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University of Maine-Wild Blueberries
1999 CSREES Progress Reports

FOOD SCIENCE AND BIOSYSTEMS SCIENCE AND ENGINEERING

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

1. TITLE: Effects of IQF Processing on Microbiological Quality of Maine Wild Blueberries (1999 Season)

METHODS: Blueberry samples were taken from various locations during processing in order to determine where reductions or increases in microbial numbers occur. Points identified for those lines using sugar floatation were (1) prior to the initial water wash, (2) following water wash, (3) following sugar floatation, (4) following chlorine spray and (5) after freezing. For processors not using sugar floatation the points were (1) prior to initial wash, (2) following water wash, (3) following chlorine rinse and (4) after freezing.

Three samples were taken at each point during early and late season harvest. Samples were transported to the Department of Food Science & Human Nutrition on ice and analyzed for total aerobic plate count, yeast, molds, coliforms, *E. coli*, *Staphylococcus* spp. and *Listeria* spp. Appropriate decimal serial dilutions were prepared and samples were plated in duplicate. Total aerobic plate counts were performed using Plate Count Agar. Yeast, molds, coliforms, *E. coli*, and *Staphylococcus* spp. were enumerated according to Standard Methods (FDA, Bacteriological Analytical Manual, 7th ed., 1992). Rapid methods for the enumeration of potential human pathogens such as *E. coli 0157:H7* and *Listeria* spp. were evaluated. These included a seven hour antigen detection test (Morningstar Diagnostics, Inc., Naperville IL Catalogue #371-050) and a selective chromogenic culture medium to aid in the detection, isolation, and presumptive identification of verotoxin-producing strains of *Escherichia coli*, particularly serotype 0157:H7 (Rainbow® Agar 0157, Biolog, Inc. Hayward, CA) and a direct label DNA probe kit from Gene-trak Systems.

RESULTS: Two distinctly different process lines from a blueberry processing plant were examined and strategic locations were chosen to evaluate the effects of IQF processing on the microbiological quality of blueberries. These locations were sampled in triplicate and analyzed using Standard Methods. Throughout the process and sampling periods an average reduction of 1.86 $\log_{10}$ occured. The greatest reduction occurred during the initial sampling period (8/3/99) and resulted in a reduction of 3.87 $\log_{10}$. The reductions were achieved through the use of an initial water wash and a subsequent chlorine spray (50-100 ppm).

The initial wash had little reducing effect on total aerobes, and in many cases actually increased the microbial counts. This increase is most likely do to the fact that it was an extremely dry year this year and the microbial population on the berries may have been stressed and did not result in growth initially. However, after being exposed to the water in the wash and allowed time in this improved environment the organisms were capable of growth. The greatest average reduction per sampling period obtained was a 0.77 log reduction. However, this step also resulted in an increase of 1.16 log during the 8/19/99 sampling period. The chlorine rinse also had surprisingly little effect on microbial numbers. The reductions ranged from 0.47-1.34 log. However, after the chlorine treatment and freezing reductions of 0.63-3.72 logs were

observed. This reduction was lower than previous years of this study, but the initial microbial levels were also significantly lower. It is believed that though the chlorine spray didn't appear to have much effect on it's own, it did increase the susceptibility of the aerobes to mortality during the freezing process.

Similar results were seen in yeast and molds. These are shown in Figures 2 and 3. The average reductions seen per processing step are shown in Figures 4 and 5.

Yeast:

In 1998, incoming samples had an average yeast count of over 64,000 CFU/g (4.8 log). These values are consistent with those expected. However, in 1999 the average yeast count was a mere 17000 CFU/g (4.23 log). The average total reduction in yeast was 1.15 logs with a maximum average reduction of 2.82 log occurring 8/3/99. The initial wash had little effect on yeast. The average reduction obtained was only a 0.03 log reduction. The chlorine rinse also had surprisingly little effect on microbial numbers. The average reduction was 0.29 log. However, after the chlorine treatment and freezing average reductions of 1.15 logs were observed. This resulted in final samples possessing average yeast counts of 240 CFU/g or 2.38 log. These values are all very consistent with the values obtained the previous year.

Mold:

Incoming samples had an average mold count of 726 CFU/g (2.86 log). The average total reduction in mold was 1.55 logs, with the initial wash having virtually no effect on molds. The chlorine rinse also had little effect, accounting for a 0.5 log reduction in mold count. However, after the chlorine treatment and freezing, average reductions of 0.79 logs were observed.

Sugar Floatation:

Sugar floatation also appeared to have little effect on the microbial population, with an average increase of only 0.2 log for both sampling periods. However, this does not mean that sugar floatation tanks are not an area of concern for microbial contamination. It simply means that it was not a major factor in this study. The potential for microbial growth in the sugar rich water is high and frequent changing and constant monitoring should be done to ensure the safety of these areas.

***Escherichia coli* and Coliforms:**

The effects of IQF processing on *Escherichia coli* and coliforms were also examined. *E. coli* and coliforms were found to be present on all incoming samples. With coliforms and *E. coli* and remaining throughout all but the final freezing process. Only one of the final frozen samples was found to contain coliforms and none tested positive for *E. coli*. This adds further evidence that chlorine by itself is not an effective antimicrobial application, but in conjunction with a freezing step it is quite effective.

In the last two years of this study, 108 samples have been tested. Sixty five point seventy four % (71 samples) have tested positive for coliform and only 36.11% (39 samples) tested positive for *E. coli*. This shows that the link between coliforms and *E. coli* may not be as strong as it was once thought. This difference is most likely due in part to the fact that a number of the background microbial flora (*Citrobacter, Klebsiella,* and others) will test positive for coliforms.

Listeria:

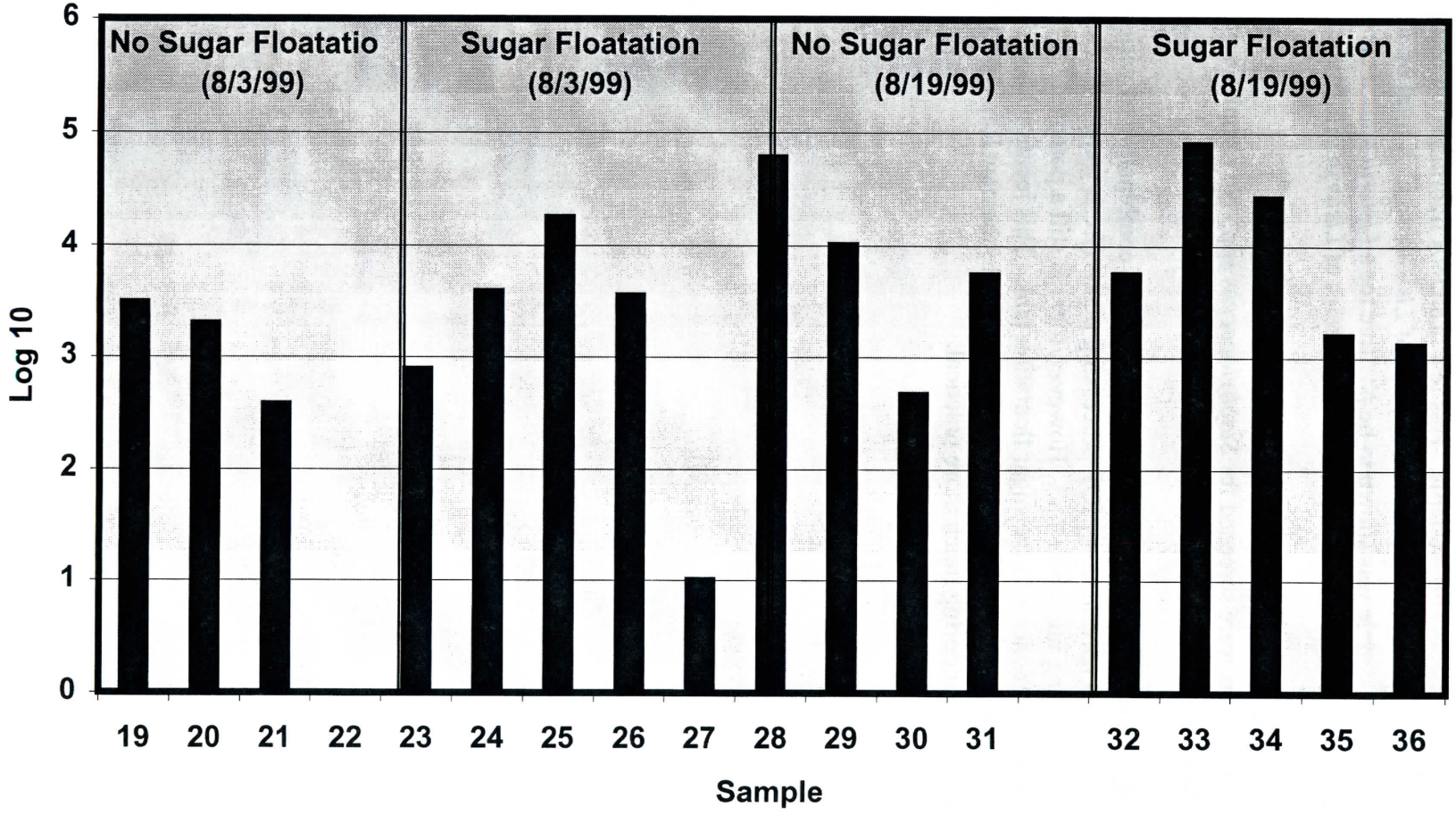
Incoming field samples were analyzed for *Listeria spp.* using the Gene-Trak□□*Listeria* DLP Assay from Gene-Trak systems. This test is a DNA hybridization test, and employs *Listeria*-specific DNA probes for the detection of *Listeria* spp. A total of 32 samples were analyzed and one sample was shown to be positive for a *Listeria* spp. This was not further cultured and we were unable to determine the species of *Listeria* present.

Staphylococcus:

All samples were screened for *Staphylococcus* spp. No samples were shown to contain *Staphylococcus* spp.

RECOMMENDATIONS: This study shows that the combination of various microbial reduction methods used in many IQF processing plants (fresh water wash and chlorine spray) is effective at reducing microbial load. However, there is still a potential for problems to occur. The point of most concern is the sugar floatation tank. This location should be monitored closely to ensure that microbial contamination is not a problem, the new Rapid Methods being developed may make this monitoring much more practical.

Figure 1: Average Aerobes/g at Points Sampled



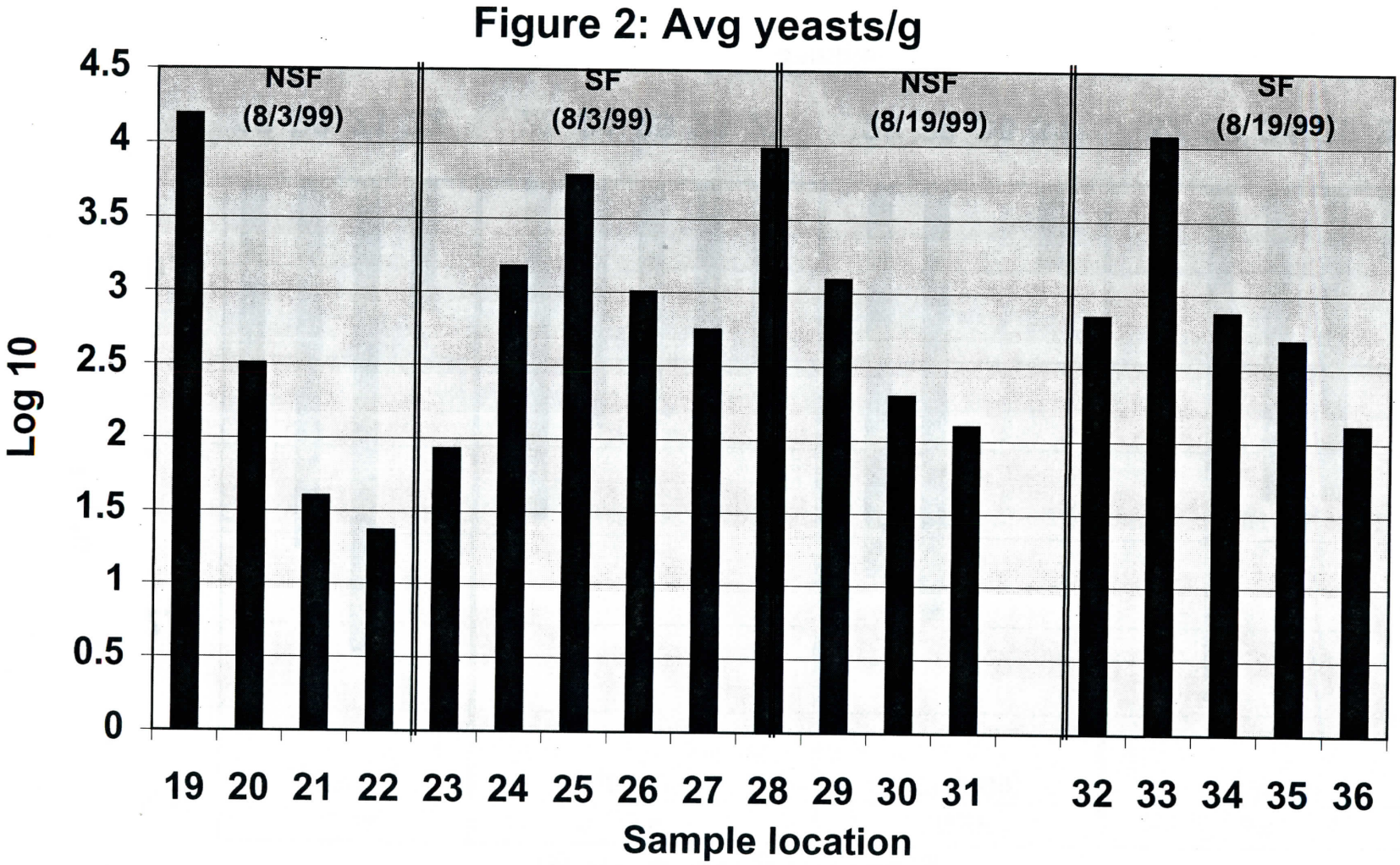


Figure 2: Avg yeasts/g
NSF (8/3/99)
SF (8/3/99)
NSF (8/19/99)
SF (8/19/99)
Log 10
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Sample location

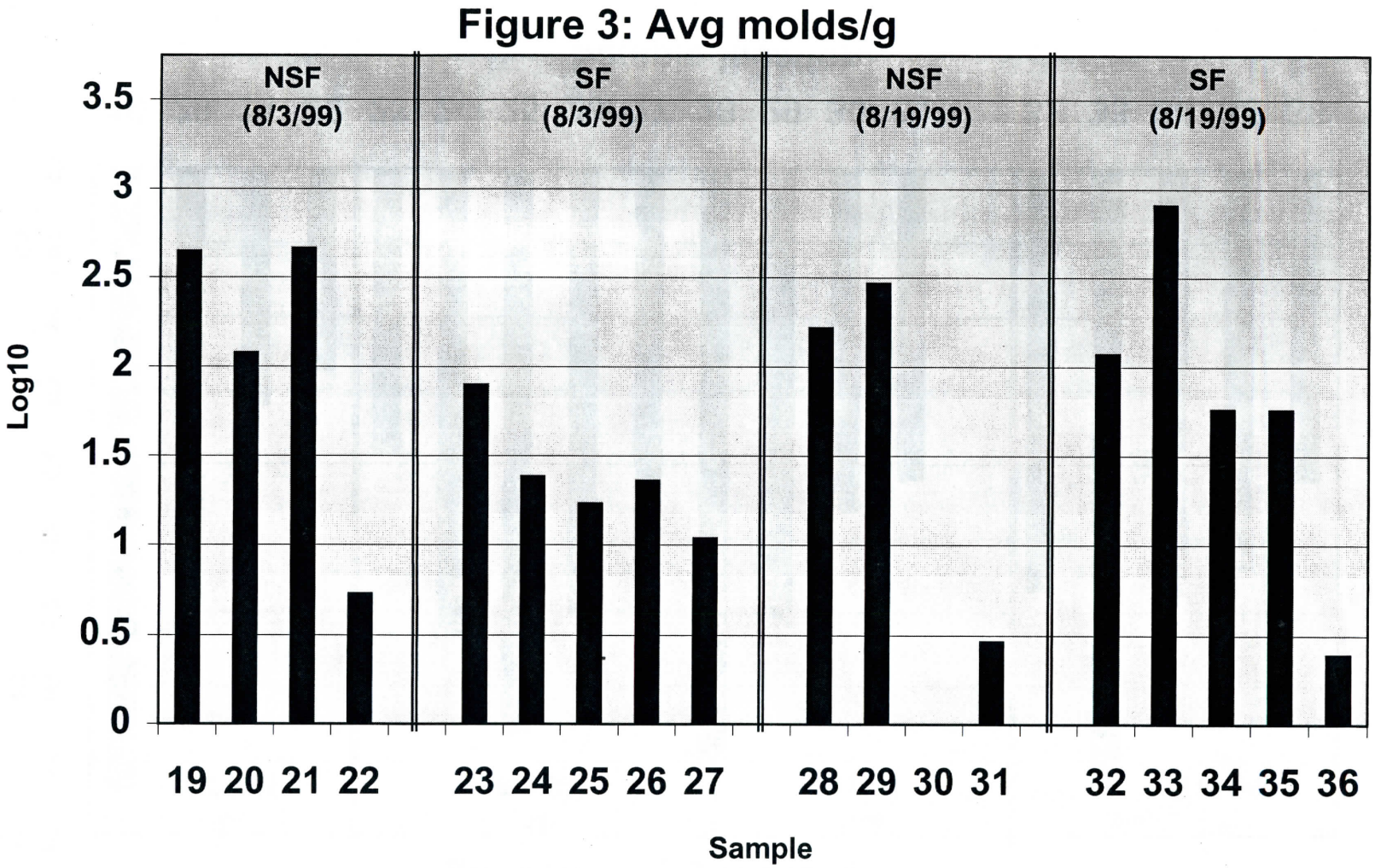


Figure 3: Avg molds/g
NSF (8/3/99)
SF (8/3/99)
NSF (8/19/99)
SF (8/19/99)
3.5
3
2.5
2
1.5
1
0.5
0
Log10
19 20 21 22
23 24 25 26 27
28 29 30 31
32 33 34 35 36
Sample

Figure 4: Average Reduction of Total Aerobes/g

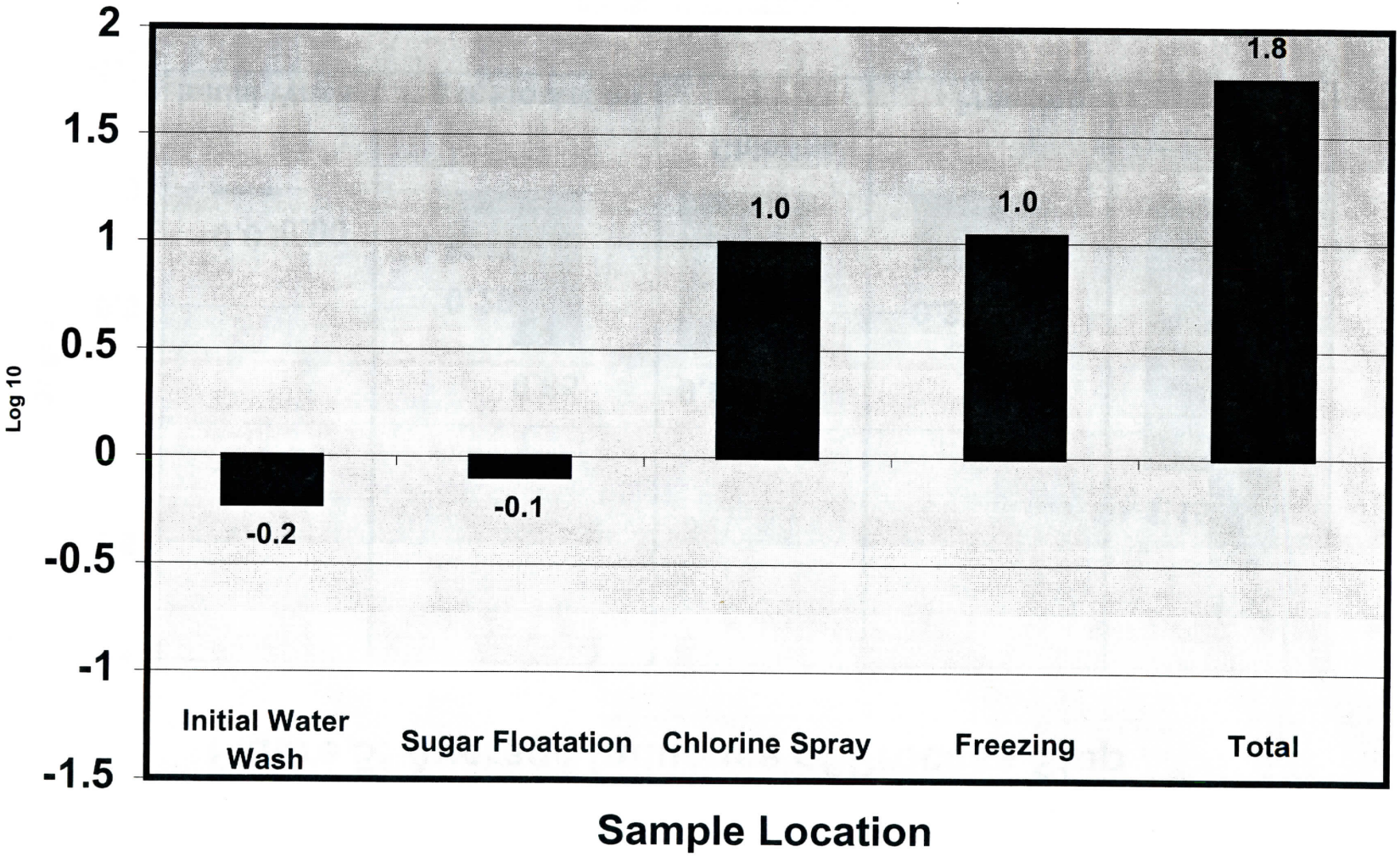
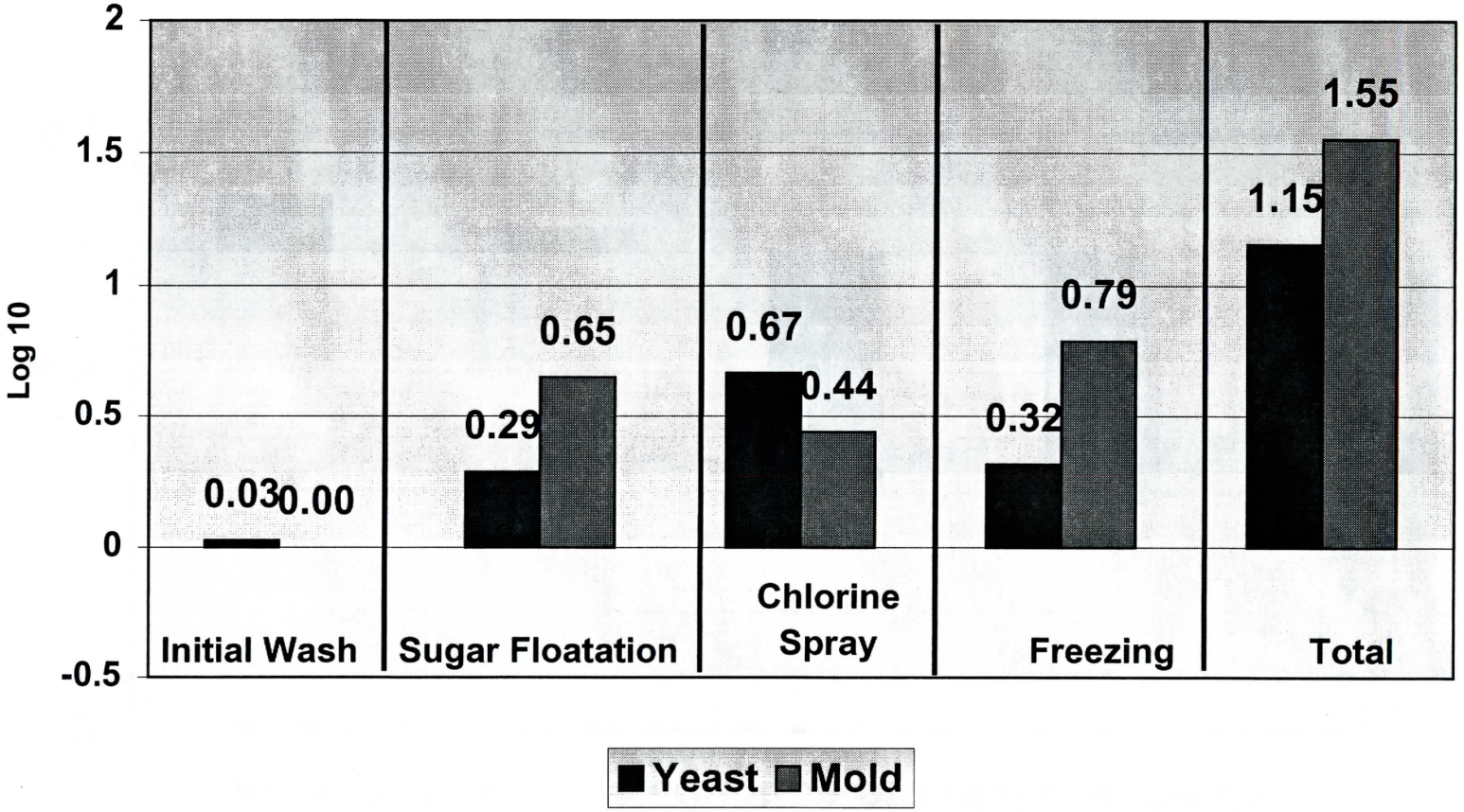


Figure 5: Average Influence of Process Step



FOOD SCIENCE AND BIOSYSTEMS SCIENCE AND ENGINEERING

INVESTIGATORS: Darrell W. Donahue, Biosystems Science and Engineering
Frank A. Drummond, Biological Sciences
Judy Collins, Biological Sciences
Student, Biosystems Science and Engineering

2. TITLE: Separation of Maggot-Infested Blueberries in the IQF Processing Line

OBJECTIVE: Exploratory research for a method to separate maggot-infested blueberries in an IQF processing line.

METHODS: Field and sample preparation

After fruit set, during July, 1999, the research team set up two insect cages (10ft x 30 ft x 6 ft tall) on non-irrigated plots at the Blueberry Hill research farm to isolate an area for the inoculation of berries with blueberry maggot fly. As laboratory-raised flies hatched they were released into the insect cage test area. During the 1999 harvest period, a total of 80 flies were released into the test area (roughly 50:50 sex ratio; 47 flies on 15 July and 33 on 19 July). Also, during the 1999 field season, 200 + quarts of Maine wild blueberries were harvested from primarily two sources; organic farmers in the Jonesboro and Harrington areas as well as the test area at Blueberry Hill Farm, Jonesboro, Maine. Table 1 gives location and amount of samples and preliminary maggot counts for each harvest.

Laboratory investigation

Each time a harvest was taken, three one-quart subsamples were collected to perform a sample maggot count. The normal boiling and dissection method (Dixon and Knowlton 1994) was used at the Biological Engineering laboratory at UMaine as a baseline test to determine the average number of maggots in a given sample of berries. The following laboratory tests were performed to evaluate the effectiveness of maggot identification.

Cold water tolerance. Three times during the 1999 harvest season quart samples were evaluated to determine cold water tolerance. The protocol was to create a 1-2°° C (34-36°F) water bath in a cooler system. The quart of berries was floated in the water bath for approximately 60 minutes, stirring occasionally. After the float time was allowed, the floating berries and other materials were skimmed off to make one sample and the materials that sank (submerged) were separated into the other sample. These two samples were subjected to the boiling and dissection method (Dixon and Knowlton 1994) to determine maggot counts. Nine samples (three samples at three different harvest times) were evaluated using the protocol.

Ultrasound evaluation. The PI cooperated with the Medical Imaging department of Eastern Maine HealthCare (Bangor, ME) to assess the effectiveness of ultrasound as method of maggot identification. These investigations were preliminary to determine the likelihood of using this technology in a processing operation. Ultrasound uses water baths as a transmit medium and most blueberry processing operations use water floatation, so ultrasound technology was investigated as a possible maggot detection method. Several trials were used to obtain the

correct settings for further investigation using the medical ultrasound machine (model: Sequoia, with a 15L8W transducer, Acuson Company, Mt. View, CA). The ultrasound frequency that rendered the best resolution was 10.5 MHz. Water baths (where berries were floated) and an ultrasound gel medium were evaluated as mediums for sound transmission. Individual berries, maggots and blueberry seeds were evaluated using these two methods. Several transverse and longitudinal ultrasound scans were performed to establish baseline image data for individual berries, maggots, and seeds.

X-ray evaluation. In cooperation with the USDA-ARS laboratory (USDA-CA) in Albany, California, line scan x-rays were taken and evaluated for effectiveness of maggot identification. Discussions with the research scientists at USDA-CA and regulators at the California Department of Food and Agriculture (CDFA), lead to two preventative treatment methods which were used to ensure maggot kill prior to entry into California. Fumigation using methyl bromide as per California standards and flash freezing to –40°C (-40°F) were the two methods eventually approved by the CDFA. Approximately 20 quarts of Maine wild blueberries were treated via each method and shipped to The USDA-CA for x-ray evaluation. The PI together with USDA-CA research staff performed several preliminary experiments to determine the best resolution with a Faxitron x-ray machine (model #4380N, Buffalo Grove, IL). The preliminary investigations yielded an optimal range of energy levels from 28-35 kV and exposure times 30 – 600 seconds at 3 mA depending on berry size. The overall best x-ray level was determined to be 30 kV and 3 mA for 2 min exposure. Individual berries were sorted by size and approximately 60 berries were placed in grid patterns on contact paper so that x-ray exposure would be transverse to the stem-calyx axis. Figure 1 shows the resulting pattern as described. After x-ray exposure using the Faxitron machine, the samples were covered with another layer of contact paper so that berry position would be preserved for later ground truth analysis (dissection to observe presence or absence of maggots). The samples were refrigerated and shipped back to the UMaine Biological Engineering Laboratory for ground truth processing. The x-ray film scans were digitally scanned and stored in computer files using Photoshop LE software (Adobe Inc., San Jose, CA). Some preliminary investigations were performed using a prototype digital x-ray machine consisting of a x-ray tube (model OEG-50, Varian Industries, Salt Lake City, UT) with a Pentak controller (Astrophysics Research, Ltd., Cressex, High Wycombe, UK), an image intensifier (model THX9467, 9 inch, Thompson Tube Electroniques Ltd, Velizy Cedex, France), a Videk CCD digital camera (Kodak, Inc., Fairfield, Conn.), a frame grabber (Imaging Technology, Bedford, MA), and a pentium PC. The procedures followed at USDA-CA were similar to those investigated previously (see Keagy and Schatzki 1993, Haff 1999).

The digitized x-ray scans were prepared for visual inspection using CorelDraw (version 8.0, Corel Corporation, Ontario, Canada). A total of 52 visual samples of the digitized scans were evaluated visually by four individuals for ground truth analysis. Example scans are shown in Figure 2. The digitized scans were viewed on a computer screen and the examiners were instructed to assign a 'Y' to indicate some structural patterns visually present and an 'N' for no apparent pattern recognition. To determine maggot presence, the berry samples, which were shipped from USDA-CA, were dissected. The blueberries were dissected and a stereo dissecting microscope (60X, Wilde Inc., Switzerland) was used to aid visual evaluation to determine maggot presence or absence. The inspection of the digital scans was paired with the actual berry

dissections to determine sample ground truth. A comparison of structural information found was made to determine existence of recognizable patterns in the data.

Researchers at USDA-CA also assisted the PI with some preliminary investigation with near-infrared radiation (NIR) in the 350 - 1100 nanometer wavelengths using a spectrometer (Model PC1000, Ocean Optics, Dunedin, FL). Individual maggots, blueberry seeds, interior fluids, skin and whole berries were evaluated. A transmittance spectra graph of these components is given in Figure 3.

RESULTS/CONCLUSIONS:

The 1999 field season was considered average with respect to maggot infestations. The release of laboratory-raised maggot flies yielded no maggot infestation in the test area at Blueberry Hill Farm: two hand-raked harvests, one week apart, yielded 0 maggot counts. The most likely cause was not enough time between the release of flies into the insect cages and harvest for experimentation to detect maggots. Maggot larvae must be more mature (larger) to enable visual evaluation. In addition, there may have been predator insects in the insect cages that preyed on the maggot fly. However, samples from organic farms yielded maggot counts on samples ranging from 6 to 25 per quart that were used for experimentation. See Table 1 for further details concerning maggot counts.

Cold water tolerance. Maggots were found in both the berry samples (floats) as well as found in the bottom of the cooler (sinks), see Table 2 for results. These data present mixed results concerning cold water tolerance. The last sample was berries in the late stages of the field season and it was suggested that maggots had begun to crawl out of the berries to prepare for the next life cycle stage. Based on these results, it is recommended that cold water tolerance should be evaluated another field season with higher maggot counts. This further evaluation will assist to sort out the mixed results found during the1999 field season.

Ultrasound evaluation. Ultrasonic evaluation proved to be able to find the maggot in individual blueberries, in both the water baths and ultrasound gel medium. However, the process was very sensitive to berry orientation, position of transmitter and receiver and position of the maggot relative to other internal berry structure. When the maggot was positioned transversely and not longitudinally, the maggot was mistaken for a seed. The ultrasound process is fairly sensitive to changes in orientation and also water bath disturbances. For these reasons we feel that current technology ultrasound should not be considered as a detection/separation technique for maggot-infested blueberries.

X-ray evaluation. Berry size (or thickness) was a major factor determining the ability to ascertain interior structure of the blueberry. After samples were sized, more uniform structure in the images was found in both the film and digitized scans. Mocked up samples, where ethanol-preserved maggots were inserted into berries, were scanned for comparison purposes, see Figure 4. Visual inspection revealed no discernable patterns or lack of structure when comparing maggot-free and maggot-infested berries. The conclusion of the research team is that the density of the maggot is close to that of the interior portions of the berry, making distinguishing between the two nearly impossible with currently available x-ray technology. Therefore, it is the

recommendation of the research team that x-ray not be pursued as a maggot identification/separation technology.

Near-Infrared Radiation (NIR). The preliminary investigations with NIR technology proved interesting. As seen in Figure 3, the transmittance of the maggot material peaks at approximately 550 nanometers (nm). The other materials examined peaked at higher wavelengths; the seed near 680 nm and flesh and whole berry near 750 nm. The distinction between these peak areas could provide for a method of separation. NIR techniques rely on the basic structural differences (protein, sugars, etc.) between components to identify transmittance or reflectance. Further investigation with the NIR technology will be required to determine its usefulness as an identification/separation technology.

RECOMMENDATIONS:

The methods investigated and results found, during the 1999 field season, suggest ultrasound and x-ray techniques will not work to identify maggots in Maine wild blueberries. Cold water tolerance should be studied in the 2000 field season to sort out the mixed results from the 1999 field data. The preliminary work performed with NIR shows promise as a method of maggot identification in blueberries. The research team suggests further research into NIR methods and techniques.

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]
07/25/99	Hitchings Farm, Harrington	25 (approximate)	Field	25, 19, 12
08/04/99	Blueberry Hill Farm, Jonesboro	15	Inside research Tent	0, 0, 0
" "	"	"	Outside tent area	4, 0, 1, 2, 0, 5
08/05/99	Beddington Ridge Farm (Ron Varin)	75	Processing line	1
"	"		Field, near woods	5, 5, 0
08/06/99	"	25	Field, near woods	5, 12
08/10/99	"	25 (approximate)	Field, near woods	13, 11, 5

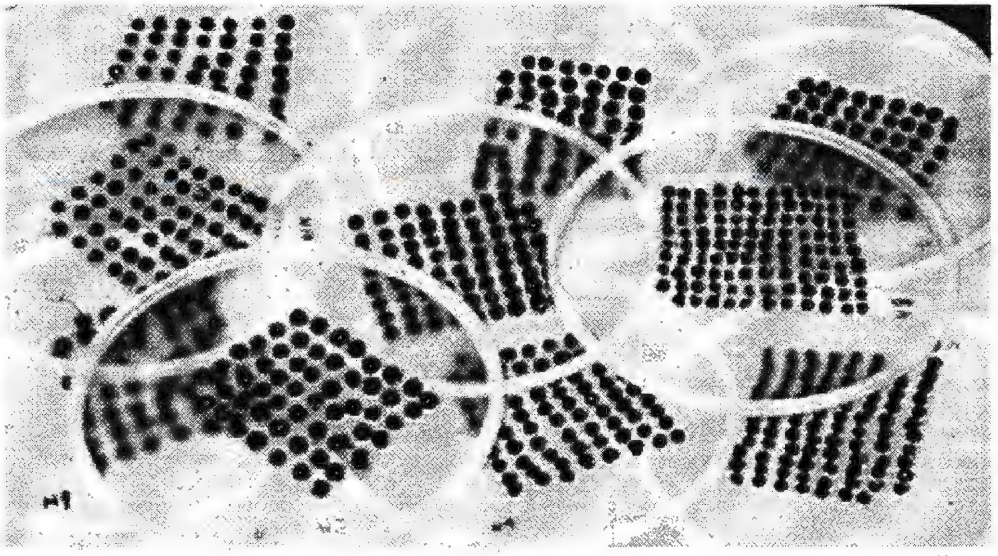
[1] Maggot counts per quart as determined by Dixon and Knowlton (1994) boil and dissection method, each number represents maggots found in a one quart sample

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

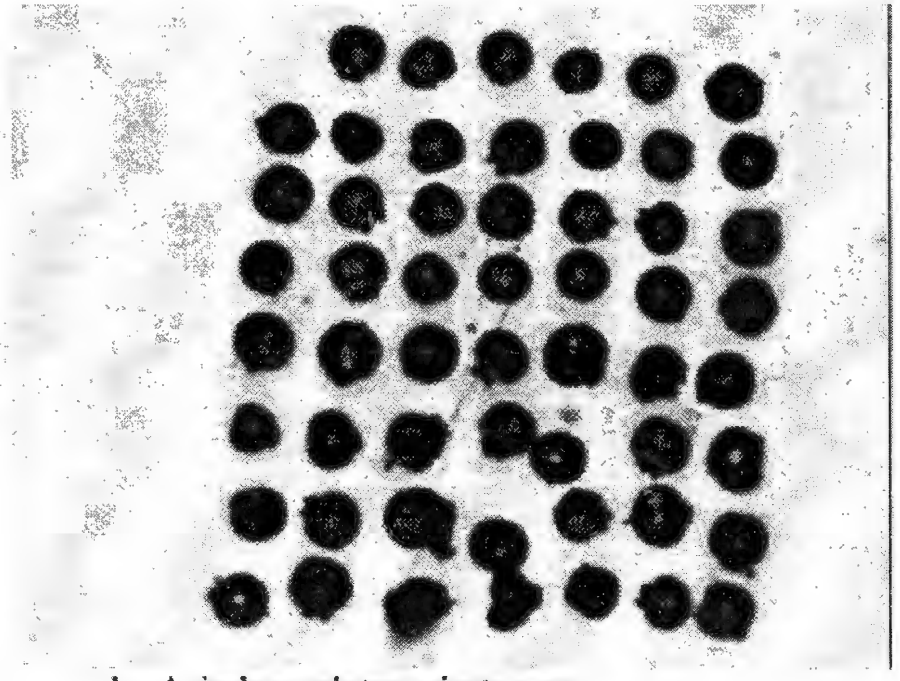
Date – Trial	Water temperature C (F)	Estimated maggot count[1] (average)	Float count	Sink count
07/29/99 – 1	2.2 (36)	4/quart	3	0
" – 2	2.2 (36)	"	2	0

" – 3	2.2 (36)	"	2	1#
08/05/99 – 1	1.7 (35)	5/quart	1	1
" – 2	1.7 (35)	"	2	0
" – 3	1.1 (34)	"	1	0
08/10/99 – 1	1.1 (34)	10/quart	12	5#
" – 2	1.7 (35)	"	5	5#
" – 3	1.1 (34)	"	7	7#

1 based on prior boil/dissection maggot counts
some sunk berries were included in this sample

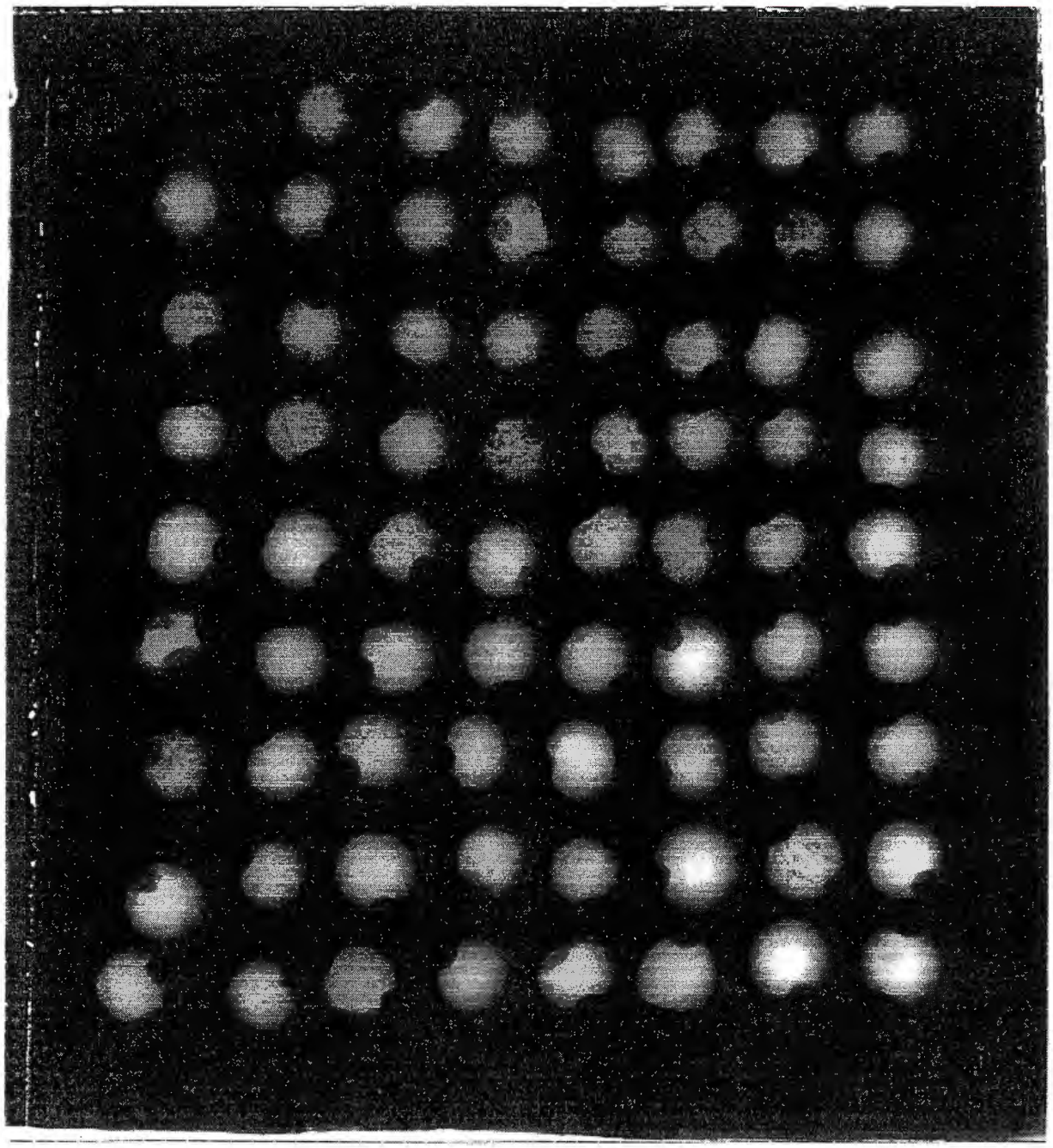


a. Prepared sample trays prior to x-ray



b. A single sample tray prior to x-ray

Figure 1. Blueberry samples for x-ray exposure



c. Digitized x-ray image of sample

Figure 1. (cont'd)

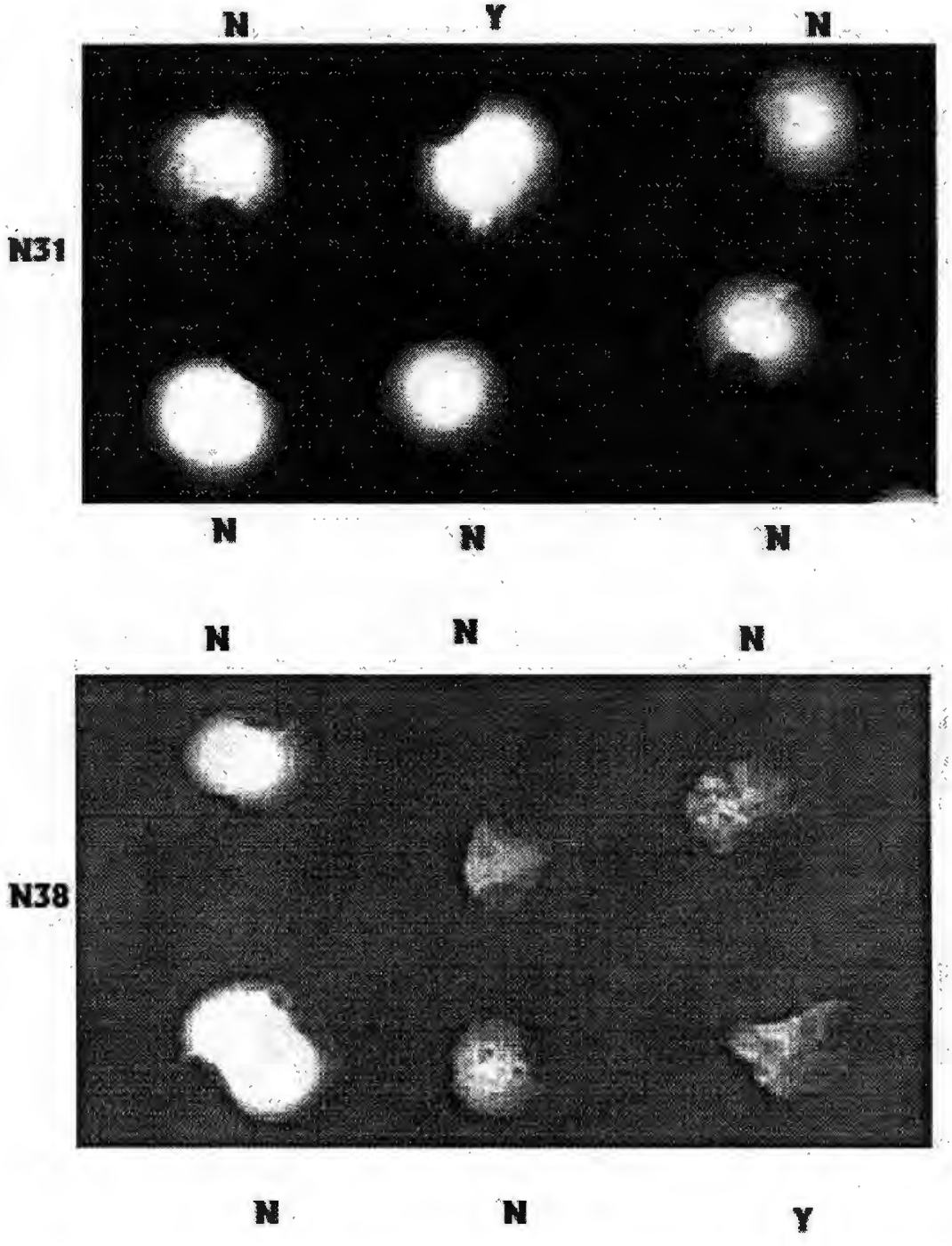


Figure 2. Two example x-ray scans where ground truth dissection found presence of a maggot (maggot presence is indicated by 'Y' or absence by 'N')

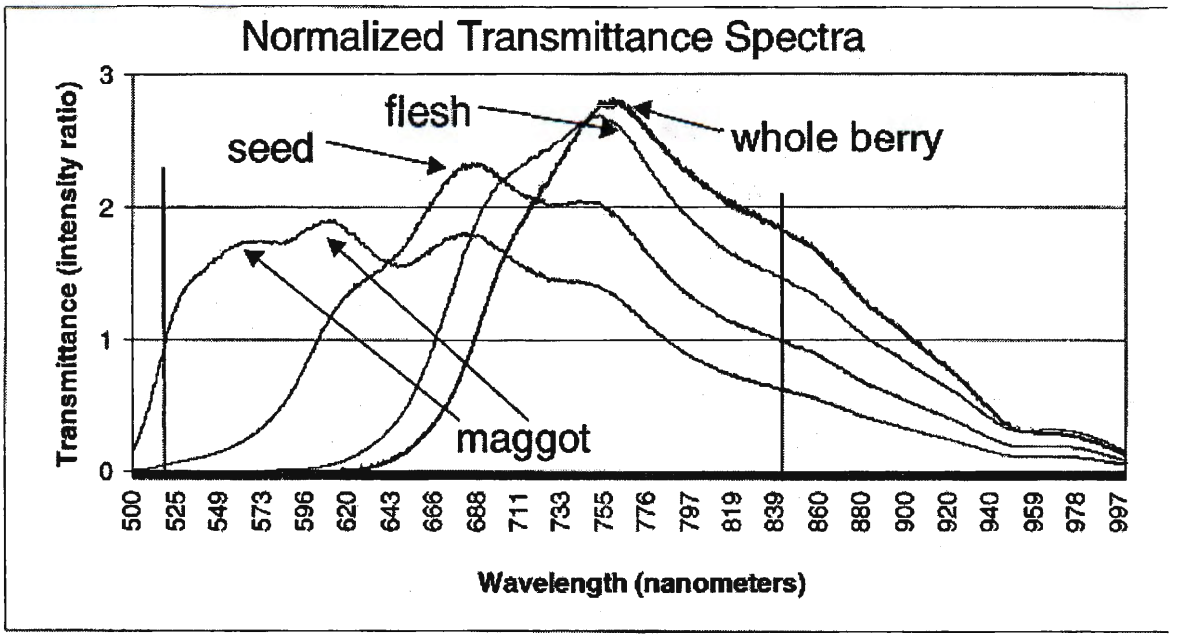
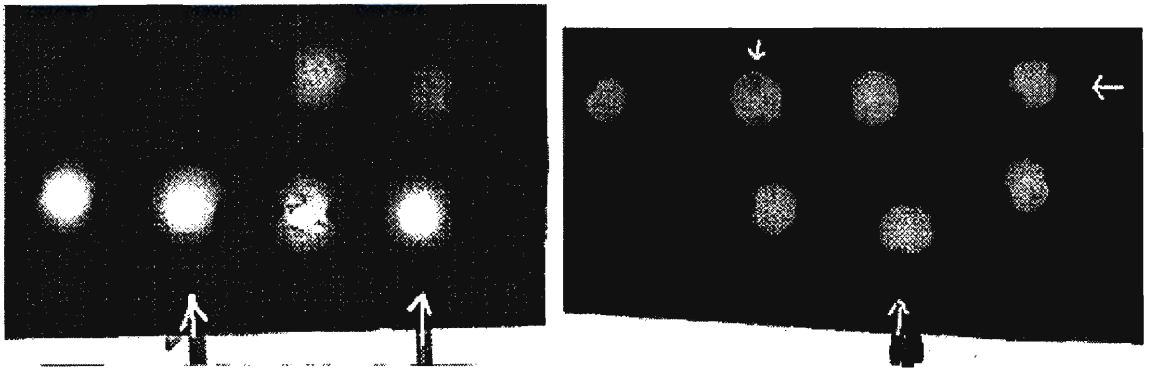


Figure 3. Near-infrared radiation normalized transmittance spectra for various components of the blueberry



a. Mock up with maggot in frozen berry

b. Mock up with maggot in natural berry

Figure 4. Example x-ray scans with 'mock up' blueberry with maggot present (arrows → point to berry with inserted maggot "mock up")

PESTICIDE RESIDUES IN BLUEBERRY CROP 1998
A REPORT

Investigators: Rodney J. Bushway, Professor of Food Science
Alfred A. Bushway, Professor of Food Science
Brian Perkins, Research Food Chemist

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

Methods: Blueberry samples (6 pounds each) were collected by the processors and brought to my laboratory in September 1998. Samples arrived frozen and were kept frozen until analysis. Pesticide residues in blueberries were analyzed using HPLC, GC-AED and ELISA methods developed in my laboratory.

Results: Sixty-five samples were analyzed from the 1998 wild blueberry crop (Table 2). Only 2 different pesticides—guthion and phosmet-- were found in the 1998 crop. Of these 65 samples 21 had phosmet residues or 32% of the blueberries sampled and 26 samples were found to contain guthion (40% of the samples). The phosmet concentration ranged from 0.015 ppm to 1.55 ppm while the guthion levels ranged from 0.008 ppm to 0.76 ppm.

Conclusion: Considering the tolerances (phosmet 10 ppm and guthion 5 ppm) these positive samples have very low residues.

Recommendations: I would suggest to continue analyzing future crops of wild blueberries to maintain a residue data base which is invaluable to the wild blueberry Industry.

Future Work: Development of LC/MS/MS methods to look at possible breakdown products and new polar pesticides.

TABLE 1
1998 Blueberry Pesticide Results

Sample	Phosmet (ppb)	Guthion (ppb)	Methoxychlor (ppb)	Carbendazim (ppb)	Hexazinone (ppb)	Propiconazole (ppb)	Captan (ppb)
1	ND	ND	ND	*	ND	ND	ND
2	ND	44	ND	*	ND	ND	ND
3	ND	72	ND	*	ND	ND	ND
4	ND	ND	ND	*	ND	ND	ND
5	ND	ND	ND	*	ND	ND	ND
6	ND	ND	ND	*	ND	ND	ND
7	20	17.7	ND	*	ND	ND	ND
8	ND	ND	ND	*	ND	ND	ND
9	ND	ND	ND	*	ND	ND	ND
10	ND	ND	ND	*	ND	ND	ND
11	164	67	ND	*	ND	ND	ND
12	ND	44.2	ND	*	ND	ND	ND
13	ND	ND	ND	*	ND	ND	ND
14	ND	27.4	ND	*	ND	ND	ND
15	ND	158	ND	*	ND	ND	ND
16	102	ND	ND	*	ND	ND	ND
17	ND	ND	ND	*	ND	ND	ND
18	ND	ND	ND	*	ND	ND	ND
19	ND	ND	ND	*	ND	ND	ND
20	115	ND	ND	*	ND	ND	ND
21	ND	ND	ND	*	ND	ND	ND
22	100	53	ND	*	ND	ND	ND
23	146	44.2	ND	*	ND	ND	ND
24	ND	ND	ND	*	ND	ND	ND
25	ND	ND	ND	*	ND	ND	ND
26	ND	ND	ND	*	ND	ND	ND
27	ND	ND	ND	*	ND	ND	ND
28	ND	ND	ND	*	ND	ND	ND
29	ND	62.1	ND	*	ND	ND	ND
30	ND	757	ND	*	ND	ND	ND
31	ND	167	ND	*	ND	ND	ND
32	ND	44.0	ND	*	ND	ND	ND
33	ND	ND	ND	*	ND	ND	ND
34	133	615	ND	*	ND	ND	ND
35	ND	ND	ND	*	ND	ND	ND
36	200	ND	ND	*	ND	ND	ND
37	ND	27.4	ND	*	ND	ND	ND
38	376	ND	ND	*	ND	ND	ND
39	110	ND	ND	*	ND	ND	ND
40	107	ND	ND	*	ND	ND	ND
41	57.1	58.7	ND	*	ND	ND	ND
42	72.8	ND	ND	*	ND	ND	ND
43	1551	ND	ND	*	ND	ND	ND
44	ND	ND	ND	*	ND	ND	ND
45	ND	ND	ND	*	ND	ND	ND

46	420	15.8	ND	*	ND	ND	ND
47	ND	ND	ND	*	ND	ND	ND
48	ND	ND	ND	*	ND	ND	ND
49	ND	15.7	ND	*	ND	ND	ND
50	900	ND	ND	*	ND	ND	ND
51	45.0	7.87	ND	*	ND	ND	ND
52	ND	47.4	ND	*	ND	ND	ND
53	15.1	ND	ND	*	ND	ND	ND
54	ND	ND	ND	*	ND	ND	ND
55	ND	7.90	ND	*	ND	ND	ND
56	420	15.8	ND	*	ND	ND	ND
57	ND	ND	ND	*	ND	ND	ND
58	ND	ND	ND	*	ND	ND	ND
59	ND	15.7	ND	*	ND	ND	ND
60	900	ND	ND	*	ND	ND	ND
61	45.0	7.87	ND	*	ND	ND	ND
62	ND	47.4	ND	*	ND	ND	ND
63	15.1	ND	ND	*	ND	ND	ND
64	ND	ND	ND	*	ND	ND	ND
65	ND	7.90	ND	*	ND	ND	ND

ND = no residue detected at following limits:
Phosmet: 1 ppb
Guthion: 1 ppb
Methoxychlor: 5 ppb
Hexazinone: 20 ppb
Propiconizole: 5 ppb (Orbit, tilt)
Captan: 5 ppb
Carbendazmin: 20 ppb (Benlate)
*Using new equipment – analyzing over the next 2 weeks.

PESTICIDE RESIDUES IN BLUEBERRY CROP 1999
A REPORT

Date: February 7, 2000

Investigators: Rodney J. Bushway, Professor of Food Science
Alfred A. Bushway, Professor of Food Science
Brian Perkins, Research Food Chemist

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

Methods: Blueberry samples (6 pounds each) were collected by the processors and brought to my laboratory in September 1998. Samples arrived frozen and were kept frozen until analysis. Pesticide residues in blueberries were analyzed using HPLC, GC-AED and ELISA methods developed in my laboratory.

Results: Fifty-five samples were analyzed from the 1999 wild blueberry crop (Table 1). There were 5 different pesticide—phosmet, guthion, methoxychlor, carbendazim, and propiconizole-- found in this crop. Of these 5 different pesticides carbendazim residues were found in 55%(range 0.025 to 0.87 ppm)of the samples followed by phosmet at 40% (range 0.006 ppm to 2.58ppm), guthion at 36% (range 0.01 ppm to 1.21ppm), methoxychlor (0.08 ppm) and propiconizole (0.10 ppm).

Conclusion: Considering the tolerances (phosmet 10 ppm, guthion 5 ppm, methoxychlor 14 ppm, carbendazim 7 ppm and propaconizole unavailable) these positive samples have very low residues.

Recommendations: I would suggest to continue analyzing future crops of wild blueberries to maintain a residue data base which is invaluable to the wild blueberry Industry.

Future Work: Development of LC/MS/MS methods to look at possible breakdown products and new polar pesticides.

TABLE 1
1999 Blueberry Pesticide Results

Sample	Phosmet (ppm)	Guthion (ppm)	Methoxychlor (ppm)	Carbendazim (ppm)	Hexazinone (ppm)	Propiconazole (ppm)	Captan (ppm)
Detection Limit - 1	0.001	0.001	0.005	0.02	0.02	0.005	0.005
2	ND	ND	ND	ND	ND	ND	ND
3	ND	ND	ND	ND	ND	ND	ND
4	ND	0.079	ND	ND	ND	ND	ND
5	0.116	ND	ND	ND	ND	ND	ND
6	ND	ND	ND	ND	ND	ND	ND
7	0.023	ND	ND	ND	ND	ND	ND
8	2.558	ND	ND	ND	ND	ND	ND
9	ND	ND	ND	ND	ND	ND	ND
10	ND	ND	ND	0.103	ND	ND	ND
11	ND	0.055	ND	ND	ND	ND	ND
12	ND	0.091	ND	ND	ND	ND	ND
13	0.02	0.072	ND	ND	ND	ND	ND
14	ND	ND	ND	0.247	ND	ND	ND
15	ND	ND	ND	ND	ND	ND	ND
16	102	ND	ND	0.563	ND	ND	ND
17	0.007	ND	ND	0.163	ND	ND	ND
18	0.028	ND	0.08	0.185	ND	ND	ND
19	ND	0.051	ND	ND	ND	ND	ND
20	ND	1.206	ND	0.047	ND	ND	ND
21	ND	0.108	ND	0.037	ND	ND	ND
22	ND	0.025	ND	ND	ND	ND	ND
23	ND	0.025	ND	0.157	ND	ND	ND
24	0.172	ND	ND	0.275	ND	ND	ND
25	ND	0.026	ND	0.456	ND	ND	ND
26	ND	0.045	ND	0.09	ND	ND	ND
27	ND	ND	ND	ND	ND	ND	ND
28	ND	0.088	ND	ND	ND	ND	ND
29	0.115	ND	ND	0.228	ND	ND	ND
30	0.023	ND	ND	0.117	ND	ND	ND
31	0.038	ND	ND	0.305	ND	ND	ND
32	ND	0.014	ND	0.064	ND	ND	ND
33	ND	ND	ND	ND	ND	ND	ND
34	0.024	0.01	ND	ND	ND	ND	ND
35	ND	ND	ND	ND	ND	ND	ND
36	ND	ND	ND	ND	ND	ND	ND
37	ND	0.021	ND	ND	ND	ND	ND
38	ND	ND	ND	ND	ND	ND	ND
39	0.303	ND	ND	ND	ND	ND	ND
40	0.006	ND	ND	0.212	ND	ND	ND
41	ND	ND	ND	0.212	ND	ND	ND
42	ND	ND	ND	ND	ND	ND	ND
43	ND	ND	ND	0.272	ND	ND	ND
44	ND	ND	ND	0.187	ND	ND	ND
45	0.006	ND	ND	0.129	ND	ND	ND
46	0.013	ND	ND	0.23	ND	ND	ND
47	ND	ND	ND	ND	ND	ND	ND
48	0.006	ND	ND	0.206	ND	ND	ND

49	ND	ND	ND	ND	ND	ND	ND
50	ND	ND	ND	0.083	ND	ND	ND
51	ND	ND	ND	0.039	ND	ND	ND
52	ND	ND	ND	ND	ND	ND	ND
53	ND	ND	ND	0.29	ND	ND	ND
54	0.008	ND	ND	0.117	ND	ND	ND
55	0.006	ND	ND	0.099	ND	ND	ND
56	ND	0.032	ND	0.872	ND	ND	ND
57	ND	ND	ND	ND	ND	ND	ND
58	0.032	ND	ND	ND	ND	ND	ND
59	ND	ND	ND	0.025	ND	ND	ND
60	ND	ND	ND	ND	ND	ND	ND
61	ND	0.278	ND	ND	ND	0.104	ND
62	0.029	ND	ND	ND	ND	ND	ND
63	ND	ND	ND	0.572	ND	ND	ND
64	ND	ND	ND	ND	ND	ND	ND
65	0.053	0.054	ND	ND	ND	ND	ND
66	ND	ND	ND	ND	ND	ND	ND
67	ND	ND	ND	ND	ND	ND	ND
68	ND	ND	ND	ND	ND	ND	ND
69	ND	0.043	ND	ND	ND	ND	ND
70	0.038	0.081	ND	ND	ND	ND	ND
Tolerances	10	5	14	7	0.2	NA	25

ENTOMOLOGY

INVESTIGATORS: F. A. Drummond, Associate Professor of Insect Ecology
J. A. Collins, Assistant Scientist of Biological Sciences

1. TITLE: Control Tactics for Blueberry Pest Insects

I. METHODS

Evaluation of insecticides for control of secondary pest insects.

Two laboratory control tests were conducted using a Burkard® computer controlled spray apparatus to apply Confirm®, an insect growth regulator and to evaluate its effectiveness against early and mid- to late instar blueberry spanworm larvae. The efficacy of phloxine *b* (the active ingredient in SureDye®), and spinosad (a derivative from the fermentation of the microorganism *Saccharpolyspora spinosa)* was evaluated in small cage studies with laboratory reared blueberry maggot adults. Surround Crop Protectant® (a particle film derived from the mineral kaolin) was applied to suppress feeding by blueberry flea beetle larvae and was tested by feeding field collected larvae blueberry stems.

Field trials were conducted to evaluate the efficacy of SpinTor® (spinosad), Mycotrol® (GHA strain *Beauveria bassiana*), Javelin® (*Bt*), Confirm®, Imidan®, and a combination of Mycotrol® and Javelin® against blueberry spanworm larvae. SpinTor®, Mycotrol®, and Surround® were tested against blueberry flea beetle larvae. All materials were applied as foliar sprays. Effectiveness in all three trials was measured by taking pre- and post-treatment sweep-net samples and by holding larvae in the laboratory for evidence of infection with *Beauveria bassiana*. Two trials were conducted against blueberry thrips. In one trial, Mycotrol® was applied as a soil drench to pruned fields. In a second trial, four materials (Diazinon®, Admire®, Esteem®, and Surround®) were applied as foliar sprays to a pruned field. Populations of thrips in both trials were monitored by counting the numbers of infested stems as evidenced by leaf curling.

Treatments were applied and residue samples collected to aid in the registration of Esteem® (pyriproxyfen), an insect growth regulator.

RESULTS

In laboratory tests against blueberry maggot adults, yeast hydrolozate bait mixed with spinosad resulted in significantly greater fly mortality by day 1 compared to mortality of flies fed only bait as a control. Mortality of flies fed phloxine *b* + bait was not significantly different from that of flies fed only bait until day 3 (Table 1). Surround® was ineffective against blueberry flea beetle larvae (Table 2). Good results were obtained with Confirm® against blueberry spanworm larvae (Table 3). The results suggest that the recommended rate should be effective in controlling spanworm larvae in the field.

In field tests, both rates of SpinTor® provided excellent control of a large flea beetle population. When adjusted to account for *Beauveria bassiana* induced mortality, Mycotrol® also performed very well. Surround® was not effective (Table 4). SpinTor® and Imidan® significantly reduced blueberry spanworm populations in two separate trials (Table 5). Larvae collected from sites treated with Mycotrol® developed a moderate to high level of infection immediately following the first application in both trials (56% on 4/23, 50% on 4/25 in trial #1;

90% on 4/30 in trial #2); however, there was a decrease in % infection on subsequent sample days. Mycotrol® 16 oz + Javelin® (8 oz) performed slightly better; however, seasonal densities were not significantly different than the untreated controls. Populations treated with Confirm® were high in initial counts, but then declined rapidly. A spring drench with Mycotrol® did not significantly reduce populations of blueberry thrips (Table 6). Also, none of the materials applied as foliar treatments gave a statistically significant reduction in populations of thrips as evidenced by leaf curling. However, subjective visual observations suggested that plots treated with Diazinon® and Admire® were in better condition than those treated with Surround® or Esteem® (Table 7).

CONCLUSIONS

Of the materials tested in 1999, SpinTor® and Confirm® showed the most promise. Also, several years of data have now been collected on Mycotrol®, a commercially available formulation of the insect pathogenic fungus *Beauveria bassiana*. The poor results against spanworm in 1999 may have been due to the unseasonably hot, dry and sunny weather through the duration of the trial. Mycotrol® breaks down rapidly under these conditions; newly emerging larvae would likely be unaffected.

II. METHODS

Alternative chemical controls for blueberry maggot.

The efficacy of four materials (Neemix®, SpinTor®, Imidan®, and Surround®) was evaluated following ground applications with an airblast sprayer. Efficacy was evaluated based on numbers of maggots in fruit at harvest. Seasonal density of blueberry maggot adults was monitored with baited yellow Pherocon® traps.

RESULTS

Seasonal density of blueberry maggot adults was generally above the recommended cumulative threshold of 10 flies/trap (Table 8). Analysis of the trap data showed no significant difference among the treatments. Of the materials tested, only the standard Imidan® significantly reduced maggot populations in comparison with the 'no insecticide' control.

CONCLUSIONS

The search for alternatives to Guthion/Sniper® and Imidan® to control blueberry maggot has been slow. Results with Neemix® have not produced consistent results. Although SureDye® has performed very well in laboratory and controlled cage studies, field trials in 1998 were inconclusive. The material was not available on a timely basis for field tests in 1999.

III. METHODS

Distribution and persistence of *Beauveria bassiana*.

Assessing background levels of *Beauveria bassiana* in Washington Co: Soil samples were collected from Washington and Knox Co. and processed in the laboratory to assess 'natural' infection levels of this insect pathogenic fungus.

Persistence of *Beauveria bassiana* in soil: Mycotrol® was applied to the soil as a drench in a pruned blueberry field. Soil samples were collected at monthly intervals to monitor residual levels of *Beauveria bassiana*.

Effect of Mycotrol® on bumble bees: Commercial bumble bees were allowed to forage in field cages covering crop year wild blueberry plants which were treated with the recommended field rate of Mycotrol® immediately prior to introduction of the bees. Evaluation of the effect of Mycotrol® on the bees was based on several factors including bee survival, health of queens and brood, bee flight activity, and blueberry fruit set.

RESULTS

Assessing background levels of *Beauveria bassiana* in Washington Co: Natural infestations of *B. bassiana* were found in only one of 23 fields. The sample was collected from a crop field located on the barrens in Washington Co. This compares to 14 of 25 fields in Washington Co. having *B. bassiana* in 1998.

Persistence of *Beauveria bassiana* in soil: More *B. bassiana* was recovered closer to the soil surface and less was recovered in deeper samples on the first sample date (Fig. 1). There was also a decrease over time with more *B. bassiana* being recovered immediately after application and less on subsequent dates. By the third sample date, little or no *B. bassiana* was found in the soil samples. The mean half-life of *B. bassiana* was 41 days. This compares to 45 days in 1998 during a similar study.

Effect of Mycotrol® on bumble bees: There was no significant difference in the number of live bumble bees collected from each hive at the conclusion of the trial (Table 9). An average of 77.75 bees were collected from hives placed in cages treated with Mycotrol®; 81.25 bees were collected from untreated control hives. No differences were observed in queen or brood. There was also no difference in the number of bees flying during four, 1 minute observations. An average of 4.3 bees were observed in both treated and untreated cages. Counts of flowers prior to introduction of the bees and of fruit after bees were removed showed no significant differences. Treated cages had an average of 7.4 flowers and 4.1 fruits per stem; control cages had 7.6 flowers and 3.5 fruits per stem.

CONCLUSIONS

Assessing background levels of *Beauveria bassiana* in Washington Co: We suspect that the drought conditions in 1999 may have contributed to the absence of natural *B. bassiana* infestation in blueberry fields. This suggests that environmental conditions may have significant impact on the levels of disease that one might expect to find in blueberry fields.

Persistence of *Beauveria bassiana* in soil: Applications of *B. bassiana* to the soil could have long lasting potential for mortality of spanworm or flea beetle pupating in or on the soil surface. To confirm this, field studies involving release of late instar flea beetle and spanworm larvae onto soil previously sprayed with *B. bassiana* need to be conducted.

Effect of Mycotrol® on bumble bees: Mycotrol® apparently had no adverse effects on commercial bumble bees.

IV. METHODS

Exclusion of blueberry maggot adults from field plots using mesh screening as a barrier.

Three, 15 x 15-ft plots were set in a crop year wild blueberry field which previous observations had shown to be heavily infested with blueberry maggot. Each plot was enclosed with black fiberglass window screening, 4-ft high, and attached to wooden stakes. Sand was used to seal the bottom. A baited yellow Pherocon® trap was placed within each enclosure and checked at three to four day intervals for blueberry maggot adults. Three additional traps were set in adjacent areas of the field between 20 and 50-ft from the enclosures. Effectiveness of the enclosures to exclude blueberry maggot adults was evaluated by counting numbers of maggots found in fruit at harvest.

RESULTS

Enclosing small field plots with window screening resulted in a significant reduction in the total number of flies captured on yellow sticky traps over the duration of the trial. There was also a significant reduction in numbers of maggots found in processed fruit (Table10).

CONCLUSIONS

Larger scale field tests still must be conducted to see if screening is useful in production level pest management.

RECOMMENDATIONS

With one exception, the list of recommended insect control materials will remain essentially unchanged for 2000. Mycotrol ES® will be added to the list of recommended materials for use against flea beetle larvae in 2000. At least one additional year of data is necessary on the effectiveness of this compound against spanworm larvae before any recommendation can be made.

I. EVALUATION OF INSECTICIDES FOR CONTROL OF SECONDARY PEST INSECTS.

Table 1. Laboratory screening of insecticides for control of blueberry maggot adults, sprayed on six dates between 24 March and 4 April 1999.

	% Mortality (SD)* on post treatment day				
Material	1	2	3	4	Mean days to death**
phloxine *b* 0.48% + bait	15.2 (16.9)	47.5 (25.2)	81.8 (18.8)	100.0 (0.0)	2.5 (0.18) c
spinosad + bait	55.8 (19.5)	86.8 (10.8)	95.8 (10.2)	100.0 (0.0)	1.6 (0.15) b
yeast hydrolozate bait	3.3 (8.2)	25.0 (29.3)	47.0 (33.2)	58.3 (29.0)	3.3 (0.18) a

* Percent mortality for six trials, combined.

** Mean days to death out of a total of four days in the experiment.

Table 2. Laboratory screening of Surround Crop Protectant for control of blueberry flea beetle larvae; sprayed 19 May 1999.

		% Mortality (SD)		
Material	Rate	5/21	5/22	5/24
Surround CP + MO3 s/s	6% solids (50 lbs/100 gals) + 1 pt/100 gals	0 (0.0)	0 (0.0)	0 (0.0)
No insecticide	-	0 (0.0)	25 (12.5)	25 (12.5)

Table 3. Laboratory screening of Confirm 70 WP for control of blueberry spanworm larvae; test #1 treated 26 April, test #2 treated 6 May 1999.

TEST #1

Trt. no.	Rate (oz/acre)	% Mortality (SD) * 04/27	04/28	04/29	04/30	04/31
1.	32.0	0 (0.0)	30 (25.8)	50 (38.3)	100 (0.0)	100(0.0)
2.	16.0	0 (0.0)	10 (11.5)	40 (28.3)	100 (0.0)	100 (0.0)
3.	3.2	5 (10.0)	10 (11.5)	25 (19.1)	100 (0.0)	100 (0.0)
4.	0.32	0 (0.0)	20 (16.3)	55 (10.0)	80 (16.3)	100 (0.0)
5.	0.032	0 (0.0)	10 (11.5)	35 (25.2)	80 (16.3)	100 (0.0)
6.	Control (H_2O) + Latron s/s 1.5 oz	0 (0.0)	0 (0.0)	20 (16.3)	55 (34.2)	65 (25.2)

* Four replicates of five larvae.

TEST #2

Trt. no.	Rate (oz/acre)	% Mortality (SD)* 05/07	05/08	05/09	05/10	05/11
1.	32.0	5 (10.0)	10 (20.0)	70 (20.0)	95 (10.0)	100 (0.0)
2.	0.32	5 (10.0)	35 (30.0)	80 (16.3)	95 (10.0)	95 (10.0)
3.	0.032	15 (10.0)	50 (20.0)	80 (16.3)	80 (16.3)	80 (16.3)
4.	0.0032	0 (0.0)	10 (20.0)	55 (10.0)	60 (16.3)	75 (19.1)
5.	Control (H_2O) + Latron s/s 1.5 oz	4 (8.9)	12 (11.0)	16 (8.9)	20 (0.0)	20 (0.0)

		05/12	05/13
1.	32.0	100 (0.0)	100 (0.0)
2.	0.32	100 (0.0)	100 (0.0)
3.	0.032	100 (0.0)	100 (0.0)
4.	0.0032	75 (19.1)	85 (19.1)
5.	Control (H_2O) + Latron 1.5 oz	24 (8.9)	32 (11.0)

* Four replicates of five larvae; five replicates of five larvae for control.

Table 4. Field control of blueberry flea beetle larvae.

Material	Amt. form./acre	Seasonal density*
SpinTor 2 SC	5.7 oz	6.8 c
SpinTor 2 SC	2.8 oz	12.3 b
Mycotrol ES	32 oz	16.0 b
Surround CP	6% solids (50 lbs/100 gals)	92.4 a
+ MO3 s/s	+ 1 pt/100 gals	
No insecticide	-	79.2 a

* Means followed by the same letter are not significantly different ($P < 0.05$; SNK).

Table 5. Field control of blueberry spanworm larvae.

Material	Amt. form./acre	Seasonal density*
TRIAL #1		
Mycotrol ES	32 oz	20.5 a
SpinTor 2 SC	5.7 oz	1.7 c
Imidan 2.5 EC	16 oz	3.6 b
No insecticide	-	14.8 a
TRIAL #2		
Mycotrol ES	32 oz	13.3 a
Mycotrol ES	16 oz	
+ Javelin WP	8 oz	8.1 a
Javelin WP	16 oz	3.7 b
Confirm 70 WP	8 oz	
+ Latron s/s	1.5 oz	3.2 b
Confirm 70 WP	16 oz	
+ Latron s/s	1.5 oz	2.4 b
SpinTor 2 SC	5.7 oz	1.0 c
Imidan 2.5 EC	16 oz	0.9 c
No insecticide		14.9 a

* Means followed by the same letter within each trial are not significantly different ($P < 0.05$; SNK).

Table 6. Control of blueberry thrips on wild blueberry with Mycotrol ES, (GHA strain *Beauveria bassiana*), applied as a soil drench.

	Average	Average/tin Stems with curls	
Material	stems/tin	number	%*
Mycotrol ES	41.2	32.2	82.0 a
No insecticide	47.4	41.6	90.0 a

* Means followed by the same letter are not significantly different ($P < 0.05$; ANOVA).

Table 7. Field control of blueberry thrips.

Material	Amt. form./ acre	Avg. no. stems/ sq ft*	% stems with curls Avg./sq ft*
Diazinon 500	32 oz	104.9 a	26.2 bc
Admire 2 F	6.4 oz	100.3 a	16.9 c
Esteem 0.86 EC IGR	15 oz	96.3 a	56.2 ab
Surround CP + MO3 s/s	6% solids (50 lbs/100 gals) + 1 pt/100 gals	98.9 a	79.0 a
No insecticide	-	102.6 a	33.6 bc

* Means within each column followed by the same letters are not significantly different ($P < 0.05$; SNK).

II. ALTERNATIVE CHEMICAL CONTROLS FOR BLUEBERRY MAGGOT.

Table 8. Field control of blueberry maggot with ground application of insecticides.

Material	Amt. form./ acre	Number of applications	Appl. dates	Avg. maggots/ quart*	Adults/trap seasonal density*
Surround CP + MO3 s/s	6% solids + 12% solids + 1 pt/100 gal	2	7/1, 7/12	2.3 ab	9.3 a
Surround CP + MO3 s/s	12% solids + 1 pt/100 gal	1	7/12	3.2 a	10.0 a
SpinTor 2 SC	8 oz	1	7/12	1.8 ab	10.9 a
Imidan 2.5 EC	32 oz	1	7/12	0.3 b	9.4 a
Neemix 4.5 WG/WDG	21 oz	1	7/12	2.6 ab	13.9 a
No insecticide	-	-	-	2.8 a	10.9 a

* Means among treatments within the same column followed by the same letters are not significantly different ($P < 0.05$; SNK).

III. DISTRIBUTION AND PERSISTENCE OF *BEAUVERIA BASSIANA*.

Figure 1. Persistence of *Beauveria bassiana* in the soil.

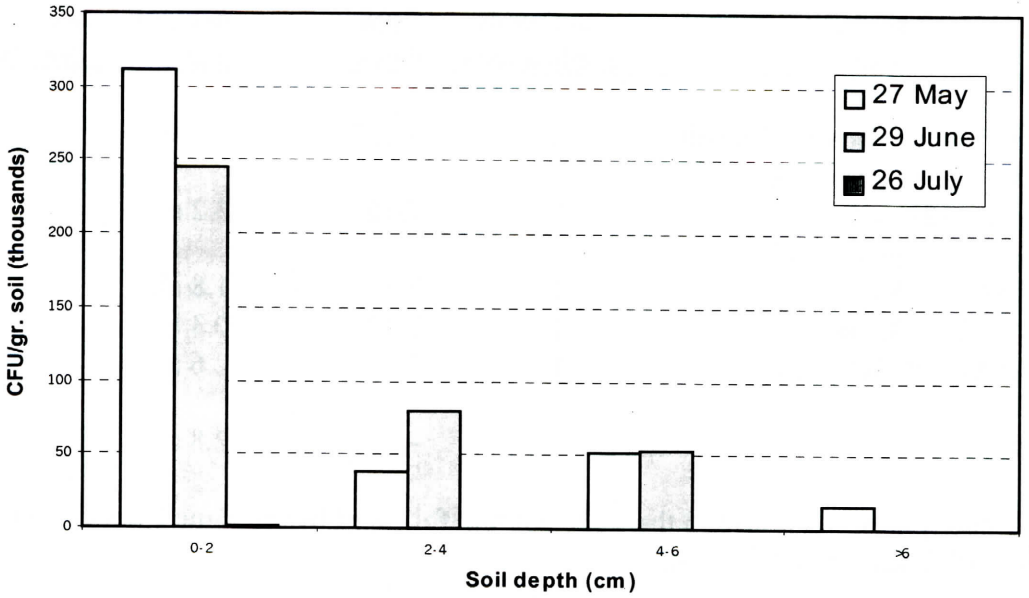


Table 9. Effect of *Beauveria bassiana* (Mycotrol ES) on commercial bumble bees. 1999

Treatment	Hive #	Live bees*	Queen	Capped brood	Uncapped brood
Mycotrol ES	1	75	Yes	Yes	No
	3	66	Yes	Yes	No
	5	86	Yes	Yes	No
	7	82	Yes	Yes	No
		77.8 (8.6) a			
Untreated control	2	104	Yes	Yes	No
	4	83	Yes	Yes	No
	6	63	Yes	Yes	No
	8	75	Yes	Yes	No
		81.2 (17.2) a			

* Means followed by the same letter are not significantly different ($P < 0.05$; ANOVA).

IV. EXCLUSION OF BLUEBERRY MAGGOT ADULTS FROM FIELD PLOTS USING MESH SCREENING AS A BARRIER.

Table 10. Summary of yellow sticky trap captures and maggot infestation of fruit comparing enclosed vs. open field plots

Treatment	Cumulative flies/trap (SD)*	Maggots/qt (SD)**
Enclosed	2.7 (3.8) a	0.1 (0.3) a
Open	19.3 (9.0) b	7.9 (6.9) b

* Cumulative flies per trap is the total flies collected on each trap over the duration of the trial divided by the number of traps (3/treatment).

** Means followed by the same letter are not significantly different ($P < 0.05$; SNK).

ENTOMOLOGY

INVESTIGATORS: F. A. Drummond, Associate Professor of Insect Ecology
J. A. Collins, Assistant Scientist of Biological Sciences

2. TITLE: IPM Strategies

I. METHODS

Within-field movement of blueberry maggot:

In late July at Blueberry Hill Farm, 56 baited yellow Pherocon® traps were distributed in an 8 x 7 foot grid with 20 feet between each row and column of traps. On two dates, blueberry maggot flies which had been reared in the laboratory from wintering pupae were marked with flourescent dye and released into the center of the field. The traps were checked daily. Any captured flies were collected and examined for dye.

Colonization of blueberry fields by blueberry maggot flies:

On 24 June, baited yellow Pherocon® traps were placed in four fields in Washington Co. The traps were distributed in linear transects. For each transect, one trap was set 30 ft outside the field edge. The next trap was at the field edge; subsequent traps were set 10, 20, 50, 100, 200, and 300 ft along a line running into the field. An additional trap was set at 500 ft in two of the fields. The traps were checked at two to three day intervals beginning on 25 June and continuing until 19 July. All traps were replaced after two weeks. Any captured flies were collected, rinsed in kerosene to remove sticky residue from the traps, and stored in 70% ethyl alcohol (ETOH) prior to inspection in the laboratory to determine gender and oviposition status.

RESULTS

Within-field movement of blueberry maggot:

Of 40 flies released, eight were recaptured (20.0%). Flies moved an average of 42.58 ft/day. Of the eight flies recaptured in 1999, five were recaptured within one day of release. The distance traveled by these flies ranged from 22.4 ft to 92.2 ft. Figure 1 shows the distribution of distance flies move per day for flies collected in both 1998 and 1999. Work has begun on a computer model of fly movement. This winter, data from this study will be added to the model and hypotheses will be generated which can be field tested in 2000.

Colonization of blueberry fields by blueberry maggot flies:

At three of the four sites (Blueberry Hill Farm was the exception), flies were heavily congregated within the 10-ft region around the field perimeter (Figure 2, graphs 1-3). The fourth graph at each site shows a projection of the fly catch across each field if a one time, 50-ft wide, perimeter spray of Imidan® or Guthion® is made around the field. After this simulated border spray, threshold levels for blueberry maggot fly (cumulative of 10/trap) were greatly exceeded in one (Jonesboro) of the four fields sampled.

CONCLUSIONS AND RECOMMENDATIONS

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

suggests that most of the maggot fly population in a field is aggregated within the first 100 ft into the field. Our blueberry maggot fly movement studies suggest that blueberry maggot flies move, on average, about 40 ft/day. These basic biology data will form the basis for future testing and recommendations on the use of spray tactics such as strip spraying and field perimeter treatments.

II. METHODS

Economic threshold of blueberry flea beetle larvae.

Crop fields: In May, seven wild blueberry clones were selected in a crop-year field at Blueberry Hill Farm; each clone was one replication. Eight, 2-ft diameter plots were set in each clone (four pairs of plots/rep). A narrow strip was mown around the plots to reduce movement of flea beetle larvae. For each replication, one of four different densities of early instar flea beetle larvae was placed in each pair of plots (0, 50, 100, or 150 larvae per plot). In late May, the number of larvae collected in two sweeps with a standard 12-inch sweep net was determined for one plot at each density within each replication. An estimate was also made of defoliation. The number of larvae was subsequently converted to larvae/10 sweeps. In mid-July, yield was assessed based on the total weight of fruit harvested from the second plot at each density within each replication. All berries within a single replication were harvested on the same day. Yield data were converted to yield/acre.

Pruned fields: Four sites were selected in a prune-year field at Blueberry Hill Farm. Four, 2-ft diameter plots were set at each site. At each site, one of four different densities of early to mid-instar flea beetle larvae was placed in each plot (0, 50, 100, or 150 larvae per plot). Each plot was covered with a mesh cage 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 at each density. A linear and quadratic regression analysis was conducted on flower buds vs. initial larval density. In spring of 2000, the number of actual flowers/bud will be determined for 25-50 additional stems from each plot.

RESULTS

Crop fields: Table 1 shows the average number of larvae collected at each density level. We were able to create near or greater than 'economic threshold' densities (30-50 flea beetle larvae/10 sweeps) at initial densities of 100 and 150 larvae (27.9 and 42.9 larvae/10 sweeps, respectively). Figure 3 shows the relationship between initial flea beetle density and numbers of flea beetle larvae collected in sweep-net samples. As in 1998, there was a significant trend. Figure 4 illustrates the regression trends between initial larval density and defoliation rating; there was a positive correlation. As in 1998, any defoliation was generally confined to the center area of the plots. Feeding damage within that area varied from little to no visible damage (rating of 0 or 1) to heavy (rating of 3) with severe defoliation of a clump of stems but little or no defoliation through the remainder of the plot. Similarly to 1998, despite the defoliation response observed in the plots, there was not a significant decrease in yield in response to increasing flea beetle densities (Figure 5).

Prune fields: The regression analyses revealed no significant correlation between initial larval density and number of flower buds per stem (Figure 6). One observation of interest is that there was a significant decrease in flower buds at an initial larval density of 50. Numbers of flower buds/stem then increased with increasing larval density.

CONCLUSIONS AND RECOMMENDATIONS.

Crop fields: The response in 1998 and 1999 in defoliation increasing as flea beetle density increases suggests that our experimental design is adequate for estimating an economic threshold. Our observations of defoliation would seem to confirm 1998 speculations that as long as sufficient food is available, larvae will remain within a fairly isolated area. The fact that we were able to produce near or greater than 'economic threshold' densities with initial densities of 100 and 150 larvae without a subsequent decrease in yield would seem to indicate that current thresholds are low, or at least conservative and can be used with little risk. Studies with larval densities three to four times the economic threshold of 50 larvae/10 sweeps are needed in the future to assess yield loss and need for new action thresholds.

Prune fields: It is possible that larvae had a 'pruning' effect on the blueberry stems which led to a stimulation of plant growth and subsequent increase in numbers of flower buds. Additional research is needed before any firm conclusion can be drawn.

I. Within-field management of blueberry Maggot.

Figure 1. Daily movement distance of blueberry maggot flies (1998 and 1999 data).

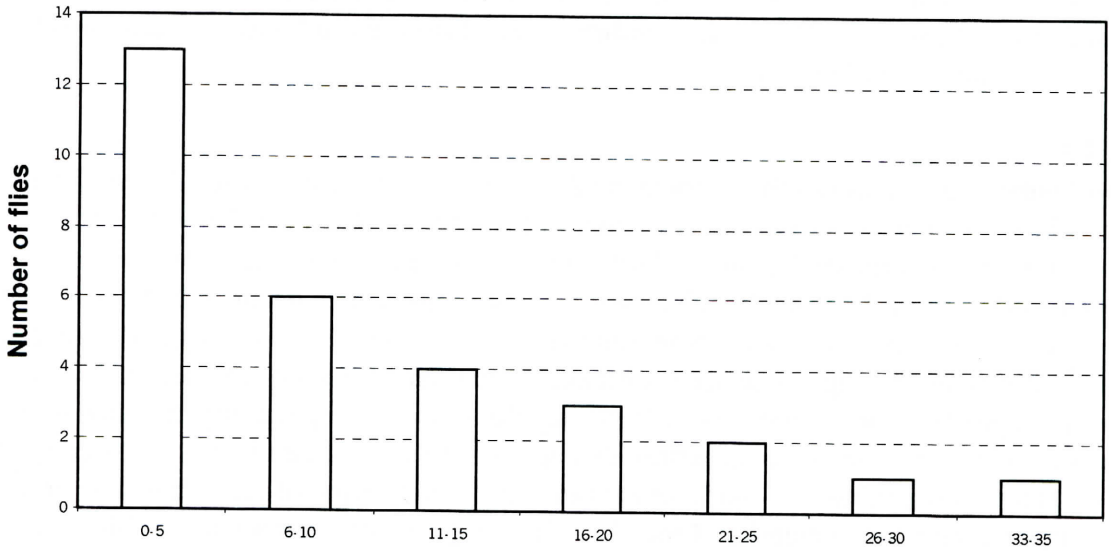
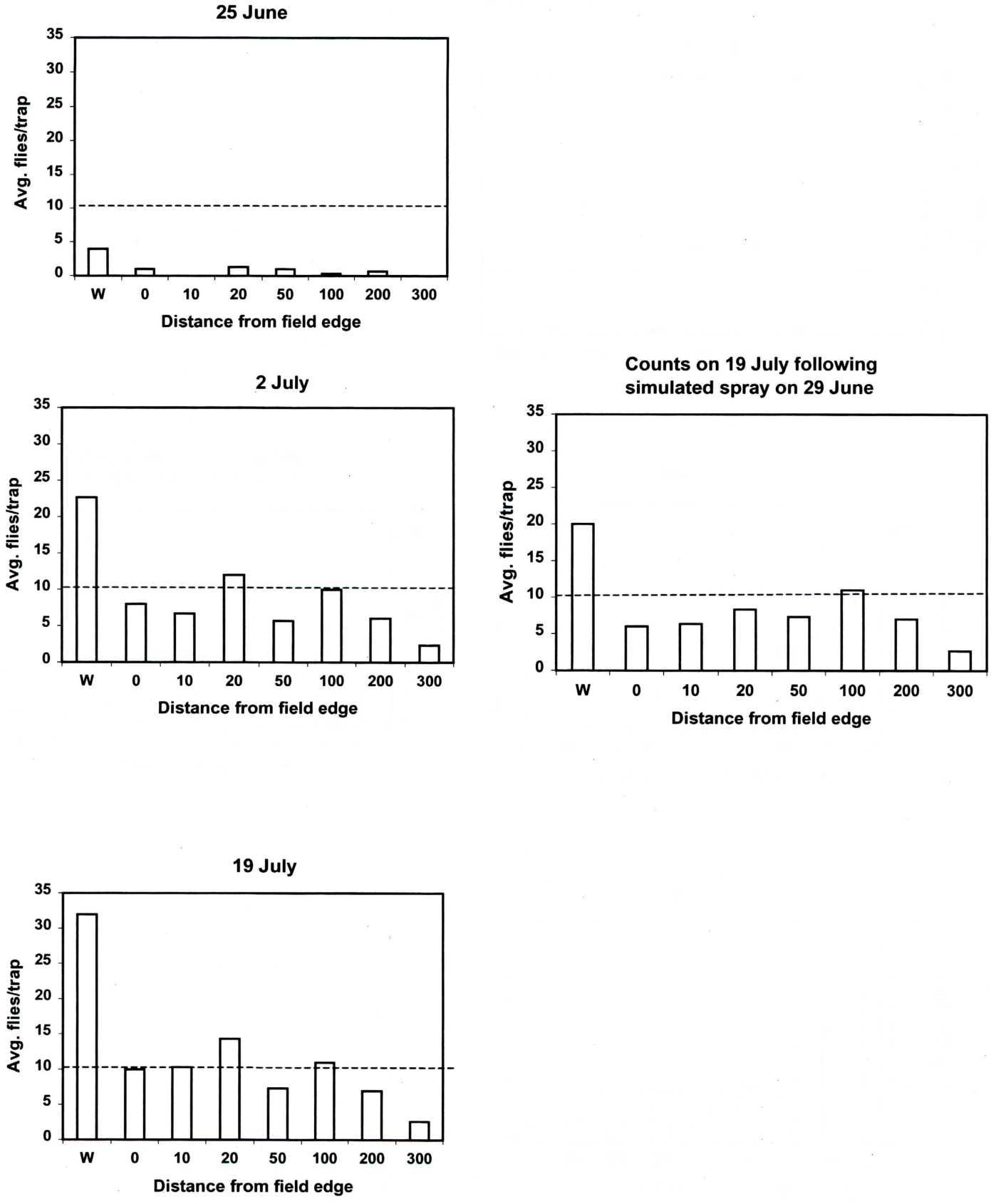
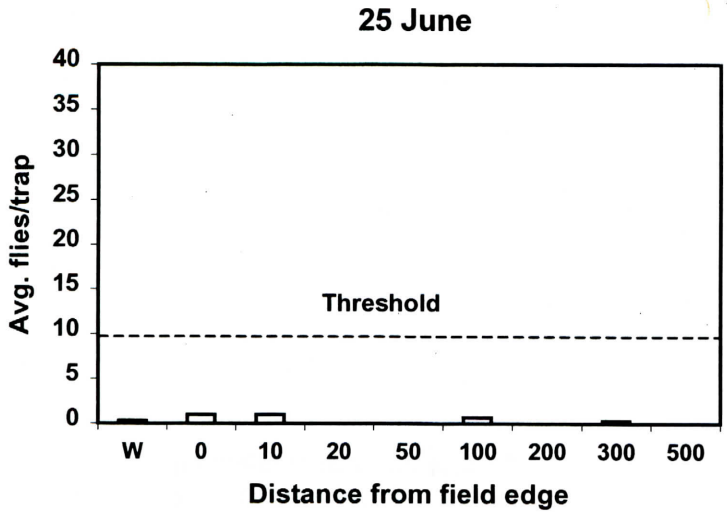


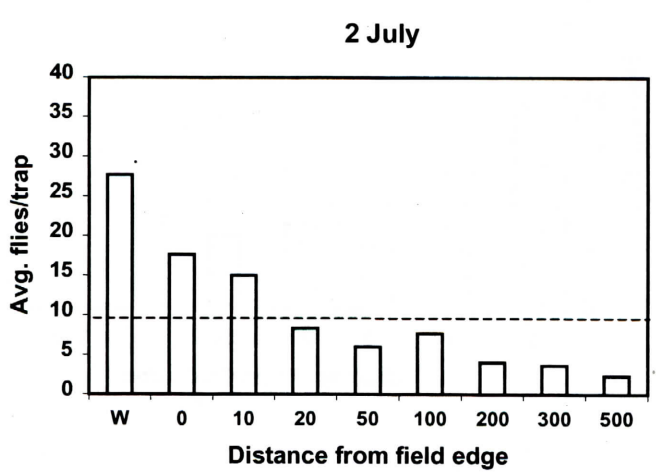
Figure 1. Flies collected per trap (males and females).

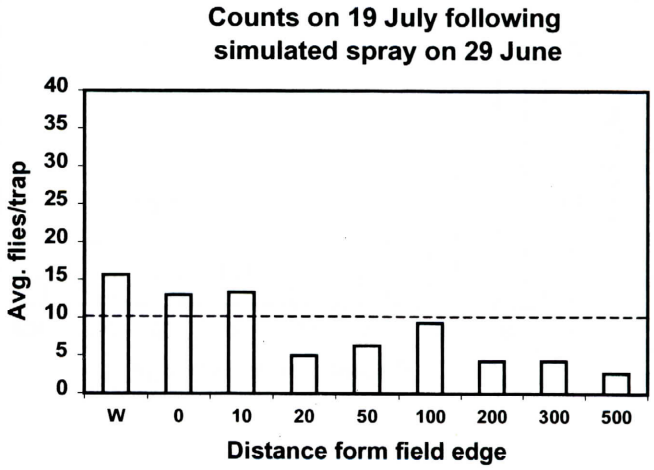
Centerville

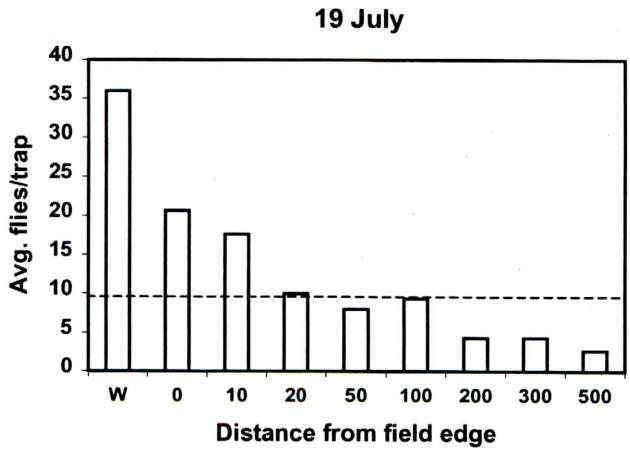


Township 19 - Lot A

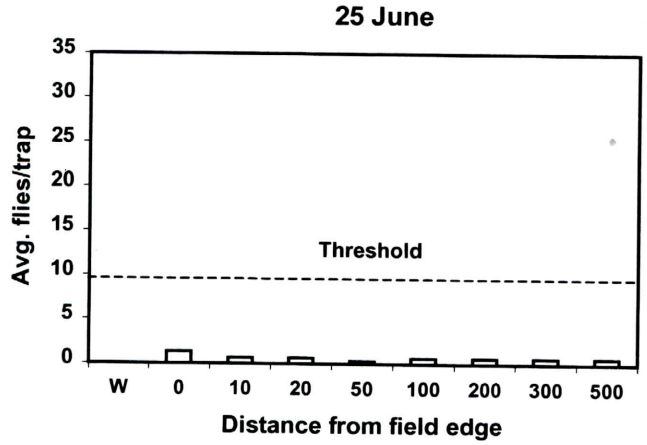


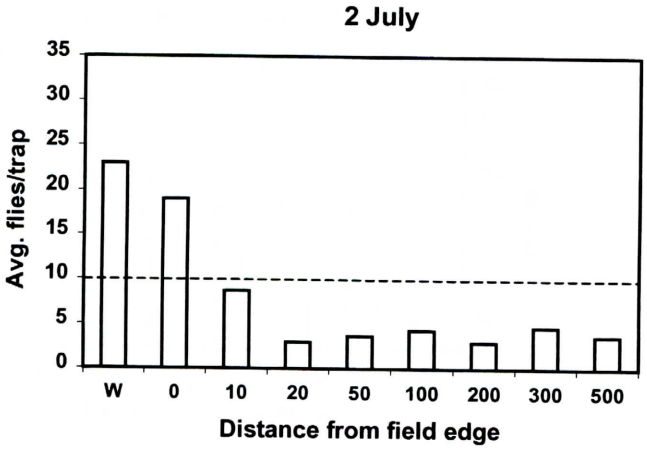


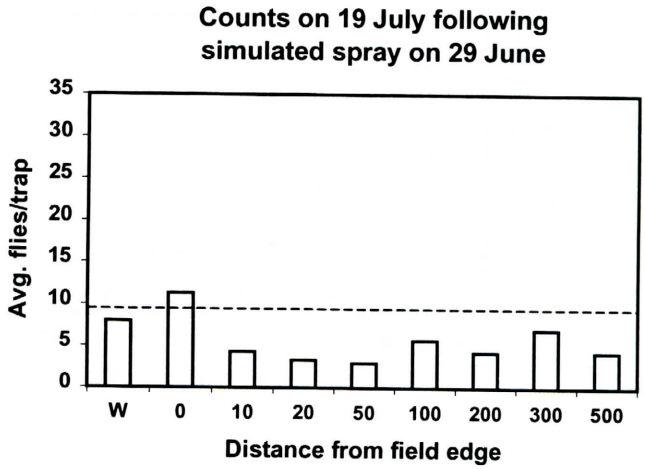


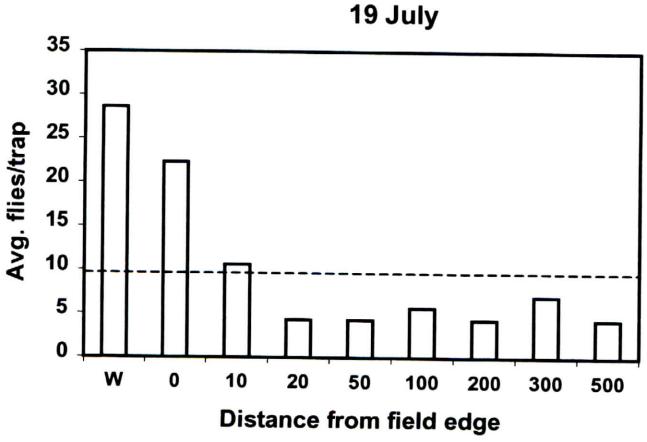


Township 19 - Lot H



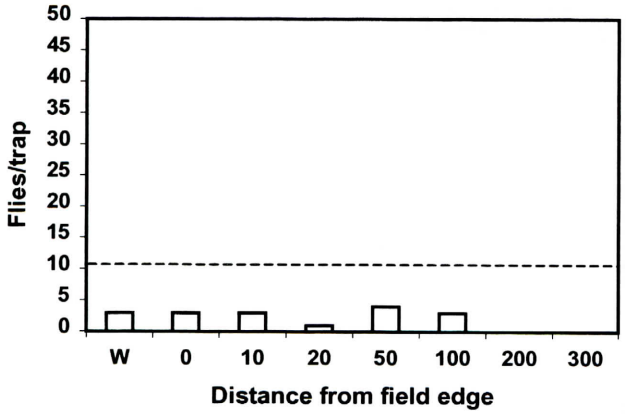




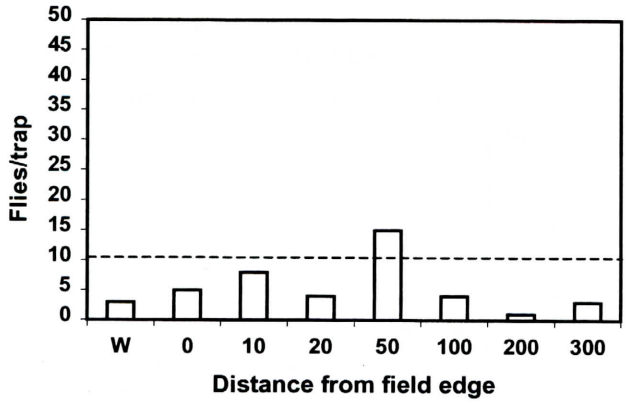


Blueberry Hill Farm

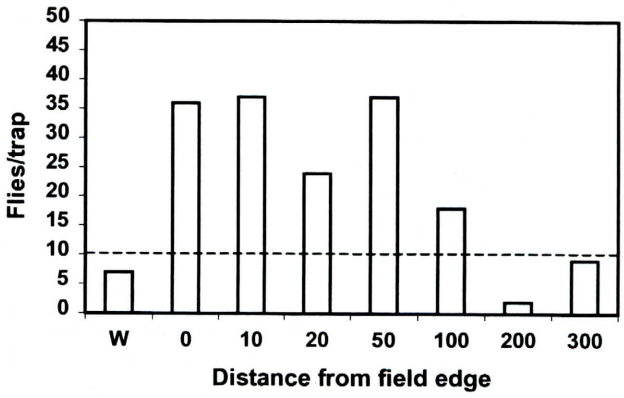
25 June



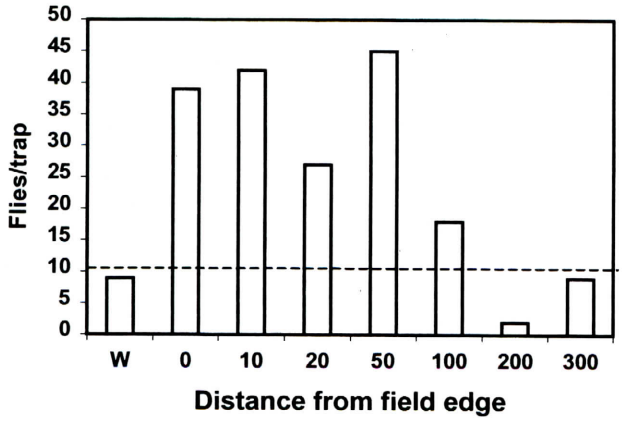
2 July



Counts on 19 July following simulated spray on 29 June



19 July



I. Economic threshold of blueberry flea beetle larvae.

Table 1. Relationship between initial larval density vs. larvae in sweep samples, crop year.

Larval density	Avg. larvae/10 sweeps	Avg. defoliation rating	Avg. lbs/acre
0	0.7	0.0	15422
50	19.2	0.7	14580
100	27.9	1.1	16228
150	42.9	1.7	16281

Figure 3. Relationship between initial larval density vs. larvae in sweep samples.

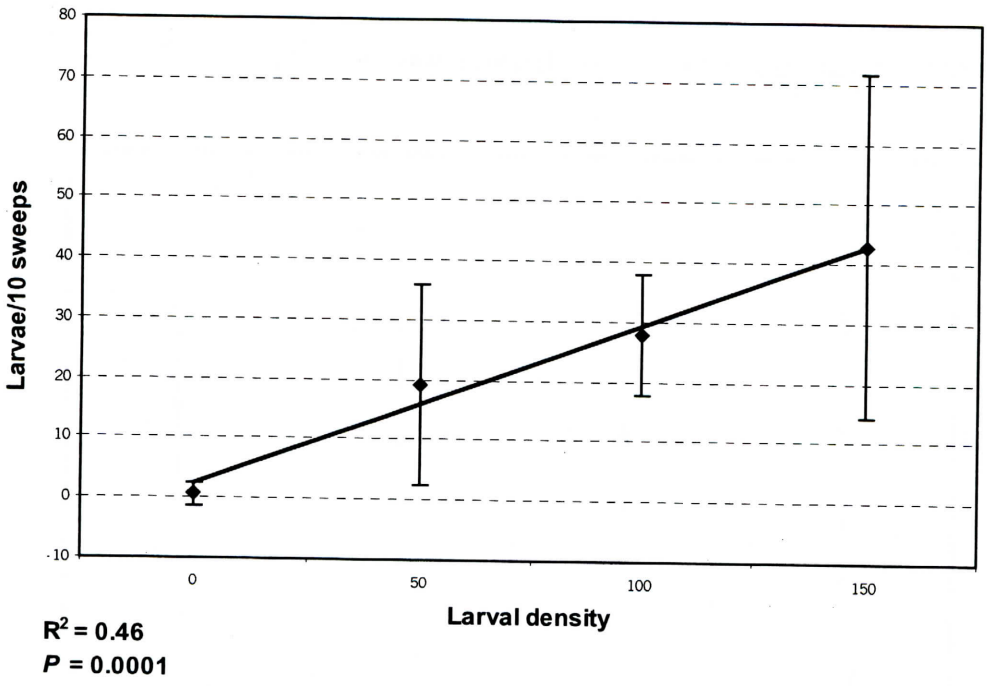


Figure 4. Relationship between initial larval density and defoliation rating.

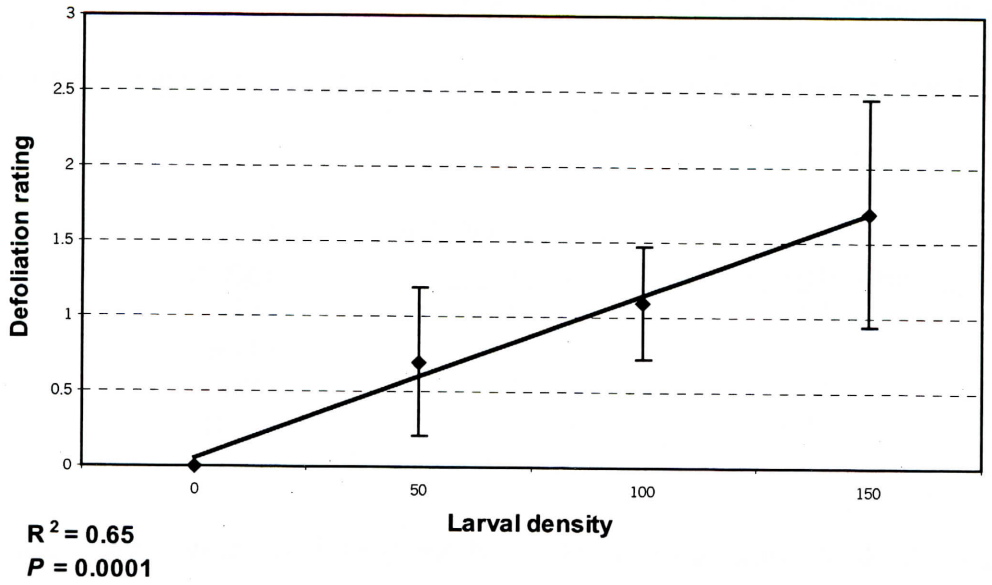


Figure 5. Relationship between initial larval density and yield.

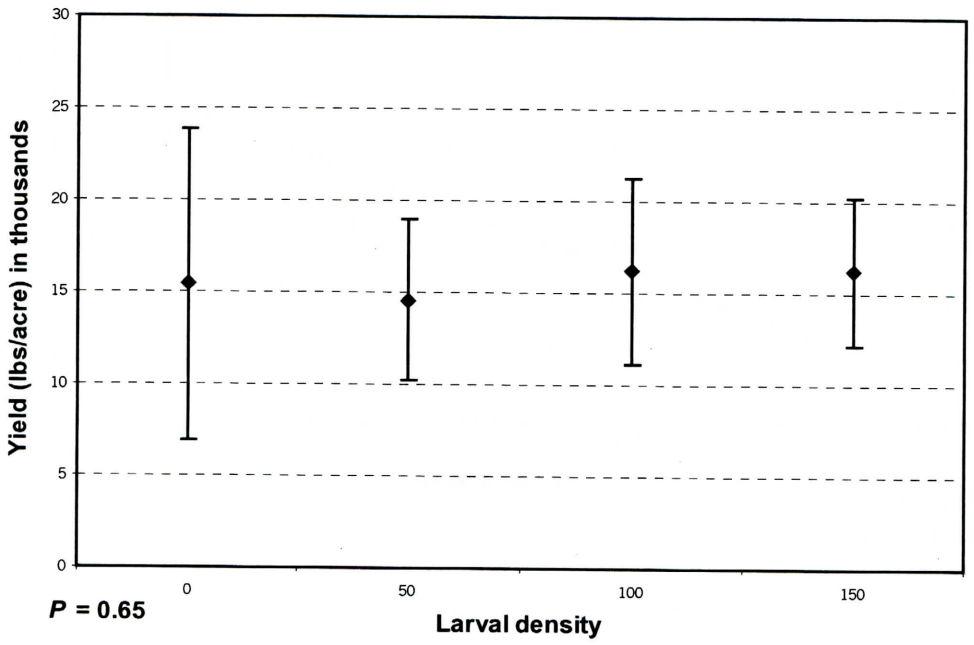
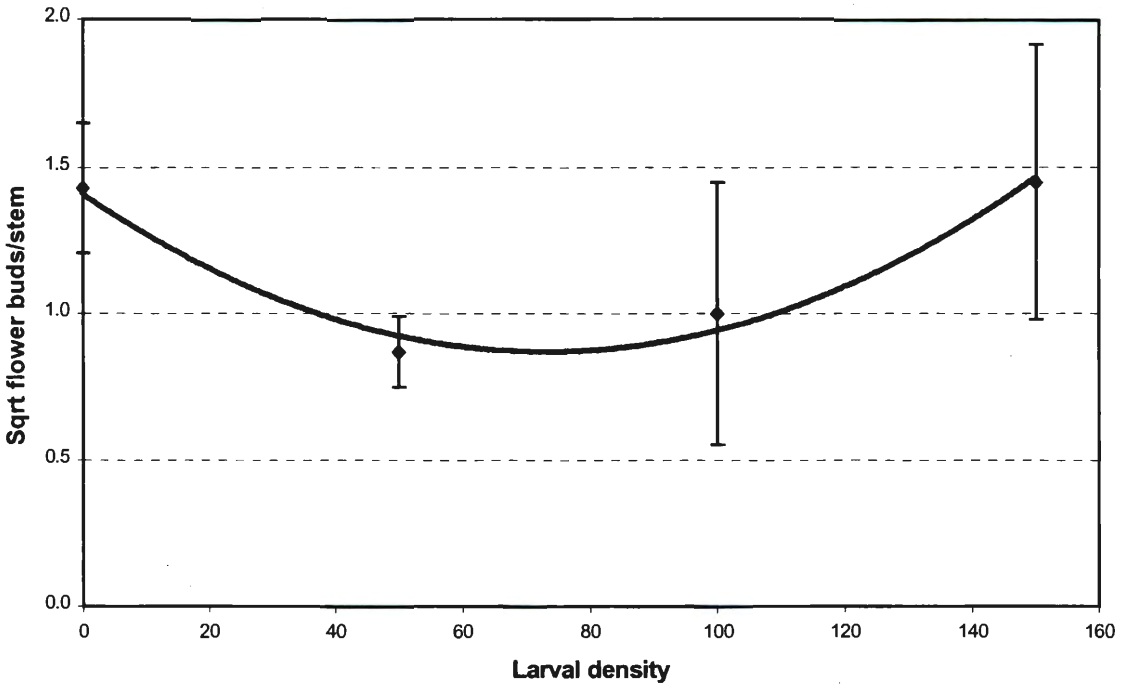


Figure 6. Relationship between initial larval density and flower buds/stem.



ENTOMOLOGY

INVESTIGATORS: F. A. Drummond, Associate Professor of Insect Ecology
J. A. Collins, Assistant Scientist of Biological Sciences

3. TITLE: Biology and Ecology of Blueberry Pest Insects

I. METHODS

Validation of a predictive model for emergence of blueberry maggot adults.

In 1998, maggot infested berries were distributed in a 1 to 2 inch layer in ten (2 sets of 5) screened boxes suspended over blueberry plants at Blueberry Hill Farm in Jonesboro. Five additional boxes were set at Blueberry Hill in Winterport. The boxes were covered with mesh cages to prevent predation by mice, birds, etc. The maggots were allowed to develop and move into the soil to pupate. The boxes and mesh cages were then removed. In mid-June 1999, emergence cages were placed over each site. The cages were monitored daily and any blueberry maggot adults were collected.

On 31 March at Jonesboro and 2 April at Winterport, two HOBO® temperature data loggers were buried at each site to monitor soil temperatures every two hours throughout the trials. One logger was 1-inch deep; the second was 2-inches deep. 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. 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

As in 1998, the emergence model predicted early to mid-emergence of blueberry maggot flies in 1999 (Figure 1). Temperatures measured at a 1-in. soil depth appeared to predict fly emergence with more accuracy than the 2-in. depth. The emergence at the Winterport site was predicted accurately throughout the entire emergence period (end of June through July 20). The emergence at both Jonesboro sites was predicted well until 50% population emergence at which time the model predictions lagged behind the observed emergence by as much as 8 to10 days for prediction of 100% emergence.

CONCLUSIONS AND RECOMMENDATIONS

A preliminary version of the predictive model for blueberry maggot adult emergence was incorporated in a software program for growers. We expect to release this software on the University of Maine Cooperative Extension web site soon. A third year of validation should shed light on any further need to fine tune the model.

II. METHODS

Growth and development of blueberry spanworm larvae.

Growth and development on different wild blueberry clones:

In May, second and third instar blueberry spanworm larvae were collected from a field in Knox Co. The larvae were brought into the laboratory and placed in individual plastic diet cups with snap-cap lids. The cups were then placed in a growth chamber at 25°C (77°F). Larvae were fed

foliage from one of six wild blueberry clones, 25 larvae/clone. Clones were chosen so as to be different based on morphological characteristics such as stem height, stem color and leaf color. Head capsule width, as an indicator of instar stage, was measured at one or two day intervals for each larva until death or pupation.

Temperature dependent growth rate:

Beginning in March, spanworm eggs collected in 1998 were incubated at one of four temperatures and observed for emergence of larvae. Incubation temperatures were 17, 20, 25, or 30°C (63, 68, 77, 86°F). For incubation, eggs were placed in groups of 5 or 10 in covered plastic diet cups along with a disk of filter paper moistened with distilled water. The cups were then placed in bell jars with distilled water in the bottom to maintain humidity and checked daily for larval emergence. Emerging larvae were placed in individual plastic diet cups with fresh blueberry foliage, held at the appropriate incubation temperature as outlined above, and monitored daily. Larval instar, based on head capsule width, was recorded and foliage replaced as necessary.

In May, early instar blueberry spanworm larvae were collected from an infested field in Knox Co. Larvae were placed in individual diet cups with fresh blueberry foliage. The cups were then placed in bell jars with distilled water to maintain humidity and reared at 20 or 25°C (68 or77°F). Thirty larvae were reared at each temperature. Larval instar, based on head capsule width, was recorded and foliage replaced as necessary.

RESULTS

Growth and development on different wild blueberry clones:

Survival of blueberry spanworm was quite high on three of the six blueberry clones, ranging between 80 and 92% (Table 1). Two clones, believed to be of the species *Vaccinium myrtilloides*, were characterized by very poor survival (0 and 48%). Species identifications are not definitive. Collections of plant material will be made next spring to determine the species of *Vaccinium* used in these experiments. Both of the clones which exhibited poor larval survival were characterized by pubescent stems.

Moderate parasitism was observed in the field collected larvae used in this study. All parasitoids were of the genus *Erromenus*. This is a common parasitoid which was found in high prevalence in 1998.

Temperature dependent growth rate:

The average number of days required for each immature life stage to complete its development at the four temperatures studied is shown in Table 2. Only the egg, first, and second instar larvae could be studied at all four temperatures. Because of high natural mortality at 17°C (63_F) in the laboratory, the third and fourth instar larvae were only studied at 20, 25, and 30°C (68, 77 and 86°F). Fifth instar larvae and pupae were only studied at 20 and 25°C (68 and 77°F) due to high levels of natural mortality at 17 and 30°C (63 and 86°F). There were enough temperatures studied for the egg, first, and second instar larvae to estimate the parameters of a sigmoidal growth rate equation.

A preliminary simulation model was constructed for the egg and first and second instar larval stages using the time-varying distributed delay algorithm. A record of daily average air temperature collected at the Blueberry Hill Research Farm in Jonesboro was used as the input data

for the model. The initial density of eggs in the simulated blueberry field was 10 eggs per square yard (Figure 2).

CONCLUSIONS AND RECOMMENDATIONS:

Growth and development on different wild blueberry clones:

The results of this study could distinguish clones with spanworm resistance that could be used to fill in bare spots in blueberry fields. Future investigations will be aimed at determining the mechanism of larval resistance.

Temperature dependent growth rate:

The preliminary simulation model results suggest that our estimates of larval development need to be refined. Although we do not have any field validation data to compare with the simulation run in Figure 2, it appears that predicted development of second instar spanworm might be slow (peak incidence ca. 1 June). Table 3 suggests that any insecticide treatment made between peak first instar incidence and peak second instar incidence will be equally effective if feeding of first instar larvae is insignificant. If feeding of first instar larvae does result in significant defoliation, then spraying at peak first instar incidence is the superior strategy. Future studies are needed to add data to the late larval instars at 17 and 30°C (63 and 86°F) and to validate the simulation model predictions by making observations on actual spanworm populations through time.

III. METHODS:

Growth and development of blueberry flea beetle larvae.

In May, early instar flea beetle larvae were collected from a field in Township 18. The larvae were brought into the laboratory and placed in individual plastic diet cups with snap-cap lids. Head capsule width, as an indicator of instar stage, was measured at one to two day intervals for each larva until death or pupation. Larvae were fed foliage from one of five wild blueberry clones, 30 larvae/clone. Clones were chosen so as to be different based on morphological characteristics such as stem height, stem color, and leaf color. Four of the selected clones were *Vaccinium angustifolium* and one was *Vaccinium myrtilloides*. There were two trials; at Blueberry Hill, where cups were held in the laboratory at room temperature. For the trial at Orono, cups were held in a growth chamber at 24°C(75°F).

RESULTS

Our attempt to rear blueberry flea beetle larvae on different wild blueberry clones was unsuccessful. We did collect ca. 400 flea beetle eggs to study the rearing of flea beetle this winter.

CONCLUSIONS AND RECOMMENDATIONS

Conditions for survival of blueberry flea beetle in the laboratory need to be studied in more detail so that a laboratory colony can be established for future laboratory insecticide bioassays.

IV. METHODS

Effect of windbreaks on insect predators in blueberry fields.

In early June, pitfall traps were buried in four wild blueberry fields in Washington Co. Each trap consisted of a 16 oz plastic cup filled with 50% ethylene glycol as a preservative. The traps were

distributed in linear transects. For each transect, one trap was set within the pine windbreak bordering the field, subsequent traps were set 10 and 100 m(33 and 330 ft) into the field. There were three transects per field. The traps were checked at weekly intervals beginning on 10 June and continuing until 16 July. Any predaceous arthropods including spiders, daddy longlegs, beetles, and ants were removed and stored in 70% ethyl alcohol for later identification.

RESULTS

Figure 3 shows that spiders and ants were extremely abundant in the windbreaks and 10 m (33 ft) out into the field. Spider densities only dropped by 50% 100 m(330 ft) from the windbreak; whereas, ant density dropped by 75% at 100 m (330 ft) from the windbreak. Predaceous beetles (total beetles and ground beetles) were trapped in highest numbers in the windbreak, but their numbers dropped off by 50-75% within the blueberry field. In general, spiders and ants were the predominant predators found in the four fields. Table 4 shows the abundance of beetle species, families, and genera across all distances over the duration of the study. Five families of predaceous beetles were found. The ground beetles (*Carabidae*) were the most common and were represented by a diversity of 22 species.

CONCLUSIONS AND RECOMMENDATIONS:

Windbreaks were found to be areas of high predator concentration in blueberry fields. This suggests that insecticide drift management relative to protecting field edges might be an important component of future pest management strategies. However, this may be in conflict with targeting blueberry maggot fly sprays since maggot flies also tend to be most abundant near field edges.

V. METHODS:

Monitoring populations of thrips in wild blueberry (pruned year) fields.

On 14 May, two blue sticky cards were placed in a pruned blueberry field in Columbia Falls which had been infested with thrips in 1998. Each card measured 3 x 5 inches and was hung just above the foliage canopy from a wooden lathe. Both cards were replaced at weekly intervals from 21 May to 6 August. The number of thrips on each card was counted using a dissecting microscope.

At weekly intervals beginning on 11 June, 20 leaf curls (only 14 curls on 9 July) infested with thrips 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 18 June and 23 July. The highest numbers of thrips in curls occurred on 9 July and 6 August. As can be seen from Figure 4, a lag occurs between peak thrips per card and peak thrips per curl. The number of thrips per curl, which is a measure of thrips population density in a field, starts to rise at about the time when the number of thrips per monitoring card nears peak numbers.

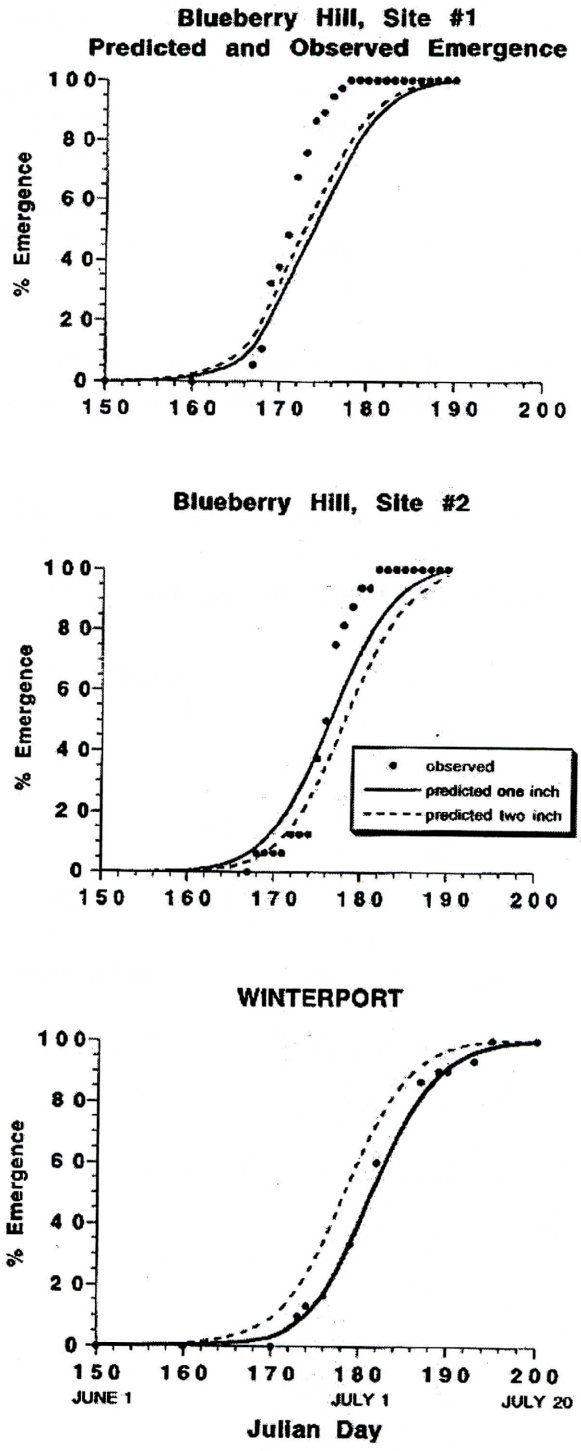
CONCLUSIONS AND RECOMMENDATIONS:

Insecticide sprays applied at the onset of thrips caught on cards may have potential for optimal timing of control measures. Future studies will test the usefulness of using thrips trap captures to

time sprays compared to the existing method of waiting until ¼ and ½ inch vegetative growth is observed on pruned plants.

I. Validation of a predictive model for emergence of blueberry maggot adults.

Figure 1. Predicted and observed emergence of blueberry maggot adults.



II. Growth and development of blueberry spanworm larvae.

Table 1. Percent survival and percent parasitism of blueberry spanworm larvae reared on clones of wild blueberry.

Clone	% Survival*	% Parasitism**	Clone description
A	68.0 bc	16.0	3-4 inch, brown stem
B	0.0 a	8.0	6-7 inch, fuzzy pale green stem
C	80.0 c	16.0	5-6 inch, green stem
D	88.0 c	24.0	6-inch, red stem
E	48.0 b	28.0	*Myrtilloides*
F	92.0 c	4.0	6-8 inch, green/orange stem

*Means followed by the same letter are not significantly different ($P < 0.05$; Wilcoxon survival test). Means were adjusted for rates of parasitism prior to analysis so that the % survival does not include parasitism.

** Parasitoids were identified as *Erromenus* sp., family Ichneumonidae.

Table 2. Results of rearing spanworm at four temperatures and models of temperature-dependent development.

	Average days at stage						
Temperature	E*	1*	2*	3	4	5	P
17	16.6	19.0	35.0				
20	13.3	10.4	6.4	7.4	8.0	7.9 1	6.0
25	8.2	5.7	4.6	5.8	5.4	6.7	8.4
30	8.3	5.5	3.2	6.0	3.0		

* Temperature-dependent development rate equations for predicting development.

Egg: Rate = $0.129/(1 + e^{(5.059 - 0.282*temp)})$, $r^2 = 0.944$.
First instar: Rate = $0.188/(1 + e^{(7.903 - 0.403 * temp)})$, $r^2 = 0.99$.
Second instar: Rate = $0.329/(1 + e^{(6.656 - 0.305 * temp)})$, $r^2 = 0.93$.
Third instar - pupa: Not enough data to estimate coefficients.

Figure 2. Development of blueberry spanworm using 1999 Jonesboro temperature data, no insecticides applied.

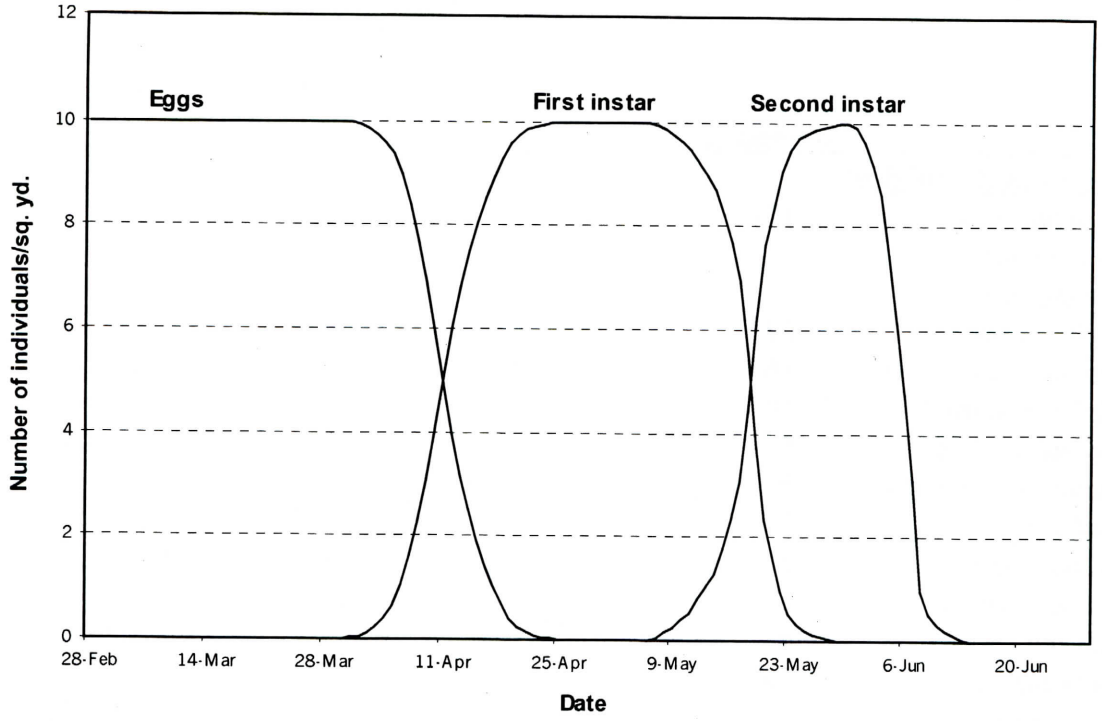


Table 3. Effect of simulated insecticide applications* on numbers of first and second instar spanworm larvae (started with 10 eggs/sq yd of blueberry ground.

Timing of application	First	Second
No spray	10.0	10.0
Early first	9.2	9.2
25% first	2.8	2.8
Peak first	1.2	1.2
Early second	2.0	1.2
25% second	5.5	1.1
Peak second	10.0	1.0

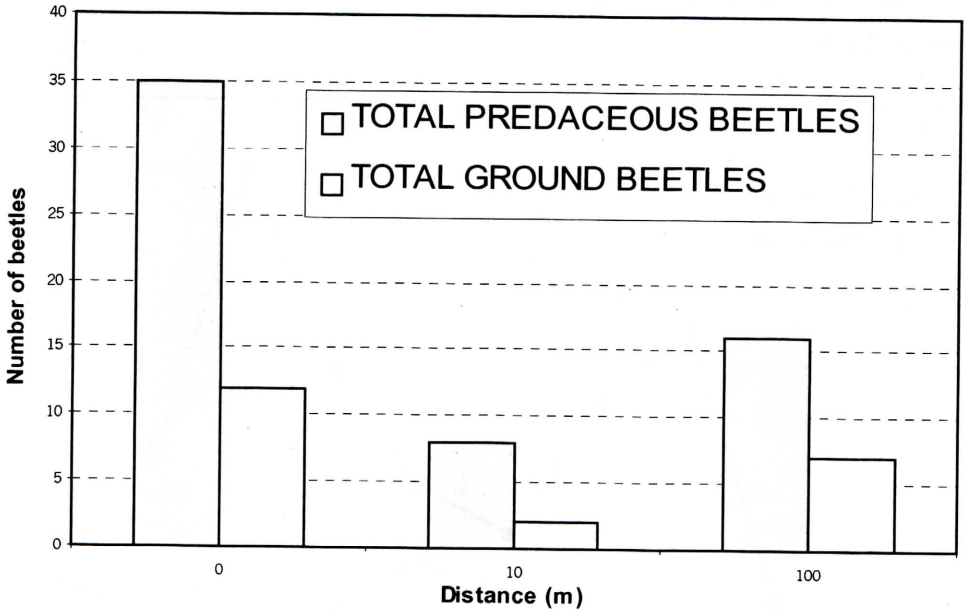
* Insecticide was characterized by 100% mortality with a two-day residual activity.

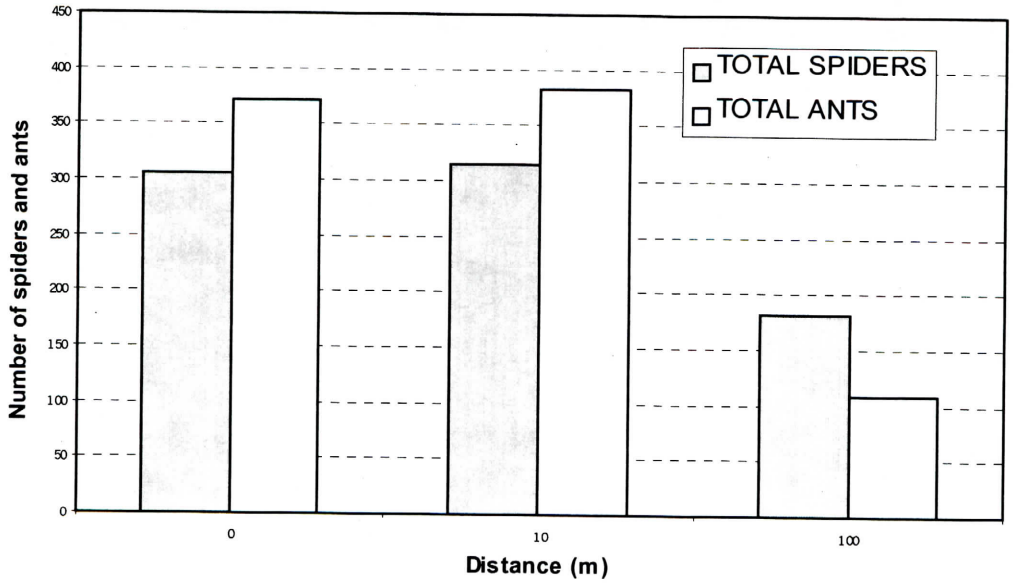
IV. Effect of windbreaks on insect predators in blueberry fields.

Table 4. Abundance of and beetle species, families, and genera.

Insect	Abundance
Ground Beetles (Carabidae)	
Carabus nemoralis	121
Platinus melanarius	4
Calathus ingratius	1
Pterostichus adstrictus	27
Pterostichus mellanarius	16
Pterostichus femoralis	10
Pterostichus covacinus	5
Pterostichus lucublandis	5
Pterostichus spp.	2
Anisodactylus spp.	2
Anisodactylus nivalis	17
Harpalus spp.	4
Harpalus rufipes	23
Amara littoralis	1
Amara spp.	11
Agonum placidum	7
Agonum muelleri	1
Agonum cuprium	3
Agonum retractum	7
Unidentified carabid	11
Unidentified carabid	9
Unidentified carabid	4
Other Beetles	
Elateridae	85
Staphylinidae	77
Ciccindellidae	13
Coccinellidae	1

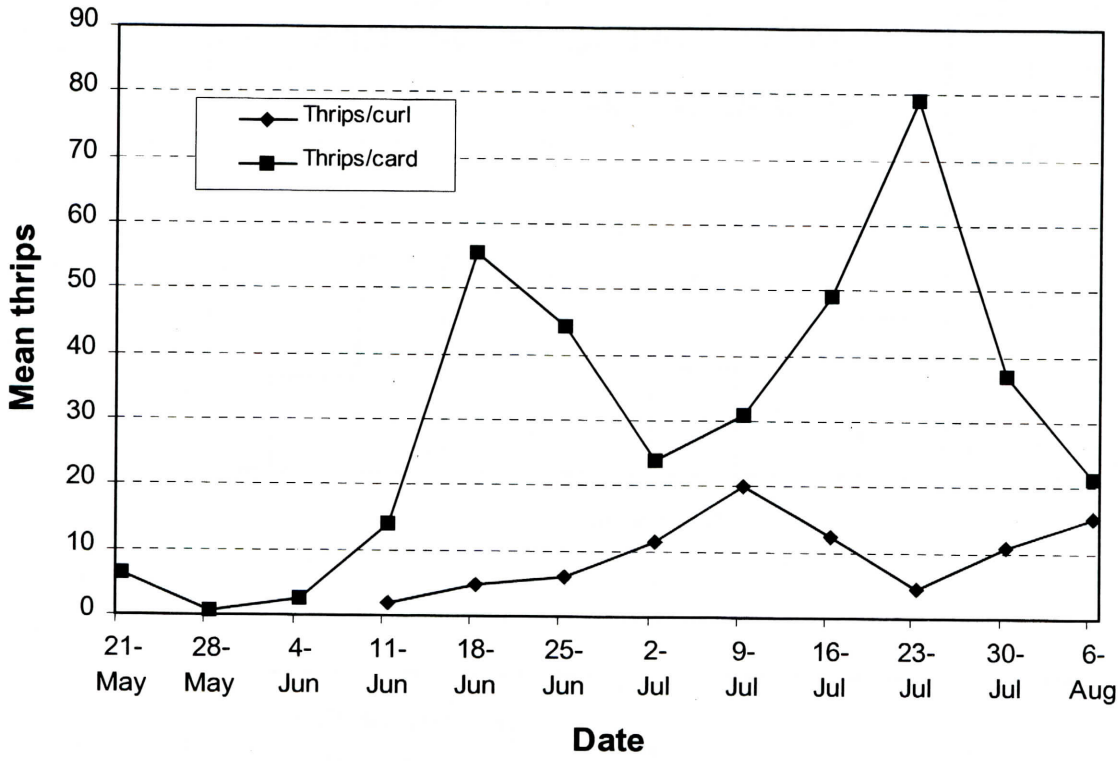
Figure 3. Effect of distance from pine windbreak on populations of predaceous insects in wild blueberry fields.





V. Monitoring populations of thrips in wild blueberry fields.

Figure 4. Comparison of numbers of thrips captured on blue sticky cards and thrips in curls.



DISEASE MANAGEMENT

INVESTIGATORS: S.L. Annis, Assistant Professor of Biological Sciences
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-two blueberry fields, 16 non-bearing and 16 bearing fields, were chosen from 4 geographic areas of Maine and sampled for stem blight and leaf spot diseases. Twenty plots of $0.25m^2$ ($0.3\ yd^2$) 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 are being identified to genus and selected isolates of putative pathogenic fungi will be cultured. Information on cultural practices, including fungicide and other treatments of fields is being obtained from growers. To date, cultures from 8 fields have been examined and the fungi identified.

RESULTS: The results from 8 fields are presented. The results of the stem symptom diagnosis for the rest of the fields is completed and is being analyzed. The identification of fungi isolated from leaves and stems of the other fields is in progress. The percentage of stems with stem blight ranged from 3 to 13.5 % with an average of 4.8%. Bearing fields typically had a higher percentage of diseased stems. At least 58 different genera of fungi have been identified from diseased stems and leaves so far. Sixteen genera are known to produce disease on blueberries or other members of the *Ericaceae*. Potential pathogens will be determined once the fungi from all the fields have been identified. Disease severity and incidence and identification of frequent potential pathogens will be analyzed with the data of cultural practices obtained from growers to develop hypothesis for methods of disease control.

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

RECOMMENDATION: Recommendations to growers on disease control cannot be made at this time. It is recommend that the disease survey be repeated next year to confirm the levels of disease incidence and potential fungal pathogens identified in fields this year. In next year's study it is also recommended that some fields surveyed this year be examined again to determine persistence of potential pathogens.

Table 1. Percentage of diseased stems in 8 blueberry fields

Field	1a	1b	2	3	4	5	6	7	8
Year	Bearing	Bearing	Bearing	Non-bearing	Bearing	Non-bearing	Non-bearing	Bearing	Non-bearing
% of diseased stems	5	5.75	13.5	3	5.2	1.6	0.5	7.1	2.4

Average percentage of stems with disease 4.8%

Table 2. Stem and Leaf Disease Survey Results from 1999

Genera and number of samples of fungi identified from diseased stems or leaves from 8 blueberry fields

	Field 1	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8	Total # in fields
	Bearing	Bearing	Bearing	Non-earing	Bearing	Non-bearing	Non-bearing	Bearing	Non-bearing	
Genus										
Acrospeira	x			L						2
Alternaria	x		x	x	x, L	x	x, L		L	7
Ascochyta								L		1
Aspergillus								x		1
Aureobasidium			x	x	x, L	x	x, L	x	x, L	7
Bactrodesmium				x	x, L					2
Bipolaris								?L		?1
Botryoderma								?		?1
Botryodiplodia								?		?1
Botrytis								x		1
Chalaropsis								?		1
Cladosporium	x		x	x	x, L		x, L	x	x, L	7
conidia, orange								L		1
conidia, yellow						x				1
Coniochaeta		x			x		x			3
Curvularia				x						1
Cylindrocarpon					?					?1
Cylindrosporium								?		?1
Cytospora			x	x	x		x		?	4+?1
Cytosporella		x							X	2
Dendrodochium					x					1
Dichomera								?L		?1
Diplococcium								?L		?1
Dothiorella		x		x, L	x		x	x, L		5
Drechslera	x									1
Epicoccum	x			x	x					3
Fusarium	x							x	x	3
Fusicoccum							?L			?1
Geotrichium								x, L		1
Gloeosporium	x							x		2
mycelia, black		x			x				L	3

mycelia, brown		x			x	x	x			4
mycelia, dark green		x		x			x	x		4
mycelia, gray				L	x					2
mycelia, green-gray							x			1
mycelia, olive						x				1
mycelia, red						x		x		2
mycelia, white	x	x		x	x	x	x	x		7
mycelia, yellow				x			x		x, L	3
mycelia,white2								x		1
mycelia,white3								x		1
Oidiodendron								?		?1
Oidium								?		?1
Pestalotia				x				x		2
	Field 1	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8	Total # in fields
	Bearing	Bearing	Bearing	Non-earing	Bearing	Non-bearing	Non-bearing	Bearing	Non-bearing	
Phoma	x								?	1+?1
Phomopsis	?	x		x, L	x, L	x				4+?1
Phyllosticta				?						?1
pycnidia	x	x		x, L	x		x, L		x, L	6
Scytalidium					?, L		L		L	2+?1
Sepedonium							?L			?1
Septocylindrium		x		x						2
Septoria				?L	L			L		2+?1
Sphaeropsis								?L		?1
sporodochia	x									1
Stagnospora								x		1
Steganosporium							L			1
Strasseria						x				1
Xylohypha	?	?	?	?	x					1+ ?4
total genera/field	11+2?	10+?2	4+?1*	17+3?*	17+2?	8*	14+2?	18+9?	9+2?	

*not finished

x= present from stem, L = present from leaf, ?= uncertain from stem, ?L= uncertain from leaf;
Genera in bold are possible pathogens of blueberry.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Richard Dyer, Research Assistant
Karen Loennecker, 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 and 1998 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 that the new 0.130% standard (Fig. 1). All fertilizers raised the leaf P concentrations compared to the controls. However, P concentrations were not raised to the new standard (0.130%) at the rate used (60 lb P/acre). 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). That leaf P concentrations were slightly higher in plots treated with DAP or MAP than TSP even though soil P concentrations were the same suggests an interaction of N and P in the plant's ability to absorb and translocate P.

1995 Stem Characteristics and 1996 Yield

The effect of fertilizer treatments on stem 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 (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. Potential yield (flower bud production) differences among

treatment plots resulted in similar differences in actual yield. Fruit yield was highest for DAP compared to the 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 (Figures 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 than 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, 1/4 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 and 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 this level of leaf N concentration was reached in 1995 when DAP was applied. In 1997 and 1999, control plots had leaf N levels above the 1.6% standard and this 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.
Analysis of soil samples has not been completed. Stem characteristics on samples collected in October 1999 have not been determined at this time.

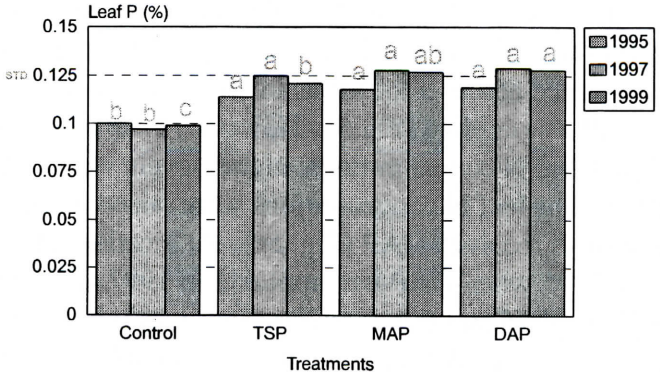
CONCLUSIONS: No conclusions can be made until the study is completed and all the data is completely analyzed and interpreted.

RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1

P/N Ratio Study

Phosphorus leaf concentrations*

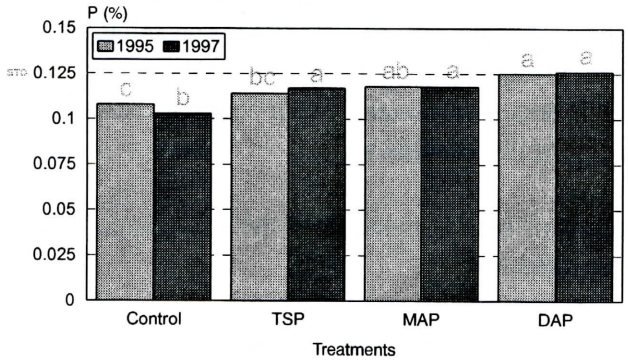


* Values are average of three locations in 1995 and 1997 and two locations in 1999. Treatment means within years not having a letter in common are significantly different at the 1% level.

Figure 2

P/N Ratio Study

Phosphorus leaf concentrations at location 1

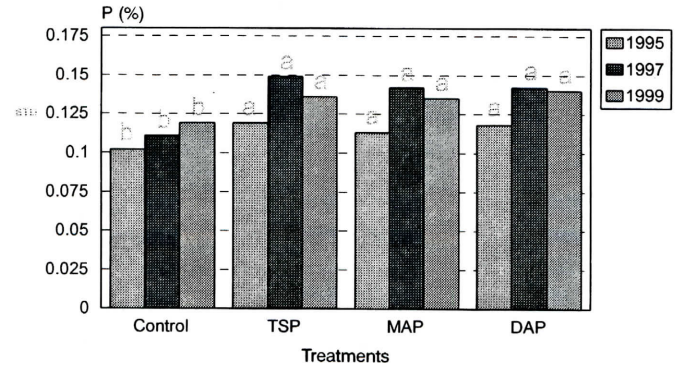


Means within years not having a letter in common are significantly different at the 1% level. This location was eliminated from the study in 1999.

Figure 3

P/N Ratio Study

Phosphorus leaf concentrations at location 2

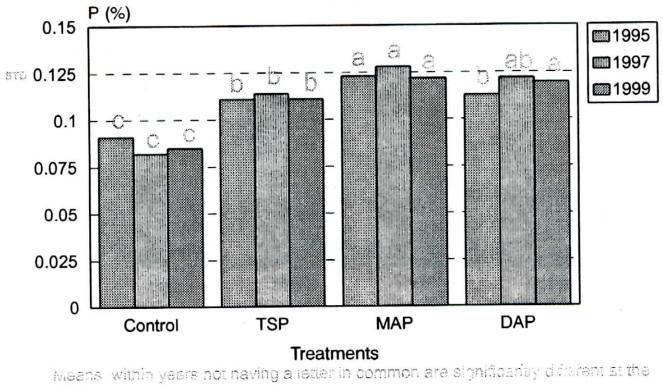


Means within years not having a letter in common are significantly different at the 1% level.

Figure 4

P/N Ratio Study

Phosphorus leaf concentrations at location 3

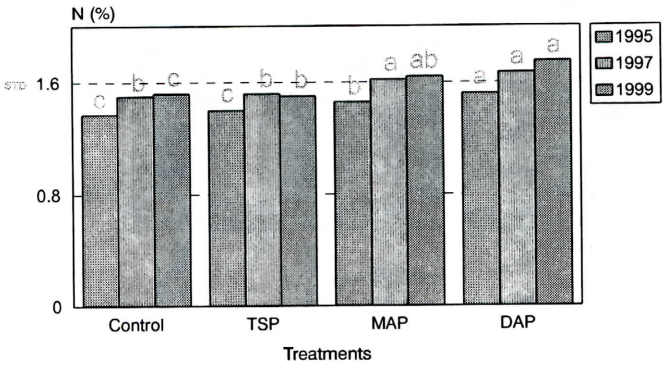


Means within years not having a letter in common are significantly different at the 1% level.

Figure 5

P/N Ratio Study

Nitrogen leaf concentrations*

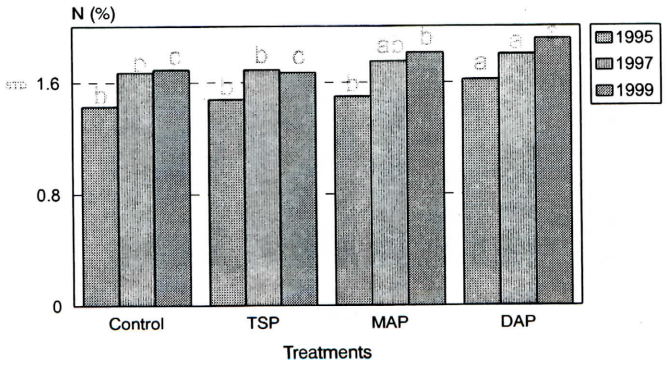


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means within years not having a letter in common are significantly different at the 1% level.

Figure 5b

P/N Ratio Study

Nitrogen leaf concentrations at location 2*

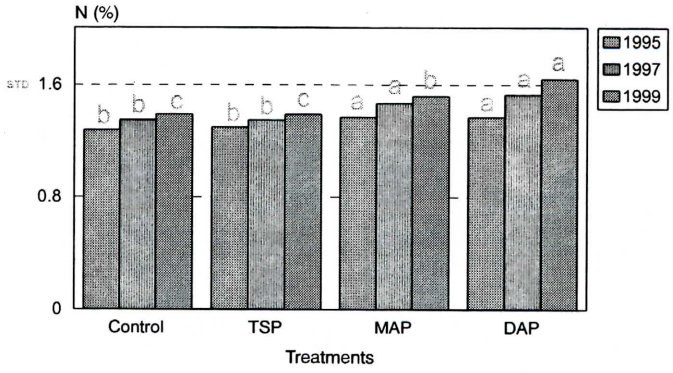


* Means within years not having a letter in common are significantly different at the 1% level.

Figure 5c

P/N Ratio Study

Nitrogen leaf concentrations at location 3*

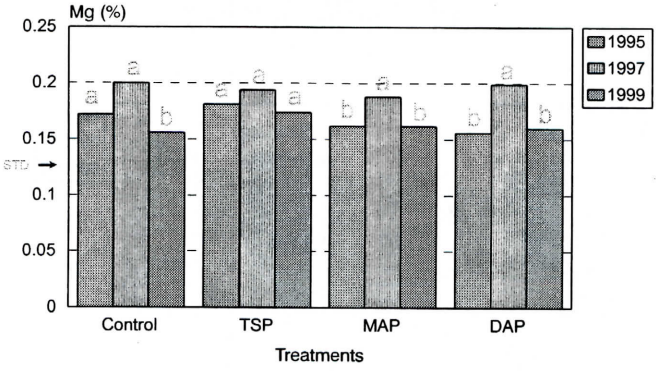


* Means within years not having a letter in common are significantly different at the 1% level.

Figure 6

P/N Ratio Study

Magnesium leaf concentrations*

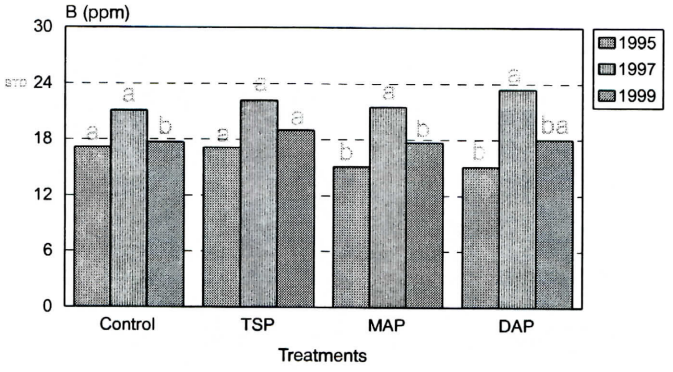


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means not having a letter in common are significantly different at the 1% level.

Figure 7

P/N Ratio Study

Boron leaf concentrations*

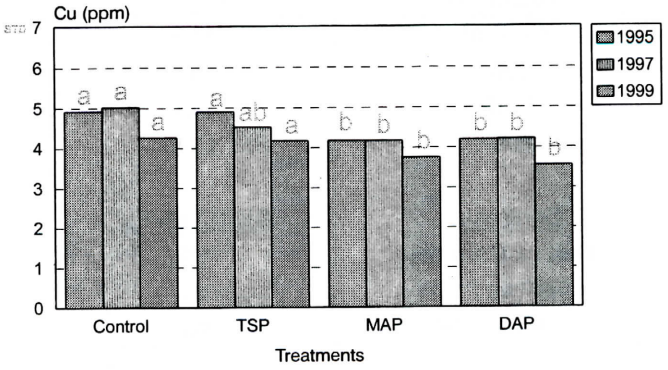


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means not having a letter in common are significantly different at the 1% level (1995), 5 % level(1997), and 5.6% level (1999).

Figure 8

P/N Ratio Study

Copper leaf concentrations*

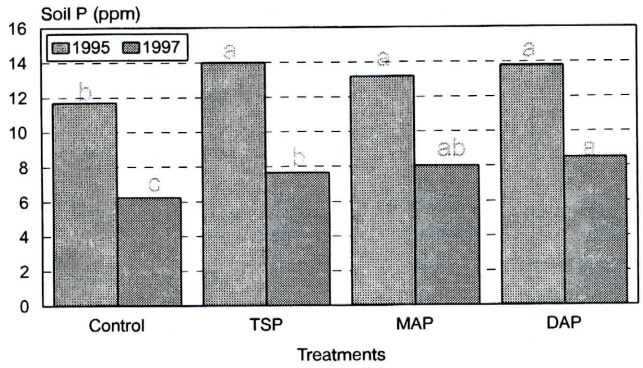


*Values are average of three locations in 1995 and 1997 and two locations in 1999. Means not having a letter in common are significantly different at the 5% level.

Figure 9

P/N Ratio Study

Soil phosphorus concentrations*

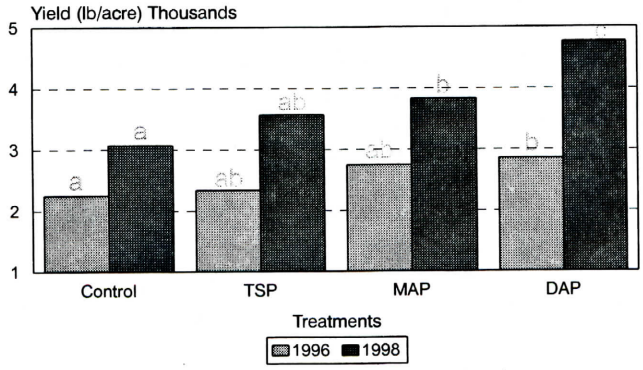


*Values are average of three locations. Treatment means for soils not having a letter in common are significantly different at the 1% level.

Figure 10

P/N Ratio Study

1996 and 1998 Yield*



*Values are average of three locations. Means not having a letter in common are significantly different at the 5% level. Yield adjusted for bare areas.

Table 1

P/N Ratio Study

Soil phosphorus concentrations

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

Table 2

P/N Ratio Study

Stem characteristics, 1995

Treatment	Stems per 1/4 sq ft^2	Stem length (in)	Flower buds per stem	Flower buds per 1/4 sq ft^2
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 treatments 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^2	Stem length (in)	Flower buds per stem	Flower buds per 1/4 sq ft^2
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

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Richard Dyer, Research Assistant
Karen Loennecker, Research Assistant

2. 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)

METHODS: 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 in October 1998 to determine treatment effects on 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 (1.65%) 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 was increased by fertilizer application on June 2 and June 16 and by the split application on May 19 and June 16, compared to other dates and the control (Fig. 13). The average number of flower buds per stem was increased by all fertilizer applications, except the earliest (May 19) and the latest (June 30), compared to the control (Fig. 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)

METHODS:

Results of Fertilizer Timing Study I indicate an effect of time of fertilizer application on nutrient uptake. However, a preemergent treatment was not included. To confirm the results of the 1998 study and to include a preemergent 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 preemergent 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. Leaf and soil samples were taken on July 2, 1999 at the tip dieback stage of stem development. Leaf samples were therefore not taken for treatment 6 application on July 7. A randomized complete block design with 8 blocks was be used.

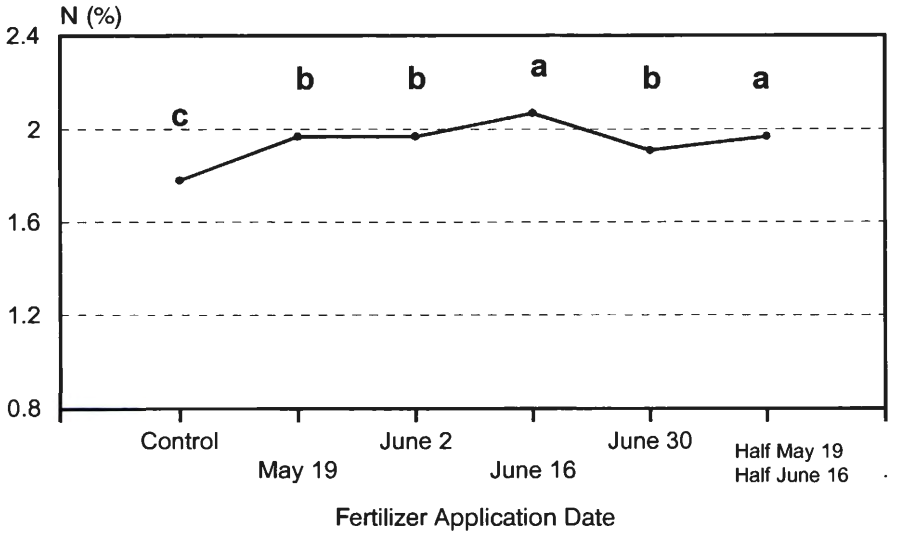
RESULTS: Fertilizing with DAP increased N and P leaf concentrations, compared to the controls (Figs. 17 & 18). For leaf N concentration there was a significant linear and quadratic trend over date of fertilizer application. Fertilizing after emergence resulted in higher lead N concentration than fertilizing 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 preemergent 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 preemergent.
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 roots system of the lowbush blueberry. Magnesium (Mg) concentration also decreased linearly with increasing date of DAP application (Fig. 20).

CONCLUSIONS: Although no conclusions can be drawn until further studies are conducted, it appears that timing may be important for maximizing lowbush blueberry nutrient uptake. 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

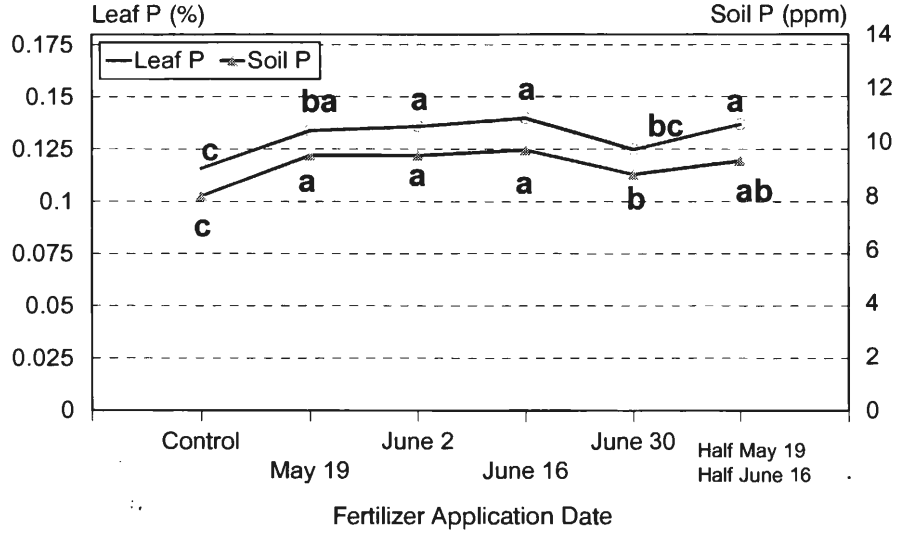
Effect of Fertilizer Timing on Leaf Nitrogen



Location 1. Values Preceded from ANOVA. Significance level = 0.05 %

Figure 2

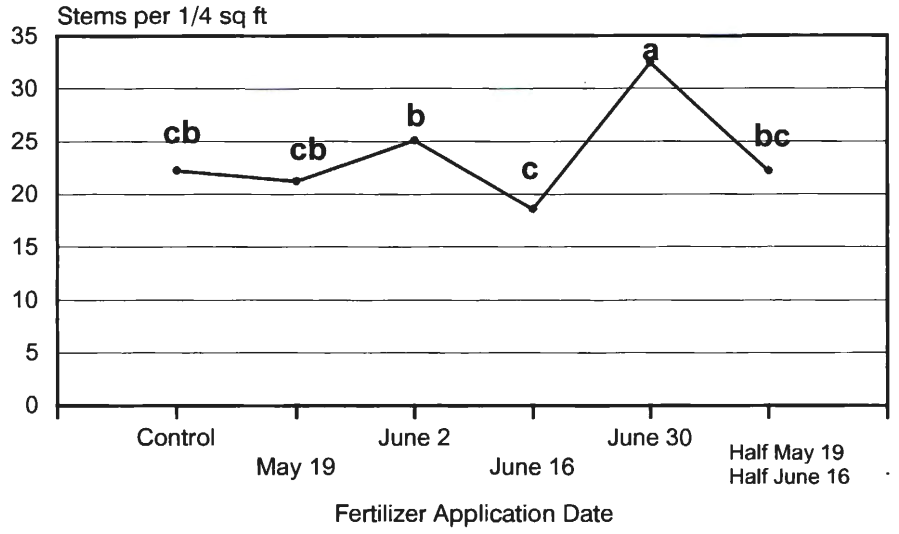
Effect of Fertilizer Timing on Leaf and Soil Phosphorus



Location 1. Values Preceded from ANOVA. Significance level = 0.05 %

Figure 8

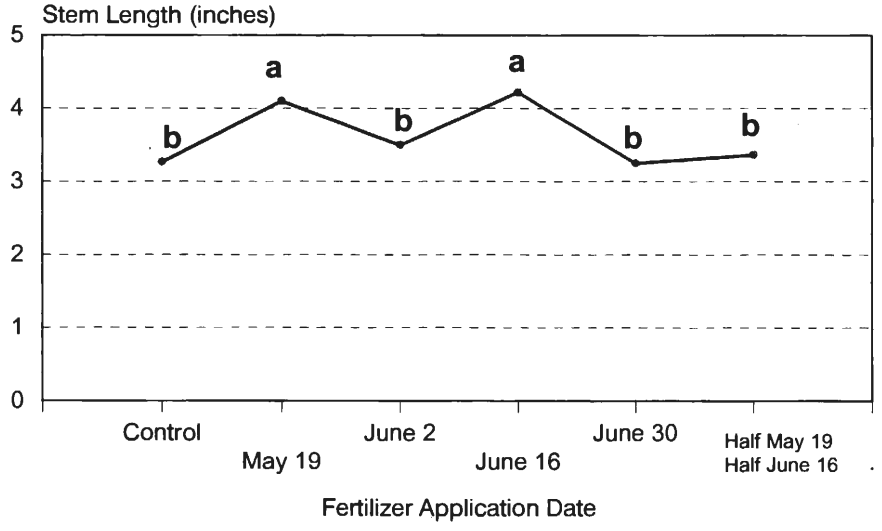
Effect of Fertilizer Timing on Stem Density



Location [illegible] Significance level = [illegible]

Figure [illegible]

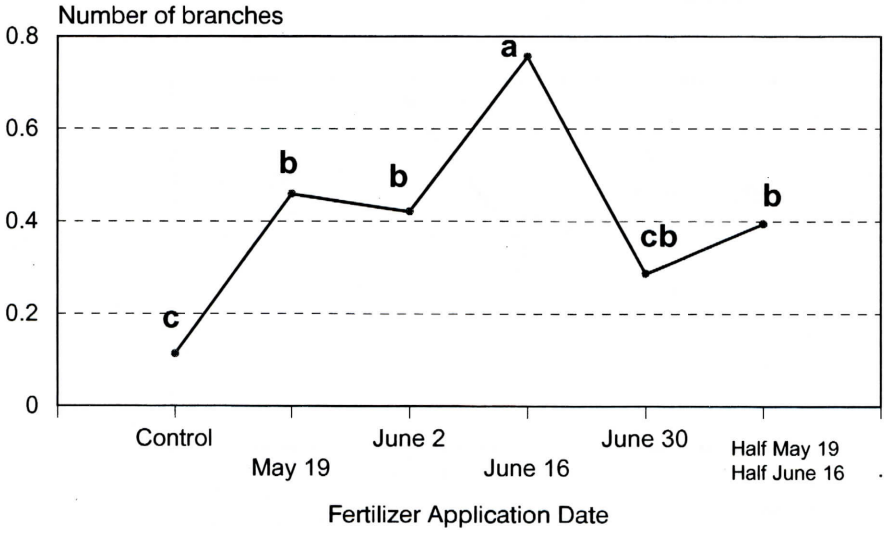
Effect of Fertilizer Timing on Stem Length



Location [illegible] Significance level = [illegible]

Figure 5

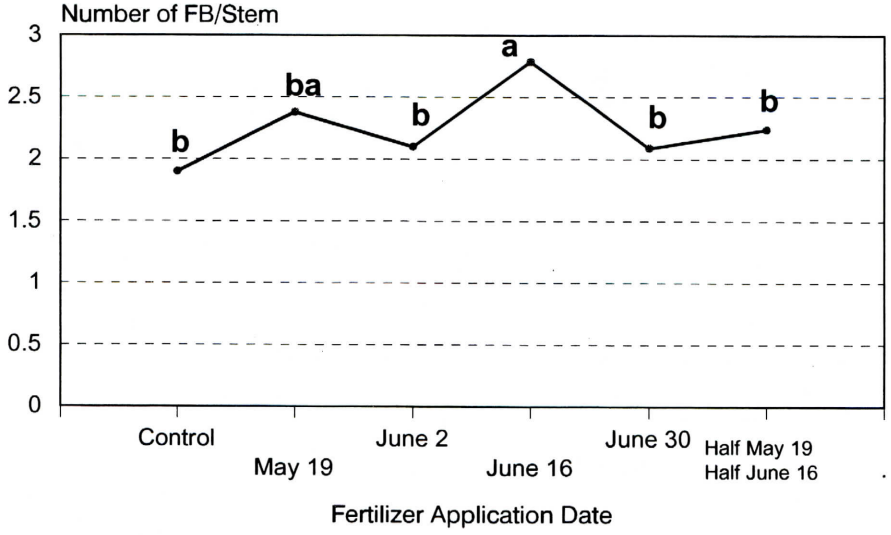
Effect of Fertilizer Timing on Stem Branching



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

Figure 6

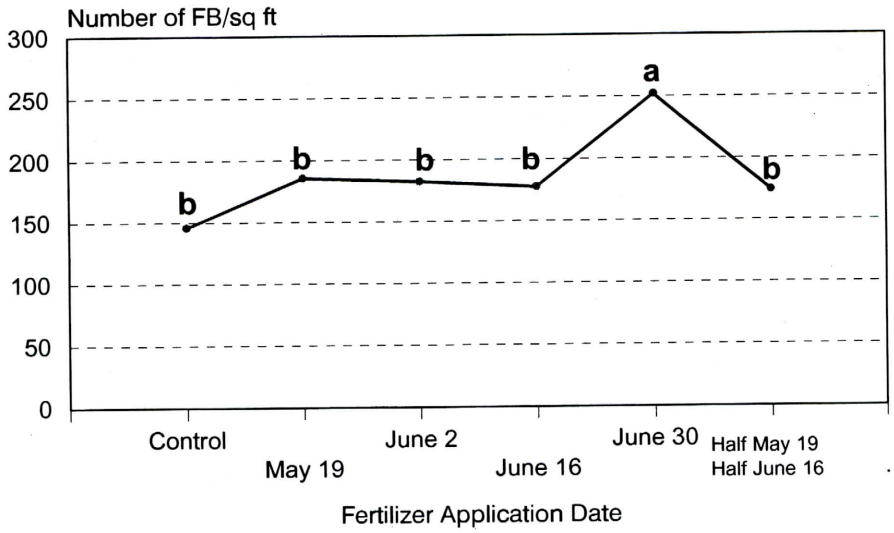
Effect of Fertilizer Timing on Flower Bud Formation



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

Figure 7

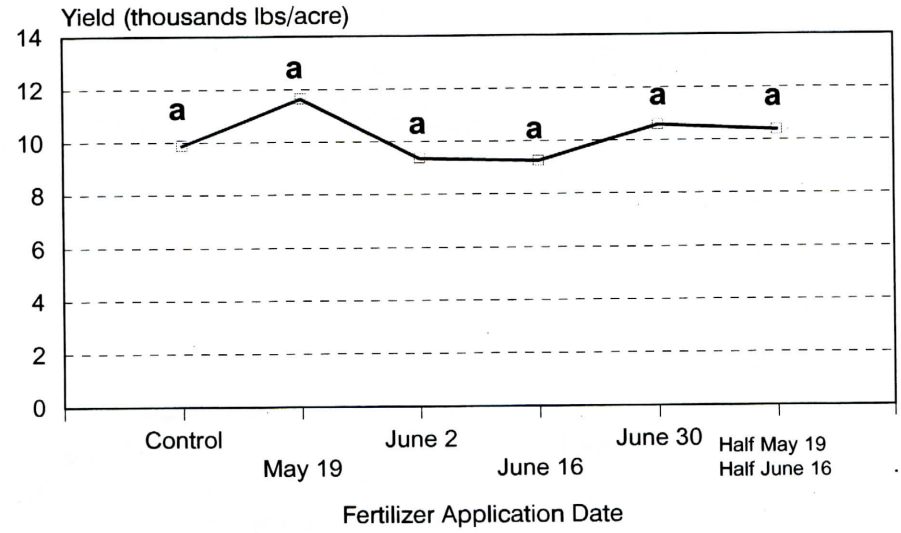
Effect of Fertilizer Timing on Flower Bud Density



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

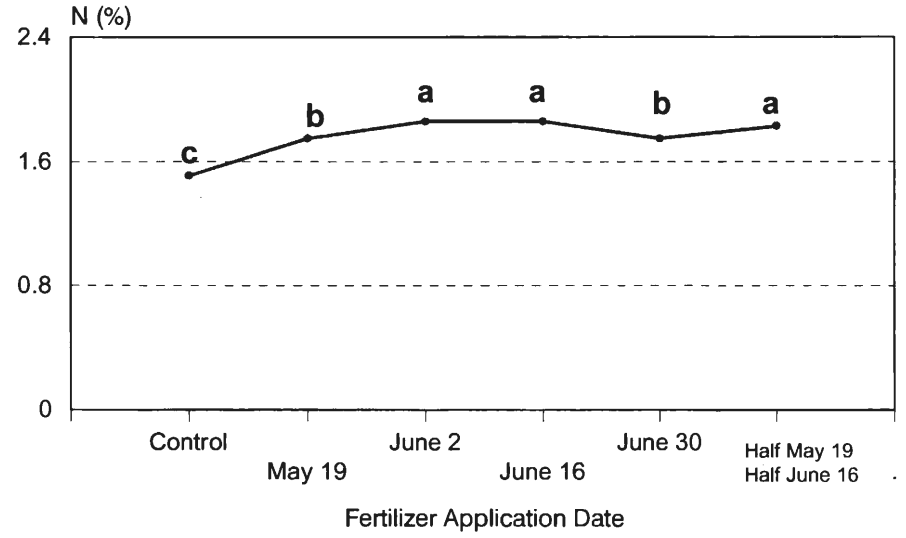
Figure 8

Effect of Fertilizer Timing on Yield



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

Effect of Fertilizer Timing on Leaf Nitrogen



Effect of Fertilizer Timing on Leaf and Soil Phosphorus

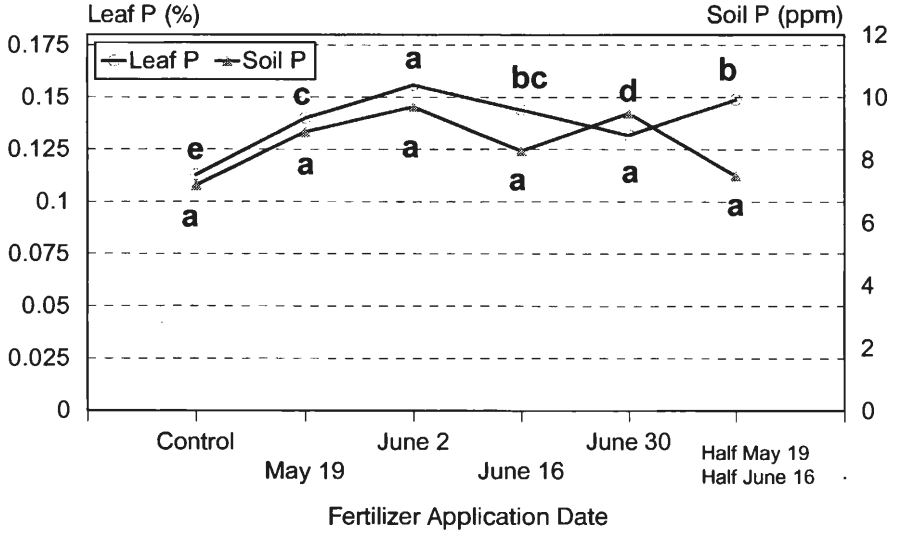
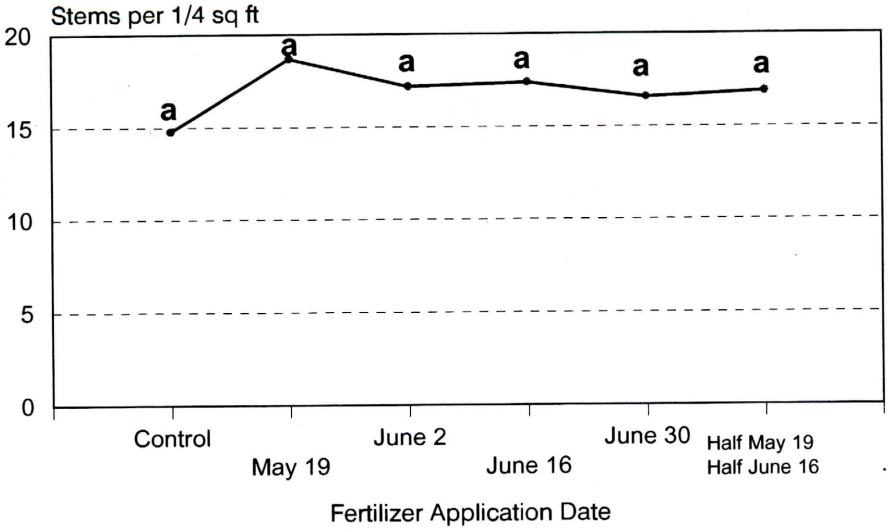


Figure 11

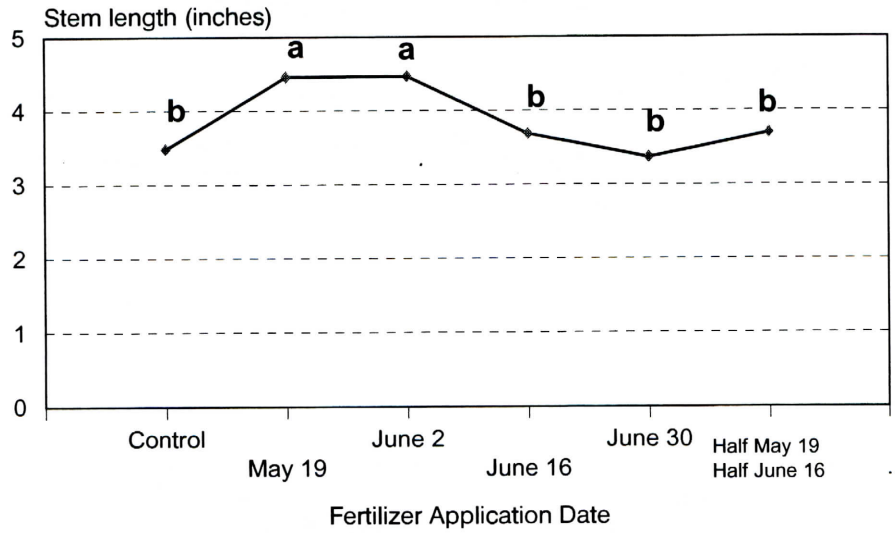
Effect of Fertilizer Timing on Stem Density



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

Figure 12

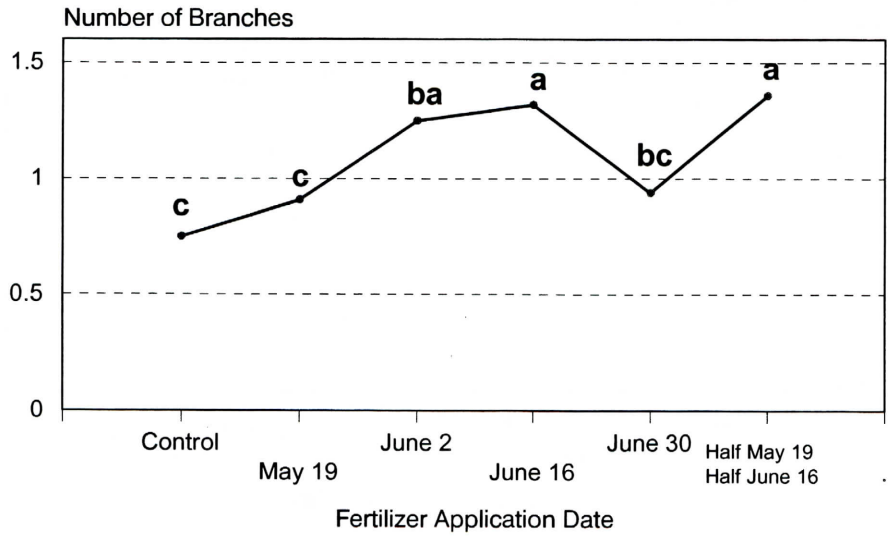
Effect of Fertilizer Timing on Stem Length



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

Figure 13

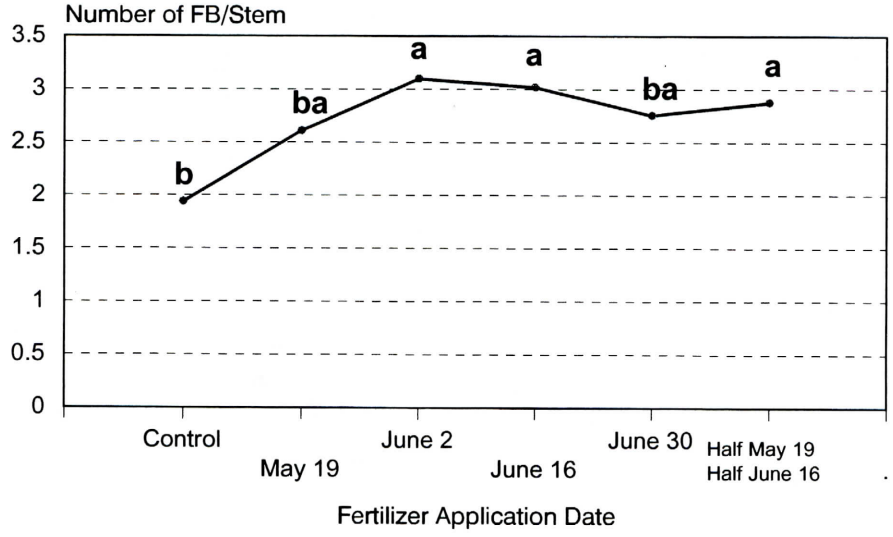
Effect of Fertilizer Timing on Stem Branching



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

Figure 14

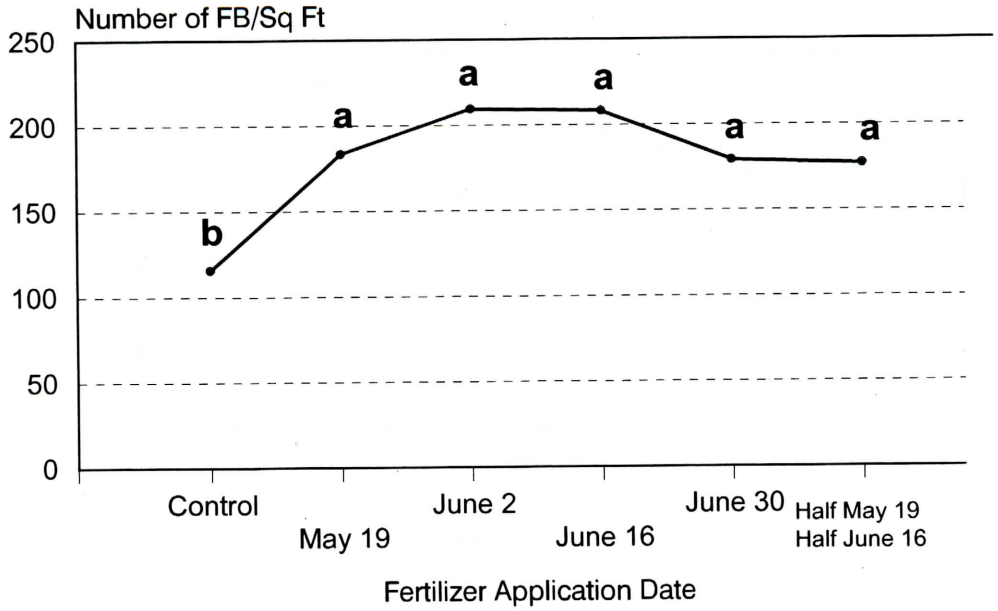
Effect of Fertilizer Timing on Flower Bud Formation



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

Figure 15

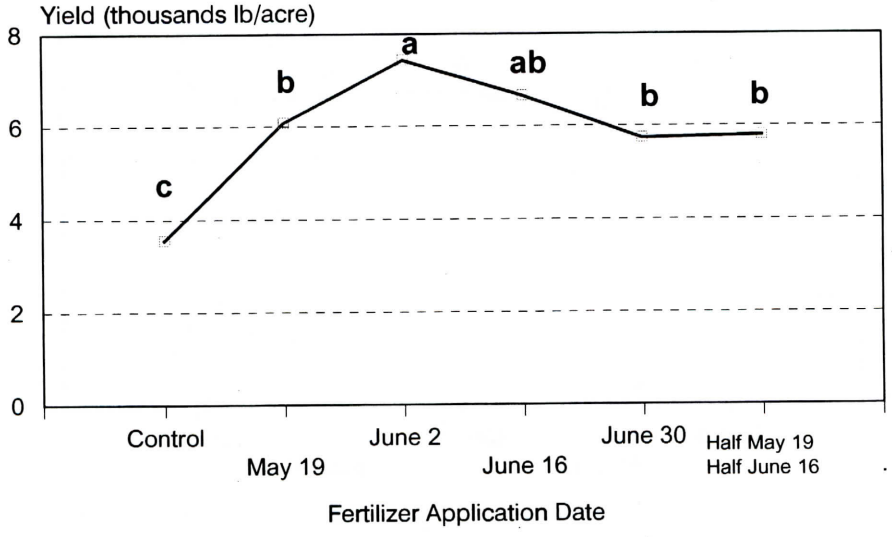
Effect of Fertilizer Timing on Flower Bud Density



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

Figure 16

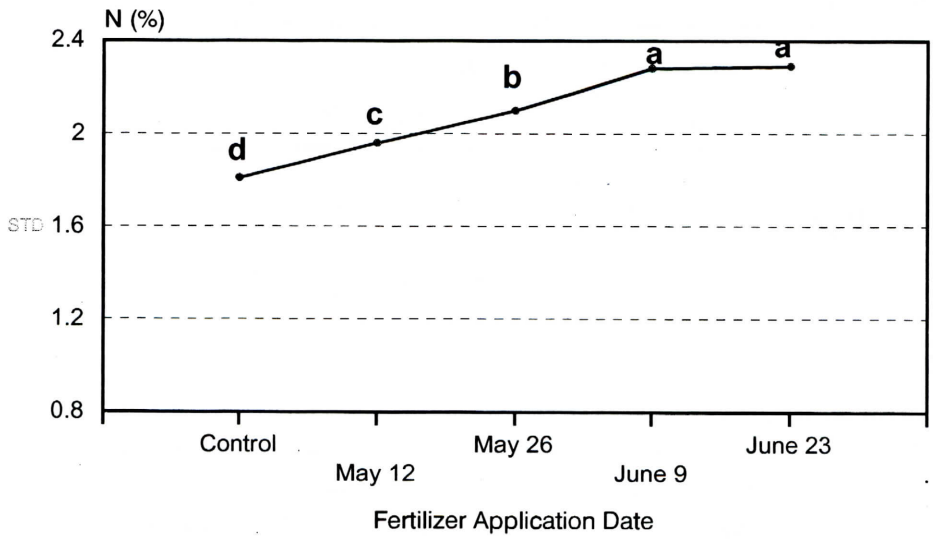
Effect of Fertilizer Timing on Yield



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

Figure 17 Effect of Fertilizer Timing on Leaf N

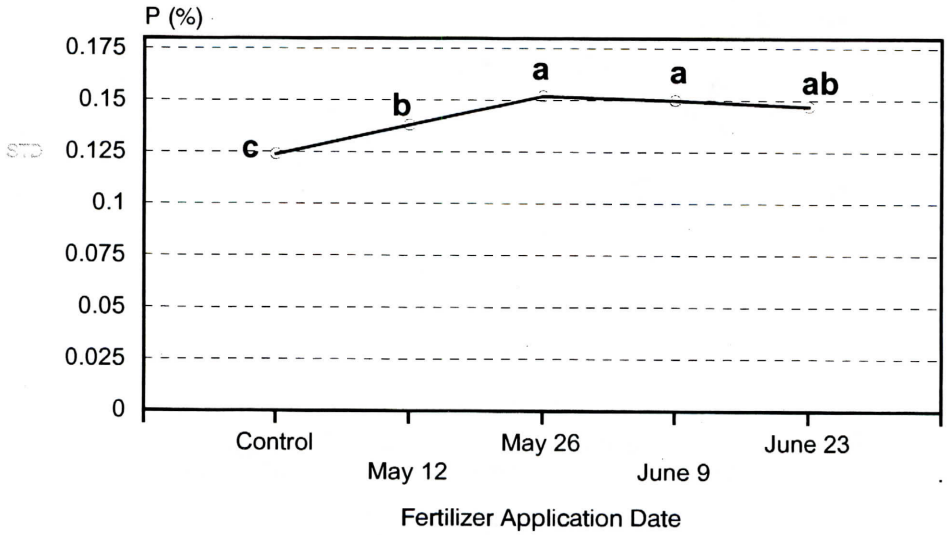
1999 Study



80lbs P/acre from DAP. Significance level = 0.01%. Significant linear and quadratic trends for fertilizer application dates, .01% and 2.6%, respectively.

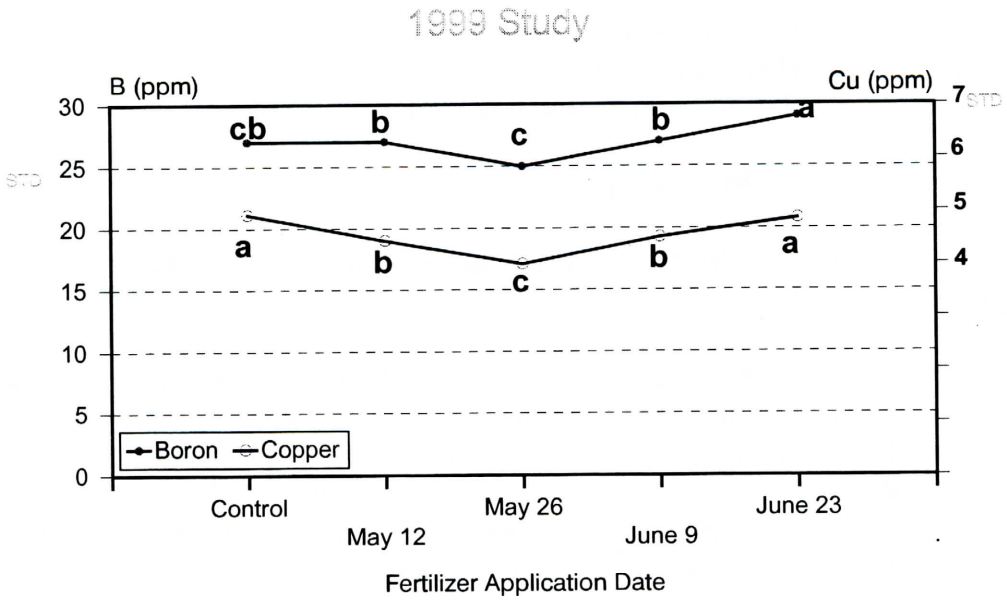
Figure 18 Effect of Fertilizer Timing on Leaf P

1999 Study



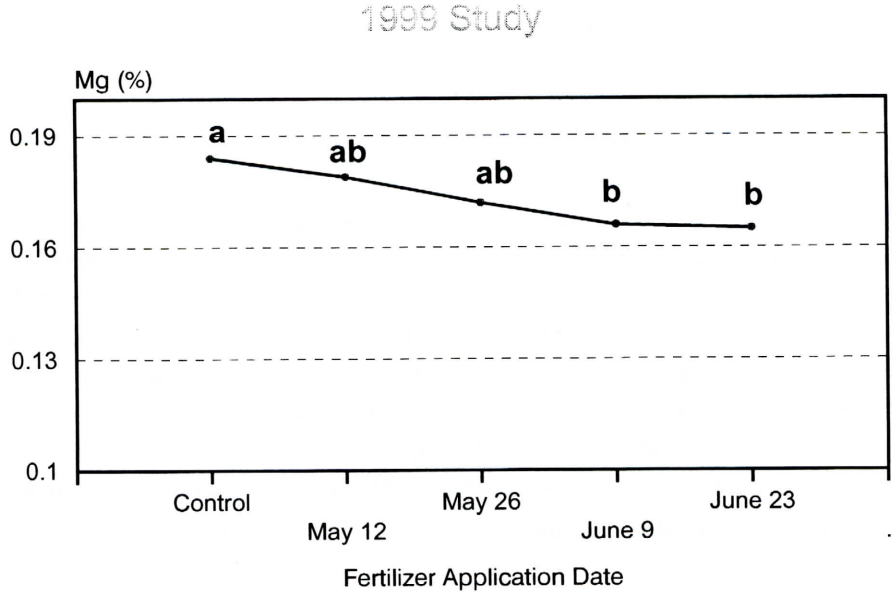
80lbs P/acre from DAP. Significance level = 0.01%. Significant quadratic trend for fertilizer application dates, 1.3% level

Figure 19 Effect of Fertilizer Timing on Leaf B and Cu



80lbs P/acre from DAP. Significance level = 0.01%. Significant quadratic trend for fertilizer application dates, 1.3% level

Figure 20 Effect of Fertilizer Timing on Leaf Mg



80lbs P/acre from DAP. Significance level = 2%. Significant linear trend for fertilizer application dates, 2.5 % level.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Richard Dyer, Research Assistant
Karen Loennecker, Research Assistant

3. 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 to determine the effect of soil pH adjustment on nutrient uptake, plant growth, and yield 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 re-analyzed 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 bi-weekly 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.
Pre-treatment 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.

Soil pH and Nutrients Among Clones

NO 14 TWP

Clone	pH	Ca	K	Mg	P	Al	Cu	Fe	Mn	Zn
1	4.8	504	60	105	15	243	0.11	14	35	1.7
2	4.6	328	58	69	18	315	0.1	13	34	1.8
3	4.6	368	45	67	17	293	0.08	13	36	1.6
4	4.7	329	50	54	18	289	0.12	12	30	1.8
5	4.7	271	44	45	15	314	0.08	11	34	1.6
6	4.6	294	51	53	19	322	0.08	15	37	2.2
7	4.6	197	47	39	18	344	0.09	13	27	1.3
8	4.7	276	51	56	18	287	0.1	12	36	1.9

Concentrations in mg/kg. Values for pH, Mg, and P were significantly different among clones

Table 2.

Soil pH and Nutrients Among Clones

Lamoine

Clone	pH	Ca	K	Mg	P	Al	Cu	Fe	Mn	Zn
1	4.2	93	58	28	17	344	0.16	36	16	1.9
2	4.2	121	43	27	12	379	0.08	23	14	1.5
3	4.3	132	47	31	13	396	0.06	20	21	1.5
4	4.1	229	57	45	19	325	0.08	36	20	2.6
5	4.3	137	51	28	15	412	0.06	24	25	2.3
6	4.2	120	51	27	17	404	0.08	28	25	2.2
7	4.1	115	38	25	12	330	0.06	30	16	1.3
8	4.3	79	32	20	11	390	0.11	24	20	1.3

Concentrations in mg/kg. Values for pH, Mn and Zn not significantly different among clones a

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 had decreased by an average of 0.33 pH units for soil beneath the 8 sections of clones treated with sulphur (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	4.39 a	1.62 b	.114 b	.493 b	.431 a	32 a
Sulphur	4.06 b	1.68 a	.121 a	.575 a	.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 non-sulphured 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 is not yet available.

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		1.98 a	.133 a	.474 a	.405 a	27 a
Sulphur		1.99 a	.137 a	.497 a	.396 a	25 a

Stems cut from within 4 inch x 2 ft quadarats 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

CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can made at this time.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate
Richard Dyer, Research Assistant
Karen Loennecker, Research Assistant

4. TITLE: Effect of Boron (B) 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 (Ca) 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.

METHODS: *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 Zinc (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 borate

Foliar Treatments

T5 =Control + DAP + Zn	T13 =Control
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. Preemergent 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 1/4 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.

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 carry-over 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 carry-over appears small (Fig. 10).

METHODOLOGY: *Boron Application Study II (1999)*

A spring frost followed by fungus blight may have affected yield data and masked the potential benefit of boron plus DAP in the 1997 boron application study. A smaller follow-up study was initiated in 1999 to evaluate just the most promising treatments: 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 and treatments were replicated eight times in a randomized complete block design. Composite leaf tissue samples were taken in July 1999 and stem samples were taken in October 1999. Yield will be 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 Iron (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).

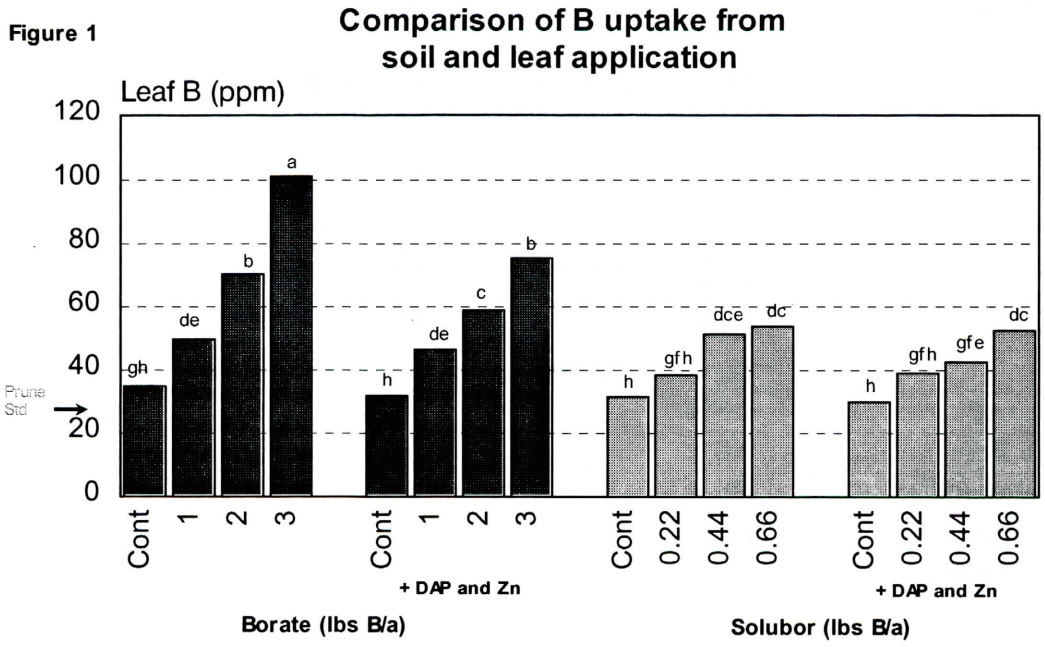
Stems sampled from plots in October 1999 indicated that stem length and branching was increased by all treatments that included DAP, compared to the control (Figs. 15 & 16). Flower bud formation was also increased by DAP treatment, compared to treatments without DAP (Table 1 and Figs. 17 & 18).

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

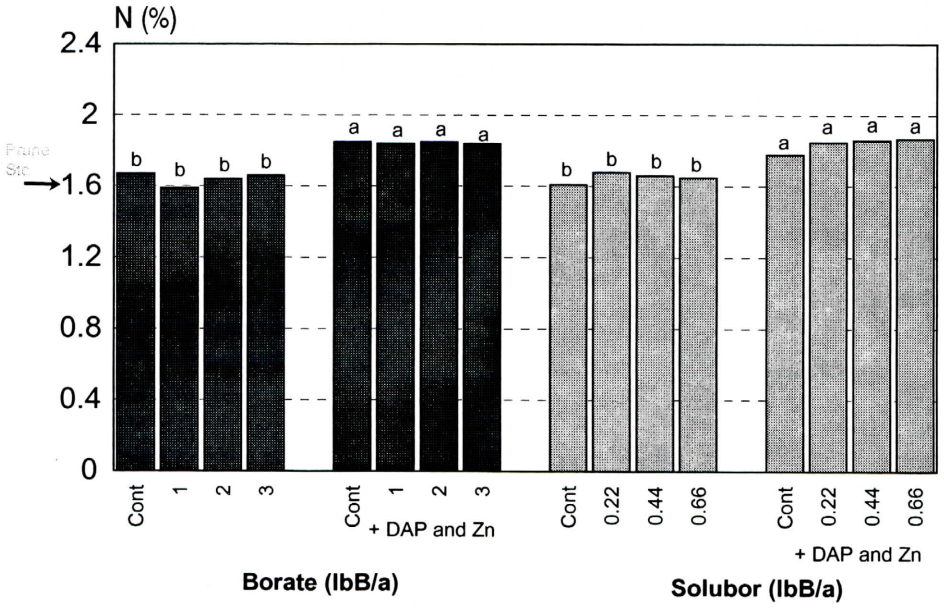
CONCLUSIONS: Spring frost damage in 1998 prevents conclusions about effect on yield of DAP and Zn plus borate or plus Solubor®. Leaf B concentrations can be raised in fields with B deficiency by either soil-applied borate or foliar-applied Solubor®. DAP and Zn treatments raised leaf N and P concentrations 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 treatments 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 1999, borate was more effective in raising leaf B concentrations than Solubor®. The N and P from DAP appears to be having the major effect on stem growth, branching and flower bud formation.

Figure 1



DAP at 80 lb P/a, $ZnSO_4$ at 3 lb Zn/a. Mean separation of 1997 leaf B concentrations by Duncan's multiple range test, P = 0.01.

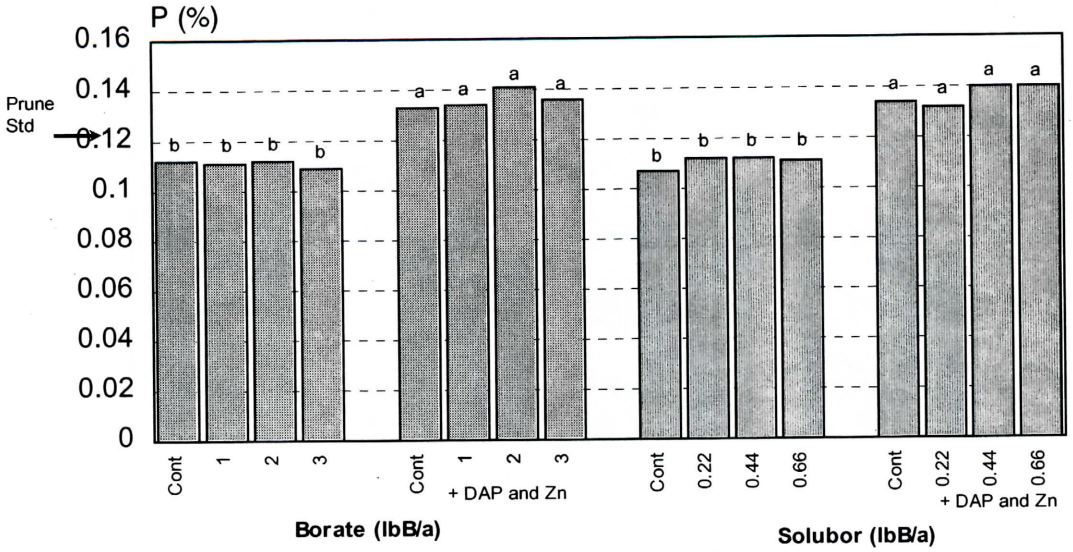
Figure 2



DAP at 80 lb P/a, $ZnSO_4$ at 3 lb Zn/a. Mean separation of 1997 leaf N concentrations by Duncan's multiple range test, P = 0.01.

Figure 3

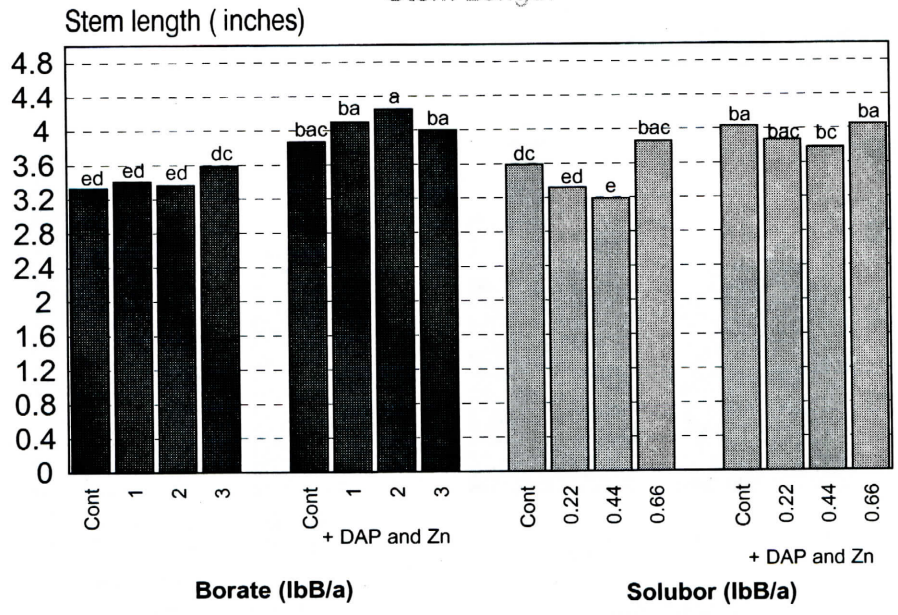
Leaf Phosphorus Concentrations



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.

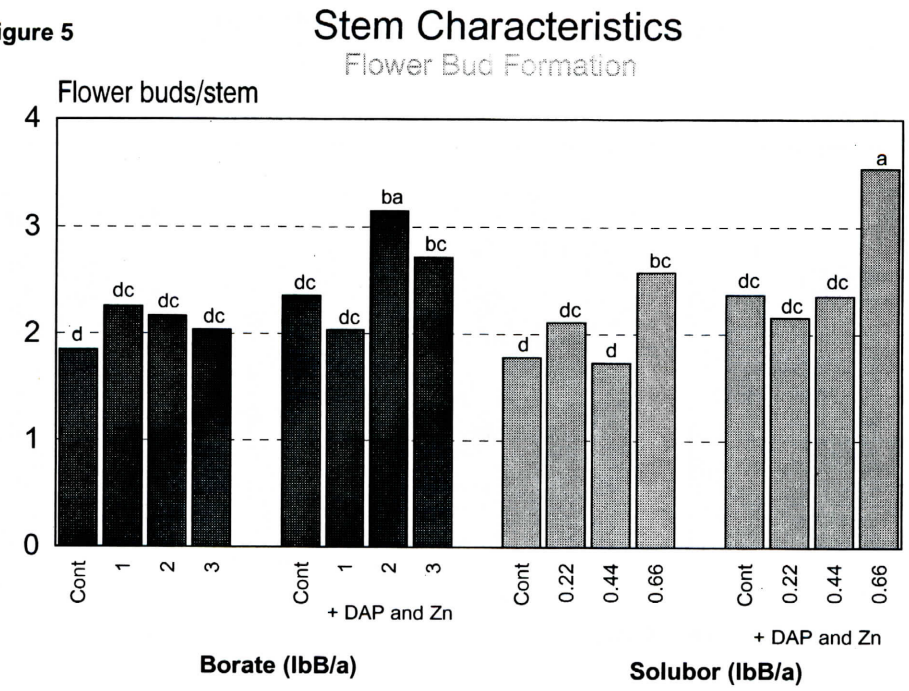
Figure 4

Stem Characteristics



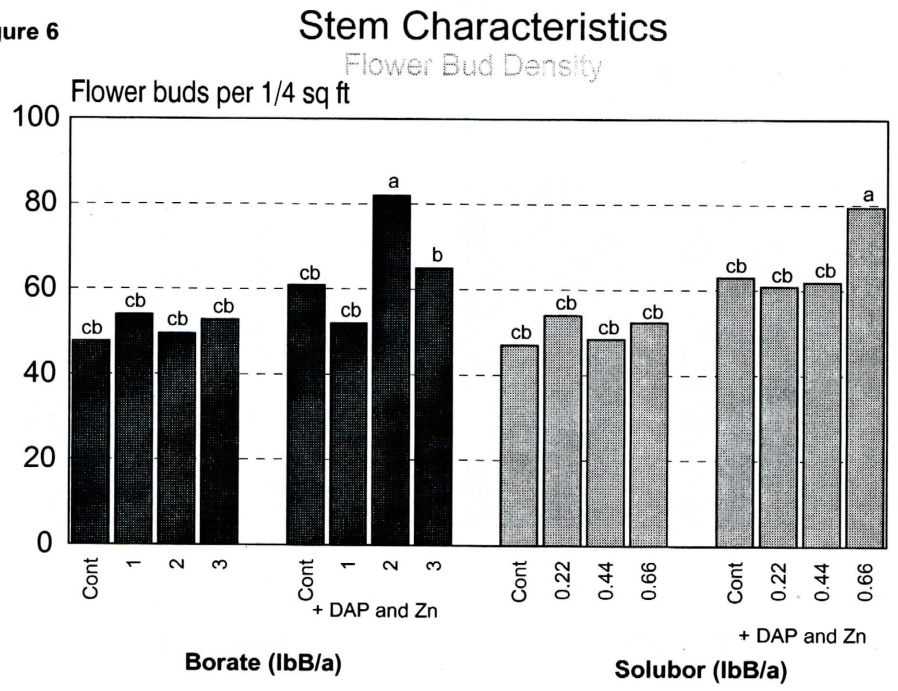
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 stem length by Duncan's multiple range test, P = 0.01.

Figure 5



DAP at 60 lb P/a, $ZnSO_4$ 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 60 lb P/a, $ZnSO_4$ at 3 lb Zn/a , Mean separation of 1997 flower bud density by Duncan's multiple range test, P = 0.01.

Figure 7 Treatments with Highest Potential Yield

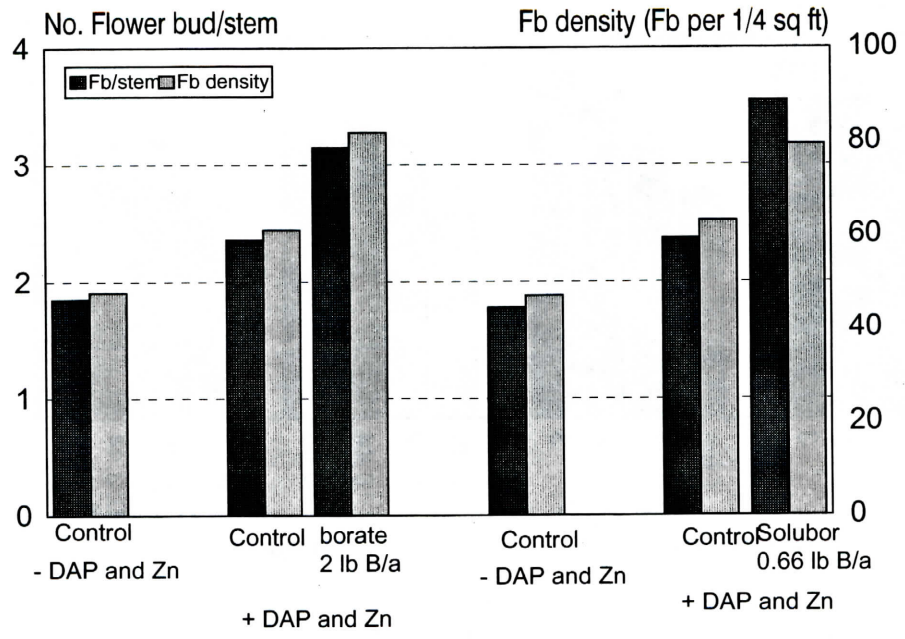
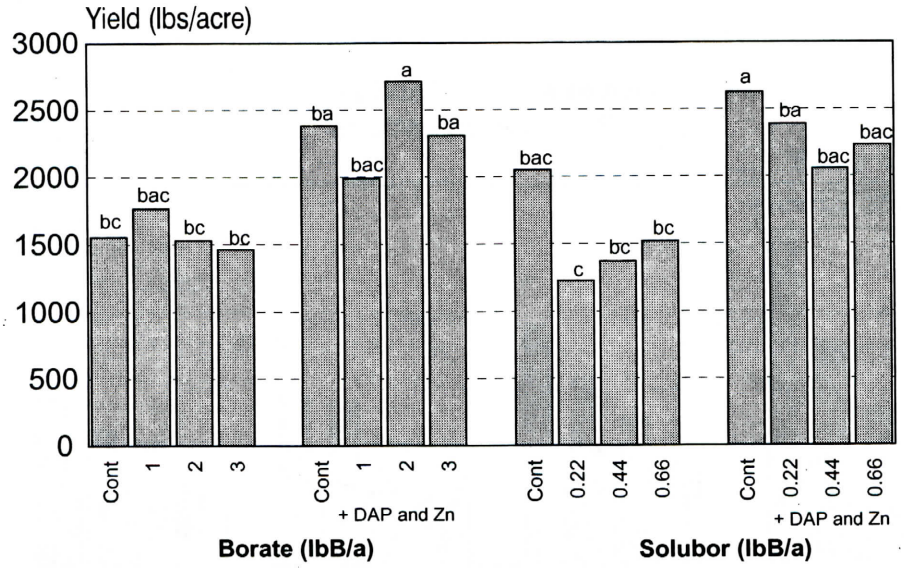


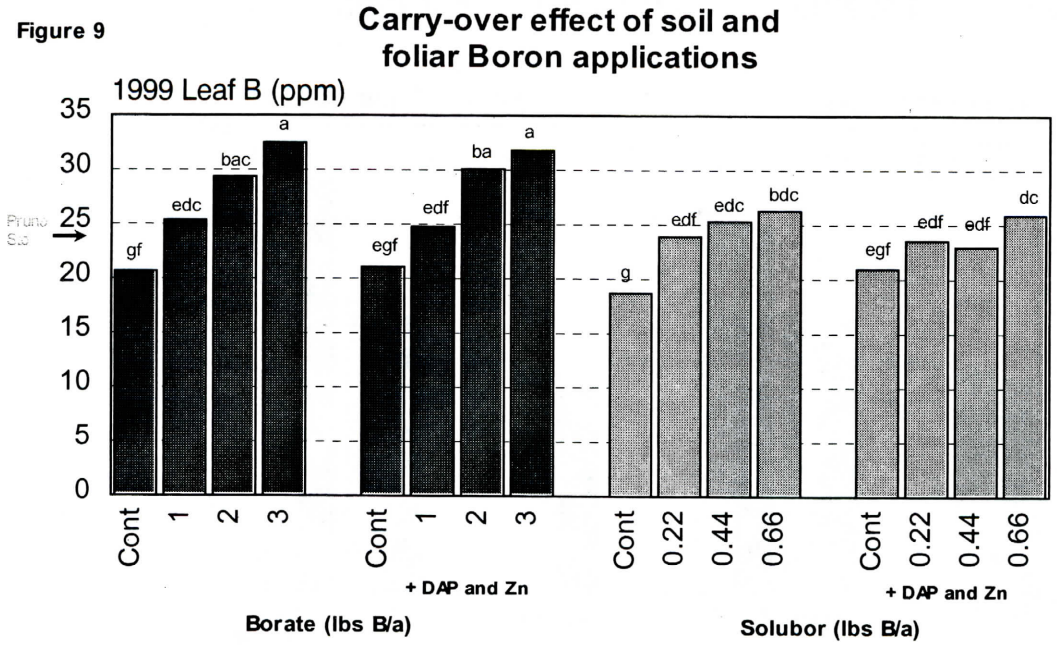
Figure 8

Blueberry Yield



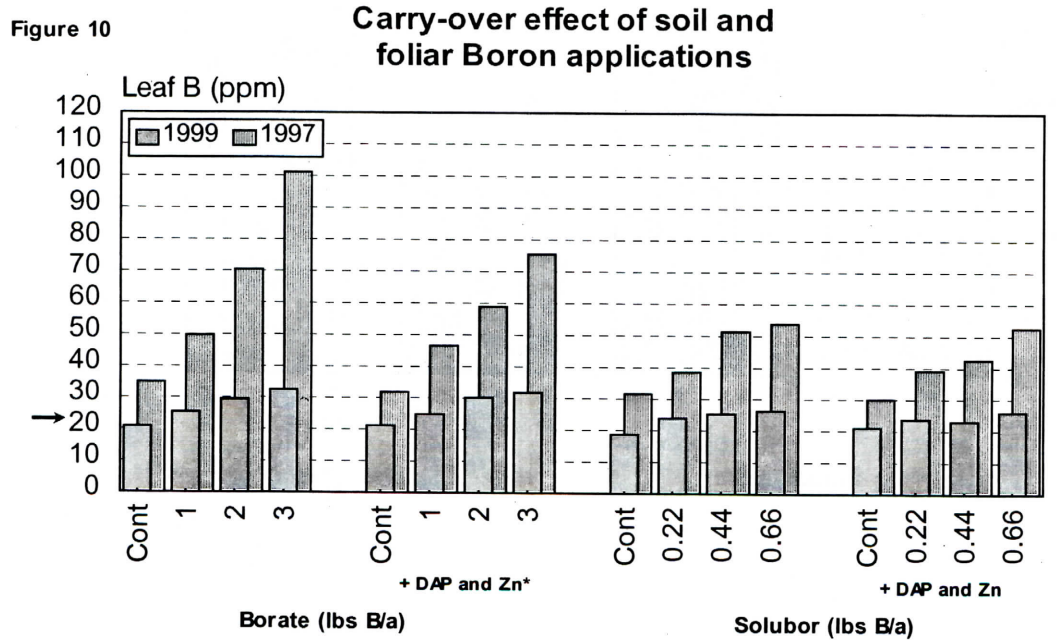
DAP at 60 lb P/a, $ZnSO_4$ at 3 lb Zn/a ; Mean separation of 1998 yield by Duncan's multiple range test, P = 0.01.

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

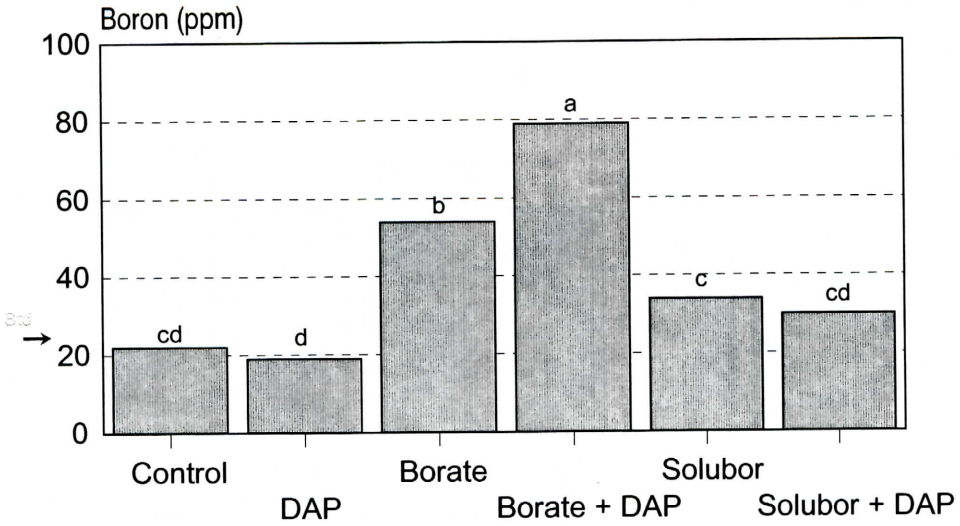


* DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a. Treatment in 1997 only. 1997 and 1999 treatment effects on leaf B concentrations significant at 1% level.

Figure 11

Boron Study- 1999

Leaf Boron Concentration

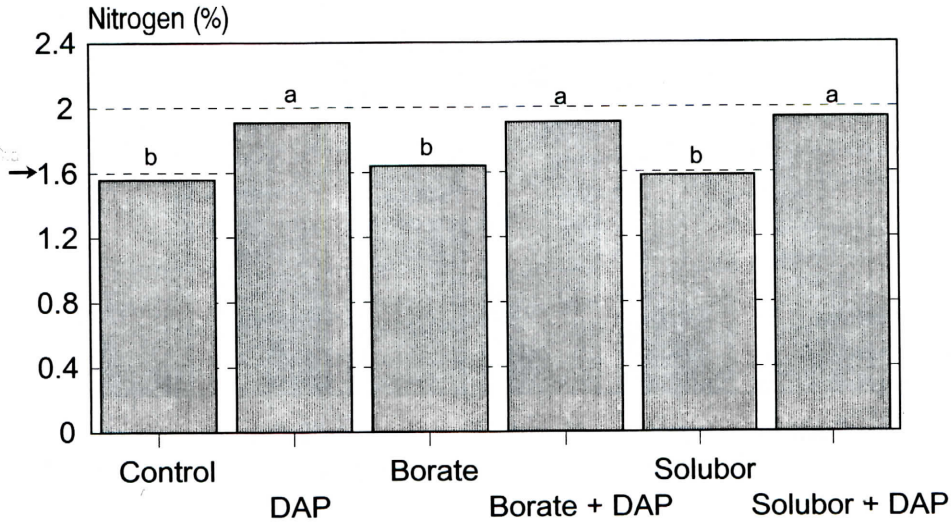


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre. separation by Duncan's Multiple range test, .01% level.

Figure 12

Boron Study- 1999

Leaf Nitrogen Concentration

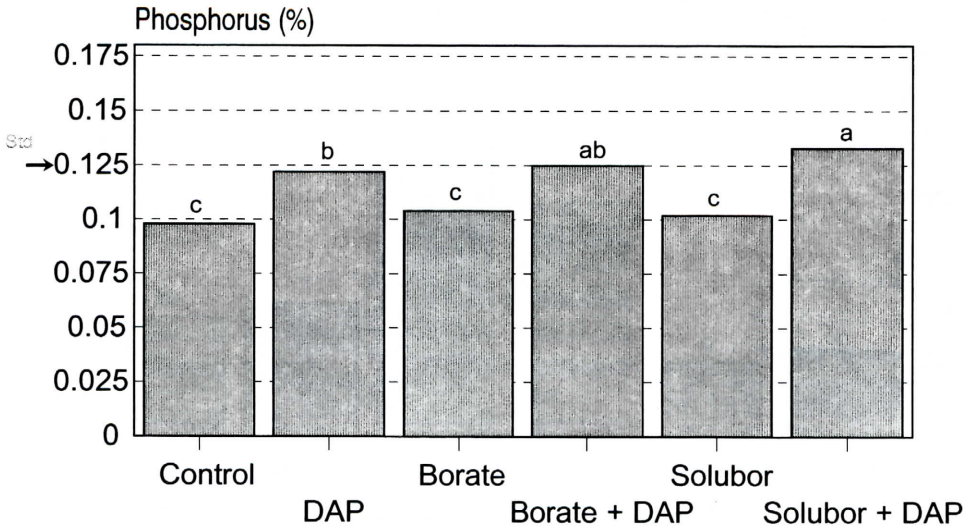


Soil-applied Borate at 2 lb B/acre. Foliar-applied Solubor at 0.66 lb B/acre. DAP at 80 lb P/acre. separation by Duncan's Multiple range test, .01% level.

Figure 13

Boron Study- 1999

Leaf Phosphorus Concentration

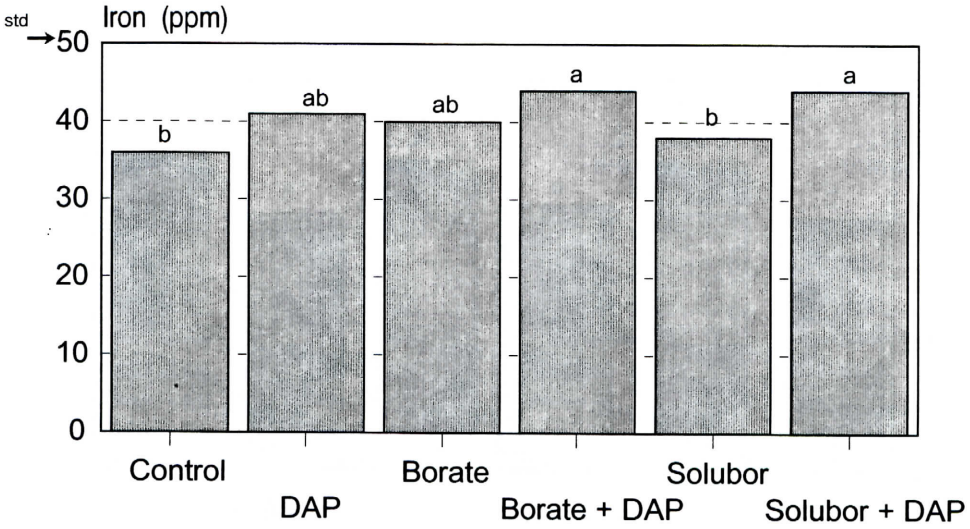


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. separation by Duncan's Multiple range test, .01% level.

Figure 14

Boron Study- 1999

Leaf Iron Concentration

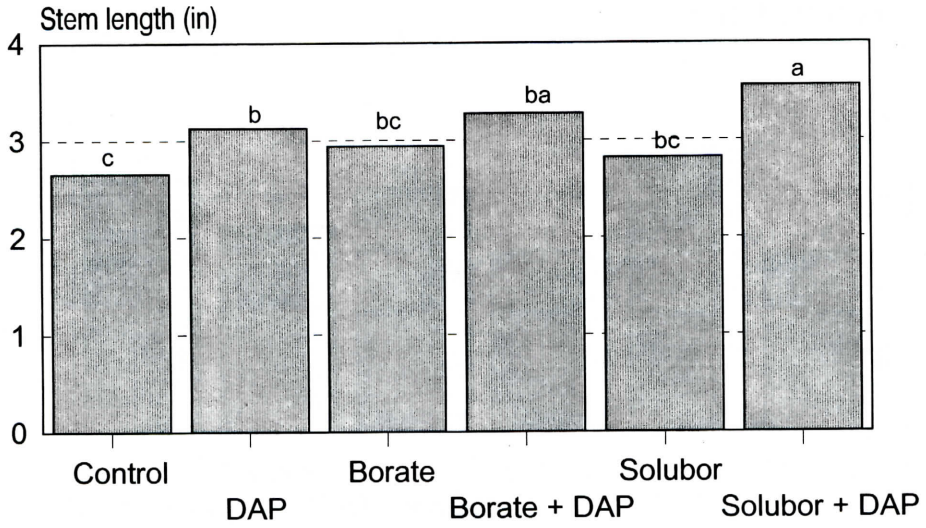


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. separation by Duncan's Multiple range test, 5% level.

Figure 15

Boron Study- 1999

Stem length

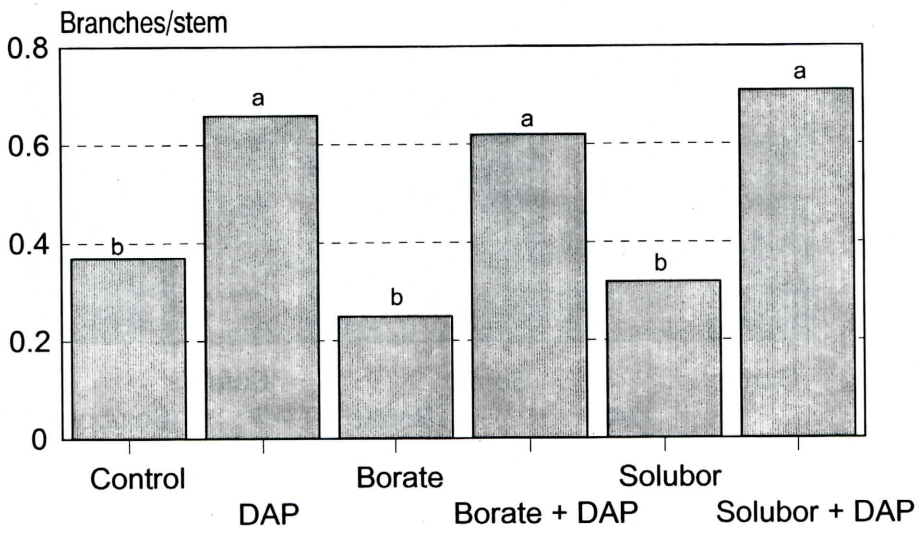


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. separation by Duncan's Multiple range test, .01%level.

Figure 16

Boron Study- 1999

Stem branching

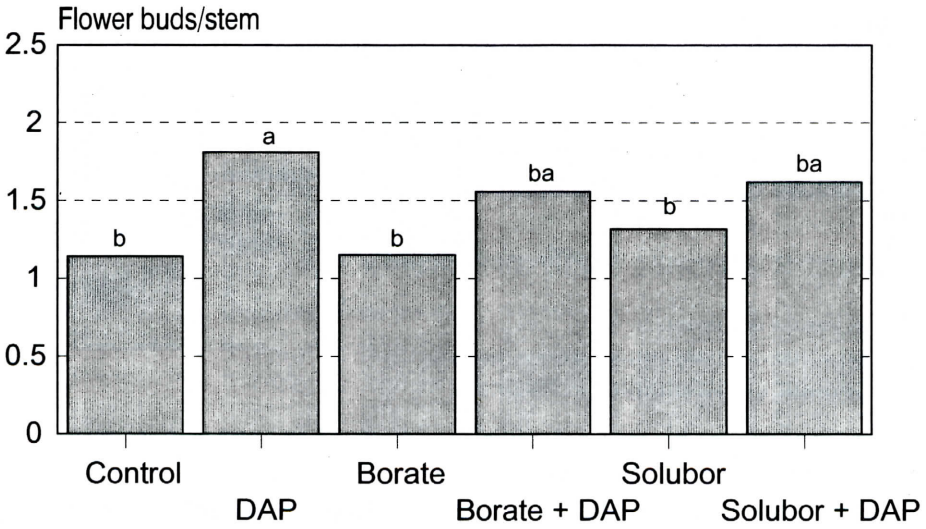


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 80 lb P/acre. separation by Duncan's Multiple range test, .01%level.

Figure 17

Boron Study- 1999

Flower bud formation

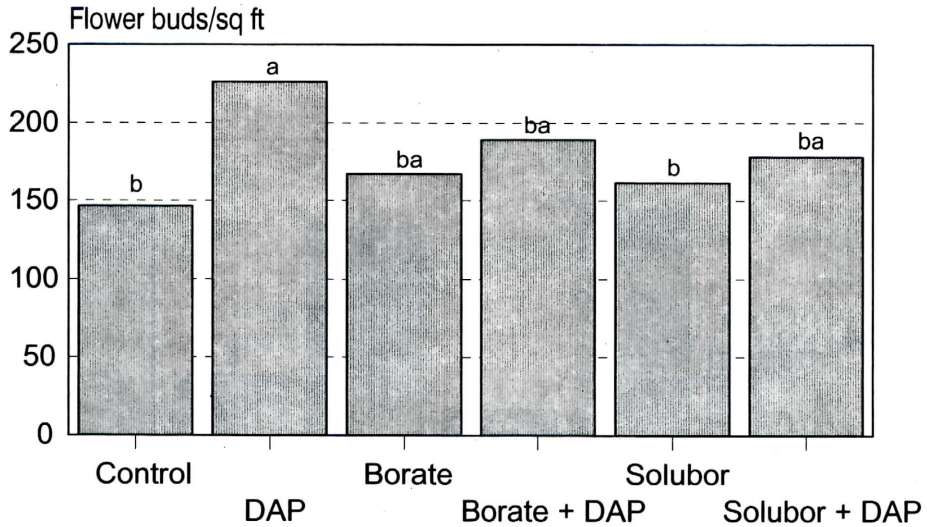


Soil-applied Borate at 2 lb B/acre. Foliar-applied Soubor at 0.66 lb B/acre. DAP at 50 lb P/acre. separation by Duncan's Multiple range test, 5% level.

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 50 lb P/acre. separation by Duncan's Multiple range test, 5% level.

PLANT NUTRITION

INVESTIGATOR: John M. Smagula, Professor of Horticulture

TITLE: Effect of Nutri-Phite™ P+K on growth and yield of lowbush blueberry (*Vaccinium angustifolium Ait.*)

OBJECTIVE: To evaluate the effectiveness of Nutri-Phite™ P+K on growth and yield of wild blueberry

METHODS:

A field was selected in Appleton, Maine which had low leaf N and P concentrations in 1997 leaf samples. Hexazinone was applied to the field in which the experiment was being conducted to control herbaceous flowering weeds and some grasses. The following fertilizer treatments were applied to 5 ft by 50 ft treatment plots (see Fig. 1):

1. Control
2. 80 lbs P from DAP
3. 80 lbs P from DAP plus Nutri-Phite™ P+K at 2 pt/acre
4. 80 lbs P from DAP plus Nutri-Phite™ 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™ 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 1/4 ft^2 quadrats per treatment plot on November 5, 1999. Fruit yield will be determined in August 2000.

RESULTS:

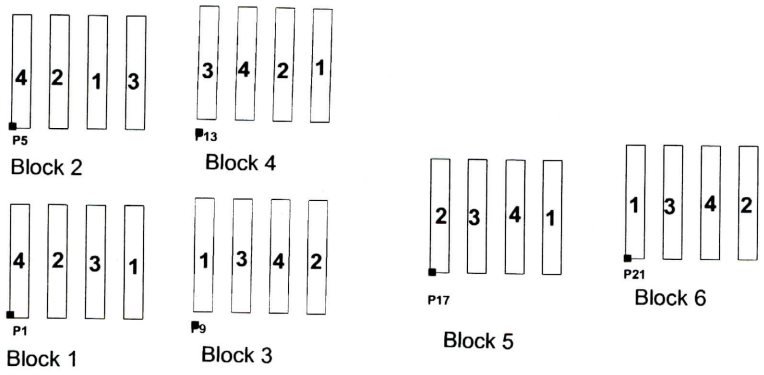
Leaf N and P concentrations were raised by DAP with or without Nutri-Phite™ P+K, compared to the control (Figs. 2 & 3). Leaf P in control plots was below the 0.125% standard and above the standard in treatment plots receiving DAP with or without Nutri-Phite™ P+K. Leaf K was above the .400% standard in control plots and not affected by any treatment (Fig. 4). 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. 5).

Observations in August revealed differences in plant cover in plots receiving DAP or DAP plus Nutri-Phite™ P+K, compared to the controls . Stem density (stems/ft^2), and stem length were not affected by treatments (Figs. 6 & 7). However, DAP or DAP with 2 or 4 pt Nutri-Phite™ P+K increased branching (Fig. 8), 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™ P+K at 2 pt/acre (Fig. 10). Flower bud density (flower buds/ft^2) was increased by DAP, DAP plus Nutri-Phite™ P+K at 2 pt/acre, and DAP plus Nutri-Phite™ P+K at 2 pt/acre (Fig. 11).

Figure 1

Nutri-Phite Study
Plot layout and Randomization

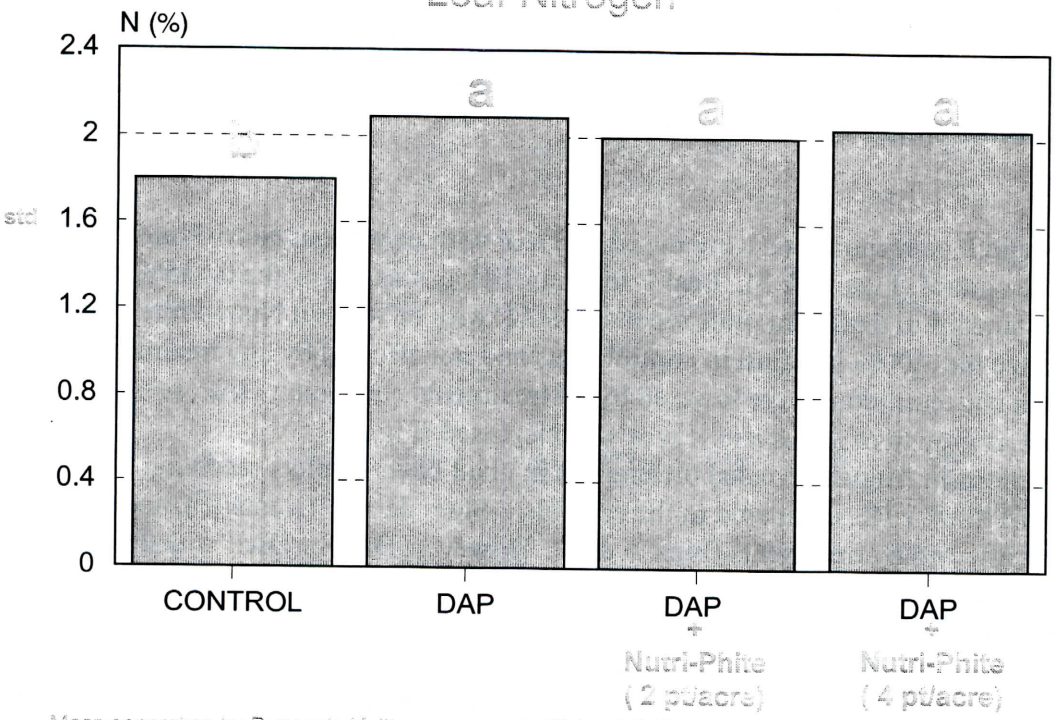
T1 = Control
T2= DAP (80 lbP/A)
T3= DAP + Nutri-Phite at 2 pt/acre
T4= DAP + Nutri-Phite at 4 pt/acre



Plot = 6 ft x 50 ft , 5 ft alley

Figure 2

Nutri-phite Study
Leaf Nitrogen

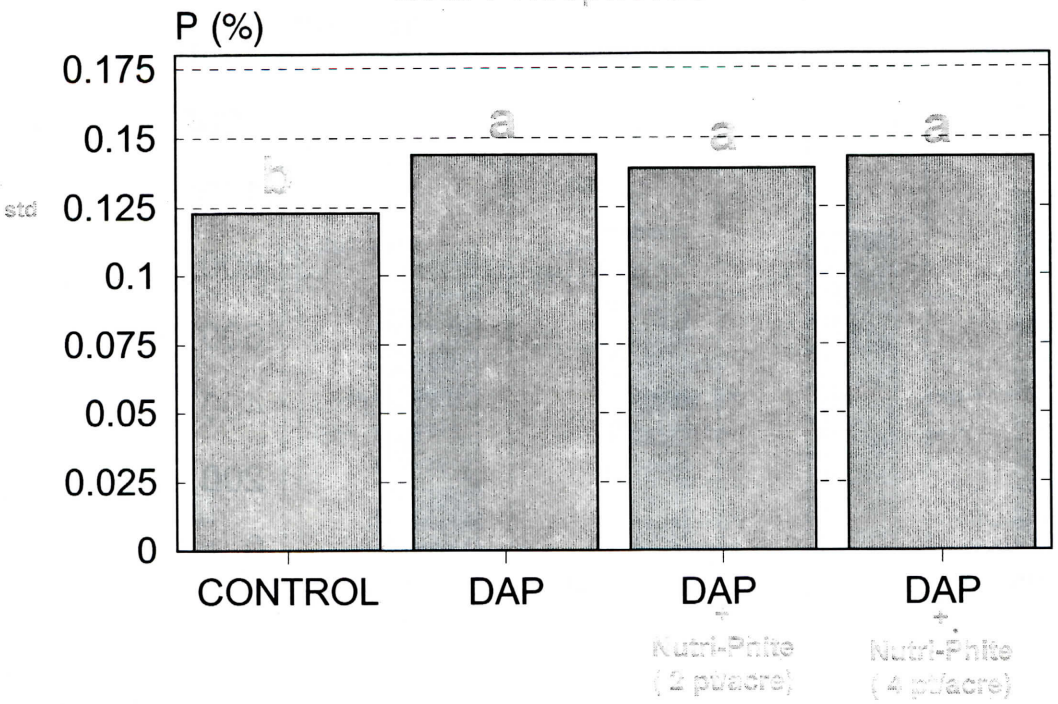


Mean separation by Duncan's Multiple range test. 1% level, DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 3

Nutri-phite Study

Leaf Phosphorus

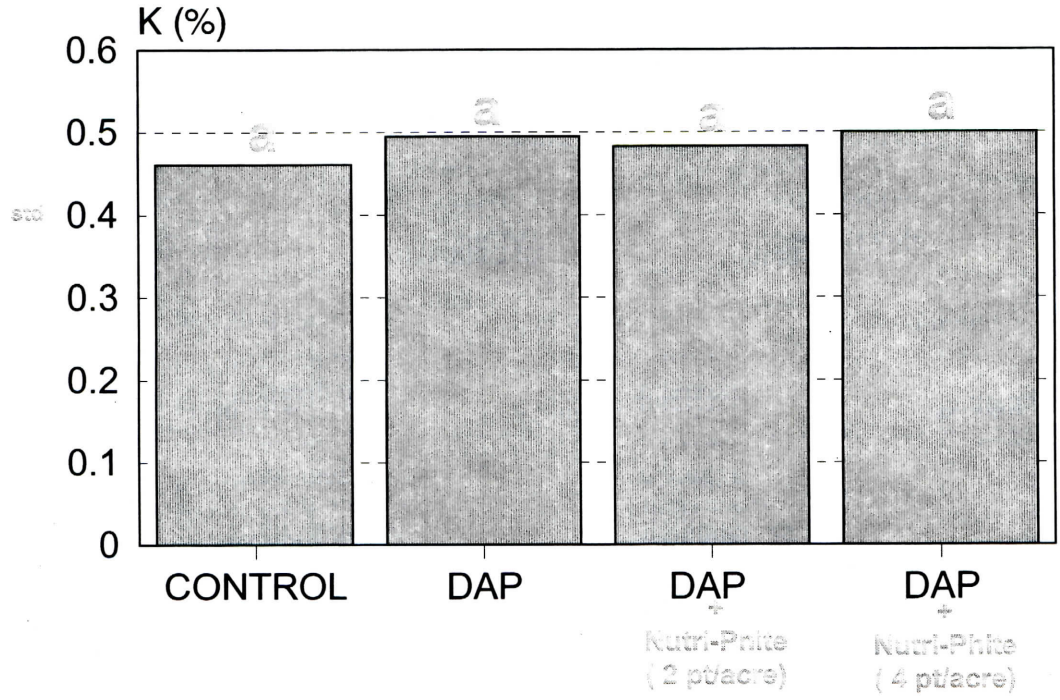


Mean separation by Duncan's Multiple range test, 1% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 4

Nutri-phite Study

Leaf Potassium

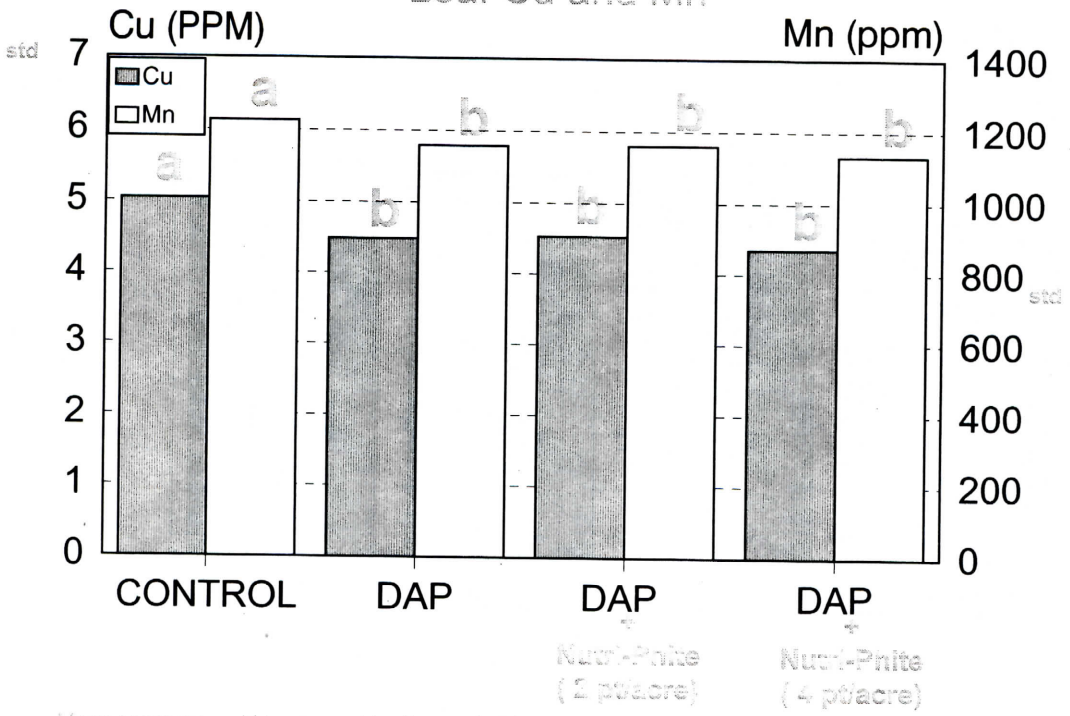


Mean separation by Duncan's Multiple range test, 5% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 5

Nutri-phite Study

Leaf Cu and Mn

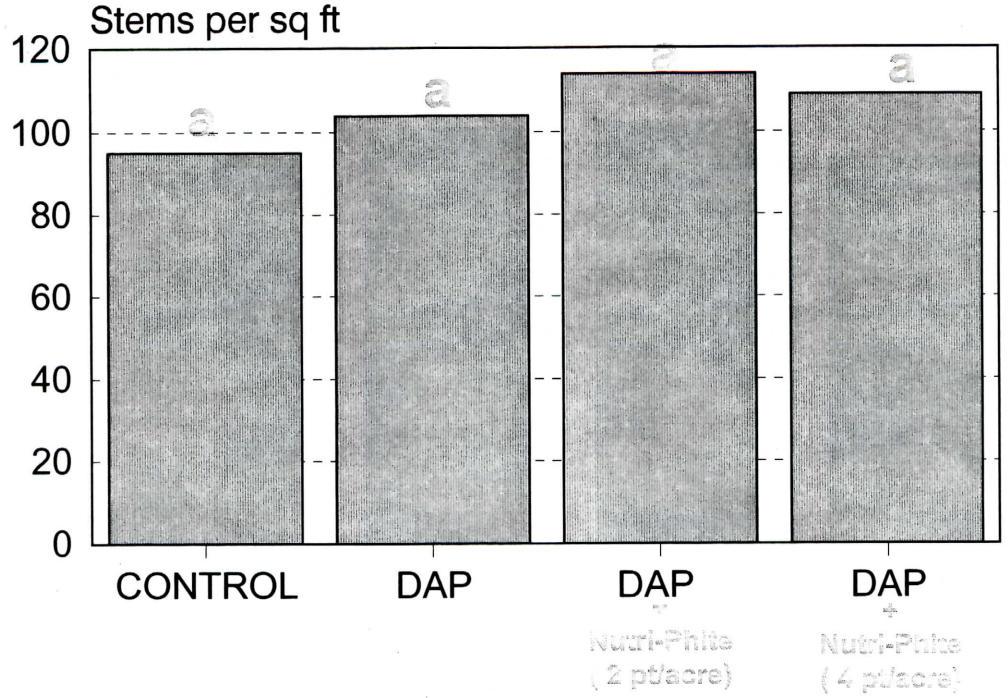


Mean separation within element by Duncan's Multiple range test, 1% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 6

Nutri-phite Study

Stem Characteristics

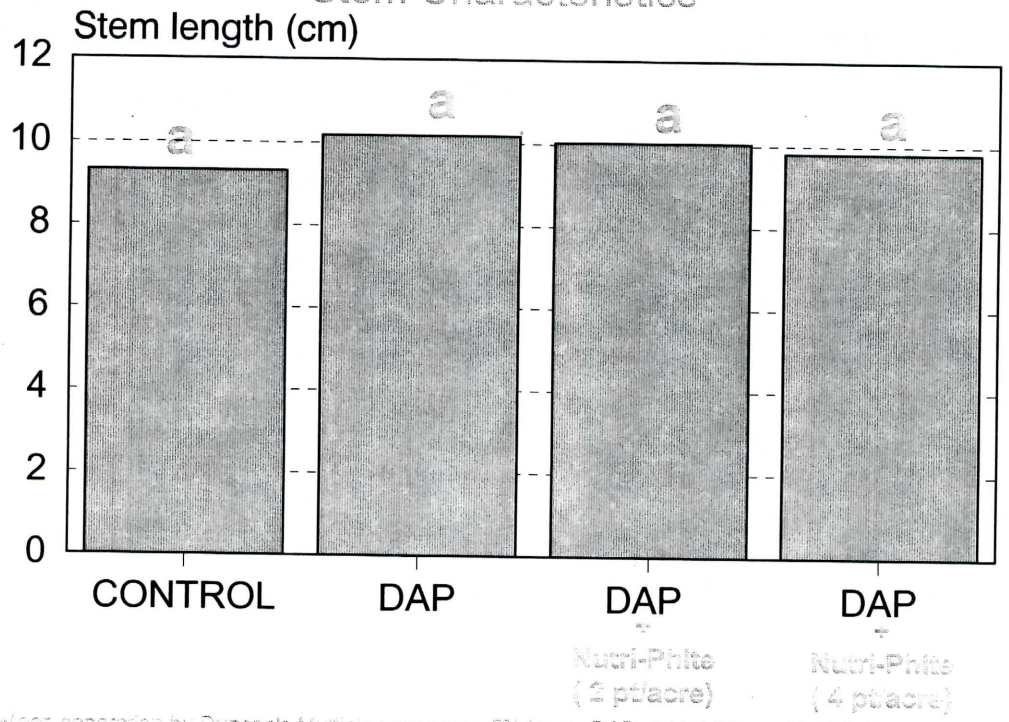


Mean separation by Duncan's Multiple range test, 5% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 7

Nutri-phite Study

Stem Characteristics

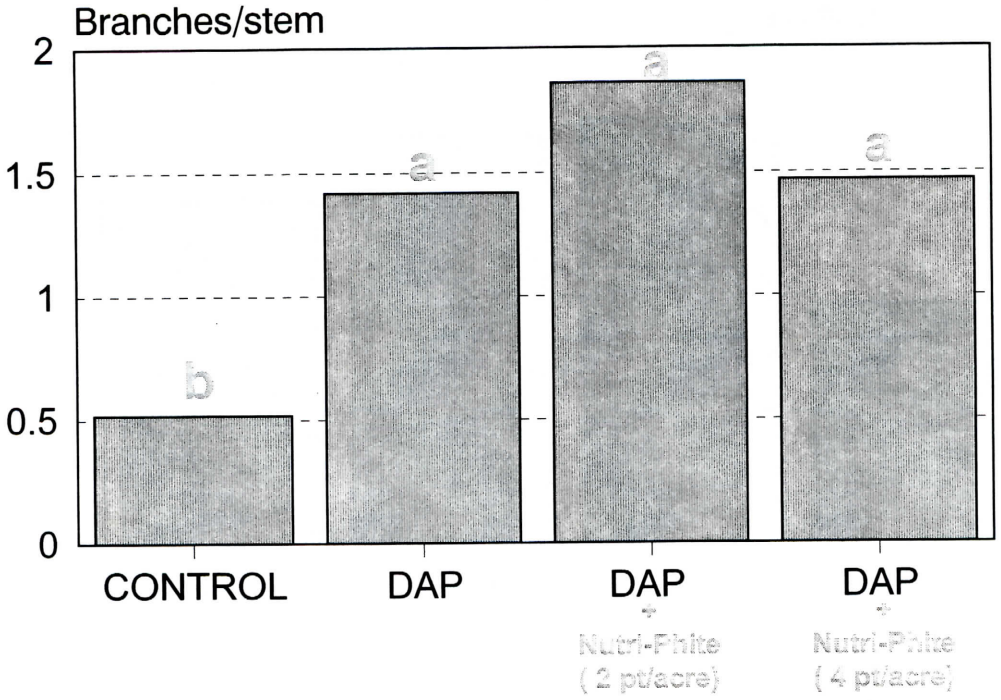


Mean separation by Duncan's Multiple range test, 5% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 8

Nutri-phite Study

Stem Characteristics

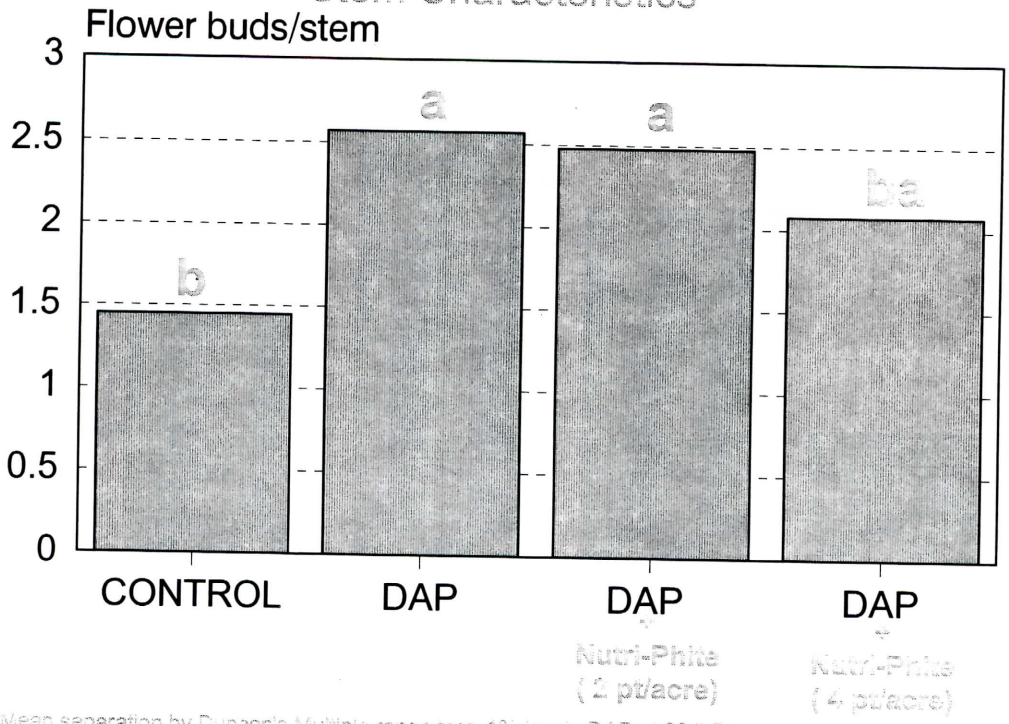


Mean separation by Duncan's Multiple range test, .01% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 9

Nutri-phite Study

Stem Characteristics

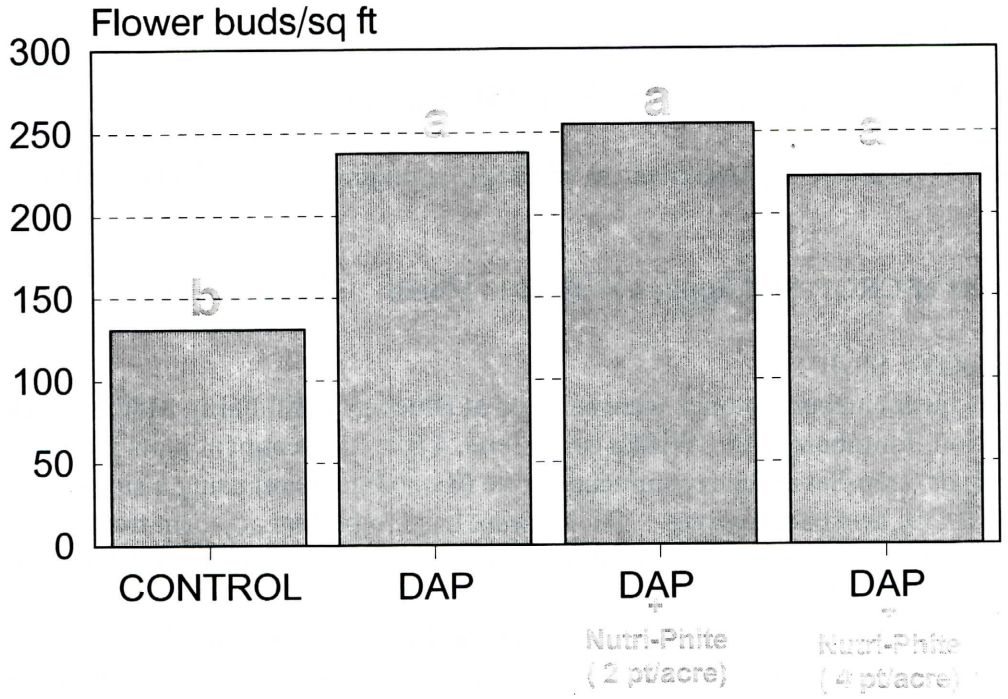


Mean separation by Duncan's Multiple range test, 1% level. DAP at 80 lbP/acre, Nutri-Phite at indicated rate.

Figure 10

Nutri-phite Study

Stem Characteristics



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

PLANT NUTRITION

5. TITLE: Effect of Crop-Set on growth and yield of lowbush blueberry (*Vaccinium angustifolium Ait.*)

INVESTIGATOR: John M. Smagula, Professor of Horticulture

OBJECTIVES: To evaluate the effectiveness of Crop-Set on growth and yield of wild blueberry

STUDY I Effect of CROP-SET applied at 10-20% bloom

METHODOLOGY: Study I

Four discrete lowbush blueberry clones were selected at Blueberry Hill Farm, Maine Agricultural Experiment Station, Jonesboro, ME. Within each clone, 4 ft x 4 ft treatment plots received nothing (control) or Crop-Set at the recommended rate (8 oz/40gal/acre) using a single nozzle spray wand and a CO_2 backpack sprayer. Shields were used to protect adjacent treatment plots from spray drift. Treatments were replicated 4 times within each clone in a randomized complete block design.

To evaluate the effect of Crop-Set on fruit-set and fruit development, 10 stems per plot were tagged at the pre-bloom stage, each having same number of flower buds . Clone 1 stems had 5 flower buds and the tagged stems of the other clones had 4 flower buds. The number of blossoms on each tagged stem was determined on 27 May 1999. This number and the number of fruit that subsequently developed on each stem was used to calculate average fruit set (number of blossoms developing into fruit) on the 10 tagged stems in each treatment plot. On 27 July 1999 tagged stems were cut, placed in bags and frozen for later determination of fruit set and berry maturity. The effect of Crop-Set on stage of fruit development (ripening) were evaluated by classifying the fruit as green, green pink, pink red, red blue or blue. Treatment plots were also harvested using a metal hand rake to determine plot fruit yield. Berries were frozen for later determination of fruit size (number of berries per cup).

RESULTS: Fruit set was not affected by Crop-Set (Fig. 1). Berry ripening was not affected by Crop-Set as the number of berries in each color classification was similar in control plots and plots sprayed with Crop-Set (Fig. 2). Plots were harvested on 6 August 1999 and there were no differences in yield (Fig. 3). Berry size, measured by counting the number of berries per cup, was not affected by Crop-Set (Fig. 4).

STUDY II Effect of CROP-SET applied at 0-20% bloom and at 90% petal drop

METHODOLOGY: Study II

To determine the effect of two applications of Crop-Set on yield and fruit size, 2 ft x 4ft treatment plots were established in each of four clones. Crop-Set was applied at the

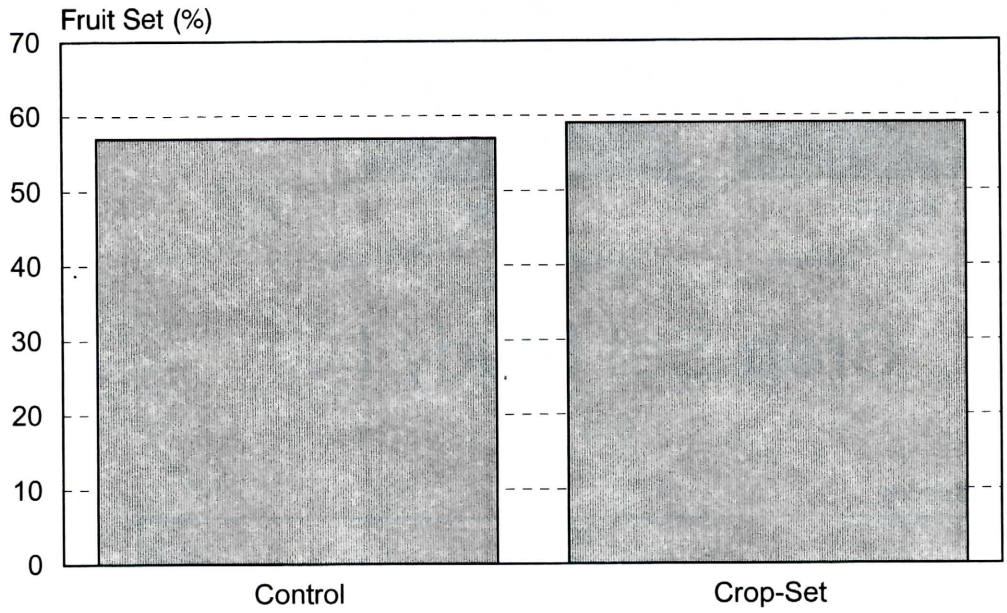
recommended rate (8oz/40gal/acre) from a single nozzle CO_2 backpack sprayer to treatment plots on 17 May 1999 and again on 1 June 1999. During spraying shields preventing drift to adjacent plots. A randomized complete block design was used with two treatments (control and CROP-SET) and four replications. Treatment plots were harvested on 6 August 1999 using a metal hand rake to determine plot fruit yield. Berries were frozen for later determination of fruit size (number of berries per cup).

RESULTS: Berry yield was not affected by Crop-Set (Fig. 5). The number of berries per cup was similar for control and Crop-Set treated plots (Fig. 6).

Figure 1

Crop-Set Study I

Fruit Set

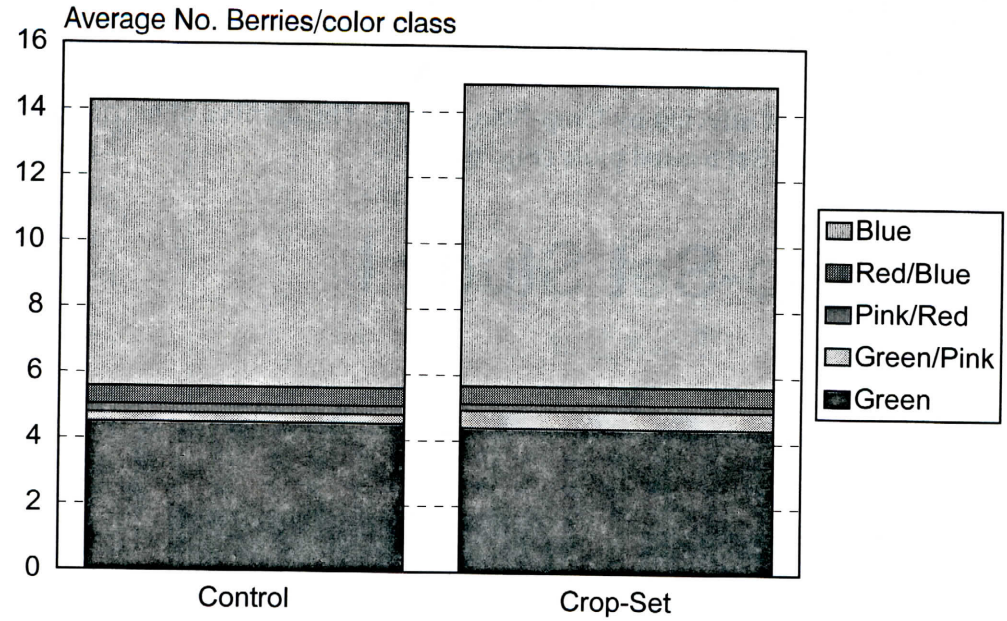


Values, averages of 4 clones, = replication/clone and 10 stems/treatment plot, are not significantly different at the 5% level. Blossoms and fruit counted 5-27-99 and 8-6-99, respectively. N = 160.

Figure 2

Crop-Set Study I

Effect on Berry Maturity

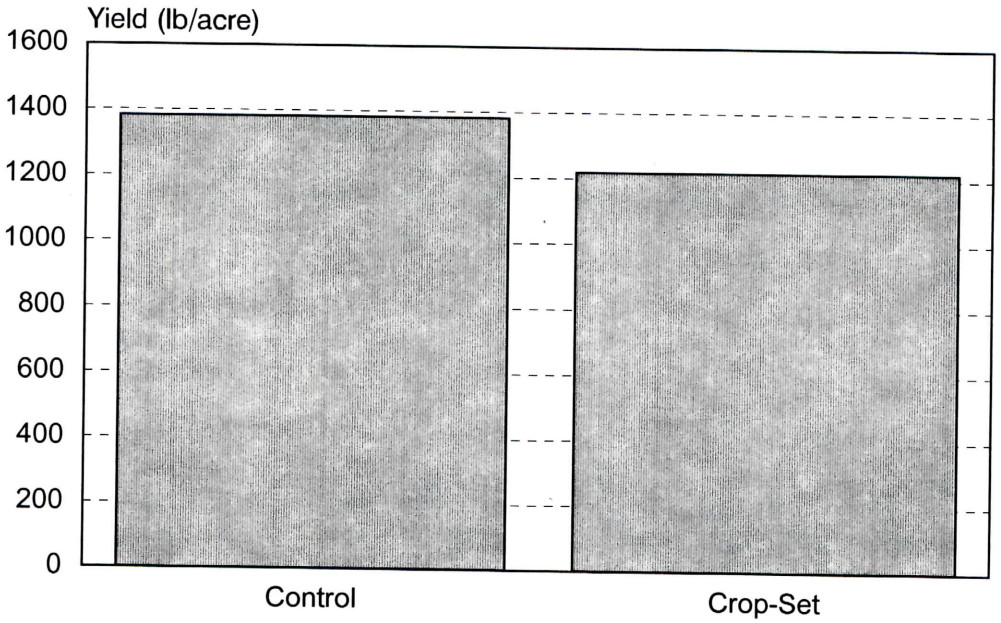


Values represent average number of fruit/stem on 10 stems in each treatment plot harvested 8-6-99. No difference in berries/stem or berries per color classification (5% level).

Figure 3

Crop-Set Study I

Yield

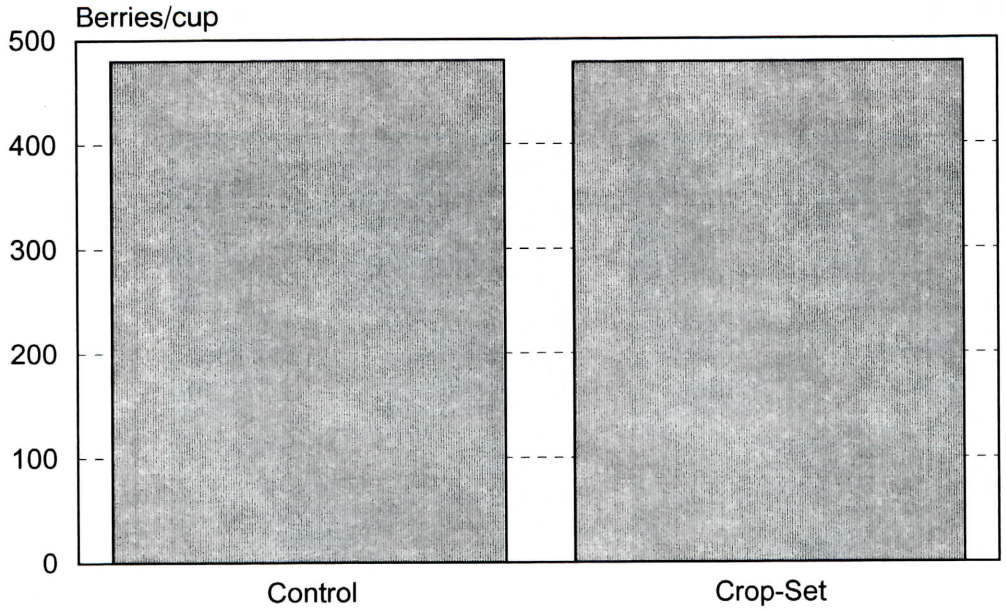


Values,average of 4 replications and 4 clones, are not significantly different at the 5 % level.

Figure 4

Crop-Set Study I

Berry Size

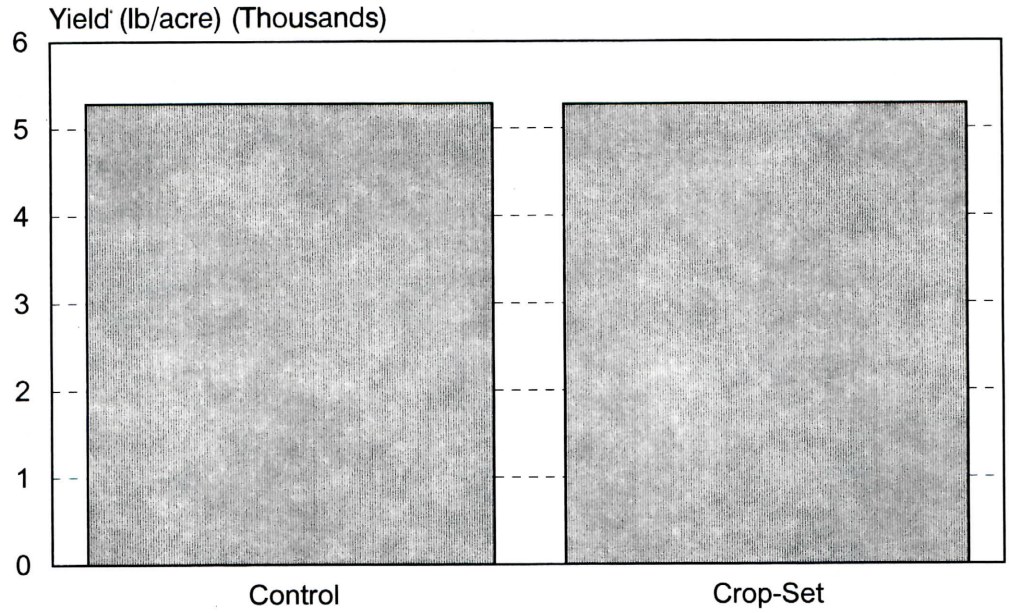


Values,average of 4 replications and 4 clones, are not significantly different at the 5 % level.

Figure 5

Crop-Set Study II

Yield

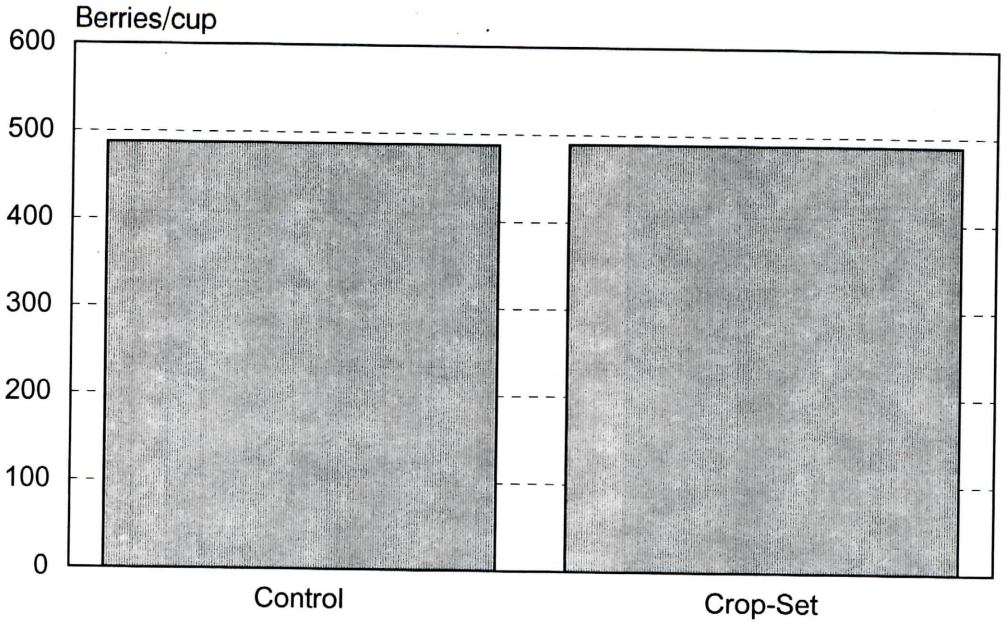


Values,average of 4 replications and 4 clones, are not significantly different at the 5 % level.

Figure 6

Crop-Set Study II

Berry Size



Values average of 4 replications and 4 clones, are not significantly different at the 5 % level.

PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Walter Litten, Faculty Associate

6. TITLE: Crop year fertilization of lowbush blueberry

OBJECTIVES: To determine the effect of crop-year fertilization on plant growth and yield.

METHODS: A commercial lowbush blueberry field that was sampled by the grower in 1995 and found deficient in P and N was used in this study. To determine if crop-year fertilization is a feasible alternative to prune-year fertilization, diammonium phosphate (DAP) with and without Zn was applied to 5 ft by 50 ft treatment plots in the following treatments:

1. Control
2. 80 lbs P from DAP plus 3 lbs Zn/acre, applied spring 1997 (prune year)
3. 80 lbs P from DAP plus 3 lbs Zn/acre, applied spring 1998 (crop year)
4. 40 lbs P from DAP plus 1.5 lbs Zn/acre, applied spring 1997 (prune year) and 40 lbs P from DAP plus 1.5 lbs Zn/acre, applied spring 1998 (crop year).
5. 80 lbs P from DAP, applied spring 1997 (prune year)

A randomized complete block design with 9 replications was used. Leaf samples were taken July 11, 1997 and again on July 2, 1998 to assess correction of leaf nutrient deficiencies. Stem samples were taken (three 1/3 sq. ft. quadrats/plot) on October 7 and 8, 1997 to evaluate treatment effects on plant growth and potential yield. Berry yield was taken in August 1998 to determine the effect of treatments on crop productivity.

RESULTS: In 1997, leaf N concentrations were increased by prune-year applications of DAP or DAP plus Zn, compared to the control (Fig. 1). The half rate (40 lbs P/acre) was as effective as the full rate (80 lbs P/acre) for the DAP plus Zn treatments.

Leaf P concentrations showed a response to fertilizer treatments similar to that of leaf N concentrations; concentrations were raised above controls to the same extent by DAP, DAP plus Zn, and the half rate DAP plus Zn (Fig. 2).

Although K was not contained in the applied fertilizer, leaf K concentrations were raised by the DAP and DAP plus Zn treatments (Fig. 3). Prune-year DAP plus Zn treatment also raised leaf Fe concentrations (Fig. 4). However, leaf Mg concentrations were depressed by all our prune-year treatments (Fig. 5), but not below the 0.13% standard.

Soil-applied $ZnSO_4$ at 3 lb Zn/acre raised leaf Zn concentration only if applied with DAP in the prune year (Fig. 6). This supports the findings in the zinc study that application of $ZnSO_4$ at 3 lb Zn/acre did not raise leaf Zn concentrations .

Analysis of 1998 leaf samples indicates that fertilizing with DAP plus Zn the crop year or the split application of DAP plus Zn between the prune and crop year raised leaf N concentrations, compared to the controls or the prune year fertilizer treatments (Fig. 7). Similarly, leaf P concentrations were highest for these same crop-year treatments, but leaf P concentrations were also higher in samples taken from plots receiving DAP or DAP plus Zn the

prune year (Fig. 8). Leaf K concentrations were not significantly higher in fertilized plots compared to the controls in the 1998 leaf samples (Fig.9). Leaf Fe concentrations were raised in treatment plots receiving in the crop year 80 lbs P/acre from DAP plus 3.0 lbs Zn/acre but not the split-application treatment in which only 40 lbs P/acre and 1.5 lbs Zn/acre was applied in 1998, the crop year (Fig.10). Similarly to the findings in 1997 leaf samples, leaf Mg was depressed by the full rate of DAP applied the crop year but not by the split application (Fig. 11). Leaf Zn concentrations were not affected by any of the treatments (Fig. 12).

Soil samples taken in July 1997 and 1998 indicated no significant increase in extractable P in treatment plots receiving fertilizer treatments, compared to the controls (Fig. 13). Soil Zn concentrations showed no significant increase due to fertilizer treatments in 1997, but in 1998 higher levels of soil Zn were found in plots fertilized with DAP plus 3.0 lbs Zn/acre in the prune year compared to the controls (Fig. 14).

Stems sampled in treatment plots in the fall 1997 were taller and more branched due to prune-year fertilizer treatments, compared to the controls or those plots that would receive only crop-year fertilization (Fig. 15). A prune-year application of 80 lbs P/acre from DAP with or without Zn increased stem length and branching more than the split application treatment in which only 40 lbs P/acre and 1.5 lbs Zn/acre was applied the prune year. However, flower bud formation was not increased by any of the fertilizer treatments, compared to the controls (Fig. 16).

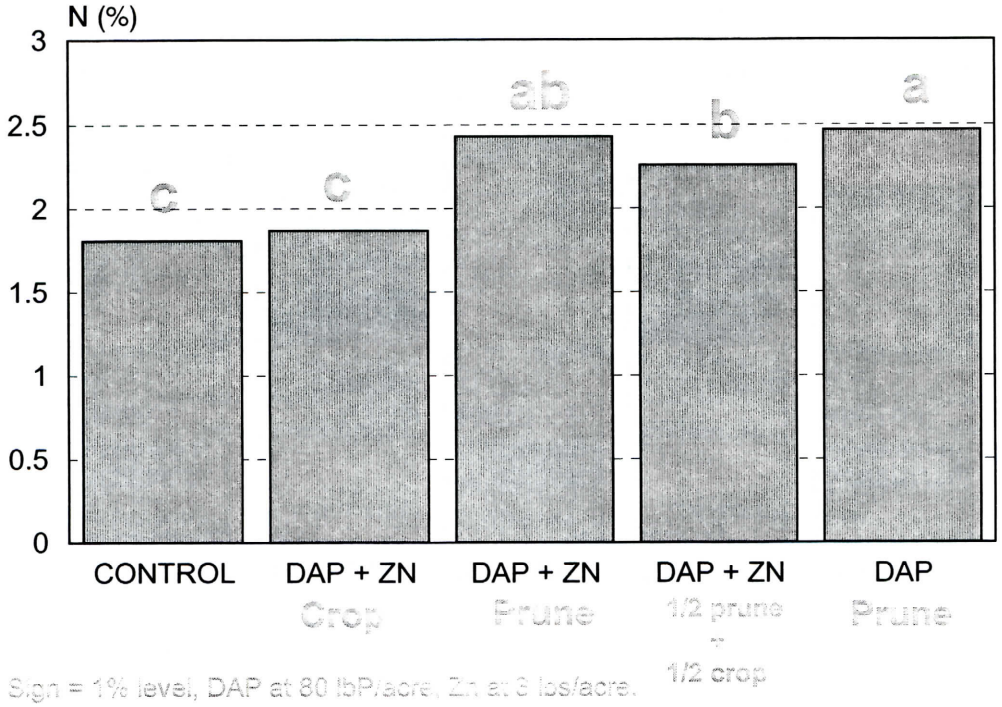
Although there was an average yield differential of about 1,500 lbs/acre between some of the treatments and the control, there was no statistical difference (Fig. 17). This implies great variation in yield among plots.

CONCLUSIONS: Since prune year applications of DAP did not increase yields it is difficult to draw conclusions about the effect of crop-year fertilization and split-year fertilizer applications on yield. The heavy soil, representative of this blueberry production area, held adequate N and P for growth during the 1997 prune year; the leaf concentrations of these two elements were above the standards in leaf samples taken from control plots. Fertilization the prune year did increase stem length and branching but not flower bud formation. Additional fertilizer did not increase yields, lending support to the leaf nutrient concentration standards.

RECOMMENDATIONS: No recommendations can made at this time regarding crop year fertilization. This study should be repeated in another field in which N and P are deficient.

Figure 1 Crop Year Fertilization Study

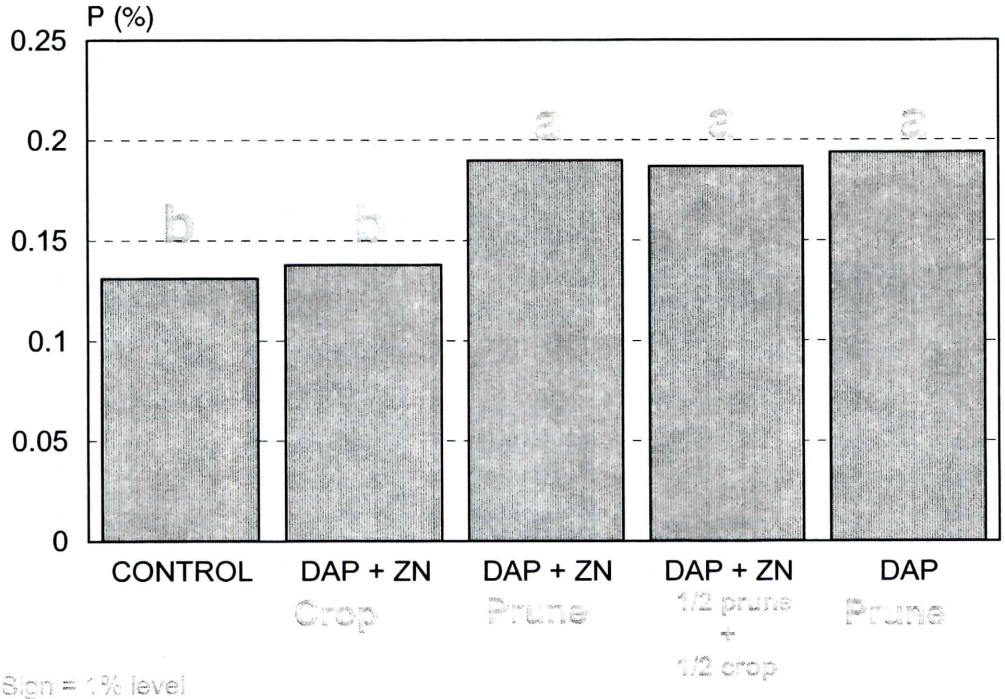
1997 Leaf Nitrogen



Sign = 1% level, DAP at 80 lbP/acre, Zn at 3 lbs/acre.

Figure 2 Crop Year Fertilization Study

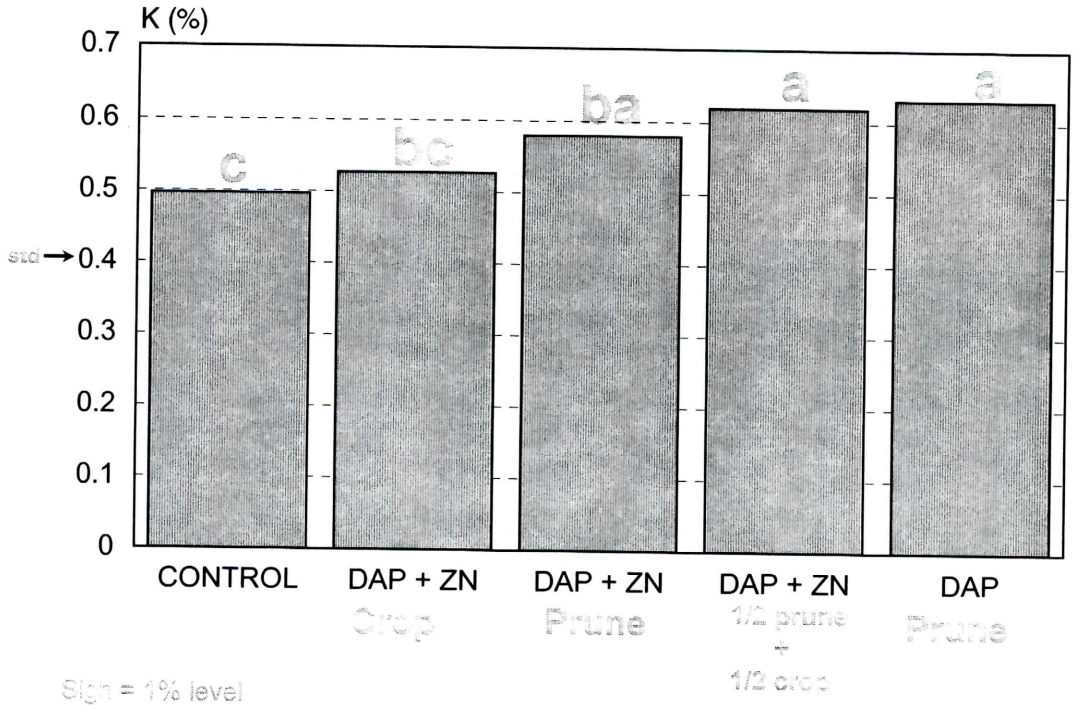
1997 Leaf Phosphorus



Sign = 1% level

Figure 3 Crop Year Fertilization Study

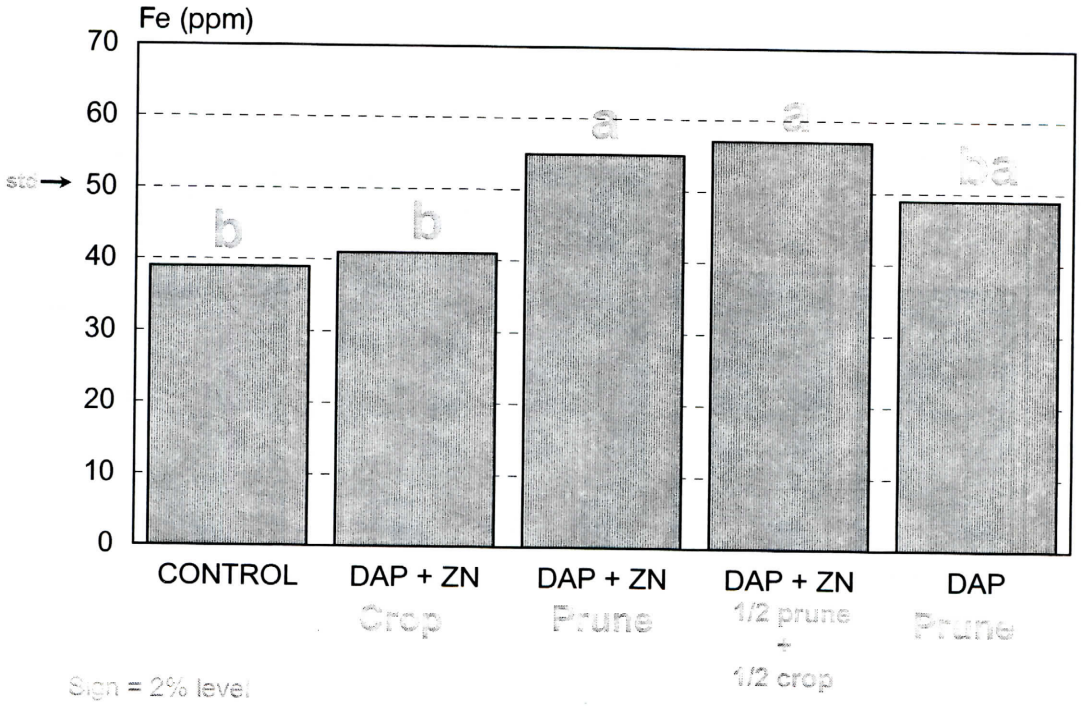
1997 Leaf Potassium



Sign = 1% level

Figure 4 Crop Year Fertilization Study

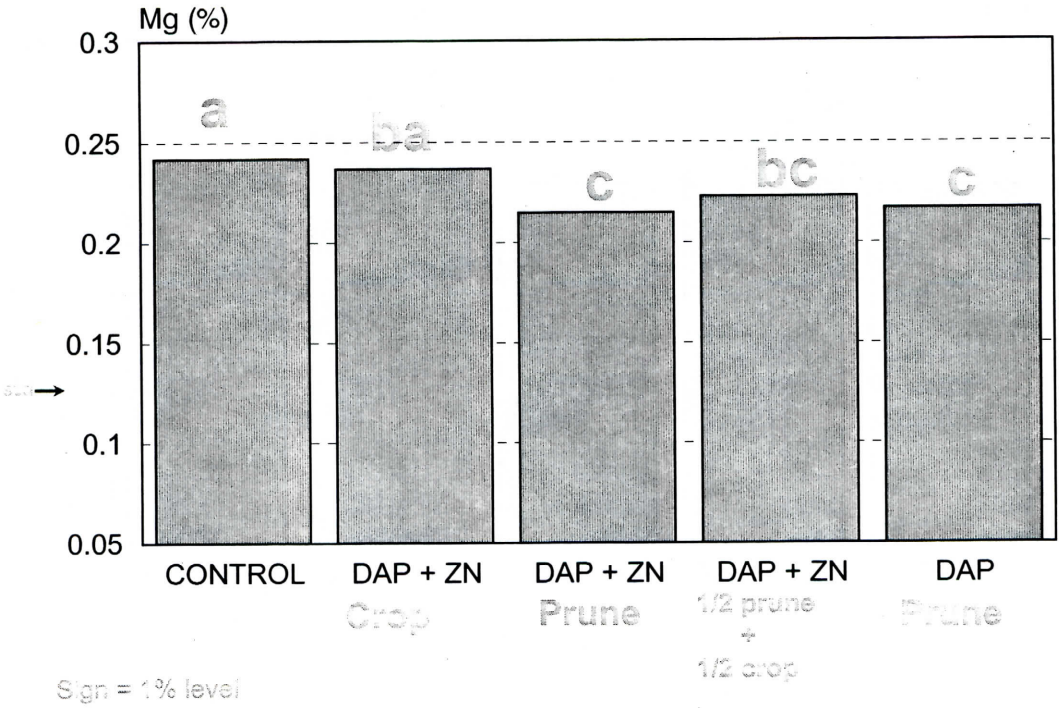
1997 Leaf Iron



Sign = 2% level

Figure 5 Crop Year Fertilization Study

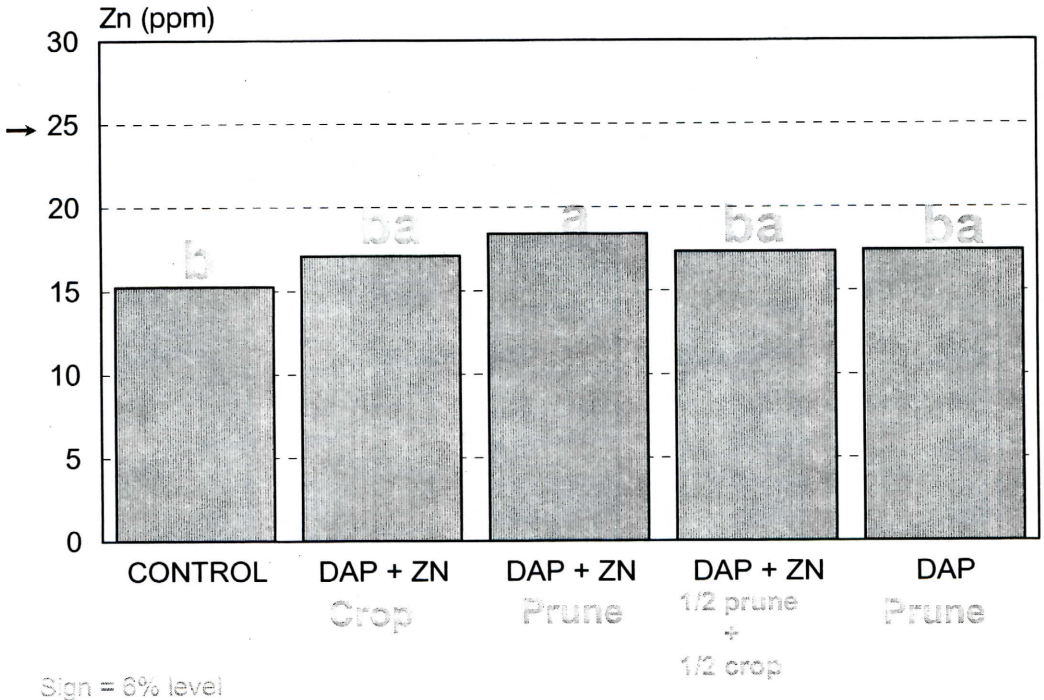
1997 Leaf Magnesium



Sign = 1% level

Figure 6 Crop Year Fertilization Study

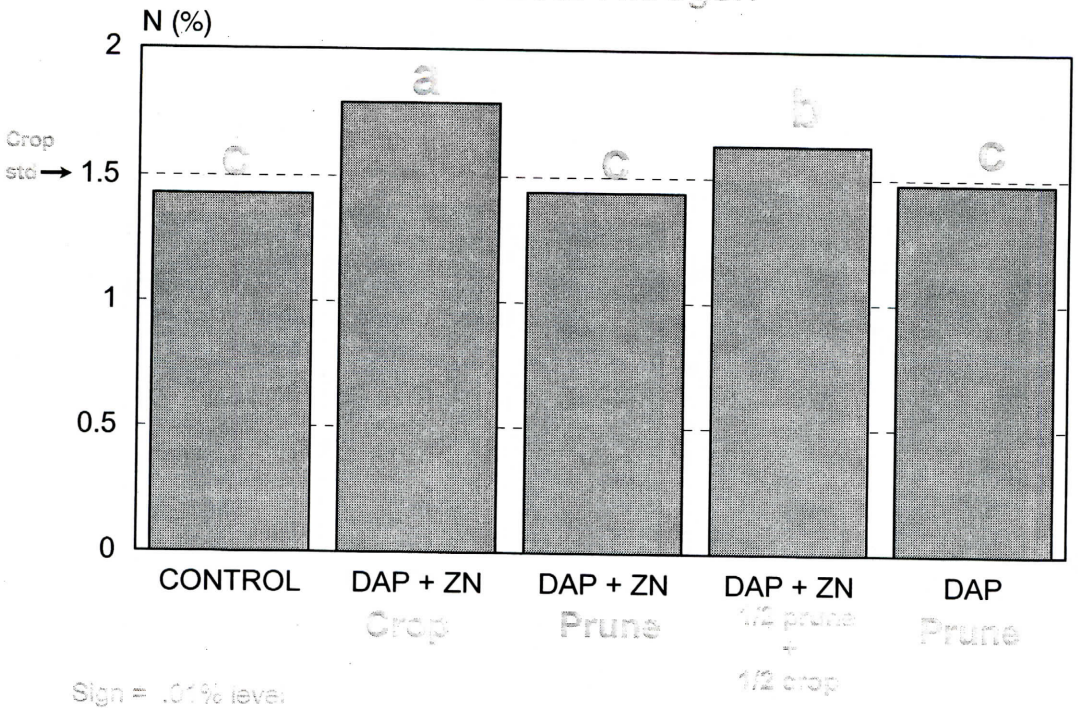
1997 Leaf Zinc



Sign = 6% level

Figure 7 Crop Year Fertilization Study

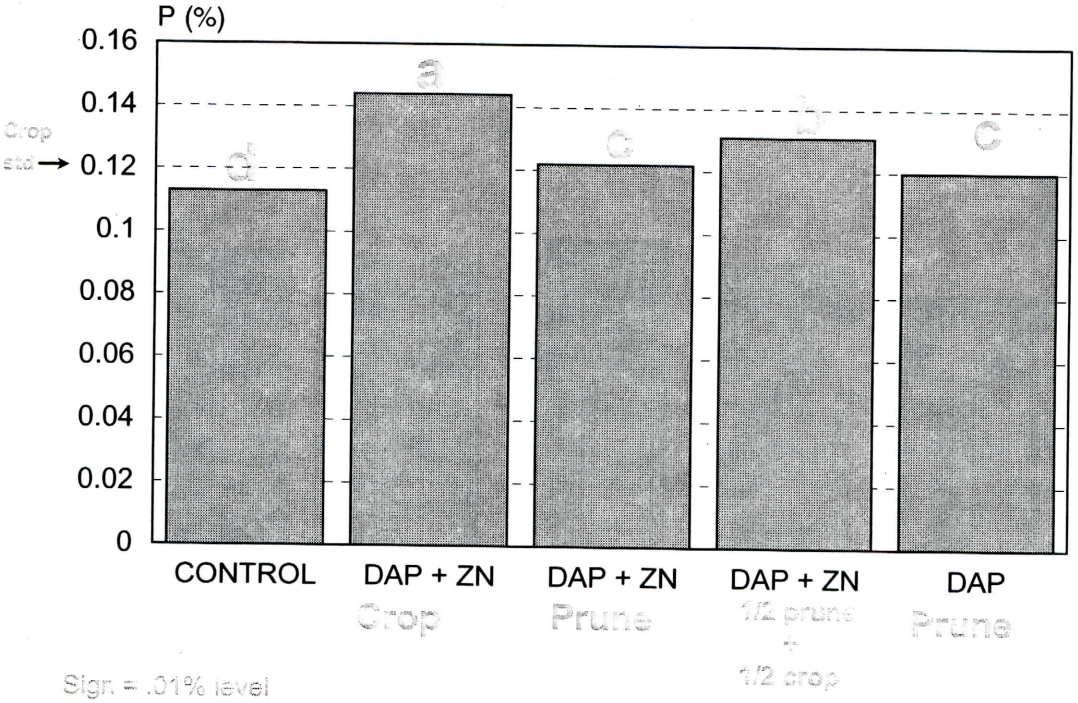
1998 Leaf Nitrogen



Sign = .01% level

Figure 8 Crop Year Fertilization Study

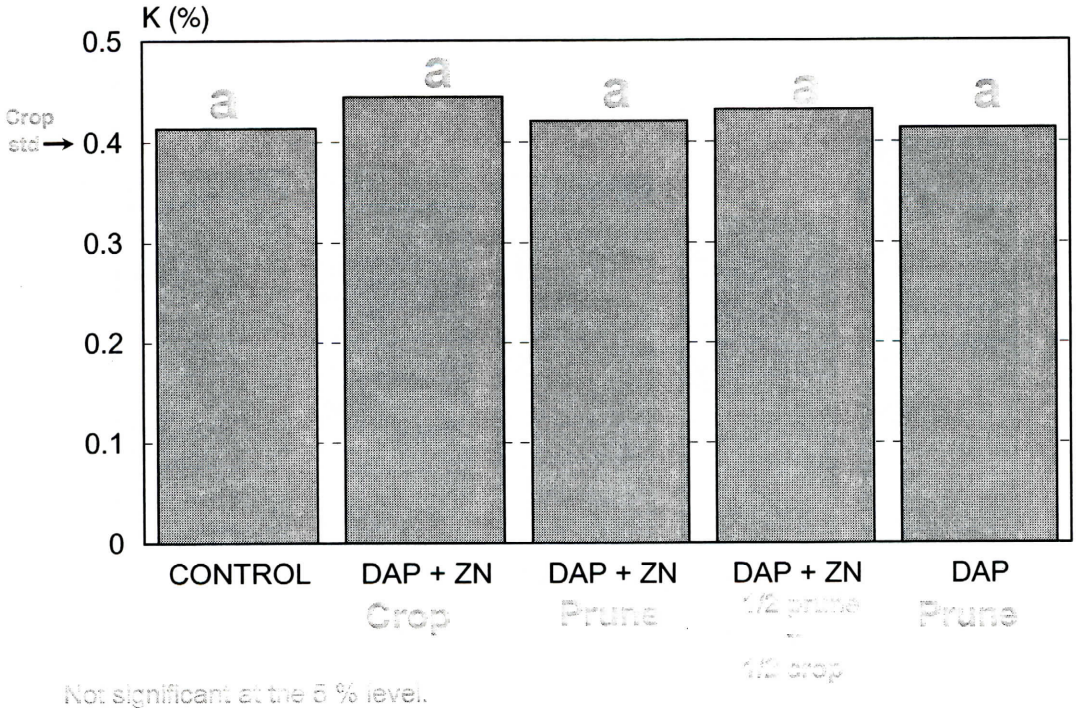
1998 Leaf Phosphorus



Sign = .01% level

Figure 9 Crop Year Fertilization Study

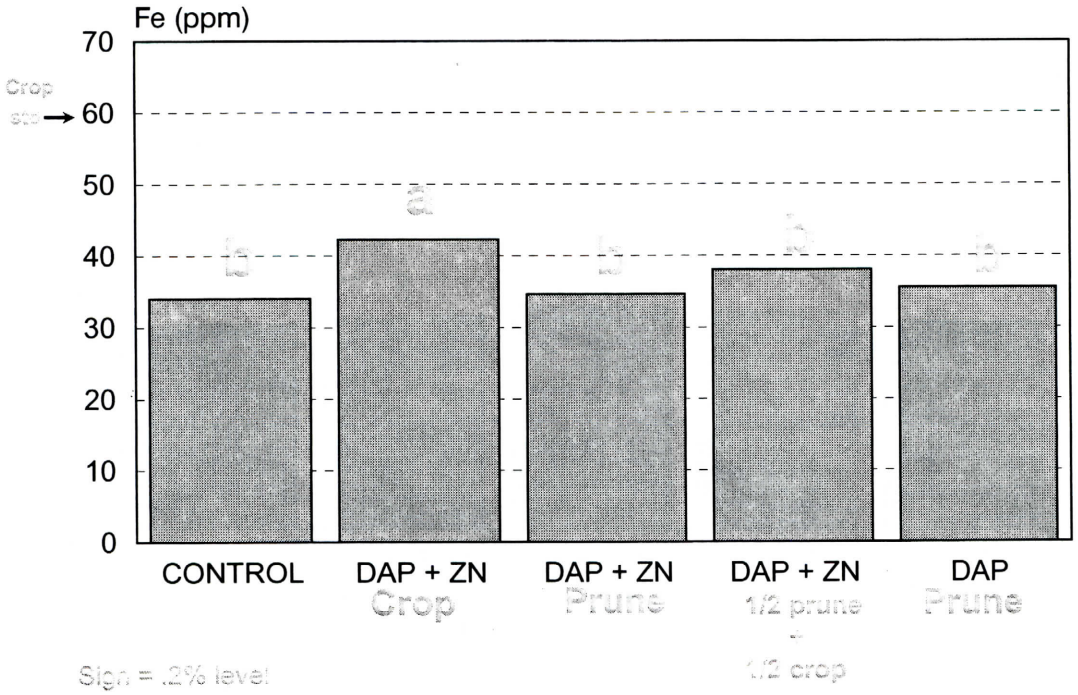
1998 Leaf Potassium



Not significant at the 5 % level.

Figure 10 Crop Year Fertilization Study

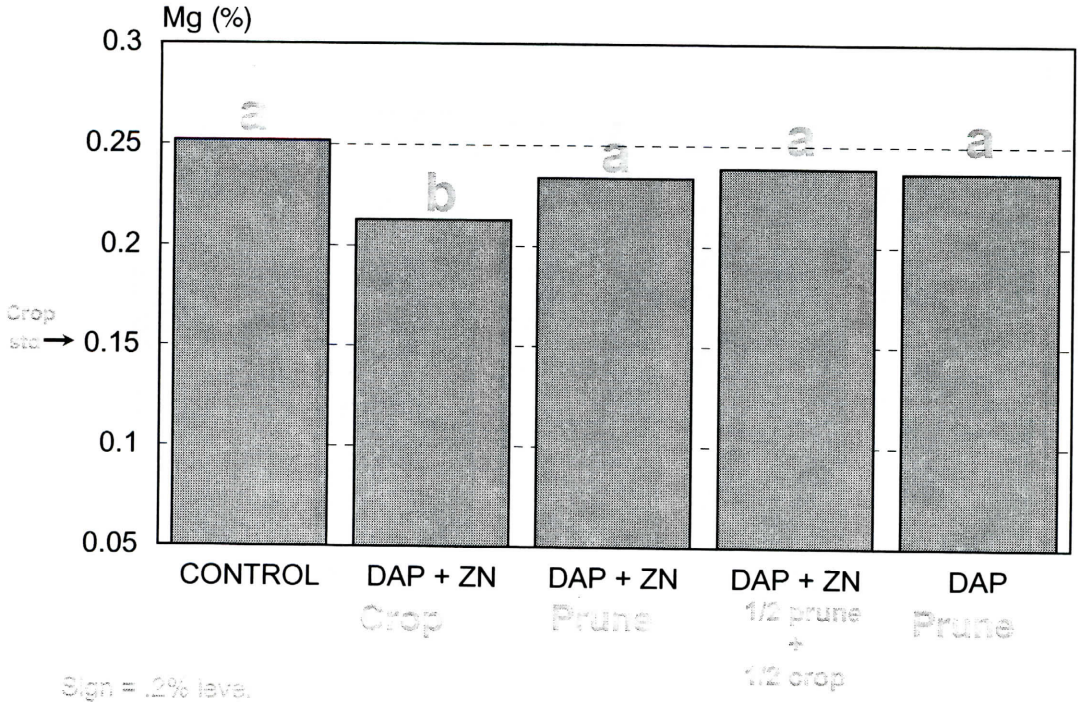
1998 Leaf Iron



Sign = .2% level

Figure 11 Crop Year Fertilization Study

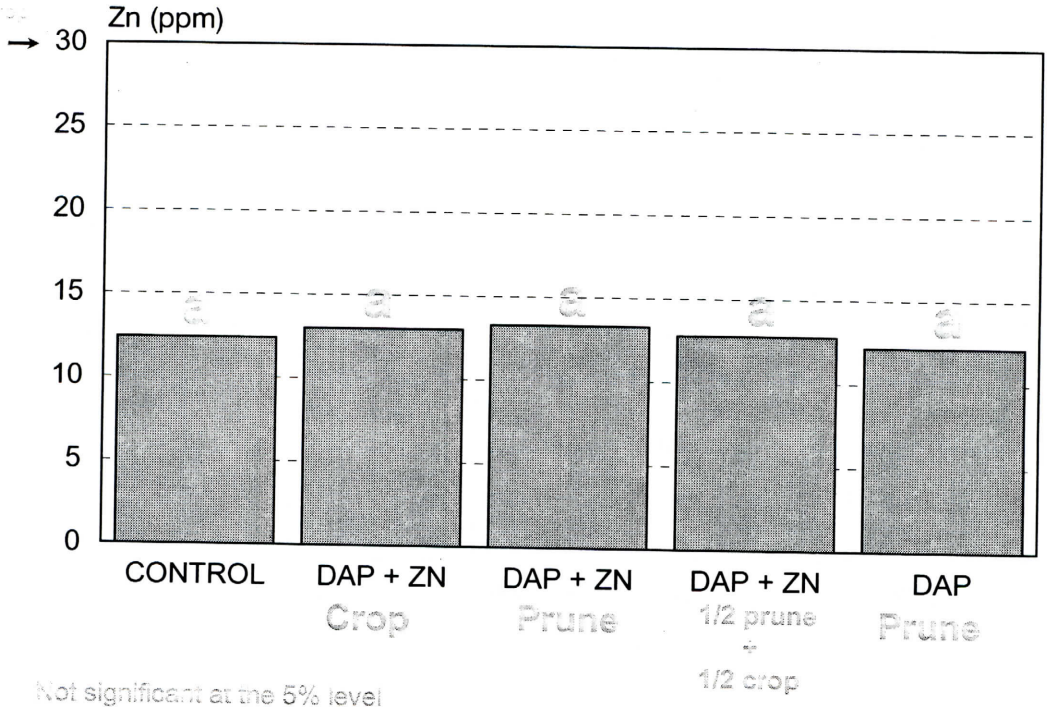
1998 Leaf Magnesium



Sign = .2% leve.

Figure 12 Crop Year Fertilization Study

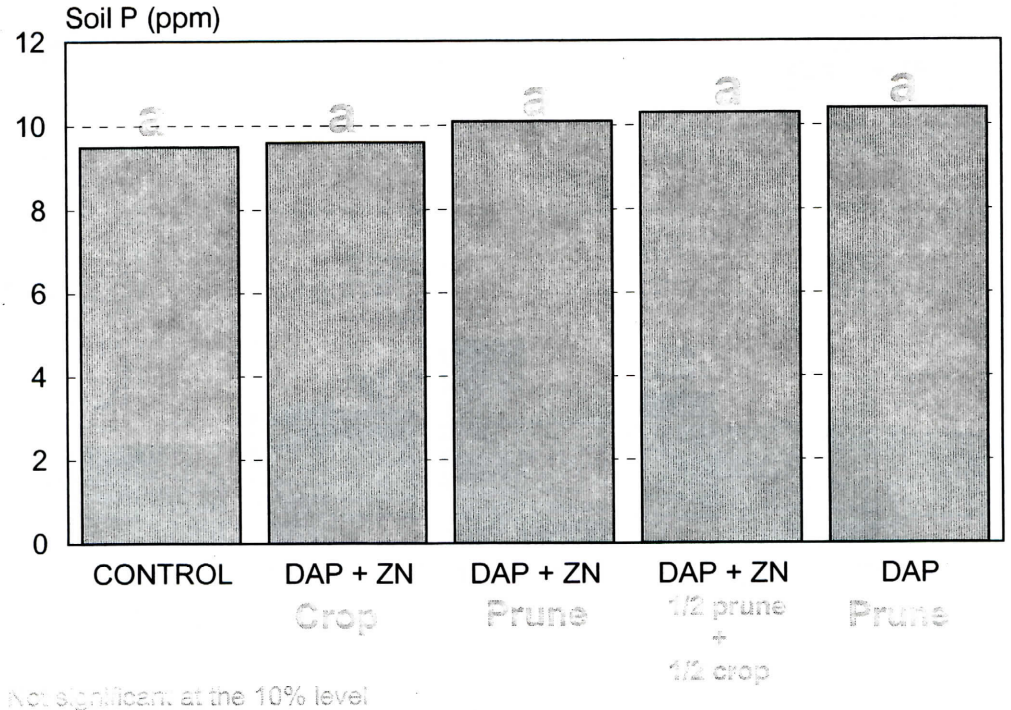
1998 Leaf Zinc



Not significant at the 5% level

Figure 13 Crop Year Fertilization Study

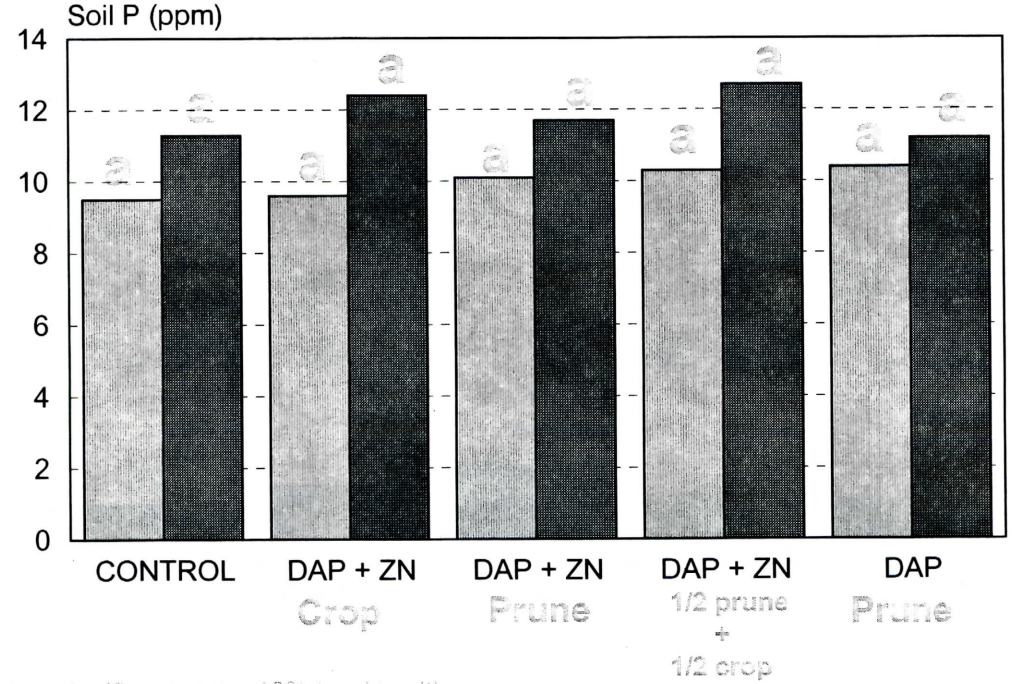
1997 Soil Phosphorus



Not significant at the 10% level

Figure 13 Crop Year Fertilization Study

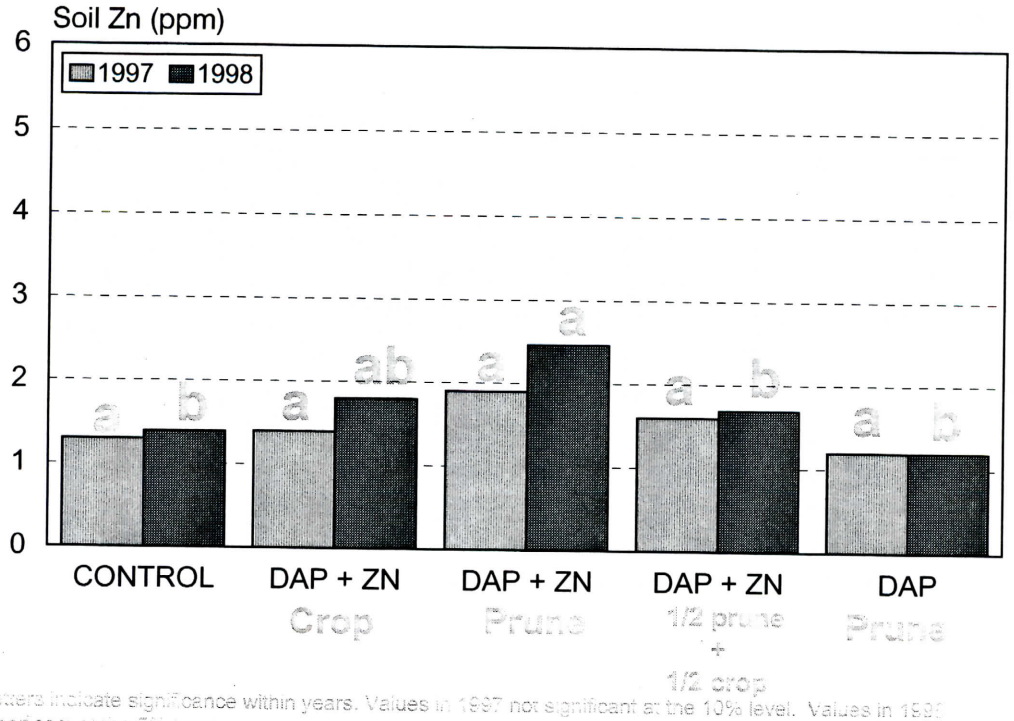
1997 and 1998 Soil Phosphorus



Not significant at the 10% level in either year.

Figure 14 Crop Year Fertilization Study

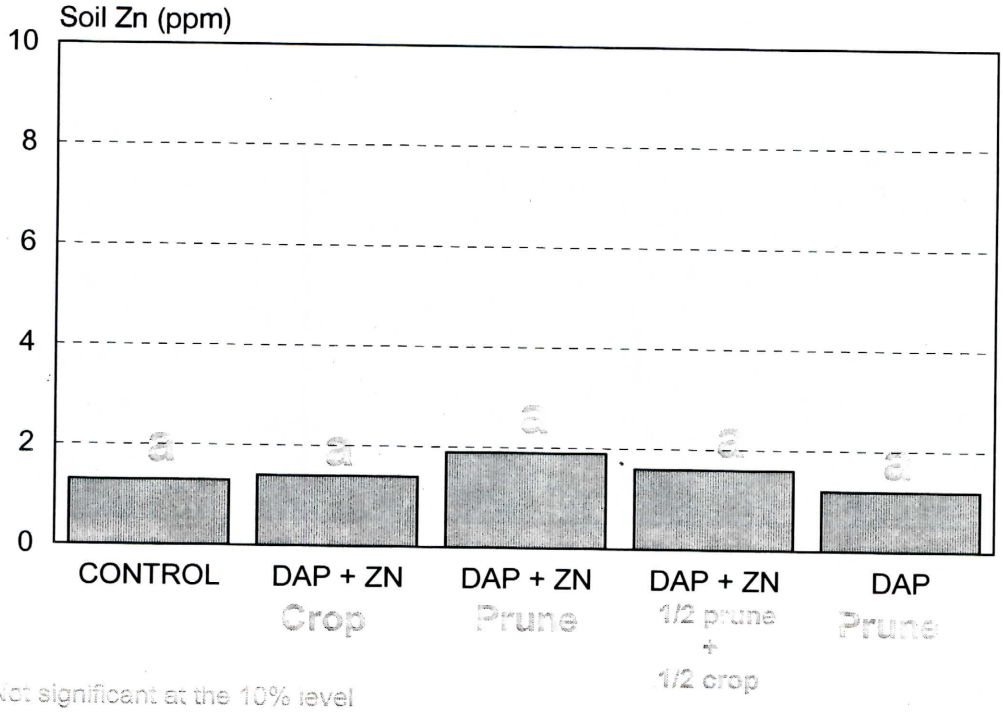
1997and 1998 Soil Zinc



Letters indicate significance within years. Values in 1997 not significant at the 10% level. Values in 1998 significant at the 5% level.

Figure 14a Crop Year Fertilization Study

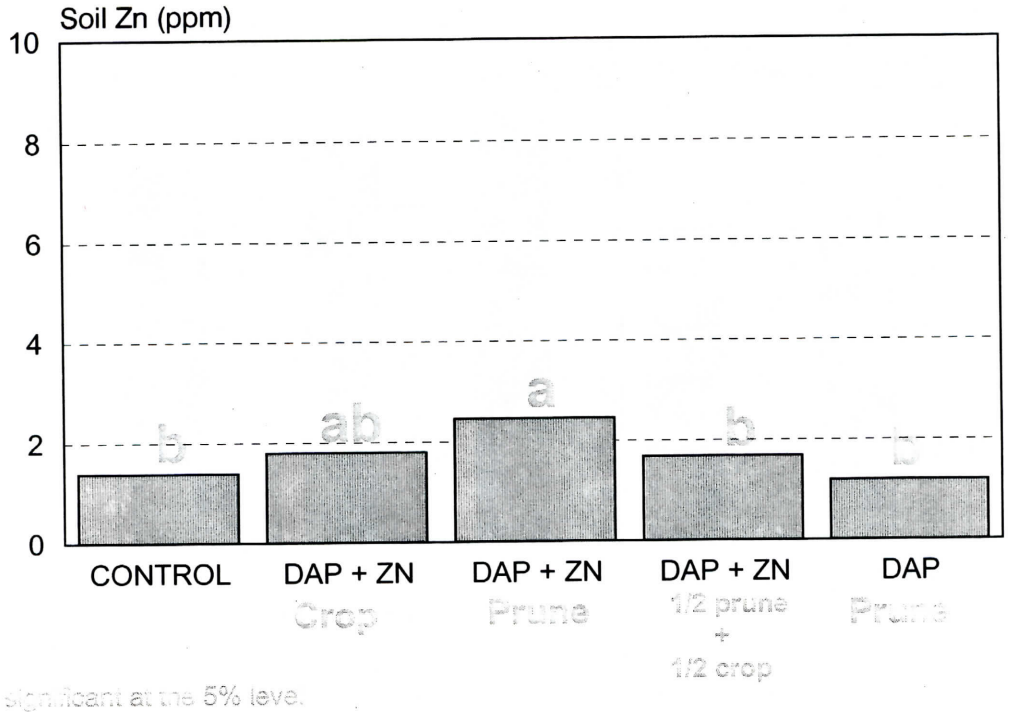
1997 Soil Zinc



Not significant at the 10% level

Figure 14b Crop Year Fertilization Study

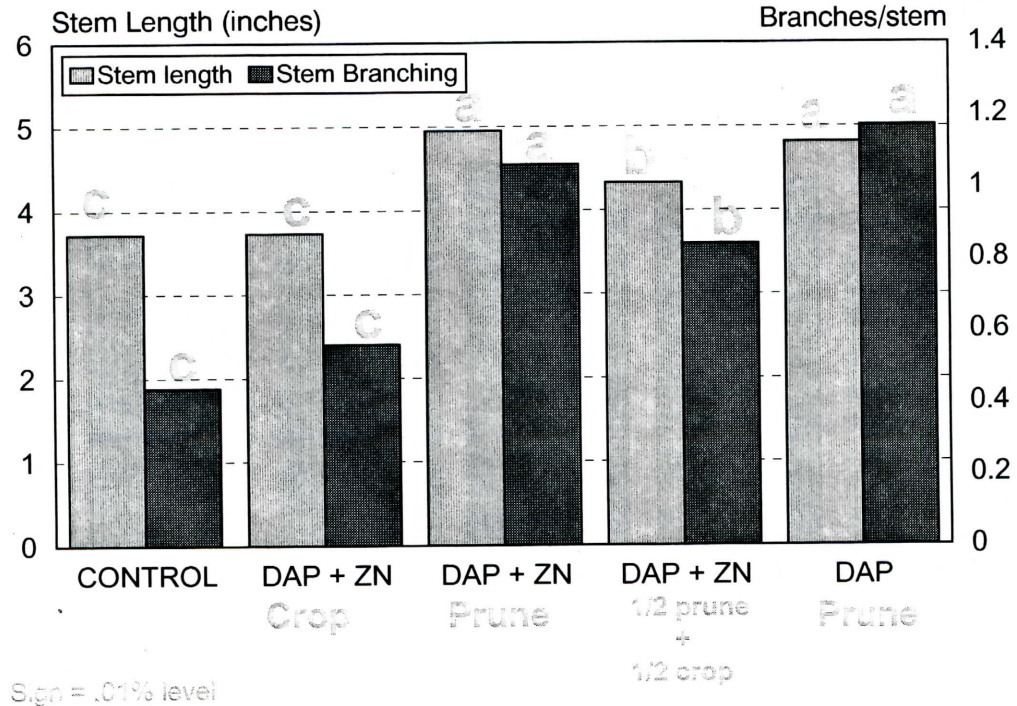
1998 Soil Zinc



significant at the 5% level.

Figure 15 Crop Year Fertilization Study

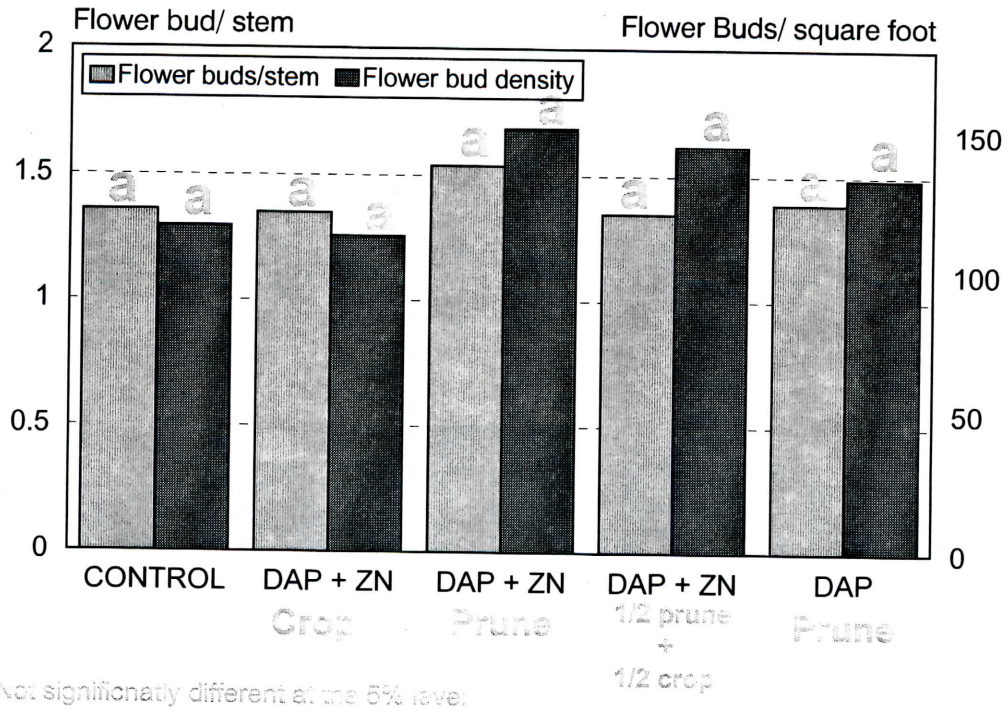
1997 Stem Characteristics



Sign = .01% level

Figure 16 Crop Year Fertilization Study

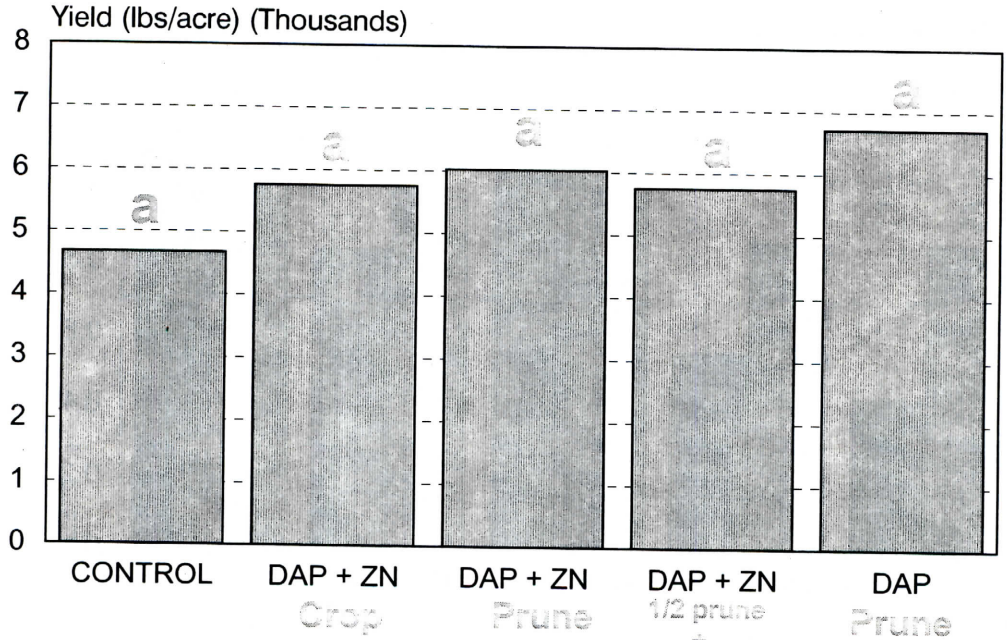
1997 Flower Bud Characteristics



Not significnatly different at the 5% level

Figure 17 Crop Year Fertilization Study

1998 Yield



Not significant at the 5% level

WEED MANAGEMENT AND FIELD COVER

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

1. TITLE: Alternative Methods of Grass Control.

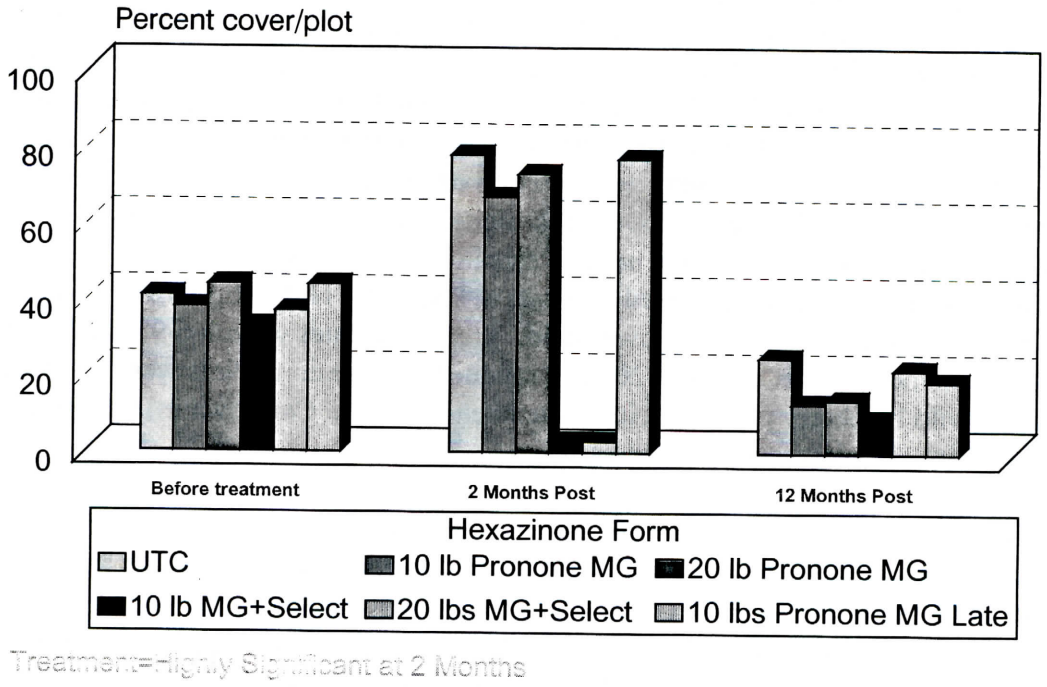
METHODS: An experiment was conducted in spring 1998 at Guptill's Blueberry Farm in Wesley, ME on mowed and burned, 12' X 40' plots to assess different control methods for late emerging grasses. Treatments included preemergence Velpar DF® at 1.3 lb product/a for all plots except an untreated control and either Pronone MG® at 10 or 20 lbs product/a in mid June (6-22-98); Pronone MG® at 10 or 20 lbs product/a in mid June plus clethodim (8-5-98), a grass-specific, postemergence herbicide, at 6 or 8 oz product/a; or a later, mid July (7-19-98), application of 10 lb product/a Pronone MG® alone. Efficacy was assessed in mid August 1998 and again in June 1999. Plots were not harvested.
Trial was repeated at another, mowed only site at Blueberry Hill Farm (BBHF) with heavy grass pressure in section 12 in the lower field. Treatment dates were 7-6-98 for Pronone® and 7-7-98 for clethodim plus a later, 7-20-98, Pronone® application. Plots were assessed for weed cover and wild blueberry phytotoxicity September 10, 1998. Carryover effects were evaluated June 29, 1999 and plots were not harvested.

RESULTS: For both sites the best grass suppression was achieved with the postemergence clethodim applications regardless of Pronone® application. The Wesley site assessments taken in June 1999 were not useable because of a major washout in the middle of the plots. This may have been due to a heaving of blueberry rhizomes the previous winter. For the BBHF site, efficacy rating assessed in September 1998 indicated postemergence grass treatments had best control of grasses, with Pronone® alone treatments applied early or late not different from untreated plots. One year later all plots had a reduction in grass cover (Figure 1).

CONCLUSION: Applications of Pronone® applied early or late will not control grasses. Postemergence treatment of grasses, with clethodim, sethoxydim, or fluazifop-p-butyl remains the best control measure for theses late emerging weeds

RECOMMENDATIONS: Continue stressing to growers the importance of keeping grass weeds under control with these postemergence materials, and pursue evaluating pendimethalin, a preemergence, grass specific herbicide for control of these late germinating grasses.

Figure 1. Effect of Treatment on Grass Cover at 2 and 12 Months Post Treatment-BBHF



Treatment=Highly Significant at 2 Months

WEED MANAGEMENT AND FIELD COVER

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

2. TITLE: Cultural Weed Management Using pH.

METHODS: After field sites have been identified in Spring 2000, a two-factor, split-block plot design will be used with pH levels adjusted to >5.0, 4.5, or <4.5 with granular sulfur and with hexazinone applied in strips at right angles at 0, 0.5, or 1 lb ai/a every other year. Weed and wild blueberry cover will be ascertained at establishment and determined each year. Wild blueberry yield will be taken every production year.

RESULTS: None at this time.

RECOMMENDATION: Continue with this first phase of trial.

CONCLUSION: None can be made at this time.

E. WEED MANAGEMENT AND FIELD COVER

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

3. TITLE: Investigation of Hexazinone Alternatives for Weed Control.

METHODS: Several new compounds were identified as potential weed control materials and tested this spring for use in wild blueberries.

Azafenidin-A trial was initiated in April 1998 in sections 6 & 7, lower field at BBHF, Jonesboro, ME. Two blocks with 6' by 90' plots were treated preemergence on 5-1-98 at 5, 10, 15 or 20 oz product/a. Additional treatments applied 5-16-98 included 5 oz/a azafenidin +Velpar DF® 1.3 lb/a, 10 oz /a azafenidin +Velpar DF® 1.3 lb/a, 10 oz/a azafenidin + Velpar DF® 2.6 lb/a, 30 oz /a azafenidin alone and an untreated control. Cover assessments were made one and two months post treatment. Stems were cut October 5, 1998 and measured for stem and bud number and stem length. Carryover effects were assessed in June 1999 and plots harvested in August 1999.

Another trial was initiated in the fall of 1998 to compare fall/spring applications. Azafenidin was applied at 0, 10 or 15 oz product/a on 10-26-98 with the spring application on 5-17-99 to 12'X40' plots in section 2, BBHF. In addition, one half of each plot received 1 lb ai/a hexazinone on 5-14-99. Weed cover was first assessed in late June 1999.

A final trial, with 6'X40' completely randomized plots sprayed 5-7-99 with the same rates, was conducted at Gordon Scott's field in Waldoboro to see if different soil properties affected herbicide activity. Carryover effects were evaluated 1 and 2 months post treatment

Rimsulfuron-Sixteen, 6' by 15' plots were established and treated with 0, 0.5, 1 or 2 oz product/a preemergence on May 14, 1998 in section 6, lower field, BBHF. Evaluations were assessed one and two months post treatment. Stems were cut October 5, 1998 and measured for bud and stem number and stem length. Carryover effects were conducted in June and plots harvested in August of 1999.

Another fall/spring trial, similar to the azafenidin trial above, was applied on 10-26-98 and 5-12-99 with 0 ,1 or 2 oz product/a to 6'X40' plots in section 1, BBHF. Weed cover was observed 1 and 2 months post spring treatment.

A spring only trial, with 6'X40' plot size and same rates, was conducted at Gordon Scott's in Waldoboro and was sprayed 5-7-99 with weed cover assessed 1 and 2 months post treatment.

Rimsulfuron is also registered in potatoes for postemergence weed control so a trial was established to evaluate a postemergence spray at the above rates on 6-18-99 in section 6, upper field at BBHF to an area with heavy dogbane cover in order to assess its effect on dogbane and wild blueberries. Carryover effects were taken 1 and 2 months post treatment.

Pendimethalin-A trial with this preemergence, grass specific herbicide was established and treated on 5-8-98 at 5 rates to 20 completely randomized, 6' by 50' plots in two blocks in sections 9 & 10, lower field, BBHF. Rates applied were 0, 2.4, 4.8, 9.6 or 19.4 pts product/a with 4 replications. Phytotoxicity to weeds and wild blueberries was conducted one and two months post treatment and stems were cut in October 1998 and measured for bud number and stem length and number. Carryover effects were assessed in June and plots harvested in August 19, 1999.

A fall application was made in late September at the same rates to 12' X 40' plots in section 7, upper field, BBHF. Weed cover was assessed in July 2, 1999.
Another, spring trial was treated with the same rates on 5-27-99 to an area with heavy grass pressure in section 1, upper field, at BBHF to 6' X 40' completely randomized plots and replicated 6 times. Carryover effects were taken 1 and 2 months post treatment.
A final, 6'X40' completely randomized trial was established at Molly Sholes in West Rockport and was sprayed 5-13-99 with the same rates. Weed numbers were assessed 1 and 2 months post treatment.

RESULTS: **Azafenidin-**Treatment above 5 oz/a provided excellent weed control but residual control was better when mixed with Velpar®. Blueberry yields from the initial 1998 trial were not affected by treatment up to 30 oz product/acre(Figure 1). The fall 1998/spring 1999 trial had no significant effect of rate or timing of application on weed cover or wild blueberry phytotoxicity. The trial in Waldoboro had significantly better weed control with treatment from azafenidin than from hexazinone, which may due to an earlier application date (5-7-99 vs 5-17-99) (Figure 2). After one month, wild blueberry cover was significantly reduced due to azafenidin treatments stunting the plants but recovered after two months (Figure 3).

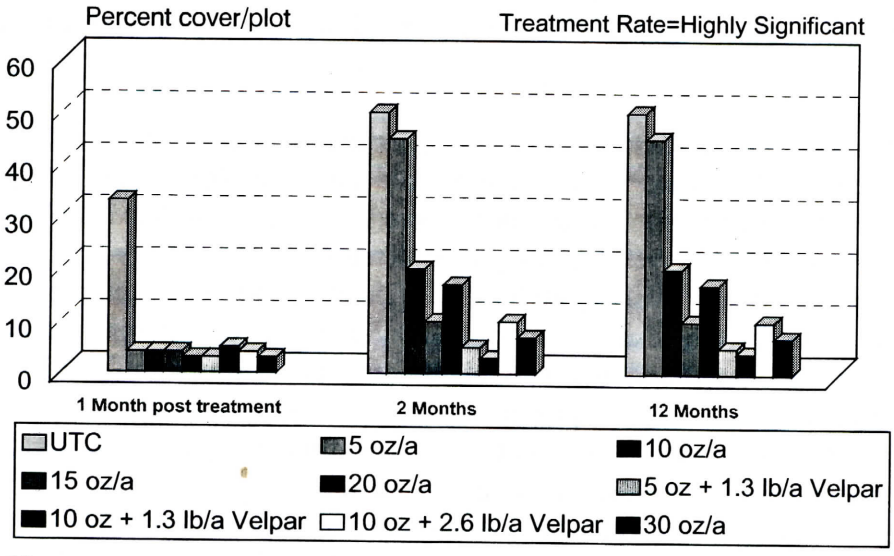
Rimsulfuron-Yields from 1998 trial were unaffected by treatment (Figure 5). Treatment had a significant effect on increasing stem bud number but that did not transfer to greater yields(Figure 4). As with azafenidin, the fall/spring trial had no effect on weed populations. The postemergence application also had no effect on the dogbane or on wild blueberry phytotoxicity.

No treatment effect from **pendimethalin** was seen on blueberry stem number, length or buds. Blueberry yields were inconsistent with treatment rate but the 2.4 and 4.8 pint rate had the highest yield and the 9.6 pint rate the lowest (Figure 6). Neither the fall 1998 or spring 1999 applications had any effect on weed numbers or wild blueberry phytotoxicity. In addition, the trial in West Rockport had no significant effect on weed control, which may have been due to either a later treatment date or insufficient weed population present for any control to have an effect.

CONCLUSION: These herbicides provide weed control of species not controlled with Velpar or Pronone without significant injury to wild blueberries plants. The applications made this spring were affected by lack of rainfall, since rain is required to move the materials into the soil before herbicidal activity can take place. Postemergence applications of rimsulfuron also remain a possibility since no phytotoxic effects to blueberries was observed.

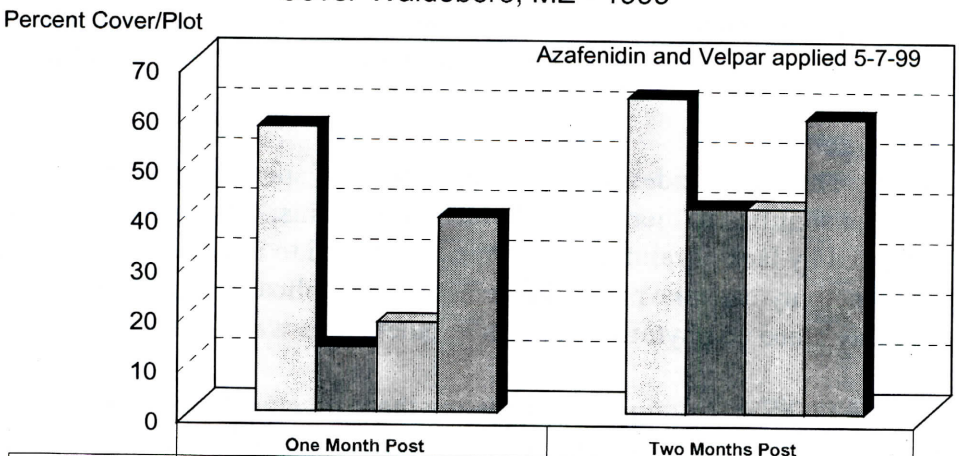
RECOMMENDATIONS: Continue investigating these preemergence applications with different timings, including early dates to accommodate the need for rainfall. Continue with postemergence applications of rimsulfuron at higher rates on different weeds to ascertain any selectivity it may have on weeds growing among wild. blueberries.

Figure 1. Effect of Azafenidin
on Weeds - 1998



All rates are in product/acre

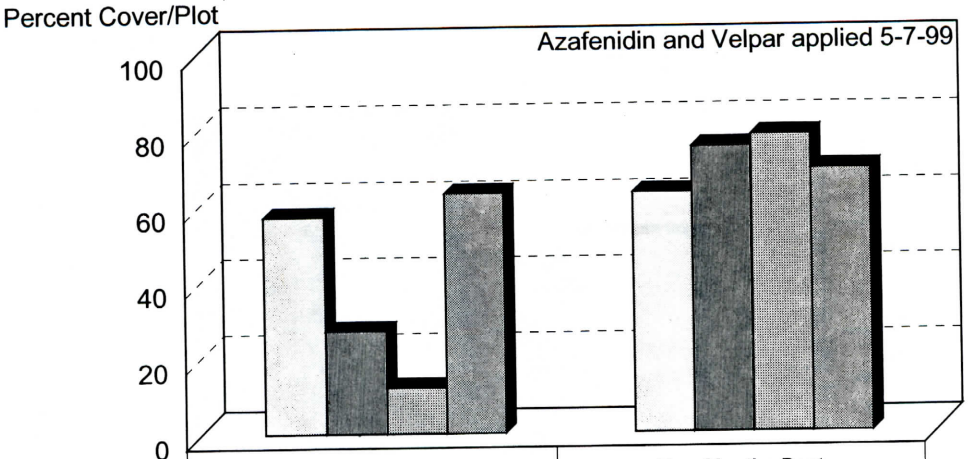
Figure 2. Effect of Azafenidin on Weed
Cover-Waldoboro, ME - 1999



	One Month Post	Two Months Post
UTC	57	63
10 oz/a	13	41
15 oz/a	18	41
Velpar 1 lb ai/a	39	59

Treatment=Highly Significant at One and Two Months Post Treatment

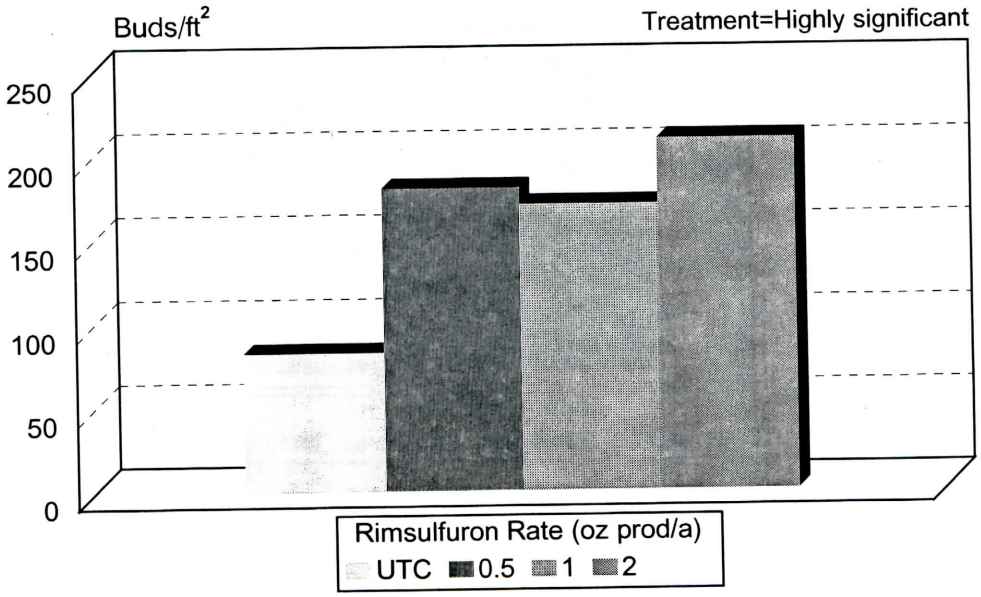
Figure 3. Effect of Azafenidin on Wild blueberry Cover-Waldoboro, ME - 1999



	One Month Post	Two Months Post
UTC	57	63
10 oz/a	27	75
15 oz/a	12	78
Velpar 1 lb ai/a	63	69

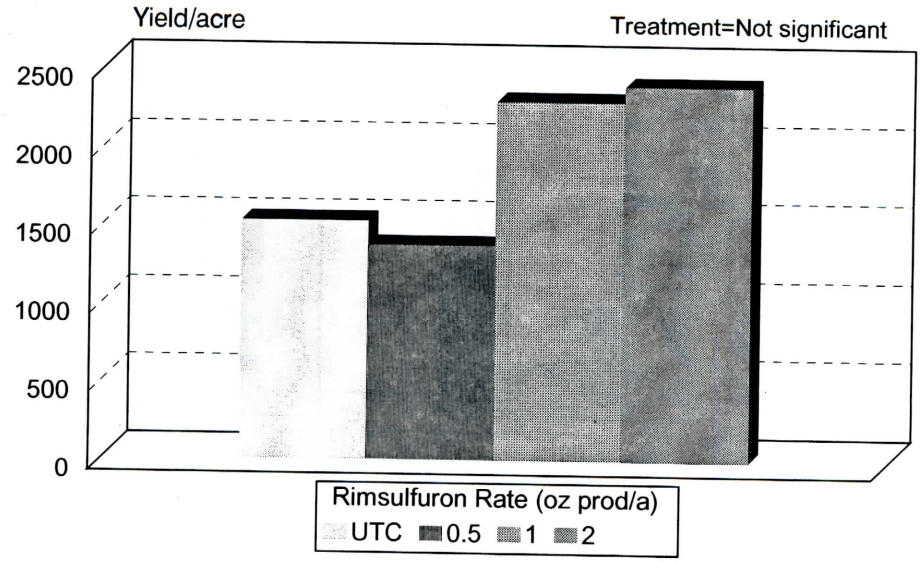
Treatment=Highly Significant at One and Two Months Post

Figure 4. Effect of Rimsulfuron on Bud Number - 1998 Trial



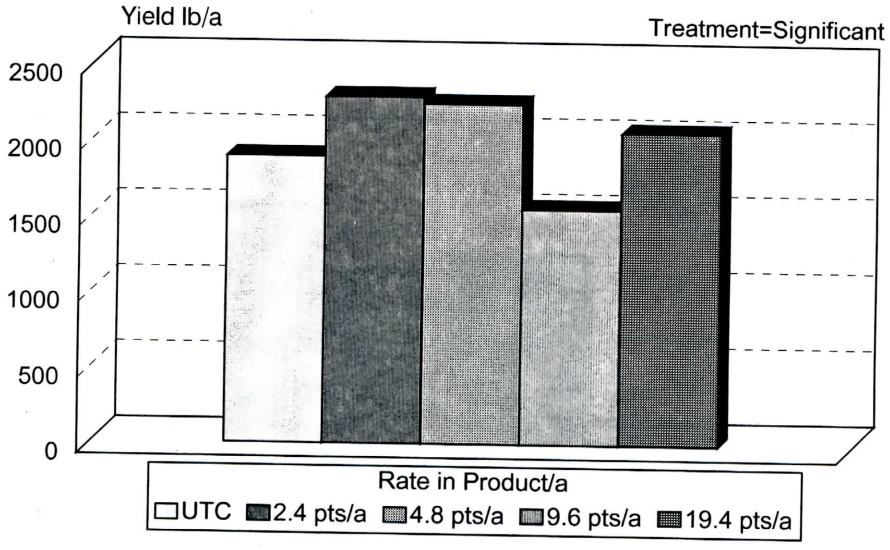
Rimsulfuron applied 5-14-98

Figure 5. Effect of Rimsulfuron on Yield - 1998 Trial



Rimsulfuron applied 5-14-98

Figure 6. Effect of Pendimethalin on Wild Blueberry Yield



Pendimethalin applied 5-8-98

WEED MANAGEMENT AND FIELD COVER

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

4. TITLE: Comparison of Sulfosate with Glyphosate for Weed Control

METHODS: A completely randomized design experiment was established with BBHF and Wesley, ME as experimental sites for five weed species to evaluate their response to sulfosate and glyphosate with and without ammonium sulfate (AMS). Individual bunchgrass plants or meter square bunchberry plots were sprayed with either 1 or 2% sulfosate or glyphosate with or without AMS on 6-30 or 7-1-99. Meter squared plots of dogbane, bracken fern or mixed hardwood individual plants were wiped with 10 or 20% sulfosate or glyphosate with or without AMS on 7-8-99. Phytotoxicity was assessed at 7, 14, 21 and 42 days after each treatment.

RESULTS: Overall, Touchdown and Roundup performed equally well at controlling most weed species at the various rates. Treatments at 14 and 21 DAT for bunchberry were significantly affected by rate and compound with the 10% Touchdown being least effective. After 42 DAT there was significant regrowth in plots without AMS (Figures 7,8). For dogbane, there was 100% control from all treatments at 21 DAT while at 7 DAT both 10% treatments without AMS were significantly more effective (Figures 1,2). Less effective but still good control was noted for bracken fern with ammonium sulfate and 20% solutions being significantly more effective (Figure 3,4). Variable results occurred in hardwoods without the AMS additive with regrowth occurring at 14 DAT in the 20% Roundup after total control at 7 DAT. After 14 days the best control was observed with 20%Touchdown with and without AMS with total control from all materials after 21 days with AMS (Figures 5,6). For bunch grass there was 100% control from all treatments after 7 DAT without any regrowth.

RECOMMENDATION: Both materials controlled all weeds, except bunchberry, equally well. The addition of AMS is not necessary but may be used to ensure adequate control especially in hardwoods

CONCLUSION: Sulfosate is as effective as glyphosate. The addition of AMS is beneficial if treating hardwood weeds. Additional control measures need to be developed for bunchberry

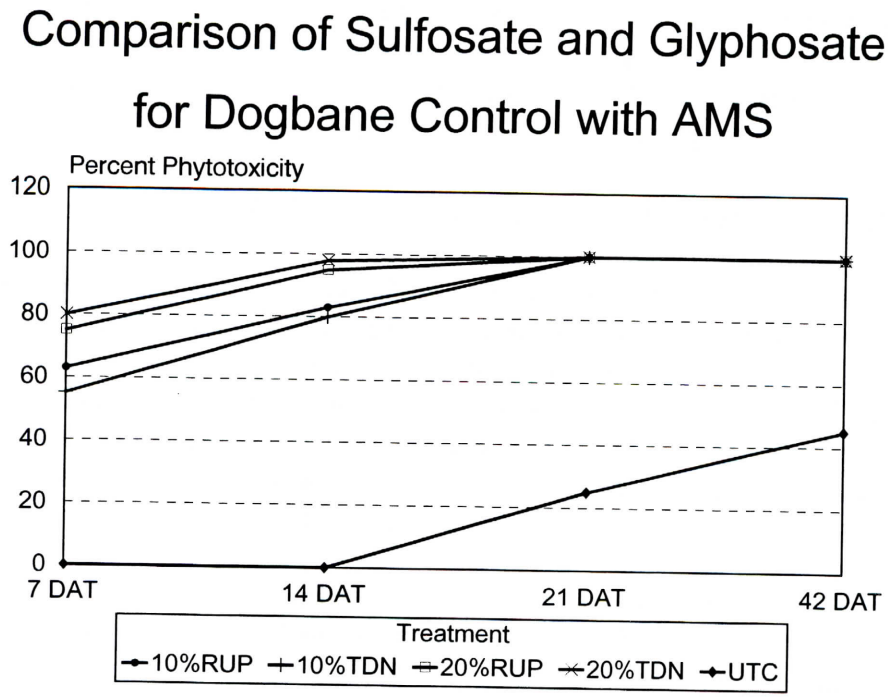


Figure 1.

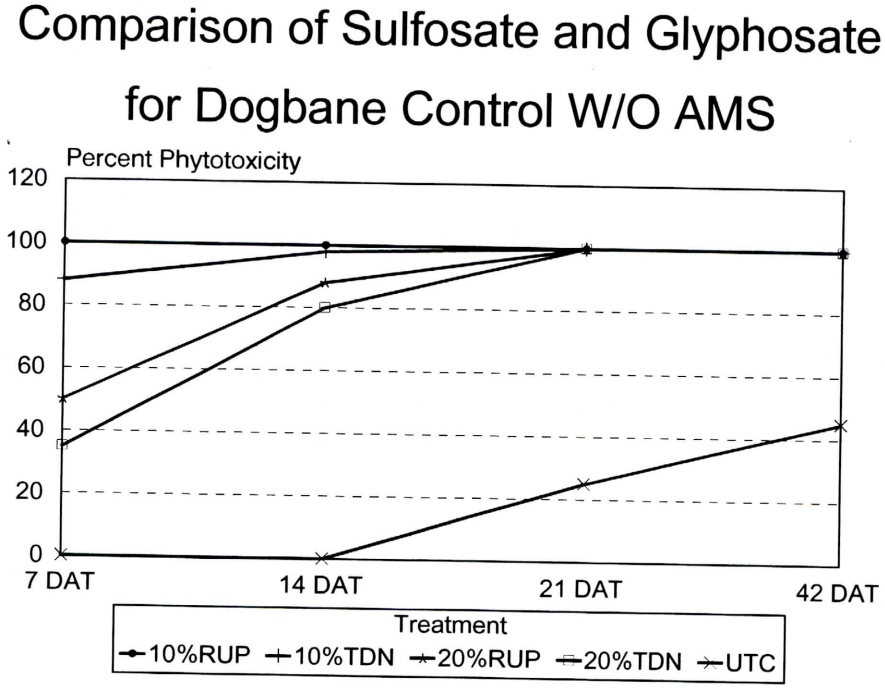


Figure 2.

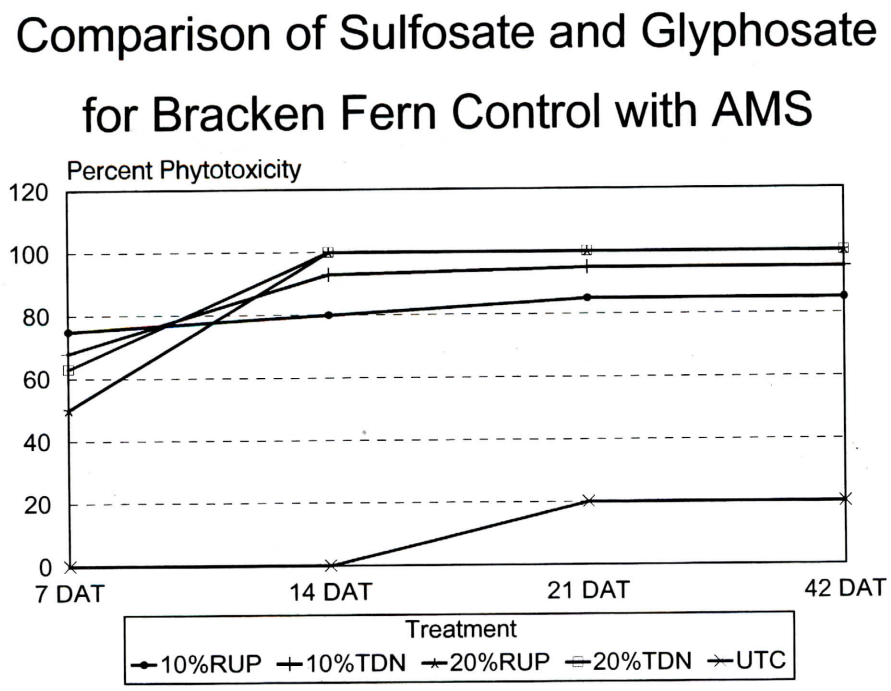


Figure 3.

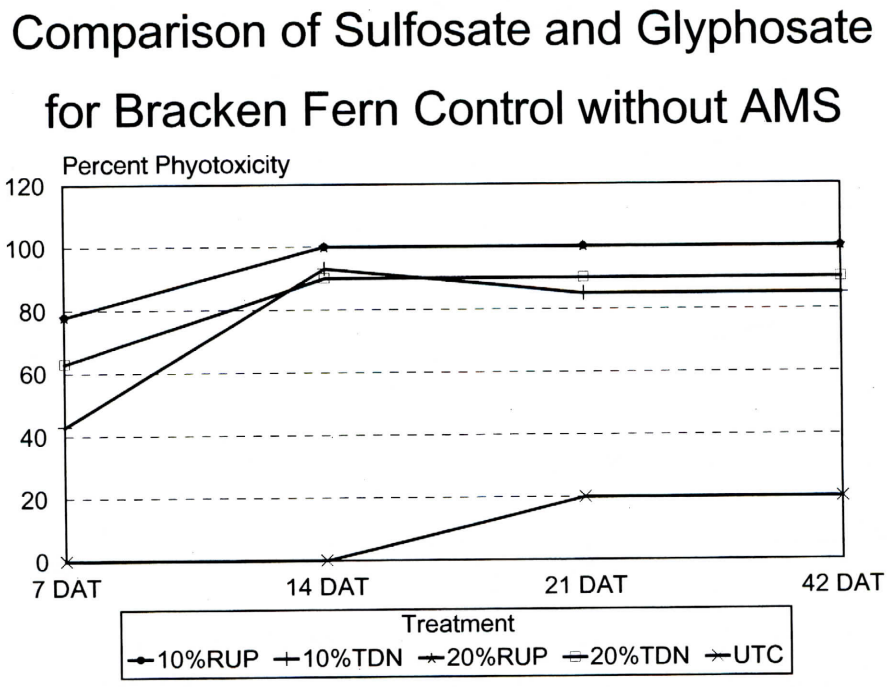


Figure 4.

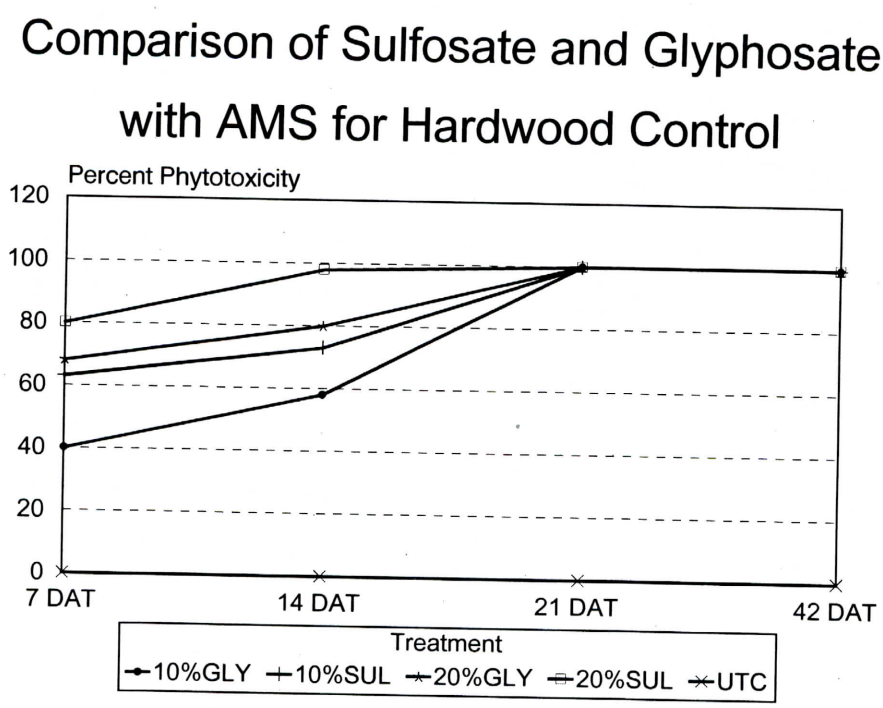
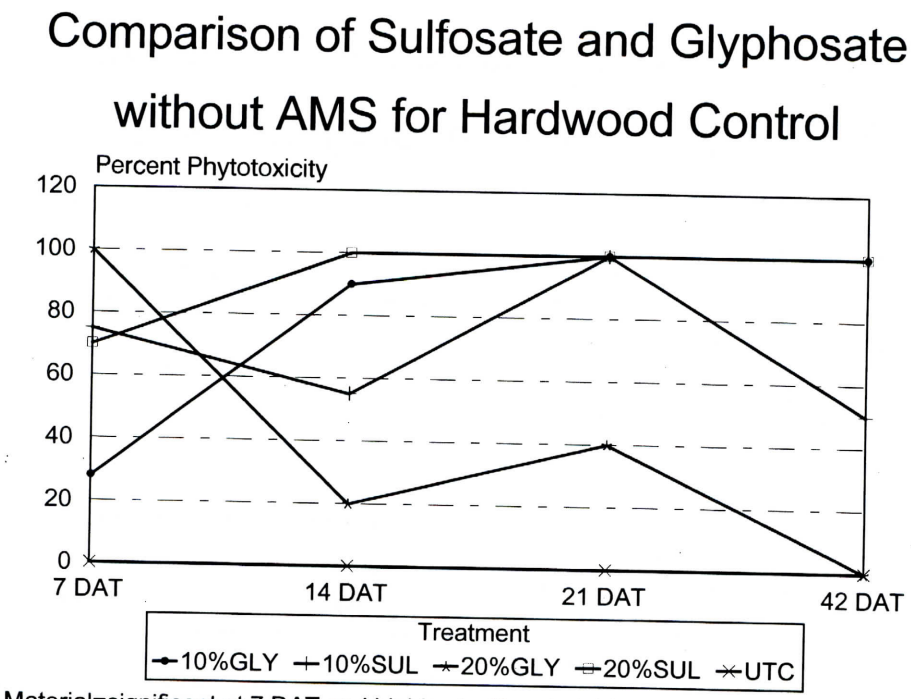


Figure 5.



Material=significant at 7 DAT and highly significant at 14 and 21 DAT, Rate=highly significant at 7 DAT, and 21 DAT

Figure 6.

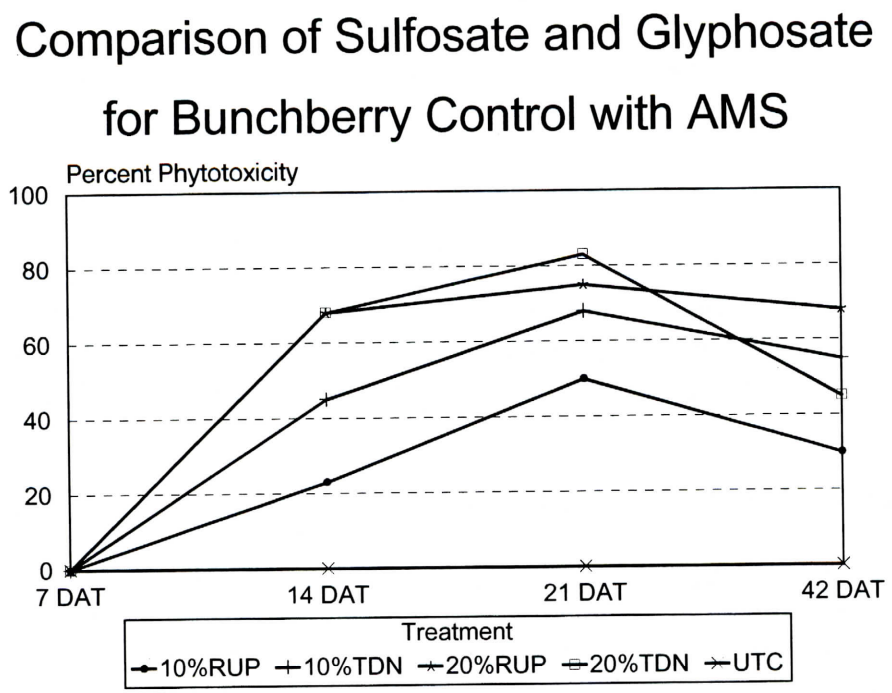


Figure 7.

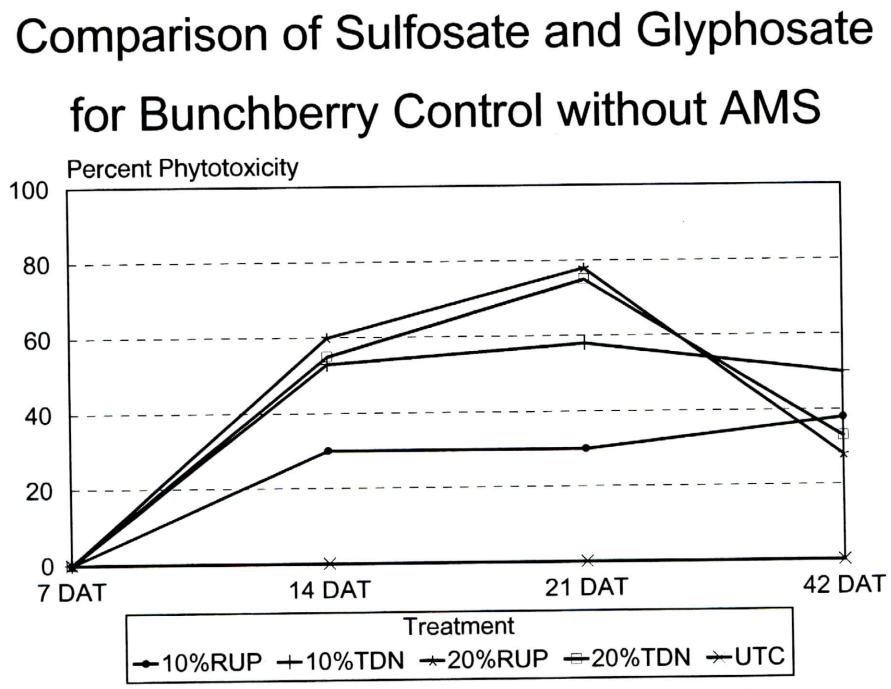


Figure 8.

WEED MANAGEMENT AND FIELD COVER

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

5 TITLE: Evaluation of VC1447 for Weed Control in Wild blueberries.

METHODS: VC1447 is a Valent product which has properties like azafenidin. The product was received too late in the spring for the establishment of a timing trial. A smaller trial was subsequently established in section 8, upper field at BBHF and applied with 0, 6 or 12 oz product/a on 5-18-99 with carryover effects evaluated one and two months month post treatment.

RESULTS: No effect of treatment on weed control was observed.

RECOMMENDATION: Valent has been very cooperative in registering products for the industry (they market Select®) so continuing research in this material should continue in case problems arise with azafenidin. A trial will be repeated in 2000 to evaluate both timing and formulation (a granular product is available) on weed species controlled..

CONCLUSION: None can be made at this time.

WEED MANAGEMENT AND FIELD COVER

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

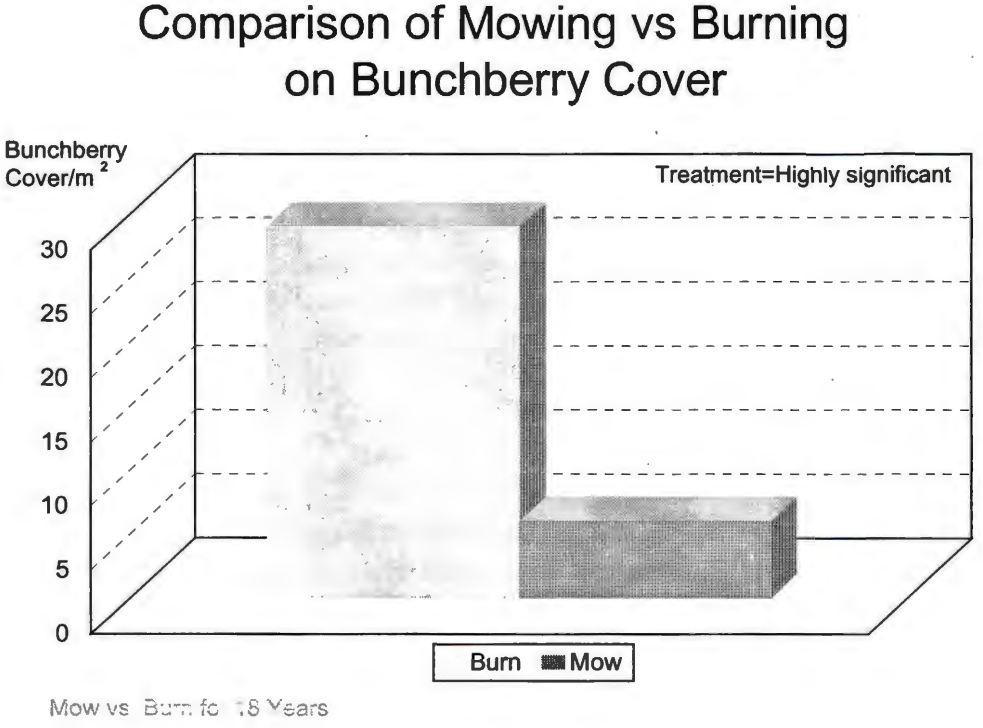
6. TITLE: Comparison of Mowing versus Burning for Bunchberry Control in Wild blueberries.

METHODS: Section 4 in the upper field at BBHF has been split in half and subsequently either mowed or burned for the past 18 years. Thirty, one yard squared cover plots from 5 different transects per pruning method were evaluated for bunchberry cover after harvest on August 30, 1999.

RESULTS: The burned section had significantly more bunchberry than the mowed plots (Figure 1).

RECOMMENDATION: In addition to continuing the split treatments, expand on the trial by oil burning 5 transects, 2 meters wide in the mowed only section repeatedly for 5 complete cycles and continue to monitor bunchberry density.

CONCLUSION: While the first assessment of this trial indicates mowing results in fewer bunchberry no conclusions can be made until treatments have been monitored for several more cycles.



EXTENSION

PRINCIPLE INVESTIGATOR: David E. Yarborough

1. TITLE: Blueberry / Cranberry Extension Education Program in 1999

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 reenforce the use of best management practices, integrated crop management and sound business management principles. Provide management information through the blueberry newsletters, through fact sheets in the wild blueberry growers 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 the weed mapping and explanation of decision making for blight control.

Professional Improvement Activities:
Participated in the Northeastern Weed Science Society meetings on January 4-7 in Cambridge, MA. Presented Affect of Azafenidin and Rimsulfuron on Weeds in Wild Blueberries and Grass Control Alternatives for Wild Blueberries. Learned of most recent research activities and met with weed specialists to discuss problems and solutions for the Maine Blueberry and cranberry industries.

Presentations:
Blueberry Pest Management, Augusta Agricultural Trade Show, February 14.

Met with hexazinone best management committee to review and make changes to Hexazinone Best Management Practices on February 26 in Augusta.

Wild blueberry Culture, Fort O'Brian School, Machiasport, April 6, Robinston grade school, November 1, Yarmouth/Cumberland School District, November 9.

Grass Control in Wild Blueberries, Blueberry Growers meetings, March 11, Milbridge; March 16 Machias; March 23 Calais.

Granular Herbicide Application and Calibration; Wild Blueberry Spring Meetings Union, March 17; Ellsworth March 18; Machias, March 20.

Organized Wild Blueberry Research and Extension Workers Conference in Bangor, Maine on March 30-31; presented, Affect of Azafenidin and Rimsulfuron on Weeds in Wild Blueberries, and Grass control Alternatives for Wild Blueberries.

Blueberry Equipment, Blueberry Production Workshop 1999, April 9-10 PEI.
Cost of Production, Blueberry Production Workshop 1999, April 9-10 PEI.
Maine's Experience with Velpar, Blueberry Production Workshop 1999, April 9-10 PEI.
Blueberry Insects, Blueberry Production Workshop 1999, April 9-10 PEI
Industry Overview, Cranberry Production Workshop 1999, April 9-10 PEI
Cost of Production, Cranberry Production Workshop 1999, April 9-10 PEI
Weed Control, Cranberry Production Workshop 1999, April 9-10 PEI

Conducted IPM field training sessions in Knox/Lincoln Counties on May 4, June 1 & 29 in Washington County on May 5, June 2 & 30 and in Hancock County on May 6, June 3 & July 1 at Allen's Freezer on Route 15 in Orland. The sessions included training on granular herbicide calibration, blight identification and control, and insect sweeping and identification, weed identification and management, blueberry maggot fly trapping, and leaf and soil sampling.

Discussed blueberry research and Extension program with members of the Blueberry Commission in Ellsworth on June 21.

I made a visit to determine the feasibility of wild blueberry sites in the St. John Valley on June 21-22, and October 27, further development is dependent on funds from the Maine Agricultural Center.

Held Annual summer field day and crop guesstimate at Blueberry Hill Farm in Jonesboro on July 21. 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.

Organized tour of wild blueberry fields in Grey, ME and explained wild blueberry culture for National Pesticide Certification and Training Workshop group on August 7.

Participated in Downeast legislative tour sponsored by the Wild Blueberry Commission on August 10.

Participated in Wild Blueberry Association of North America health Summit in Bar Harbor on August 12-13.

Wild Blueberry Production in North America at the Jilin College of Forestry, in Jilin City China on 5 September. With Chad Finn ,USDA-ARS, Oregon State University, evaluated highbush and lowbush plantings and indigenous blueberry fields at nine sites located throughout Jilin Province, China.

Participated in the IR-4 annual meeting in Washington, DC on October 4-7 to establish priorities for Maine for minor use pesticide trials.

Met with Maine Blueberry Advisory Committee on February 25, October 19-20 and November 10 to summarize blueberry research and Extension education program and propose program for 2000.

Wild Blueberry Culture in Maine, Robinston grade school, November 1.

Wild Blueberry Culture in Maine, Cumberland-N. Yarmouth SAD 51, November 9.

Wild Blueberry Culture and Wild Blueberry Pest Management; LHC 110 class , November 17.

Wild Blueberry Irrigation in Maine and Best Management Practices for Wild Blueberries at Wild Blueberry Producers Association of Nova Scotia, Truro, Nova Scotia, November 19-20.

Blueberry Weed Management New England Vegetable and Berry Conference, Sturbridge, MA, December 14-16.

Lowbush Blueberry Production - An Overview. New England Vegetable and Berry Conference, Sturbridge, MA, December 14-16.

Public testimony:
Board of Pesticide control:
May 14, 1999- Best Management Practices Update and Results of water sampling program for hexazinone.
December 8, 1999 - public hearing.
December 17, 1999 - meeting.
January 1, 1999 - meeting.

Television/radio/newspaper Interviews:
Bangor Daily News: May 14; May 17; May 20; June 18; June 25; June 30; July 21
Bangor Business Monthly: June 3; August 17

Currier Gazette: July 29
Downeast Coastal Press: November 22
Ellsworth American: May 17, December 29
Ellsworth Weekly Packet: February 19, July 27, August 4
Maine Public Radio: May 10, August 2
Maine Sunday Telegram; August 18
Quoddy Times: November 19, March 4
TV CH 5: May 20, August 24
WKIT Radio: May 17
Times Record (Brunswick): November 6
USA Today; June 24
Wall Street Journal: June 24

Other Activities:
I am on the Health Research Committee of the Wild Blueberry Association of North America. The purpose of the committee is to determine health research needs of the wild blueberry industry and to help coordinate programs, and to enhance communication among researchers and WBANA members. Food Science research projects are being coordinated in this committee to reduce duplication and foster cooperation on projects between Maine and Canada.

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. Four IR-4 projects were done in Maine in 1999.

I am coordinator for the CSREES special research grant 'Lowbush blueberry production and processing technologies' which is granted by the USDA; $205,832 was awarded for 1999. I coordinate proposals and reports from the researchers involved.

I have reviewed manuscripts for HortScience, American Society for Horticultural Science, Canadian Journal of Plant Science and the Maine Agricultural and Forestry Experiment Station.

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, and identify and control 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 1999 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 7 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 results in greater returns and a stable, sustainable industry.

RECOMMENDATIONS: Continue to support Extension educational program.

EXTENSION

INVESTIGATOR: David E. Yarborough, Extension blueberry specialist
Timothy M. Hess, Research Associate

2. TITLE: Effect of Rate, Formulation and Application Method on Efficacy and Phytotoxicity of Granular Hexazinone in Wild Blueberry Fields

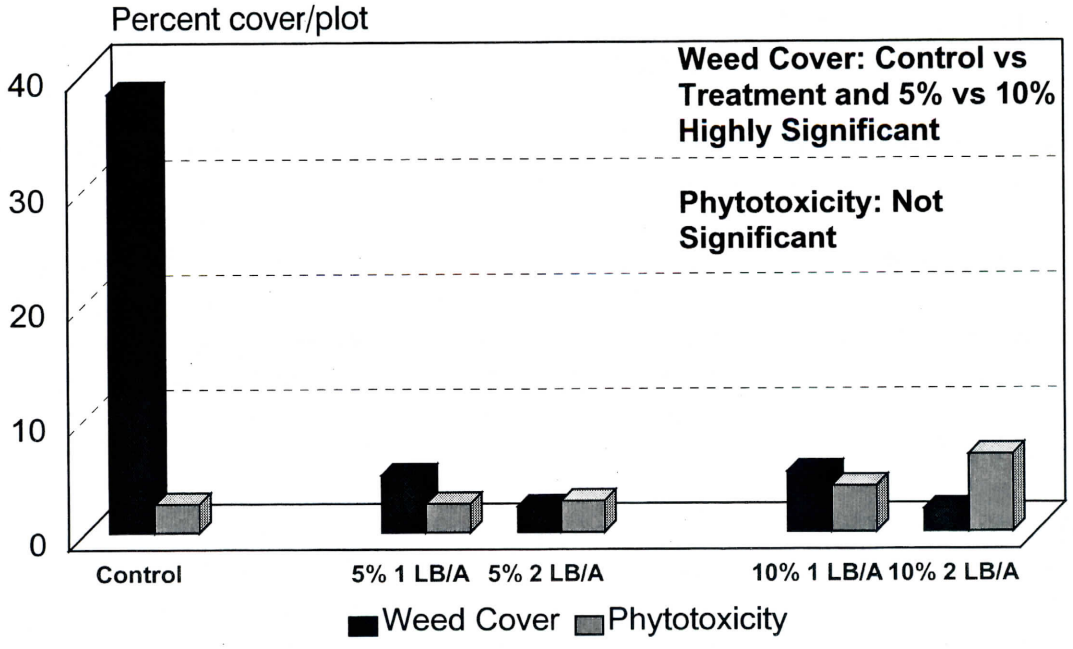
METHODS: Granular hexazinone was applied as Pronone MG® on 6/16/99 with either an air assist spreader or Vicon® spreader at 1 or 2 lb ai/a in a 5% or 10% formulation to 1.5 acre blocks on a commercial blueberry field on Township 18 MD, Maine. Ten, 1 meter square transect per treatment block were evaluated for two untreated blocks and for each application equipment, formulation and rate (2x2x2= 8 treatment blocks) on 8/6/99 for weed cover and phytotoxicity to blueberry plants.

RESULTS: The effect of equipment was highly significant with the air-assist application having a greater weed cover and less phytotoxicity and the Vicon spreader with less weed cover and a higher phytoxicity rating. With both the air-assist spreader and the Vicon® spreader, weed cover was reduced for the treated vs the untreated and was lower for the 2 lb vs the 1 lb rate but formulation percentage had no effect on weed cover. Phytotoxicity was significantly higher on the 10% vs the 5% formulation, when applied with the Vicon® spreader, but neither rate or formulation had any significant effect on phytotoxicity when applied with an air assist spreader.

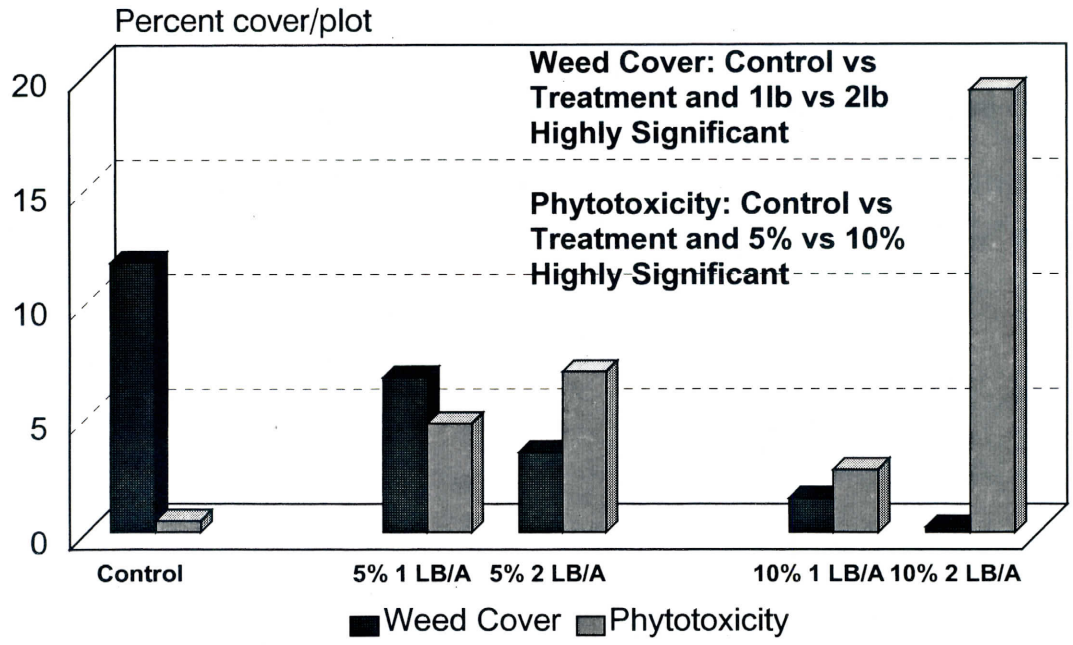
CONCLUSION: The 5% granule would provide better crop safety when used at the higher rate in the Vicon® spreader but had no significant effect on weed cover. No effect on weed cover or phytotoxicity for the 5% vs 10% formulation was seen when applied with the air-assist spreader.

RECOMMENDATION: Use an air-assist spreader if applying Pronone over 1 lb/a or pursue a 5% granule formulation to increase crop safety when using over 2 lb/a.

Effect of Pronone Applied with Air Assist Spreader on Weed Cover and Blueberry Injury



Effect of Pronone Applied with Vicon Spreader on Weed Cover and Blueberry Injury



EXTENSION

INVESTIGATOR: David E. Yarborough, Extension blueberry specialist

COOPERATOR: David Lambert, Associate Professor of Plant Pathology

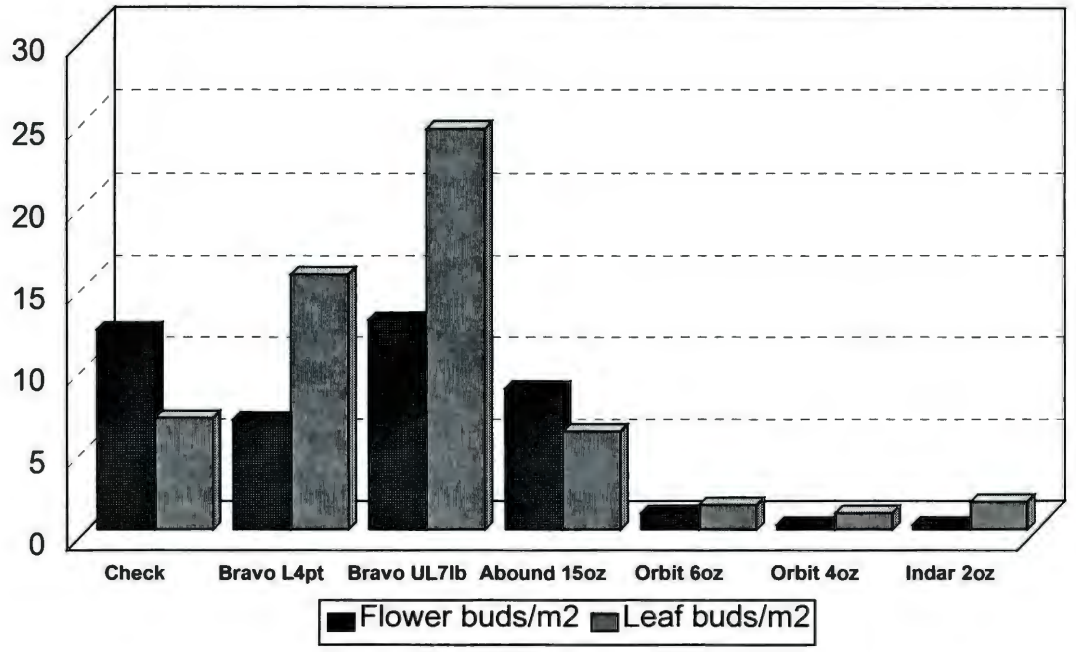
3. TITLE: 1999 Fungicide evaluation field trial

METHODS: Two sites were used, Blueberry Hill Farm Agricultural Experiment Station in Jonesboro, Maine and Cherryfield Foods Inc. Section MN5B on T-19 MD, Maine. Fungicides were applied with an air blast sprayer in 20 gpa on 5/6/99 in Jonesboro and on 5/6/99 and 5/17/99 in T-19 MD, with the exception of Bravo Ultrex, which was applied by aircraft in 5 gpa on 5/7/99 on T-19. On 6/4/99, 40, 0.25m^2 quadrats on the treated and an untreated block were assessed for the number of flower buds and leaf infected by *Monilinia vaccinii-corymbosi*. Leaf spot disease symptoms were evaluated for the treated and untreated areas on 7/22/99 on four replications within 4 clones using a CRB design and a 0.25 m^2 quadrat. Ratings used were 0= no disease, 1=light disease, 2=moderate disease, 3=high disease incidence. Leaf tissue was sampled on 6/25/99 and plated on 7/1/99 and of 166 plates, 33 have been examined.

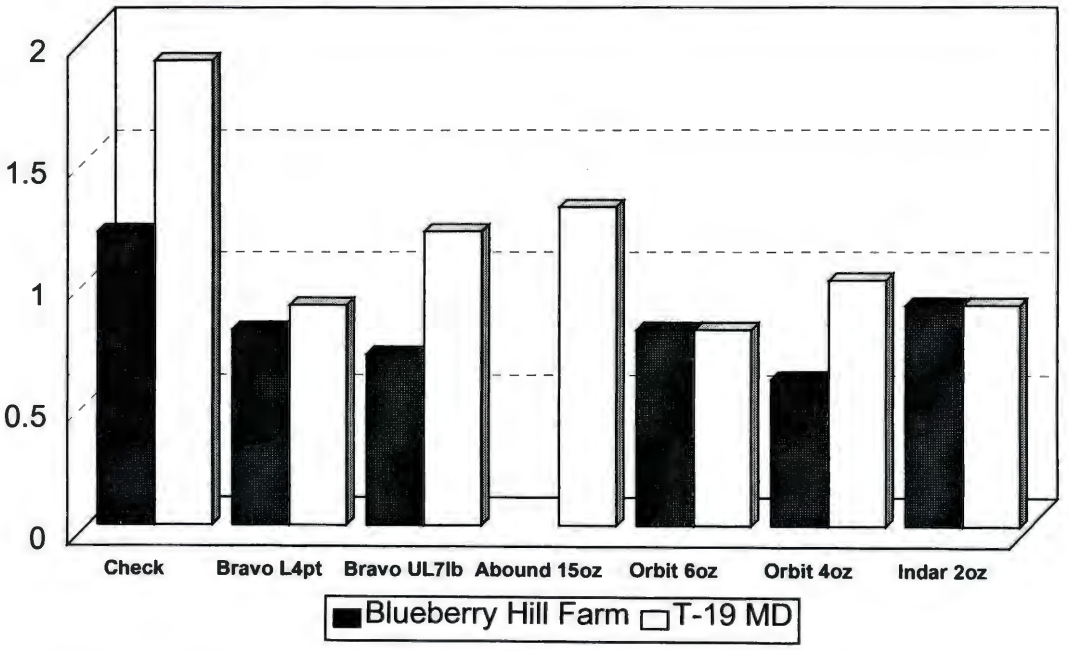
RESULTS: At Blueberry Hill Farm only one infected leaf and no infected blossoms were found. Because there was not enough infection at the site, the pots were not rated. In T-19 Orbit at 4 and 6 oz/a and Indar at 2 oz had fewer infected flowers and leaves than the control, but there was no difference between the rates. The Bravo and Abound treatments were not different from the untreated check for blight infection. At BBHF there was no significant difference in the check versus the treated for leaf spot rating, but on T-19 all of the fungicides reduced leaf spot compared to the control, with Orbit, Indar and Bravo L having the least symptoms. Fungi isolated from plated stems include: *Alternaria, Aposphaeria, Aureobasidium, Cladosporium, Dendrodochium, Dothiorella, Epicoccum,* and *Phomopsis*. Fungi isolated from plated leaves include: *Alternaria, Dothiorella, Epicoccum, Phomopsis,* and *Septoria*.
CONCLUSION: Orbit and Indar are most effective fungicides for the conrol of mummyberry and leaf spot dieseases.

RECOMMENDATIONS: Continue to pursue Section 18 label on Orbit until Orbit or Indar receives a Section 3 label. Until that time there are no effective fungicides registered to control mummyberry disease in wild blueberries.

Effect of Fungicide on Mummyberry control
T-19 MD - 1999



Effect of Fungicide on Leaf Spot Disease
Blueberry Hill Farm and T-19 MD - 1999



Leaf spot Rating 0=none 3=severe

EXTENSION

INVESTIGATOR: David E. Yarborough, Cooperative Extension blueberry specialist

COOPERATOR: John Jemison, Cooperative Extension water quality specialist

4. TITLE: 1999 Hexazinone groundwater survey

METHODS: Seven wells and four streams or ponds adjacent to, or in wild blueberry fields in two counties, were sampled in 1999 in May, June, July, August, and October. Three wells were put in by the Maine Department of Conservation in 1986 and the others were drilled. 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 received Velpar® L preemergence; site 23 received Velpar® L impregnated on diammonium phosphate (DAP) fertilizer; sites 31, 32, and 36 received Pronone® MG and sites 9 and 13 were not treated (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: In 1999, no increase in the levels of hexazinone was found. Site 32, previously reviewed by the Board of Pesticides Control with the highest level, but the cause was determined to be a point source contamination. The level on site 32 varied from 13 to 18 ppb, which is down from the high of 105 ppb in April of 1997. The 1999 monitoring data are consistent with past results, showing seasonal changes but no trend of increasing levels, under current use patterns. Figure 1 gives the long-term trends over 10 years and 55 sampling dates. Site 12 was treated with granular hexazinone from 1993 through 1996 and had the lowest level of hexazinone but is now above site 11 which was treated with a liquid and had higher levels. Site 9 has not been treated with hexazinone but with alternatve herbicides since 1993 and the hexazinone level has been declining steadily over the years from 27 ppb to less than five ppb.

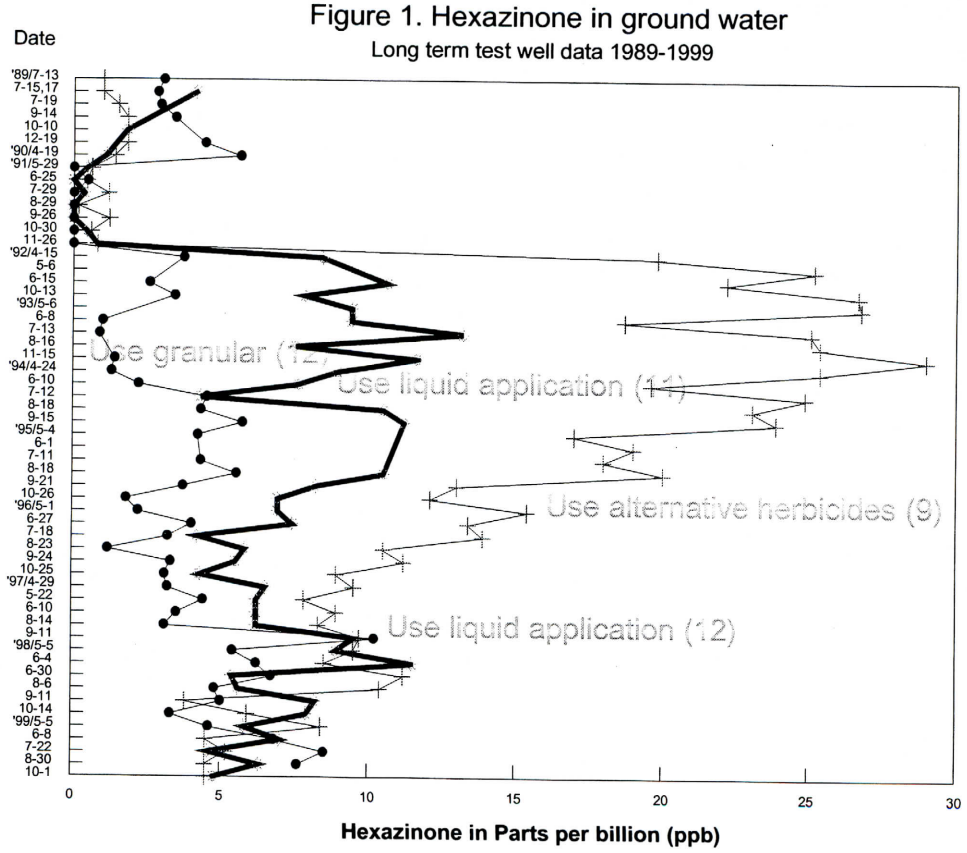
CONCLUSION: These data further substantiate that the current use patterns are not resulting in any increase in hexazinone levels in the groundwater

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.

Table 1. 1999 Hexazinone Test Result Summary
University of Maine Well Water Survey
Hexazinone in parts per billion

Site/Treatment	May	June	July	August	October
Wells					
9 test/untreated	8.4	4.5	5.2	4.5	4.5
11 test/liquid	5.8	7.0	4.6	6.3	4.8
12 test/liquid	4.6	6.8	8.5	7.6	-
13 drill/untreated	2.4	1.9	2.3	1.5	2.0
23 drill/liquid+DAP	2.0	-	-	-	-
31 drill/granular	5.7	5.7	4.9	4.9	4.3
32 drill/granular	15.3	14.0	18.2	13.3	16.7
36 drill/granular	4.8	4.8	5.0	4.4	2.7
Surface					
9 stream/untreated	ND	ND	0.3	0.4	ND
11 pond/liquid	5.0	5.7	6.6	2.0	3.8
12 stream/liquid	-	4.4	3.6	4.8	4..4
13 pond/untreated	0.7	ND	0.3	ND	ND

Figure 1. Hexazinone in ground water



POLLINATION

INVESTIGATORS: F. A. Drummond, Associate Professor of Entomology
C. S. Stubbs, Post-Doctoral Research Scientist

TITLE: Sustainable pollination of wild lowbush blueberry

OBJECTIVE: Conduct pollination field trials and develop management practices for the use of the fuzzyfoot bee, *Anthophora pilipes*.

Revised Objectives:

1) Conduct pollination field cage trial and population build-up of the fuzzyfoot bee.
2) Determine over-wintering survival of fuzzyfoot bee in Maine.
3) Produce University of Maine Cooperative Fact Sheet on native leafcutting bees and their conservation.

METHODOLOGY:

Five blueberry fields of similar size were used. Traditional management practices were used in all fields, except that no insecticides or fungicides had ever been used in the field designated for the release of the fuzzyfoot bees. Honey bees were stocked at 3 hives/acre in two fields and commercial bumble bees were stocked at 1-2 colonies/acre in two fields. Two wooden shelters for fuzzyfoot bees were set up in the remaining field. Eighty meter transects were established from each cluster of hives/colonies/shelters (one--three transects per cluster). In all fields, except one honey bee field, ten blueberry stems were marked at distances of 15, 30, 45, 60, and 75 meters (16.35, 32.70, 49.05, 65.40, and 81.75 yds.), and the number of flowers per stem recorded when bloom was approximately 5%. For that honey bee field, marked stems were at 4.51, 9.03, 13.73, 18.30, and 22.86 meters (3, 10, 15, 20, and 25 yds). In mid-May, when the Maine Department of Agriculture determined that we could not field release the fuzzyfoot bees, 10 additional fruit set-yield stations were established (five stations per cage, each with 10 marked stems to a total of 50 marked stems per screen cage). The field transects previously set up for the fuzzyfoot release were then used to assess wild native bee performance as pollinators compared to the fuzzyfoot in the two field cages and to the fields with honey bees or commercial bumblebees.

Measurements of bee density (15, one m^2 plots), recording number of bees, species, and foraging behavior (pollen and/or nectar collecting) were made at the five study sites. Two weeks after bloom the stems were reexamined to determine percentage fruit set. Berries were harvested in late July and berry number per stem, berry weight, and seeds per berry recorded. Percentage fruit set and percentage yield (based on the number of harvested berries from the flowers on marked stems) were compared with descriptive and inferential statistics (Kruskal-Wallis $p \leq 0.05$).

In mid-May we received four shipments of adobe nest blocks containing a total of 21 nests of fuzzyfoot bees that had been kept in quarantine since July 1998 at the USDA Containment Laboratory at the Beneficial Insects Introduction Research laboratory, Newark Delaware. These blocks, plus the 11 nests in adobe blocks in cold storage (36^0F) at the University of Maine from the previous field season, were set out in the wooden shelters.

During bloom we compared fuzzyfoot bee flower handling time to two commercially available bees (honey bees and bumble bees, *Bombus impatiens*) and to native orange-belt bumble bees (*Bombus ternarius*). After bloom, because the fuzzyfoot bees were still alive, we provided them with a variety

of wild flowers on a daily basis (e.g. lupine, wild cherry, blackberry) in order to keep them alive and reproducing. As in the previous year, we assessed nesting behavior, success of nesting, ease of handling, and rate of parasitism, if any.

The last fuzzyfoot female adult activity was observed on 25 June. Adobe nest blocks were removed from the field on June 27 and stored indoors at room temperature until October 5 at which time they were placed in cold storage (36^0F).

The over-wintering study was initiated on December 5. Half of the nests (n = 18) were moved to a heavily secured wooden shelter in Winterport where the air temperature is being monitored. These fuzzyfoot nests will remain and be monitored at the Winterport site until March 30 in order to determine if the fuzzyfoot can over-winter outdoors in Maine.

RESULTS AND DISCUSSION

Flower handling time (n = 50 single flower visits per species, except n = 25 for the native orange-belt bumble bee) was significantly different (p = <.0001, Kruskal-Wallis) for the fuzzyfoot, honey bee, commercial bumble bee (*Bombus impatiens*), and orange-belt bumble bee (*Bombus ternarius*). Flower handling time ranged from 1-36 seconds. Average flower handling time for *A. pilipes* was 3.4 ± 2.8 sec, 9.1 ± 1.2 sec for the honey bee, 3.9 ± 1.6 sec for *B. impatiens* and 1.6 ± .19 sec for the orange-belt bumble bee, *B. ternarius*. All bees observed collected blueberry pollen, except for the honey bees. Only six honey bees were observed collecting pollen; the other 48 were collecting nectar.

There was no significant difference in percentage fruit set (measured two weeks after bloom) for the fuzzyfoot, the honey bee, commercial bumble bee (*Bombus impatiens*) and the native wild bees. (See Figure 1.) Average percentage fruit set for the fuzzyfoot, *A. pilipes*, was 79.3 ± 5.67% (range 65--85%); for honey bees 82.40 ± 11.49% (range 63--96%, for *B. impatiens* 85.3 ± 4.42 (range 80--95%); and for wild native bees 86.26 ± 8.13% (range 73--99%).

Average percentage yield (harvested berries from the flowers counted on the marked stems, which was measured in late July) was significantly different (p = .0002). (See Figure 2.) Percentage yield for the fuzzyfoot, *A. pilipes*, was 45.60 ± 10.46% (range 35--68%); for honey bees 59.60 ± 17.27 % (range 35--89%); for *B. impatiens* 50.0 ± 11.65 (range 37-67%); for native bees 68.4 ± 11.91% (range 42--85%). It should be noted that growing conditions for blueberry within the screen cages were not as favorable as those outside the cages. Reduced light within the cages doubtless contributed to berry drop as did our walking in the cages in order to bring alternate forage in order to keep the fuzzyfoot bees alive. Thus percentage harvested berries for the caged fuzzyfoot bees and the other bees are not truly comparable. In other words, we suspect that there would have been no significant difference in percentage harvested berries if the fuzzyfoot had been allowed to field pollinate the blueberry plants at that study site because percentage fruit set and berry weights were not significantly different (*see below*).

Berry weights were not significantly different among bees (Figure 3). Average berry weight for the fuzzyfoot, *A. pilipes*, was .454 ± .132 grams (range .350--.660 g); for honey bees .452 ± .158 grams (range .180--1.0 g); for *B. impatiens* .436 ± .143 grams (range .360--.740 g); and for native bees .429 ± .158 grams (range .280--.850 g). The fact that berry weights for the fuzzyfoot were similar to the other bees, despite being in cages, further indicates the excellent potential for this bee as a pollinator of lowbush blueberry.

Average seeds per berry were significantly different (Fig. 4- Note that the same letter in the figure indicates no significant difference. Thus the average number of seeds per berry for honey bees and fuzzyfoot bees was fairly similar). The average seeds per berry for *A. pilipes*, was 31.5

± 11.7 seeds (range 38--53 seeds); for honey bees 29.95 ± 13.39 (range 11--69 seeds); for *B. impatiens* 37.64 ± 12.06 (22--71 seeds); and for native bees 36.15 ± 11.41 (range 18--69 seeds). The significantly lower number of seeds per berry for the honey bee is consistent with earlier findings and this field season's observations that most honey bees collect nectar but not blueberry pollen.

No parasites were observed in the field cages. At the end of the field season there were 36 new fuzzyfoot nests produced, which was a net gain of 3 nests. In part, this gain may be due to wild blackberry pollen and nectar, being added to the forage after bloom. (In 1998 there was no net gain in nests produced, blackberry was not available that year.) However, further testing would be necessary as other factors may be contributing to increased fecundity.

Our minute observations of the one m^2 plots of bee density indicated higher than average densities of native bumble bees in two fields. These fields had more than 1 bumble bee queen per m^2 foraging per minute. In fact, one of the fields had an average of 2.6 bumble bee queens per m^2 foraging per minute. It is thought that additional stocking with honey bees is unnecessary when there is at least one wild bee per m^2 per minute.

A Cooperative Extension Fact Sheet on native leafcutting bees and their conservation, which includes color photos to help identify them and instructions on the building and placement of wooden nest blocks, is in the final stages of publication.

RECOMMENDATIONS:

In 1998, the fuzzyfoot, *Anthophora pilipes*, performed as well as the commercial bumble bee, *B. impatiens*, and better than the alfalfa leafcutting bee in our flight cage studies conducted at Blueberry Hill Farm. In 1999, the fuzzyfoot performed as well for fruit set as the honey bee, the commercial bumble bee *B. impatiens*, and native bees in the field. This coupled with its good performance for berry weight and seeds per berry provide further evidence that *A. pilipes* has potential as an inexpensive, easy to handle alternative to the honey bee for lowbush blueberry pollination.

If the fuzzyfoot bee does not over-winter outdoors this winter, it could not compete for nest sites with our native species. (It should be noted that Dr. S. W. T. Batra reported that it could not over-winter outdoors in Maryland.) Therefore, we await the results from the over-wintering study and discussing these results with the Blueberry Advisory Board and the Maine Department of Agriculture before field release of this bee in 2000.

Our previous research, in conjunction with the 1999 findings, has demonstrated that the contribution of native bees to lowbush blueberry pollination can be substantial, especially by bumble bees. Pollination continues to be the major economic expense for most growers. With the exception of the leafcutting species of *Osmia*, little is known about our native Maine pollinators. Therefore we recommend that research should be initiated to examine what factors contributed to significantly above average bumble bee densities in certain fields and not in others.

Figure 1. Percentage fruit set for fuzzyfoot bees (caged), honey bees, commercial bumble bees, and wild native bees.

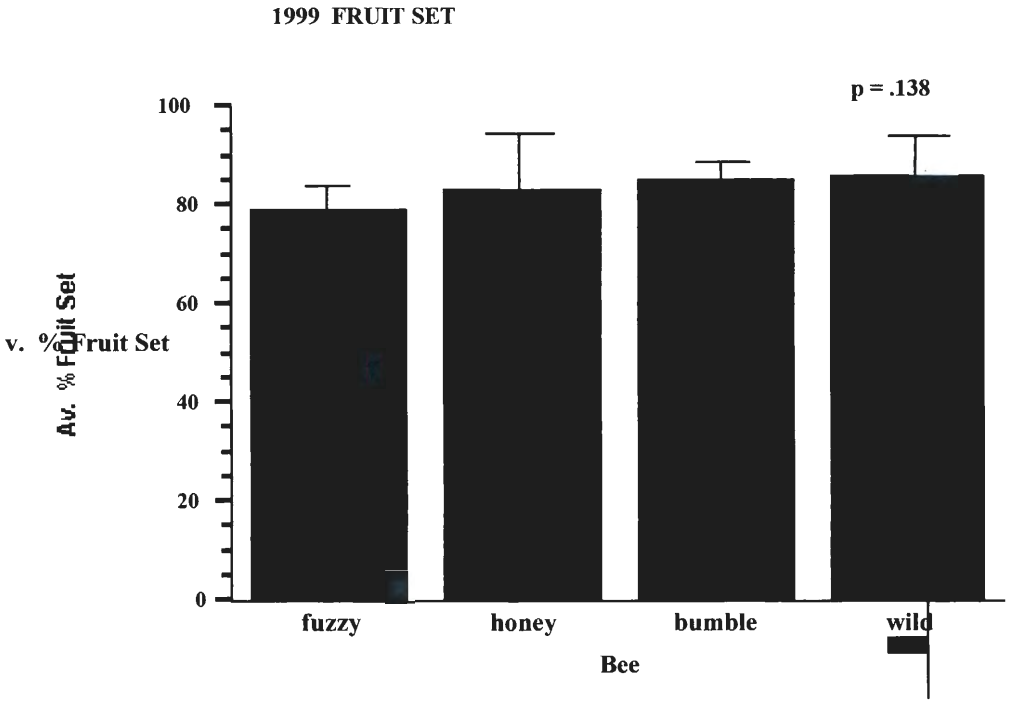


Figure 2. Percentage harvested berries for fuzzyfoot bees (caged), honey bees, commercial bumble bees, and wild native bees.

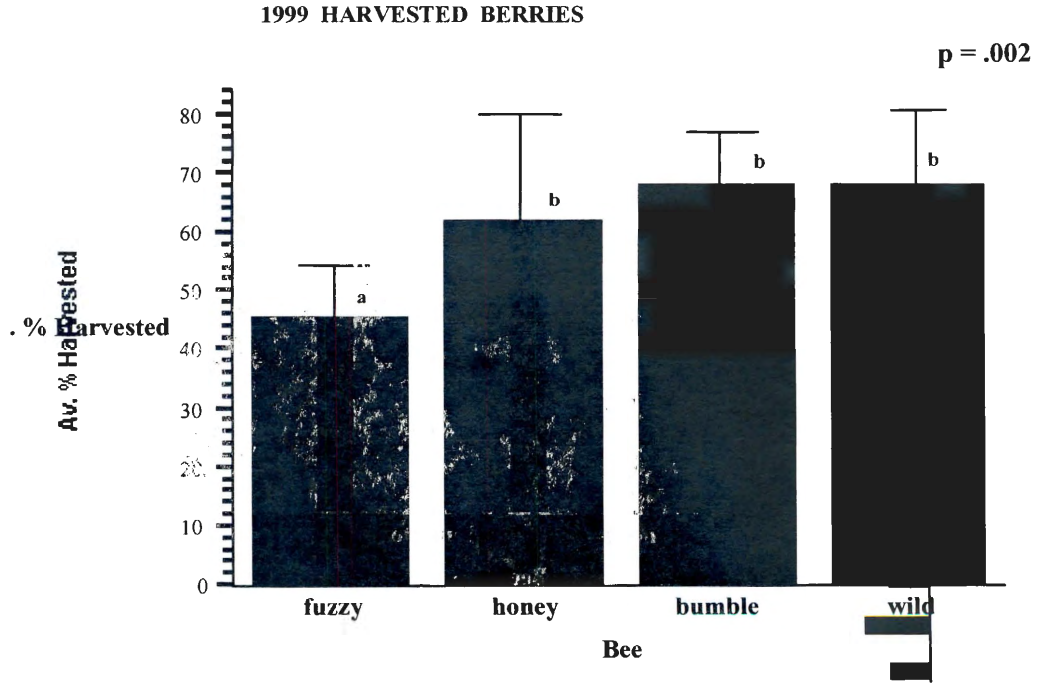


Figure 3. Average berry weight for fuzzyfoot bees (caged), honey bees, commercial bumble bees, and wild native bees.

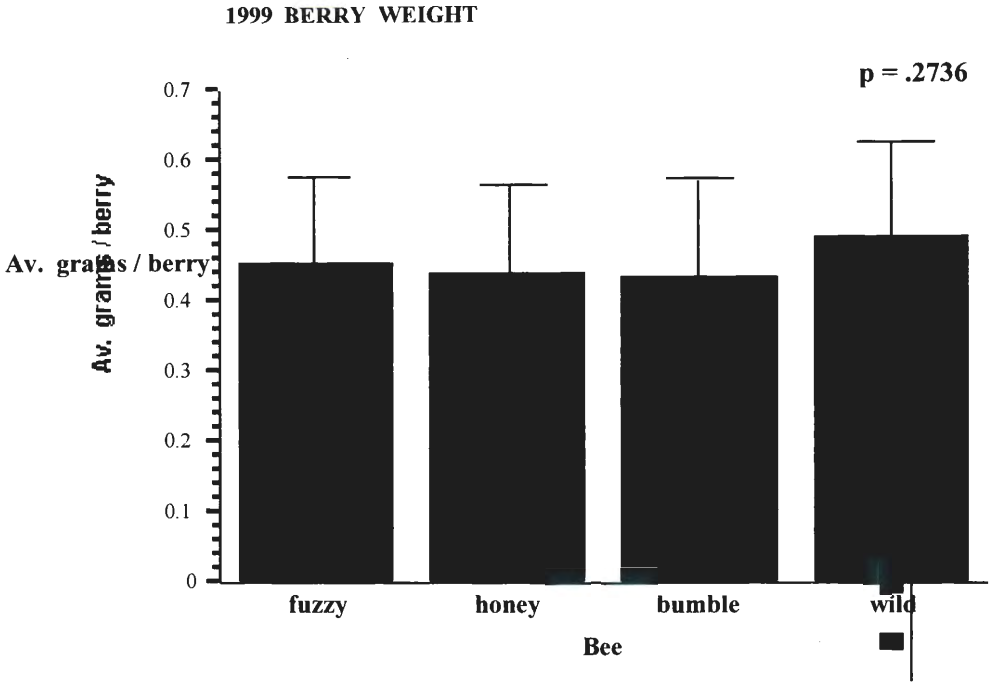


Figure 4. Average seeds per berry for fuzzyfoot bees (caged), honey bees, commercial bumble bees, and wild native bees.