be masked by deficiency of other nutrients, a field low in N, P and Zn was used and half of the plots (T1-T8) received DAP plus Zn and half (T9-T16) did not. Composite leaf tissue samples were taken in July 23, 1997 in each treatment plot. Stem samples from 4 randomly placed ¼ ft^2 quadrats were collected in October 1997 and measured for stem length and flower bud formation. Yield was determined in August 1998. Soil and leaf samples were taken in July 1999 to determine if there was a carryover effect from the 1997 treatments.

RESULTS: *Boron Application Study I (1997)*

Boron leaf concentrations were increased by both soil and foliar treatments, compared to controls (Fig. 1). The leaf B concentrations in control plots were above the 24 ppm standard and were raised by all soil applied borate treatments and by the foliar Solubor® treatments at 0.44 and 0.66 lbs B/a. A reduction in leaf B concentration was noted when plots receiving soil applied borate (2 or 3 lbs B/a) also received DAP and Zn fertilizer. This could have been the result of a dilution effect caused by increase growth from the DAP.

N and P leaf concentrations were increased when DAP and Zn were included in the fertilizer treatment, presumably due to the DAP component (Figs. 2 & 3). Phosphorus leaf concentrations showed deficiency in plots not receiving DAP. Soil P concentrations were not consistently raised by treatments which included DAP (Fig. 3b).

Most of the treatment plots that received DAP and Zn fertilizer had taller stems than those that did not (Fig. 4). B application did not affect stem length. A comparison of flower bud formation among treatment plots receiving borate suggests that an increase in flower buds/stem resulted from a combination of DAP and Zn fertilizer and 2 lbs B/a (Fig. 5). With foliar application of B, the greatest flower bud formation also occurred when DAP and Zn fertilizer was combined with B application (Solubor® at 0.66 lb B/a). Flower bud density (flower buds per unit area) also suggests an interaction between DAP and Zn and boron treatments (Fig. 6). Treatments with the highest potential yield based on number of flower buds/stem and flower bud density are summarized in Figure 7. Treatment plots receiving DAP and Zn plus 2 lbs B/a from borate and those receiving DAP and Zn plus 0.66 lbs B/a had about the same leaf B concentrations, 59 and 52 ppm B, respectively. They also had similar leaf N and P concentrations.

The potential yield trends were not seen when actual yield was taken in August 1998 (Fig. 8). A spring frost during blossoming resulted in slight damage that was confounded by mummy berry fungal disease (*Monolinia vaccinii*) and resulted in lower than normal yield. This affected yield results and could have compromised the benefit of boron application. Application of borate with or without DAP plus Zn resulted in leaf B concentrations above the 24 ppm standard, while the leaf B concentrations in the control plots were below the standard (Fig. 9). Solubor® applications without DAP and Zn in 1997 at 0.44 or 0.66 lbs B/a also raised 1999 leaf B concentrations above the standard. When plots were treated with Solubor® plus DAP and Zn, only the 0.66 lb B/a rate resulted in leaf B concentrations above the standard. A carryover effect of both soil (borate) and foliar (Solubor®) applications was seen. However, when compared to the leaf concentrations in 1997 when the treatments were made the carryover appears small (Fig. 10).

METHODOLOGY: *Boron Application Study II (1999)*

A smaller follow up study was initiated in 1999 to evaluate just the most promising

treatments of the 1997 study: DAP plus soil borate application at 2 lbs B/acre and DAP plus foliar Solubor® treatment at 0.66 lbs B/acre. A treatment plot receiving only DAP and one receiving no fertilizer application (control) allowed us to separate the treatment effects of boron.

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

Application to 5 ft x 25 ft treatment plots was as described in the 1997 study. Soil applied DAP or borate was broadcast on the appropriate plots May 18, 1999. Solubor was sprayed on June 16,1999. Treatments were replicated eight times in a randomized, complete block design. Composite leaf tissue samples were taken July 8,1999 and stem samples were taken September 20, 1999. Yield was measured in August 2000.

RESULTS: *Boron Application Study II (1999)*

Control plots were below the standard 24 ppm leaf B concentration. Leaf B concentrations were raised above the 24 ppm standard by borate with or without DAP; however, the concentration was considerably higher with DAP (Fig11). The leaf B concentrations in leaf samples from plots receiving Solubor® with or without DAP also averaged above the 24 ppm standard, but were not statistically different from the control.

N and P were also deficient and these deficiencies were corrected by DAP, borate plus DAP, or Solubor® plus DAP treatments (Figs. 12 &13).

Leaf Fe concentrations were all below the 50 ppm leaf standard**,** but appear to be elevated by borate plus DAP and Solubor® plus DAP (Fig. 14).

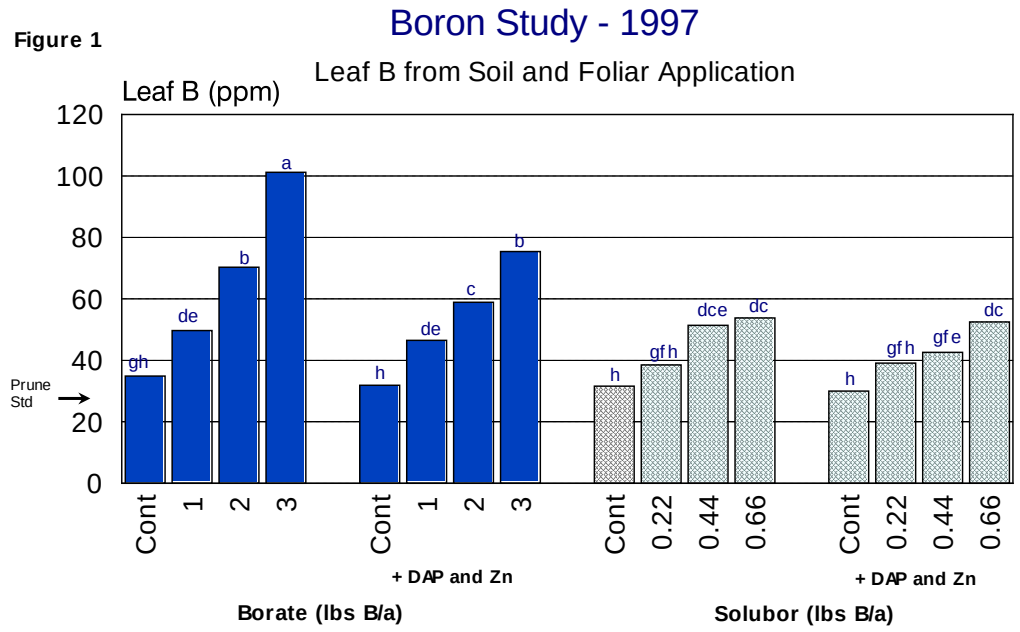
Stems sampled from plots in October 1999 indicated that stem length and branching were increased by all treatments that included DAP, compared to the control (Figs. 15 &16). Flower bud formation was also increased by DAP treatment, compared to treatments without DAP (Table 1 and Figs. 17 & 18). The 2000 yield averaged 4551 lbs/acre greater in plots receiving DAP, compared to the control (Fig 19). Borate or Solubor did not enhance this effect.

Table 1. Effect of 1999 boron treatments on flower bud formation.

Treatment	Flower buds/stem	Flower buds/sq ft
Control	**1.14**	**146**
DAP	**1.81**	**266**
Borate	**1.15**	**167**
Borate + DAP	**1.56**	**189**
Solubor®	**1.32**	**161**
Solubor® + DAP	**1.62**	**178**
Contrasts	**Significance level**	**Significance level**
DAP vs No DAP	**0.5%**	**1.8%**
Boron vs No Boron	**NS**	**NS**
Boron vs Solubor®	**NS**	**NS**
Borate vs Borate + DAP	**6.5%**	**NS**
Solubor® vs Solubor® + DAP	**NS**	**NS**

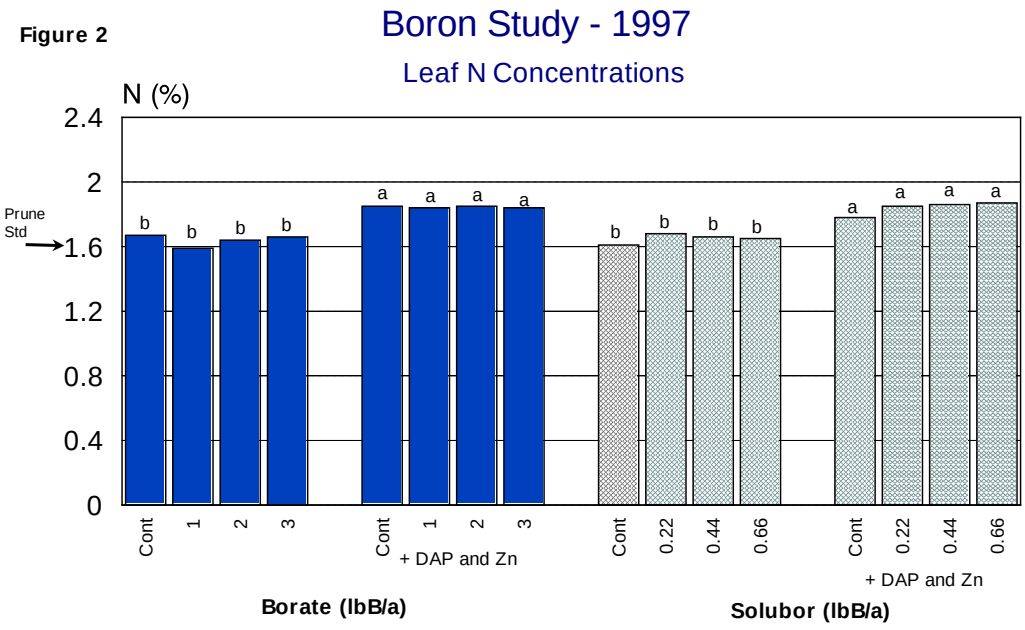
CONCLUSIONS: Spring frost damage in 1998 prevents conclusions about effect on yield of DAP and Zn plus borate or plus Solubor®. Leaf B concentrations can be raised in fields with B deficiency by either soil applied borate or foliar applied Solubor®. DAP and Zn treatments raised leaf N and P concentrations and resulted in taller stems. Under the conditions of this study, flower bud formation was increased by a combination of DAP plus Zn and 2 lb B/a borate or 0.66 lb B/a Solubor®. With no additional B applied in 1999, leaf B concentrations were slightly higher in soil treated and foliar treated plots than in controls suggesting a small carryover from 1997 applied B. In the 1999 study, borate was more effective in raising leaf B concentrations than Solubor®, but raising the leaf B above the standard had no effect on yield. The N and P from DAP appears to be having the major effect on stem growth, branching, flower bud formation, and yield.

Figure 1



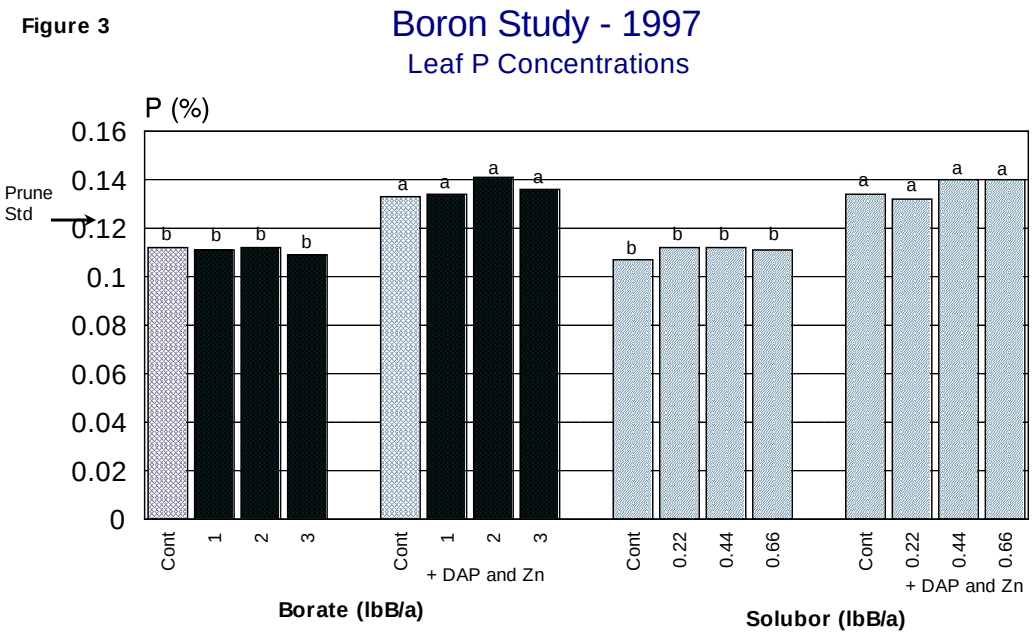
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 leaf B concentrations by Duncan's multiple range test, P = 0.01.

Figure 2



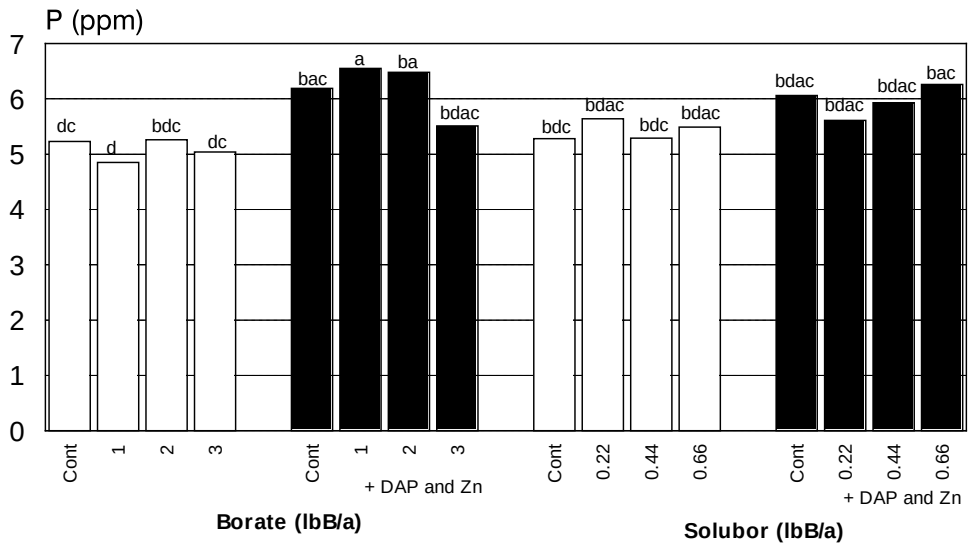
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 leaf N concentrations by Duncan's multiple range test, P = 0.01.

Figure 3



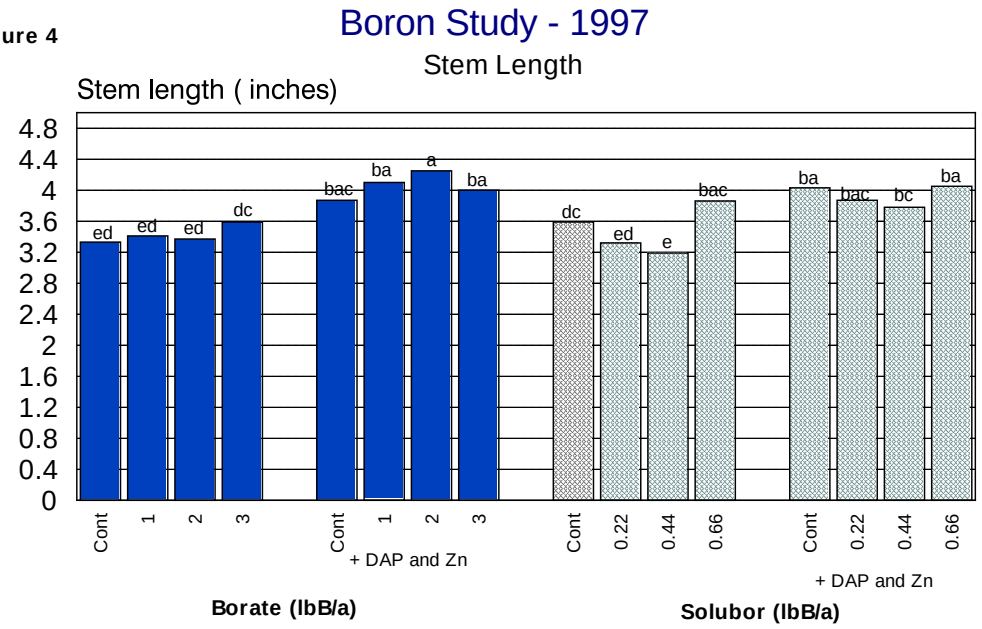
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 leaf P concentrations by Duncan's multiple range test, P = 0.01.

Figure 3b



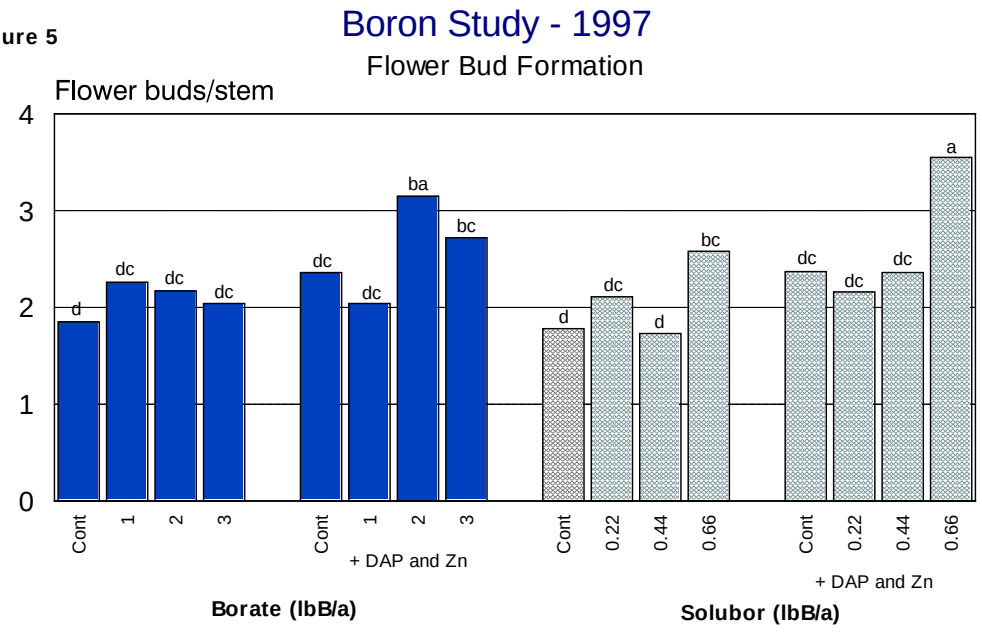
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 leaf P concentrations by Duncan's multiple range test, P = 0.01.

Figure 4



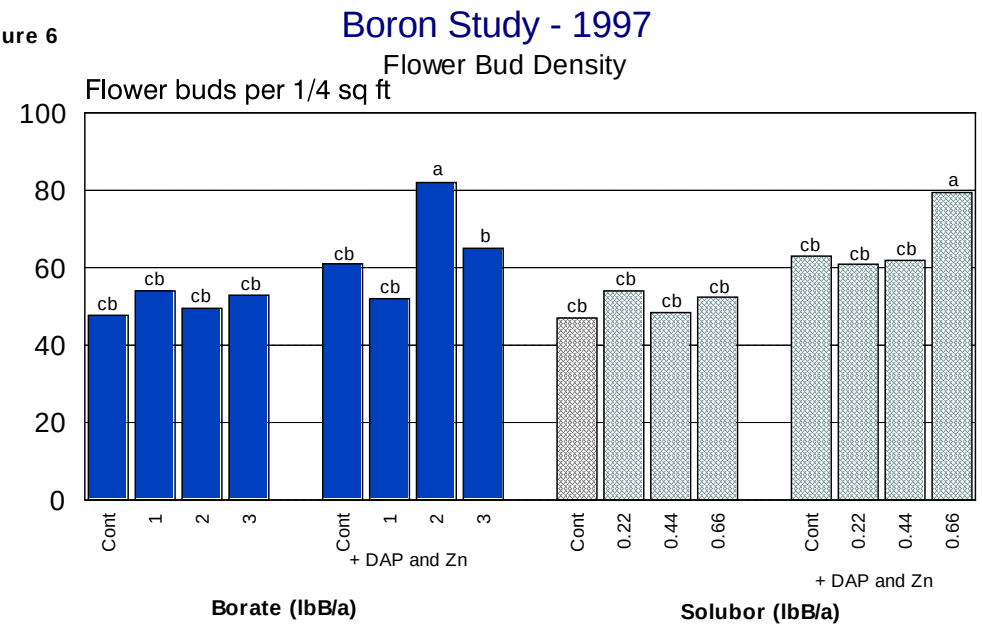
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 stem length by Duncan's multiple range test, P = 0.01.

Figure 5



DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 flower buds/stem by Duncan's multiple range test, P = 0.01.

Figure 6



DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 flower bud density by Duncan's multiple range test, P = 0.01.

Figure 7

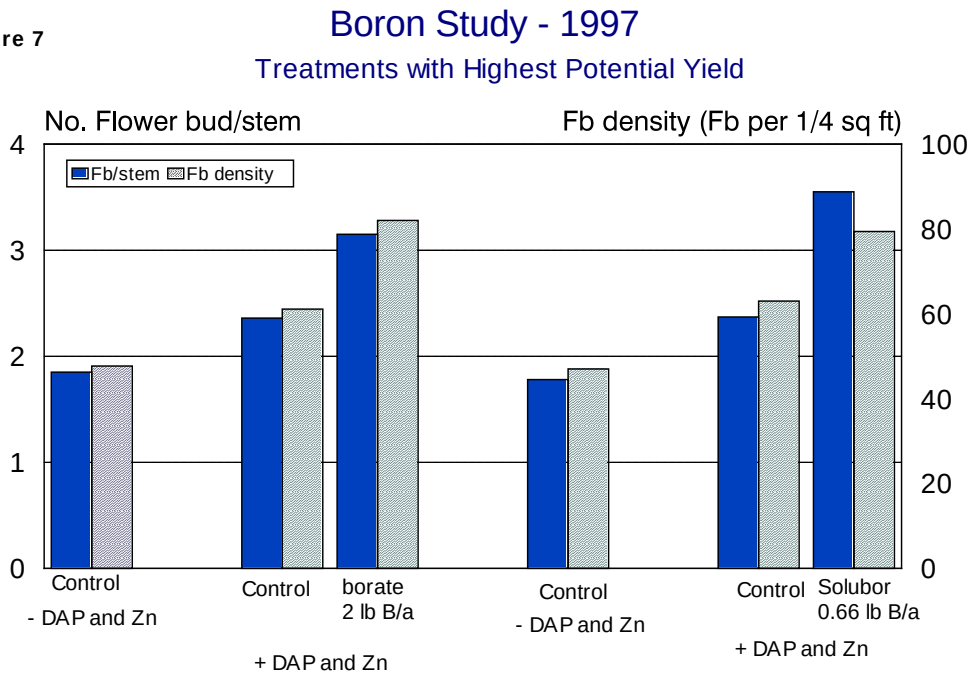
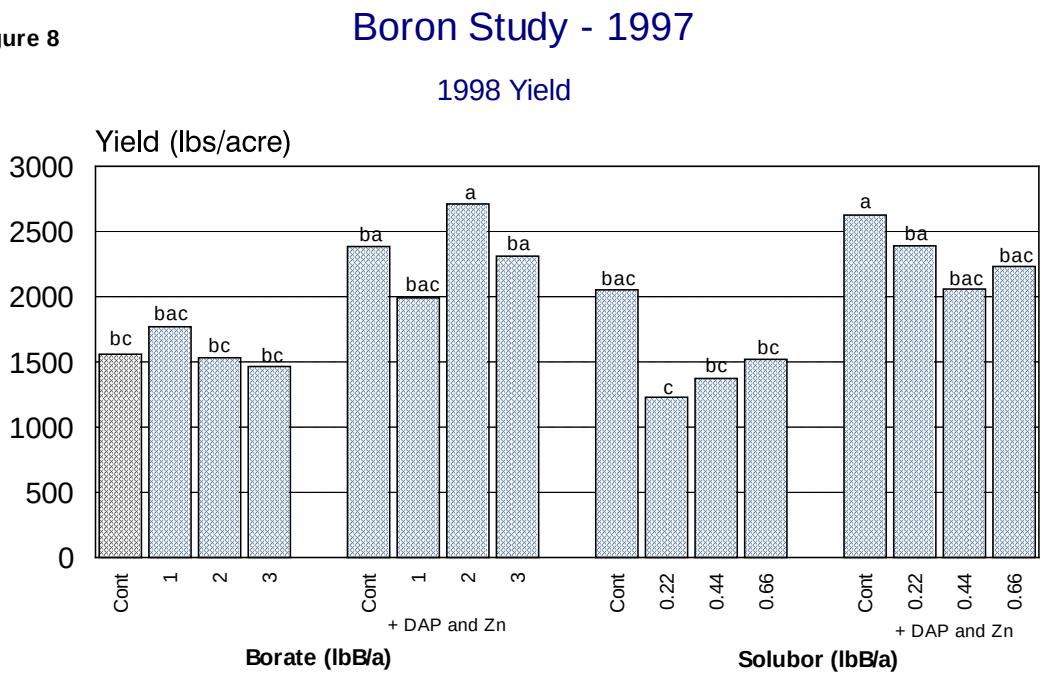
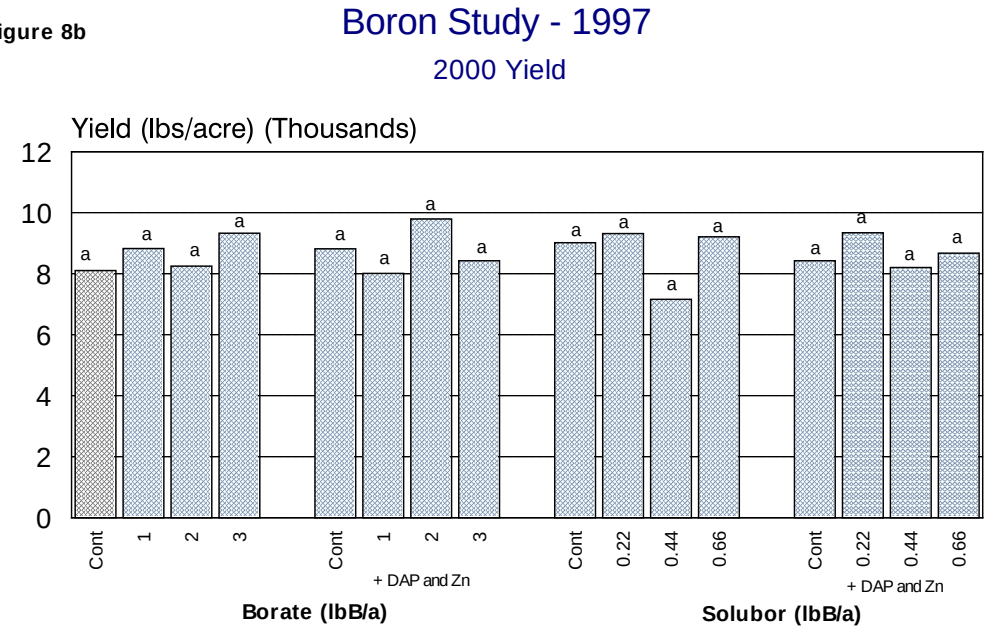


Figure 8



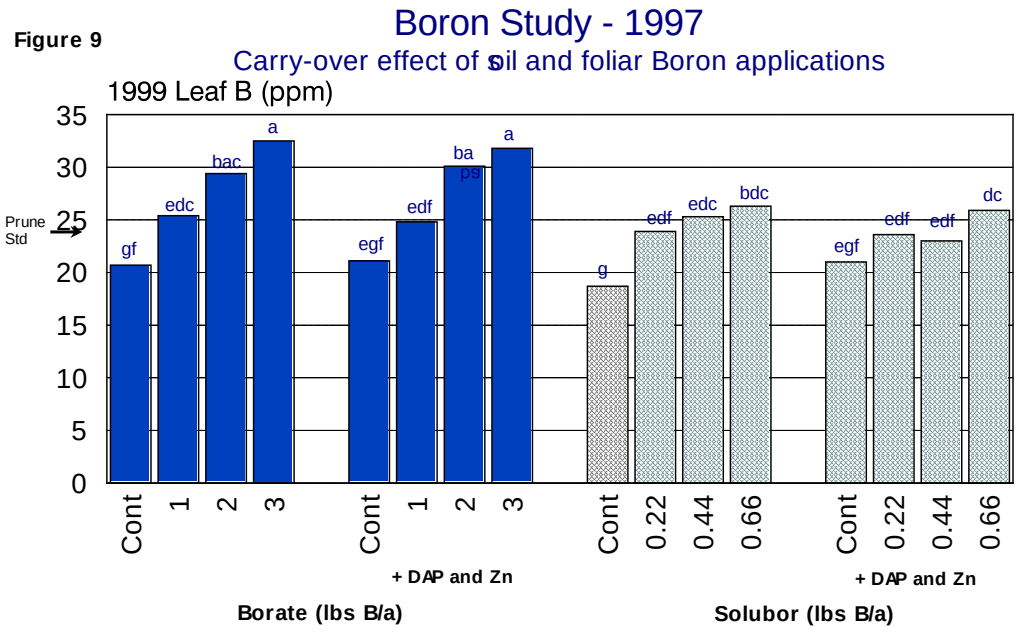
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1998 yield by Duncan's multiple range test, P = 0.01.

Figure 8b



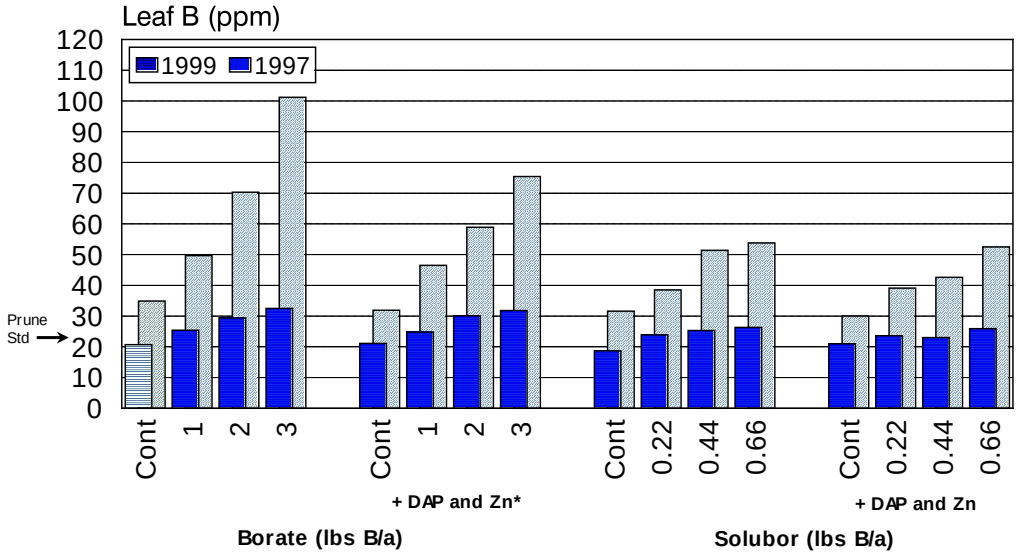
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1998 yield by Duncan's multiple range test, P = 0.5.

Figure 9



DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1999 leaf B concentrations by Duncan's multiple range test, P = 0.01.

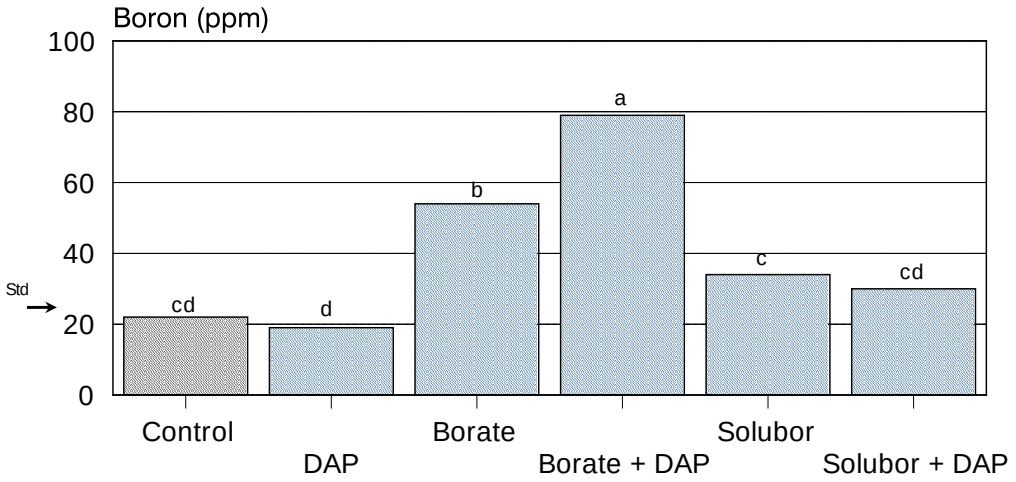
Figure 10



* DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a. Treatment in 1997 only. 1997 and 1999 treatment effects on leaf B concentrations significant at 1% level.

Figure 11

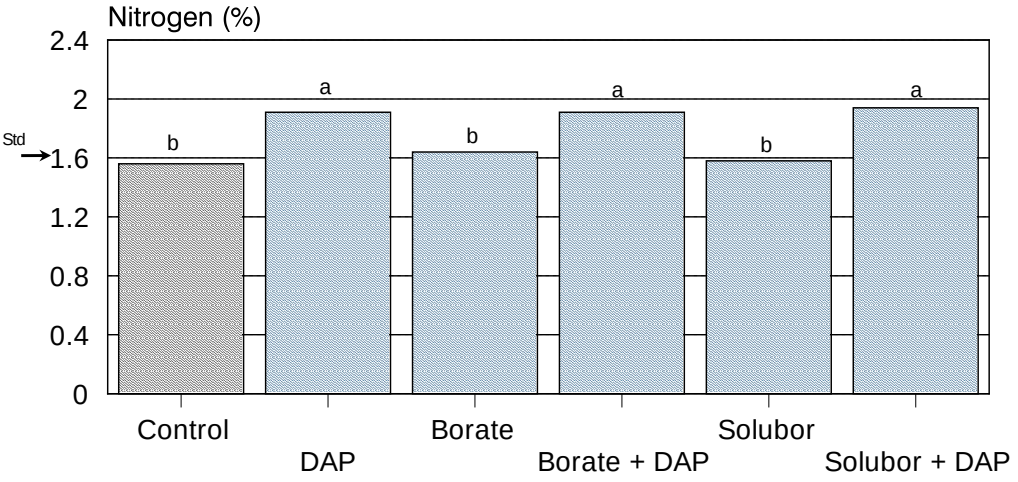
Boron Study- 1999
Leaf Boron Concentration



Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, .01% level.

Figure 12

Boron Study- 1999
Leaf Nitrogen Concentration

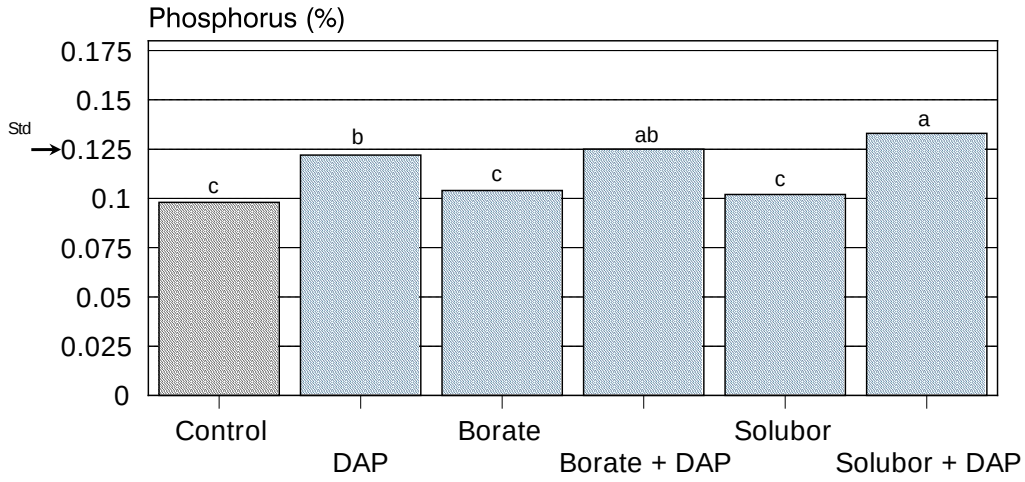


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, .01% level.

Figure 13

Boron Study- 1999

Leaf Phosphorus Concentration

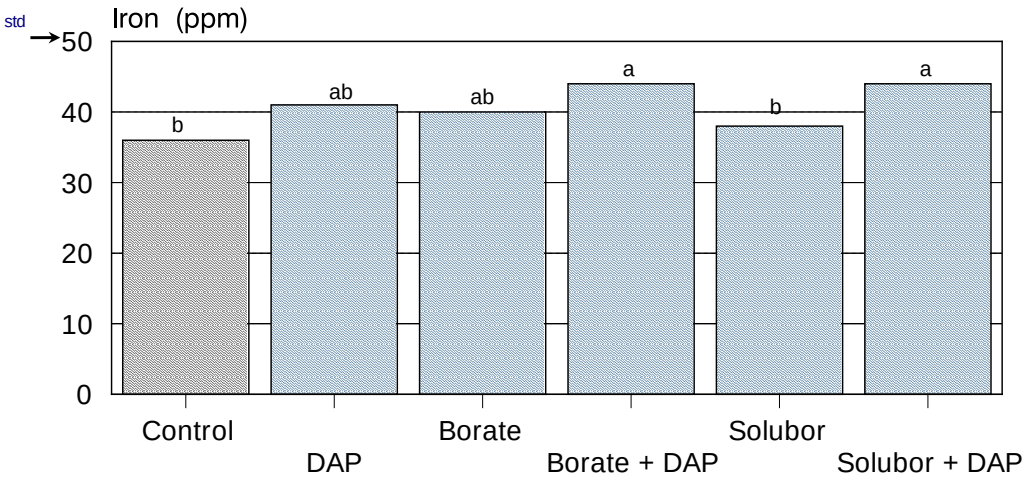


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, .01% level.

Figure 14

Boron Study- 1999

Leaf Iron Concentration

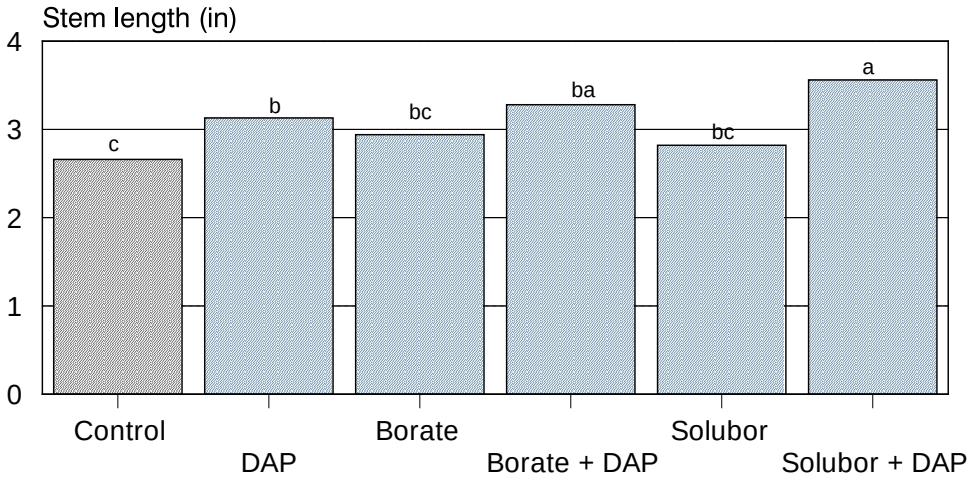


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, 5% level.

Figure 15

Boron Study- 1999

Stem length

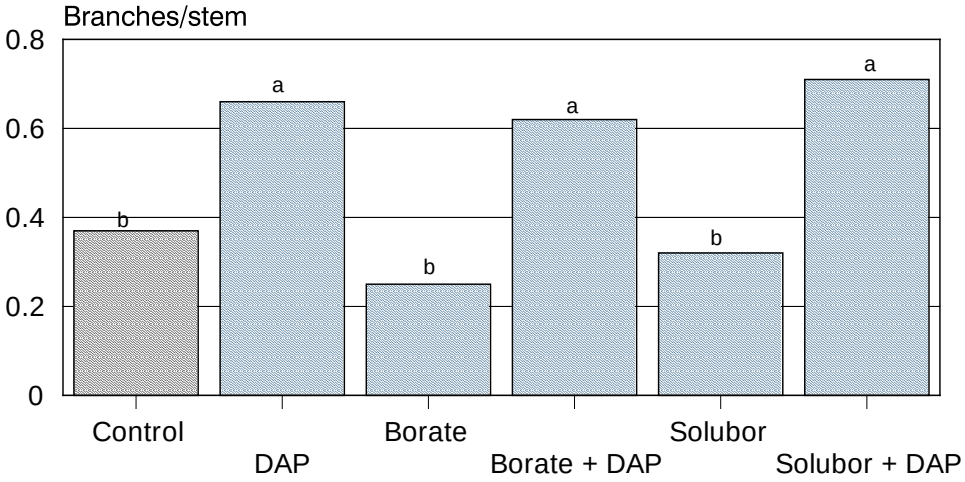


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, .01%level.

Figure 16

Boron Study- 1999

Stem branching

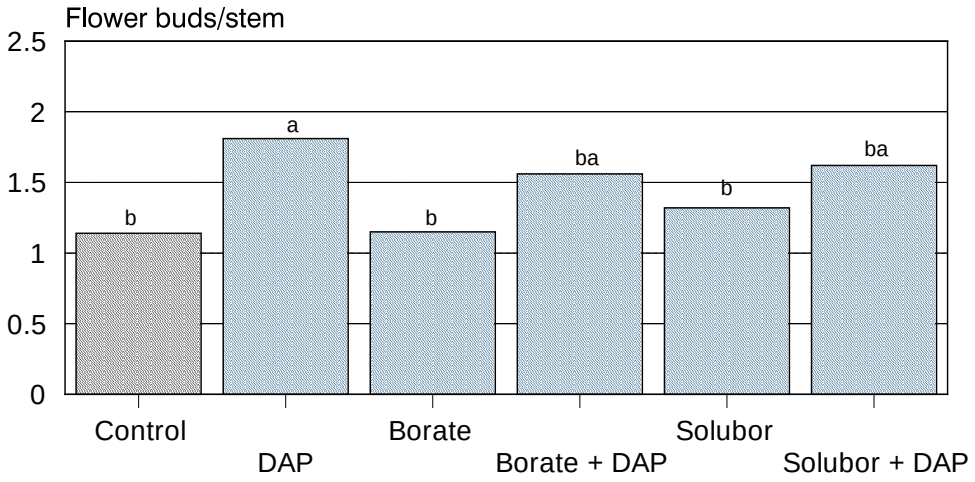


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, .01%level.

Figure 17

Boron Study- 1999

Flower bud formation

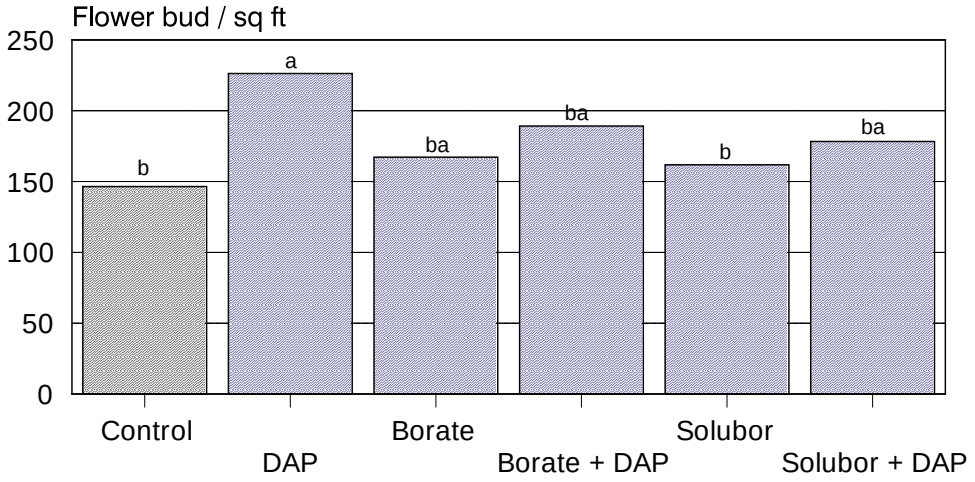


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, 5% level.

Figure 18

Boron Study- 1999

Flower bud density

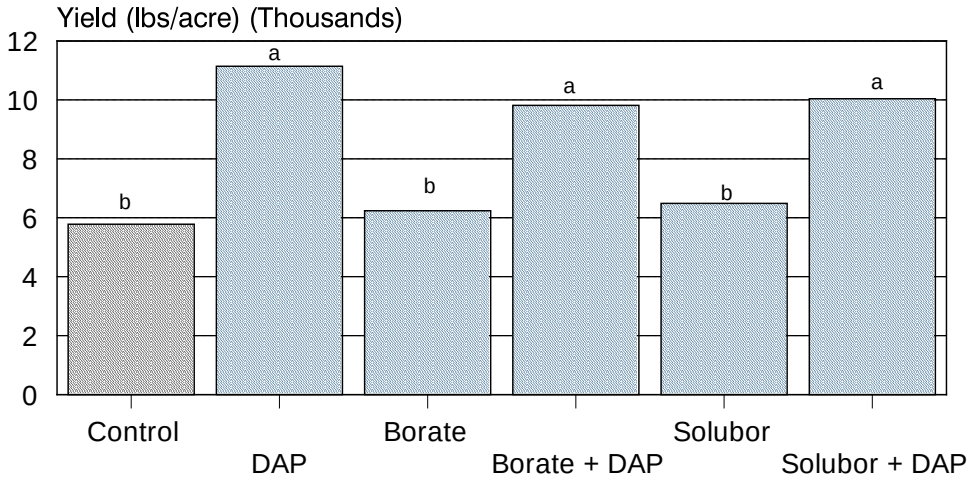


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. Mean separation by Duncan's Multiple range test, 5% level.

Figure 19

Boron Study- 1999

2000 Yield



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

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Adam Nielsen, Research Assistant
Stephenson NgaNga, Research Assistant
Tarsha Rideout, Research Assistant

3. TITLE: Effect of Foliar Iron and Copper Application on Growth and Yield of Lowbush Blueberries

OBJECTIVE: Determine the effect of raising leaf iron and copper concentrations on growth and yield of lowbush blueberries.

Brief justification

The standard set for iron (Fe) and copper (Cu) by Trevett in 1972 is 50 and 7 ppm, respectively. Many fields have leaf tissue concentrations below these concentration, so raising the leaf Fe and Cu concentrations to above the standard will test the accuracy of the standard and provide growers with information about methods to raise leaf Fe and Cu concentrations.

METHODOLOGY: A commercial lowbush blueberry field was selected in Beddington, Maine because 1998 leaf samples indicated a deficiency of Fe (32 ppm) and Cu (4.3 ppm). For Fe, the Ciba-Geigy product Sprint 330, containing 10% Fe (10% chelated iron) was applied as a foliar spray at 1 lb Fe/acre plus a wetting agent (Tween 20 at 1 pt/25 gal) to help ensure uniform distribution. Copper chelate (Miller Chemical and Fertilizer Corp., Hanover, PA) containing 14% Cu (chelated Cu, 14%) was applied as a foliar spray at 0.5 lb Cu/acre. As recommended by the manufacturer, urea at 5 lb/acre was added to the copper chelate solution. Treatment plots 6 ft x 50 ft received the following foliar sprays in June 20, 2000: 1 lb Fe/acre, 0.5 lb Cu/acre, 1 lb Fe/acre plus 0.5 Cu/acre. Three other plots will receive the same treatments in 2001, the crop year. Composite leaf samples were collected on July 14, 2000 for leaf nutrient analysis. Stem samples from 4 randomly placed ¼ ft^2 quadrats were collected in October 2000 for determining effect on stem length and branching and flower bud formation. Yield will be determined in 2001.

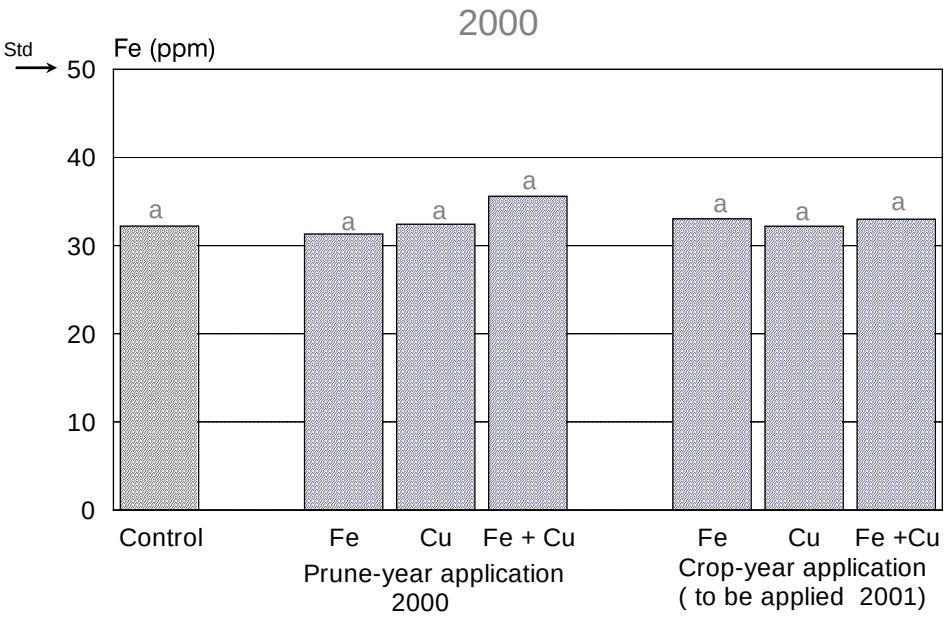
RESULTS: N and P concentrations were above the 1.6 ppm and 0.125% standards, respectively (data not shown). Leaf Fe concentrations were not increased by prune year application of Fe chelate at 1 lb Fe/acre (Fig. 1). Leaf Cu concentrations were raised by foliar sprays containing Cu but concentrations were not raised to the standard (7 ppm) (Fig. 2).

CONCLUSIONS: The accuracy of the Fe and Cu leaf standard were not tested because the leaf concentrations of these elements were not raised to the level of the standard by the treatments.

RECOMMENDATIONS: Study each element separately to determine the correct rate of chelate to raise each nutrient element in blueberry leaves to the standard, then repeat this study

Figure 1

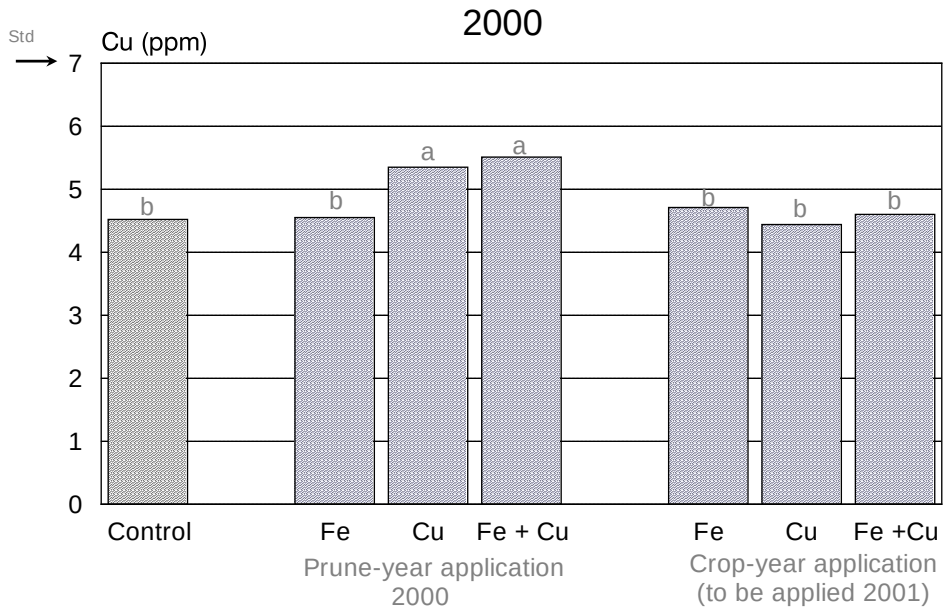
Effect of Prune-yearTreatments on Leaf Fe Concentrations



Fe applied as iron chelate micronutrient (10% Fe) at 1lb/acre. Cu applied as soluble chelated micronutrient (Cu 14%) at 0.5 lb/acre. Means not significantly different at 5% level.

Figure 2

Effect of Prune-yearTreatments on Leaf Cu Concentrations



Fe applied as iron chelate micronutrient (10% Fe) at .5 lbs/acre. Cu applied as Soluble chelated micronutrient (14% Cu) at 0.5 lb/acre, plus Urea (5 lbs/acre). Means significantly different at 0.01% level.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Adam Nielsen, Research Assistant
Stephenson NgaNga, Research Assistant
Tarsha Rideout, Research Assistant

4. 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.

METHODS: An experiment was established at two locations in 1994. Eight clones were selected at a field in Lamoine that had shown a history of low soil pH (3.9) and 8 clones were also chosen at a field in NO 14 TWP with a history of high soil pH (5.3). Within each clone, two 4 ft x 8 ft plots were established. One of these plots was a control while the other plot was to have its pH adjusted toward the optimum pH 4.8 recommended in Blueberry Fact Sheet No.220.

The field in NO 14 TWP was part of the Washington County Integrated Crop Management (ICM) program and soil test results indicated this field had a soil pH value of 5.3. The soil within clones but outside of treatment plots at the NO 14 TWP site was sampled in October 1994. Results indicated that pH averaged 4.75 for the 8 clones, much lower than expected. Since this was not the normal time of year to take soil samples for pH, it was felt that the pH would rise during the growing season and approach 5.3. The other treatment plots within each clone were treated in May 1995 with 450 lbs sulfur/acre to adjust the soil pH downward.

The pH of soils under the selected clones in Lamoine, assessed in May 1995, averaged 4.6, considerably higher than 4.0, so one of each pair of plots was treated with 700 lbs sulphur/acre to create a pH 3.9 treatment plot.

The difference in pH between that measured for previous samples and that measured in soil recently sampled raised questions. Was there an error in analysis? Soil samples taken in July 1993 as part of a phosphorus study indicated that the Lamoine field had a fairly uniform pH of 3.9-4.0. When some of these samples were reanalyzed for pH, the results were similar. Could the discrepancy be due to the time of the year that samples were taken? The NO 14 TWP soil, sampled in October 1994, had a lower pH than those sampled in July in the ICM program. This prompted a study of the change in pH over the course of the 1995 growing season. At both sites, soil pH was tracked biweekly from May 5 to October 20, 1995 by taking ten, 3-inch deep cores with a soil sample tube just outside the treatment plots to avoid affecting the plots themselves. Also, to determine the spatial variability in pH within a clone, two 3-inch cores were taken every 2 feet along a straight line in an East-West direction across the clones outside the plots in Lamoine.

In July 1995, leaf tissue samples and soil samples were taken in each plot at both locations to assess plant and soil nutrients.

Stem length measurements and flower bud counts were made on stems cut from within one randomly selected 4 in x 2 ft quadrat in each treatment plot in November 1995. A non-destructive count of stem density was also made in each of three randomly selected 4 in x 1 ft permanent quadrats. The destructive sampling each prune year will avoid a previous sample

location and be taken at least 4 inches from the other samples.

Pretreatment yield was collected in August 1994 and the effect of treatment on yield was determined in August 1996 and 1998 and will be collected again in 2000.

RESULTS: August 1994 yields of the two 4 ft x 8 ft plots within each clone revealed large differences in yield from clone to clone and considerable differences within clones (Figs. 1 & 2). The average August 1994 yield of all clones at the high pH NO 14 TWP field was 8,290 lb/acre compared to 6,077 lb/acre at the low pH Lamoine field. Yields from the entire field would likely be lower than these figures since clones were selected for good cover, minimal weeds and no apparent pest damage. As did yield, the availability of soil mineral nutrients varied widely over the 16 clones of the study at the two locations (Tables 1 & 2).

Table 1

S

L

C	p	C	K	M	P	A	C	F	M	Z
8	4	7	3	2	1	3	0	2	2	1
7	4	1	3	2	1	3	0	3	1	2
6	4	1	5	2	1	4	0	2	2	2
5	4	1	5	2	1	4	0	2	2	2
4	4	2	5	4	1	3	0	3	2	2
3	4	1	4	3	1	3	0	2	1	1
2	4	1	4	2	1	3	0	2	1	1
1	4	9	5	2	1	3	0	3	1	1

Table 2

S

N

C	b	C	K	M	P	A	C	F	M	Z
1	4	5	6	1	1	2	0	1	3	1
2	4	3	5	6	1	3	0	1	3	1
3	4	3	4	6	1	3	0	1	3	1
4	4	3	5	5	1	2	0	1	3	1
5	4	2	4	4	1	3	0	1	3	1
6	4	2	5	5	1	3	0	1	3	2
7	4	1	5	3	1	3	0	1	2	1

The soil pH at each location varied from clone to clone (Figs. 3 & 4). This reinforces the need for blueberry growers to take a large number of samples to get a true representation of the pH in their field.

How does the pH vary across a clone? When soil samples taken 2 ft apart along a transect on one side of the clones in Lamoine were compared to those taken from the other side (about 10 ft apart), we found the pH fairly uniform. For all the clones, the pH varied by .04 pH units from one side to the other. Along the transect the pH variation was also about .04. These are very minor compared to the differences among clones, which were scattered over this 5 acre field.

Did the pH vary over the growing season? A change in pH was found during the growing season (Fig. 5) and this reinforces the need to be consistent in the time that soil samples are taken. The current recommendations are that soil samples be taken at the tip dieback stage of growth which occurs the last week of June or the first week of July, depending upon the weather.

Destructive and non-destructive stem samples taken in 1995 characterized the clones used in this study but no changes in stem characteristics were brought about by pH adjustment treatments. This was expected as pH adjustment in an unplowed soil is slow due to the high organic matter content. No pH differences were found between the control and treatment plots in the NO 14 TWP field, while only a small decrease (0.09 pH unit) was found in the treatment plots at the Lamoine field, sampled in July 1995 (Table 3).

Table 3

Soil pH, July 1995		
Treatment	Lamoine	No 14 TWP
Control	4.24 a	4.65 a
Sulphur	4.15 b	4.65 a

Non-destructive stem density measurements gave a range of 50 to 95 stems/ft^2 among the clones in the NO 14 TWP field and 131 to 192 stems/ft^2 among the clones in the Lamoine field (Table 4). Destructive stem density measurements gave similar results. The average stem height ranged from 4.0 to 6.8 inches and fruit bud formation ranged from 1.2 to 3.8 buds/stem among

the clones in the NO 14 TWP field. In the Lamoine field, average stem height ranged from 3.0 to 5.3 inches and fruit bud formation ranged from 0.4 to 2.0 among the clones. While stem density was considerably higher in the Lamoine field, stem height and the number of fruit buds/stem were lower. Stem density, measured by non-destructive counts, was no different between control and sulphur treated plots (Table 5). Stems cut from randomly selected sub plots (destructive samples) for stem density, length and fruit bud counts also showed no difference between control and treatment plots (Table 5). These base line data will be valuable in assessing the effects of future soil pH changes.

Table 4
October1995 stem characteristics of non-destructive and destructive samples among clones.

	Non-destructive				Destructive					
	Stem density (sq ft)				Stem density (sq ft)		Length (in)		Fb/stem	
Clone	Lamoine	NO 14 TWP			Lamoine	NO 14 TWP	Lamoine	NO 14 TWP	Lamoine	NO 14 TWP
1	151	68			118	53	3.7	5.2	1.1	2.3
2	164	78			126	73	3.3	4.0	1.1	2.6
3	131	82			99	50	5.0	5.6	2	3.5
4	158	50			143	30	5.3	6.8	0.7	4
5	159	77			179	72	3.0	4.7	1.6	3.4
6	165	95			243	84	3.7	6.0	0.8	3.8
7	192	73			206	90	3.8	4.8	0.4	1.2
8	134	68			120	80	4.2	5.9	1.7	1.5

Table 5
October 1995 stem characteristics of non-destructive and destructive samples, as affected by sulphur treatment.

	Non-destructive			Destructive					
	Stem density (sq ft)			Stem density (sq ft)		Length (in)		Fb/stem	
Treatment	Lamoine	NO 14 TWP		Lamoine	NO 14 TWP	Lamoine	NO 14 TWP	Lamoine	NO 14 TWP
Control	155 a	76 a		150 a	65 a	4.2 a	5.5 a	1.4 a	2.7 a
Sulphur	159 a	71 a		158 a	63 a	3.8 a	5.3 a	1.0 a	2.8 a

Leaf samples taken in July 1995 showed no differences in leaf nutrient concentrations between pH-adjusted and non-adjusted plots at both sites.

An extremely wet spring in 1996 resulted in fungal disease in some clones at the NO14 TWP field, so berry yield was not taken from the affected clones. The yield was not influenced by pH adjustment treatments at either Lamoine or NO 14 TWP (Fig. 6).

1997 Results

Management problems at the NO 14 TWP site (poor weed control, extremely late pruning, and destruction of treatment plots by rock removal activity) resulted in our **abandoning this site**. Soil samples taken in July 1997 to monitor changes in pH at Lamoine indicated that

pH of soil beneath the 8 sections of clones treated with sulphur was not different from the untreated soil in adjacent plots (Table 6). July 1997 leaf samples from treatment plots at the Lamoine site indicated that N, P, K concentrations were raised by sulphur treatment and Ca and B concentrations were lowered by this treatment (Table 6).

Table 6. July1997 soil pH and leaf nutrient concentrations at Lamoine as affected by sulphur treatment. .

Treatment	Soil pH	Leaf nutrient concentrations				
		N (%)	P (%)	K (%)	Ca (%)	B (ppm)
Control	4.24 a	1.62 b	0.114 b	0.493 b	0.431 a	32 a
Sulphur	4.06 a	1.68 a	0.121 a	0.575 a	0.413 b	29 b

Stem samples were taken in October 1997 because leaf sample data suggested significant change in leaf nutrient concentrations and a possibility that stem characteristics and density could be affected by the sulphur treatment. Stem characteristics were not, however, affected by sulphur treatment (Table 7).

Table 7. October 1997 stem characteristics of non-destructive and destructive samples at Lamoine as affected by sulphur treatment.

	Non-destructive	Destructive		
Treatment	Stem density (no stems/sq ft)	Stem density (no stems/sq ft)	Stem length (in)	Flower buds/stem
Control	144 a	129 a	4.0 a	1.7 a
Sulphur	138 a	120 a	3.7 a	2.0 a

1998 Results

The pH of soil samples taken in July 1998 indicate that the pH of control plots continues to increase and the pH of sulphured plots continues to decrease (Fig. 7).

Yield data taken in Lamoine in 1998 (Fig. 8) showed no difference between sulphured and nonsulphured plots. The 1996 Lamoine yield is also given for comparison. The yield variation (1994,1996, and 1998) among the control and sulphur-treated plots within the 8 clones in Lamoine is presented in Figure 9. It indicates that weather affects yield far more than does pH adjustment with sulfur.

1999 Results

Leaf tissue analysis indicated no significant difference between the control and sulphur treated plots in 1999 (table 8). Soil data indicated a significant difference in pH between the control and sulphur treated plots (table8).

Table 8. July1999 soil pH and leaf nutrient concentrations at Lamoine as affected by sulphur treatment. .

Treatment	Soil pH	Leaf nutrient concentrations				
		N (%)	P (%)	K (%)	Ca (%)	B (ppm)
Control	4.28 a	1.98 a	0.133 a	0.474 a	0.405 a	27 a
Sulphur	4.08 b	1.99 a	0.137 a	0.497 a	0.396 a	25 a

Stems cut from within 4 inch x 2 ft quadrats indicated no difference in density of emerging stems, stem length, branching, or flower bud formation between the control and Sulphur treated plots (Table 9).

Table 9. October 1999 stem characteristics of destructive samples at Lamoine as affected by sulphur treatment.

Treatment	Stem characteristics			
	Stem density (no stems/sq ft)	Stem length (in)	Stem branches	Flower buds/stem
Control	138 a	4.05 a	1.06 a	1.82 a
Sulphur	132 a	4.41 a	1.31 a	1.78 a

2000 Results

The 2000 yield was not different between treatment plots (Fig. 8).

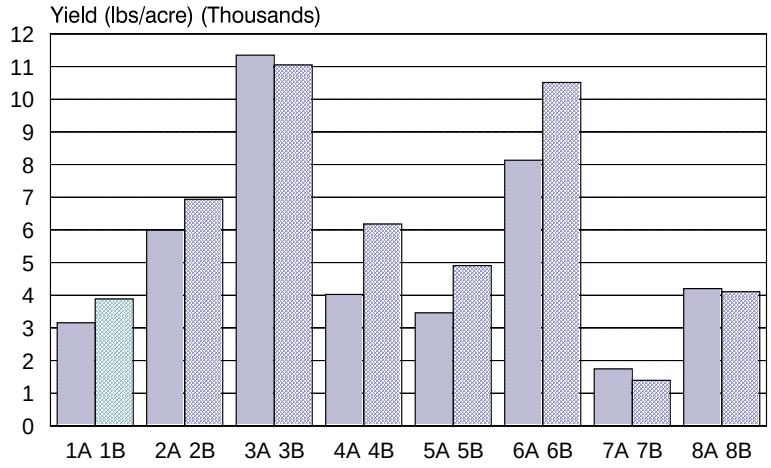
CONCLUSIONS: No conclusions can be made from this study because pH was not significantly different between treatment plots in this study.

RECOMMENDATIONS: No recommendations can made at this time.

Figure 1

YIELD DATA COMPARSION OF TREATMENT PLOTS

Lamoine

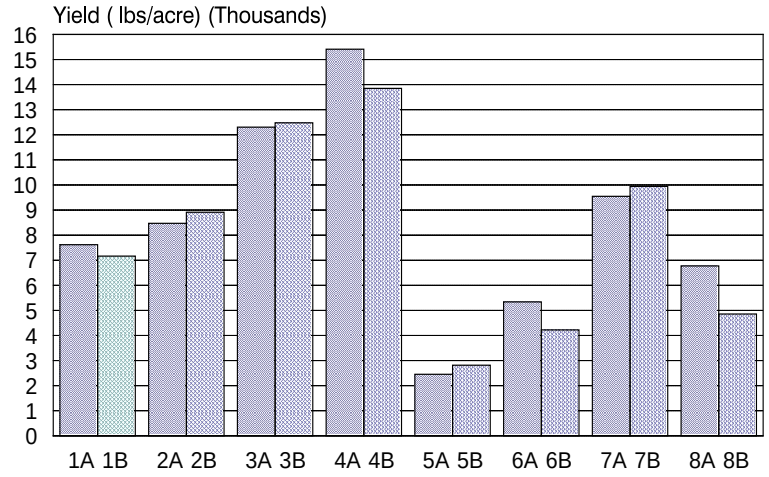


1994

Figure 2

YIELD DATA COMPARSION OF TREATMENT PLOTS

NO 14 TWP



1994

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Figure 3

VARIATION OF pH AMONG CLONES

LAMOINE

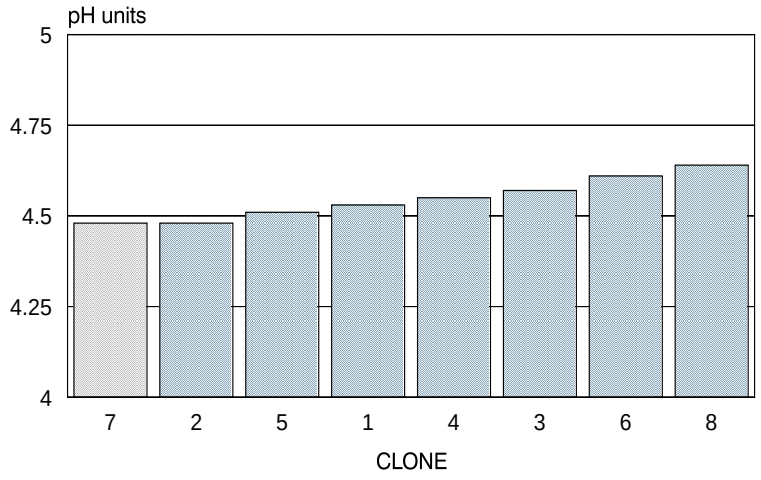


Figure 4

VARIATION OF pH AMONG CLONES

NO 14 TWP

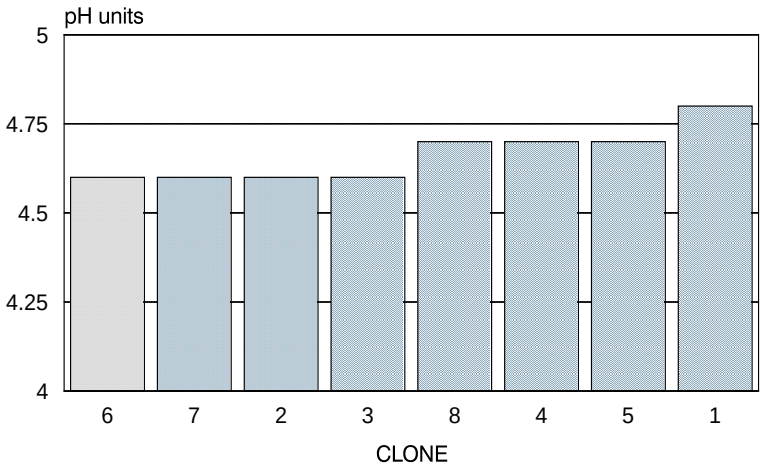


Figure 5

CHANGE IN pH DURING GROWING SEASON

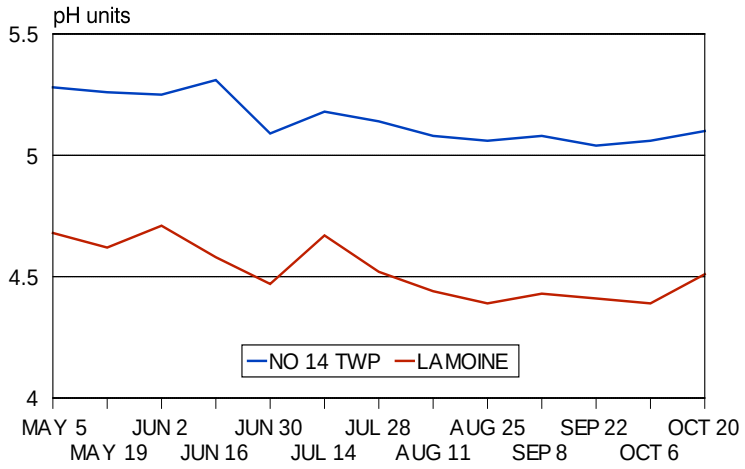
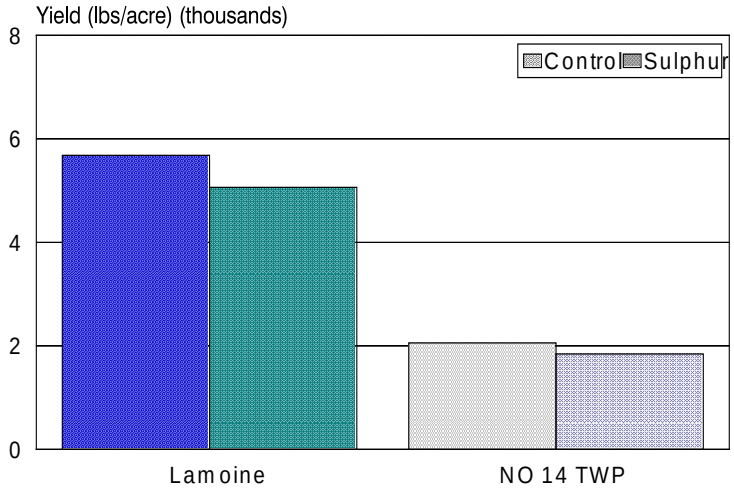


Figure 6

1996 Yield

Average Yield at Lamoine and NO 14 TWP

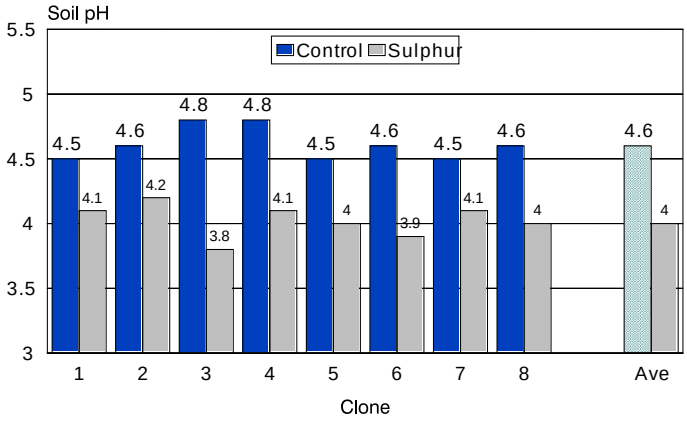


No significant difference betw een treatments at either location

Figure 7

Soil pH

Litten Field, Lamoine

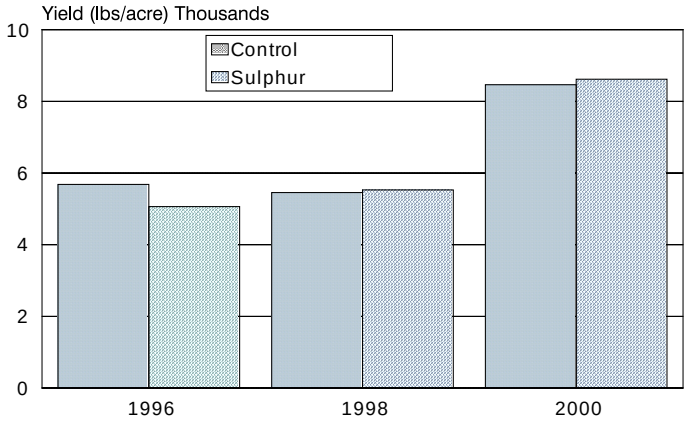


1998 data

Figure 8

1996, 1998 and 2000 Yield

Lamoine

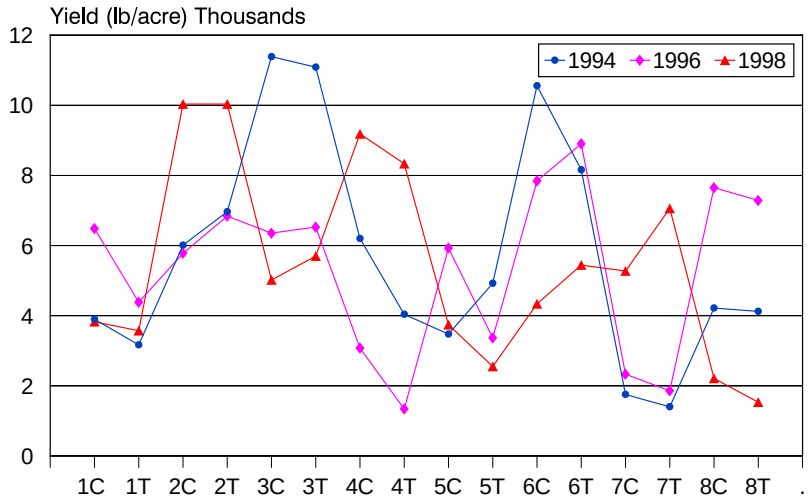


Average yield of 8 clones. No significant difference between control and sulphur treament in either 1996,1998 or 2000.

Figure 9

Comparison of Treatment Plot Yield Data over Time

Lamoine



C = control, no sulphur; T= treatment w ith sulphur.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Adam Nielsen, Research Assistant
Stephenson NgaNga, Research Assistant
Tarsha Rideout, Research Assistant

5. TITLE: Effect of **Nutri-Phite**[tm] P+K on Growth and Yield of Lowbush Blueberry.

OBJECTIVE: To evaluate the effectiveness of Nutri-Phite[tm] P+K on growth and yield of wild blueberry.

Phosphorus deficiency is wide spread among the acid soils of eastern Maine and correcting this deficiency with phosphorus containing soil applied fertilizers has increased leaf P concentrations and yield. Nutri-Phite[tm] P+K contains a readily absorbed form of phosphorus (phosphite), reported to increase leaf P when applied to foliage of plants and to increase critical biochemical pathways important to growth and yield. This material was tested at manufacturers recommended rates, following the application of DAP at a rate expected to correct leaf P deficiency in lowbush blueberry.

METHODOLOGY: A field was selected in Appleton, Maine in 2000 which had low leaf N and P concentrations in 1997 leaf samples. Hexazinone was applied in 1999 to control herbaceous flowering weeds and some grasses. The following fertilizer treatments were applied in 1999 to 5 ft by 50 ft treatment plots:

1. Control
2. 80 lbs P from DAP
3. 80 lbs P from DAP plus Nutri-Phite[tm] P+K at 2 pt/acre
4. 80 lbs P from DAP plus Nutri-Phite[tm] P+K at 4 pt/acre

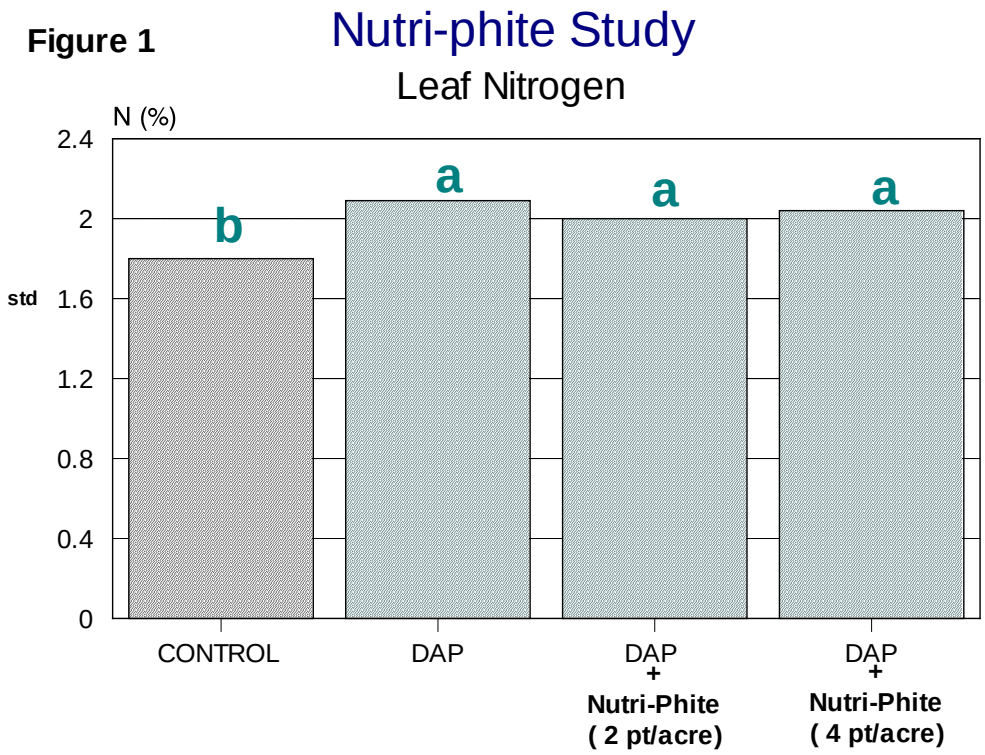
A randomized complete block design was used with 6 blocks. DAP was applied using a hand spreader on May 21, 1999 and Nutri-Phite[tm] P+K (0-28-26) was applied in a spray volume of 57.5 gal/acre on June 17, 1999. Leaf nutrient concentrations were determined by analyzing composite leaf samples taken from 50 randomly sampled stems per plot on July 6, 1999. Growth characteristics (including stem height, branching and flower bud formation) are being measured on stems cut at ground level in four ¼ ft^2 quadrats per treatment plot on November 5, 1999. Fruit yield was determined in August 2000.

RESULTS: Leaf N and P concentrations were raised by DAP with or without Nutri-Phite[tm] P+K, compared to the control (Figs. 1 & 2). Leaf P in control plots was below the 0.125% standard and above the standard in treatment plots receiving DAP with or without Nutri-Phite[tm] P+K. Leaf K was above the .400% standard in control plots and not affected by any treatment (Fig. 3). Leaf Cu and Mn concentrations were lowered by all treatments containing DAP, presumably by a dilution effect as growth of stems and leaves was increased (Fig. 4).

Observations in August revealed differences in plant cover in plots receiving DAP or DAP plus Nutri-Phite[tm] P+K, compared to the controls . Stem density (stems/ft^2), and stem length were not affected by treatments (Figs. 5 & 6). However, DAP or DAP with 2 or 4 pt Nutri-Phite[tm] P+K increased branching (Fig. 7), resulting in a greater plant cover appearance.

This increased cover implies more leaf area to undergo photosynthesis. Flower buds per stem were increased by DAP and DAP plus Nutri-Phite[tm] P+K at 2 pt/acre (Fig. 8). Flower bud density (flower buds/ft^2) was increased by DAP, DAP plus Nutri-Phite[tm] P+K at 2 pt/acre, and DAP plus Nutri-Phite[tm] P+K at 2 pt/acre (Fig. 9). DAP raised yields by about 4 to 5 thousand pounds per acre. Nutri-Phite[tm] P+K at either rate did not enhance the effect of DAP on Yield.

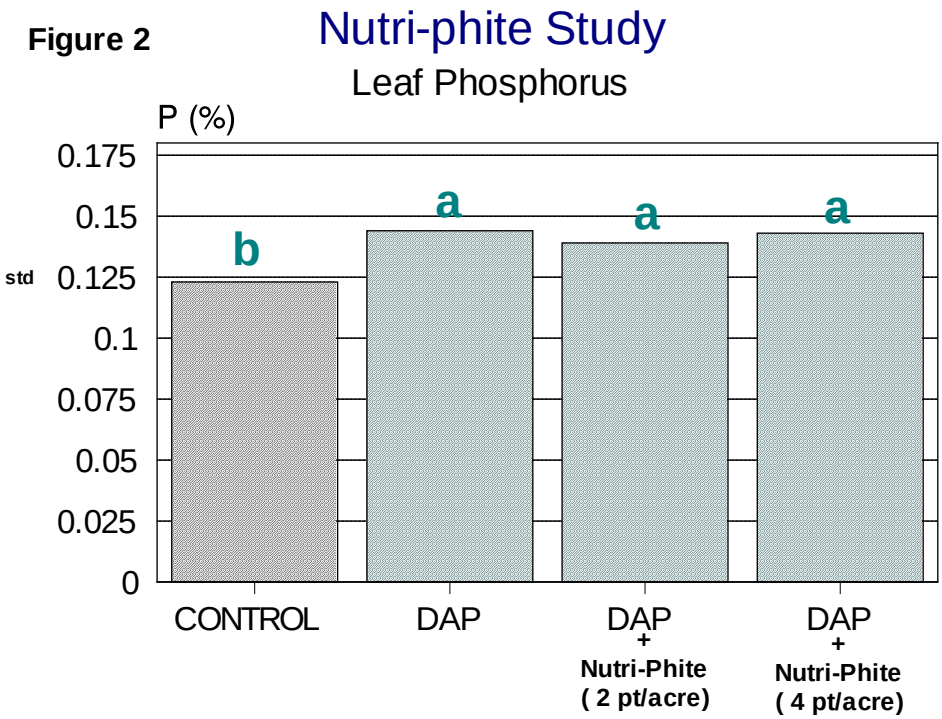
Figure 1



Mean separation by Duncan's Multiple range test, 1% level, DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

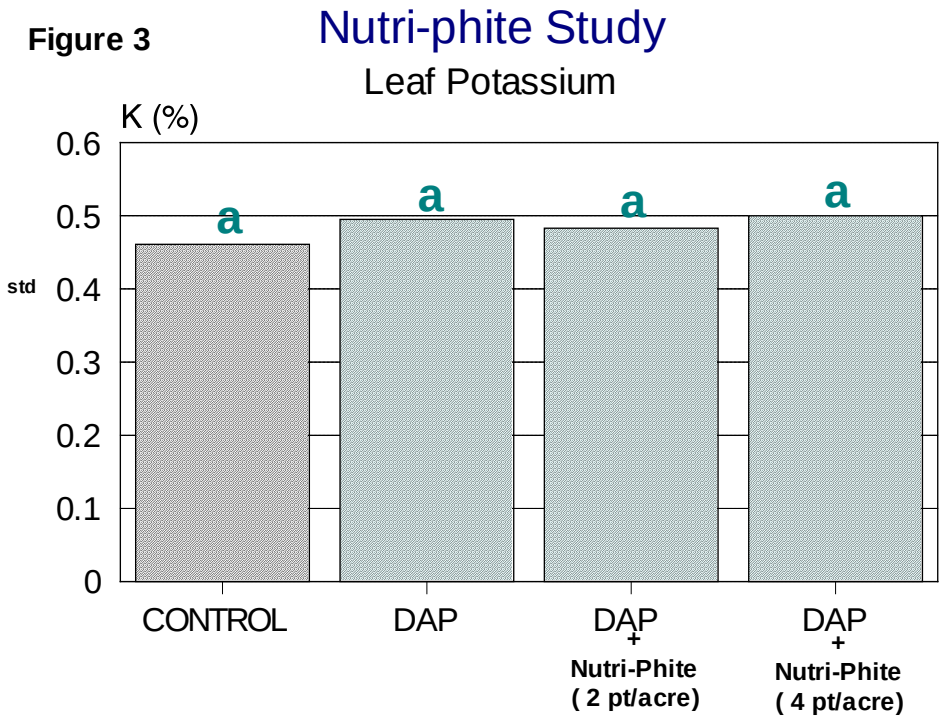
CONCLUSIONS: Correcting P deficiency with DAP resulted in an increase in potential yield (density of flower buds per unit area) and actual yield harvested in August 2000. Nutri-Phite[tm] P+K was not effective in raising leaf P concentration nor yield.

Figure 2



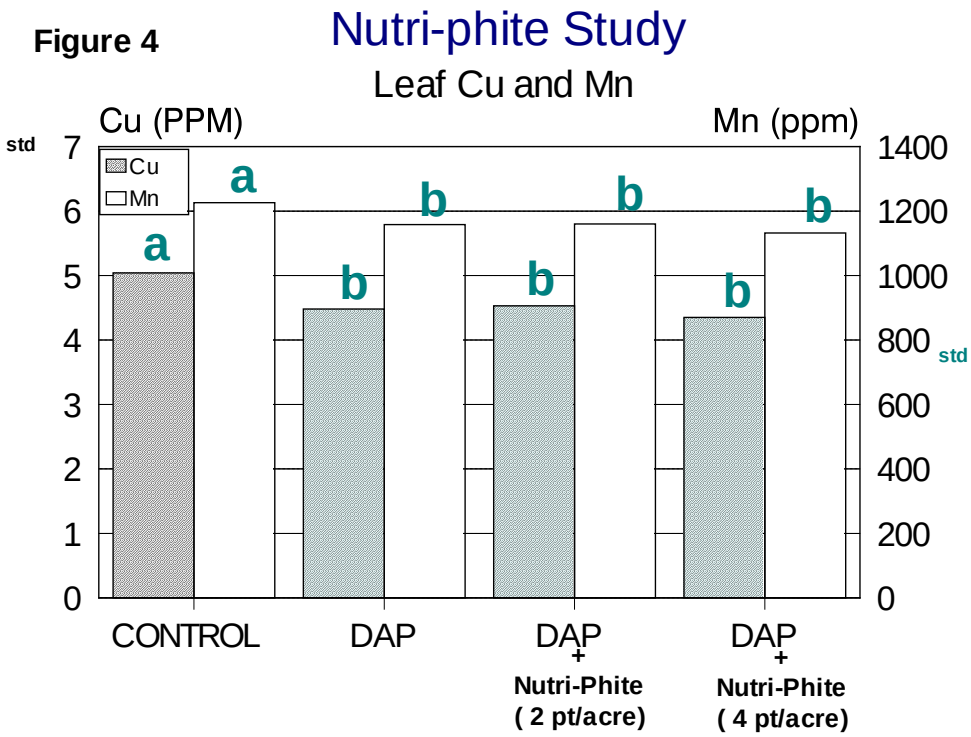
Mean separation by Duncan's Multiple range test, 1% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 3



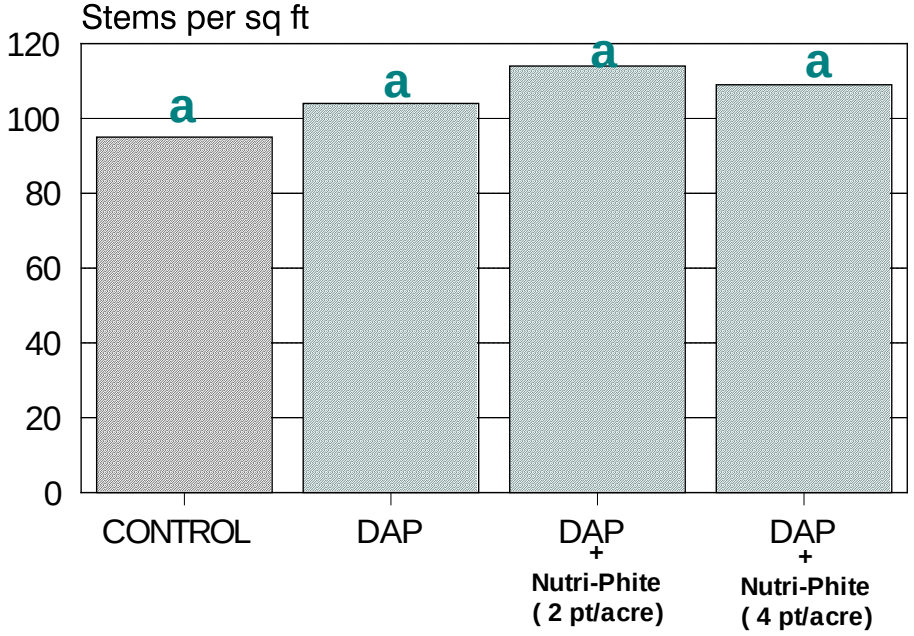
Mean separation by Duncan's Multiple range test, 5% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 4



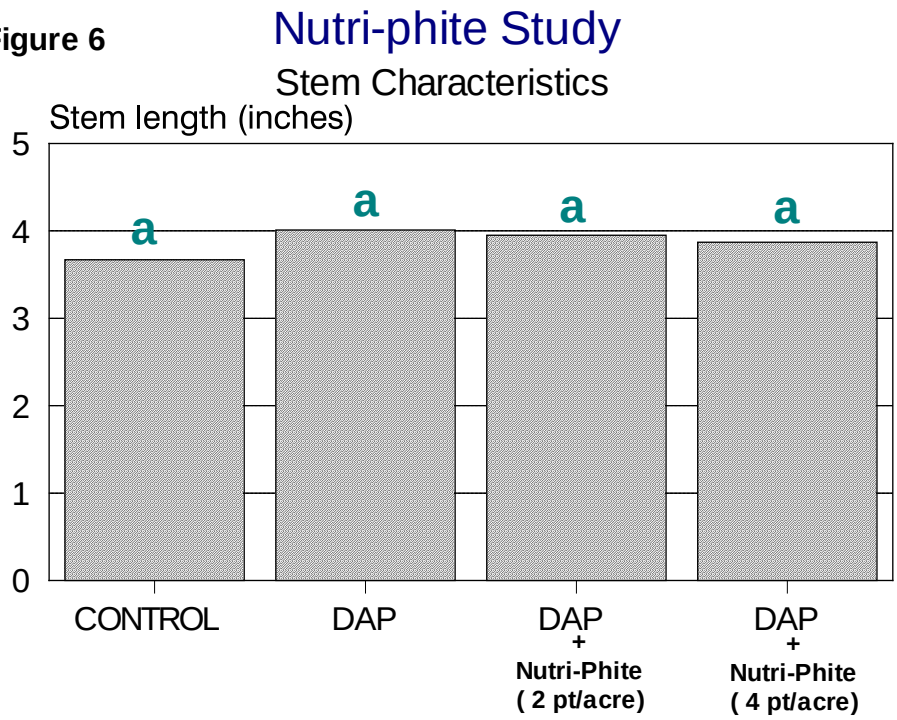
Mean separation within element by Duncan's Multiple range test, 1% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 5



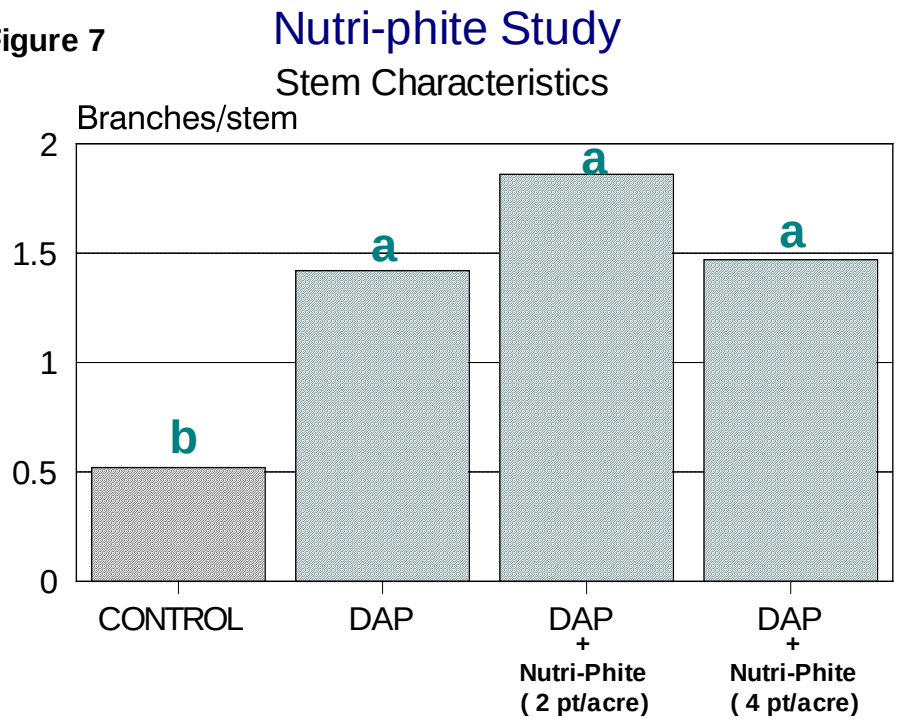
Mean separation by Duncan's Multiple range test, 5% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 6



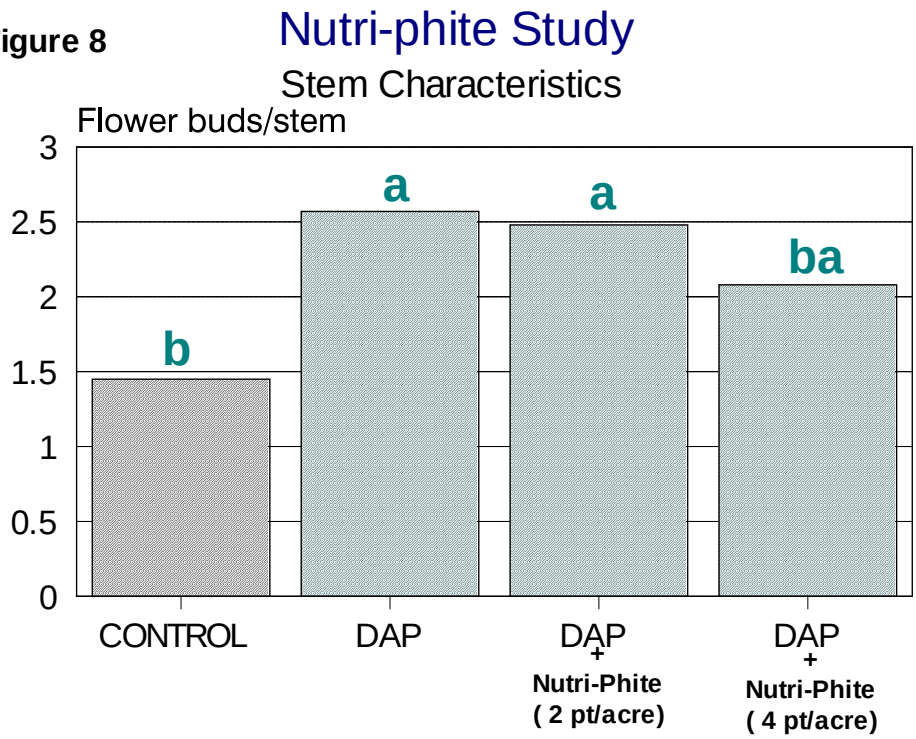
Mean separation by Duncan's Multiple range test, 5% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 7



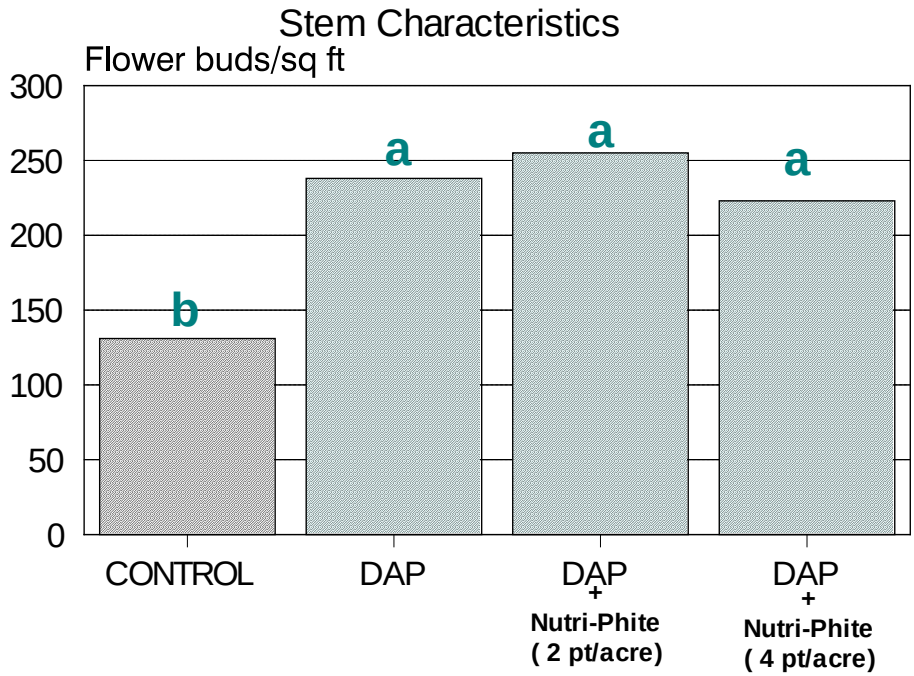
Mean separation by Duncan's Multiple range test, .01% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 8



Mean separation by Duncan's Multiple range test, 1% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 9



Mean separation by Duncan's Multiple range test, 0.1% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Adam Nielsen, Research Assistant
Stephenson NgaNga, Research Assistant
Tarsha Rideout, Research Assistant

6. TITLE: Effect of Fertilizer Timing on Lowbush Blueberry Growth and Productivity.

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

Fertilizer Timing Study I (1998)

METHODOLOGY: Two locations were used in this study; Location 1 in Lincoln County with a heavier soil and location 2 in Washington County with a typical gravelly, sandy loam soil. At both locations, fertilizer was applied according to the University of Maine Analytical Lab recommendations based on leaf tissue samples submitted in July 1996. Fertilizer recommendations were: at location 1, 80 lbs P/acre from MAP and at location 2, 80 lbs P/acre from DAP. These were applied to 5 ft x 50 ft treatment plots in pruned fields on May 19, June 2, June 16 or June 30, 1998. At each location an unfertilized plot served as a control. A split application of half the recommended fertilizer rate on May 19 and June 16 was included as a sixth treatment at each location. Treatments were replicated 8 times at each location.

To determine the effect of timing on nutrient uptake, leaves were randomly sampled from all treatment plots at tip dieback during the first week in July 1998. Soil samples were also taken at this time. Stems were sampled from each treatment plot by cutting all stems at ground level in four ¼ ft^2 quadrats in October 1998 to determine treatment effects on stem density, stem length, and flower bud formation and harvest yields were measured in August 1999.

RESULTS:

Location 1

N and P leaf concentrations were affected by the date of fertilizer application (MAP at 80 lbs P/acre) at location 1 (Figs. 1 & 2). All fertilizer applications increased the leaf N concentrations compared to the controls (Fig. 1). Leaf N concentrations in leaf samples from control plots averaged 1.78%, which is above the 1.6% standard proposed by Professor Trevett in 1972. This is not surprising considering the heavier soil in this field. Previous leaf tissue samples showing adequate N resulted in a recommendation for MAP and not DAP. The June 16 application and split application of May 19 and June 16 resulted in the highest leaf nitrogen concentration. Leaf P concentrations were raised by MAP fertilization on all dates except the last, June 30 (Fig. 2). A split application of half on May 19 and half on June 16 was also effective in raising leaf P concentrations to a level of sufficiency.

Soil P concentrations in soil samples taken in 1998 show a similar pattern found for leaf P concentrations (Fig 2). All treatments raised soil P concentrations, compared to the control. The highest concentrations resulted from fertilizer application on May 19, June 2, June 16, and the split application of May 19 and June 16.

Stem density was increased by late MAP fertilizer application (June 30) compared to all other application dates and the control (Fig. 3). Stem length was increased by fertilization on May 19 and June 16, compared to the control (Fig. 4). Very little branching was observed on stems sampled at location 1; a small but significant increase was attributed to fertilization at all dates except June 30 (Fig. 5). The June 16 fertilization resulted in the greatest branching. The greatest number of flower buds per stem was found in plots receiving MAP on June 16 (Fig. 6). However, flower bud density or the number of flower buds per unit area was not higher in plots receiving MAP on June 16, compared to other dates of application or the control. The plots receiving fertilizer on the last application date, June 30, had a significantly higher flower bud density presumably due to the greater density of stems per square foot (Fig. 7). There was no effect on yield in 1999 (Fig. 8).

Location 2

On the sandy soil of location 2, leaf nitrogen was below the standard (1.6%) in leaves sampled from the control plots (Fig. 9). The leaf N concentrations were raised above the standard by DAP fertilizer at all application dates; the highest concentration resulted from fertilizing on June 2 and June 16 and from the split application on May 19 and June 16. While leaf soil and leaf P concentrations seem to follow a similar trend with regard to treatments, only Leaf P concentrations were affected by date of fertilizer application (Fig. 10). The June 2 application date resulted in the highest leaf P concentration, but all applications of DAP (including the split application) raised leaf P concentrations above the 0.125 % standard proposed by Trevett in 1972). That we have raised yields in response to P fertilization when leaf concentrations were at the 0.125% suggests the standard should be raised to 0.130%. Stem density was not influenced by fertilization (Fig. 11). Stem length was increased by early fertilization on May 19 or June 2, compared to other dates and the control (Fig. 12). Branching and flower buds/stem were increased by fertilizer application on June 2 and June 16 and by the split application on May 19 and June 16, compared to the control (Figs. 13 and 14). Flower bud density was also increased by fertilization at all dates, including the split application, compared to the control (Fig. 15). Yield was increased by all fertilizer treatments but was highest when fertilizer was applied on June 2 compared to other dates (Fig. 16).

Fertilizer Timing Study II (1999)

METHODOLOGY: Results of fertilizer timing study I indicate an effect of time of fertilizer application on nutrient uptake; however, a preemergence treatment was not included. To confirm the results of the 1998 study and to include a preemergence treatment, a field was selected in the Appleton, Maine area. Although we had hoped to include a sandy podsol soil, typical of the blueberry "barrens", one was not available that had previous leaf tissue analysis and had not been previously fertilized. Fertilizer was applied by hand spreader to 5 x 50 ft treatment plots at the rate recommended (80 lbs P from DAP), based on leaf tissue analysis. Treatment plots received a preemergence fertilizer treatment or one of four applications at two week intervals on May 12, May 26, June 9, June 23, or July 7. An unfertilized plot served as a control. A randomized complete block design with 8 blocks was used. Leaf and soil samples were taken on July 2, 1999 at the tip dieback stage of stem development. Leaf samples were therefor not taken for treatment 6 application on July 7. Stems were sampled from each treatment plot by cutting all stems at ground level in four ¼ ft^2 quadrats in October 1999 to

determine treatment effects on stem density, stem length and flower bud formation. Yield was determined in August 2000.

RESULTS: Fertilizing with DAP increased N and P leaf concentrations, compared to the controls (Figs. 17 & 18). For leaf N concentration there was a significant linear and quadratic trend over date of fertilizer application. Fertilizing after emergence resulted in higher leaf N concentration than fertilizing before shoots emerged; the later the application date the higher the concentration until June 9. The leaf N concentration resulting from the June 23 application of DAP was similar to that on June 9. Leaf P concentration exhibited a quadratic trend over fertilizer application date. The leaf P concentration increased with the May 26 application date compared with the preemergence application on May 12 but did not increase with later application date. In fact, the leaf P concentration of plots receiving the last application date, for which leaf samples where taken, was not different from plots receiving the fertilizer preemergence. Soil P concentration was not significantly different among fertilizer application dates (Fig. 18).

It is interesting to note that B and Cu showed a negative, quadratic response to later application of DAP (Fig. 19). Perhaps the increased N and P uptake that appears to be occurring at the May 26 application date has stimulated more growth (including larger leaves) resulting in a dilution of B and Cu that was taken in through the root system of the lowbush blueberry. Magnesium (Mg) concentration also decreased linearly with increasing date of DAP application (Fig. 20).

Stem length and branching were increased by all fertilizer treatments compared to the controls, except for the July 7 application date which had no effect on stem length as cessation of stem elongation (tip dieback) was occurring at that time (Fig. 21). In 1999, application on May 26 resulted in the greatest stem length. Branching was increased by applying DAP in mid or late June compared to earlier or later application or to the control. Average length of the branches was not affected by treatments (data not shown). Average flower buds per stem was increased by fertilizing on June 9 or June 23, compared to the control (Fig 22). There was no difference in number of flower buds per stem among the fertilizer application dates. Flower bud density was greater with any fertilizer date, compared to the control and no difference was found among application dates; this trend was also observed for yield (Fig. 23).

Fertilizer Timing Study III (2000)

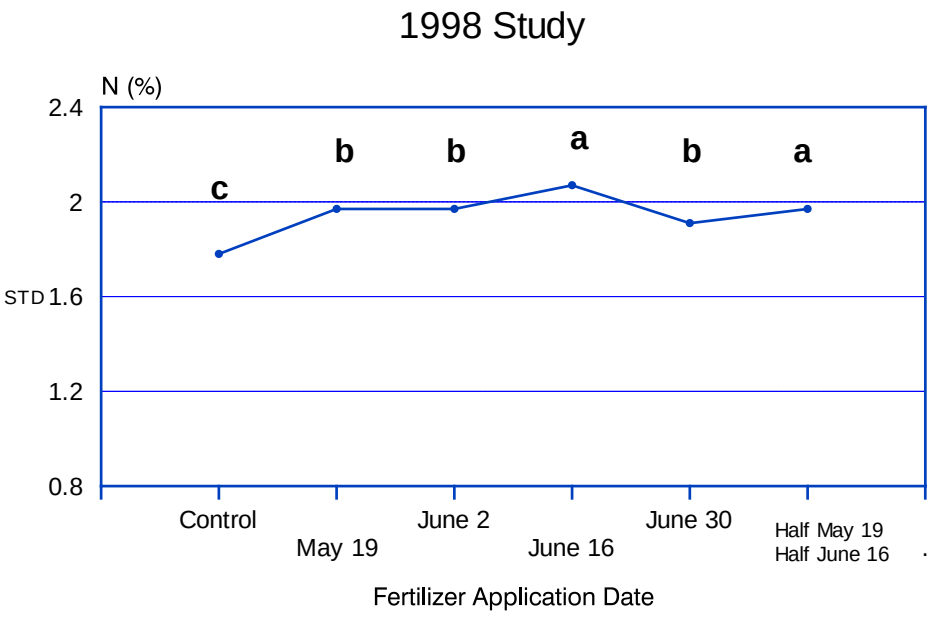
METHODOLOGY: N and P concentrations appear to be affected by the time of DAP fertilizer application in some commercial lowbush blueberry fields. In this study we related July leaf concentrations to the stage of plant development on the date of application by recording stem height at the time of DAP application. A commercial lowbush blueberry field with a sandy soil, characteristic of the blueberry barrens, low in N and P, was used in this study. Treatment plots received a preemergence DAP treatment on May 17 or one of four applications on May 31, June 14, June 28, or July 12. Stem growth was monitored by measuring stem height of 20 tagged stems in each control plot at the time of fertilizer application. Leaf tissue samples were taken on July 12, at the tip dieback stage of growth and analyzed for nutrients. Stems were sampled in October 2000 to determine treatment effects on stem length, branching, and flower bud formation. Yield will be measured in 2001.

RESULTS: Leaf N concentrations were increased more by application of DAP on May 31 or later, compared to the control or the May 17 application date (Fig. 24). The stem height at time of these applications is plotted in figure 24. Soil P concentration was not affected by date of fertilizer application but leaf P concentrations were higher when fertilizer was applied on May 31 or June 14, compared to the control (Fig 25). Fertilizer application when shoots were between 1 and 2 inches tall was more effective than before (May 17) or than later (June 28) in raising leaf P.

CONCLUSIONS: Although no conclusions can be drawn until further studies are conducted, it appears that timing may be more important on sandy textured soils than on heavier soils for maximizing lowbush blueberry nutrient uptake and yield. Future studies should concentrate on the stage of growth at time of fertilization rather than date.

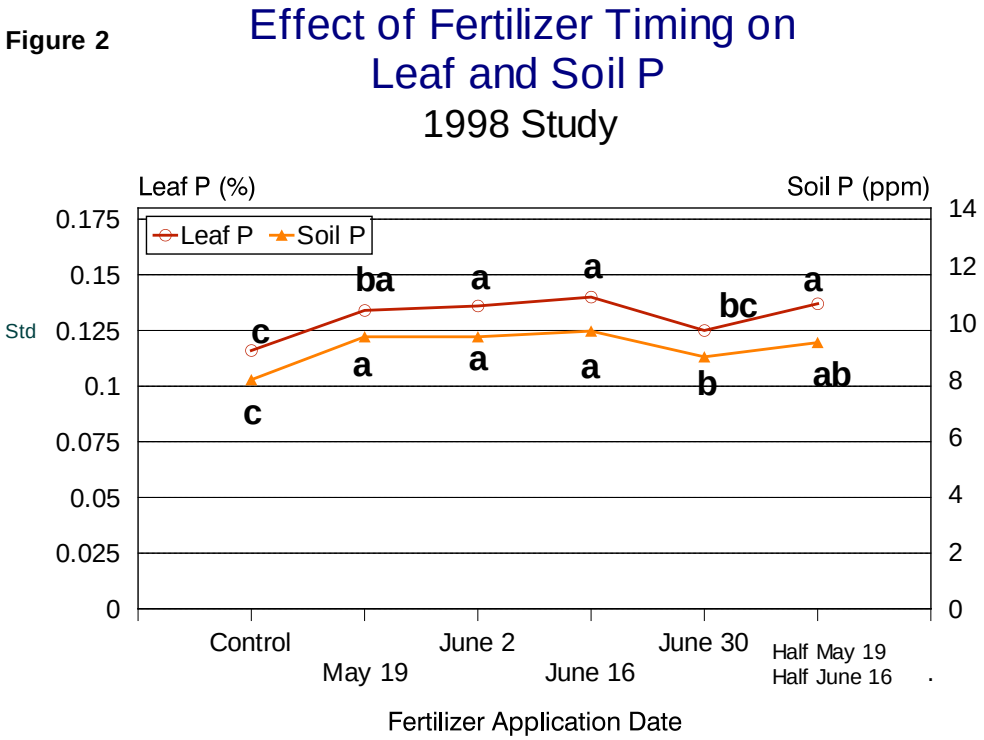
RECOMMENDATIONS: No recommendations can be made at this time regarding timing of fertilization.

Figure 1 Effect of Fertilizer Timing onLeaf N



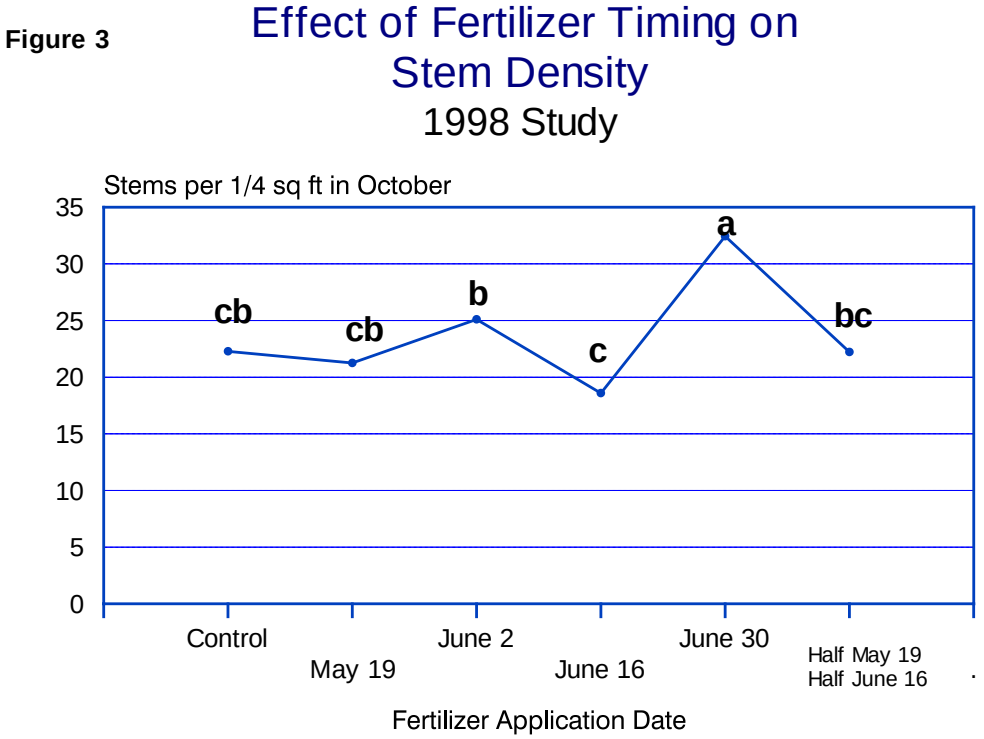
Location 1, 80lbs P/acre from MAP, Significance level = 0.01%.

Figure 2



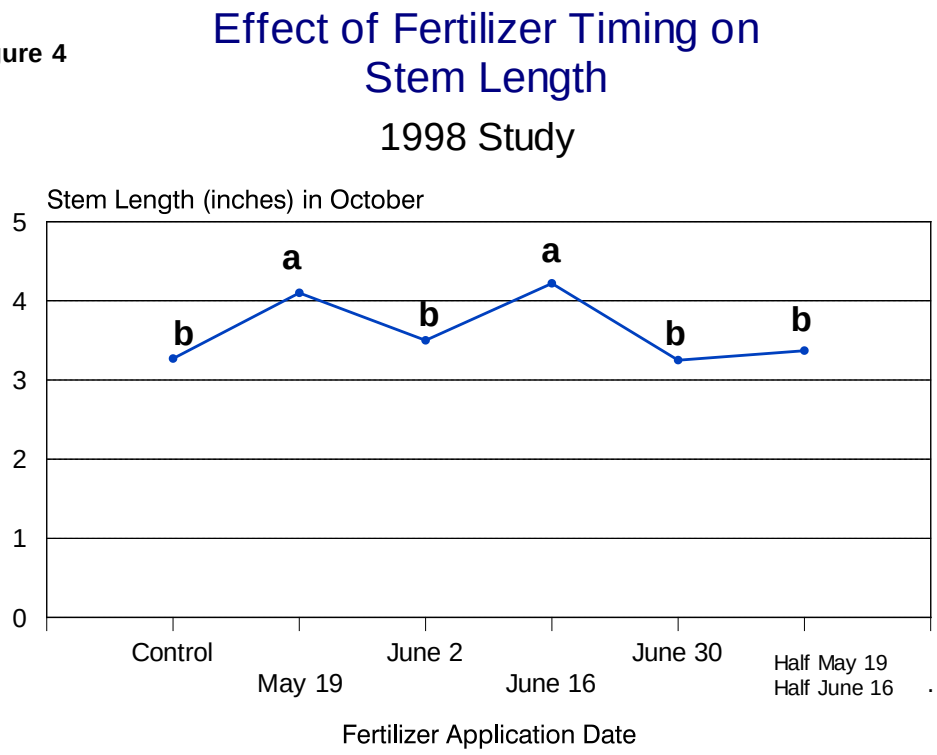
Location 1, 80lbs P/acre from MAP, Significance level = 0.01%.

Figure 3



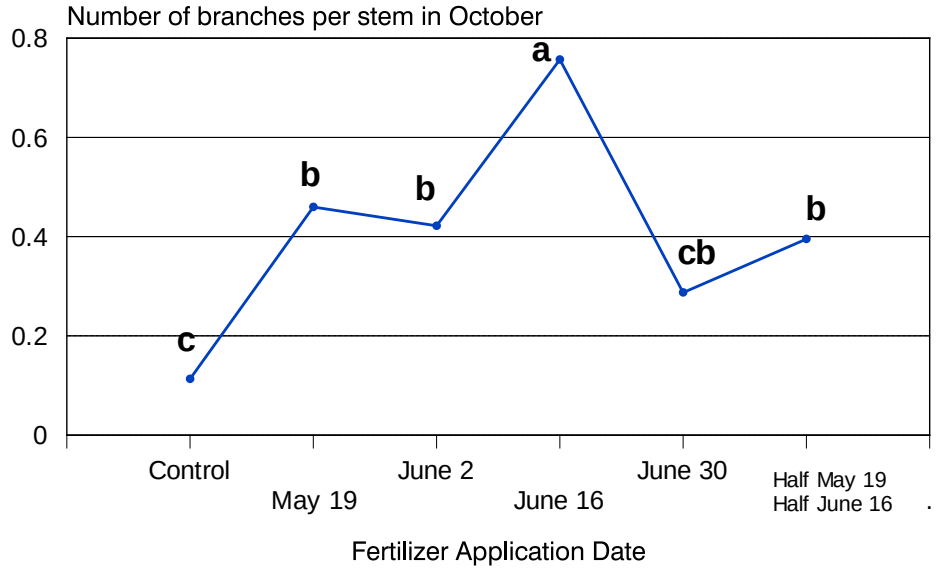
Location 1, 80lbs P/acre from MAP, Significance level = 0.01%.

Figure 4



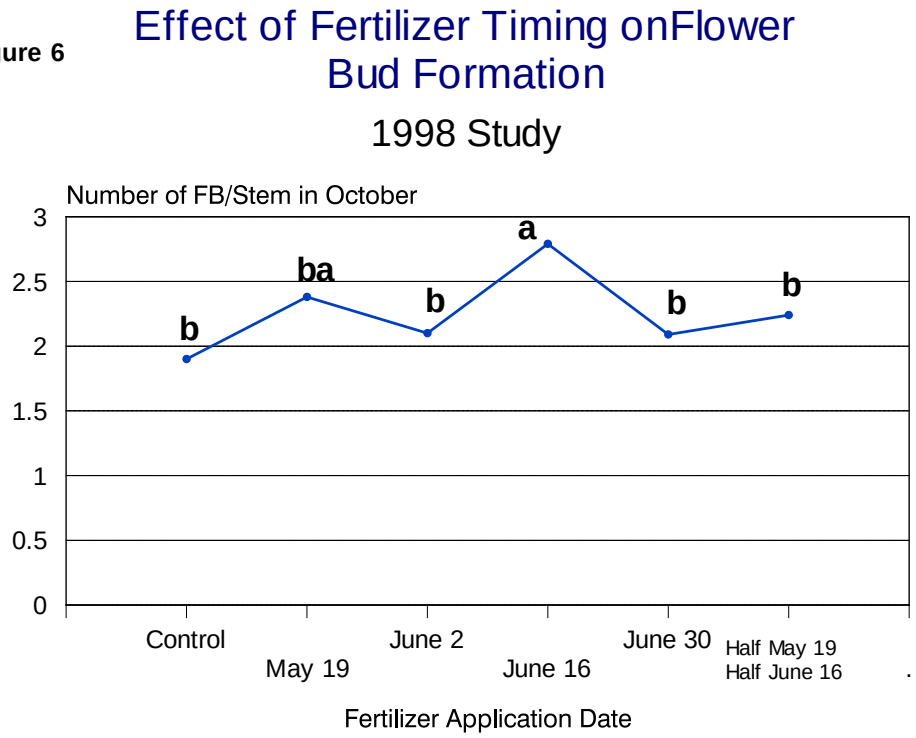
Location 1, 80lbs P/acre from MAP, Significance level = 0.01%.

Figure 5



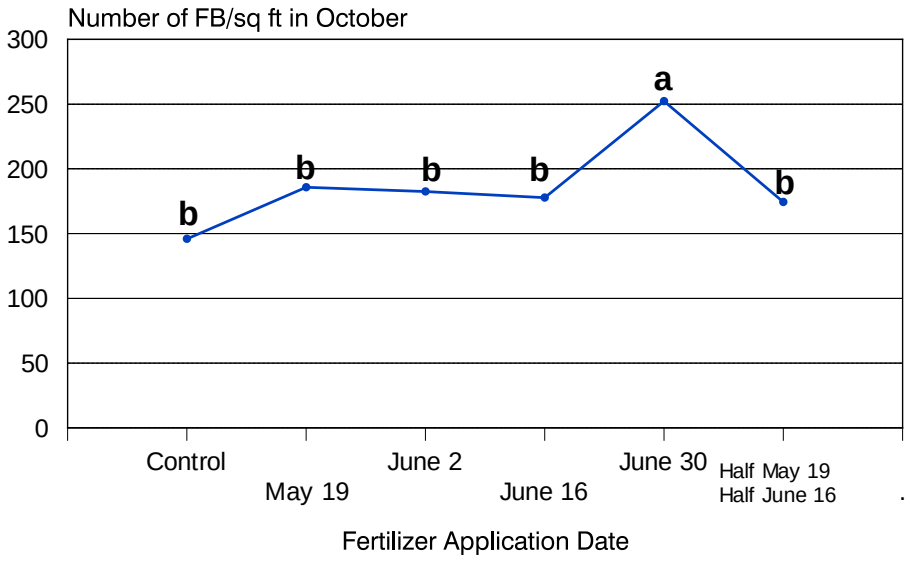
Location 1, 80lbs P/acre from MAP, Significance level = 0.01%.

Figure 6



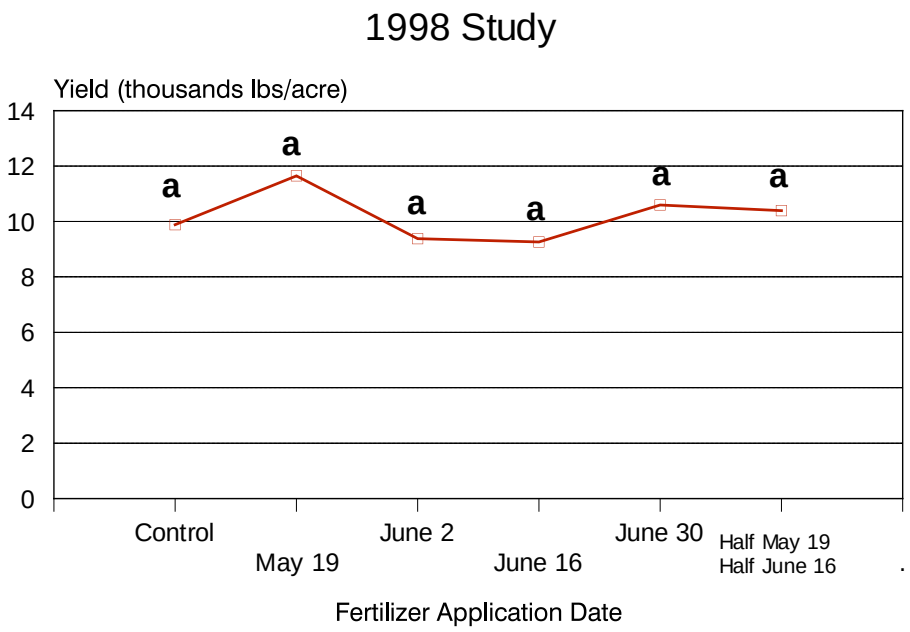
Location 1, 80lbs P/acre from MAP, Significance level = .4%.

Figure 7



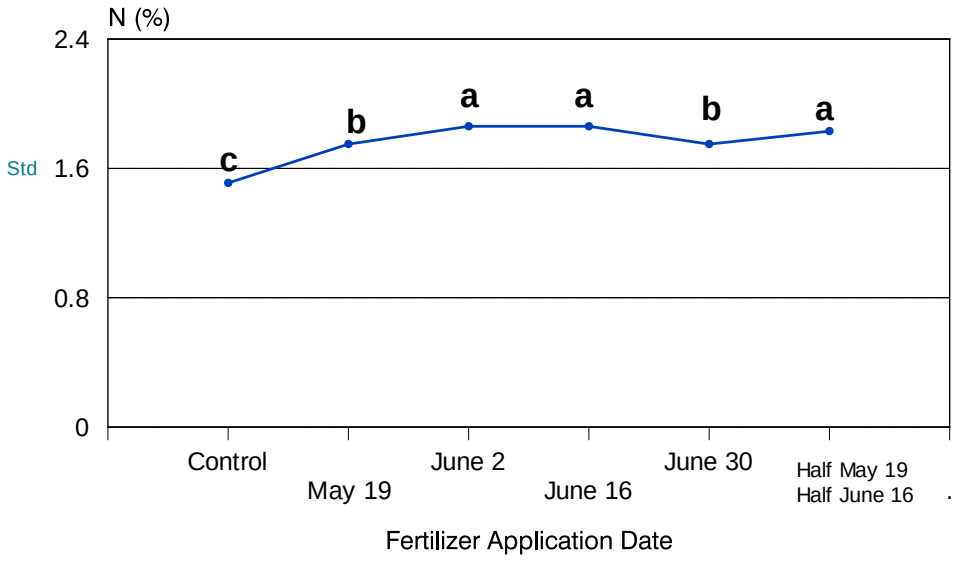
Location 1, 80lbs P/acre from MAP, Significance level = .01%.

Figure 8 Effect of Fertilizer Timing onYield



Location 1, 80lbs P/acre from MAP, Significance level = Not significant

Figure 9 Effect of Fertilizer Timing on Leaf Nitrogen

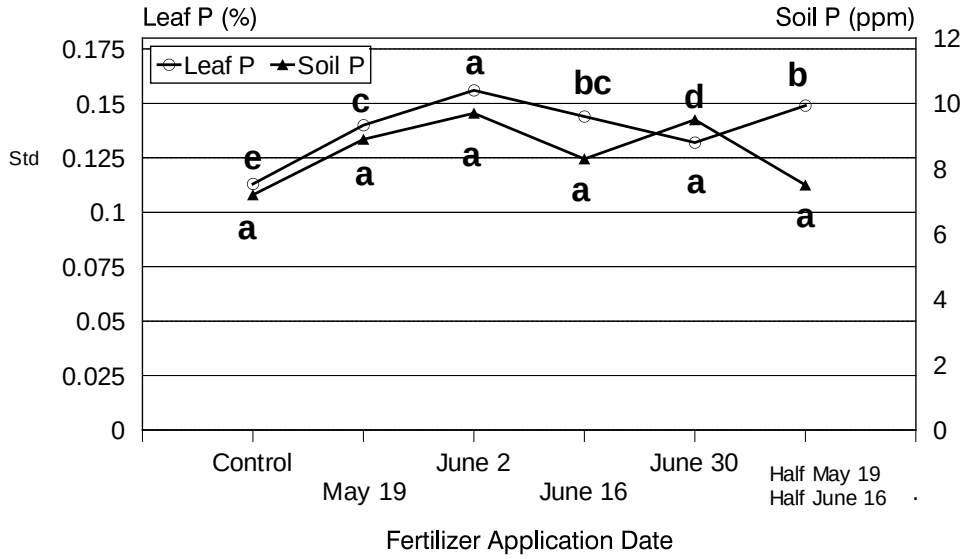


Location 2, 80lbs P/acre from DAP, Significance level = 0.01%.

Figure 10

Effect of Fertilizer Timing on Leaf and Soil Phosphorus

1998 Study

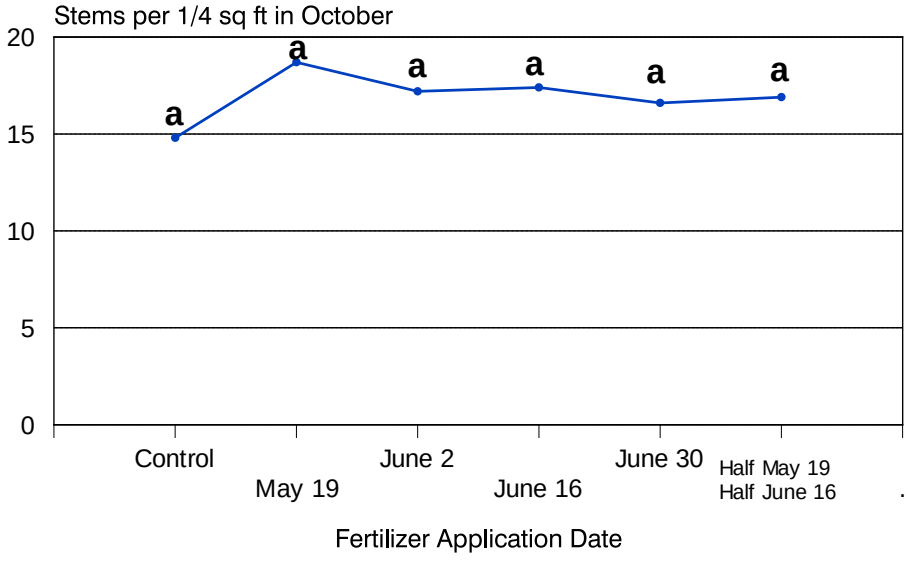


Location 2, 80lbs P/acre from DAP, Leaf P significance level = 0.01%. Soil P values not significantly different at 5% level.

Figure 11

Effect of Fertilizer Timing onStem Density

1998 Study

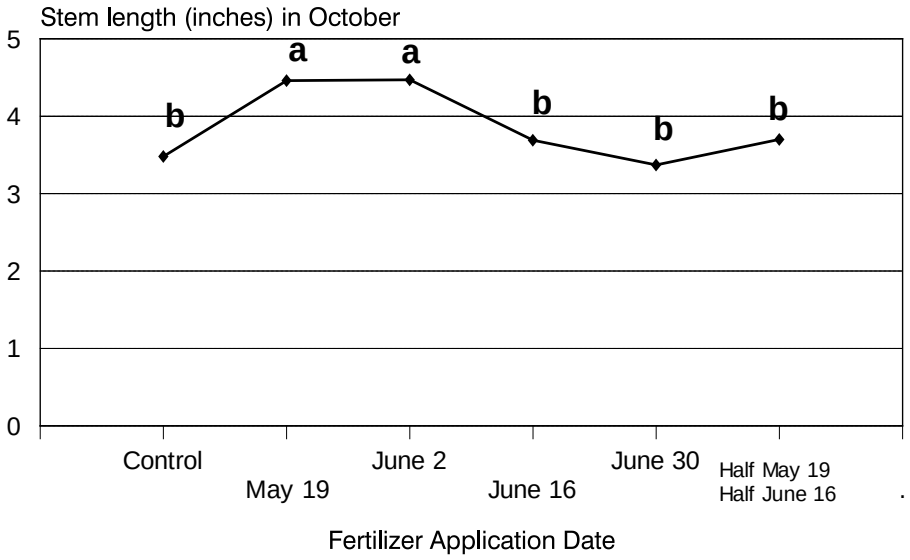


Location 2, 80lbs P/acre from DAP, Significance level = 5%.

Figure 12

Effect of Fertilizer Timing onStem Length

1998 Study

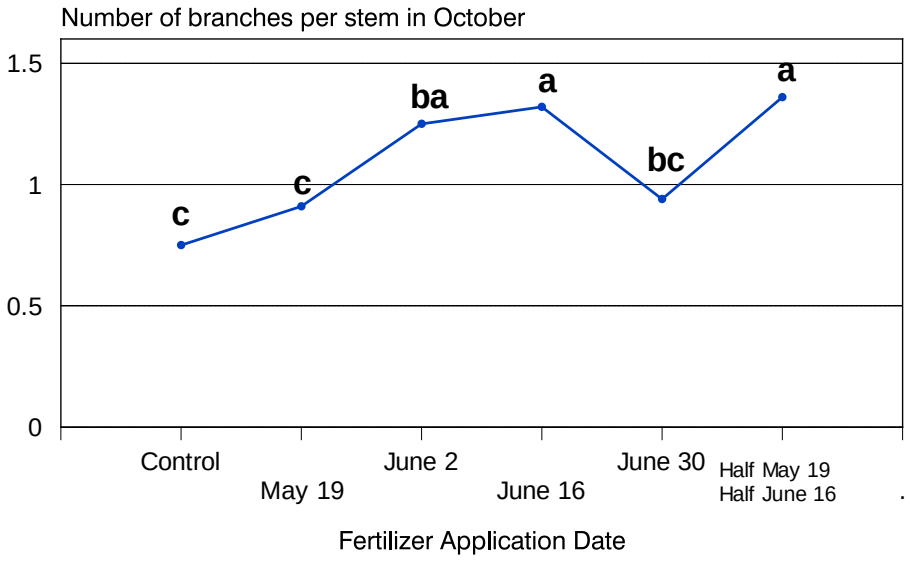


Location 2, 80lbs P/acre from DAP, Significance level = 0.01%.

Figure 13

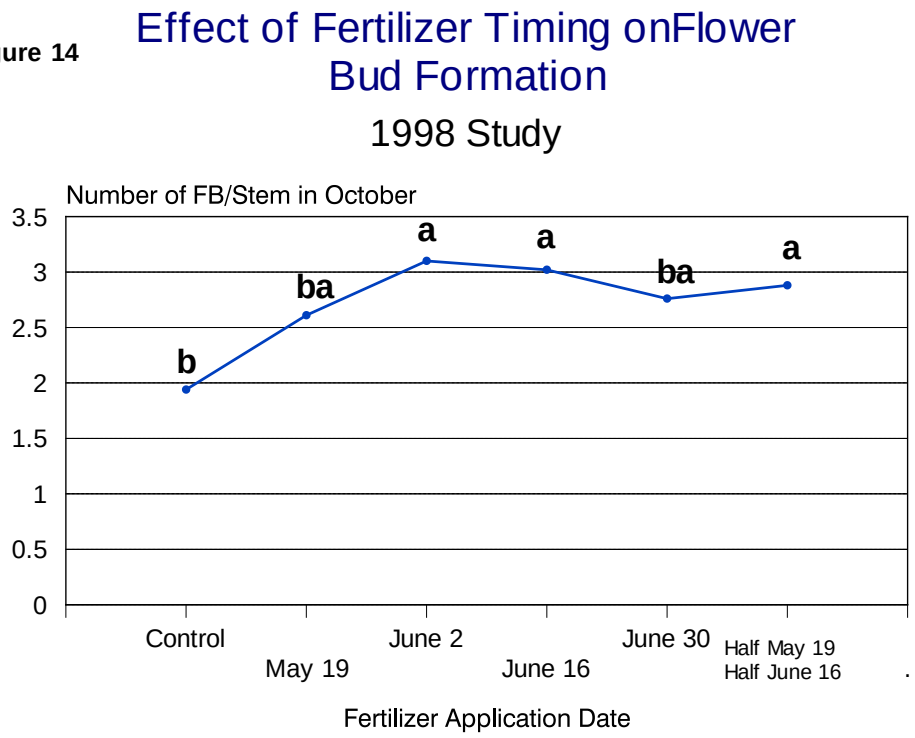
Effect of Fertilizer Timing onStem Branching

1998 Study



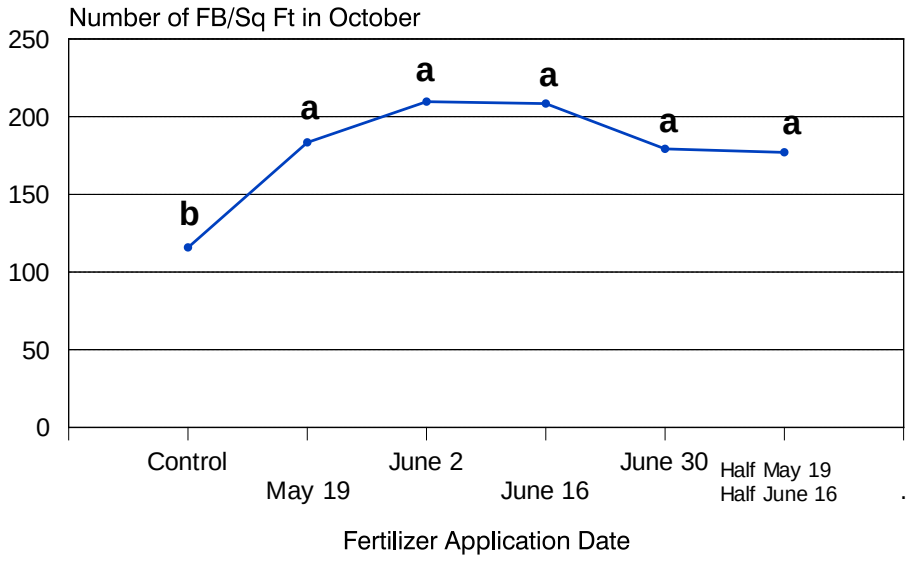
Location 2, 80lbs P/acre from DAP, Significance level = 0.01%.

Figure 14



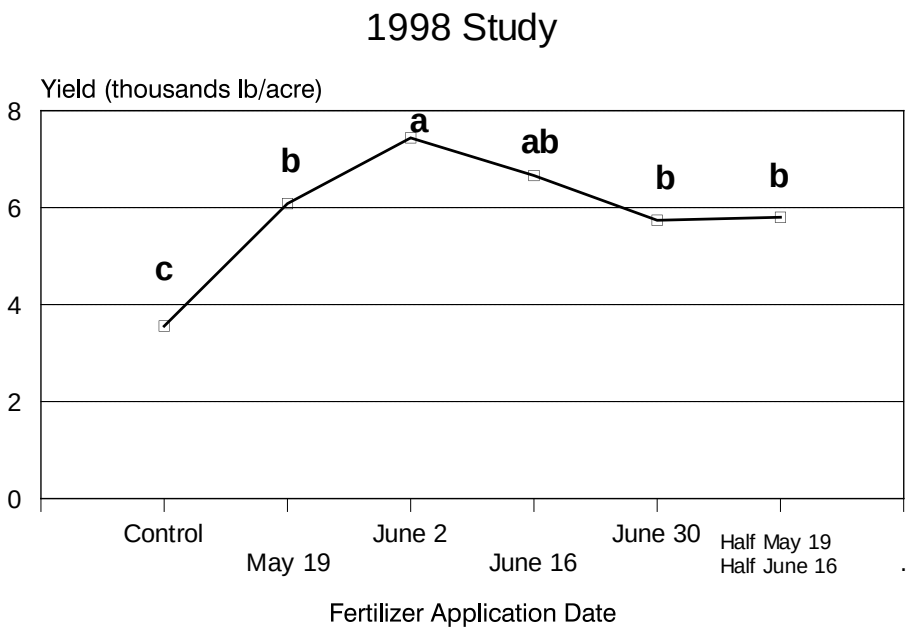
Location 2, 80lbs P/acre from DAP, Significance level = 5.6%.

Figure 15



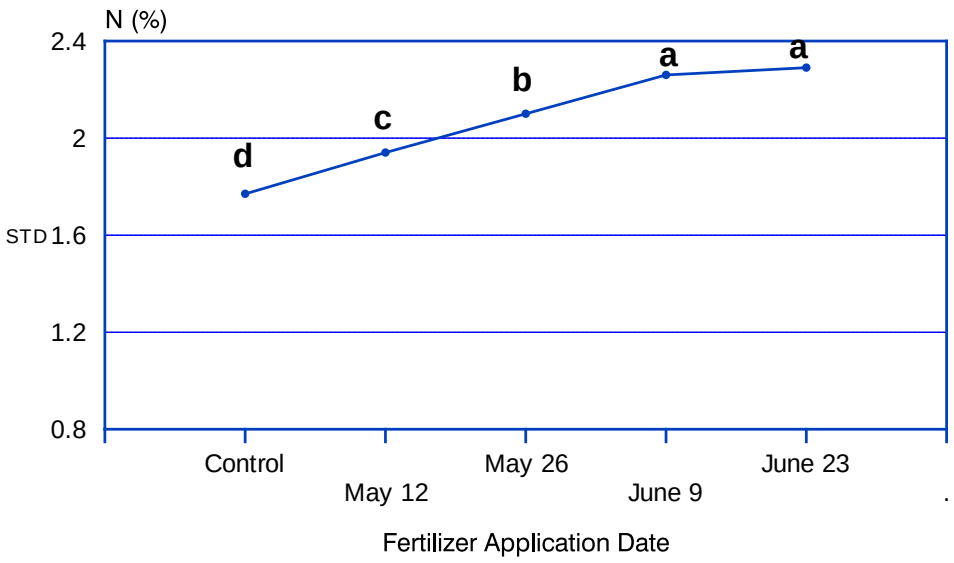
Location 2, 80lbs P/acre from DAP, Significance level = .3%.

Figure 16 Effect of Fertilizer Timing on Yield



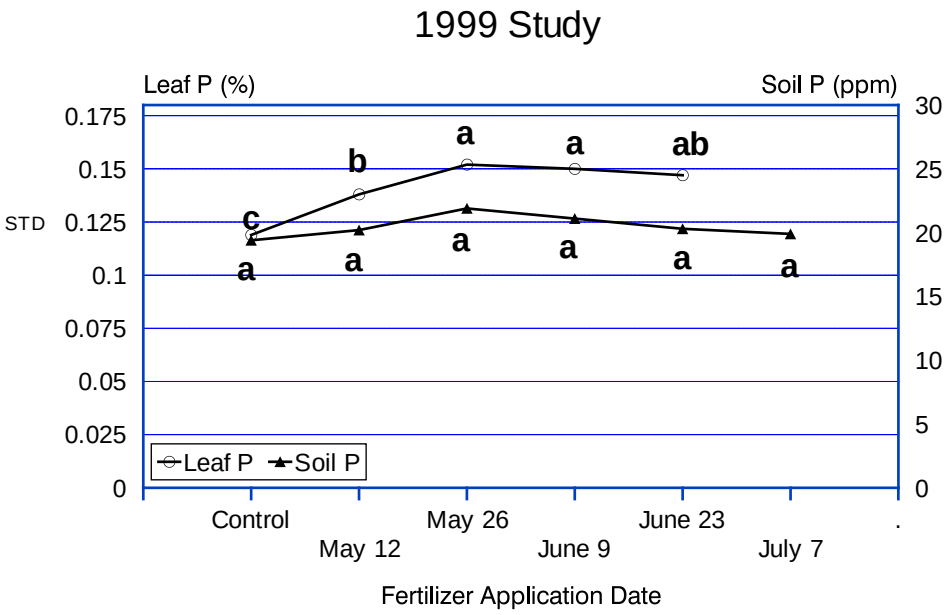
Location 2, 80lbs P/acre from DAP, Significance level = .01%

Figure 17 Effect of Fertilizer Timing onLeaf N



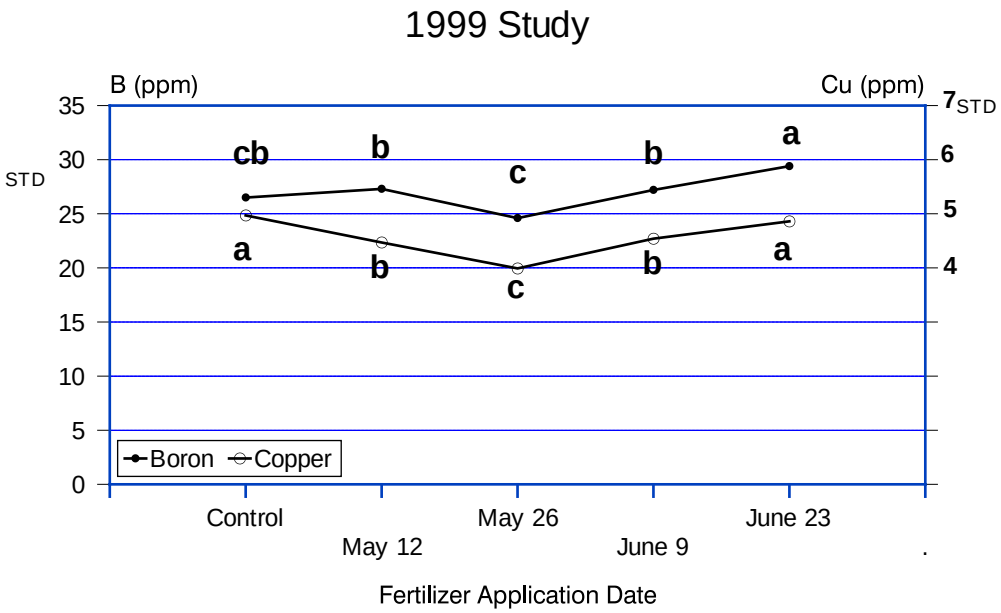
80lbs P/acre from DAP, Significance level = 0.01%. Significant linear trend for fertilizer application dates, .01%.

Figure 18 **Effect of Fertilizer Timing on Leaf and Soil P**



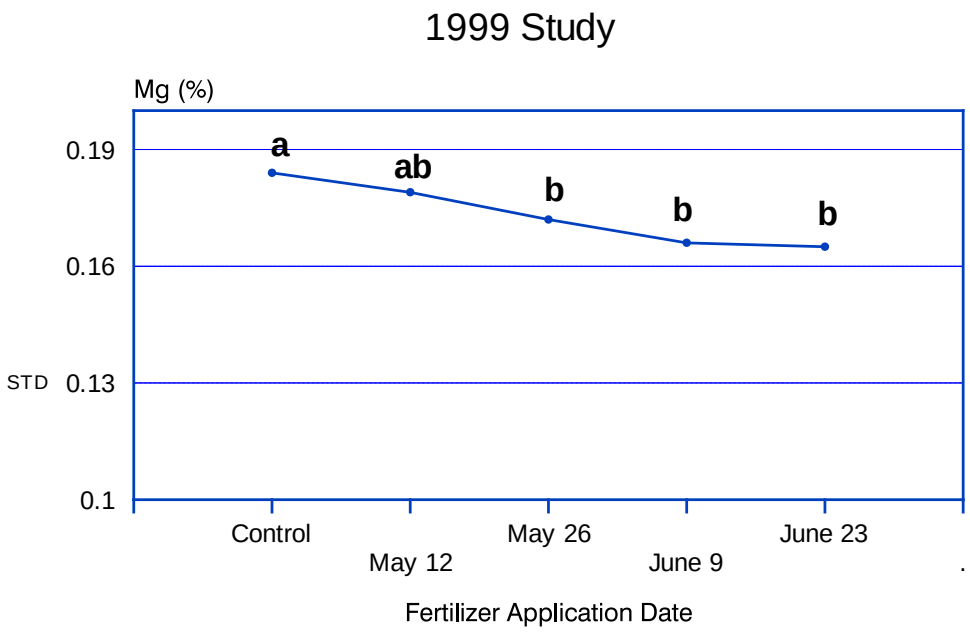
80lbs P/acre from DAP, Leaf P Significance level = 0.01%. Significant linear and quadratic trend for fertilizer application dates, .01% level linear and .1% quadratic. Soil P not Significant at 5% level.

Figure 19 **Effect of Fertilizer Timing on Leaf B and Cu**



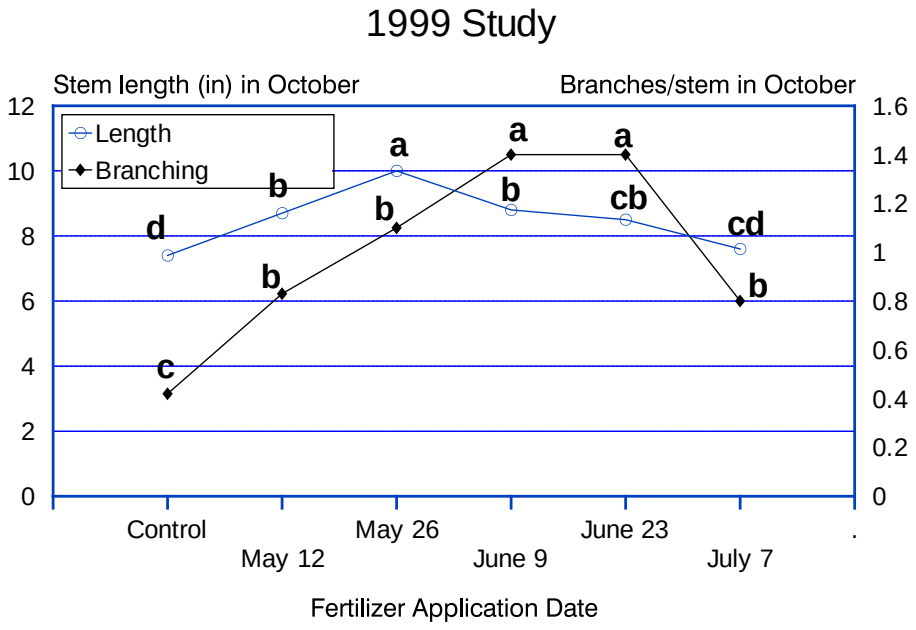
80lbs P/acre from DAP, Significance level = 0.01%. Significant quadratic trend for Cu in response to fertilizer application dates, 0.01% level.

Figure 20 Effect of Fertilizer Timing onLeaf Mg



80lbs P/acre from DAP, Significance level = 2%. Significant negative linear trend for fertilizer application dates, 0.5 % level.

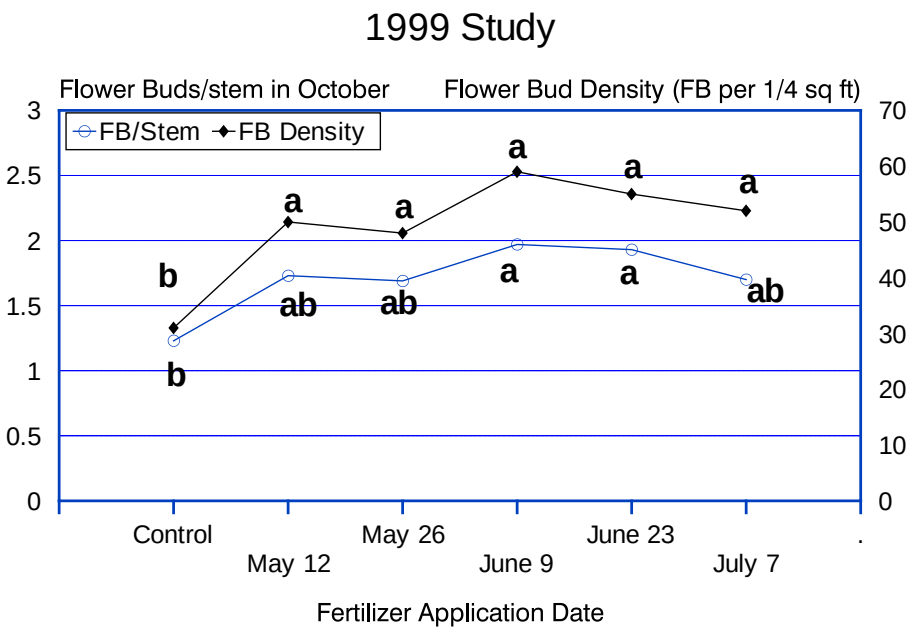
Figure 21 Effect of Fertilizer Timing on Stem length and Branching



80lbs P/acre from DAP, Significance level = 0.01%.

Figure 22

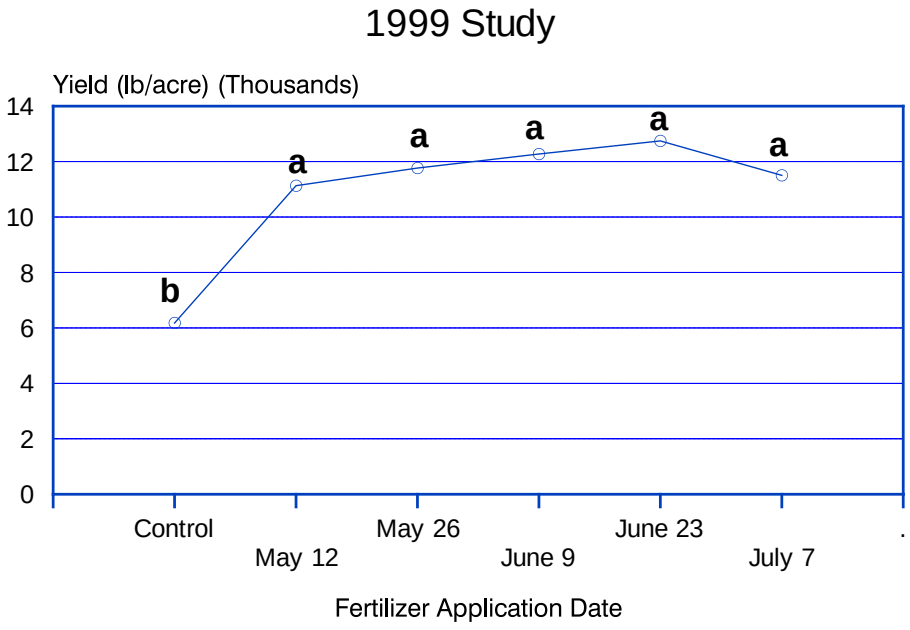
Effect of Fertilizer Timing on Flower Bud Formation



80lbs P/acre from DAP, Significance level = 5% for flower buds, 0.01% for FB Density.

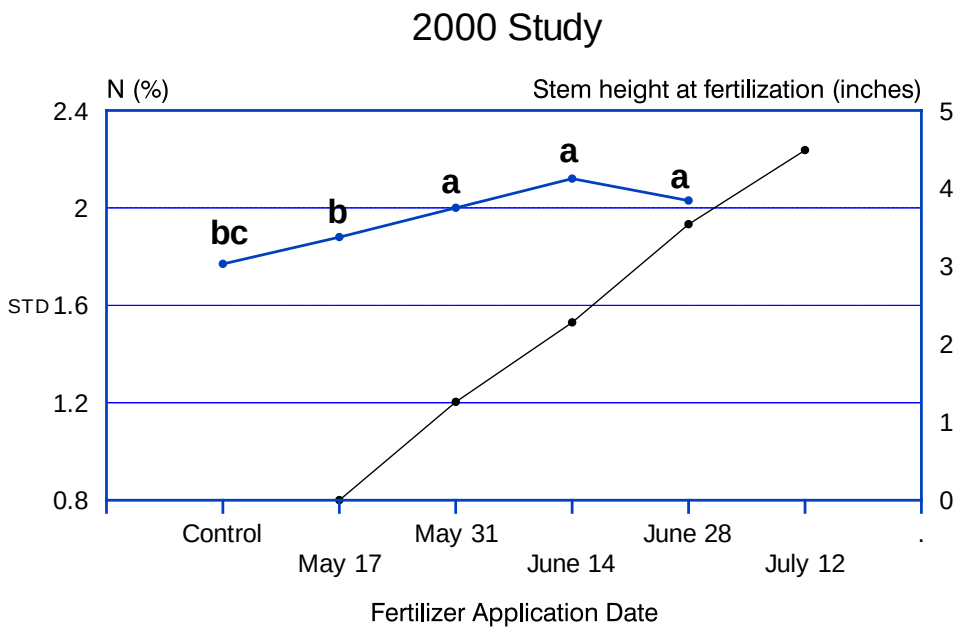
Figure 23

Effect of Fertilizer Timing on Yield



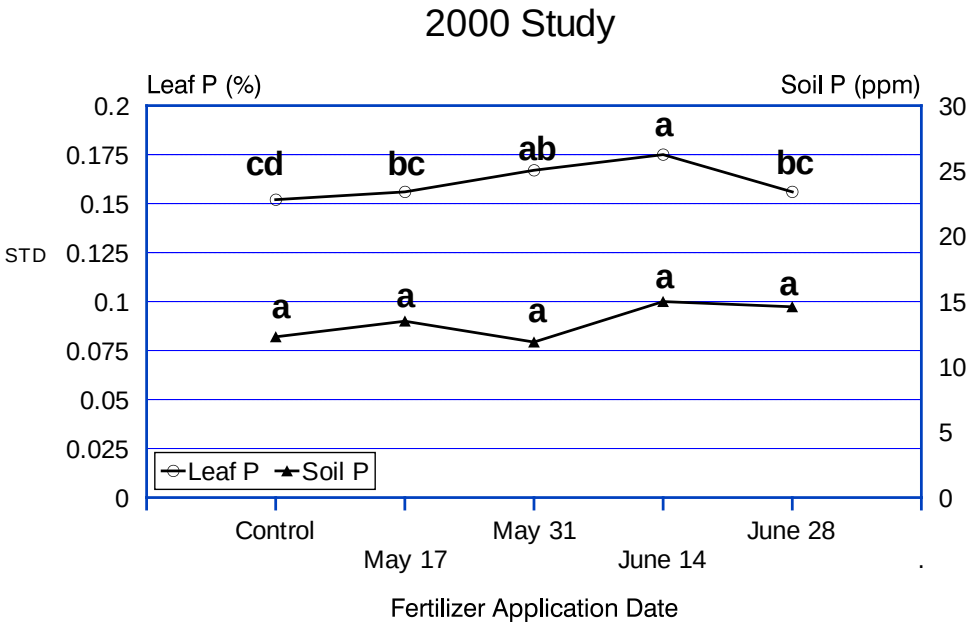
80lbs P/acre from DAP, Significance level = .01%.

Figure 24 **Leaf N in Relation to Fertilizer Timing and Stem Height**



80lbs P/acre from DAP, Significance level = 0.01%. Stem height was measured on 20 tagged stems in each control plot.

Figure 25 **Effect of Fertilizer Timing on Leaf and Soil P**



80lbs P/acre from DAP, Leaf P Significance level = 0.01%. Soil P not Significant at 5% level.

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

1. TITLE: Assessment of Azafenidin for Weed Control in Wild Blueberries.

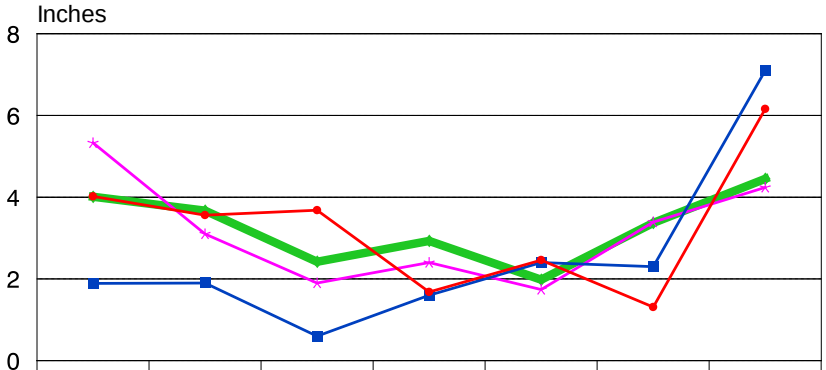
METHODS: Trials conducted in 1998 with azafenidin provided significant weed control was found at 10 oz product/a. In 1999, rainfall was not adequate to move the herbicide into the soil profile so it did not provide any weed control. In 2000 a trial to evaluate timing and rates was treated on 5-4-2000 or 5-17-2000, with 0, 5, 10, 15 or 30 oz product/a to 6'X40' completely randomized plots replicated 4 times and was located in section 5 at Blueberry Hill Farm. Weed and blueberry cover were evaluated at 1 and 3 months post treatment and will be evaluated in next June and plots will be harvested in August 2001. In addition, a trial with the same rates and plot size was located on a commercial blueberry field in T-19 and was treated on 5-16-2000 and evaluated for weed and blueberry cover at 1 and 3 months post treatment.

RESULTS: Rainfall in 1998 and 2000 was closer to the 5 year average than in 1999, a year in which azafenidin was ineffective (Figure 1). The trial in 1999 was also treated later in the spring than in other years (5-17-99 versus 5-1-98 or 5-4-2000). In addition, weed control was good in both 1998 and 2000 since 7.6 and 8.4 inches fell in April and May, respectively, versus only 3.8 inches of rain during April and May 1999. A trial in Waldoboro was effective in 1999 because the application was made earlier in the season, 5-7-99 (Figure 2) versus 5-19-99 at BBHF in Jonesboro. Azafenidin also provided better weed suppression than the Velpar treatments (Figure 2). In 2000, however, weed control was not as evident as in 1998 but was still significant with the earlier treatment date providing the best weed control(Figure 3). The commercial field in T-19 did not have enough weed pressure to be evaluated.

CONCLUSION: Trials at different locations will be conducted in 2001 and will be applied in mid-April, to allow for rainfall to move the herbicide through the soil profile.

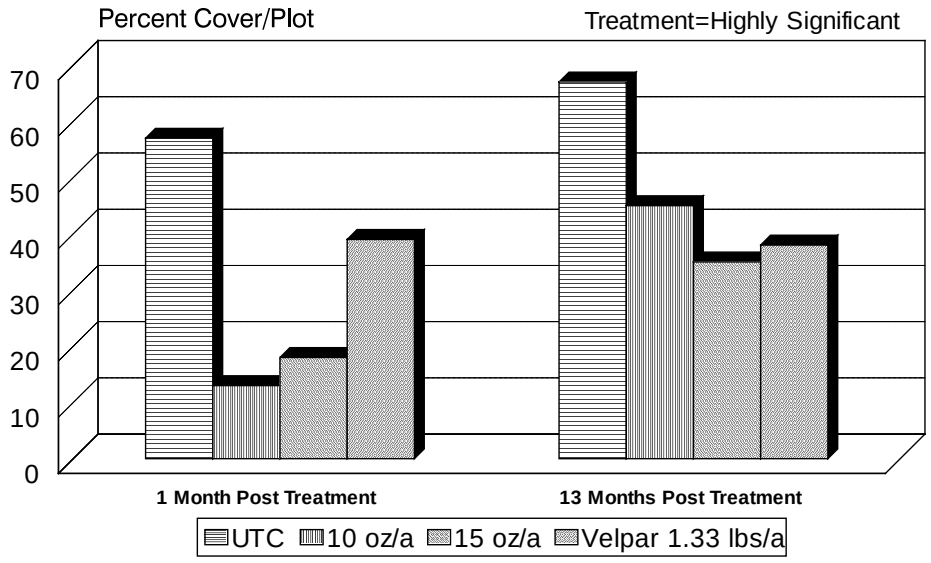
RECOMMENDATIONS: Continue evaluation of azafenidin on two different soil types early in the spring.

Figure 1. Annual Precipitation at Blueberry Hill Farm- 5 year average 1998, 1999 and 2000



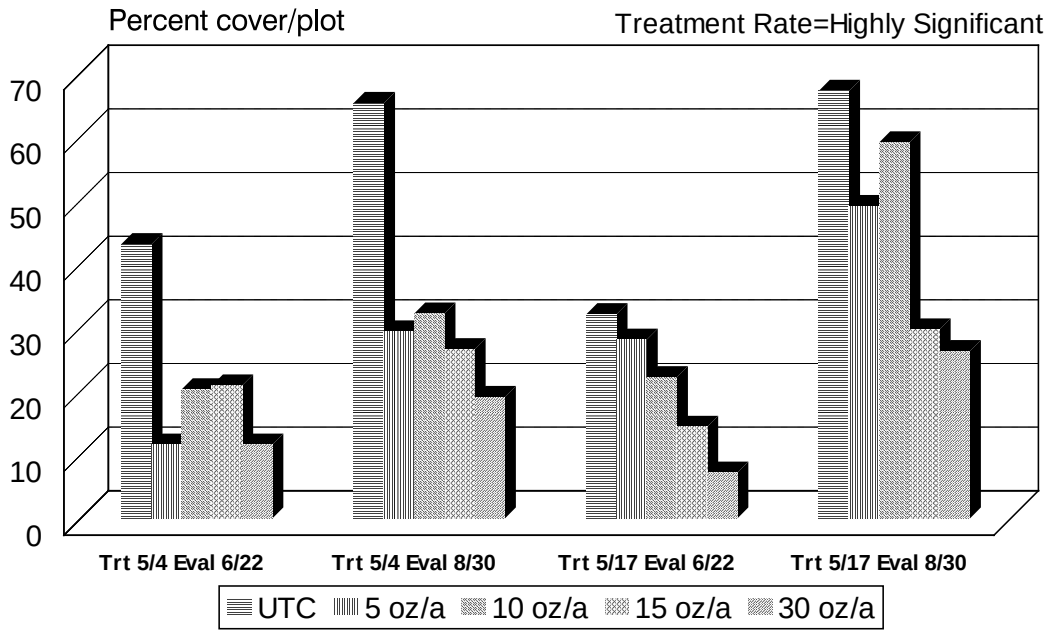
	April	*May*	*June*	*July*	*Aug*	*Sep*	*Oct*
1998	4	3.6	3.7	1.7	2.5	1.3	6.2
1999	*1.9*	*1.9*	*0.6*	*1.6*	*2.4*	*2.3*	*7.1*
2000	5.3	3.1	1.9	2.4	1.7	3.4	4.2
5 yr avg.	4	3.7	2.4	2.9	2	3.4	4.5

Figure 2. Effect of Azafenidin on Weed Cover-Waldoboro, ME - 1999



Treatments Applied 5-7-99, Rates in Product/a

Figure 3. Effect of Azafenidin on Weeds - 2000
by Treatment and Evaluation Date



All rates are in product/acre

WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

2. TITLE: Assessment of Rimsulfuron for Weed Control in Wild Blueberries.

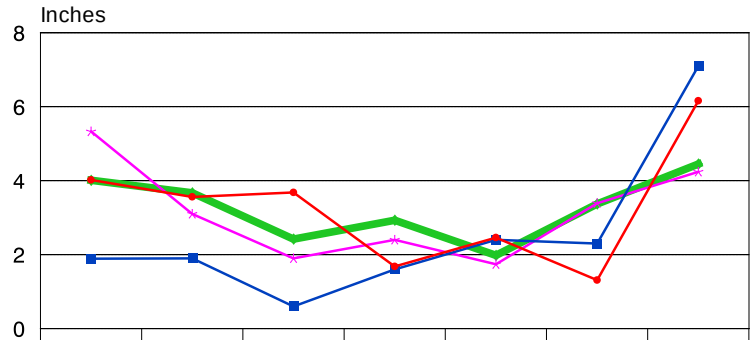
METHODS: Rimsulfuron is a reduced risk, preemergence herbicide, which provided good weed control in 1998 without injury to wild blueberries. As with azafenidin, the treatments in 1999 did not provide weed suppression nor did a fall 1998 application. The latest trial was established at Blueberry Hill Farm in section 6 of lower field and was treated on 5-4-2000 or 5-16-2000, just before emergence, with 0, 1, 2 or 4 oz prod/a to 6'X40' plots replicated 4 times. Weed and blueberry cover ratings were taken at 1 and 3 months post treatment. Carryover effects will again be assessed in June and plots harvested in August 2001. Another trial with the same rates was treated on 5-16-2000 on a commercial blueberry field in T-19.

RESULTS: The 1998 rimsulfuron treatments controlled weeds without affecting blueberry yield. Dry conditions in 1999 reduced movement of the herbicide into the soil profile where germinating seeds need to come into contact with the herbicide to be effective (Figure 1). The 2000 trial at Blueberry Hill Farm did not have significant weed control probably because only 5 inches of rain occurred in May and June versus 7.6 in the same months in 1998 (Figure 2). The Cherry Field Foods site did not have enough weed pressure to evaluate the treatments.

CONCLUSION: Further work to determine the best timing of application needs to be made before recommending use of this herbicide. Trials at different locations in 2001 will be treated in mid-April, to allow for rainfall to move the herbicide through the soil profile.

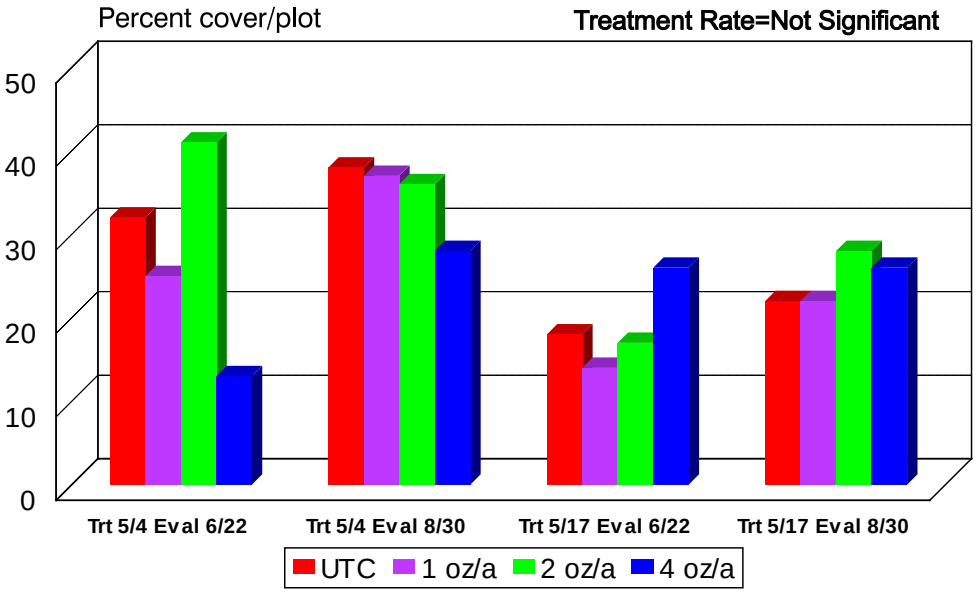
RECOMMENDATIONS: Continue evaluation of rimsulfuron.

Figure 1. Annual Precipitation at
Blueberry Hill Farm- 5 year average
1998, 1999 and 2000



	April	May	June	July	Aug	Sep	Oct
1998	4	3.6	3.7	1.7	2.5	1.3	6.2
1999	*1.9*	*1.9*	*0.6*	*1.6*	*2.4*	*2.3*	*7.1*
2000	5.3	3.1	1.9	2.4	1.7	3.4	4.2
5 yr avg.	4	3.7	2.4	2.9	2	3.4	4.5

Figure 2. Effect of Rimsulfuron on Weeds - 2000
by Treatment and Evaluation Date



All rates are in product/acre

WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

3. TITLE: Assessment of Pendimethalin for Weed Control in Wild Blueberries.

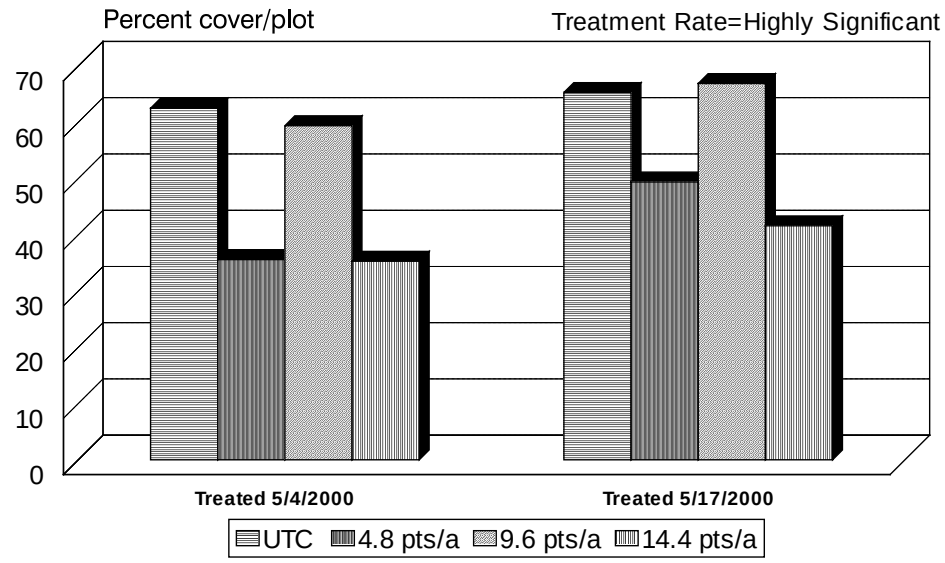
METHODS: Pendimethalin, a grass specific herbicide, was found to significantly reduce weed pressure without injury to wild blueberries in 1998. In a study conducted in 1999 pendimethalin treatments did not provide significant weed suppression The 2000 trial consisted of 4 blocks with 6'X40' completely randomized plots treated on 5-4-2000 or 5-17-2000, just before emergence, with 0, 4.8, 9.6 or 14.4 pints product/a. Weed and blueberry cover was rated at 1 and 3 months post treatment and will be reevaluated in June 2001. The same treatments were made on 5-16-2000 to a commercial field in T-19. There was insufficient weed pressure to determine treatment effects so no evaluation was made.

RESULTS:. In 1998 pendimethalin provided significant weed control of both grass and broadleaf weeds without affecting blueberry yield. Dry conditions and a later spring application in 1999 may have not allowed the herbicide to move through the soil profile to be effective. In 2000, enough rain occurred in April and May for the herbicide to reduce weed cover (Figure 1). In 2000 weed cover was reduced except in plots with large bare areas. The 9.6 pint/acre treatment was not effective because of low blueberry cover which allowed weeds to invade (Figure 2).

CONCLUSION: Since grasses are becoming a problem because of reduced hexazinone use rates preemergence, grass specific herbicides may provide a new treatment option. A pendimethalin trial in 2001 will investigate how early applications and different soil types will affect herbicide performance.

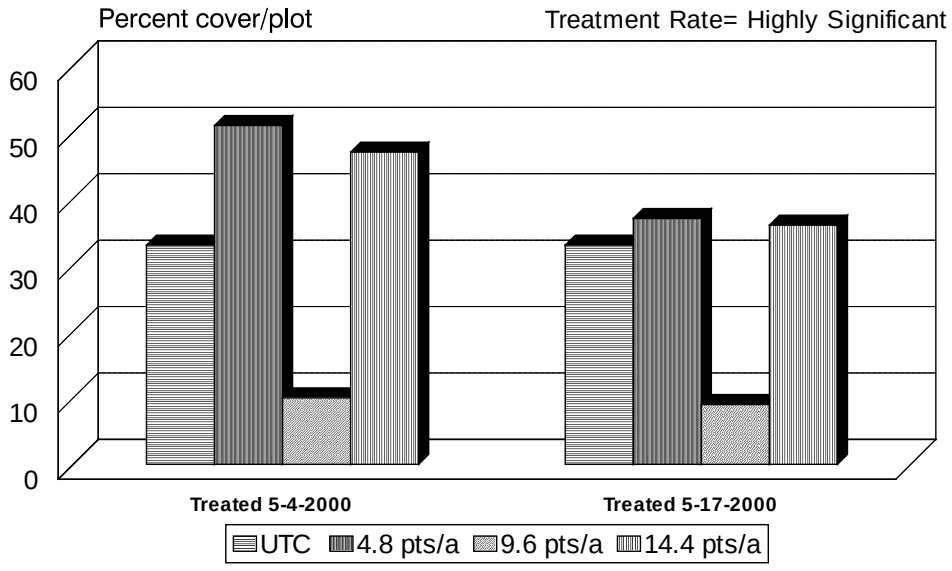
RECOMMENDATIONS: Continue evaluation of pendimethalin.

Figure 1. Effect of Pendimethalin on Weeds - 2000



All rates are in product/acre. Rated on 6/22/00

Figure 2. Effect of Pendimethalin on Blueberry Cover - 2000



All rates are in product/acre. Rated 6/22/2000

WEED

MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

4. TITLE: Assessment of VC1447 for Weed Control in Wild Blueberries.

METHODS: VC1447 is a preemergence Valent product that has properties similar to azafenidin. Applications late in the spring of 1999 were found to be ineffective at suppressing weeds so an earlier application trial was established in 2000. The 6'X40' completely randomized plots were established in section 7, lower field at Blueberry Hill Farm and were treated 5-5-2000 or 5-17-2000 at 0, 12 or 24 oz product/a. Plots were assessed for weed cover at 1 and 3 months post treatment.

RESULTS: Neither rate was effective at controlling weeds.

CONCLUSION: Terminate any further work with VC1447.

WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

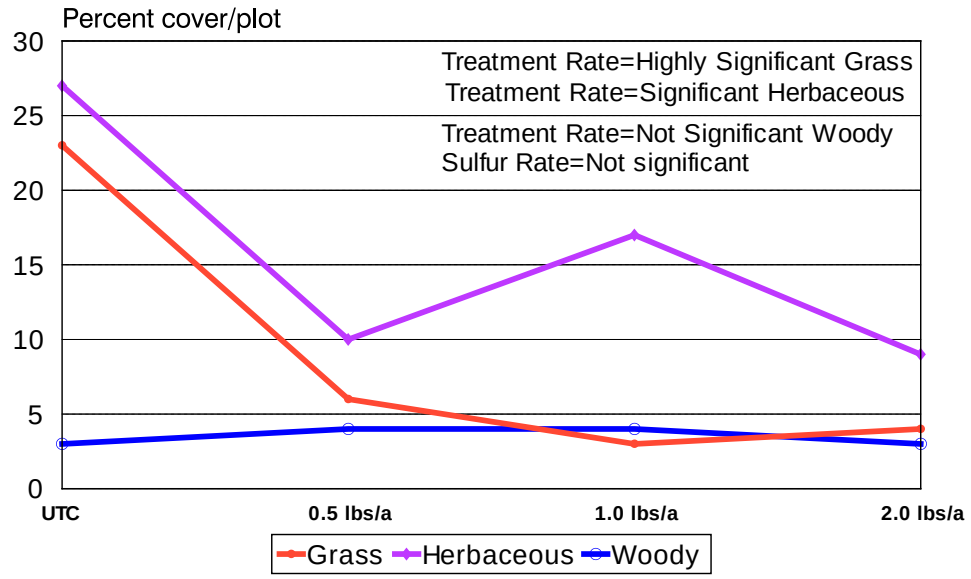
5. TITLE: Cultural Management Using pH for Weed Control in Wild Blueberries.

METHODS: Six sites were located throughout the state in Appleton, West Rockport, Machiasport, Whiting and two in Wesley. Plots were treated this spring preemergence with Velpar® at 0, 0.5, 1 or 2 lbs ai/a with 0, 500 or 1000 lbs/a sulfur at right angles to the Velpar® treatment to make a total of 12 treatment combinations/site. Plots were evaluated for weed suppression and blueberry injury at 2 months post treatment and will be reevaluated in June over the next 5 years. Soil pH will be tested every May and adjusted if needed.

RESULTS: It is expected that the sulfur application will take several years to produce weed suppression. After the first season there was a significant reduction in both herbaceous and grass weeds fro the Velpar® treatment but no effect was observed for the sulfur treatment (Figure 1).

RECOMMENDATION: Continue with project for 3 cycles.

Figure 1. Effect of Velpar and Sulfur from 6 locations
on Grass and Herbaceous and Woody Weed Cover - 2000



WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

6. TITLE: Evaluation of Sprout-Less Weeder® for Weed Control in Wild Blueberries

METHODS: Thirty hardwood saplings completely randomized throughout the field at the Blueberry Hill Farm Whitneyville site were treated on 9-7-2000 with a 100% solution of the new formulation of Touchdown 5. Thirty samplings cut without the herbicide application will be the untreated controls. Regrowth will be assessed in June 2001 and the trial will be repeated and compare effects of both Touchdown 5 and RoundUp Ultra.

RESULTS: The first results will be obtained in June.

RECOMMENDATION: Continue with the project.

WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

7. TITLE: Evaluation of RoundUp Ultra® and Touchdown 5® for Weed Control in Wild Blueberries

METHODS: Twenty hardwood saplings were wiped 9-7-2000 with 20% solutions of RoundUp Ultra® or Touchdown 5® in a completely randomized trial at the Blueberry Hill Farm Whitneyville. Twenty saplings were cut without herbicide application and will be the controls. Regrowth will be assessed in June 2001 and the trial will be repeated.

RESULTS: The first results will be obtained in June.

RECOMMENDATION: Continue with the project.

WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate

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

METHODS: Tissue culture and wild blueberry sod plugs were planted at a 1 foot spacing and mulched with 4" bark. Wild blueberry plant spread from 10 subplots in each area will be measured by cover ratings taken each year in August to evaluate spread. At Blueberry Hill Farm, in section 8 in the lower field, plants were interplanted in bare spots among the established clones. At a Guptils Wild blueberry Farm in Wesley, a 30'x30' plot was established by the freezer. 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. An 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.

RESULTS: The first cover and survival data will be obtained in June 2001.

RECOMMENDATION: Continue with project over a 6 year evaluation and use sites to demonstrate feasibility of interplanting tissue culture wild blueberry plants

WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Dave Lambert, Associate Professor of Plant Pathology

9. TITLE: Evaluation of Fungicides Efficacy in Wild Blueberry Fields.

METHODS: Two sites were treated, one at Blueberry Hill Farm Agricultural Experiment Station in Jonesboro, Maine and the other at Wyman's Spring Pond I commercial field in Deblois, Maine. Orbit® at 4 and 6 oz/a and Switch® at 11 and 14 oz/a in 20 gpa was applied with an air blast sprayer in Jonesboro and Switch® at 11 and 14 oz/a in 20 gpa was applied with an air blast sprayer and Orbit® at 4 and 6 oz/a by fixed wing aircraft at 5 gpa in Deblois. Orbit® is the standard treatment and Switch® is a reduced risk fungicide.

RESULTS: Blueberry Hill Farm had very low levels of infection so there was no significant difference in infected leaf and infected blossoms compared to the untreated area for either of the fungicide treatments. Since the Switch® at 14 oz/a had similar readings to the control, the 11 oz/a treatment was not rated. At the Deblois site, the Switch® treatment had statistically similar levels of infection compared to the control, indicating that the Switch® treatment was not effective in preventing disease symptoms. Calcium nitrate applied by the grower was also ineffective in controlling the disease symptoms. With the air application of Orbit®, the 6 oz treatment was more effective than the 4 oz/a treatment in reducing *Monilinia* infection of both blossoms and leaves. In past years with ground application no differences were found between the rates, indicating that with the reduced carrier volume, a higher rate is more effective in preventing *Monilinia* infection.

Table 1. Jonesboro, ME site:

	Infected Blossom/m²	Leaves/m²
Control	0.57	0.23
Switch® 14 oz/a	0.11	0.23
Orbit® 4 oz/a	0.34	0.00
Orbit® 6 oz/a	0.23	0.23

Table 2. Deblois, ME site:

	Infected Blossom/m²	Leaves/m²
Control	38.2A	63.7A
Switch® 14 oz/a	34.2A	75.6A
Calcium Nitrate	30.5C	49.4C
Orbit® 4 oz/a	4.2B	19.1B
Orbit® 6 oz/a	0.5A	2.2A

CONCLUSION: Switch® treatment was not effective in preventing *Monilinia* infection. The 6 oz/a Orbit® rate is more effective than the 4 oz/a rate in preventing *Monilinia* infection with an air application with a reduced carrier volume.

RECOMMENDATION: Continue evaluation of fungicides.

WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture

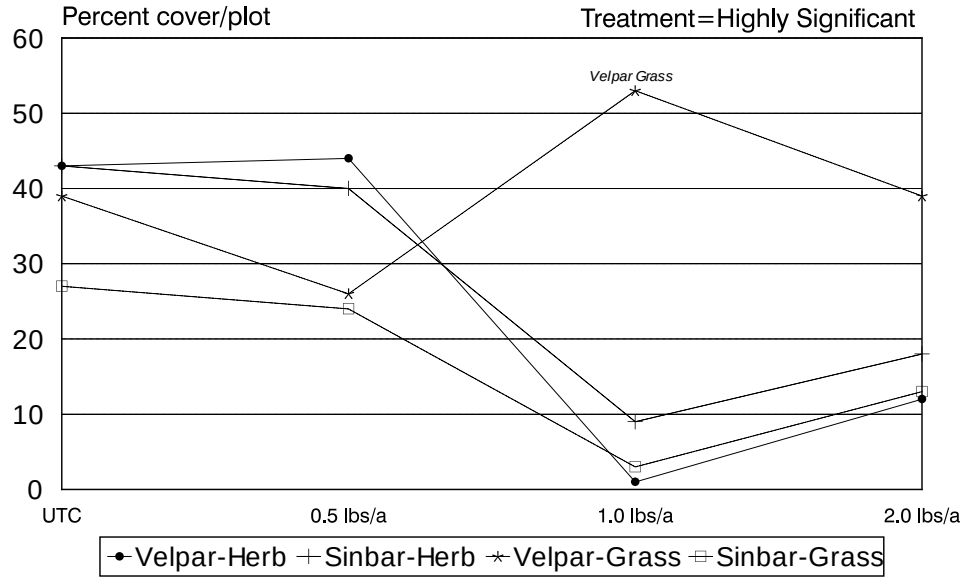
9. TITLE: .Velpar® and Sinbar/Karmex® Demonstration Plot Comparison Trial.

METHODS: A plot for demonstration was established in section 7 of lower field at the Blueberry Hill Farm Agricultural Experiment Station and was treated on 5-18-2000 with Velpar® or Sinbar+Karmex® at 0, 0.5, 1 or 2 lb/a. The blocks are ¼ acres in size. Herbaceous and grass weed cover were determined at 1 and 3 months post treatment.

RESULTS: The plots illustrated that Velpar at 1 and 2 lb/a had much greater grass cover and that the Sinbar+Karmex mixture significantly reduced grass while still controlling herbaceous weeds, indicating the advantages of rotating herbicide treatments (Figure 1). Results were demonstrated to growers at Blueberry Hill Farm Experiment Station Field Day.

RECOMMENDATION: Use information to illustrate the advantage of rotating herbicides.

Figure 1. Effect of Velpar and Sinbar/Karmex on Grass and Herb Weed Cover - 2000



EXTENSION

PRINCIPLE INVESTIGATOR: David E. Yarborough

1. TITLE: Blueberry Extension Education Program in 2000

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, 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 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:

Presented *Effect of Rate, Formulation and Application Method on Efficacy and Phytotoxicity of Granular Hexazinone in Wild Blueberry Fields*, and *Comparison of Sulfosate and Glyphosate for Weed Control in Wild Blueberries* at Northeastern Weed Science Society Meeting Baltimore, MD, January 3-6, 2000 and at North American Wild Blueberry Research and Extension Conference, Charlottetown, PEI Canada, March 22-23, 2000.

Presentations:

Blueberry Pest Management, Augusta Agricultural Trade Show, Augusta, ME, January 21, 2000.

Presented *Wild Blueberry Irrigation in Maine and Update* and *Background on Hexazinone Use*

in Maine at the New Brunswick Horticulture Congress, Fredericton, NB, Canada on February 18-19, 2000.

Participated in Legislature Day in Augusta on February 29, 2000 to explain wild blueberry culture to legislators.
Held 2000 Wild Blueberry Spring Meetings, South Paris, March 28, Union, March 29; Ellsworth March 30; Machias, March 25, 2000.

Conducted ICM field training sessions: *Knox/Lincoln Counties* May 2, 30 & June 27; *Washington County* May 3, 31 & June 28; *Hancock County* May 4, June 1 & 29, 2000. The sessions included training on granular herbicide calibration, blight identification and control, insect sweeping and identification, weed identification and management, blueberry maggot fly trapping and leaf and soil sampling.

I organized wild blueberry irrigation tour with David Bell, Wild Blueberry Commission on July 11, 2000. This tour allowed growers to see and discuss the new developments in irrigation.

Presented Cranberry Tag Team Presentation: *Cranberry Weed Management.* T-19 Passamaquoddy Cranberry Beds, July 14, 2000.

Held annual summer field day and crop guesstimate at Blueberry Hill Farm in Jonesboro on July 19, 2000. A review of the weed control alternatives and the insect control and IPM strategies research was demonstrated and discussed. This annual meeting gives researchers and Extension faculty an opportunity to review and discuss programs and to get grower input.

Conducted tour of wild blueberry fields and processing facilities for Chinese Forestry Group Directors from Jilin Province on August 4-6, 2000.

Organized and conducted tour of wild blueberry production and processing for a group of journalists from the Acadian Institute for Journalism, August 9, 2000.

Participated in Wild Blueberry Association of North America Health Summit in Bar Harbor on August 10-11, 2000.

Conducted field day demonstration of interplanting wild blueberries in a former potato field in Hamlin, Maine on August 28, 2000.

Explained Maine wild blueberry production to hundreds of attendants of the Big E Agricultural Fair in Springfield, MA on September 15-17, 2000.

Participated in the IR-4 annual meeting in Colorado Springs, CO on October 10-12, 2000 to establish priorities for Maine for minor use pesticide trials.

Met with Maine Blueberry Advisory Committee on March 1 and October 24-25 to summarize blueberry research and Extension education program and propose program for 2001.

Participated in Conservation Fair 2000 at the Union Fair Grounds on October 27, 2000. Talked to over 1500 school children on wild blueberry culture.

Presented Wild Blueberry Culture in Maine to Cumberland-N. Yarmouth SAD 51, 4th and 5th grade classes on October 30, 2000.

Discussed blueberry research and Extension program with members of the Blueberry Commission in Ellsworth on November 8, 2000.

Teach Wild Blueberry Culture and Wild Blueberry Pest Management for LHC 110 class , November 29, 2000.

Television/radio/newspaper Interviews 2000:
Aroostook Republican and News: June 6
Associated Press: May 11; May 18
Bangor Daily News: July 21
Bangor Business Monthly: August 17
Currier Gazette: July 29; February 29
Camden Herald: February 29
Downeast Coastal Press: November 22
Ellsworth American: December 29
Ellsworth Weekly Packet: July 27, August 4
Maine Public Radio: August 2, November 6
Maine Sunday Telegram; August 18
Portland Press Herald; January 26; February 22;
TV CH 5: August 24
St. John's Valley Times: June 5
Times Record (Brunswick): November 6

Other Activities:

I am IR-4 liaison for the state of Maine. IR-4 is a federal agency which facilitates the registration of pesticides on minor use crops. Assistance is given for registration when the need is demonstrated but the chemicals are not economically feasible for companies to register. This allows for the use of materials needed in IPM programs that would have been lost. Five IR-4 projects were done in Maine in 2000.
I am coordinator for the CSREES special research grant 'Lowbush Blueberry Production and Processing Technologies' which is granted by the USDA; $205,810 was awarded for 2000. I coordinate proposals and reports from the researchers involved.

I have reviewed manuscripts for the Canadian Journal of Plant Science and the Maine Agricultural and Forestry Experiment Station. I reviewed 'Nitrogen for Bearing Cranberries in North America' for Oregon State University. I reviewed a proposal for the Maine Technology Institute on ‘A walk behind wild blueberry and cranberry harvester for small growers’.

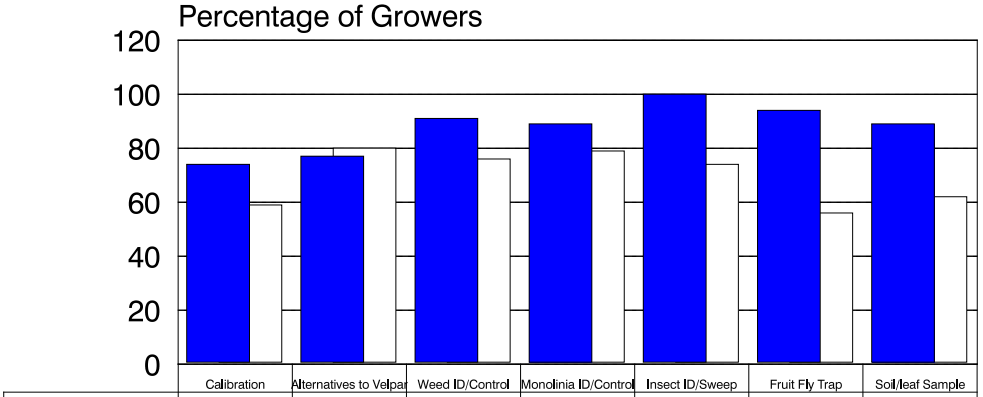
CONCLUSION: Growers are participating in IPM programs in the four primary blueberry growing counties, Washington, Hancock, Knox and Lincoln. The skills survey results indicate that growers are learning new skills and making positive changes in their management practices. A high percentage of participating 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 enable growers to improve the efficiency of blueberry culture by reducing unnessary pesticides and fertilizers.

The hexazinone groundwater survey I have conducted from 1992 to 2000 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 8 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.

2000 Skills Survey Results

Wild Blueberry ICM Educational Program



	Calibration	Alternatives to Velpar	Weed ID/Control	Monolinia ID/Control	Insect ID/Sweep	Fruit Fly Trap	Soil/leaf Sample
Learned	74	77	91	89	100	94	89
Changed	59	80	76	79	74	56	62

Integrated Crop Management Skills

94 Growers/scouts in 4 counties on 28,552 acres (40% return)
66% do pesticide applications and 78% have pesticide license

EXTENSION

INVESTIGATOR: David E. Yarborough, Cooperative Extension blueberry specialist

COOPERATOR: John Jemison, Cooperative Extension water quality specialist

2. TITLE: 2000 Hexazinone Groundwater Survey

METHODS: Surveyed 5 drilled wells, 3 test wells, one dug well and 4 adjacent surface water samples taken each month from May through September to evaluate the difference in liquid vs granular forms and to test for Terbacil on two sites. Three wells were put in by the Maine Department of Conservation in 1986 and the others were drilled and one was a shallow dug well. Well sites were chosen on the basis of a high probability of finding hexazinone. Fields may be grouped by hexazinone treatment: sites 11 and 12 and 13 received Velpar® L preemergence; site 25 received Velpar® L on the top portion of the field and Terbacil adjacent to the road; sites 31, 32, 36 and 38 received Pronone® MG and site 9 just received terbacil/diuron (Table 1). Residue analysis of the water was performed at the University of Maine Food Science & Human Nutrition Department with a high pressure liquid chromatograph which has a detection limit of 0.1 parts per billion (ppb). The objective of this study was to survey wells with different treatments to determine if the Best Management Practices (BMP's) followed reduced the potential intrusion of hexazinone into groundwater.

RESULTS: No significant changes in levels obtained compared to last year with levels ranging from ND to 13.6 ppb. Site 32, that had a point source detection of 105 in 1997, is now below 10 ppb. There was one Terbacil detect in an adjacent stream for June only. Survey of processors indicate average hexazinone use at 1.2 lb/a and that granular use is down to 18% but Terbacil and no herbicide use at 11% for both practices (Figure 1).
CONCLUSION: These data further substantiate that the current use patterns are not resulting in any increase in hexazinone levels in the groundwater (Figure 2).

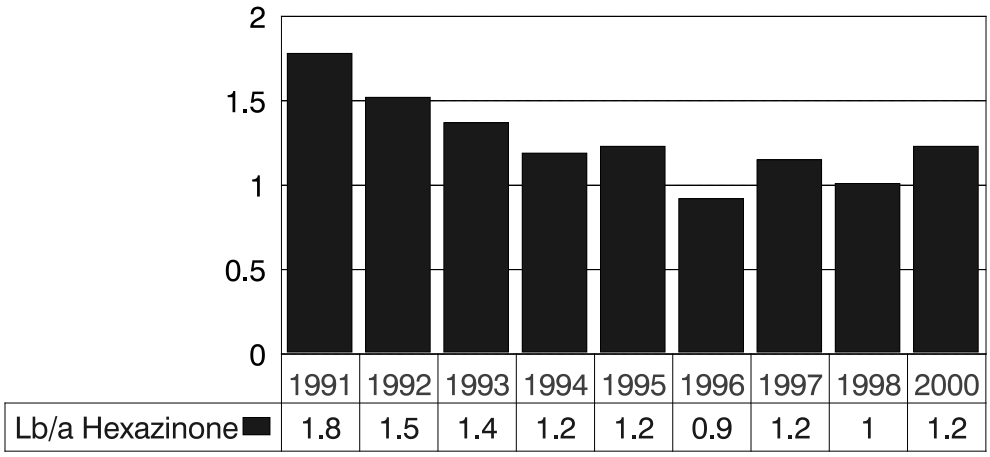
RECOMMENDATIONS: Continue to sample wells to ensure best management practices do not result in hexazinone detections above the health advisory limit (HAL). Continue to vary management practices to determine how they influence hexazinone movement in wild blueberry soils and review and update practices 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. In addition, expand test samples to analyze for terbacil, diuron, and propaconazol, if those treatments were made on the fields.

Table 1. 2000 Hexazinone Test Result Summary
University of Maine Well Water Survey
Hexazinone/Terbacil in parts per billion

SiteWell/herbicide	May	June	July	August	September
Wells					
9 test/Terbacil	2.7/ND	2.85	2.3/ND	2.5/ND	1.5
11 test/liquid	2.9	3.2	3.4	2.3	2.6
12 test/liquid	4.8	5.4	4.1	3.8	2.8
13 drill/liquid	1.6	1.8	ND	1.7	1.4
25 drill/liquid+Terbacil	0.2	0.5/ND	0.5/ND	0.6	ND
31 drill/granular	3.6	3.2	4.2	4.1	2.9
32 drill/granular	13.6	12.1	12.0	11.6	9.1
36 drill/granular	1.6	2.2	2.2	4.0	2.6
38 dug/granular	0.1	ND	ND	ND	ND
Surface					
9 stream/untreated	ND/ND	2.9/1.2	ND/ND	-/ND	ND
11 pond/liquid	4.1	5.0	5.1	2.1	2.3
12 stream/liquid	-	4.0	3.9	4.1	NS
13 pond/untreated	0.2	0.3	ND	ND	ND

Industry Survey of hexazinone Use

Averages of 8 processors



	1991	1992	1993	1994	1995	1996	1997	1998	2000
Lb/a Hexazinone	1.8	1.5	1.4	1.2	1.2	0.9	1.2	1	1.2

Granular 1994-4%, 1998-29% 2000-18% Terbacil 11% None 11%

Figure 1.