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1998 CSREES Wild Blueberry Project Results

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1998 CSREES Wild blueberry Project Results

A. FOOD SCIENCE AND BIOSYSTEMS ENGINEERING

INVESTIGATORS: Darrell W. Donahue, Biosystems Science and Engineering
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1. 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: During the 1998 field season over a three-week period, 97 quarts of blueberries were harvested from an organic blueberry producer and brought back to the UMaine Biological Engineering Laboratory for analysis.

Sample maggot counts were obtained by the normal boiling and dissection method (Dixon and Knowlton 1994). This baseline test was used to determine the average number of maggots in a given sample of berries. The boiling test was performed at each time of harvest to determine a baseline average maggot count of berries harvested on that test date. Once the boiling test was achieved, standard sugar floatation, firmness, x-ray, and ultrasound tests were performed to determine if these methods would be able to isolate maggot infested berries. A preliminary investigation, using high fructose corn syrup for floatation tests at 50, 20 and 10 brix (% total solids), was performed to determine at what brix content separation/floatation occurred. The preliminary results indicated that further floatation studies should be conducted near the 10 brix content. Therefore, 5 different brix contents were used for further exploration; 15, 10, 5, 2.5 and 0 percent brix. Floatation tests at these brix levels, with replication, were performed on three separate dates; 14 August, 17 August, and 19 August, 1998.

In order to determine if maggot infested berries would have different levels of firmness than other berries, a firmness test was done on a sample of 50 berries from each harvest date (100 berries on 19 August 1998). Individual berries were subjected to a compressive force test as described in the ASAE S368.3 MAR95 standard (ASAE 1995) using an Instron® materials testing machine (model 4466, Instron Corporation, Canton, MA). After being crushed in the compressive force test, the berries were inspected using a low power Olympus dissecting microscope (model SZ, zoom magnification from 10-70X, Olympus America, Inc., Medville, NY) to determine if a maggot was present.

For the x-ray tests, maggot infested (infested) and maggot free (free) blueberries were placed in a holder and line scanned using two typical x-ray machines: one at the UMaine Cutler health center (scans were performed at 100mA, 40kV for 1/60 second) and the other at the USDA animal and plant health inspection service at Bangor international airport (line scan operation at 21 kHz, model 0422-35, Astrophysics Research Corporation, Long Beach, CA).

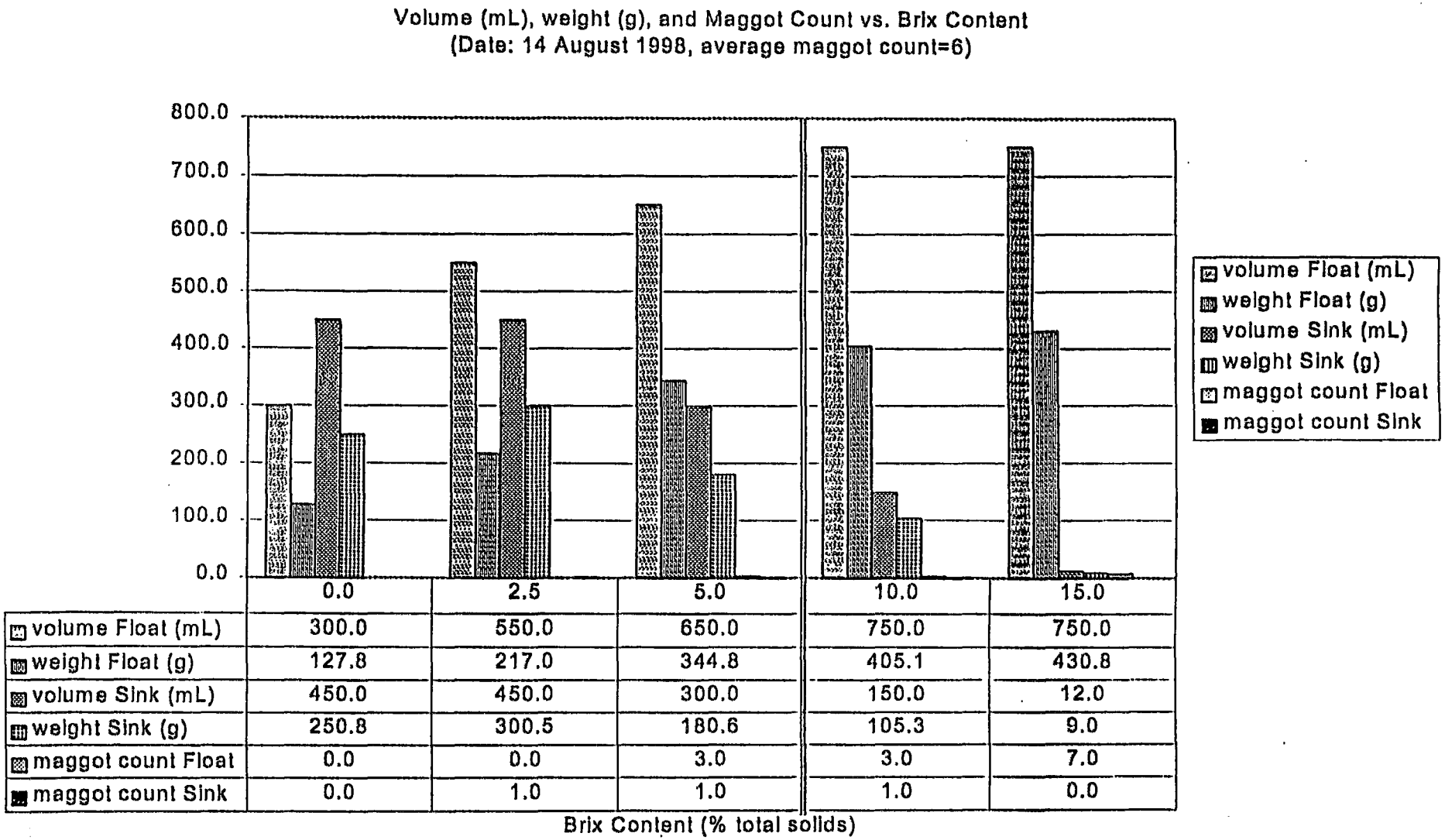
In addition, a portable ultrasound machine (model 500V, Aloka Company LTD, Japan) and transducer (linear array transducer, 7.5 MHz, Aloka Company LTD, Japan) were used to see

if there were differences seen between maggots and blueberries. Blueberries and maggot samples were suspended in a water bath and then the probe was used to view the samples. A wild blueberry was also artificially implanted with a maggot for ultrasound testing.

RESULTS: Figures 1 to 3 give the floatation results in chart format. The results of the floatation studies reveal no pattern of being able to separate maggot infested berries using high fructose corn syrup standard floatation techniques at the brix levels examined. The variation in floatation among infested and free blueberries was high, this combined with a low sample maggot count throughout the season makes floatation/separation methods difficult. Results of the Instron firmness tests revealed that there were no significant differences in firmness between infested and free blueberries. Therefore, a mechanical bouncing method of separation would not be successful. The x-ray scans showed difficulty in distinguishing the internal fluid material of the wild blueberry from seeds or maggots. However, it was noted that the densities (and component makeup) of the maggot and internal wild blueberry components are different and a x-ray system where frequency can be attenuated might be used to ascertain detectable differences in infested blueberries. There were density differences seen in the ultrasound tests between the maggot and wild blueberry suspended in a water bath. However, these results were not as repeatable when a maggot was artificially implanted in a wild blueberry.

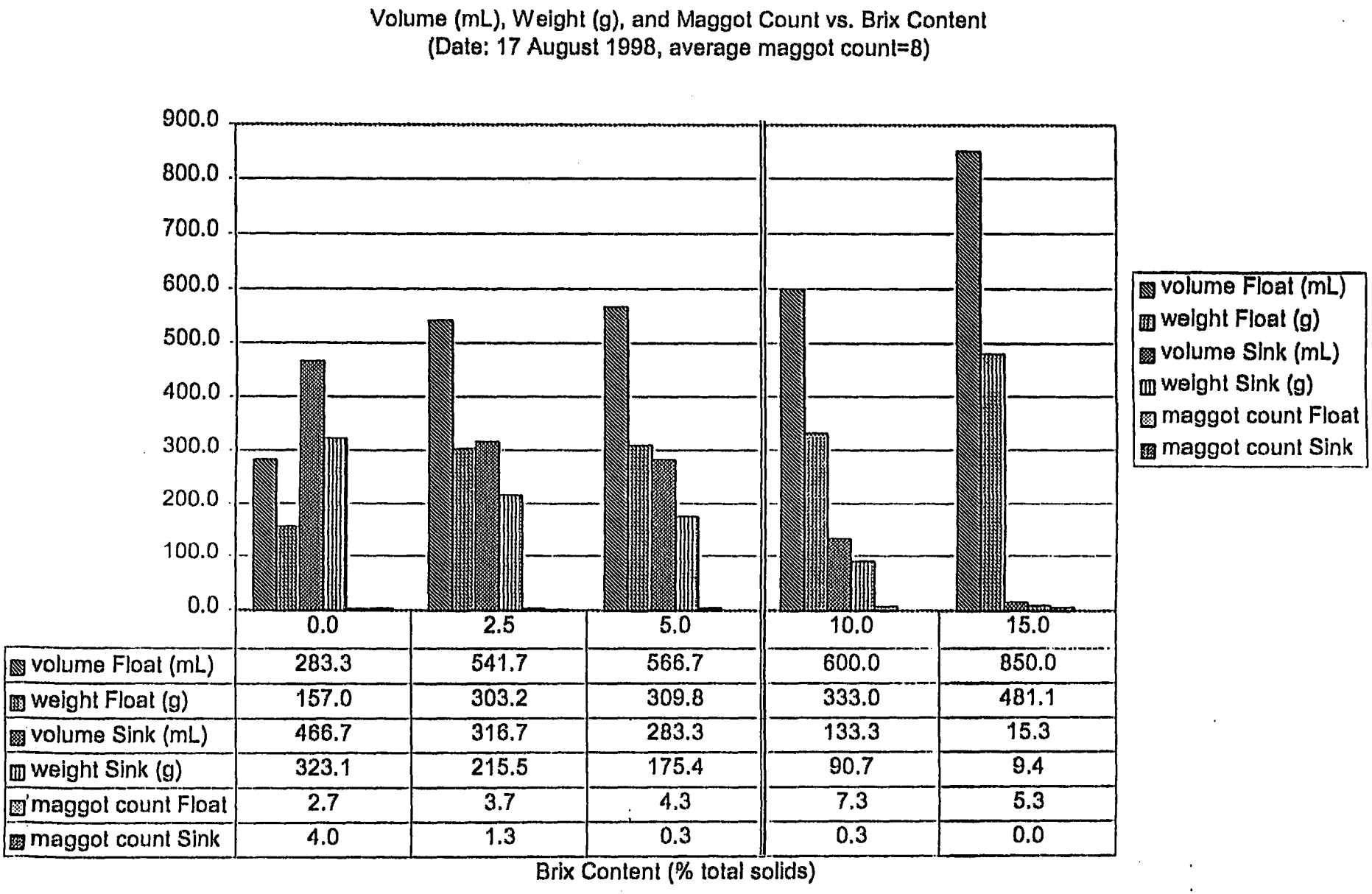
CONCLUSIONS: Based on the results of these preliminary studies, maggot infested blueberries cannot be separated via standard sugar floatation or bouncing methods. Possibilities exist to detect the differences between maggots and wild blueberry internal fluids using specifically attenuating and penetrating sound and light spectra from x-rays, ultrasound and sonograms. If any of these methods are determined viable, these functions can be adapted to the wild blueberry sorter currently employed in most IQF processing plants.

RECOMMENDATIONS: The research team suggests continuing the project during the 1999 field season to investigate further the use of the variation of sound and light spectra to determine if there are wavelengths at which maggots and wild blueberry internal fluid material are distinguishable. Efforts will be made to ensure higher wild blueberry maggot infestation (via artificial infestation) so samples will have a higher percent of maggots. Higher maggot infestation will facilitate better comparisons of maggot and non-maggot infested blueberries.



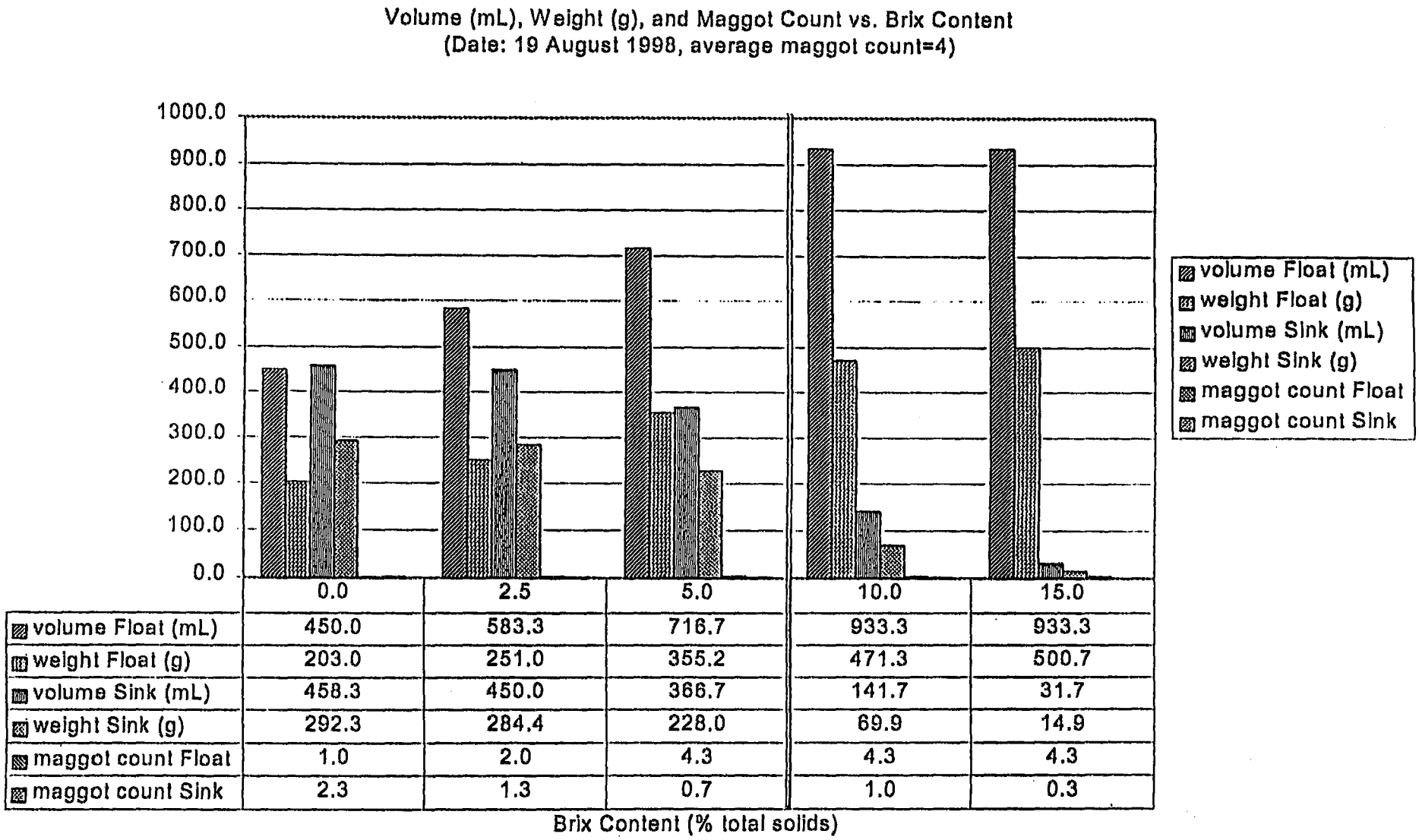
	0.0	2.5	5.0	10.0	15.0
volume Float (mL)	300.0	550.0	650.0	750.0	750.0
weight Float (g)	127.8	217.0	344.8	405.1	430.8
volume Sink (mL)	450.0	450.0	300.0	150.0	12.0
weight Sink (g)	250.8	300.5	180.6	105.3	9.0
maggot count Float	0.0	0.0	3.0	3.0	7.0
maggot count Sink	0.0	1.0	1.0	1.0	0.0

Figure 1. Volume (ml), weight (g) and maggot count by brix count (% total solids) for 14 August 1998 trial (sample baseline maggot count for the trial = 6)



	0.0	2.5	5.0	10.0	15.0
volume Float (mL)	283.3	541.7	566.7	600.0	850.0
weight Float (g)	157.0	303.2	309.8	333.0	481.1
volume Sink (mL)	466.7	316.7	283.3	133.3	15.3
weight Sink (g)	323.1	215.5	175.4	90.7	9.4
maggot count Float	2.7	3.7	4.3	7.3	5.3
maggot count Sink	4.0	1.3	0.3	0.3	0.0

Figure 2. Volume (ml), weight (g) and maggot count by brix count (% total solids) for 17 August 1998 trial (sample baseline maggot count for the trial = 8)



	0.0	2.5	5.0	10.0	15.0
volume Float (mL)	450.0	583.3	716.7	933.3	933.3
weight Float (g)	203.0	251.0	355.2	471.3	500.7
volume Sink (mL)	458.3	450.0	366.7	141.7	31.7
weight Sink (g)	292.3	284.4	228.0	69.9	14.9
maggot count Float	1.0	2.0	4.3	4.3	4.3
maggot count Sink	2.3	1.3	0.7	1.0	0.3

Figure 3. Volume (ml), weight (g) and maggot count by brix count (% total solids) for 19 August 1998 trial (sample baseline maggot count for the trial = 4)

A. FOOD SCIENCE AND BIOSYSTEMS ENGINEERING

INVESTIGATORS: Darrell W. Donahue, Biosystems Science and Engineering
Al Bushway, Food Science and Nutrition
Jack Smagula, Biosystems Science and Engineering

2. **TITLE**: Assessment of pre harvest treatments on wild blueberry fruit quality

OBJECTIVES: Identify the effects of light acid sprays and calcium based solutions on the quality of Maine wild blueberries

METHODS: Clonal selection, preparation and spraying

The work of the study was done on a private grower's field on the Washington Junction Road in Ellsworth, Maine (Merrill Farms). The experiment was discussed with the grower and consensus was formed. Prior to fruit set in early July, seven clones of Maine wild blueberries were selected for assessment with the spray study. The clones were identified, marked and within each clone four subplots were selected 1 m x 1 m in size. Once fruit began to mature (blue hue, based on the judgement of the producer and horticulturist), spraying was initiated. The following treatment solutions were used: 1% calcium chloride, 1% acetic acid, 0.001 mole/L of methyl jasmonate, and a control solution of water.

The solutions were prepared using distilled water on July 20 for the first spray. On July 21, the first spray was performed using a random order assignment of subplots to treatments. Pressurized agricultural sparyers (model 1542, Sears Company, Chicago, Illinois) were used and all sprayers were pumped to approximately the same operating pressure using the standard pumping process. Based on previous sprayer use, there was approximately 60 ml of solution remaining in the spray tank after each use. Therefore, 560 ml of each solution was filled into the spray tanks, the appropriate operating pressure reach via the pumping mechanism, and then the solution was delivered through a standard spray nozzle. The $1m^2$ area was thoroughly covered by the sprayer operator in an overlay pattern. Spray guards, 1.22 m high, were put around the spray area to prevent spray drift onto other subplots. The amount of solution remaining in the sprayers at the end of each spray was recorded. The solutions were mixed again on July 26 and the second spray procedure was performed on July 27. The second spray was done 1 day early than originally planned because of pending weather conditions for July 28.

Harvest and laboratory sample preparation

All clones were hand-rake harvested on August 4. Each subplot was harvested into a typical field tote box and labeled with the subplot number. The samples were transported back to the University of Maine (UMaine) Biological Engineering Laboratory for further testing. From each field box four samples were taken aseptically. First, thirty individual berries were randomly selected for an initial force test. In addition, 3 pint clam-style containers (approximately 280 g) were filled from the harvested sample for shelf-life studies. These samples were transferred to a

laboratory cooler for shelf-life storage and were held at 4-5° C for the remainder of the shelf-life period.

Firmness measurements

Twenty berries of the initially selected berries were subjected to a compression test as described in the ASAE standard S368.3 MAR95 (ASAE 1995). The test sequence was automated using a FirmTech1 testing machine from BioWorks, Incorporated (model: FirmTech1, Stillwater, OK) In addition, five berries were used to perform a composite compression test with the Instron materials testing machine (Model 4466, Instron Corporation, Canton, MA), following the aforementioned ASAE standard, with the following modification. Five berries, approximately the same size, were placed in a star configuration on a plate and placed on the Instron test surface. The compression test was started and continued until all berries were crushed. Force and deformation were electronically recorded using the Series IX software® by Instron. The Instron test was performed in duplicate and paralleled with the samples tested with the FirmTech1. The modification in the procedure was examined as a method to determine average berry firmness that might be faster than the single berry test as done with the FirmTech1 instrument (see Donahue and Work 1998, Donahue et al.1998). The initial firmness tests as described above were performed and then repeated once each week for three weeks.

Microbiological analysis

Fifty gram samples of blueberries from each treatment were weighed into Stomacher bags, 450 ml of 0.1% Bacto-peptone was added and the contents were massaged for 2 min. Appropriate serial dilutions were prepared in 0.1% Bacto-peptone and were plated in duplicate on Plate Count Agar (PCA) for total aerobic plate counts and on Acidified Potato Dextrose Agar (PDA) for yeast and molds. PCA and PDA plates were incubated at 22-24° C for 2 and 5 days, respectively. Colonies were counted and recorded as colony forming units/g of blueberries (CFU/g).

Anthocyanin Leakage (Leakage) Test

Anthocyanin leakage was measured by the method of Sapers and Phillips (1985) with modification. Thirty grams of berries were suspended by nylon screen (Charcoal Fiberglass, Phifer Wire Products, Inc, AL) in a 300 ml glass beaker. One hundred ml of buffer (potassium hydrogen phthalate, pH 3.0, Fisher Scientific Co., GA) were used as the extraction solution. A magnetic stirring bar was placed at the bottom of the beaker. Samples were submerged into the solution that was stirred for 10 min at a speed of 8 rpm on the magnetic stirrer (Fisher Thermix, Fisher Scientific Co., MA). Extract was vacuum filtered through Whatman No. 1 paper (Whatman Co., Atlanta, GA). Absorption of the extract was measured at 525 nm using a Beckman Spectrophotometer (DU-64 Spectrophotometer, Beckman Instruments, Inc., CA). Delphinidin-3-glucoside is the major pigment in blueberries, but it has a low molar absorbance, therefore based on Wrolstad's suggestion (1976), the total anthocyanin leakage of blueberries was calculated in terms of malvidin-3-glucoside (MW = 493.5) by Beer's Law (extinction

coefficient = 28,000).

RESULTS: A visual inspection of the fields during spraying found that all clones treated with calcium chloride spray turned the leaves reddish, probably an ionic effect of the residual chlorine causing plant stress. The results of the compressive tests show no significant differences ($p \leq 0.05$) between the spray treatments. The results of the microbiological analysis and anthocyanin leakage test results show no significant differences ($p > 0.05$) between the spray treatments. There were significant differences ($p \leq 0.05$) in both sets of data among clones. This indicates that the variation among clones masks other treatment effects.

Figures 1 through 6 give the results in graphical form in measured variable count versus treatment by week. Molds (CFU/g) tend to increase over the shelf-life period. There is no discernable pattern in the aerobes count (CFU/g) over the shelf-life period or by treatment. Yeast count (CFU/g) increased until week three and then leveled off to week four because of competition. The anthocyanin leakage was higher in the citric acid treatment, an effect of acid leaking out pigments from the berries. Overall results show trends of peak force and berry firmness increasing during the shelf-life study.

CONCLUSIONS: Field spraying of solutions has no effect on the fresh-pack quality of Maine wild blueberries. While these particular solutions have been proven effective on other small fruits when used, results here indicated there were no benefits of using citric acid, calcium chloride or methyl jasmonate for pre-harvest treatment of Maine wild blueberries.

RECOMMENDATIONS: The recommendation of the research team is to no longer investigate the use of these pre-harvest treatments to sustain or improve fresh-pack quality. If feasible, research to study the effects of the post-harvest application of these solutions can be initiated. However, at the present time this option seems not practical.

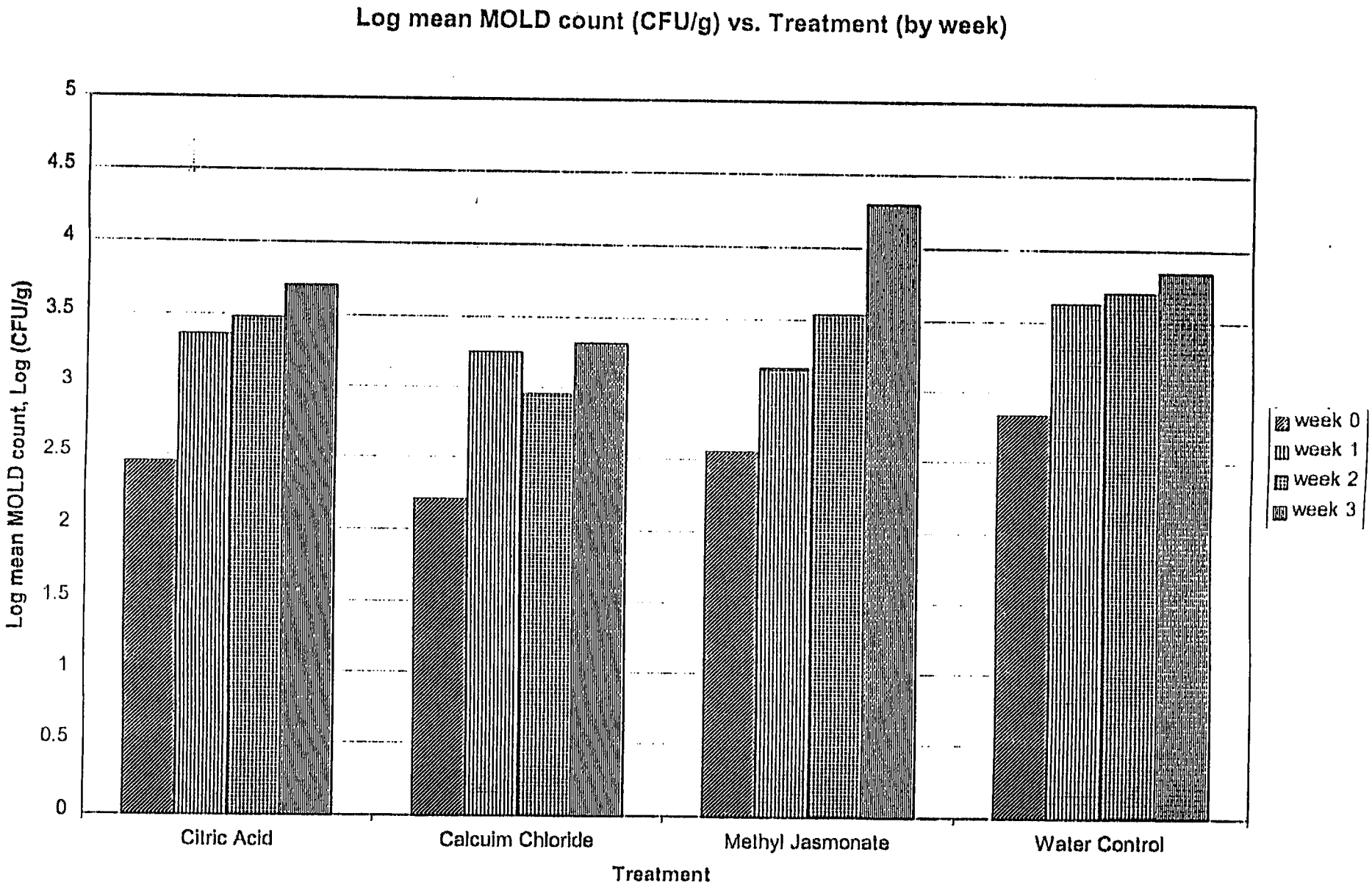


Figure 1. Log mean mold count (CFU/g) versus treatment by week

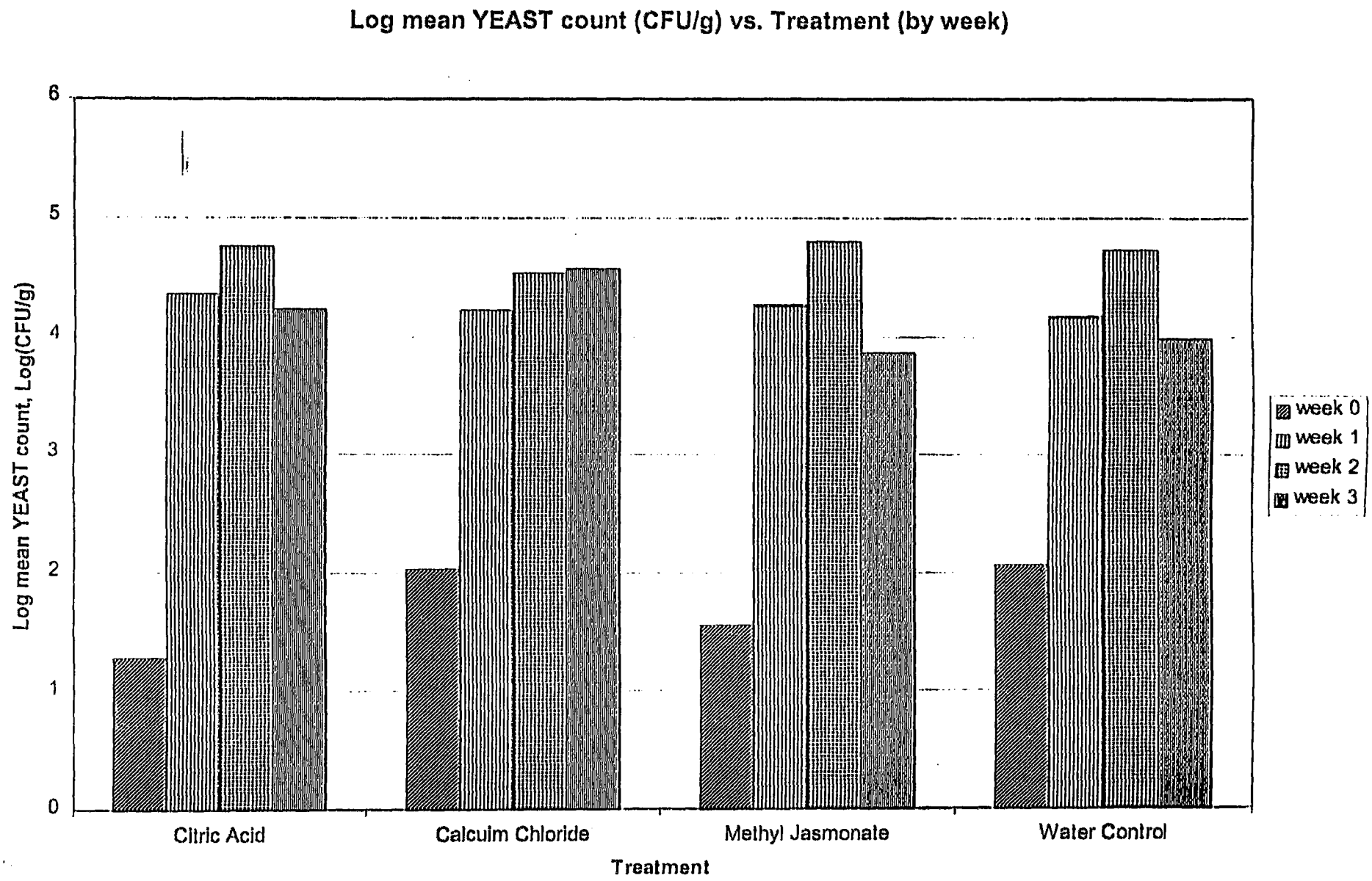


Figure 2. Log mean yeast count (CFU/g) versus treatment by week

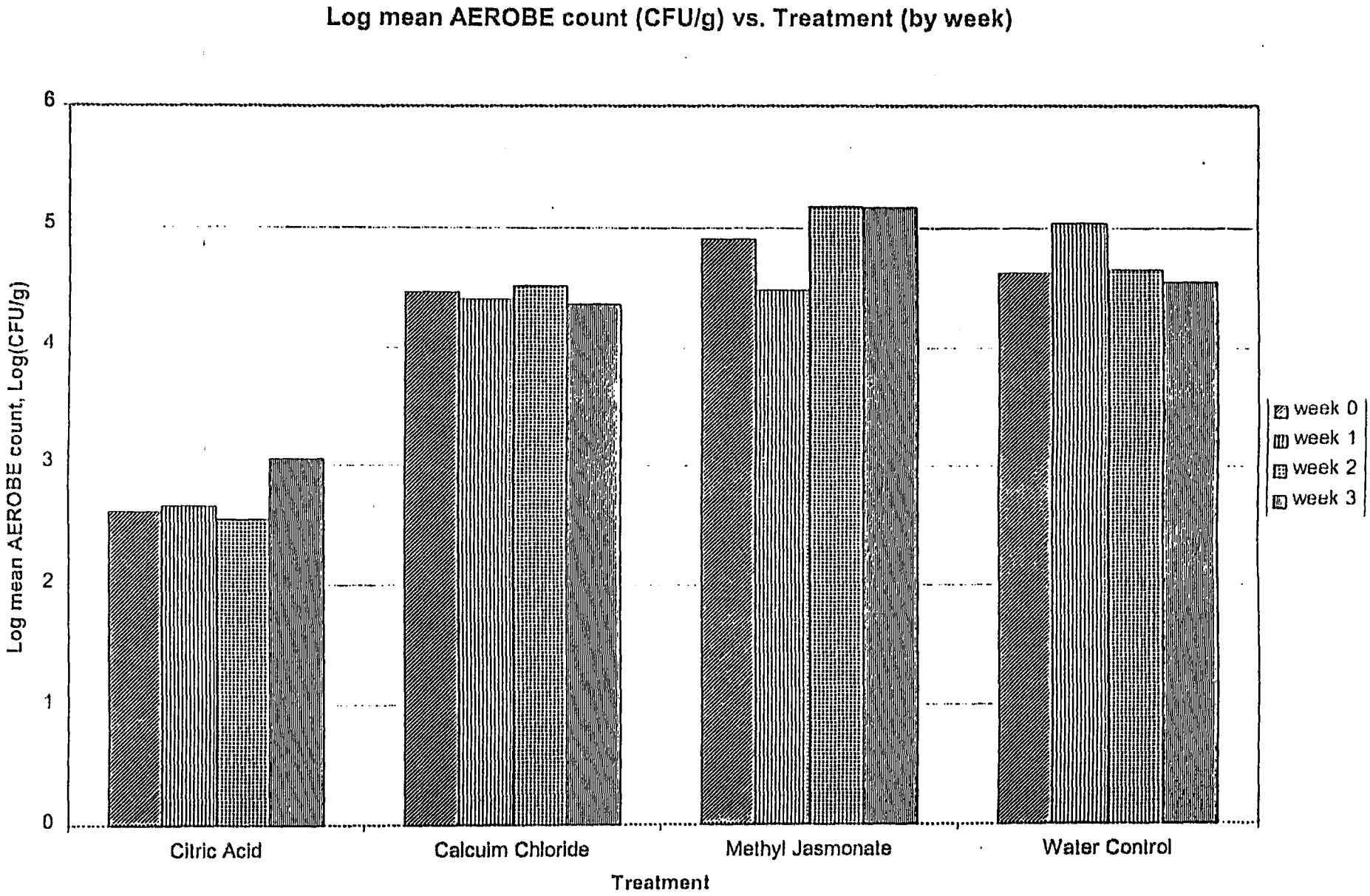


Figure 3. Log mean aerobe count (CFU/g) versus treatment by week

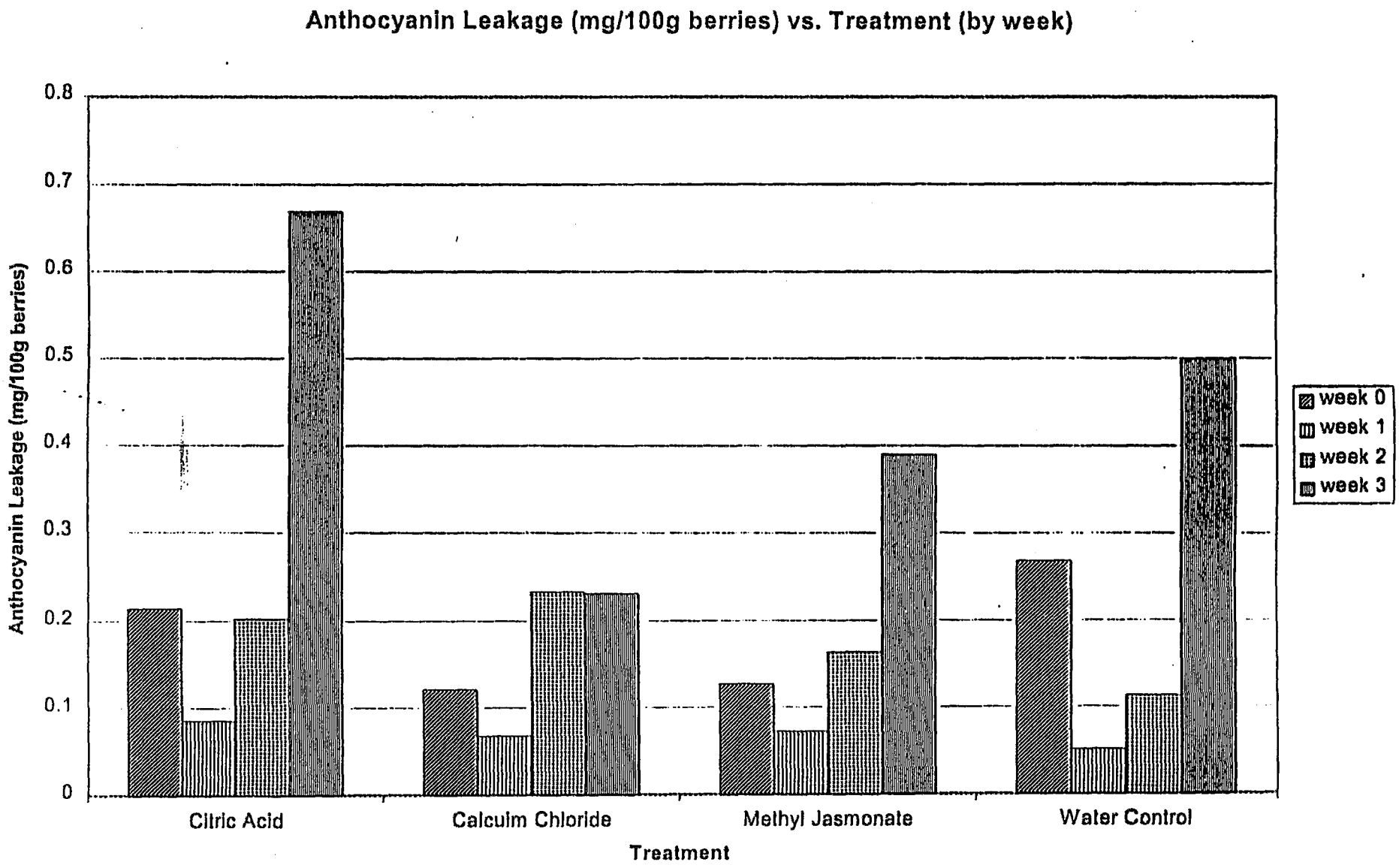


Figure 4. Anthocyanin leakage (mg/100g berries) versus treatment by week

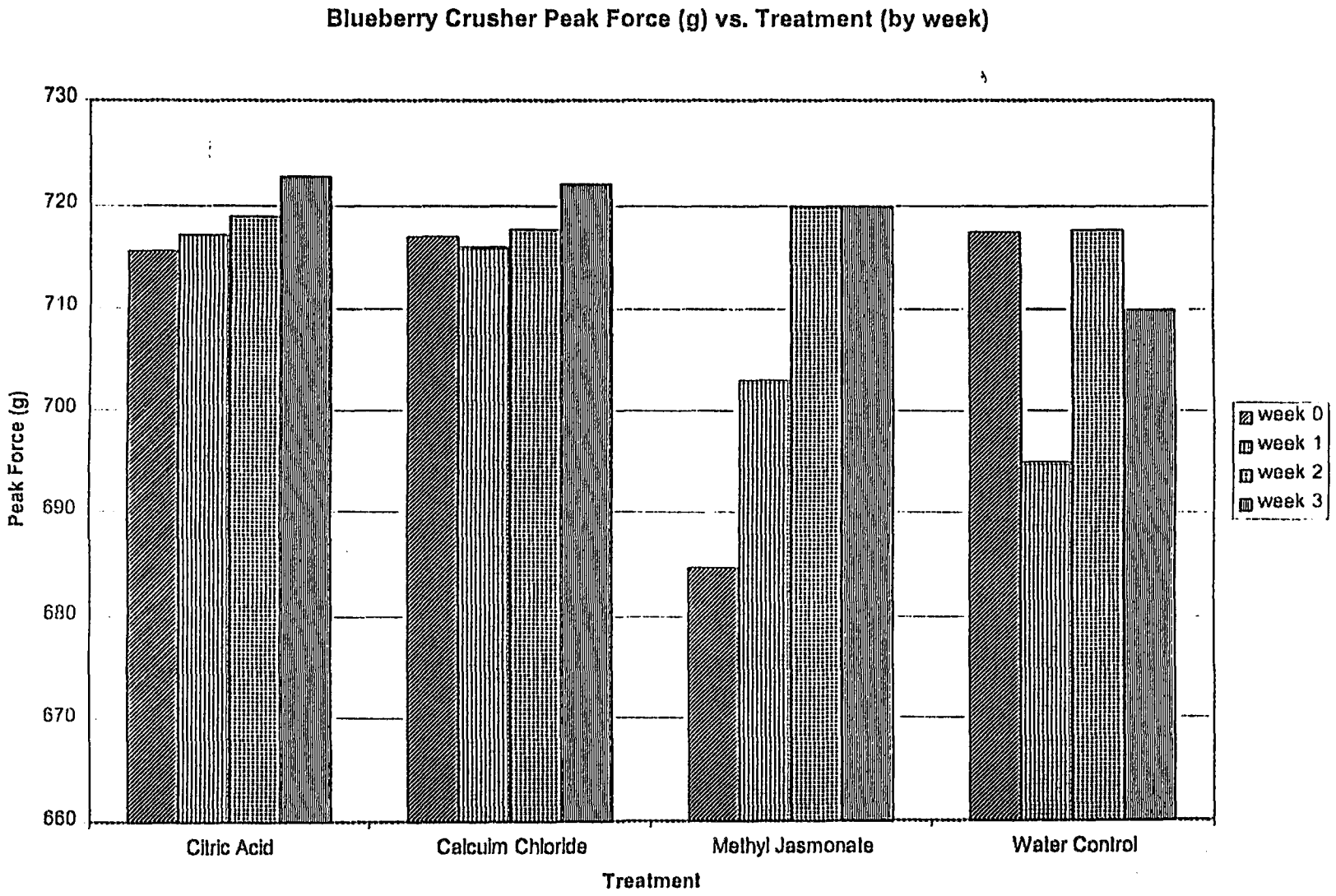


Figure 5. Blueberry peak force required for crushing (g) versus treatment by week

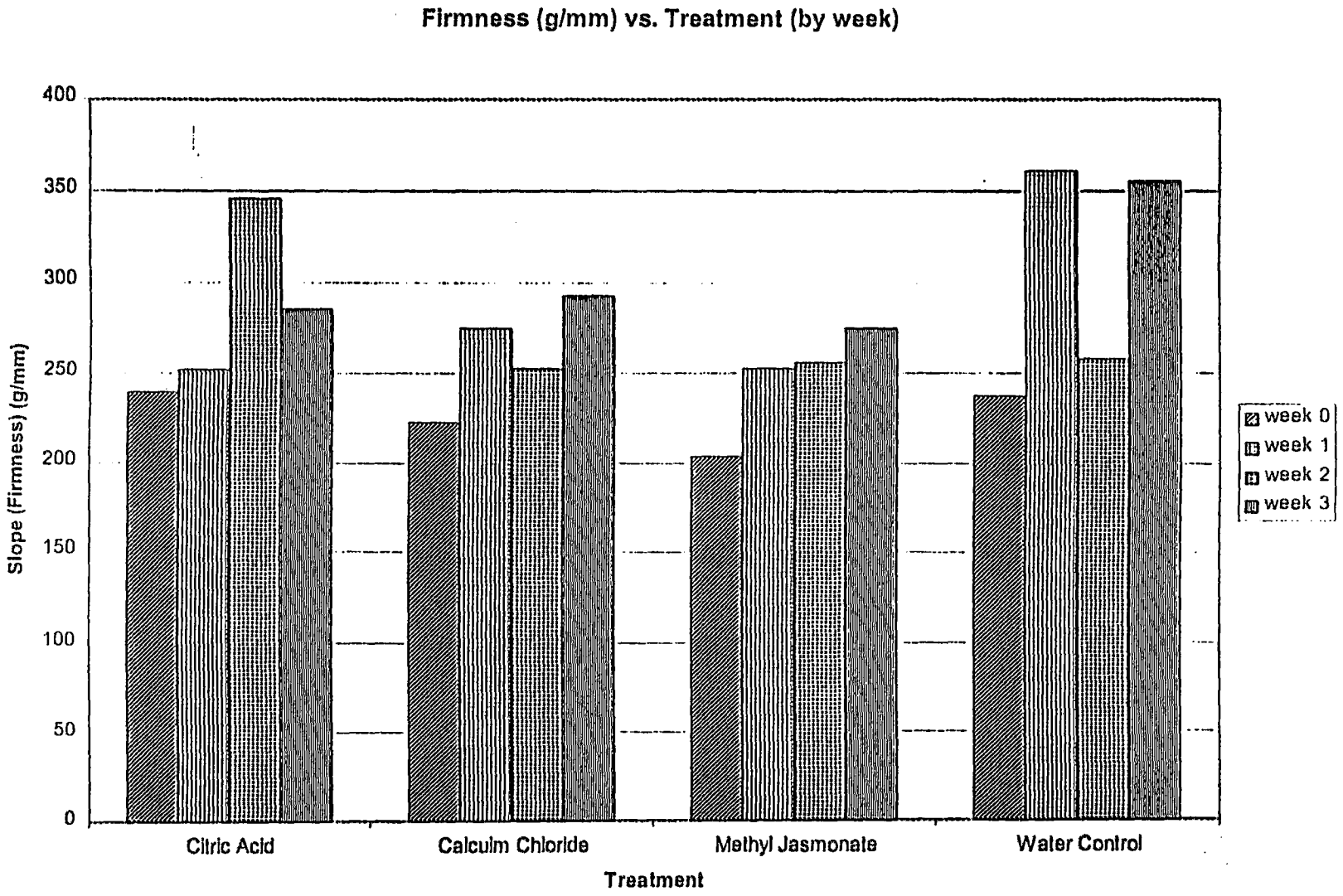


Figure 6. Firmness (slope, g/mm) versus treatment by week

Blueberries as a Natural Colorant for Breakfast Cereals

Mary Ellen Camire
Dept. of Food Science & Human Nutrition

Current Status

Puree as a colorant

Blueberry puree was mixed with commeal and extruded in a Brabender single screw extruder. The resulting cooked product had a slight purple color, but browning was excessive. Since the puree used was not pasteurized, berry enzymes remained active. The enzymes transformed colorless phenolic compounds into brown compounds. The color change was rapid and occurred before extrusion cooking. Although pasteurization immediately after pureeing berries could inactivate the enzymes, there are other problems associated with the use of puree in cereals.

The most efficient method for mixing puree with grains for extrusion is the use of a metered pump. The narrow diameter of most pumps is easily clogged. The numerous small seeds and pieces of skin in puree can be serious limitations for this application. Seeds and other solids could be removed by straining, but much of the anthocyanin pigment is concentrated in the skin, this is not practical. Finally, the high moisture content of puree (>80%) limits the amount of blueberry color. Since it is difficult to extrude food mixtures with moisture contents over 30%, only a small amount of puree can be used in an extruded cereal. Therefore, further research will not use puree.

Blueberry concentrate

Cereals colored with blueberry concentrate at a level of 17% were produced on a small twin screw extruder at the U.S. Army Research, Development, and Engineering Center in Natick, MA. Ascorbic acid (vitamin C) was added at levels of 0.1 and 1.0%. Other scientists have found that anthocyanins were damaged first during high temperature processing in order to save ascorbic acid. We hoped that excess ascorbic acid might "protect" anthocyanins during extrusion. Unfortunately, vitamin C had no effect on anthocyanin retention. All three cereals - with 0.0, 0.1, or 1.0% vitamin C- had an approximate 70% loss in anthocyanins due to processing. The color of the sample with 1.0% vitamin C was significantly more red than the sample without the vitamin. The cereals with added vitamin C also had a greater polymeric color and contribution of tannin to color, suggesting that large, dark polymers were formed.

The cereals were smaller and harder than similar cereals produced at the same time that contained only commeal and sugar, somewhat like a Corn Pop®. A consumer panel rated the cereal with blueberry concentrate and 0.1% ascorbic acid "just right" for color and hardness. The consumer rating indicated that more sweetness (Figure 1) and less tart flavor were needed. This preliminary study demonstrated that an acceptable breakfast cereal can be produced with blueberry concentrate.

This research will be submitted for presentation at the annual meeting of the Institute of Food Technologists in July, 1999.

Product comparison

In January, the final experiment will be started. Corn-based cereals will be made with blueberry concentrate, blueberry "spent", and grape juice concentrate. Physical properties such as color, expansion and hardness will be evaluated in addition to chemical measurement of anthocyanins. Parents who purchase cereal for their children will be recruited to taste the cereals. The parents will be informed that the products are colored with naturals fruit pigments and that anthocyanins have many health benefits. Sensory researchers have found that consumers view "healthy" products more favorably when informed of the health benefits of the products before evaluating them. Pigment changes in storage will also be studied. The project should be completed by June. Results will be presented at the American Association of Cereal Chemists meeting in October, 1999.

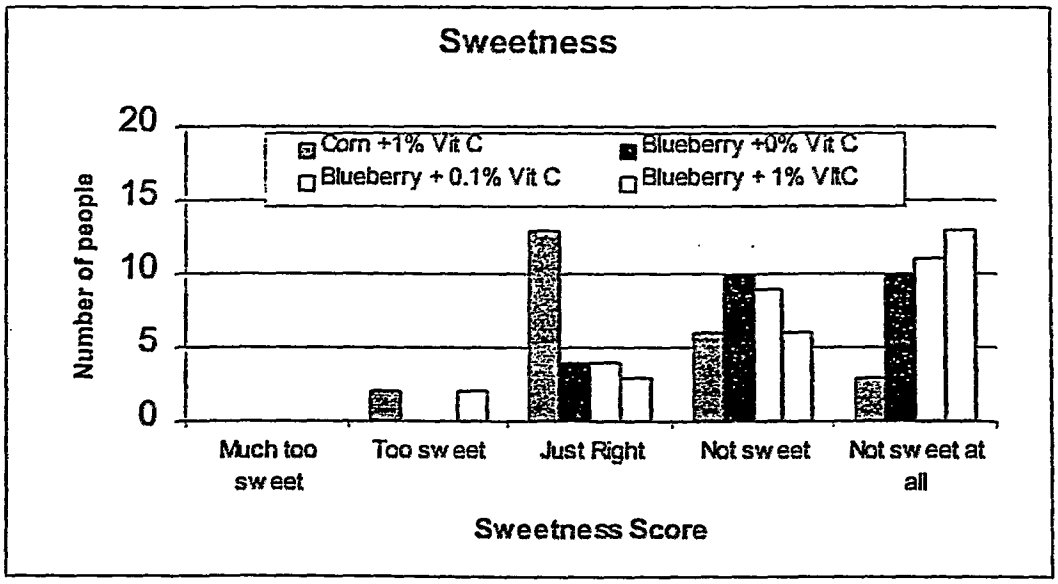


Figure
1. Consumer ratings of corn cereals containing blueberry concentrate and vitamin

A. FOOD SCIENCE AND BIOSYSTEMS ENGINEERING

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

TITLE: Factors affecting the quality of IQF blueberries

METHODS: Blueberry samples were taken from various locations during processing in order to determine where reductions or increases in microbial numbers occurred. Points identified were (1) prior to initial water wash (2) following water wash (3) following sugar floatation (4) following chlorine rinse (5) after freezing for the sugar floatation line. When sugar floatation was not used the points were (1) prior to initial wash (2) following water wash (3) following chlorine rinse (4) after freezing. Three samples were taken at each point twice during the harvest season (early and late). Samples were transported on ice to the Department of Food Science and Human Nutrition and analyzed for total aerobic plate count, yeasts, molds, coliforms and *E. coli*. Appropriate serial decimal dilutions were prepared and samples plated in triplicate. Total aerobic plate counts were performed using Plate Count Agar. Yeasts, molds, coliforms and *E. coli* were enumerated according to Standard Methods (FDA, Bacteriological Analytical Manual, 7th ed., 1992). Rainbow Agar 0157 (Biolog, Inc., Haywood, CA) was used to screen *E. coli* positive samples for verotoxin-producing strains of *E. coli*, particularly serotype 0157:H7. Suspicious colonies were further evaluated by Affiliated Laboratories, Inc., Bangor, ME.

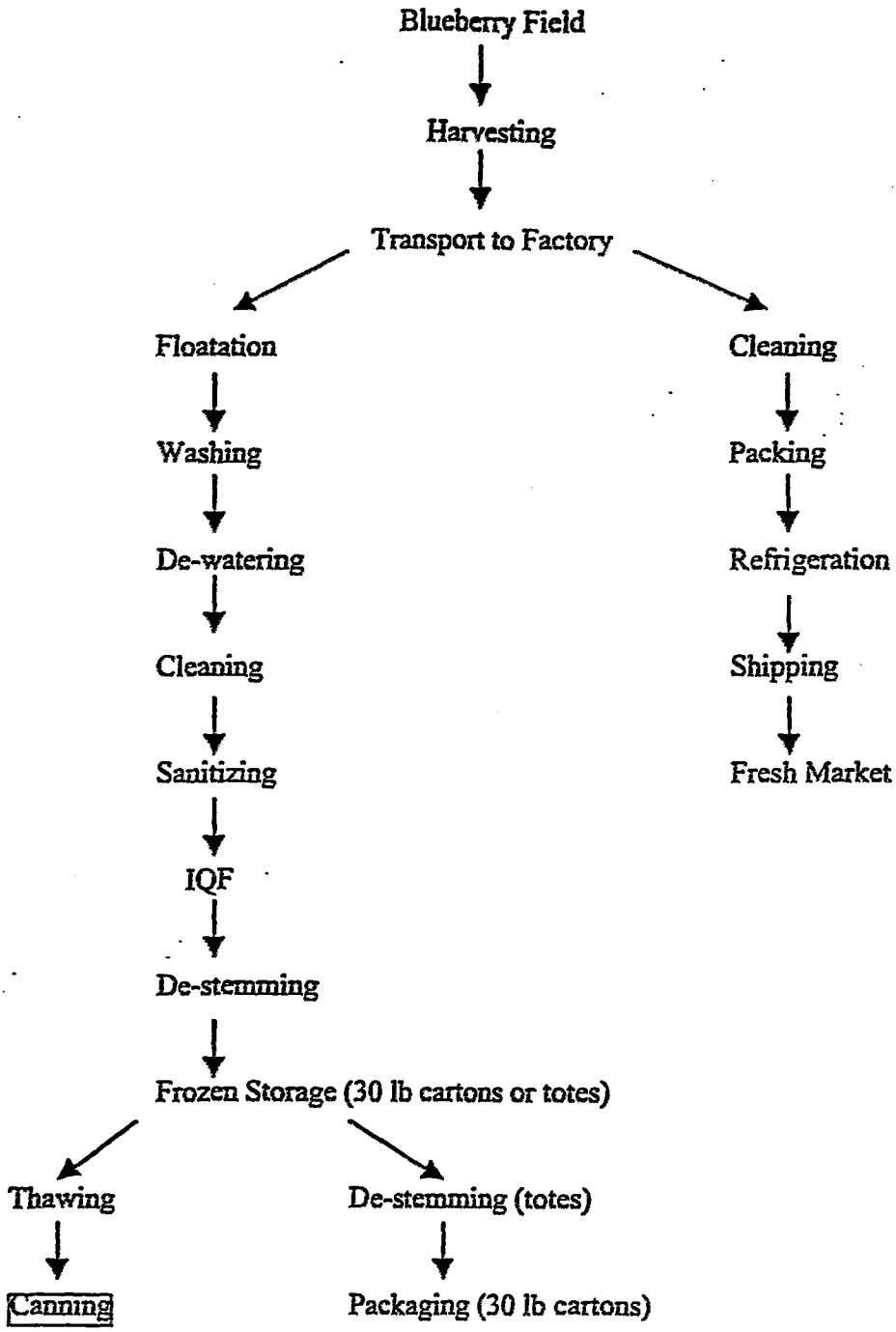
A microbiological risk assessment of the blueberry industry was completed to determine which established and emerging microorganisms could be potential problems for the industry.

RESULTS: The results from the risk assessment are provided in the following document. The steps in processing where microbiological hazards could be a problem were identified, and methods to control, reduce or eliminate these hazards were provided.

Results from the microbial analyses demonstrated a 3-4 log reduction in total aerobes as a result of processing (Figures 1 and 5). Similar results were seen with yeasts and molds (Figures 2 and 3). The greatest reduction occurred following freezing. Of the eighteen process line locations sampled (Table 1), nine were found to contain *E. coli* (Figure 4). Of the four samples taken after chlorination two were positive for *E. coli*. However, none of the final frozen samples tested positive. Ten isolates from Rainbow Agar 0157 were sent for toxicological screen. Of the ten samples screened, only two were *E. coli*, and neither were toxin producing. Results from the sugar floatation line indicate that microbial levels may increase on fruit following this procedure.

Wild Blueberry Processing

University of Maine-Wild blueberries



Critical Control Point

Biological Hazard Analysis Worksheet

Fresh Market

Ingredient or Processing Step	*Identify potential hazard introduced, controlled or enhanced at this step*	*Are any potential hazards significant? (Yes/No)*	*Justify your decision for preceding column*	*What preventive measures can be applied to prevent the significant hazard?*	*Is this step a critical control point? (Yes/No)*
Harvesting	Bacterial pathogens	Yes	In addition to contamination by wild animals and birds, workers can also be responsible for contamination	Although workers can be provided with sanitation equipment, no control possible over wild animals and birds	No
Transport	Bacterial pathogens	Yes	Any contamination that occurred in the field will now be spread among the berries	Sanitizing containers used in transport can reduce the spread of the pathogens	No
Cleaning	Bacterial pathogens	Yes	Cleaning may reduce to some extent gross contamination, but it will not effectively remove pathogens	Since better quality product is selected for this process line, it may be selective for less contaminated product; ozonation could be explored as a controlling factor	No
Packing	Bacterial pathogens	Yes	No processing step to this point effectively reduces pathogens that may be present	No preventive measures can be applied, except that perhaps >time= is a desirable factor, since pathogens will be dying slowly	No
Refrigeration	Bacterial pathogens	Yes	No processing step to this point effectively reduces pathogens that may be present	No preventive measures can be applied, except that perhaps >time= is a desirable factor, since pathogens will be dying slowly	No
Shipping	Bacterial pathogens	Yes	No processing step to this point effectively reduces pathogens that may be present	Refrigeration may favor reducing bacterial pathogens, since fruits are not conducive to the growth of enteric bacteria	No
Fresh Market	Bacterial pathogens	Yes	No processing step to this point effectively reduces pathogens that may be present	Berries used by consumer in heated recipes as sauces and baked recipes will essentially be >pasteurized=, otherwise pathogens will survive	No

Biological Hazard Analysis Worksheet

Frozen Market & Canning

Ingredient or Processing Step	*Identify potential hazard introduced, controlled or enhanced at this step*	*Are any potential hazards significant? (Yes/No)*	*Justify your decision for preceding column*	*What preventive measures can be applied to prevent the significant hazard?*	*Is this step a critical control point? (Yes/No)*
Harvesting	Bacterial pathogens	Yes	In addition to contamination by wild animals and birds, workers can also be responsible for contamination	Although workers can be provided with sanitation equipment, no control possible over wild animals and birds	No
Transport	Bacterial pathogens	Yes	Any contamination that occurred in the field will now be spread among the berries	Sanitizing containers used in transport can reduce the spread of the pathogens	No
Cleaning	Bacterial pathogens	Yes	Cleaning may reduce to some extent gross contamination, but it will not effectively remove pathogens	Since better quality product is selected for this process line, it may be selective for less contaminated product; ozonation could be explored as a controlling factor	No
Sugar Floatation	Bacterial pathogens	Yes	Floatation process may initially reduce bacterial population, but thereafter the buildup is very rapid	No preventive measures can be easily applied here	No
Washing	Bacterial pathogens	Yes	Washing may remove a large portion of bacteria and possible pathogen, but this step can not be considered effective control	No preventive measures can be easily applied here	No
De-watering	Bacterial pathogens	Yes	De-watering may reduce bacterial load further and therefore also some pathogens	Not an effective step in controlling hazard	No
Cleaning	Bacterial pathogens	Yes	Many pathogens that were initially present will continue to persist	No preventive measures	No
Sanitizing	Bacterial pathogens	Yes	Substantial reduction in bacterial and pathogen population is expected, but it does not compare with pasteurization	Effectiveness in eradication pathogens depends on sanitizer=s contact and dwell time; effectiveness must be evaluated	No
IQF	Bacterial pathogens	Yes	Freezing is not a method of destroying bacteria, although it causes some mortality	No preventive measure	No

Frozen Market & Canning (continued)

Ingredient or Processing Step	*Identify potential hazard introduced, controlled or enhanced at this step*	*Are any potential hazards significant? (Yes/No)*	*Justify your decision for preceding column*	*What preventive measures can be applied to prevent the significant hazard?*	*Is this step a critical control point? (Yes/No)*
De-stemming	Bacterial pathogens	Yes	This processing step is not likely to increase bacterial population, although release of juice may occur	Ozonation could be used in this step as a pathogen controlling factor	No
Frozen Storage	Bacterial pathogens	Yes	Freezing is not a method of destroying bacteria, although it causes some mortality	No preventive measures	No
Re-packaging	Bacterial pathogens	Yes	SSOP will prevent additional contamination of the berries	Ozonation could be used in this step as a pathogen controlling factor	No
Frozen Market	Bacterial pathogens	Yes	Live pathogens may still be present	Berries used by consumer in heated recipes as sauces and baked recipes will essentially be >pasteurized=, otherwise pathogens survive will	No
Thawing	Bacterial pathogens	Yes	Live pathogens may still be present	No preventive measures	No
Canning	Bacterial pathogens	Yes	Live pathogens may still be present	Canning involves a thermal process which will destroy all vegetative cells of pathogens	Yes

Fresh berries B

- Contamination in the wild by birds and possibly by field animals. The pathogens may include *Salmonella* and *Listeria monocytogenes* and possibly *E. coli* O157:H7. Contamination with other pathogens to a smaller extent may also occur (*Aeromonas hydrophila, Plesiomonas shigelloides, Yersinia enterocolitica*).
- While Gram negative microorganisms die off at a known rate, Gram positive microorganisms disappear at somewhat slower rate.
- Not knowing when contamination occurred, the worst possible case would be contamination shortly before harvesting.

Harvesting B

- Contamination during harvesting will occur by contaminated equipment.
- Equipment that became contaminated during harvesting will spread the contaminant thereafter.
- Workers with poor sanitary habits can be a source of contamination.

Transport to plant B

- Collecting bins that become contaminated during storage will be a source of contamination of the fresh harvest.
- Collecting bins can be contaminated during harvesting with contaminated berries, spreading the contaminant thereafter.
- Pathogens involved may include *Salmonella* sp., *Listeria monocytogenes*, *E. coli* O157:H7, *Aeromonas hydrophila, Plesiomonas shigelloides,* and *Yersinia enterocolitica.*

Cleaning B

- Selecting the better quality berries for the fresh market as well as cleaning the product may result in less contaminated fruit going to this market, however, this step by itself does not mean absence of pathogens.
- Ozonation could be considered for use to >sanitize= the product without physical alteration of the berries, but the process must be evaluated in its sanitizing efficiency and its effect on the quality of the product.

Refrigeration B

- Fruit surfaces are not exceptionally conducive to growth of food pathogens, in fact, such pathogens will in majority of cases die off slowly.
- Refrigeration is expected to cause a decrease in the survival rate of pathogens on fruit surfaces.
- Survival rate of food pathogens on blueberry surfaces is not available.
- Damaged berries will exude juices in which bacteria will become embedded. Survival of pathogens in such an environment is not known.

Floatation, Washing, and De-watering B

- Floatation, washing, and de-watering the berries will physically remove some microorganisms and with them some pathogens.

- If the floatation solution or wash water are recycled, a buildup of bacteria in the liquid will be very rapid. Thus what may initially serve as reduction in bacterial numbers, will very rapidly become a source of heavy contamination.
- A brief, even a very brief spry rinse after the washing or de-watering step will be extremely effective in reducing bacterial load significantly.

Sanitizing B

- Chlorine rinse will be very effective in destroying microorganisms and with them a good number of pathogens.
- Efficiency depends on actual contact of chlorinated water with bacteria on fruit surface and the dwell time.
- Chlorinated water is applied as a spray, thus acting as a sanitizer and a rinse, but the effect of dwell time must be evaluated.
- Most fruits are coated with waxes, which prevent thorough wetting of the surface. This characteristic may be a disadvantage and the use of wetting agents should be considered.
- It may be especially difficult to effectively wet the calyx area.
- Other sanitizers that are worth examining are: ozone, chlorine dioxide, hydrogen peroxide.
- The effect of sanitizers on blueberry pigments should be examined.

Freezing B

- Freezing causes some loss of bacterial viability, but it is not an effective way of destroying pathogens or spoilage microorganisms that may be present.
- Frozen bacterial cells are in a state of suspended animation and will probably die off slower than when they are refrigerated. However, specific examples for blueberries are not known.

Canning B

- Canning of fruits involves a thermal process which is very detrimental to vegetative cells, because of the high acidity of the product.

RECOMMENDATIONS:

- For long range risk management, a monitoring program would be highly advisable. Such monitoring could involve half a dozen permanent sampling plots in several fields in different locations (near woods and streams, shaded and open areas Y). These plots should be sampled in triplicate once to three times annually for Total Viable Count, yeast, molds, *E. coli*, hemorrhagic *E. coli*, *Salmonella*, and *Listeria monocytogenes*. As long as the presumptive tests for pathogens are negative, the cost of the analysis at UM laboratory would be minimal.
- Two methods for detecting *E. coli* O157:H7 are examined in J. Food Prot. *61*, 110-112 (1998).

Figure 1: Average Aerobes/g at Points Sampled

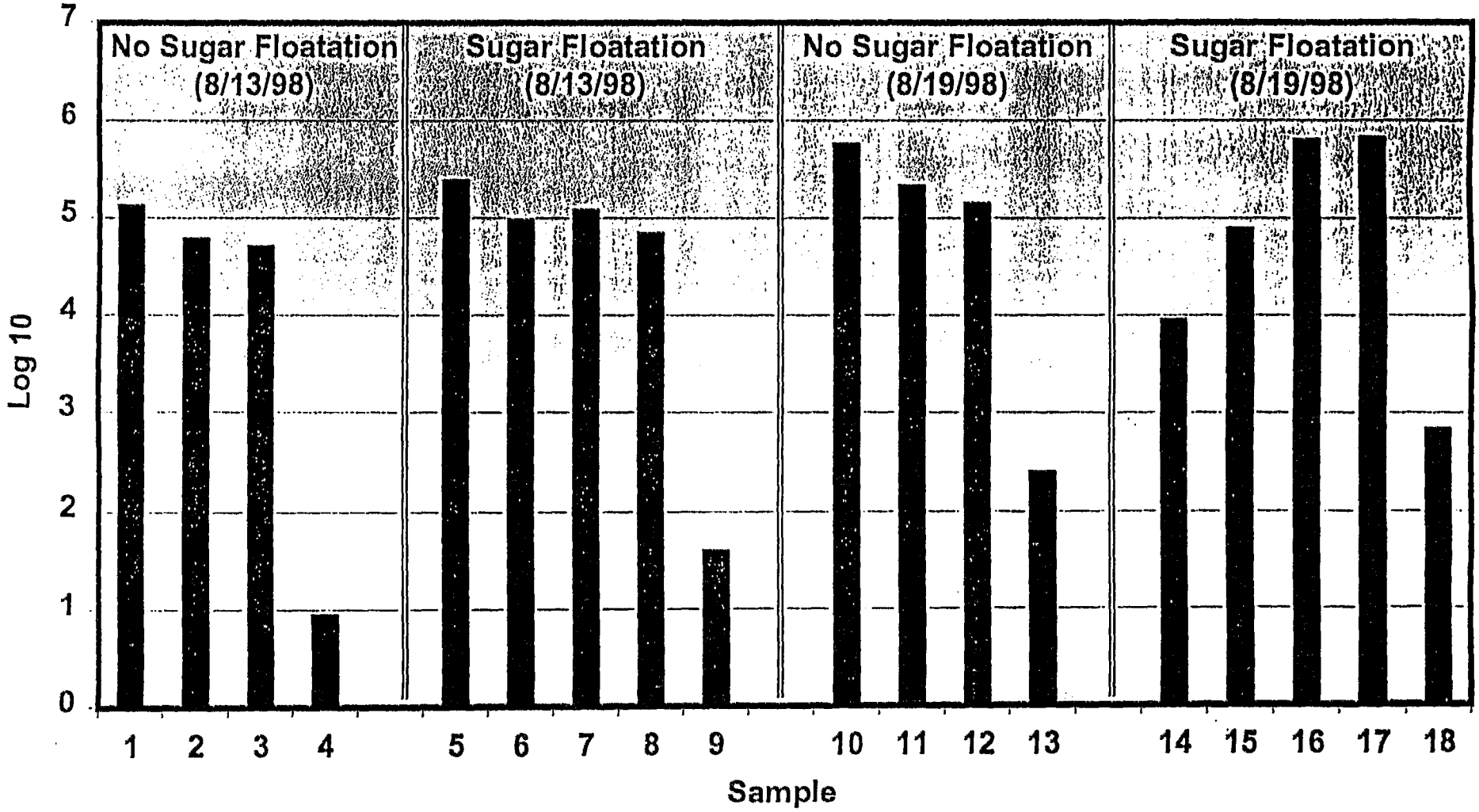


Figure 2: Avg yeasts/g

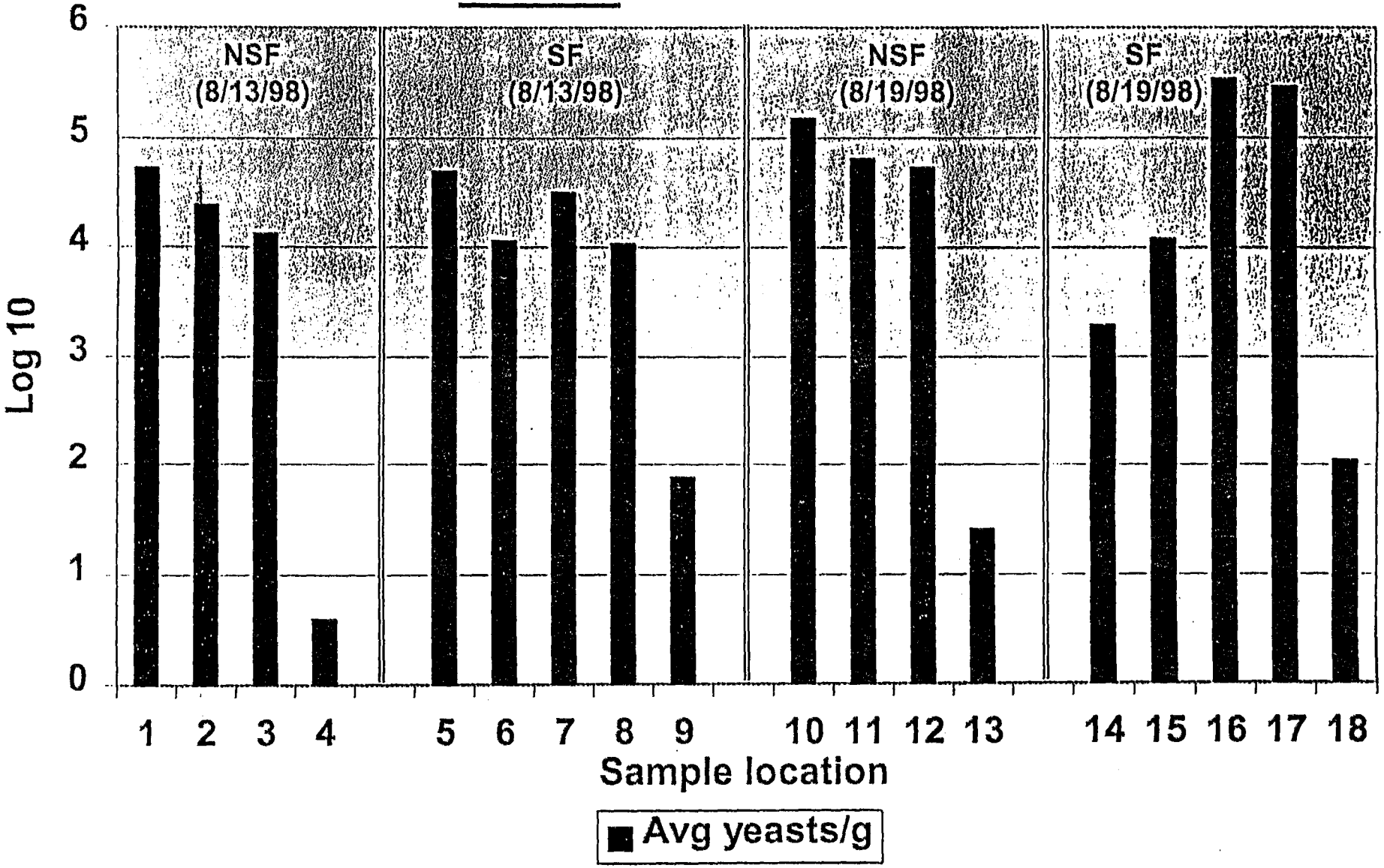


Figure 3: Avg molds/g

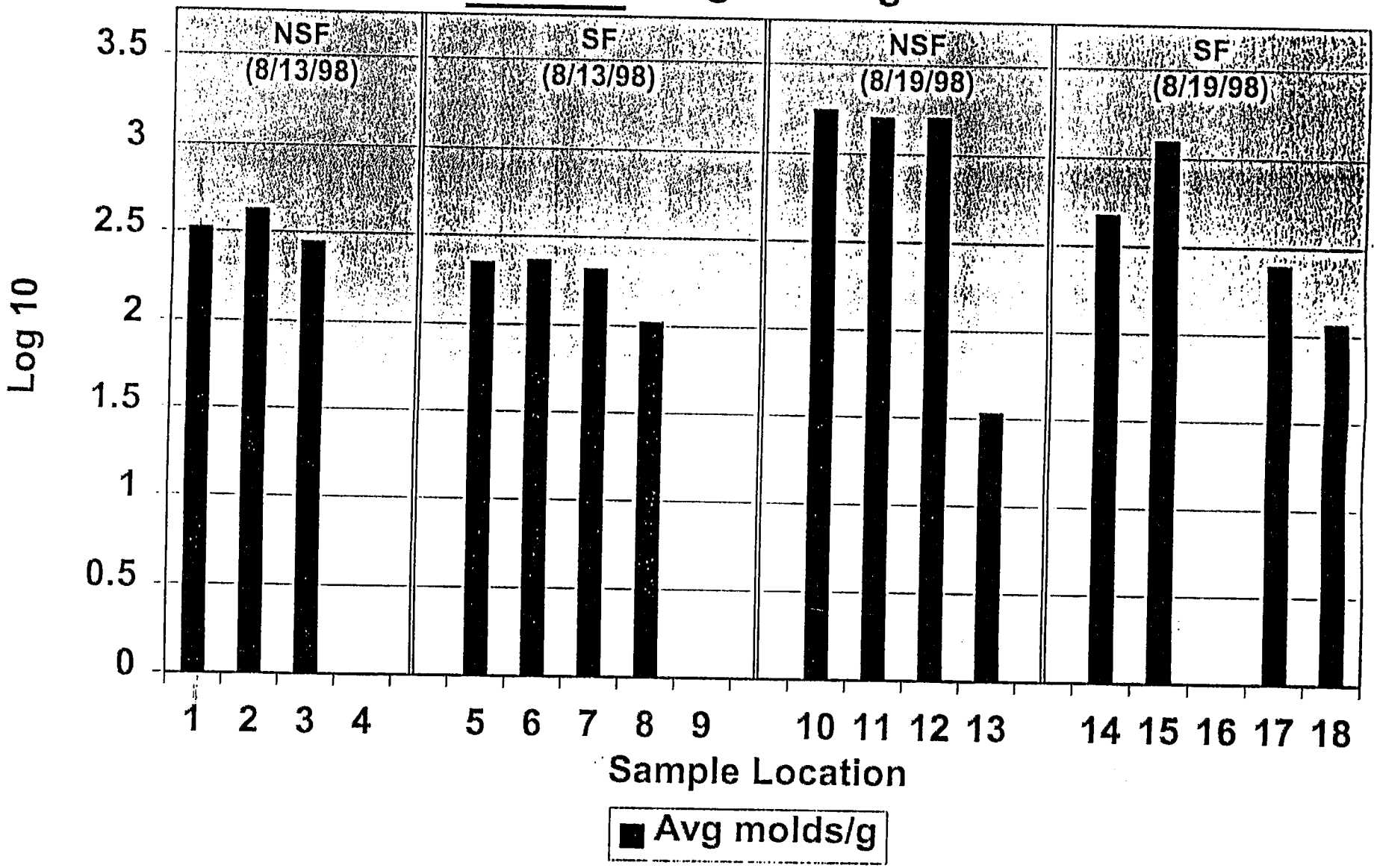


Figure 4: Average Counts/g

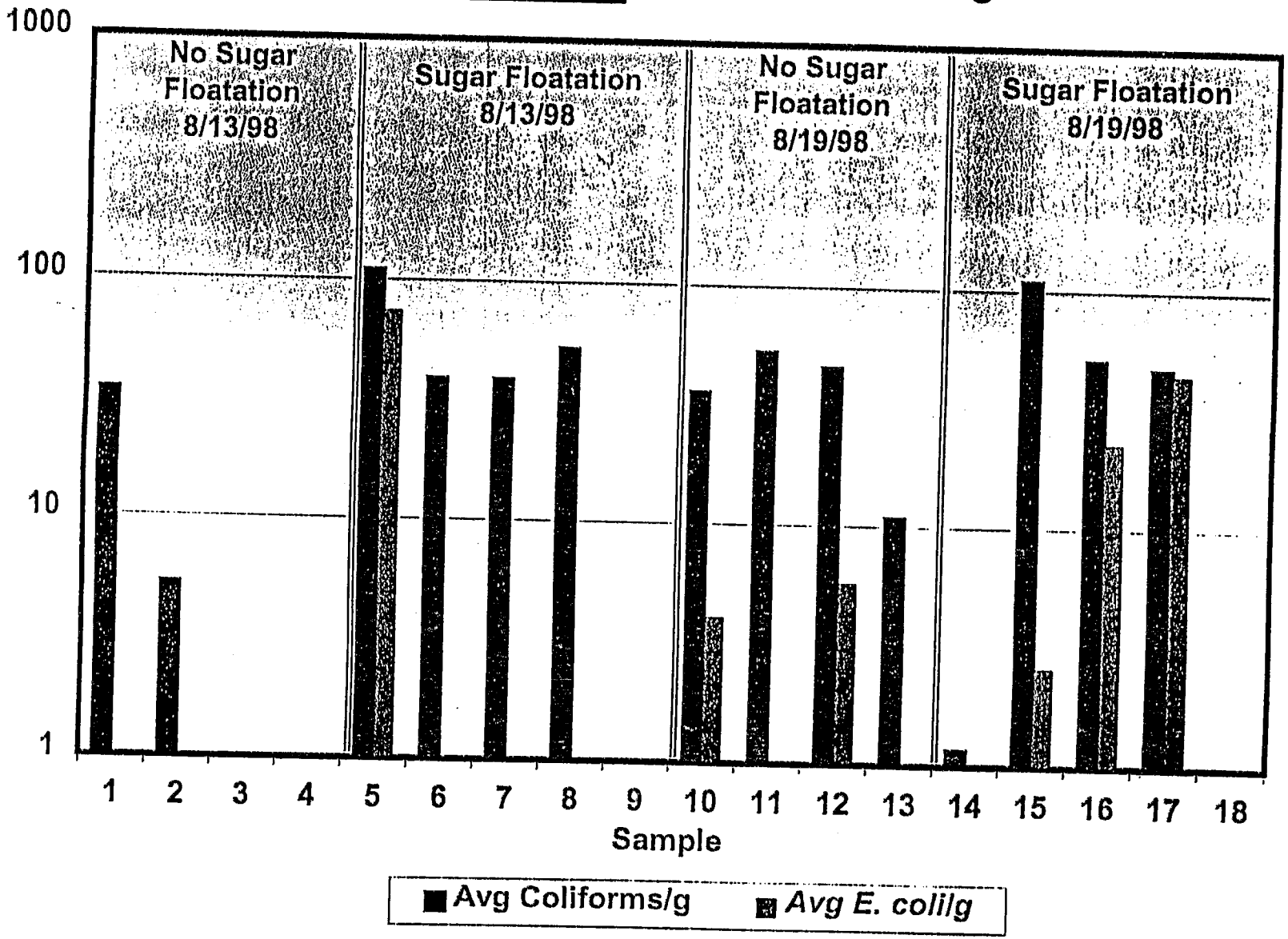


Figure 5: Average Reduction of Total Aerobes/g

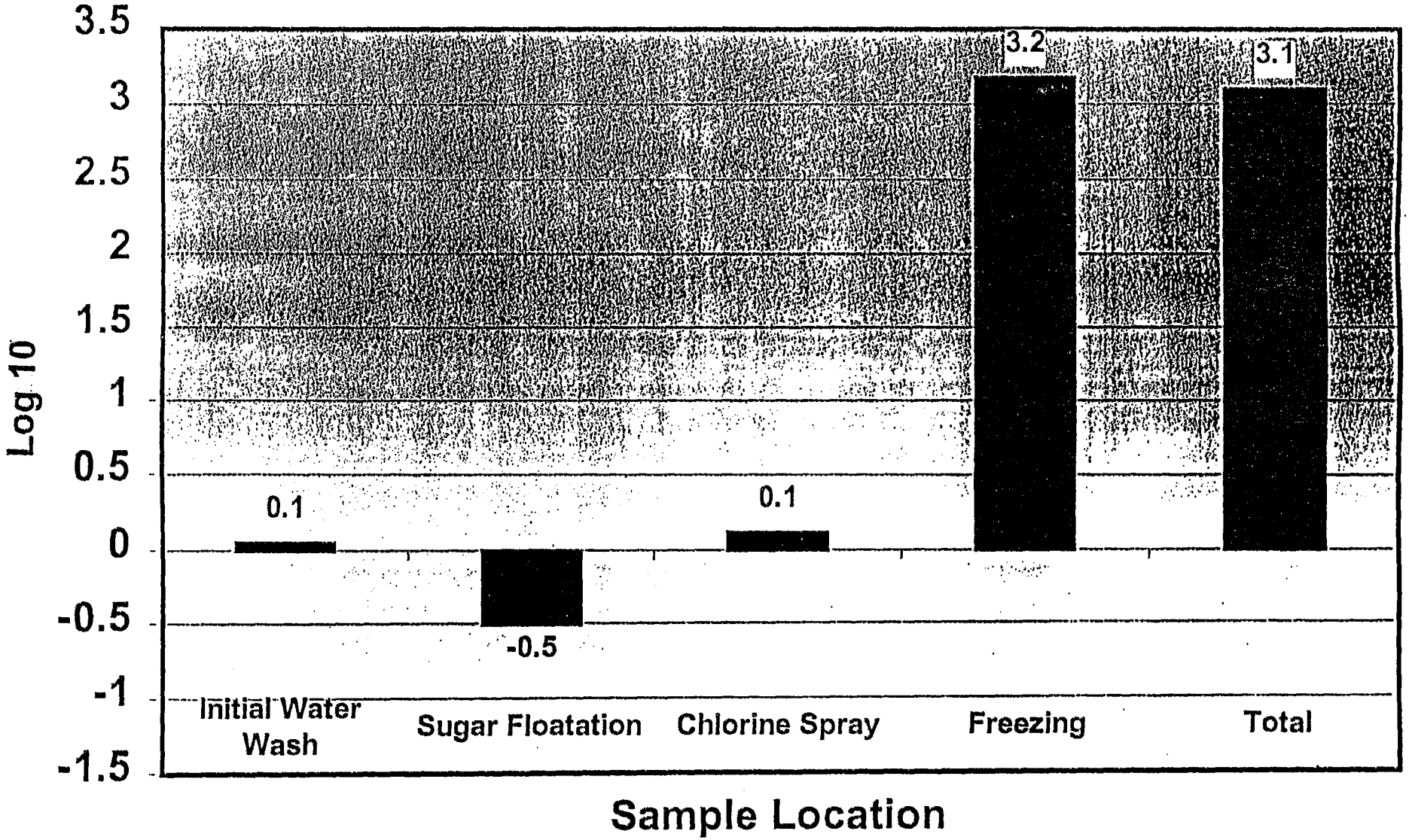


Table 1: Microbiological Examination of A Blueberry IQF Processing Plant

Sample #	Processing Location	Date of Sampling
1	Incoming from Field	8/13/98
2	After Initial Wash	8/13/98
3	After Chlorine Rinse	8/13/98
4	After Freezing	8/13/98
5	Incoming from Field	8/13/98
6	After Initial Wash	8/13/98
7	After Sugar Floatation	8/13/98
8	After Chlorine Rinse	8/13/98
9	After Freezing	8/13/98
10	Incoming from Field	8/19/98
11	After Initial Wash	8/19/98
12	After Chlorine Rinse	8/19/98
13	After Freezing	8/19/98
14	Incoming from Field	8/19/98
15	After Initial Wash	8/19/98
16	After Sugar Floatation	8/19/98
17	After Chlorine Rinse	8/19/98
18	After Freezing	8/19/98

INVESTIGATORS: F. A. Drummond, Project Leader
J. A. Collins, Assistant Scientist

TITLE: Control Tactics for Blueberry Pest Insects

METHODS:

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

Laboratory Bioassays: Two laboratory control tests were conducted using a Burkard® computer controlled spray apparatus to apply the new biorational material, SpinTor (spinosad), a derivative from the fermentation of *Saccharpolyspora spinosa*. In a third test, blueberry foliage was dipped into solutions of SpinTor at various rates.. The pest insects assayed were: blueberry flea beetle larvae and blueberry leaf beetle adults. Replications ranged from 3 to 6 and the frequency of sampling for the assessment of mortality was 1 to 3 days. Insects were determined dead if they did not move when touched with a laboratory dissecting needle. Statistical analysis was used to quantify the relationship between dose of spinosad and mortality.

Blueberry spanworm eggs and blueberry maggot pupae were collected in 1998. Trials will be conducted this winter if insects can be reared successfully in the laboratory.

Field Trials: Field trials were conducted to evaluate the efficacy of the recommended field rates of SpinTor and Mycotrol (an insect pathogenic fungus), as well as a mixture of the two sprays each at half the recommended field rate, against blueberry flea beetle larvae. The materials were applied as foliar sprays. Effectiveness was measured by taking pre- and post-treatment sweep-net samples and by holding larvae in the laboratory for evidence of infection.

Two trials were conducted against blueberry thrips. In one trial, Mycotrol was applied as a soil drench to pruned fields. In a second trial, three materials (Mycotrol, SpinTor, and Admire) were applied as foliar sprays to a crop field after leaf curling had already occurred. Populations of thrips in both trials were monitored by counting the number of infested stems and numbers of live thrips per curl.

IR4 Residue Trial: Treatments were applied and residue samples collected to aid in the registration of spinosad.

Residual of *Beauveria bassiana* in the soil: Two field sites (Jonesboro and Columbia Falls) were established in the fall of 1997. At each site, three, 10-in diameter stove pipe tins that had been disinfected with a 10% bleach solution were placed in the field. The soil within each tin was treated with a soil drench of Mycotrol, a commercially available formulation of *Beauveria bassiana*, a fungus that infects and kills many insects. At each site on each of three dates, soil cores were taken from one of the tins. A different tin was used on each date. The cores were divided into sections, by depth, and then processed to determine the amount of *Beauveria* present in each section.

B. Alternative chemical controls for blueberry maggot.

The efficacy of four materials (Neemix, Asana, Imidan, and SureDye) was evaluated. Ground applications were made using an airblast sprayer. Three rates of aerially applied

Imidan 2.5 EC were also tested. Evaluation of effectiveness was based on sampling ripening berries in selected areas and processing for maggots.

The effect of SureDye, a food coloring, was tested in field cages. SureDye was applied to 3, 6 x 12-ft mesh cages. Three additional cages served as controls. Eleven blueberry maggot adults were released into each cage which were then monitored with yellow sticky traps.

C. Evaluation of spray drift from aerial application of pesticides.

This study was conducted to evaluate drift associated with aerial application of pesticides. A Cessna Ag Wagon® equipped with 30, CP nozzles on 2 ½ inch drop tubes was used to apply the trial. Water sensitive paper was used to monitor spray-droplet density.

RESULTS:

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

Laboratory Bioassays: The emphasis of laboratory bioassays in 1998 was on the efficacy of SpinTor. Good results were obtained against flea beetle larvae (Table 1). Results against leaf beetle adults were mixed. When foliage was dipped in solutions of different dosages, the recommended field rate provided excellent control (Table 2). However, when SpinTor was applied as a foliar spray it was less effective (Table 3). The results suggest that the recommended rate should be an effective rate to control flea beetle larvae in the field.

Field Trials: SpinTor and Mycotrol significantly reduced flea beetle larval populations (Table 4); a mixture of a half rate of SpinTor and a half rate of Mycotrol also gave excellent control (Table 5). Both of these biocontrol agents offer promise for control of blueberry flea beetle. Neither spring nor fall soil drenches with Mycotrol significantly reduced populations of blueberry thrips at the two sites (Table 6). Mycotrol, SpinTor, and Admire applied as foliar sprays were also not effective in controlling thrips (Table 7). None of these materials appear effective for thrips control.

Residual of *Beauveria bassiana* in the soil: As expected, more *Beauveria* was recovered closer to the soil surface and progressively less was recovered in deeper samples on the first sample date. There was also generally a decrease over time with more *Beauveria* being recovered immediately after application and less on subsequent dates (Fig. 1). The results show that *B. Bassiana* is still present in the soil seven months after application.

B. Alternative chemical controls for blueberry maggot.

Ground applications of Asana (esfenvalerate), Neemix (azadirachtin), Imidan (phosmet), and SureDye all reduced populations in comparison with "no insecticide" controls. However, only the standard, Imidan, gave a significant reduction at $P \leq 0.05$ (Table 8).

All rates and numbers of applications of aerially applied Imidan 2.5 EC were apparently very effective in controlling infestation by blueberry maggot. A rate of 1.0 or 1.5 pts/acre appeared to be as effective as 2.0 pts (Table 9). SureDye significantly reduced numbers adult flies captured in the controlled cage study (Table 10). These results suggest that SureDye and Neemix may have potential for maggot control, but further testing needs to be done.

C. Evaluation of spray drift from aerial application of pesticides.

No significant drift in the upwind direction was observed. The greatest concentration of spray was observed directly under the spray boom with a significant decrease downwind from the application (Fig. 2). Cards placed directly beneath the aircraft (distance from centerline of swath = 0) had 61.7 droplets/cm^2. Cards placed 50-ft from the centerline of the swath (25-ft from edge of spray boom) had 22.0 droplets/cm^2. There were only 3.2 droplets/cm^2 on cards placed 100-ft from the centerline (75-ft from edge of spray boom).

CONCLUSIONS:

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

IR4 is currently in the early stages of the process to register spinosad for use on highbush and wild blueberry. One year of data shows this material has good potential for controlling blueberry flea beetle larvae. Additional work will be required before this material can be recommended. Tests in 1999 will focus on blueberry flea beetle adults and spanworm larvae.

Several years of data have now been collected on Mycotrol, a commercially available formulation of the insect pathogenic fungus *Beauveria bassiana*. Results of this years work indicate that *Beauveria* does appear to remain in the soil over the winter, but at levels ranging from 15-50% of the levels found in early fall samples. This implies that multi-season long control could result from a single application of *Beauveria bassiana*.

B. Alternative chemical controls for blueberry maggot.

Results with Neemix and SureDye over the past two years have not produced consistent results. Although SureDye has performed very well in laboratory and controlled cage studies, field trials in 1999 were inconclusive. Questions also remain about the potential phytotoxic effects of this material on wild blueberry. Results with Neemix have also been mixed. This material appeared to be very effective in field tests in 1997; however, in 1998 it did not perform as well. Additional work will be required with both of these materials before any recommendations can be made.

C. Evaluation of spray drift from aerial application of pesticides.

The results of this trial confirm that any drift occurs downwind of the application with winds of at least 3-5 mph and that such drift is minimal at the tested wind speed. Waiting until a light wind is blowing away from sensitive areas effectively eliminates drift towards those areas. If good application practices are followed, all but a small percentage of the spray is confined to the target and adjacent downwind area (125-ft from edge of spray swath).

RECOMMENDATIONS.

Recommendations for control of blueberry pest insects will remain unchanged from 1998. Work is currently underway to add blueberry to the Asana label; however, this material will not be available for use until 1999 at the earliest. Once Asana has been cleared it could be recommended against spanworm and flea beetle, not for maggot control.

LABORATORY BIOASSAYS

Table 1. Laboratory screening of spinosad for control of blueberry flea beetle larvae, spray tower application.

Rate (mls/acre)	% Mortality (SD)*					
	05/20	05/21	05/22**	05/23	05/24	05/25
168.4***	87.5 (15.0)	92.5 (15.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
16.84	97.5 (5.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
1.684	30.0 (33.7)	32.5 (12.6)	87.5 (9.6)	97.5 (5.0)	100.0 (0.0)	100.0 (0.0)
0.1684	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	5.0 (5.8)
0.01684	2.5 (5.0)	5.0 (10.0)	7.5 (5.0)	7.5 (5.0)	7.5 (5.0)	7.5 (5.0)
Control (H_2O)	0.0 (0.0)	0.0 (0.0)	5.0 (5.8)	5.0 (5.8)	5.0 (5.8)	7.5 (5.0)

* 4 replicates of ten larvae.

** LD_{50} = 2.81 mls/acre, LD_{90} = 9.49 mls/acre, LD_{99} = 25.56 mls/acre; estimates based upon log dose - probit regression: $y = 3.910 + 2.427x$, $r^2 = .86$; $P = 0.0245$.

*** Recommended field rate.

Table 2. Laboratory screening of spinosad for control of blueberry leaf beetle adults, leaf dip application.

Rate (mls/acre)	% Mortality (SD)*					
	05/29	05/30	05/31**	06/01	06/03	06/04
168.4***	93.3 (5.8)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
16.84	40.0 (10.0)	76.7 (15.3)	86.7 (5.8)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
1.684	13.3 (11.5)	53.3 (30.6)	53.3 (32.1)	63.3 (30.6)	63.3 (30.6)	63.3 (30.6)
0.1684	0.0 (0.0)	0.0 (0.0)	6.7 (5.8)	6.7 (5.8)	6.7 (5.8)	6.7 (5.8)
0.01684	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	3.3 (5.8)	3.3 (5.8)
Control (H_2O)	0.0 (0.0)	0.0 (0.0)	3.3 (5.8)	10.0 (17.3)	16.7 (20.8)	23.3 (15.3)

* 3 replicates of ten adults.

** LD_{50} = 3.45 mls/acre, LD_{90} = 16.66 mls/acre, LD_{99} = 60.23 mls/acre; estimates based upon log dose - probit regression: $y = 3.994 + 1.872x$, $r^2 = 0.96$; $P = 0.004$.

*** Recommended field rate.

Table 3. Laboratory screening of spinosad for control of blueberry leaf beetle adults, spray tower application.

Rate (mls/acre)	% Mortality (SD)*				
	09/17	09/18	09/19**	09/21	09/23
1684.0	30.0 (30.3)	40.0 (33.5)	56.7 (42.7)	66.7 (37.2)	73.3 (35.0)
168.4***	3.3 (8.2)	6.7 (8.2)	10.0 (11.0)	20.0 (21.9)	23.3 (23.4)
16.84	6.7 (16.3)	6.7 (16.3)	6.7 (16.3)	3.3 (16.3)	15.0 (12.2)
1.684	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
0.1684	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Control (H_2O)	3.3 (8.2)	3.3 (8.2)	3.3 (8.2)	10.0 (16.7)	10.0 (16.7)

* 6 replicates of five adults.

** LD_{50} = 1324.34 mls/acre, LD_{90} = 11168.63 mls/acre, LD_{99} = 63386.97 mls/acre; estimates based upon log dose - probit regression: $y = 0.676 + 1.385x$, $r^2 = 0.91$; $P = 0.0114$.

*** Recommended field rate.

FIELD TRIALS.

Table 4. Field control of blueberry flea beetle larvae.

Material	Amt. form./acre	Larvae/10 sweeps Seasonal density
Mycotrol ES	32 oz	9.1 c
Mycotrol ES	16 oz	19.0 b
Spinosad	5.7 oz	2.8 d
No insecticide	-	67.7 a

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

Table 5. Field control of blueberry flea beetle larvae.

Material	Amt. form./acre	Larvae/10 sweeps Seasonal density
Spinosad	5.7 oz	1.6 a
Spinosad + Mycotrol ES	2.8 oz + 16 oz	1.5 a
No insecticide	-	17.9 b

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

Table 6. Control of blueberry thrips with Mycotrol applied as a soil drench.

	Avg. stems/ tin	Avg./tin Stems with curls Number	%	Avg. curls /stem	Avg. thrips /curl
Trial #1:					
Trt #1 (Fall 1997)	93.6	79.8	85.3 a	3.7 a	0.99 a
Trt #2 (Spring 1998)	47.6	42.0	88.2 a	3.4 a	1.46 a
Untreated Control	62.4	48.6	77.9 a	5.8 a	0.70 b
Trial #2:					
Trt #1 (Fall 1997)	82.0	37.6	45.9 a	4.2 a	0.71 a
Trt #2 (Spring 1998)	54.0	24.0	44.4 a	4.2 a	0.69 a
Untreated Control	61.0	12.6	20.7 a	2.8 b	0.45 b

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

Table 7. Field control of blueberry thrips on wild blueberry (crop year) with insecticides.

Material	Amt. form./acre	Avg. thrips per curl Seasonal density
Mycotrol ES	32 oz	7.3 a
Spinosad	5.7 oz	3.9 a
Admire 2 F	6.4 oz	4.9 a
No insecticide	-	7.1 a

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

MAGGOT CONTROL TESTS

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

Material	Number appl.	Number sites	Number quarts sampled	maggots/quart
Asana .66 XL	2	3	18	0.8 ab
Neemix 4.5 WD/WDG	3	3	18	0.4 ab
Imidan 70 WP	2	3	18	0.3 b
SureDye 2010	3	2	12	0.7 ab
No insecticide	-	5	30	1.2 a

Means among treatments at each site followed by the same letter(s) are not significantly different ($P < 0.05$; DMRT).

Table 9. Field control of blueberry maggot with aerial application of Imidan 2.5 EC.

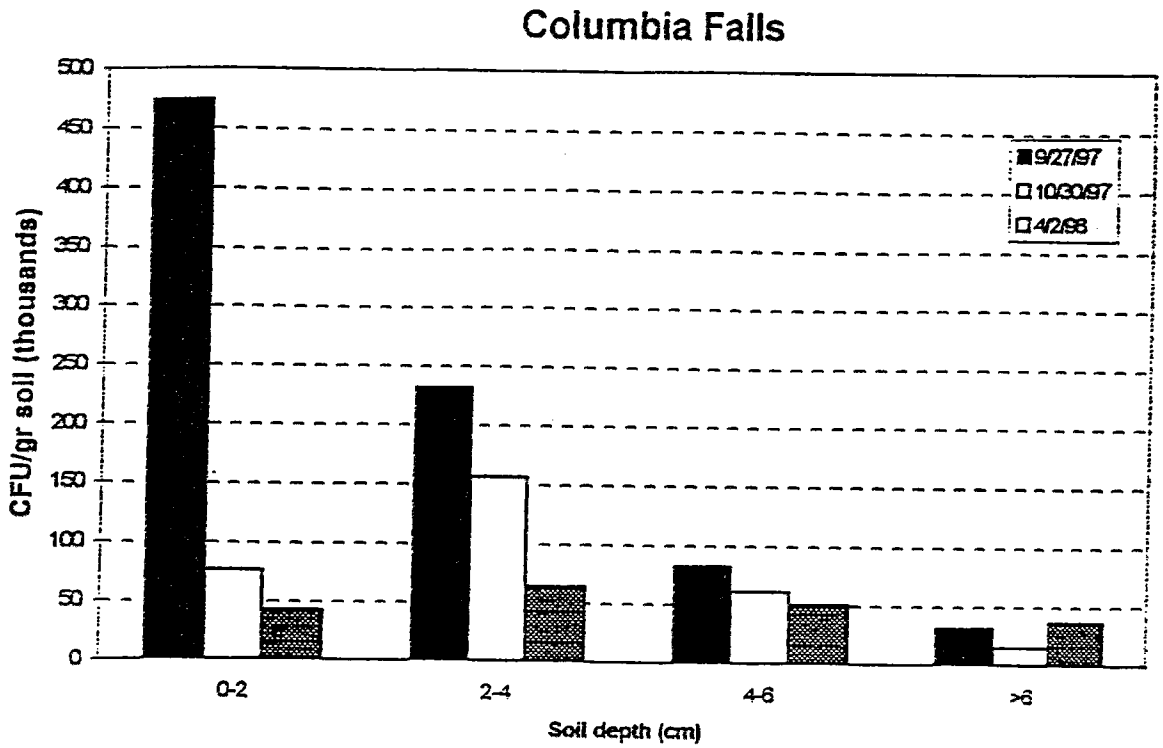
Site	Amt. form./ acre	Number appl.	Adult seasonal density	Cumm. flies/ trap	Maggots/qt
1	2.0 pts.	1	2.1	9.4	0.2
2	1.5 pts.	2	3.4	24.1	0.1
3	1.5 pts.	2	1.0	9.2	0.3
4	1.5 pts.	3	7.5	17.4	0.5
5	1.0 pts.	1	2.8	11.5	0.0
6	1.0 pts.	2	1.4	12.6	0.2

Table 10. Control of blueberry maggot on wild blueberry (crop year) with SureDye.

Material	Avg. number of adults collected/cage
SureDye 2010	0.3 b
No insecticide	2.0 a

Means followed by the same letter are not significantly ($P < 0.10$, SNK).

Fig. 1. Residual of *Beauveria bassiana* in the soil.



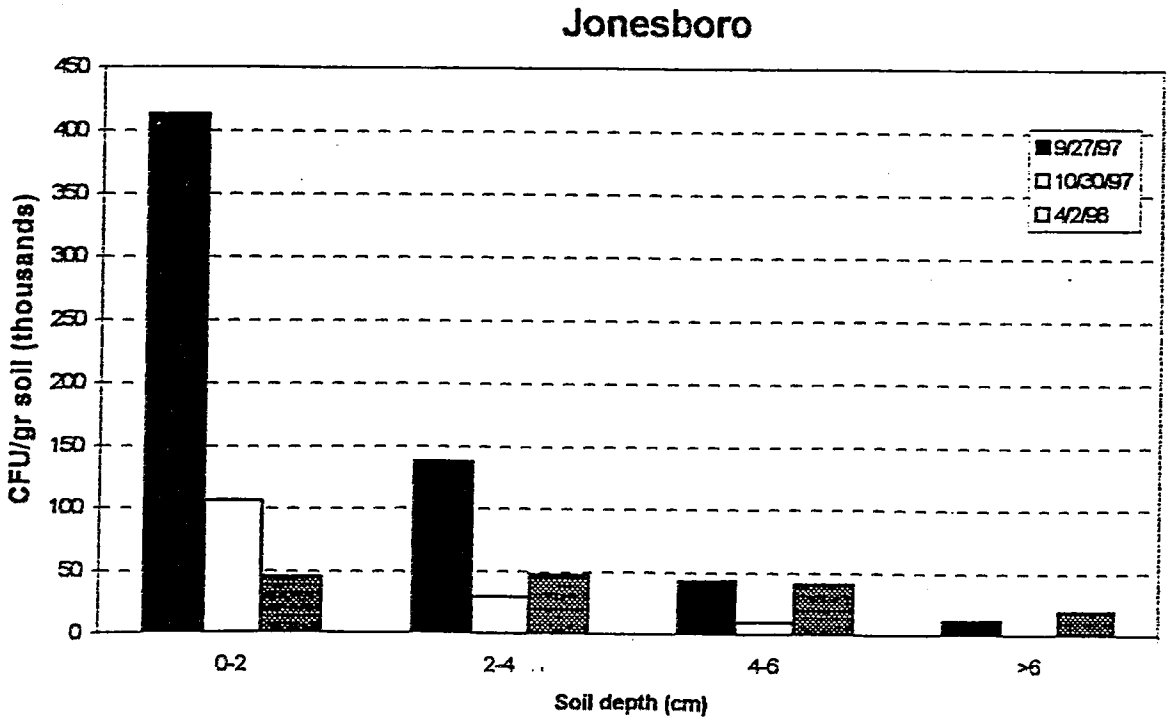
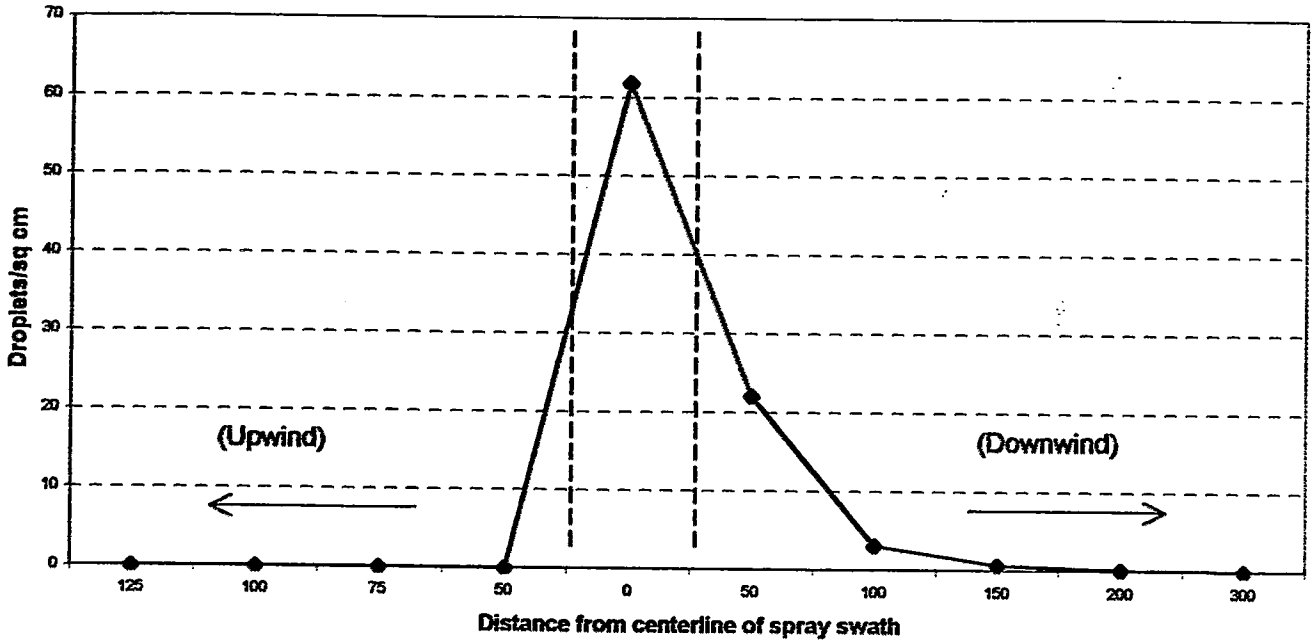


Fig. 2. Evaluation of drift upwind and downwind of application



INVESTIGATORS: F. A. Drummond, Associate Professor
J. A. Collins, Assistant Scientist

TITLE: Biology and Ecology of Blueberry Pest Insects

METHODS

A. Development of a degree day model for estimating time of blueberry maggot emergence.

In 1997, maggot infested berries were distributed in a 1 to 2 inch layer in twelve screened boxes suspended over blueberry plants at Blueberry Hill Farm in Jonesboro. Three 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 1998, emergence cages were placed over each site. The cages were monitored daily and any blueberry maggot adults were collected.

Prior to the start of blueberry maggot emergence, a temperature data logger was buried between 1 and 2 inches deep in the soil at each site to measure soil temperatures every two hours throughout the trials. The temperature data was downloaded at the end of the season and used to determine the daily percent development of blueberry maggot pupae towards emergence of adult flies. 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.

B. Pupation depth of blueberry maggot flies.

In April 1998, 6-inch deep core samples were collected from three of the 12 cages used to estimate time of blueberry maggot emergence at Jonesboro. The cores were cut into 1-inch sections and a floatation procedure was used to check each section for pupae.

C. Population dynamics study of blueberry spanworm.

Lack of suitable populations inhibited the completion of this study in 1998. However, heavy moth flights were observed at two sites late in the season. Good larval populations are expected for studies next year.

D. Development of laboratory rearing techniques for blueberry thrips.

Attempts to keep thrips alive in the laboratory continued to be unsuccessful. No additional work is anticipated at this time.

RESULTS:

A. Development of a degree day model for estimating time of blueberry maggot emergence.

Figure 1 shows the predicted (from the temperature data recorded at 1 to 2 inch soil depths) and observed fly emergence. Predicted fly emergence lagged slightly behind the observed emergence in both fields. The lag did not occur in Winterport until about 20% of the flies had emerged. By 80% emergence, in Winterport, the lag was about 4 days. The Jonesboro site showed a consistent lag of 3-4 days for most of the fly emergence (except for between 90-100% emergence when the model predicted emergence ahead of the observed emergence by 1 to 2

days). These results suggest that the depth at which soil temperatures were monitored in 1998 may have been too deep. Only 2 maggot pupae were recovered from soil cores; both were between 0 and 1 inches deep.

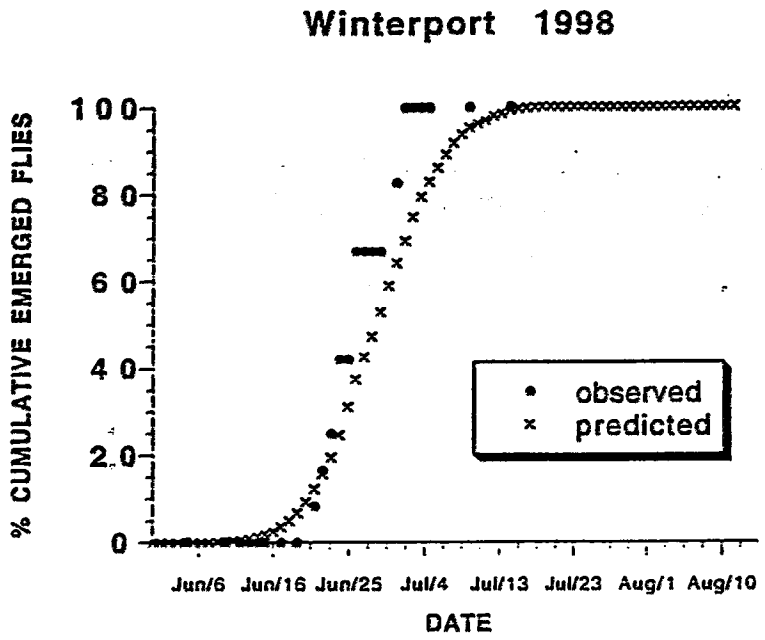
CONCLUSIONS:

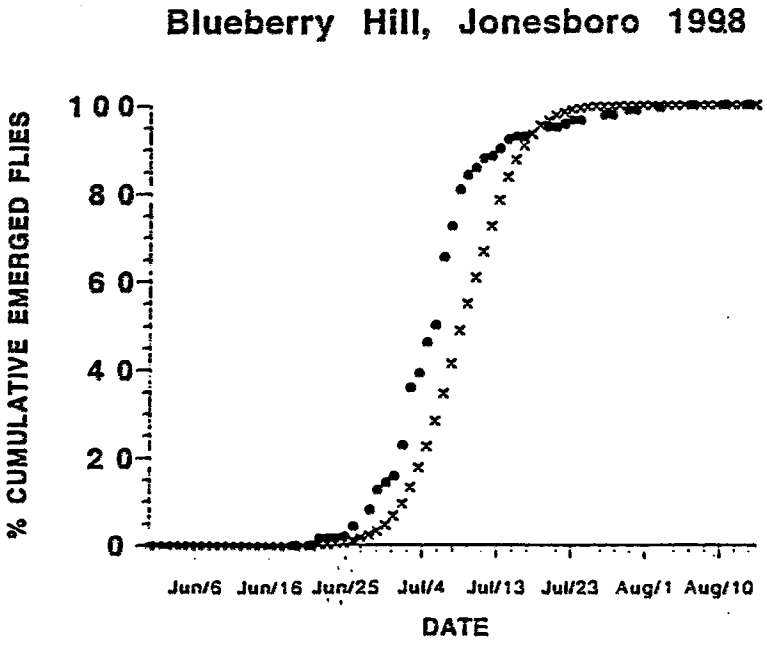
The accuracy of the predictive model, as it stands now, appears to be suitable as an early warning system for growers to use as an aid for determining when flies should emerge and when blueberry maggot fly traps should be deployed in the field.

RECOMMENDATIONS:

Research will be conducted for at least two more years to fine tune and test the model. Validation is necessary under differing weather conditions and soil types. In 1999, we will put a soil temperature data logger between 1 and 2 inches deep and a second between 0 and 1 inches deep to determine which depth is optimal for predicting fly emergence.

Fig. 1. Predicted and observed maggot fly emergence.





INVESTIGATORS: F. A. Drummond, Associate Professor
J. A. Collins, Assistant Scientist

TITLE: IPM Strategies

METHODS

A. Economic threshold of blueberry flea beetle larvae.

Seven wild blueberry clones were selected in a crop-year field at Blueberry Hill Farm; each clone was one replication. Twelve, 2-ft diameter plots were set in each clone. Four of the twelve plots were covered with mesh cages to exclude other foliage feeding pests and for estimates of larval density vs. % defoliation. Four plots were left uncovered to allow for pollination to evaluate yield. The remaining four uncovered plots were used to determine larval density vs. % defoliation in covered vs. open plots. A narrow strip was mown around the uncovered plots to reduce movement of larvae out of the plots.

Early instar flea beetle larvae were collected from an infested field. One of four different densities of larvae was placed in each plot (0, 20, 40, or 80 larvae per plot).

In late May, the number of larvae collected in 2 sweeps with a standard 12-inch sweep net and % defoliation were determined for each covered plot and four uncovered plots per replication. Number of larvae was subsequently converted to larvae/10 sweeps. Defoliation was estimated by rating foliar feeding damage. In early Aug, yield was assessed based on the total weight of fruit harvested from each of four uncovered plots per replication. Berry weight was determined by randomly selecting and weighing 10 berries from each yield plot. Yield data was converted to yield/acre.

B. Within-field management of blueberry maggot.

Within-field movement of blueberry maggot: At Blueberry Hill Farm, 100 yellow Pherocon® AM traps were set in a 10 x 10 grid with 25-ft between each row and column of traps. On various dates, adult flies which had been reared in the laboratory from overwintering pupae were marked with a florescent dye and released into the center of the field. Flies were released at the same spot each day. The traps were checked daily and captured flies were collected, rinsed in kerosene to remove sticky residue from the traps, and stored in 70% ethyl alcohol. The flies were later examined for the presence or absence of dye.

Relationship between maggot fly density and physical features of terrain: In late July, using the same trapping grid outlined above, observations were made within 3-ft of each trap site and rankings (high, medium, or low) were estimated for fruit density and canopy density, and for topography of the terrain (flat, depression, or elevation). Statistical analysis was performed to test for correlations between fly density and fruit density, canopy density, or topography.

Exclusion of blueberry maggot adults from field plots using mesh fencing: Six, 10 x 10-ft plots were established in a crop-year blueberry field at Blueberry Hill Farm. The plots were set along the edge of the field 90-ft from the edge of the woods. Three of the plots were left open and marked with corner stakes. The other three plots were enclosed with black fiberglass window screening, 4-ft high, and attached to wooden stakes. A Pherocon® AM trap was placed within each plot and checked every 1 to 2 days for blueberry maggot adults.

Estimating height of flight for blueberry maggot fly: Three, 8-ft tall metal poles were set up in a crop-year field at Blueberry Hill Farm. The poles were set 150-ft into the field from the edge of the woods. Two Pherocon® AM traps were hung from each pole facing the woods. One trap was 5 ft above the canopy and the second 8 ft above the canopy. A third trap was hung 6-10 inches above the canopy from a separate pole. All traps were checked periodically and the number of flies recorded.

C. Within field management of blueberry flea beetle.

Using scouting reports, a blueberry flea beetle population was located in a crop-year field in Township 25. Sampling stations were set in a 10 x 10 grid with 30-ft between each row and column of stations. On 27 May, 10 sweeps with a 12-inch sweep net were taken around and within 3 ft of each station. The number of larval flea beetles in each 10-sweep sample was recorded. The data was fit to a geo-statistical model (semi-variance model) and the model was used to generate maps of the spatial distribution of this pest. An analysis was then conducted to determine the number of samples needed to accurately estimate the spatial maps.

RESULTS

A. Economic threshold of blueberry flea beetle larvae.

Figure 1 depicts the relationship between the initial flea beetle abundance in each plot (for both caged and open plots) and numbers of flea beetle collected in these same plots using a sweep net. The figure suggests three things. First, that there was either some movement of larvae between plots or that a low background level of flea beetle existed in the field. In the open plots, about 2.5 larvae/10 sweeps were recovered in the zero density plots and in the caged plots about 1.5 larvae/10 sweeps were recovered. The slope or angle of the fitted lines for the caged and open plots are not significantly different. This suggests that the densities experienced similar levels of mortality and development rates. This is an important finding since it allows similar conclusions to be drawn from both types of plots, but it also means that in repeating the study next year, open plots should be sufficient. The third conclusion that can be drawn from the data in Figure 1 is that there is a high level of variability between the "set densities" and sweep net estimates of density. Only 10% (open) and 20% (caged) of the variation in the sweep net abundances can be explained by the initial densities introduced into the plots. Despite our attempt to create greater than "economic threshold" densities (30-50 flea beetle/10 sweeps), on average we established levels much below threshold (about 5 flea beetle/10 sweeps).

Figure 2 shows that in both the caged and open plots, significant regression trends exist between initial larval density and defoliation; 77% and 57% of the variation in defoliation, respectively, is explained by initial density suggesting that the flea beetle densities were a large factor accounting for defoliation. The slopes or angles of the trend lines are not significantly different, meaning that the defoliation response was similar in caged plots when compared to open plots. It can also be seen in Figure 2 that defoliation reached average ratings between moderate and heavy at the highest flea beetle densities.

Despite the defoliation response observed in the plots, there was not a significant decrease in yield or berry weight in regards to increasing flea beetle densities (Fig. 3 & 4).

B. Within field management of blueberry maggot.

Within-field movement of blueberry maggot: In general, the capture of released flies was quite high (Table 1); 9 of 26 released flies were captured from the first release date, 1 of 9 from the second, 8 of 25 from the third, and 4 of 17 from the fourth. Twenty-two of 77 flies (28.5%) were captured over the entire experiment. Flies did not appear to diffuse with a constant velocity away from the release point. Instead, Figure 10 suggests that flies moved randomly about the field with an average movement distance of 9.3 m (30.5 ft)/day.

Relationship between maggot fly density and physical features of the terrain: Traps placed closest to the woods captured the most flies (Fig. 5 & 6). In general, progressively fewer flies were captured the further from the woods traps were placed. The greatest drop in fly captures occurred between 150 and 200 ft from the woods edge; particularly during weeks 2 and 3 when greatest fly captures were recorded.

Figure 7 shows the relationship between fly density and fruit density and Figure 8 shows the relationship between fly density and cover density for the last week (week 4) of the study. Week 4 was used for the analysis since it was expected that at that point that the majority of flies would be sexually mature and searching for oviposition sites. Fruit and cover densities were rated as low = 1, low/moderate = 1.5, moderate = 2, moderate/high = 2.5, or high = 3. Analyses indicated that there is a weak, but positive correlation between fly density and fruit density and between fly density and cover density. There was no correlation between topography and fly density (Fig. 9).

Exclusion of blueberry maggot adults from field plots using mesh fencing: The addition of mesh fencing did result in a significant reduction (56%) in the total number of flies captured on the Pherocon® AM traps over the duration of the trial (Table 2).

Estimating height of flight of blueberry maggot fly: Only traps placed 6-10 inches above the canopy captured any flies (between 0 and 12 flies) (Table 3).

C. Within field management of blueberry flea beetle.

The number of 10-sweep samples taken was 100. Samples were 30-ft apart and it took 2.7 person-hrs to complete the sampling. In Figure 11, we map just the localities above the economic threshold for simulated sampling of different intensities. Black shaded areas indicate locations within the field where 30 or more flea beetle larvae per 10 sweeps were captured; less then 30 larvae per 10 sweeps were captured in the non-shaded areas. Using our data we calculated the distance apart and time required to take proportionately fewer samples. For example, 1.4 person-hours would be needed to take 50, 10-sweep samples placed 60-ft apart. We then calculated how many 10-sweep samples would be required to ensure that areas of high flea beetle concentration would be included in the spatial maps. As can be seen from Figure 11, if the distance between samples is greater than 45-ft, there is a high probability that areas with insect densities above the recommended threshold of 30 flea beetle larvae per 10 sweeps will be either missed or incorrectly estimated to exist. Taking an adequate number of samples placed at least 45-ft apart, while providing an excellent map of larval densities, is likely to be too labor intensive and not economically feasible for pest management scouting. Table 4 shows that the estimate of the average number of flea beetle larvae per 10 sweeps in a field is not greatly affected as one lessens sweeping intensity from 100 sets of 10 sweeps down to 25 sets of 10 sweeps. Thus,

sweeping for the purpose of estimating mean density can be limited to 0.7 person-hours or 25 sets of 10 sweeps. However, when the number of sweep samples is reduced to only 12 samples per field the estimate of the average number of flea beetles per field begins to become less accurate.

CONCLUSIONS

A. Economic threshold of blueberry flea beetle larvae.

We conclude that blueberry plants during the cropping season are quite robust (in terms of yield loss) to high flea beetle densities and the resulting defoliation. We hope to conduct this study again next year at levels triple or quadruple the flea beetle densities used in 1998. The response of defoliation increasing as flea beetle density increased suggests to us that our experimental design is adequate for estimating an economic threshold given that higher initial densities are used.

B. Within field management of blueberry maggot.

Current control recommendations state that if six or more blueberry maggot flies are found on any one trap in a single visit or if a cumulative total of ten flies are captured on a single trap in more than one visit then some control measure should be considered. Using this criteria, only one of 10 traps placed 375 ft from the woods edge reached the application threshold of 10 cumulative flies. No flies at this distance had six or more flies in one visit. Traps placed closer to the woods were more likely to reach the recommended application thresholds. Ten of 10 traps placed at 150 ft exceeded the cumulative total, while 9 of 10 traps at 175 ft exceeded the cumulative total. These results confirm the validity of the current practice emphasizing the placement of traps along field perimeters. In addition, these results suggest that perimeter insecticide treatments may be a feasible strategy for managing maggots. Flies move into managed fields from adjacent wooded areas. The under story is likely to contain untreated blueberry plants and weedy vegetation. Another possibility is that flies move back and forth between the woods and the field. Fruit density and canopy density may have a small influence on trap capture (fly abundance), but probably not enough that these factors should be incorporated into trap placement decisions. The current belief that low areas in fields are areas where flies congregate was not borne out by our trapping study.

As far as we know, this year's data is the first measure of blueberry maggot fly movement. A preliminary simulation model of fly movement into a blueberry field will be constructed this year and used to investigate the effectiveness of perimeter sprays for maggot control.

Exclusion of blueberry maggot adults from field plots using mesh fencing: Results from this study do not suggest that mesh screening will prevent all flies from entering large fields, but may have some application for organic production. Larger scale field tests will have to be conducted in order to see if screening is useful in production level pest management.

Estimation of height of blueberry maggot fly flight: This confirms that blueberry maggot flies remain relatively close to the canopy. The majority of the flies captured were at the canopy level suggesting that flies generally stay low to the ground when migrating into fields. These results support our conclusions that mesh screening might have potential to reduce numbers of low flying flies colonizing fields.

C. Within field management of blueberry flea beetle.

Flea beetle larvae are not uniformly scattered over a field but instead are highly clumped or patchy. This has implications for reduced spray regimes if mapping of populations can be carried out economically. A strategy could be designed where one only sprays parts of the field that are above threshold Figure 11 and Table 4 suggest that mapping the distribution of larval flea beetles within a field is dependent upon intensive sampling and that a maximum of 35-45 ft between sets of 10 sweeps is necessary. The sampling intensity of sets of sweeps spaced 30-ft apart leads to a map prediction of 28.4% of the field being above threshold. This prediction only drops to 28.1% with sampling being reduced to 45-ft apart, and the areas of the field that are predicted to have above threshold densities are similar between the two predictions. However, reducing sampling to distances of greater than 45-ft between sets of sweeps results in quite different maps, and distances greater than 120-ft yield predictions for the area above threshold to be 36.4 and 65.8%. Clearly, the sampling intensity to map the larval flea beetle distribution in a field is very expensive and probably not economically feasible.

RECOMMENDATIONS.

Results are too preliminary on which to base changes in current pest management practices. While we did not show a yield loss response as a result of the flea beetle density gradient we established, we do feel that the current economic threshold of 30-50 flea beetle larvae/10 sweeps is conservative. Therefore, growers can afford to experiment with slightly higher threshold levels.

Table 1: Summary of release data.

Release date	Number flies released	Dye color	Release point	Number flies captured
25 Jun	26	pink	Location 1	9
30 Jun	9	green	Location 1	1
14 Jul	25	pink	Location 2	8
15 Jul	17	blue	Location 2	4

Table 2. Summary of yellow sticky trap captures comparing screened and unscreened field plots.

Treatment	Cumulative flies/trap (SD)
Screened	12.3 (4.5) b
Unscreened	27.3 (0.6) a

Cumulative flies/trap is the total flies collected on each trap over the duration of the trial divided by the number of traps. Means followed by the same letter are not significantly different ($P < 0.05$; DMRT).

Table 3. Comparison of numbers of maggot flies captured at different heights above the canopy.

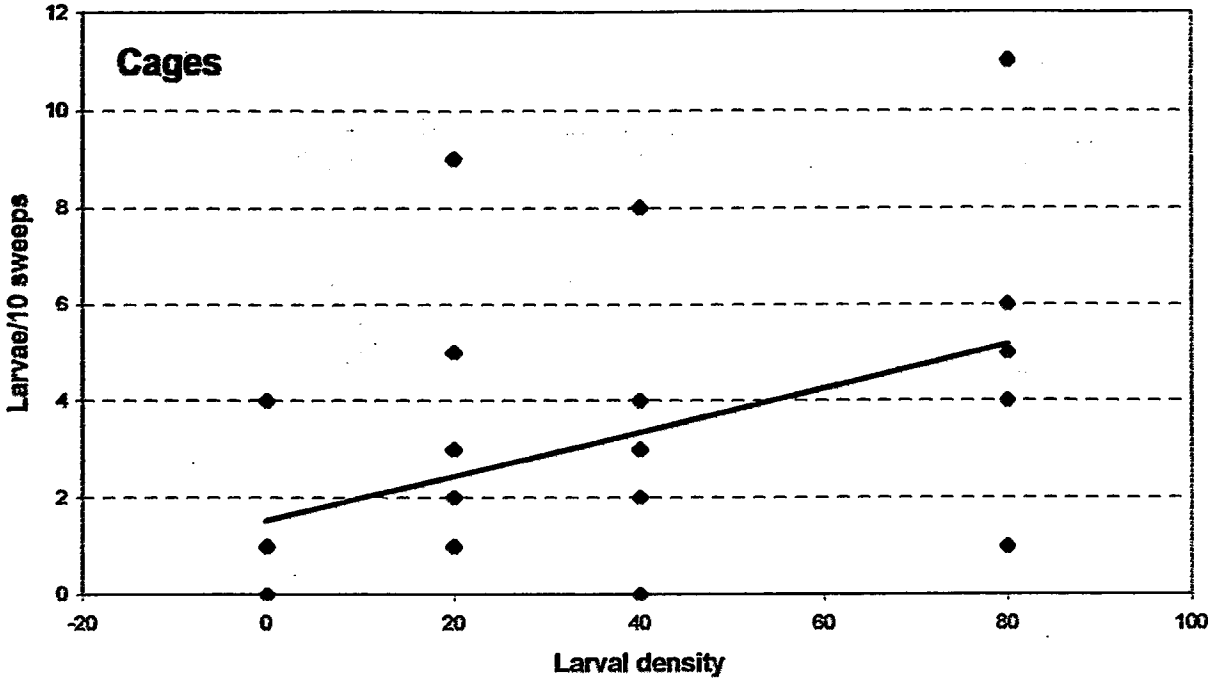
Height	Avg. number of flies captured
8-ft	0.0
5-ft	0.0
6-10 inches	2.1

Table 4: Effects of sampling intensity on estimation of mean larval flea beetle density within a field above economic threshold of 30 adults/10 sweeps.

Sampling intensity				
# samples	Distance (ft) between samples	Hours	Mean flea beetle/10 sweeps (± SD)	% Area of field above threshold
100	30	2.7	39.4 (16.8)	28.4
90	33	2.4	38.6 (16.6)	26.3
75	45	2.0	40.3 (16.9)	28.1
50	60	1.4	38.6 (11.3)	27.2
25	120	0.7	40.7 (11.2)	36.4
12	240	0.4	45.5 (11.8)	65.8

Values and SD derived from resampling data 1,000 times.

Fig. 1. Blueberry flea beetle larval density vs. larvae in sweep samples.



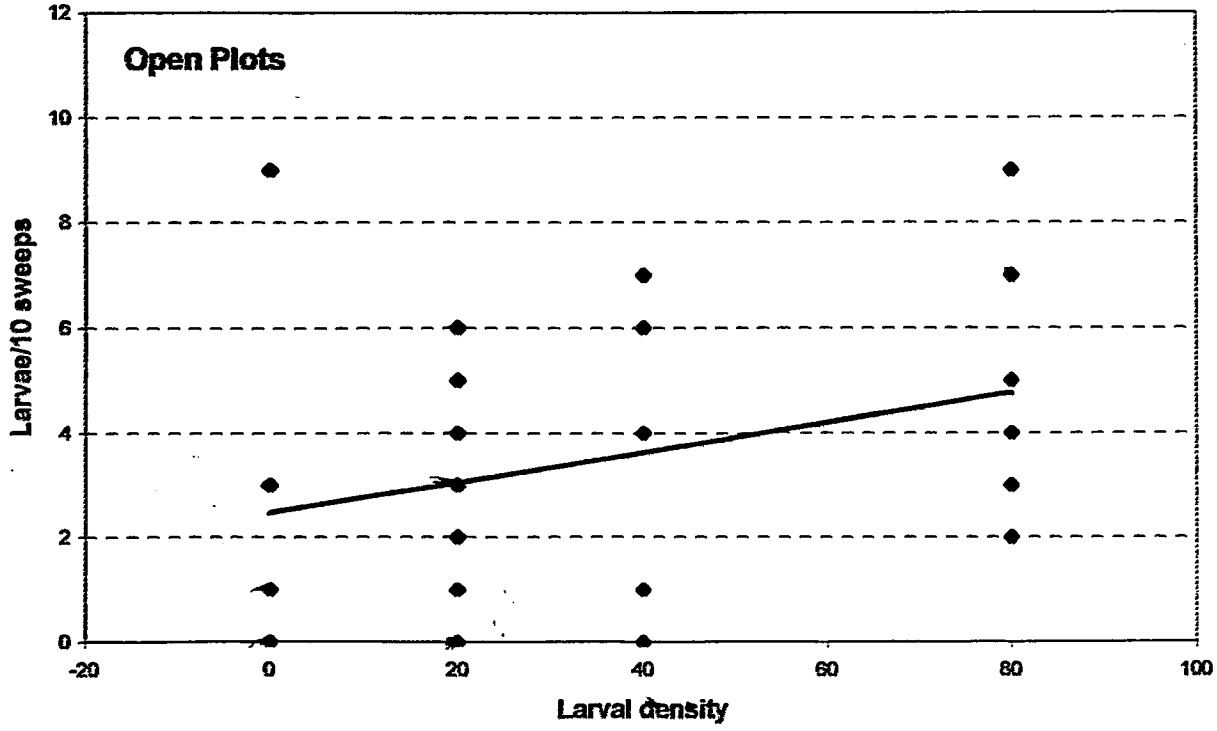
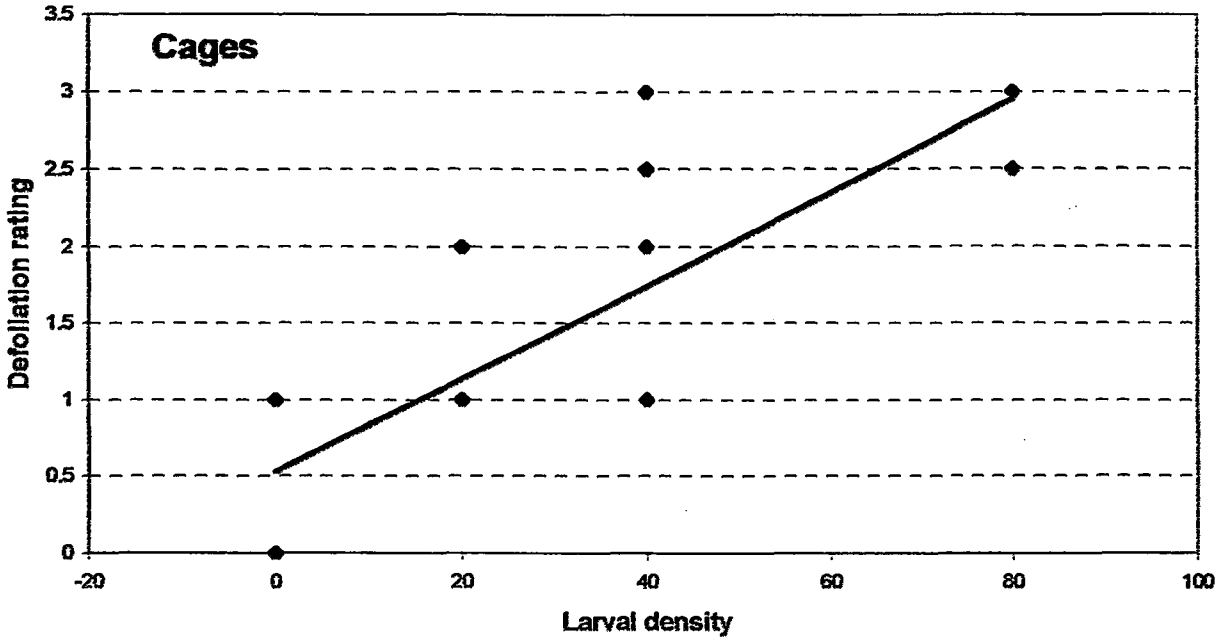


Fig. 2. Blueberry flea beetle larval density vs. defoliation damage



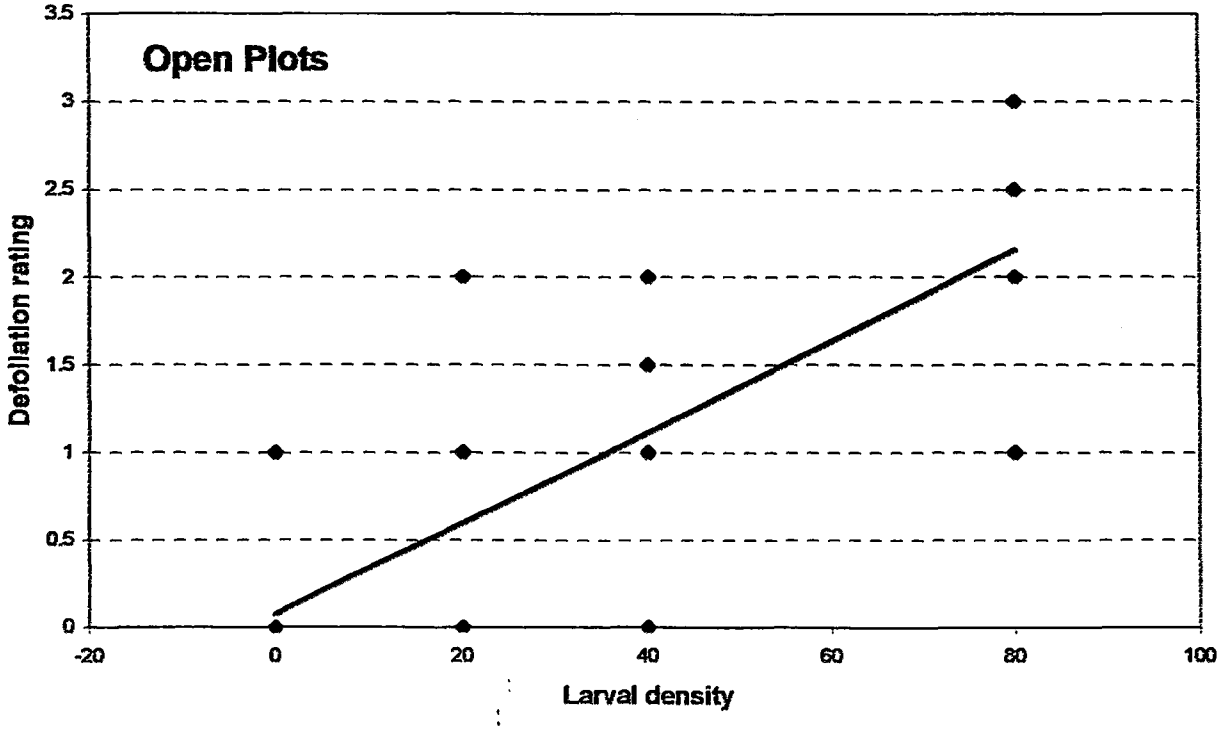


Fig. 3. Blueberry flea beetle larval density vs yield

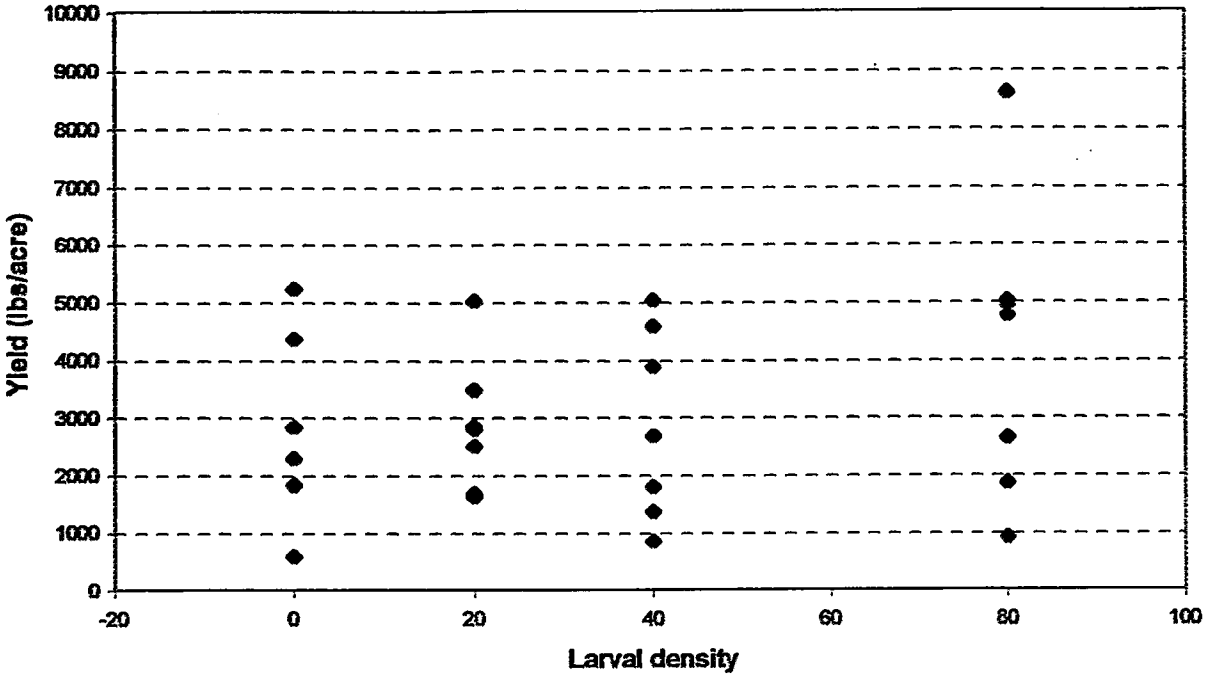


Fig. 4. Blueberry flea beetle larval density vs. berry weight

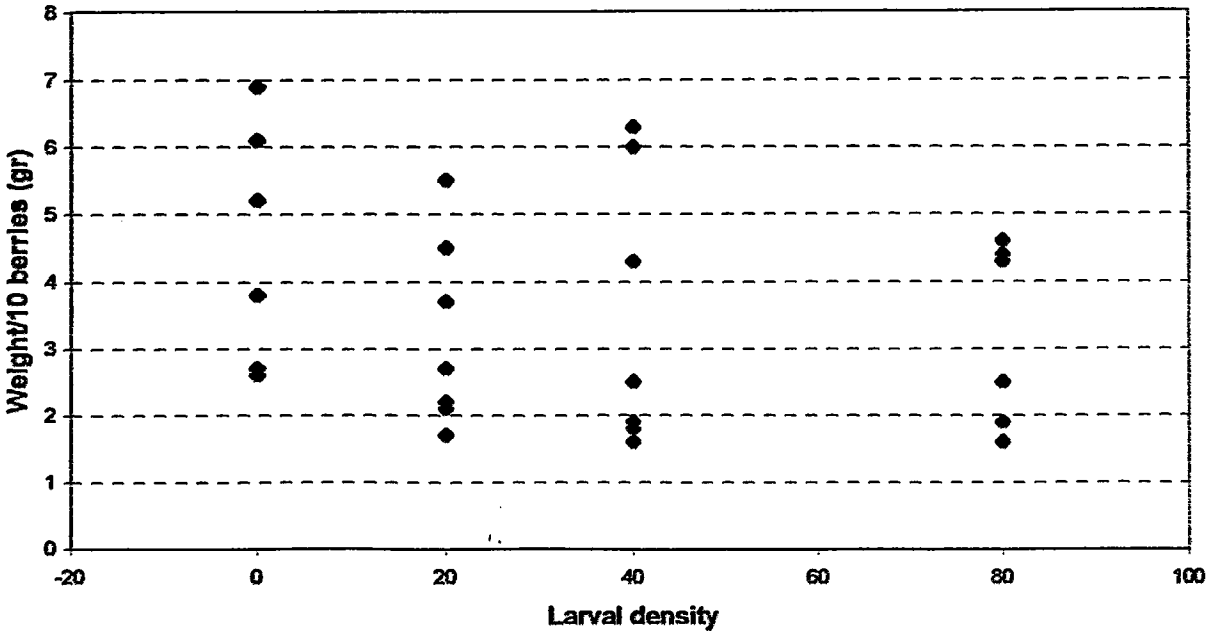


Fig. 5. Relationship between distance from field edge (woods) and fly density for each week

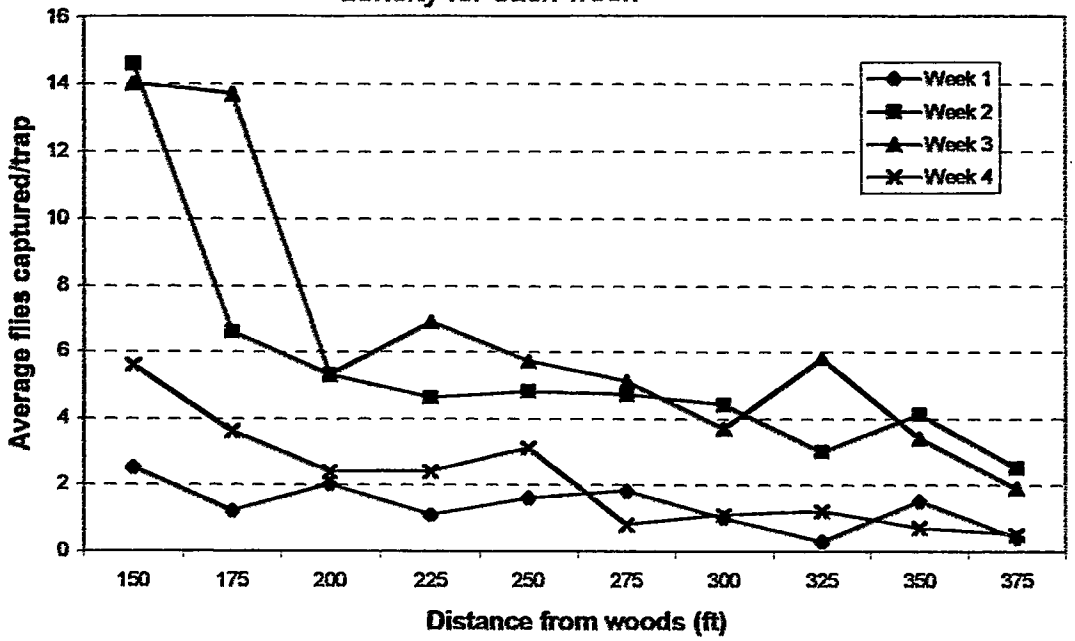


Fig. 6. Relationship between distance from field edge (woods) and fly density for all weeks combined

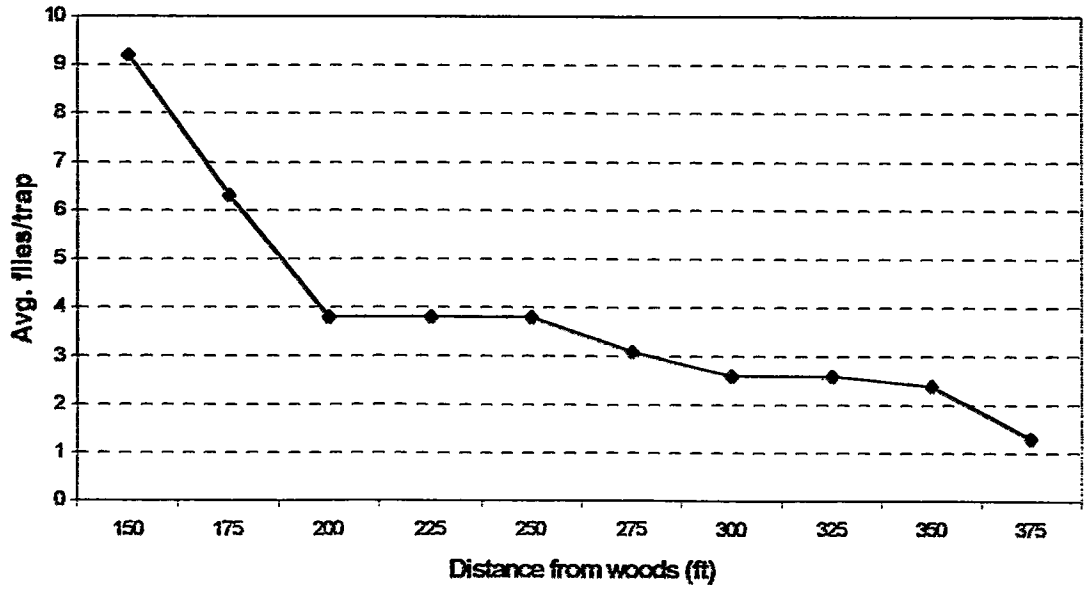
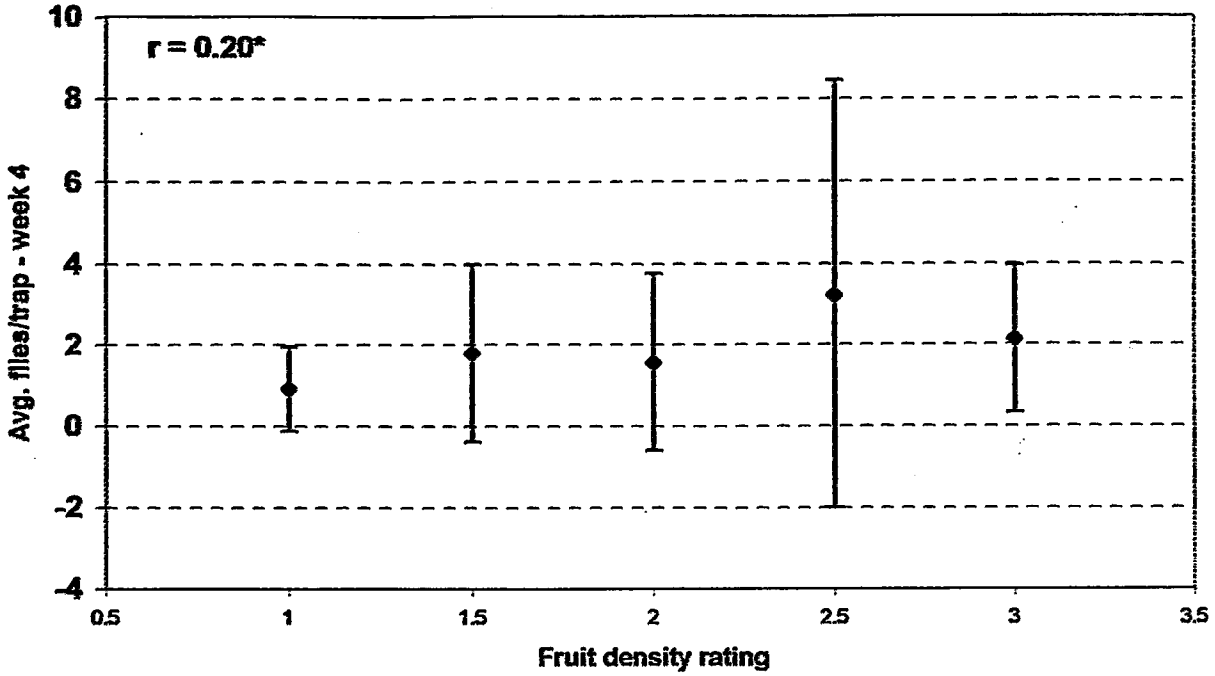
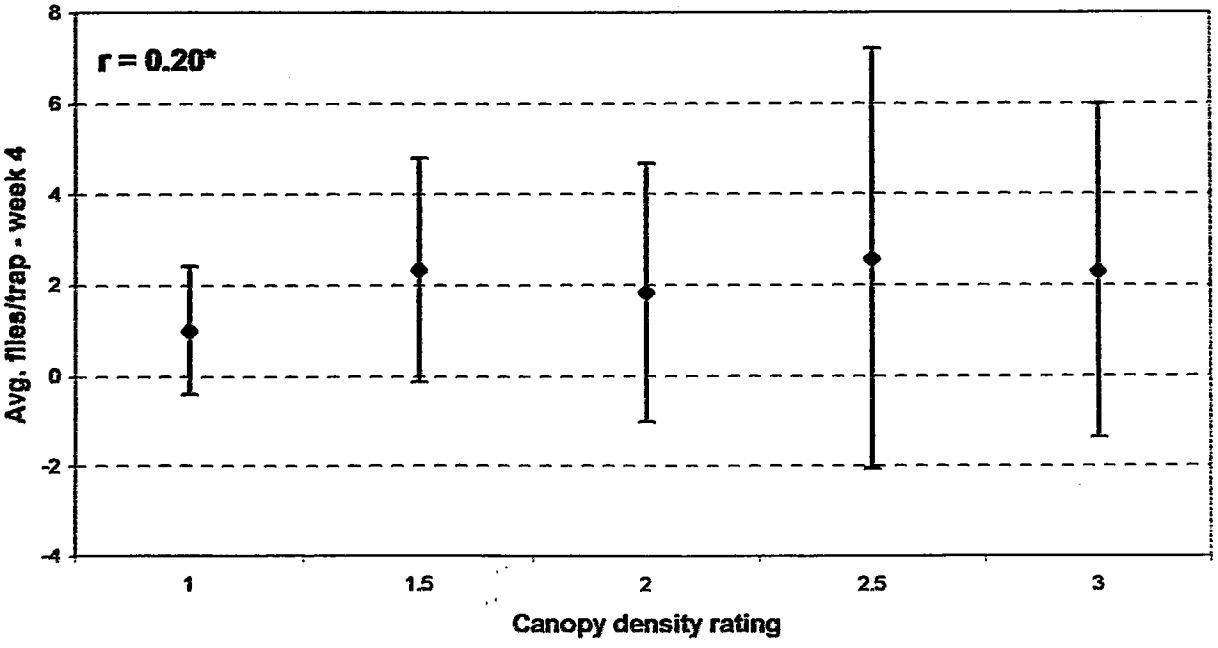


Fig. 7. Relationship between maggot fly density and fruit density.



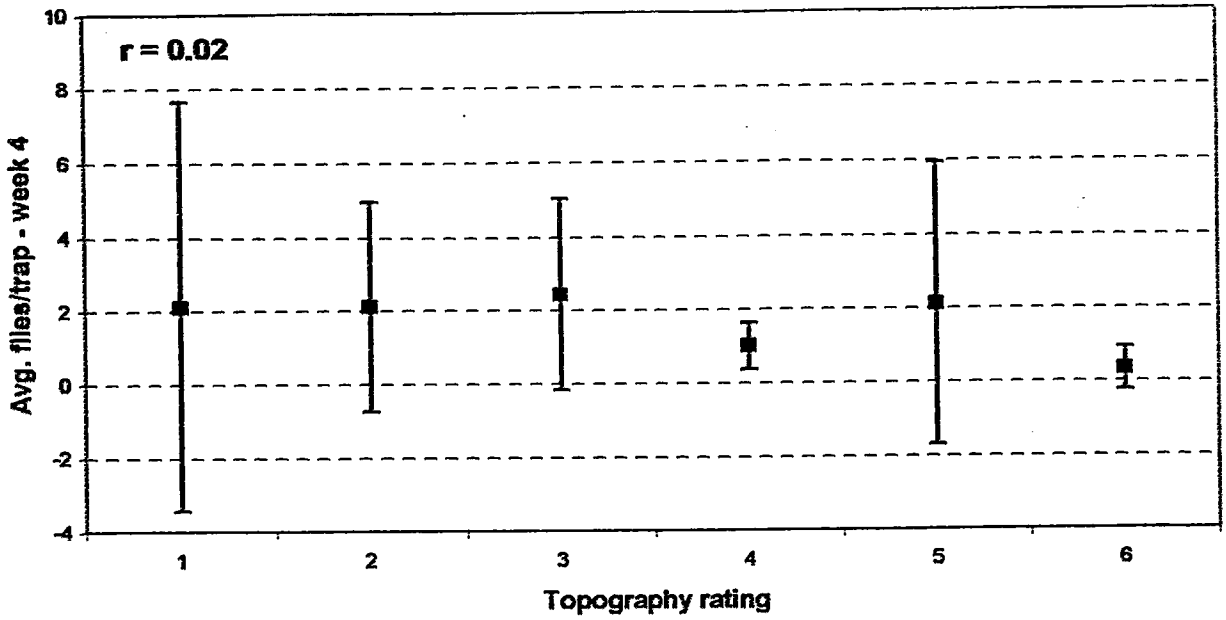
* Significant at $P > 0.05$, Spearman's Rank Correlation Coefficient.

Fig. 8. Relationship between maggot fly density and canopy density.



* Significant at $P > 0.05$, Spearman's Rank Correlation Coefficient.

Fig. 9. Relationship between maggot fly density and topography.



1= depression, 2 = depression/flat, 3 = flat, 4 = flat/elevation, 5 = elevation, 6 = elevation/depression

Fig. 10. Movement distance of blueberry maggot flies.

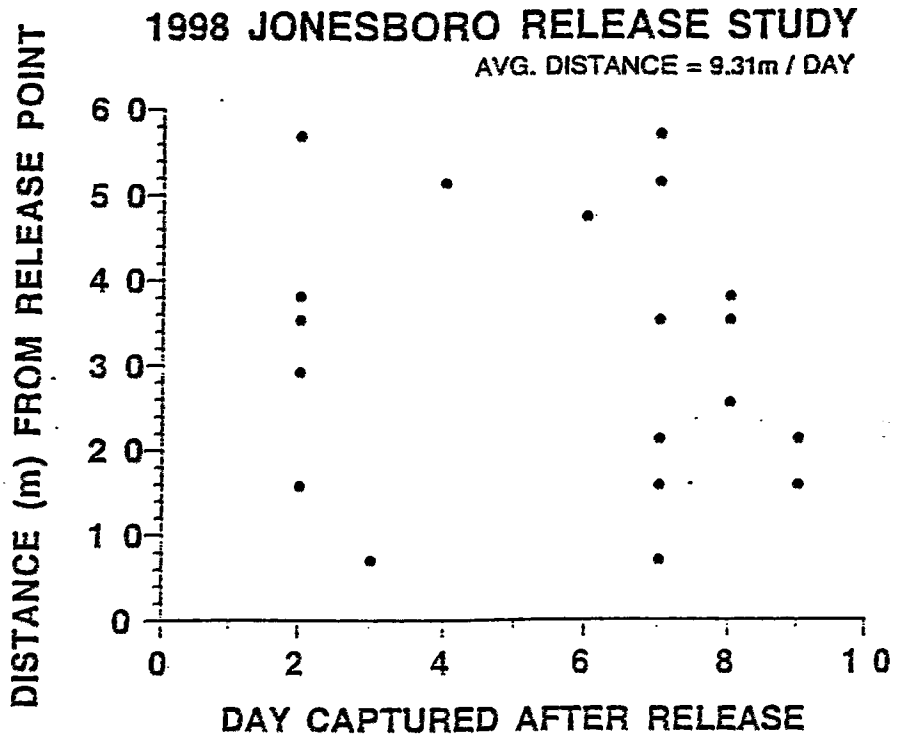
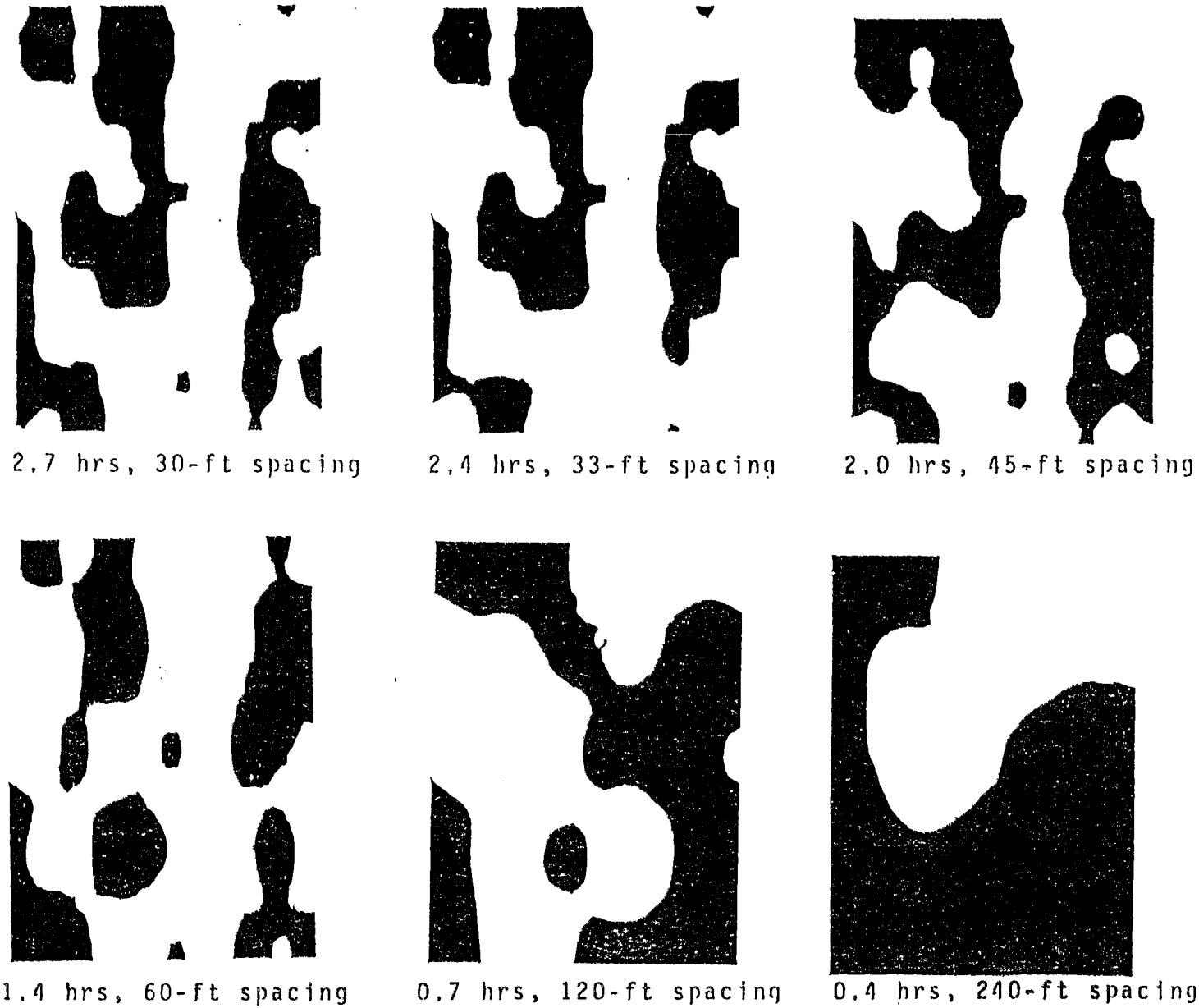


Fig. 11. Distribution of blueberry flea beetle larvae.



B. ENTOMOLOGY AND POLLINATION

INVESTIGATORS: F. A. Drummond, Associate Professor of Applied Ecology and Environmental Sciences
C. S. Stubbs, Post-Doctoral Research Scientist

4. TITLE: Sustainable Pollination of Wild Blueberry

OBJECTIVES: 1) To conduct field trials comparing the pollinator and cost effectiveness of the commercially available bumble bee, *Bombus impatiens*, and the honey bee, *Apis mellifera*.
2) To assess the impact of Asana® on bees by determining the direct effects of Asana® on leafcutting bees and honeybees nd by determining the best application time, for protecting bees, if any, for applying Asana®.
3) To evaluate the efficiency of alfalfa leafcutting bees, bumble bees, and the fuzzy-footed bee, *Anthophora pilipes*, as pollinators of wild blueberry in flight cages in the field.

METHODOLOGY: Objective 1: This study was Year 3 of a three year project. Six wild blueberry fields of similar size and management were used. Honey bees were stocked at three hives/acre in three of the fields and *B. impatiens* at 3 colonies/acre in the other three fields. One hundred twenty-foot transects were established from each cluster of hives/colonies (three transects from each cluster). At distances of 10, 20, 40, 80, and 120 ft, ten wild blueberry stems were marked and the number of flowers recorded. Two weeks after bloom the stems were reexamined to determine % fruit set. Berries were harvested in late July and berry number, weight, size and seeds per berry recorded. Percentage fruit set and yield (based on the number of havested berries from the flowers on marked stems) were compared with descriptive and inferential statistics (Mann Whitney, $p \leq 0.05$). Observations of bee foraging behavior were made during bloom. These data, plus the cost of renting bees, were used in conjunction with the foraging data, fruit set, and yield data to determine the relative pollinator and cost effectiveness of both bee species.

Objective 2: Field applications of Asana® were made at Blueberry Hill in order that the effects on honey bees, the alfalfa leafcutting bee, and native pollinators could be determined. Three experimental plots (27 ft X 40 ft) were sprayed with Asana® at the recommended dosage of 9.6 oz/acre in the late evening. Three control plots were not sprayed. We counted flowers on 50 marked stems per plot in order to assess fruit set and yield. Honey bee and alfalfa leafcutting bee numbers were monitored prior to and after the spray to determine any direct lethal effects. Numbers of nesting female alfalfa leafcutting bees, which provides a measure of bee mortality, if any, and nest construction were measured during bloom in experimental and control bee shelters. Bee abundance, bee mortality, and reproductive success were compared using descriptive and inferential statistics to determine if Asana® can be applied during bloom without detrimental effects to pollinators. Control and spray plots were harvested in August to determine if there

were differences in yield. Samples of honey, wax, and dead honey bees were sent to the Cornell Diagnostic Laboratory, Ithaca, NY to test for pesticide residue.

Objective 3: Fuzzy-footed bees were reared out of their adobe nest blocks in two field flight cages. Two other flight cages contained a bumble bee colony and two more cages contained 1 gallon of alfalfa leafcutting bees, respectively. We compared flower handling time to two other commercially available bees (alfalfa leafcutting bee and bumble bees). We counted flowers on 50 marked stems per flight cage in order to assess fruit set and yield. We assessed nesting behavior, success of nesting, ease of handling, and rate of parasitism, if any, in order to determine if they are suitable and cost effective pollinators of wild blueberry.

RESULTS: Objective 1: To conduct field trials comparing the pollinator and cost effectiveness of commercially available *Bombus impatiens* and *Apis mellifera*.

In 1998, for fruit set there was a significant difference ($p = <.0001$) between bumble bees (72.7± 15.5%) and honey bees (48.6 ± 22.2%). For percentage yield (% harvested berries from the marked stems), it was significantly higher ($p = <.0001$) in fields with bumble bees (40.6 ± 14.9%) versus fields with honey bees (25.7± 15.0%).

For data pooled across the two treatments (honey bees versus bumble bees), there were no significant differences in average berry weight ($p = .5546$) or average seeds per berry ($p = .6689$). For honey bees, the average berry weight was .459 ± .12 g and average seeds per berry was 39.1 ± 13.9 seeds. For bumble bees, the average berry weight was .476 ± .17 g and average seeds per berry was 38.7 ± 14.6 seeds.

Field observations of the commercial bumble bee and honey bee indicated that the bumble bee foraged again this year in heavy rain, whereas the honey bee did not. Bumble bees also started foraging earlier in the morning than honey bees.

In 1998, the average price of honey bee hives was $50, which was an increase from 1995 of $15 per hive. The bumble bees were sold in units of four, termed "quads" because each quad contained four colonies. The price per bumble bee colony, if purchased in bulk (50 quads or more), was $70 or $280 per quad.

Objective 2: To assess the impact of Asana® on bees by determining the direct effects of Asana® on leafcutting bees and honey bees and by determining the best application time, for protecting bees, if any, for applying Asana®.

Adult foraging alfalfa bee and honey bee numbers were similar in both the treatment (38 ± 32.1 adult bees) and in the untreated plots (41.9 ± 37 adult bees) during bloom. This difference was not significant ($p = .7811$, Mann-Whitney). No leafcutting nest tunnels were capped at the end of bloom, but when these nesting materials were stripped in early September, the number of tunnels capped in the control nest materials was 333 tunnels compared to 57 tunnels in the spray plots. As soon as the leaf cells "harden off" (early December), we will incubate the leaf cells from both the untreated and treated plots to assess viability. Fruit set was not significantly different: 73.4 % in the control and 77.9 % in the spray plots. Percentage yield (% of berries harvested from marked stems) was significantly higher in the spray plots (Mann Whitney, p =

<.0001). Average percentage yield in the spray plots was 55.3 ± 14.6% and in the control plots, the average percentage yield was 32.7 ± 12.6%. Average yield in the spray plots (1080 sq. ft.) was 20.5 ± 11.5 lbs blueberries and 14.0 ± 4.7 lbs in the nonspray plots. This difference was not significant (p = .3827, Mann-Whitney). The results of the leafcutting bee cell viability will be available in late December. The Cornell Laboratory did pick up minute traces of esfenvalerate; in the honey wax sample <0.25 mg/kg and in the bee sample <0.70 mg/kg.

Objective 3: To evaluate the efficiency of bumble bees (*Bombus impatiens*), alfalfa leafcutting bees (*Megachile rotundata*) and the fuzzyfoot bee, *Anthophora pilipes*, as pollinators of wild blueberry in field flight cages.

Foraging behavior (n = 25 single flower visits per species) was not significantly different (p = .1959, Kruskal-Wallis) for the fuzzyfoot, the alfalfa leafcutting bee, and the bumble bee. Flower handling time ranged from 1-25 sec. Average flower handling time for *A. pilipes* was 3.8 ± 2.0 sec, 3.9 ± 1.6 sec for *B. impatiens*, and 3.3 ± 7.3 sec for the alfalfa leafcutting bee. No parasites were observed. There was a significant difference in percentage fruit set and percentage yield (Figs. 1 and 2). Average percentage fruit set for the fuzzyfoot, *A. pilipes*, was 77.4 ± 10.78% (range 62-100%); for *B. impatiens* 85.9 ± 7.43 (range 75-99%); for *M. rotundata* 71.7 ± 15.68% (range 42-88%). Average percentage yield (percentage of berries harvested from flowers counted on marked stems) for the fuzzyfoot, *A. pilipes*, was 29.57± 9.09% (range 20-45%); for *B. impatiens* 50.0 ± 11.65 (range 37-67%); for *M. rotundata* 21.2 ± 18.96% (range 25-34%). Average berry weight, and seeds per berry were significantly different (Figs. 3 and 4). Numerical increase for the fuzzyfoot was 11 new tunnels were capped. The last fuzzyfoot observed active was on June 29. The capped fuzzyfoot bee blocks were put into locked cold storage at 36° F after they had "hardened off" at the University of Maine in the early fall.

RECOMMENDATIONS: The commercial bumble bee, *B. impatiens*, demonstrated that it is an excellent pollinator of wild blueberry both in the field and greenhouse studies. We have now shown that its stocking density should be 3 colonies per acre. If growers order in sufficient quantities, the price per quad is almost competitive with the honey bee, for which an accurate stocking density for wild blueberry does not exist.

The 1998 findings from the Asana® spray study suggest that it does not harm honey bees, or adversely affect fruit set and yield. Therefore growers may safely apply it in the late evening if they are using honey bees to pollinate their crop. The sublethal effects, on alfalfa leafcutting bee reproductive output will be available at the end of December. Honey bee keepers should be made aware of the fact that minute traces of the active ingredient esfenvalerate were found in the honey, wax, and on dead bees.

The fuzzyfoot, *Anthophora pilipes*, performed as well as *B. impatiens*, and better than the alfalfa leafcutting bee in our flight cage studies in the field. Therefore, findings from our studies provide further evidence that *A. pilipes* has excellent potential as a pollinator for wild blueberry. The fact that we think this bee can be reared commercially, in the future, at prices competitive to the honey bee or even better makes it an extremely important bee wild blueberry pollination.

Also the fact that it is much easier to handle than the alfalfa leafcutting bee (simply store the blocks indoors over winter in cold storage) and does not have the parasite problem that the alfalfa leafcutting bee has, makes the fuzzyfoot bee in the long term a much more viable bee for wild blueberry pollination in Maine. We recommend that field trials be continued with an emphasis on developing management practices for *Anthophora pilipes*, the fuzzyfoot bee.

Figure 1: Average percentage fruit set for the fuzzyfoot bee (*pilipes*), alfalfa leafcutting bee (*rotundata*), and bumble bee (*impatiens*).

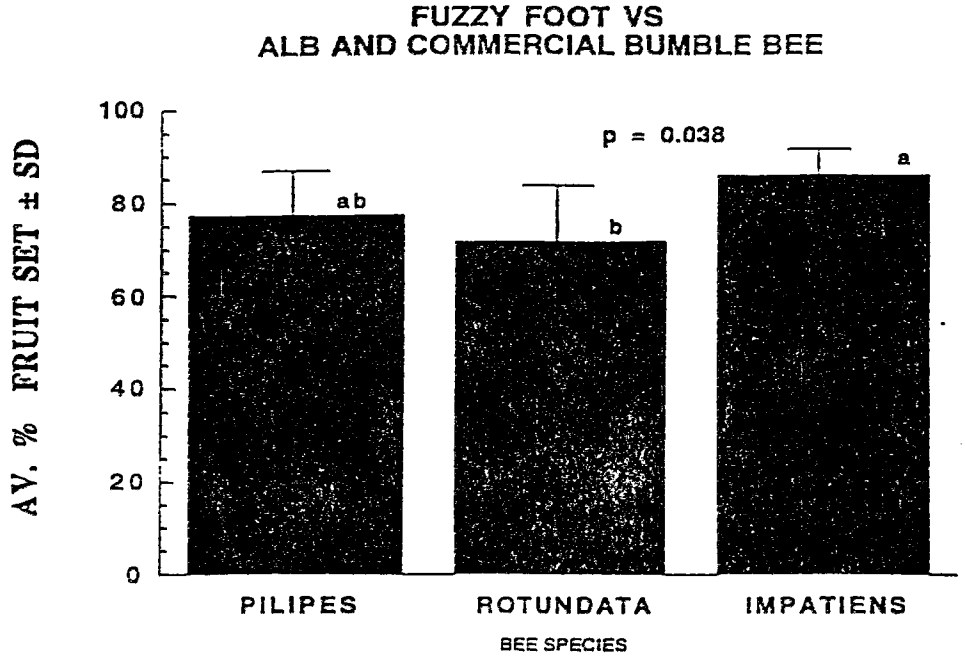


Figure 2: Average percentage yield (based on number of harvested berries from number of flowers on marked stems) for the fuzzyfoot bee (*pilipes*), alfalfa leafcutting bee (*rotundata*), and bumble bee (*impatiens*).

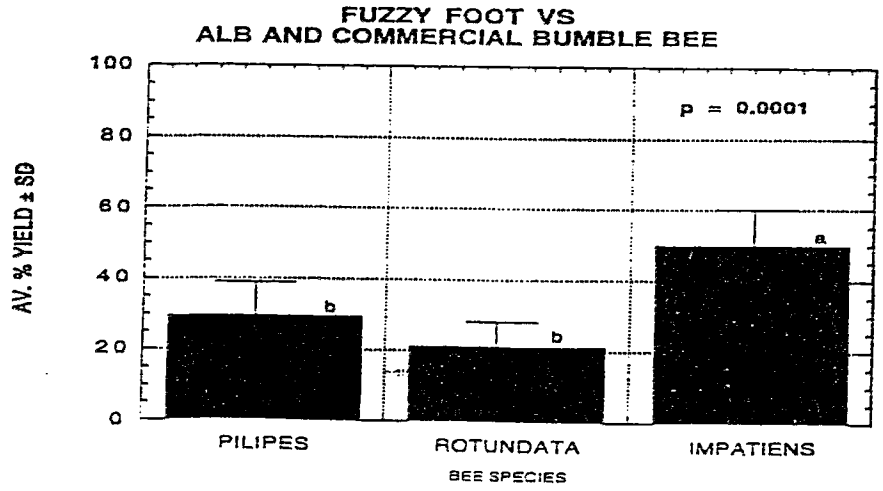


Figure 4: Average number of seeds per berry for the fuzzyfoot bee (*pilipes*), alfalfa leafcutting bee (*rotundata*), and bumble bee (*impatiens*).

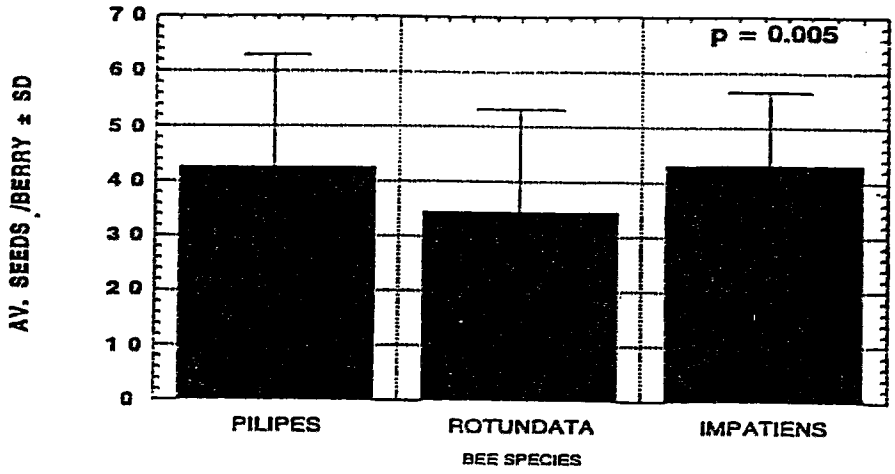
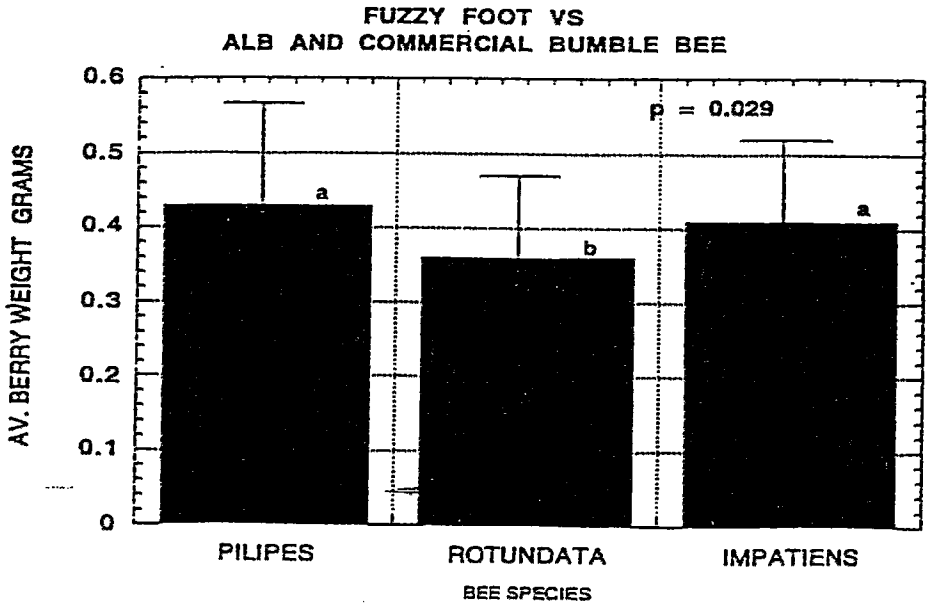


Figure 3: Average grams per berry for the fuzzyfoot bee (*pilipes*), alfalfa leafcutting bee (*rotundata*), and bumble bee (*impatiens*).



C. DISEASE CONTROL

INVESTIGATOR: David Lambert, Associate Professor of Plant Pathology

1. TITLE: Evaluation of Foliar Fungicides for Control of Mummy Berry

METHODS: Three by fifteen foot plots were established in Twp. 19, Washington Co., ME in eight randomized complete blocks. The selected site had a history of moderate-severe disease, which varied in intensity with clone. Recommended fertilization, cultural and insect control practices were followed. Fungicide treatments were applied with a carbon dioxide pressurized sprayer having three 8001 flat fan nozzles which delivered 45 gpa at 30 psi. Standard applications for control of ascospore (primary) infection were made on 27 April and 11 May. A treatment for fruit (secondary) infection was applied May 21. In mid- June, 250 blossom clusters along the center of each plot were rated for incidence of infection. In mid-July, fruit infection was likewise assessed. Data were analyzed using Tukey's hsd test.

RESULTS:

Treatment	Rate/A	Time	Blossom Blight %	Fruit Infection %
Untreated Control			16.0 cd *	16.1 c
Orbit 3.6 E	0.25 pt	4/27, 5/11	3.1 ab	2.4 ab
Indar 75WP	4.0 oz	4/27/5/11	1.7 a	2.5 ab
Indar 75WP	5.3 oz	4/27, 5/11	1.0 a	1.1 a
Bravo 720	4.25 pt	4/27, 5/11	5.4 b	3.2 ab
Quadris 25SC	1.06 pt	4/27, 5/11	11.9 c	11.5 bc
Orbit 3.6 E	0.25 pt	5/21	20.7 d	2.1 ab
Indar 75WP	4.0 oz	5/21	13.5 c	2.1 ab
Bravo 720	4.25 pt	5/21	21.7 d	12.6 bc
Quadris 25SC	1.06 pt	5/21	16.6 cd	11.2 bc

* Means followed by the same letter do not differ at P = 0.05.

CONCLUSIONS: Lowest primary and secondary disease ratings were obtained with Indar at the 5.3 oz rate, although incidence with Orbit or with Indar at a lower rate were not significantly different. Significant control of primary infection was obtained with Bravo but not Quadris. Control of primary infection was as effective as the single late application for control of fruit infection. No treatments produced symptoms of phytotoxicity.

RECOMMENDATIONS: Indar should be further evaluated on a larger scale. These results support numerous trials elsewhere which indicate that Indar is at least as effective as Orbit for mummy berry control.

D. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Andrea Southworth, Research Assistant
Walter Litten, Faculty Associate

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. Boron 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 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 from plots were highest for MAP and DAP compared to the TSP and 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 (0.130%) 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.

1998 Stem and Yield Characteristics

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.

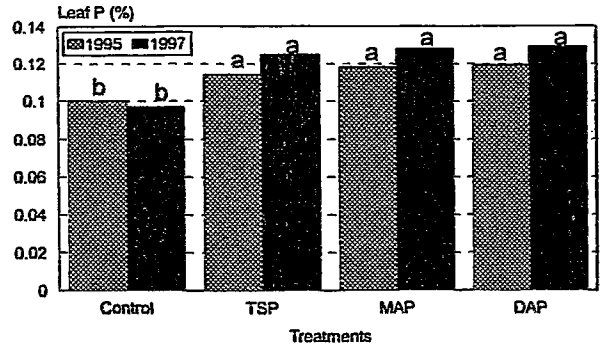
CONCLUSIONS: No conclusions can be made until the study is completed and all the data is completely analyzed and interpreted.

RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1

P/N Ratio Study

Phosphorus leaf concentrations*

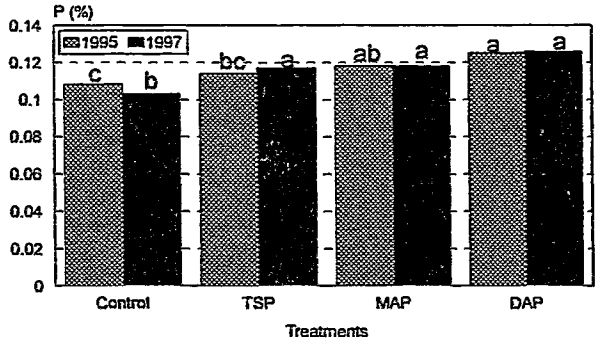


*Values are average of three locations. Treatment means within years not having a letter in common are significantly different at the 1% level.

Figure 2

P/N Ratio Study

Phosphorus leaf concentrations at location 1

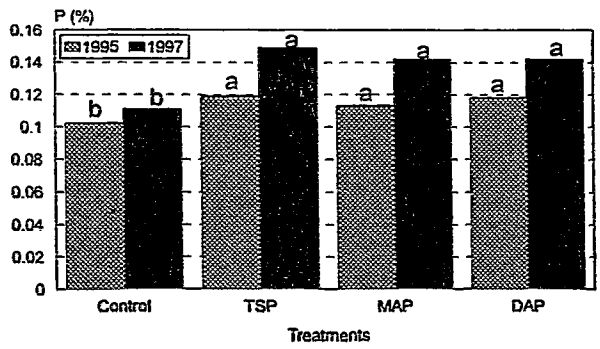


Means within years not having a letter in common are significantly different at the 1% level.

Figure 3

P/N Ratio Study

Phosphorus leaf concentrations at location 2

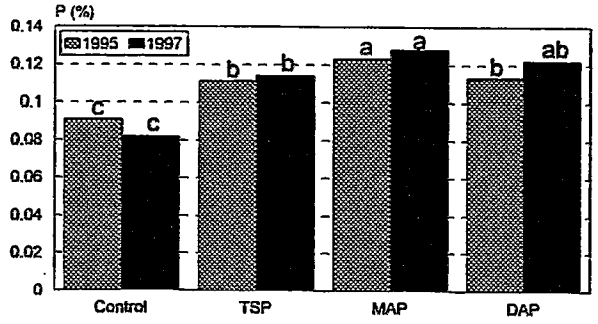


Means within years not having a letter in common are significantly different at the 1% level.

Figure 4

P/N Ratio Study

Phosphorus leaf concentrations at location 3

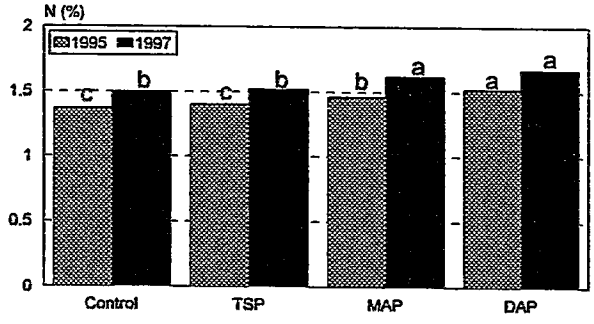


Means within years not having a letter in common are significantly different at the 1% level.

Figure 5

P/N Ratio Study

Nitrogen leaf concentrations*

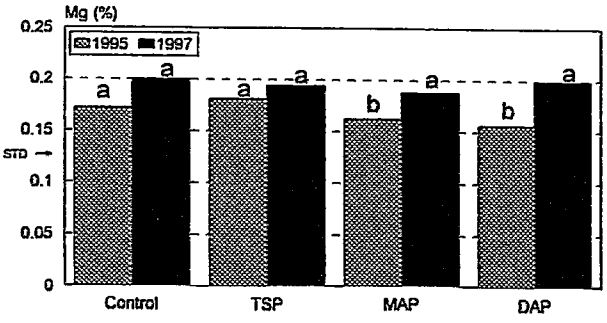


*Values are average of three locations. Means within years not having a letter in common are significantly different at the 1% level.

Figure 6

P/N Ratio Study

Magnesium leaf concentrations*

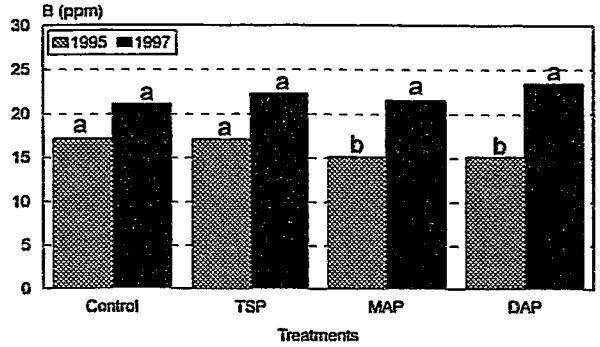


*Values are average of three locations. Means not having a letter in common are significantly different at the 1% level.

Figure 7

P/N Ratio Study

Boron leaf concentrations*

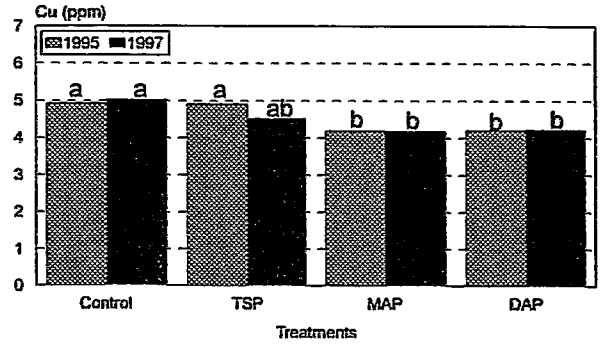


*Values are average of three locations. Means not having a letter in common are significantly different at the 1% level.

Figure 8

P/N Ratio Study

Copper leaf concentrations*

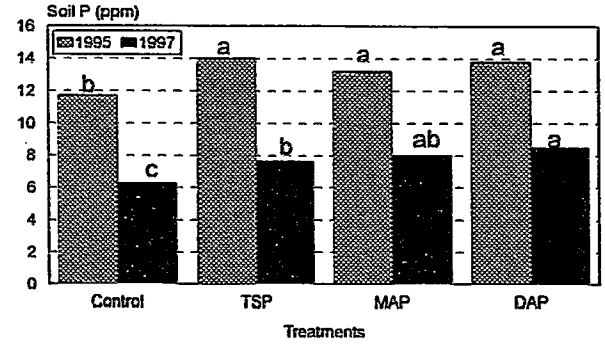


*Values are average of three locations. Means not having a letter in common are significantly different at the 1% level.

Figure 9

P/N Ratio Study

Soil phosphorus concentrations*

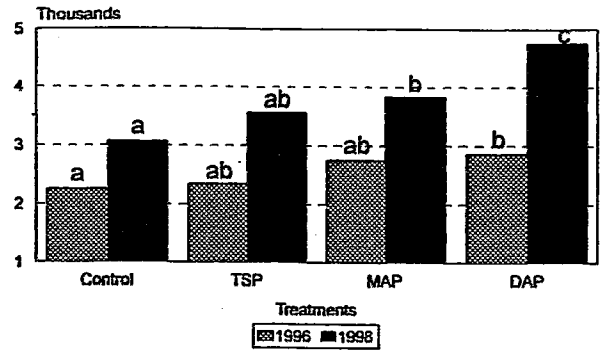


*Values are average of three locations. Treatment means for soils not having a letter in common are significantly different at the 1% level.

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

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

Table 3

P/N Ratio Study

Stem characteristics, 1997

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

D. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Andrea Southworth, Research Assistant
Walter Litten, Faculty Associate

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

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

Boron availability may be limited in the acid podsol soils in which most of Maine's lowbush blueberries are grown. In 1984, a comparison of six grower-classified "good" and six "poor" fields indicated that they had equal numbers of flower buds per stem but that higher levels of boron and calcium were found in the leaf tissue of the "good" fields. A survey of leaf nutrient concentrations in commercial wild 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. Larger berries may be produced due to more seed development within the fruit. When wild blueberry plants are unable to obtain adequate amounts of boron, applying boron through soil fertilization or foliar leaf application could improve fruit set, and stimulate greater numbers of berries to develop. There is little information comparing the effectiveness of soil and foliar boron application in correcting boron deficiency of the wild blueberry.

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

Soil Treatments

T1 =Control + DAP + Zn	T9 =Control
T2 =1.0 lb B/a Borate + DAP + Zn	T10 =1.0 lb B/a Borate
T3 =2.0 lb B/a Borate + DAP + Zn	T11 =2.0 lb B/a Borate
T4 =3.0 lb B/a Borate + DAP + Zn	T12 =3.0 lb B/a 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.

RESULTS: 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.

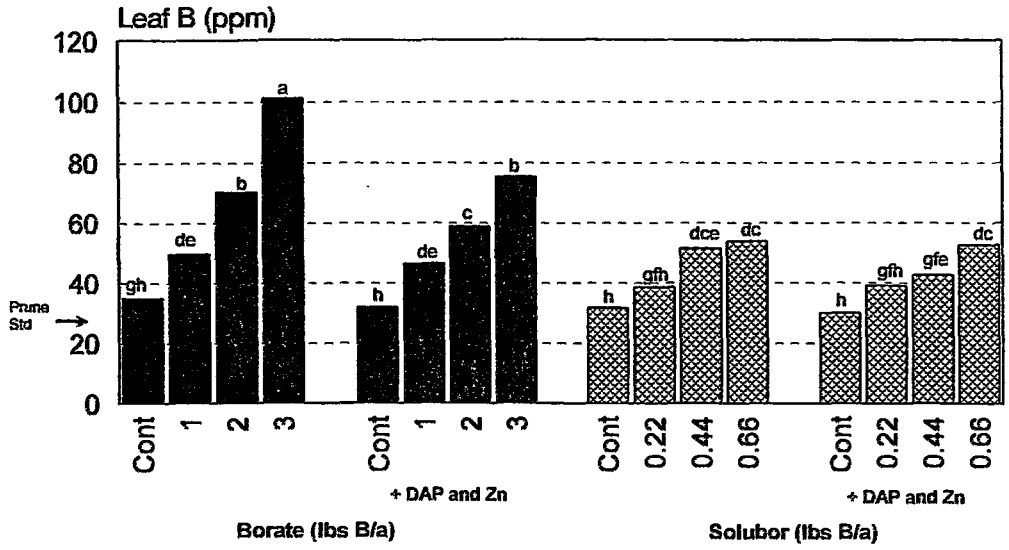
Most of the treatment plots that received DAP and Zn fertilizer had taller stems than those that did not (Fig. 4). B application did not affect stem length. A comparison of flower bud formation among treatment plots receiving borate suggests that an increase in flower buds/stem resulted from a combination 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.

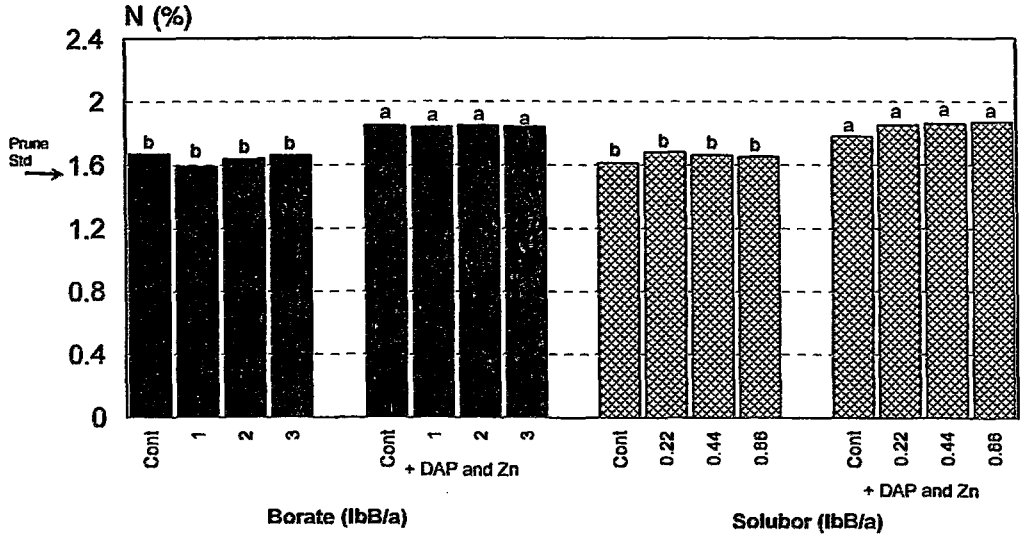
CONCLUSIONS: Spring frost damage in 1998 prevents conclusions about effect on yield of DAP and Zn plus borate or plus Solubor. Leaf B concentrations can be raised in fields with B deficiency by either soil-applied borate or foliar-applied Solubor. DAP and Zn treatments raised leaf N and P concentrations 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. These treatments should be tested in a year without frost damage.

Figure 1 **Comparison of B uptake from soil and leaf application**



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

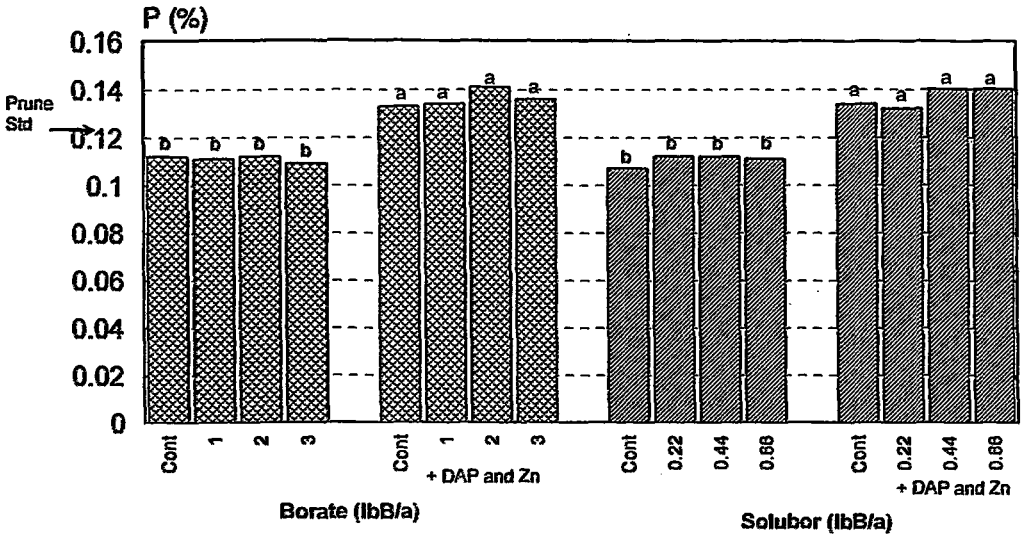
Figure 2 **Leaf Nitrogen Concentrations**



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

Figure 3

Leaf Phosphorus Concentrations

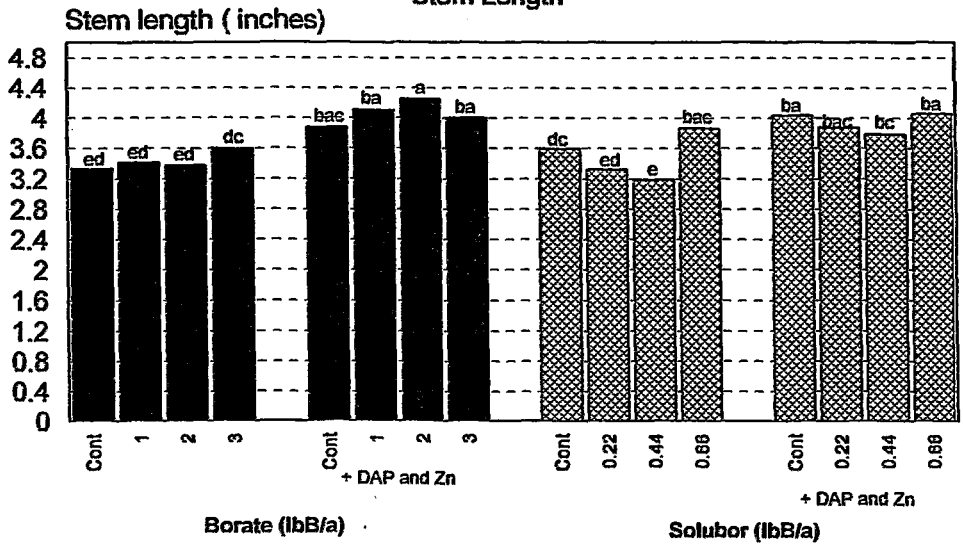


DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 leaf P concentrations by Duncan's multiple range test, P = 0.01.

Figure 4

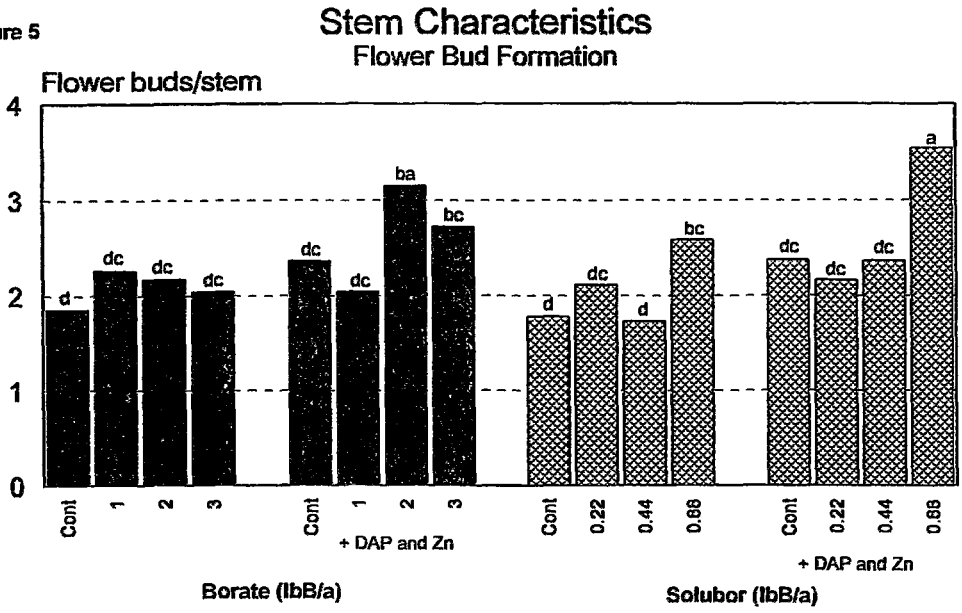
Stem Characteristics

Stem Length



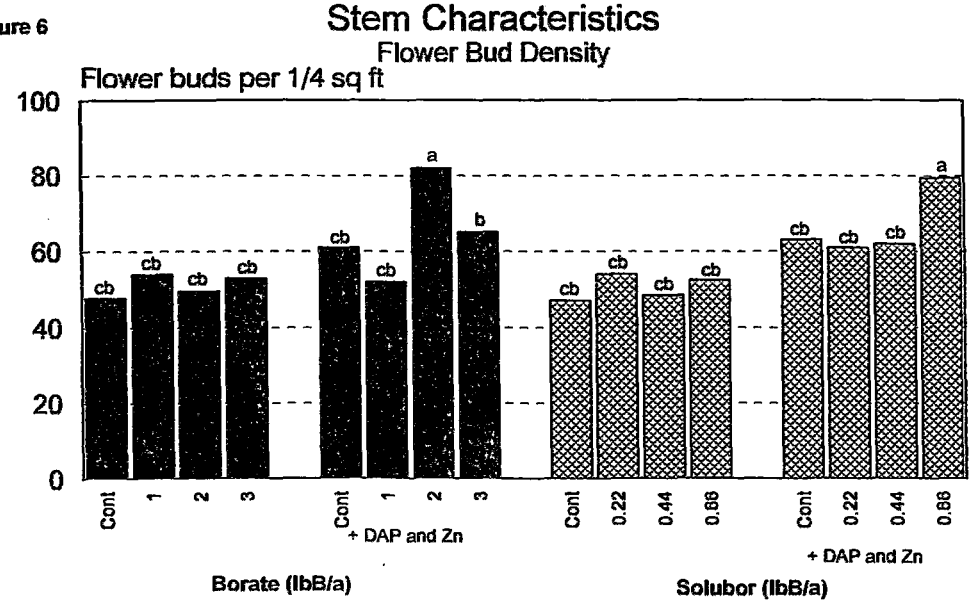
DAP at 80 lb P/a, ZnSO4 at 3 lb Zn/a , Mean separation of 1997 stem length by Duncan's multiple range test, P = 0.01.

Figure 5



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

Figure 6



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

Figure 7

Treatments with Highest Potential Yield

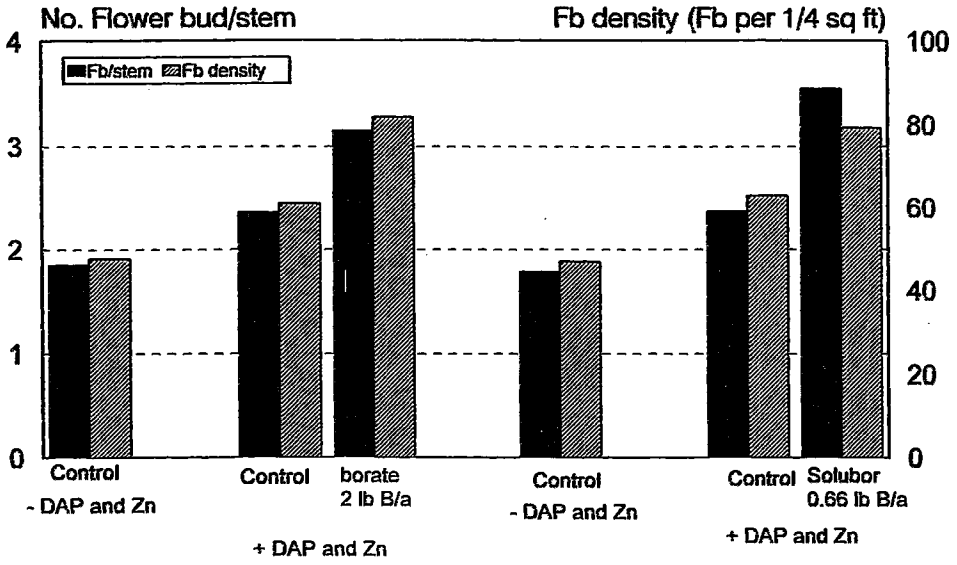
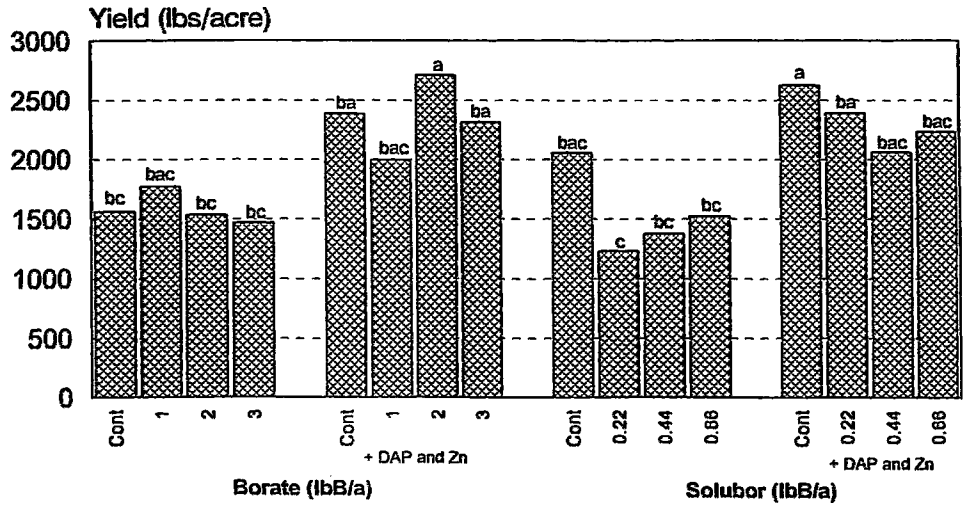


Figure 8

Blueberry Yield



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

D. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Andrea Southworth, Research Assistant
Walter Litten, Faculty Associate

3. TITLE: Effect of Zinc Application on Growth and Yield of Lowbush Blueberries.

OBJECTIVES: Determine the effect of raising foliar zinc concentrations on growth and yield of lowbush blueberries.

METHODS: Two commercial wild blueberry fields in Liberty (Turner/Mann) and Washington (Rotch) were used in this study. Treatment plots measuring 5 ft x 50 ft (with 5 ft between plots) received the following treatments:

1. Control
2. Zintrac - 1 pt/acre (40%Zn) - June 20 and June 30 foliar applications (prune year)
3. Zintrac - 1 quart/acre - June 20 foliar application (prune year)
4. Zintrac - 1 pt/acre - one July foliar application during crop year
5. Zintrac - 1 pt/acre - one July foliar application during crop year
6. Zn SO_4 - 3 lbs Zn/acre - May 30 soil application

These treatments were randomly assigned to treatment plots in a randomized complete block design with 9 blocks. On July 2, 1997, fertilizer and herbicide were applied by Coastal Blueberry Company in the form of 10 lbs Pronone and 110 lbs DAP/acre (containing 5 lbs boron/ton). Composite leaf tissue samples were taken in July 1997 from 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 number of flower buds/stem. Leaf samples were taken again in July 1998 but only from the Rotch location. Leaves sampled from Treatment 5 were washed with a 1% hydrochloric acid solution to determine if a Zintrac residue on the leaf surface was giving us false leaf Zn concentrations. Yield was determined in August 1998.

RESULTS: At both locations leaf Zn concentrations were raised more by two applications of Zintrac at 1 pt/acre than by one application of Zintrac at 1 qt/acre (Figs. 1 & 2). At the Turner/Mann field (Fig. 1), the 1 qt/acre rate raised leaf Zn concentrations compared to the control, but not at the Rotch field. Soil application of $ZnSO_4$ at 3 lbs Zn/acre did not raise leaf Zn concentrations at either field. Leaf N and P concentrations of control plots were above their respective standards of 1.6% and 0.125%, respectively, and Zn treatments had little effect on N or P concentrations.

The characteristics of stems sampled in the fall 1997 (stem density, stem length, flower bud formation) were not meaningfully affected by any of the treatments at the Turner/Mann (Figs. 3 & 4) or the Rotch (Figs. 5 & 6) fields.

Crop year leaf Zn concentrations in leaves sampled from the Rotch field indicated no carryover effect from the 1997 Zn applications but crop-year foliar applications of Zn did raise leaf Zn concentrations, compared to the controls (Fig 7). Similar leaf Zn concentrations in treatment 5 and 7 leaf samples suggests that surface contamination by residual Zintrac did not occur in 1997 or 1998. These higher leaf Zn concentrations had no apparent effect on fruit set and yield. Yield was not affected by any of the treatments at either the Turner/Mann field (Fig. 8) or the Rotch field (Fig.9).

CONCLUSIONS: Raising leaf Zn concentrations had no effect on wild blueberry productivity. However, multiple applications of lower foliar rates of Zintrac were more effective than soil application or a higher single application rate in raising leaf Zn concentrations. The Zn standard may be too low since raising leaf Zn concentrations had no effect on growth or yield.

RECOMMENDATIONS: No recommendations for Zn fertilization can be made at this time.

Figure 1 Leaf Zinc Concentration

Turner/Mann Field

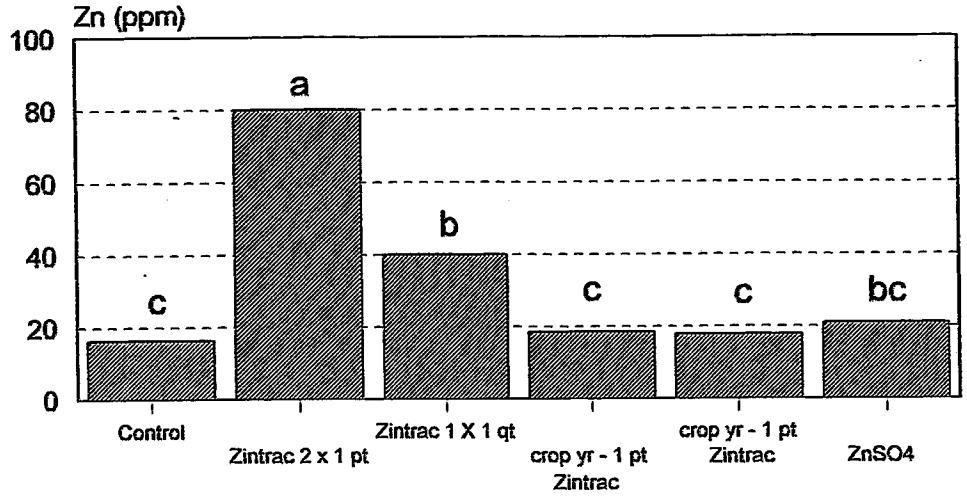


Figure 2 Leaf Zinc Concentration

Rotch Field

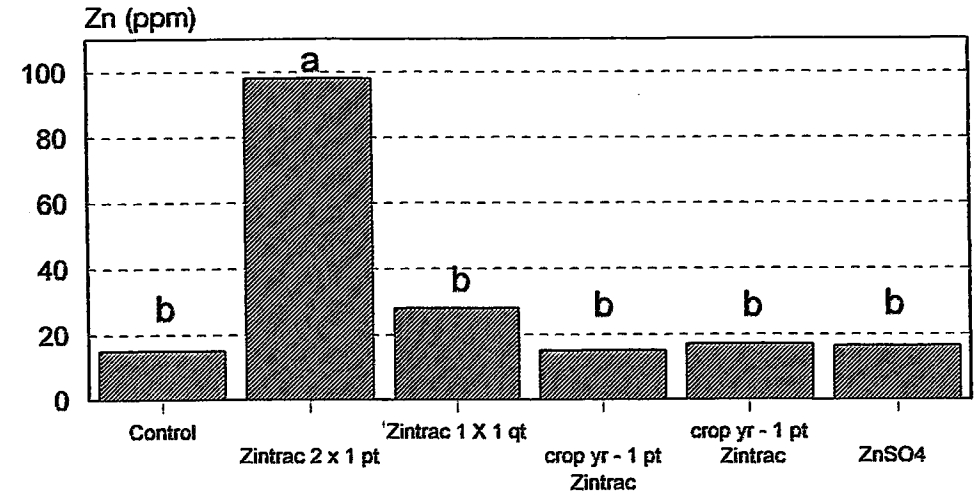


Figure 3 Stem Characteristics

Turner/Mann Field

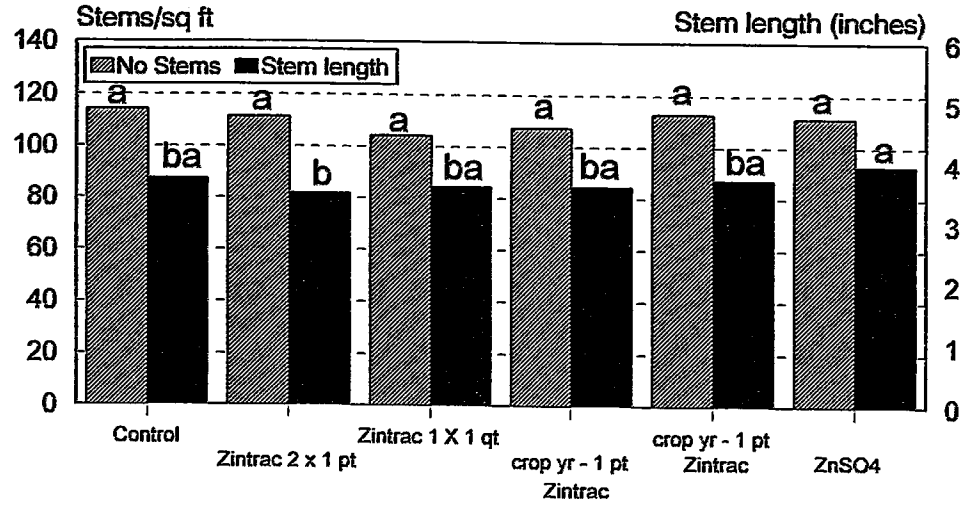


Figure 4 Stem Characteristics

Turner/Mann Field

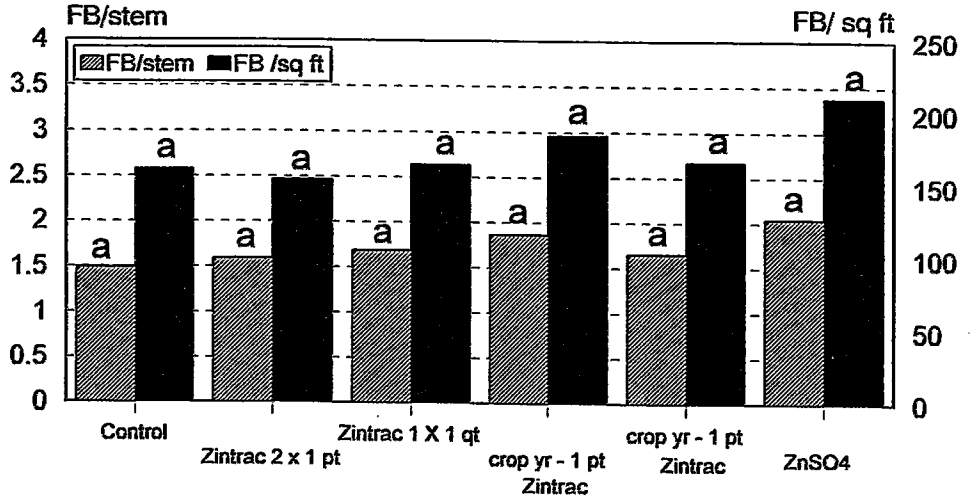


Figure 5 Stem Characteristics

Rotch Field

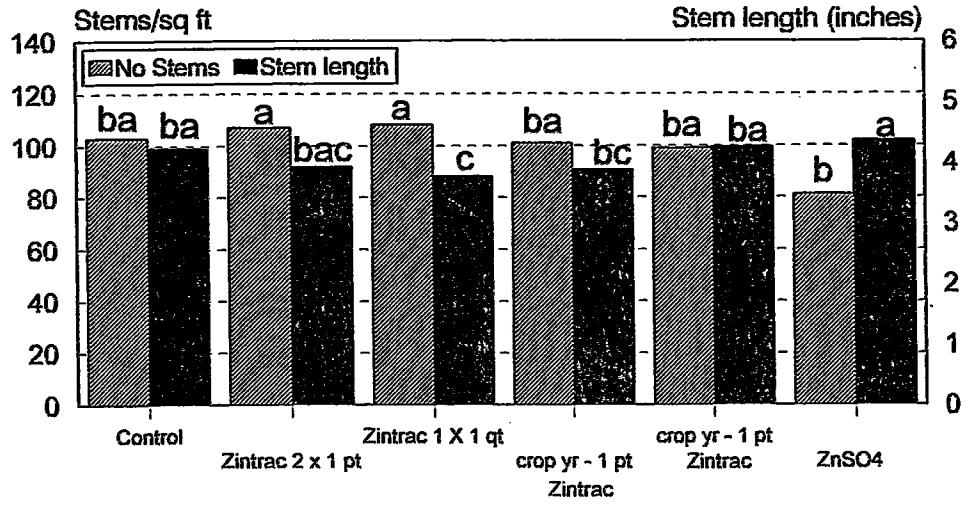


Figure 6 Stem Characteristics

Rotch Field

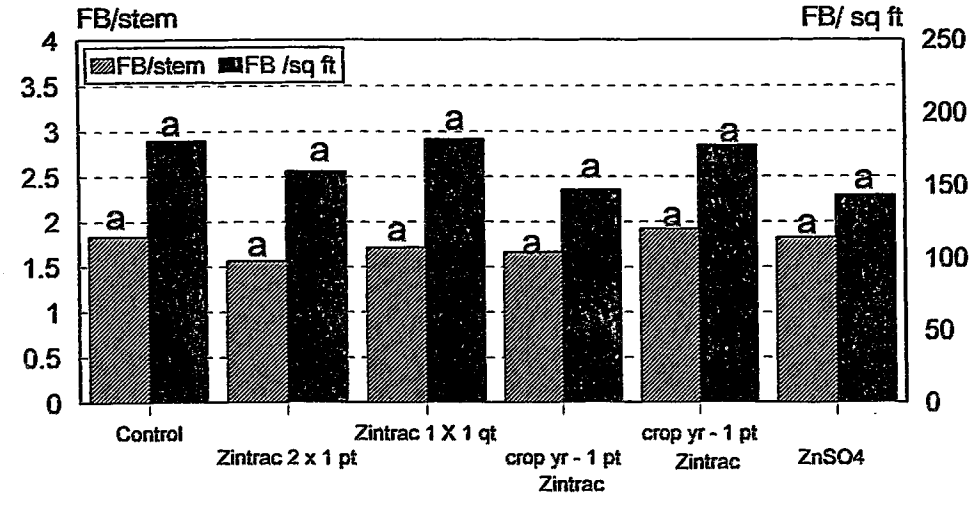


Figure 7 1998 Leaf Zinc Concentration

Rotch Field

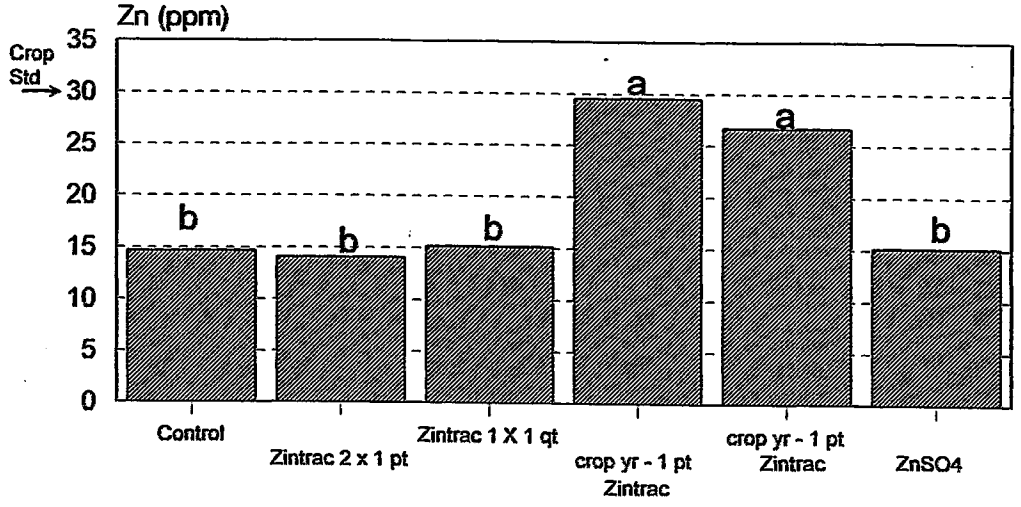


Figure 8

Blueberry Yield

Turner/Mann Field

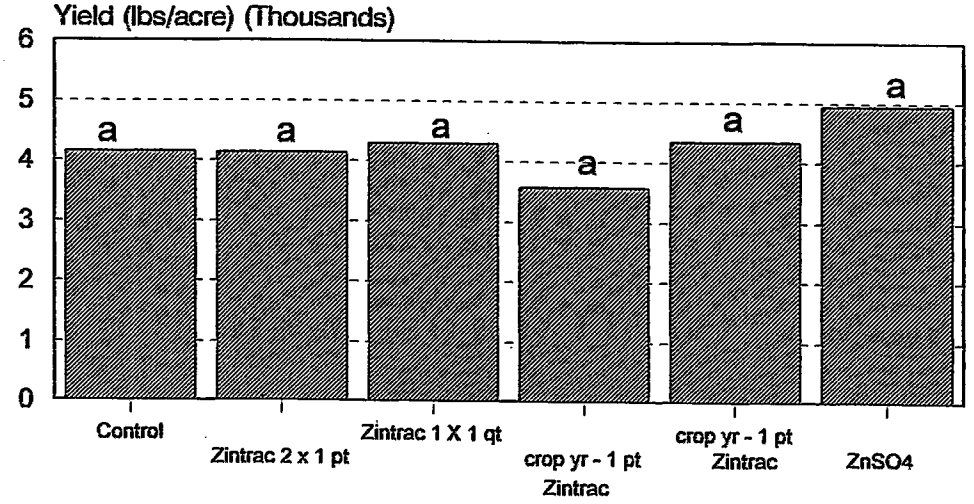
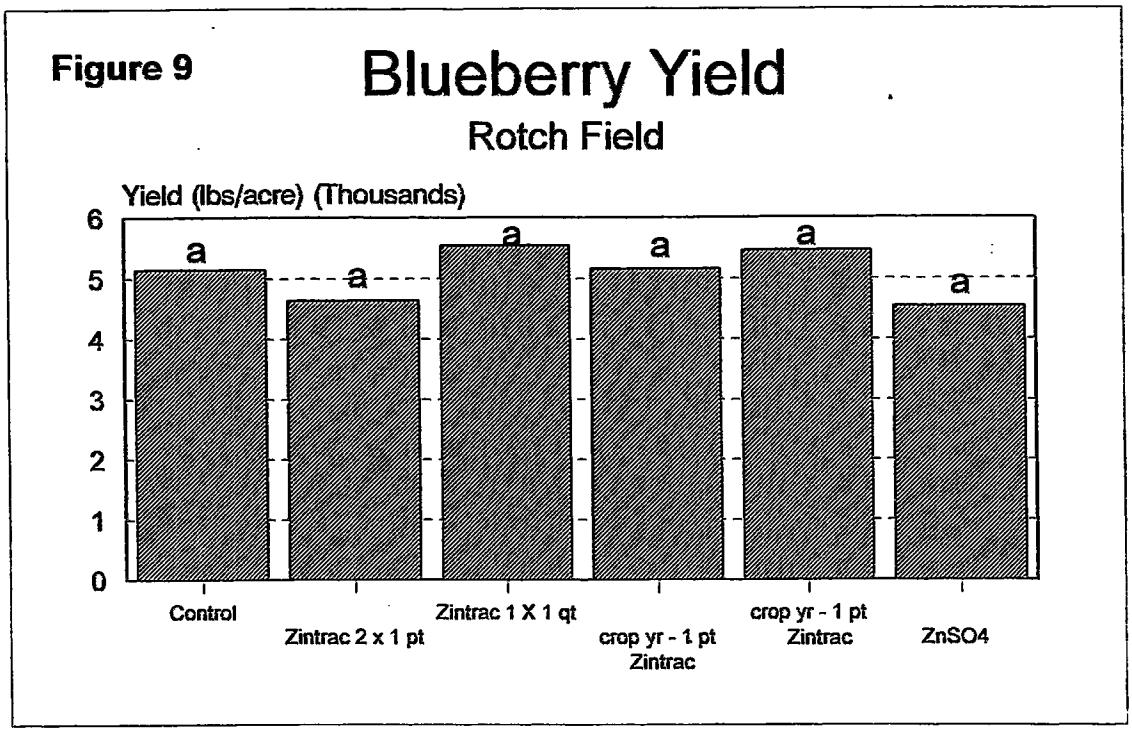


Figure 9


Blueberry Yield
Rotch Field
Yield (lbs/acre) (Thousands)
6
5
4
3
2
1
0
a
a
a
a
a
a
Control
Zintrac 2 x 1 pt
Zintrac 1 X 1 qt
crop yr - 1 pt Zintrac
crop yr - 1 pt Zintrac
ZnSO4

D. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Andrea Southworth, Research Assistant
Walter Litten, Faculty Associate

4. TITLE: Effect of Soil pH on Nutrient Uptake

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

METHODS: An experiment 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 the 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

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 at the 10%

Table 2

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 at the 10% le

The soil pH at each location varied from clone to clone (Figs. 3 & 4). This reinforces the need for wild 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

Stem density ranged from 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). The average stem height ranged from 3.9 to 6.7 inches and fruit bud formation ranged from 1.2 to 4 bud/stem among the clones in the NO 14 TWP field. In the Lamoine field average stem height ranged from 3.3 to 5.1 inches and fruit bud formation ranged from 0.3 to 2.3 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

Stem characteristics of non-destructive and destructive samples among clones, 1995.

	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

Stem characteristics of non-destructive and destructive samples as affected by sulphur treatment, 1995.

	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

Soil pH and leaf nutrient concentrations at Lamoine as affected by sulphur treatment, July1997.

		Leaf nutrient concentrations				
Treatment	Soil pH	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

Stem characteristics of non-destructive and destructive samples at Lamoine as affected by sulphur treatment,1997.

	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.

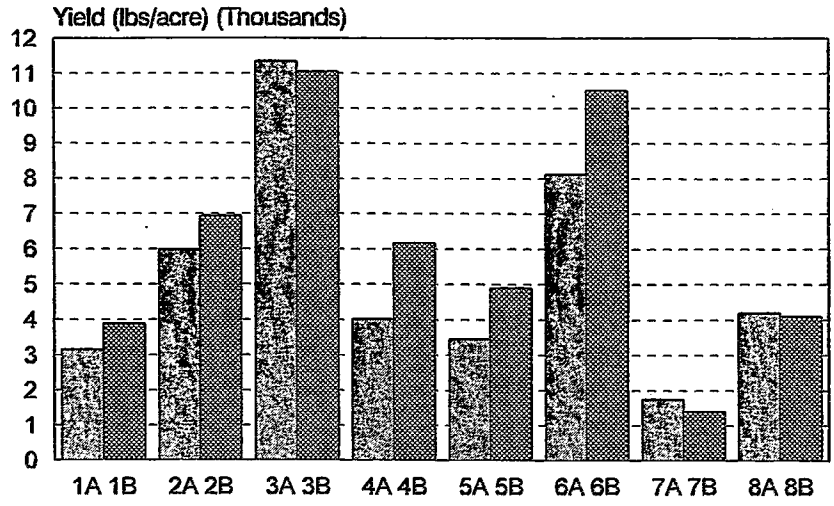
CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can made at this time.

Figure 1

YIELD DATA COMPARSION OF TREATMENT PLOTS

Lamoine

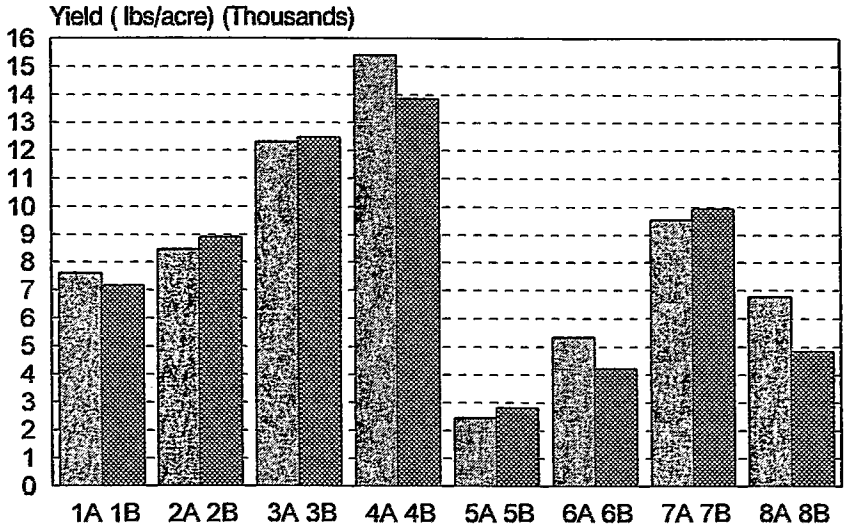


1994

Figure 2

YIELD DATA COMPARSION OF TREATMENT PLOTS

NO 14 TWP



1994

Figure 3

VARIATION OF pH AMONG CLONES

LAMOINE

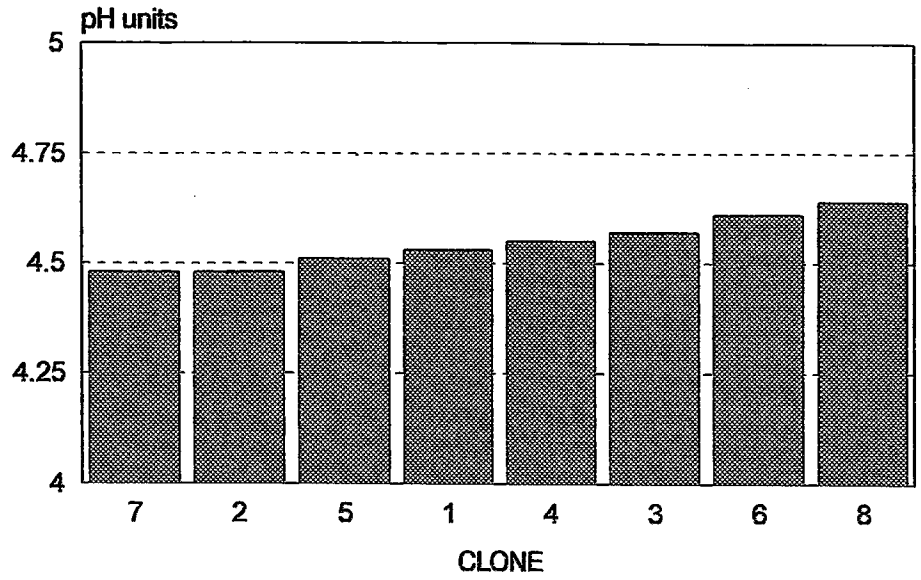


Figure 4

VARIATION OF pH AMONG CLONES

NO 14 TWP

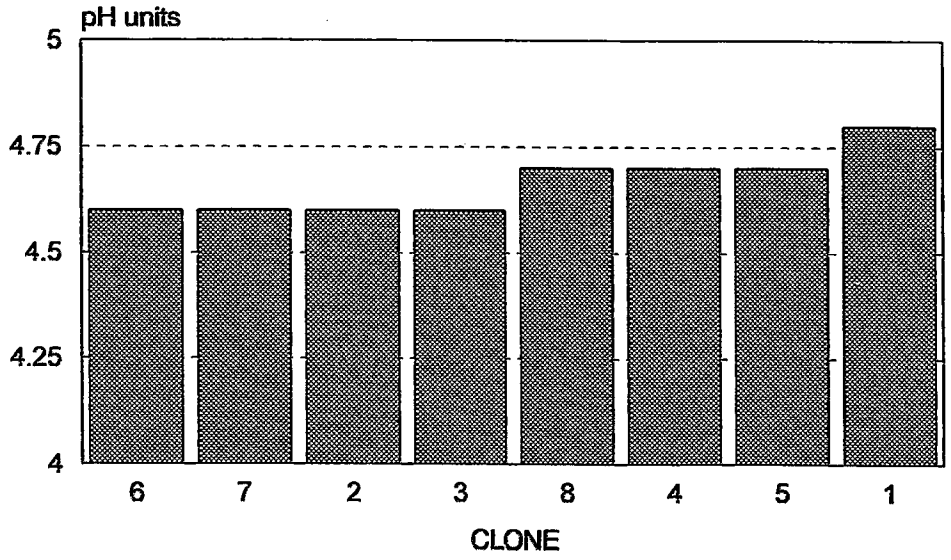


Figure 5

CHANGE IN pH DURING GROWING SEASON

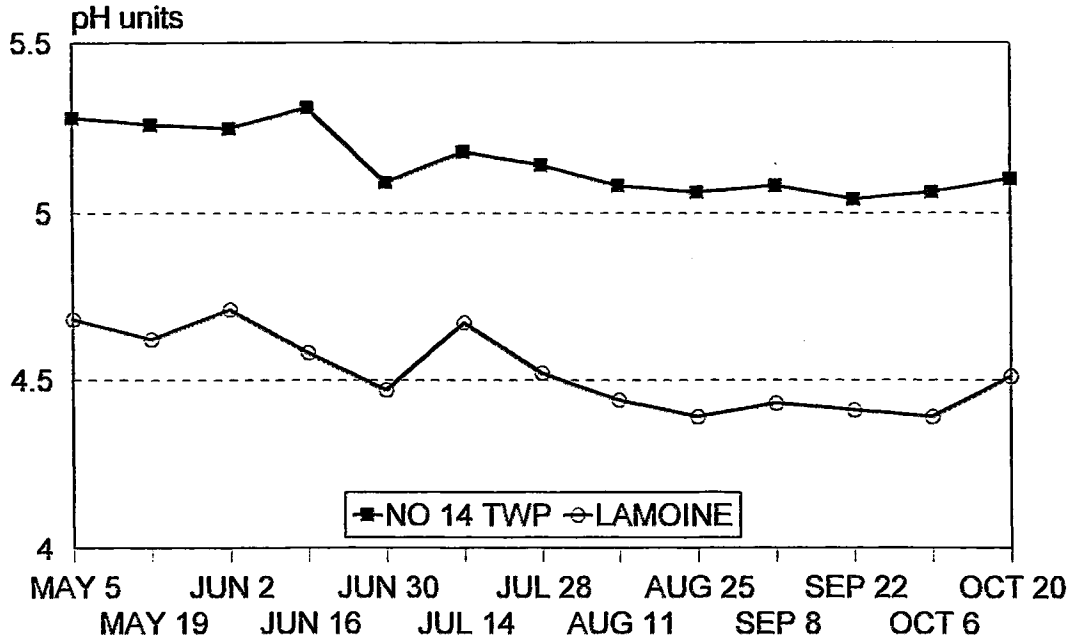
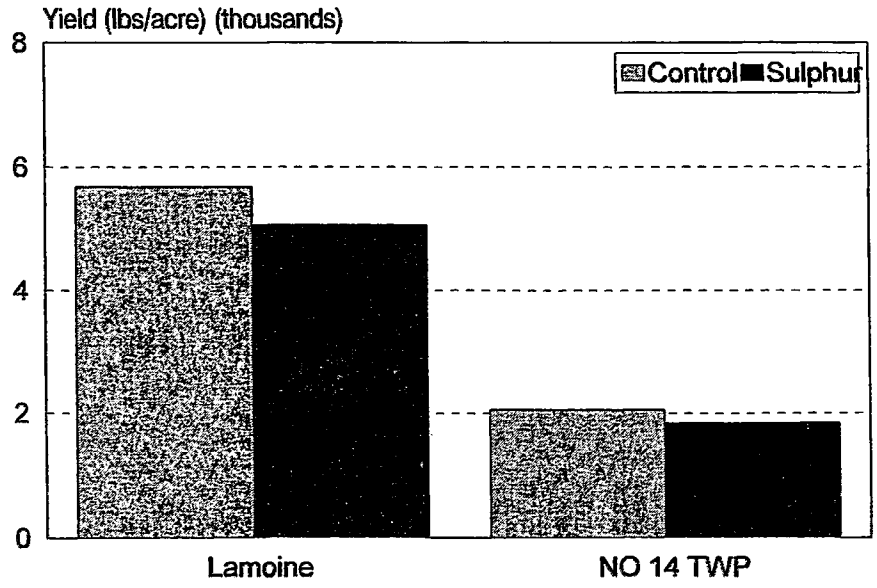


Figure 6

1996 Yield

Average Yield at Lamoine and NO 14 TWP

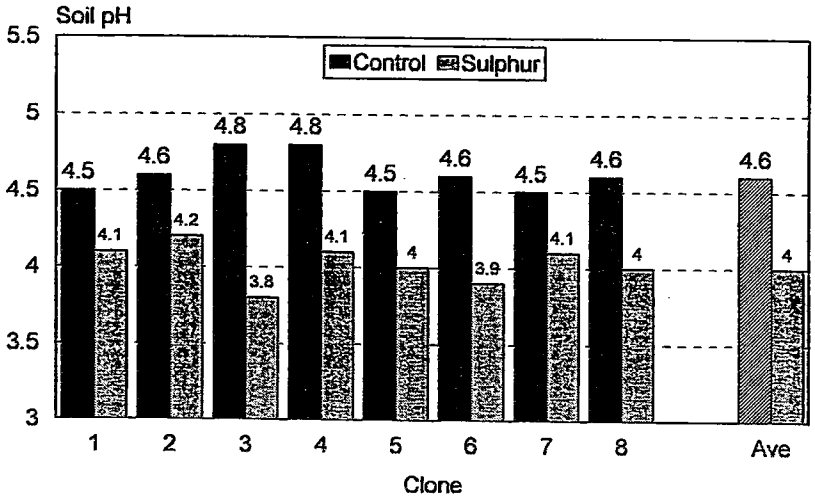


No significant difference between treatments at either location

Figure 7

Soil pH

Litten Field, Lamoine

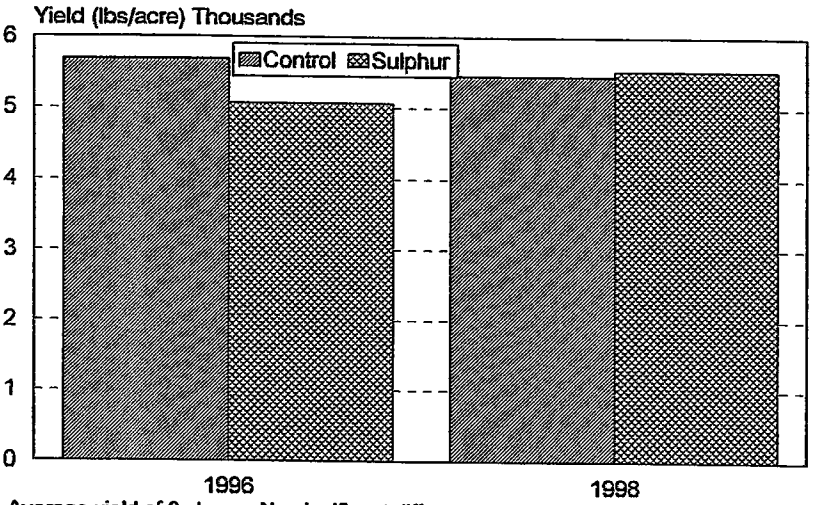


1998 data

Figure 8

1996 and 1998 Yield

Lamoine

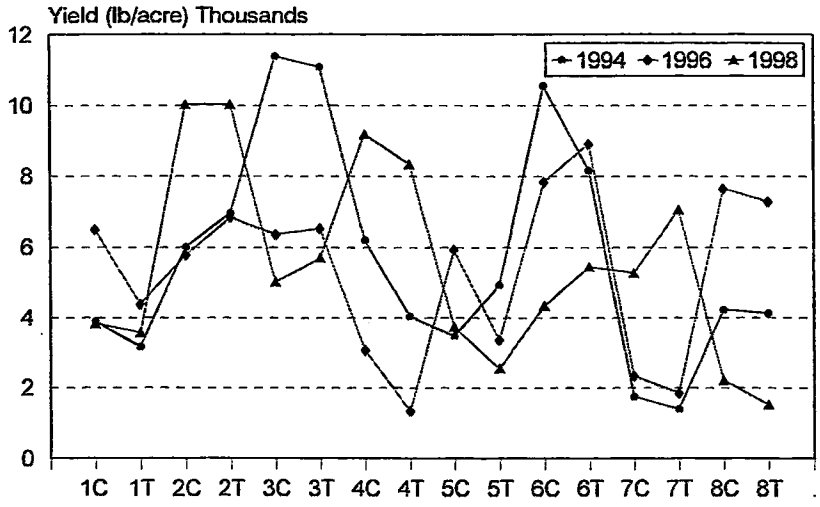


Average yield of 8 clones. No significant difference between control and sulphur treament in either 1996 or 1998.

Figure 9

Comparison of Treatment Plot Yield Data over Time

Lamoine



C = control, no sulphur; T= treatment with sulphur.

D. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Andrea Southworth, Research Assistant
Walter Litten, Faculty Associate

5. TITLE: Crop Year Fertilization of Wild blueberry.

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

METHODS: A commercial wild blueberry field that was sampled 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 indicated no significant increase in extractable P in treatment plots receiving fertilizer treatments, compared to the controls (Fig. 13). Soil Zn concentrations also showed no significant increase due to fertilizer treatments (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).

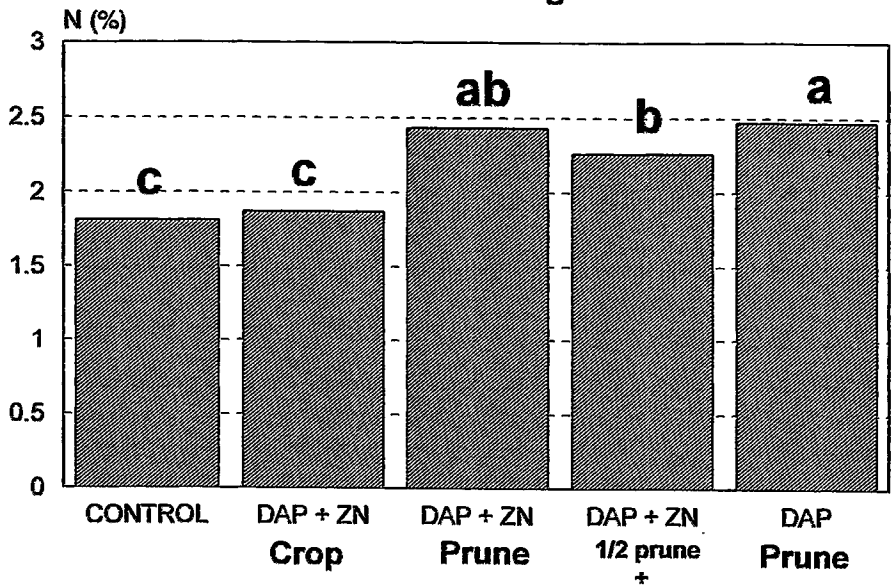
Although there was an average yield differential of about 1,500 lbs/acre between some of the treatments and the control, there was no statistical difference (Fig. 17). This implies great variation in yield among plots.

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 wild 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

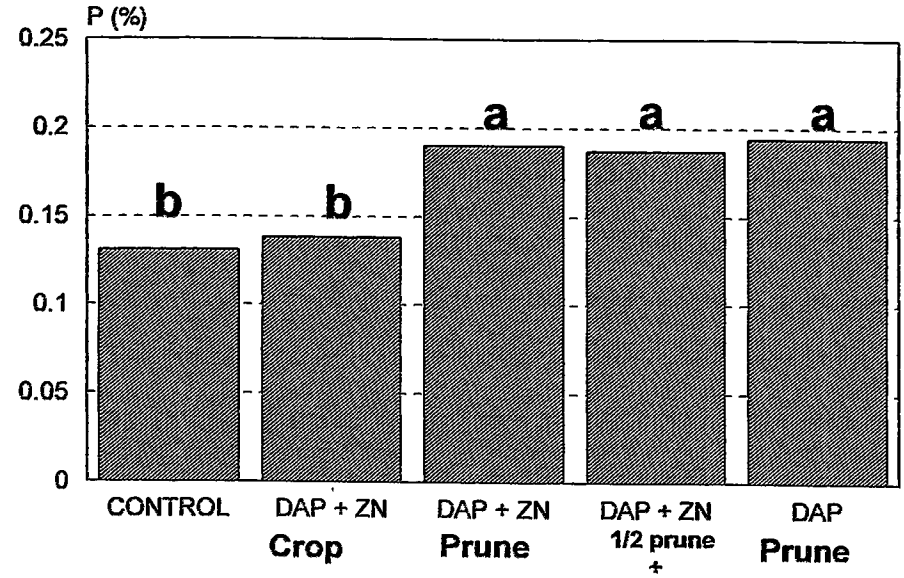
1997 Leaf Nitrogen



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

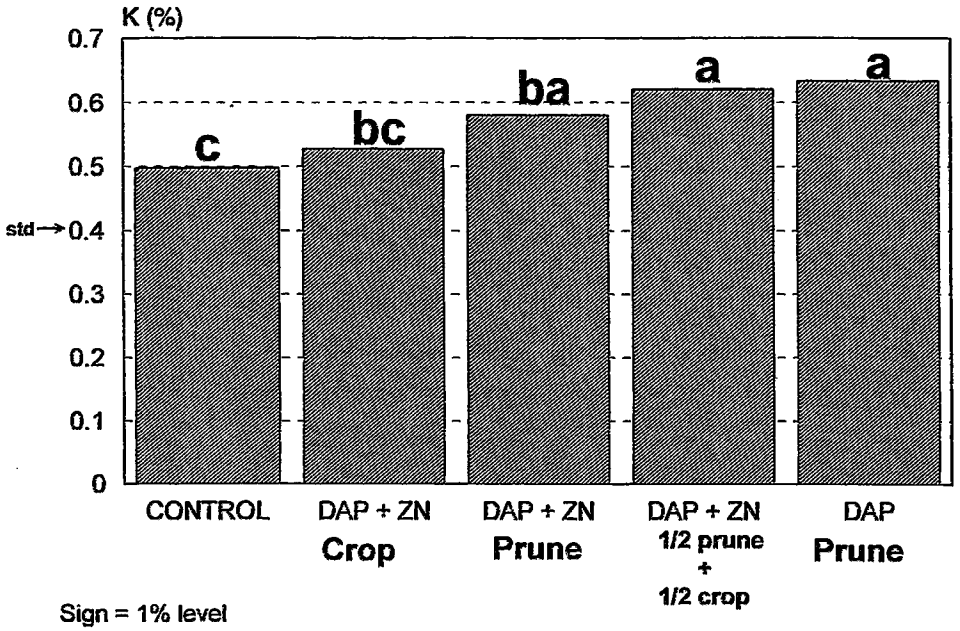
Figure 2 Crop Year Fertilization Study

1997 Leaf Phosphorus



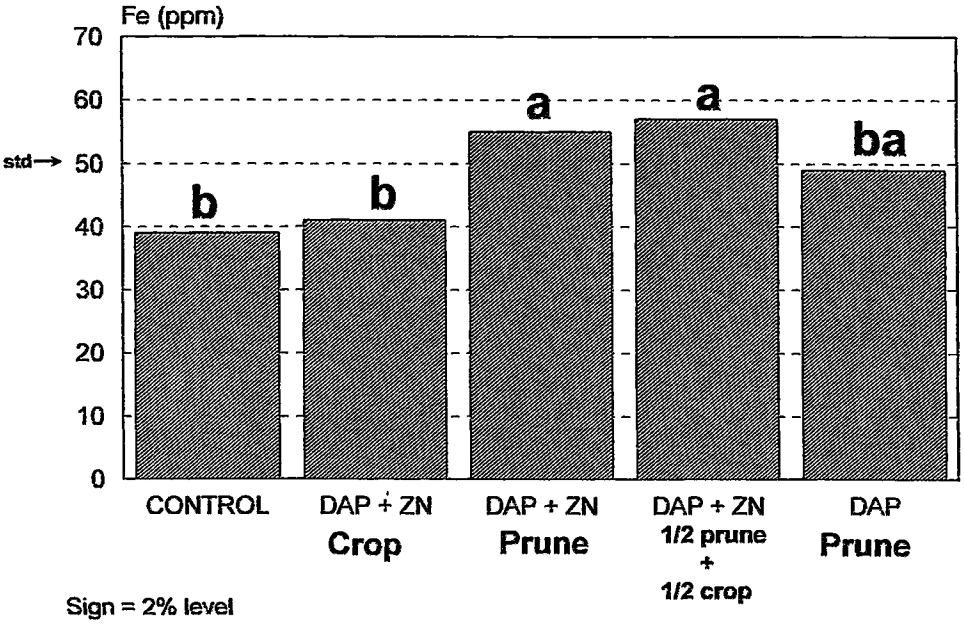
Sign = 1% level

Figure 3 Crop Year Fertilization Study
1997 Leaf Potassium



Sign = 1% level

Figure 4 Crop Year Fertilization Study
1997 Leaf Iron



Sign = 2% level

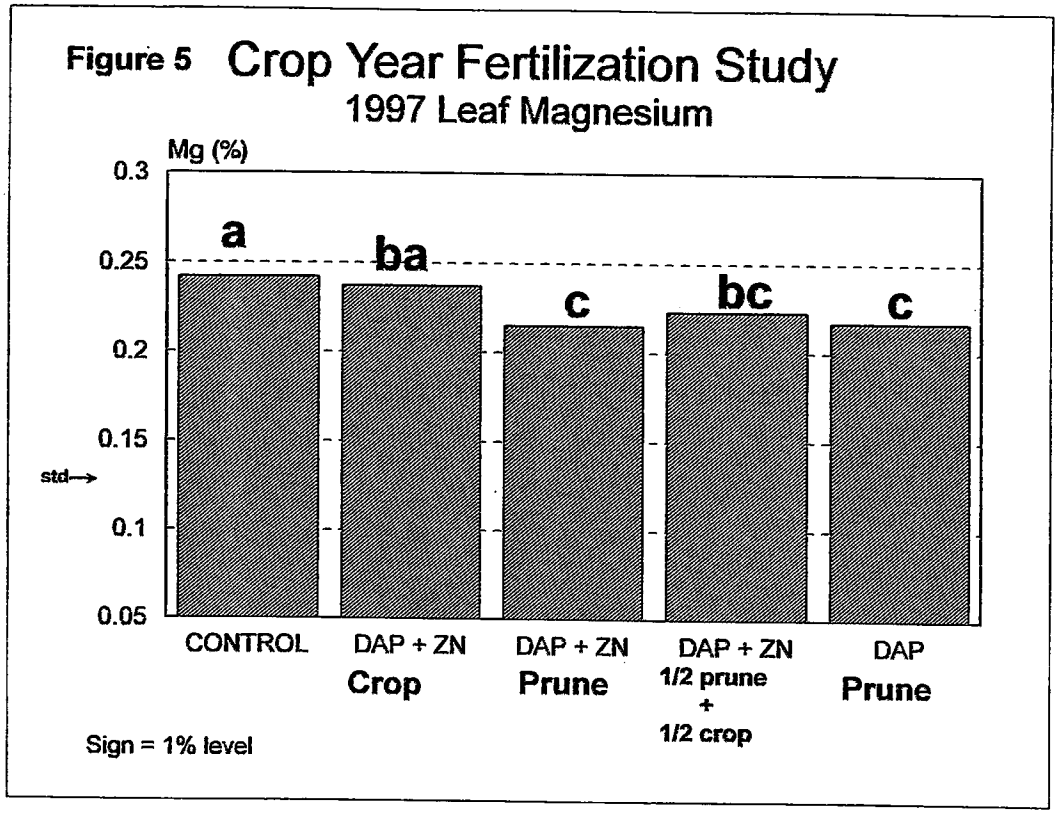


Figure 5 Crop Year Fertilization Study
1997 Leaf Magnesium
Mg (%)
0.3
0.25
0.2
0.15
std→
0.1
0.05
a
ba
c
bc
c
CONTROL
DAP + ZN
Crop
DAP + ZN
Prune
DAP + ZN
1/2 prune
+
1/2 crop
DAP
Prune
Sign = 1% level

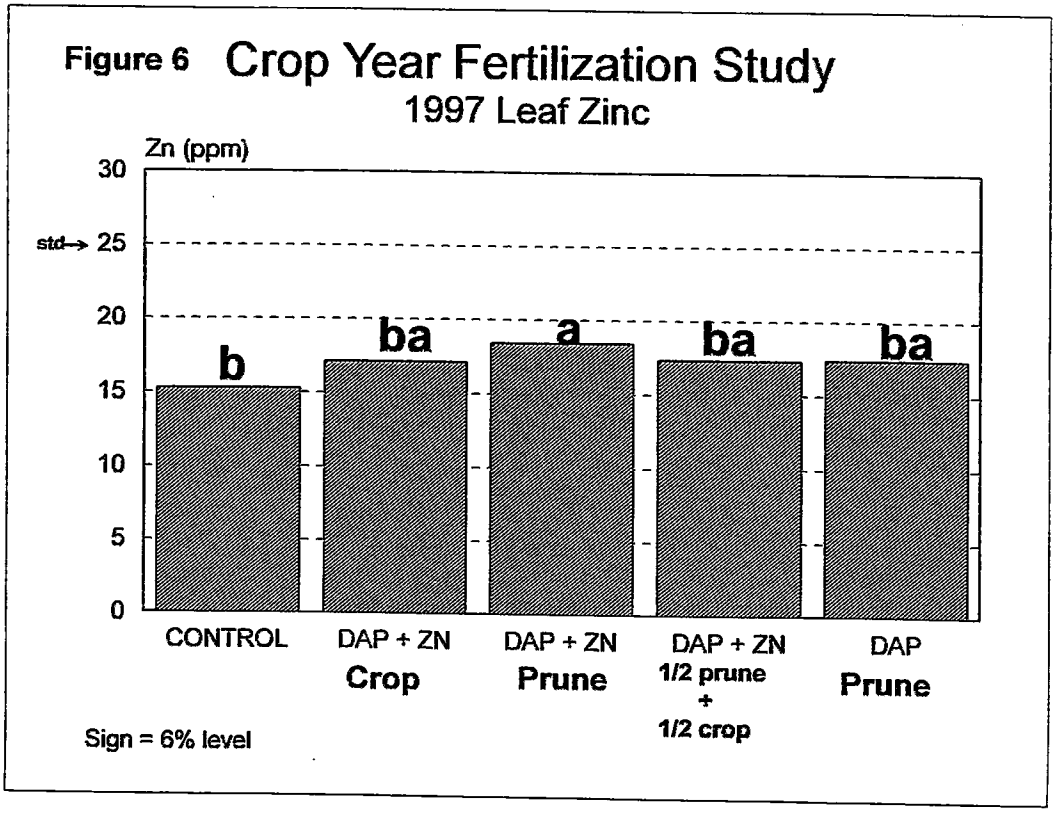
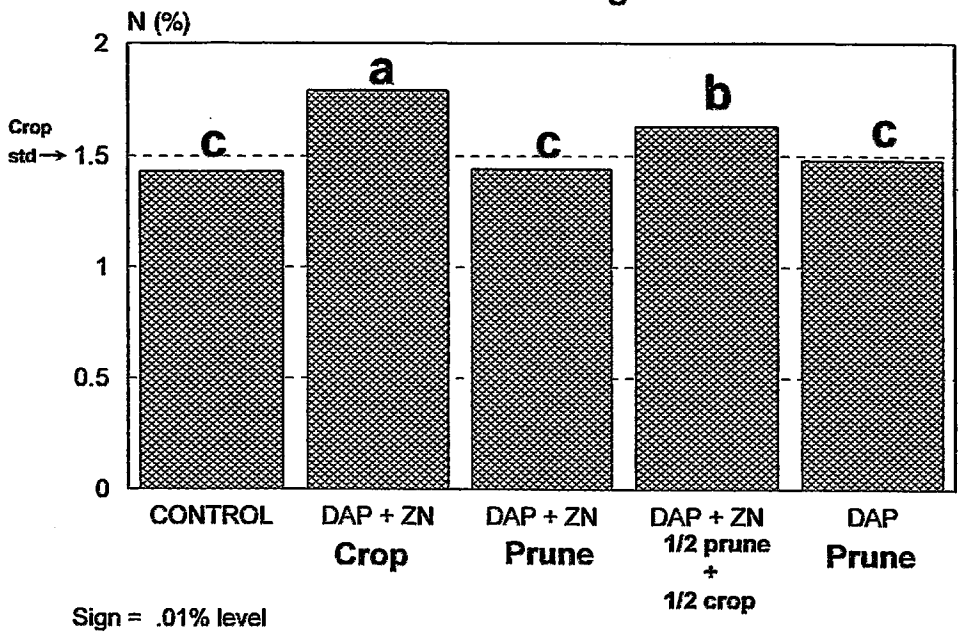


Figure 6 Crop Year Fertilization Study
1997 Leaf Zinc
Zn (ppm)
30
std→ 25
20
15
10
5
0
b
ba
a
ba
ba
CONTROL
DAP + ZN
Crop
DAP + ZN
Prune
DAP + ZN
1/2 prune
+
1/2 crop
DAP
Prune
Sign = 6% level

Figure 7 Crop Year Fertilization Study

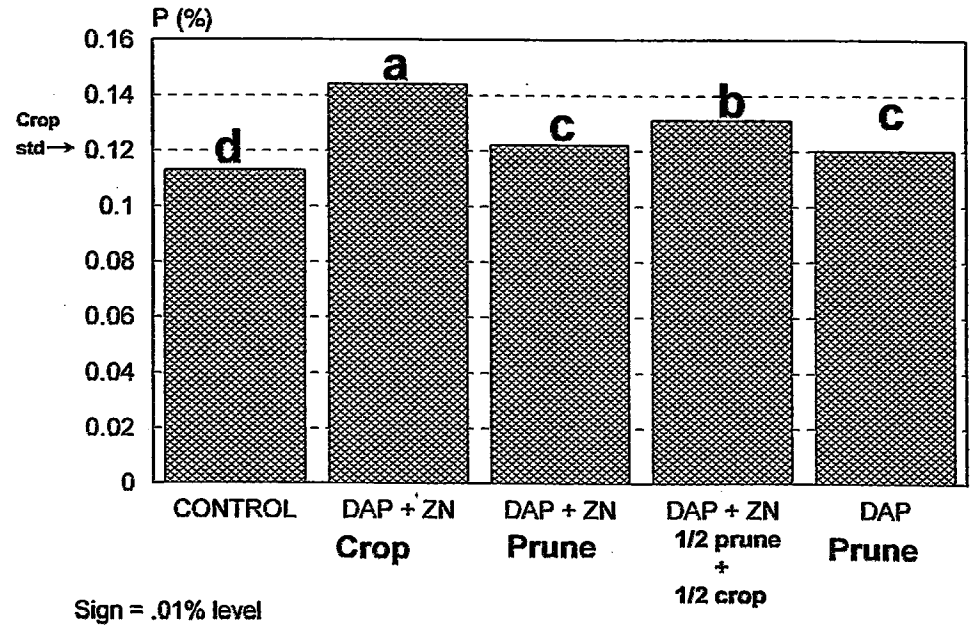
1998 Leaf Nitrogen



Sign = .01% level

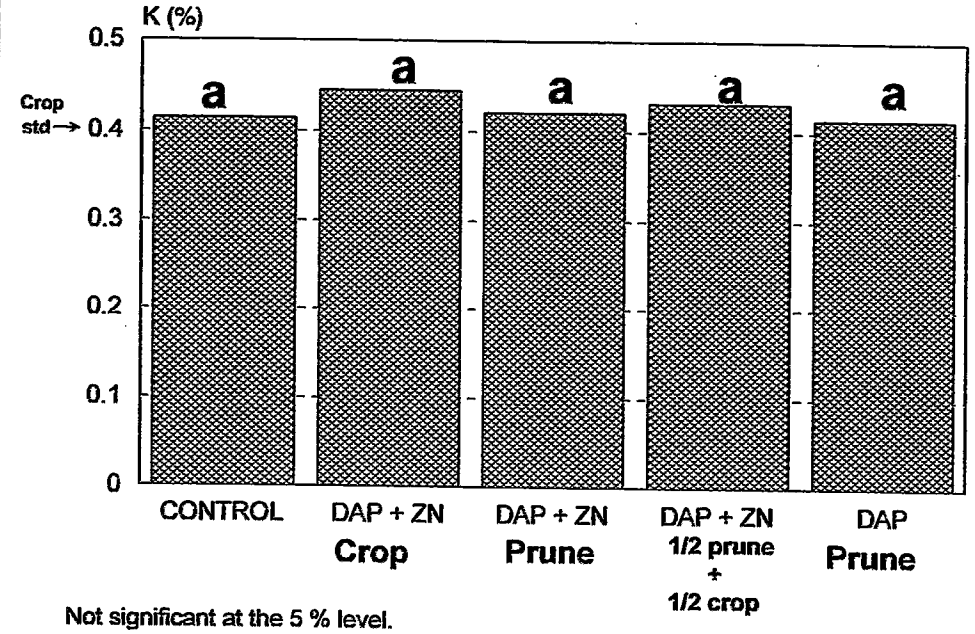
Figure 8 Crop Year Fertilization Study

1998 Leaf Phosphorus



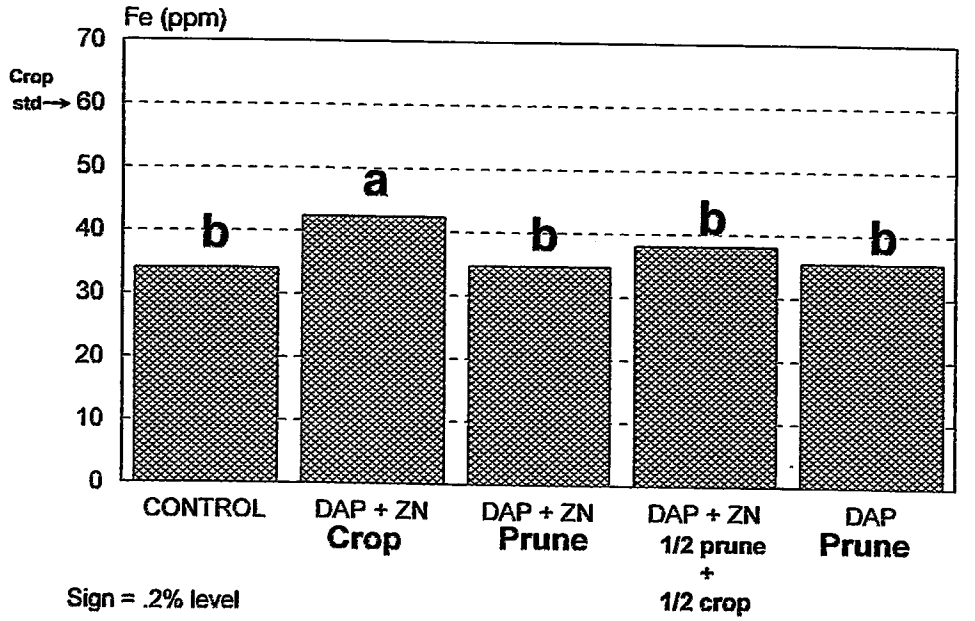
Sign = .01% level

Figure 9 Crop Year Fertilization Study
1998 Leaf Potassium



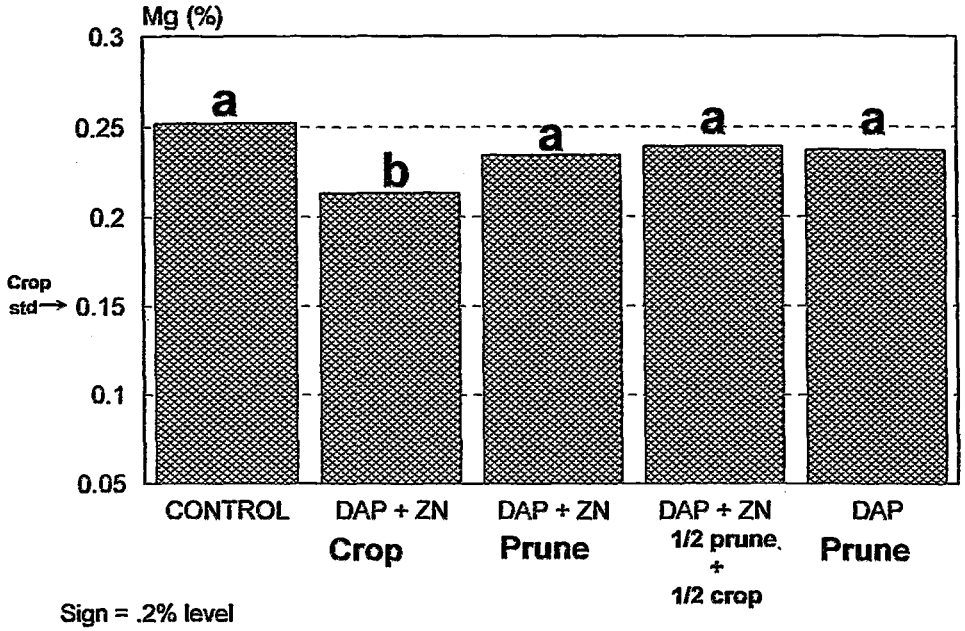
Not significant at the 5 % level.

Figure 10 Crop Year Fertilization Study
1998 Leaf Iron



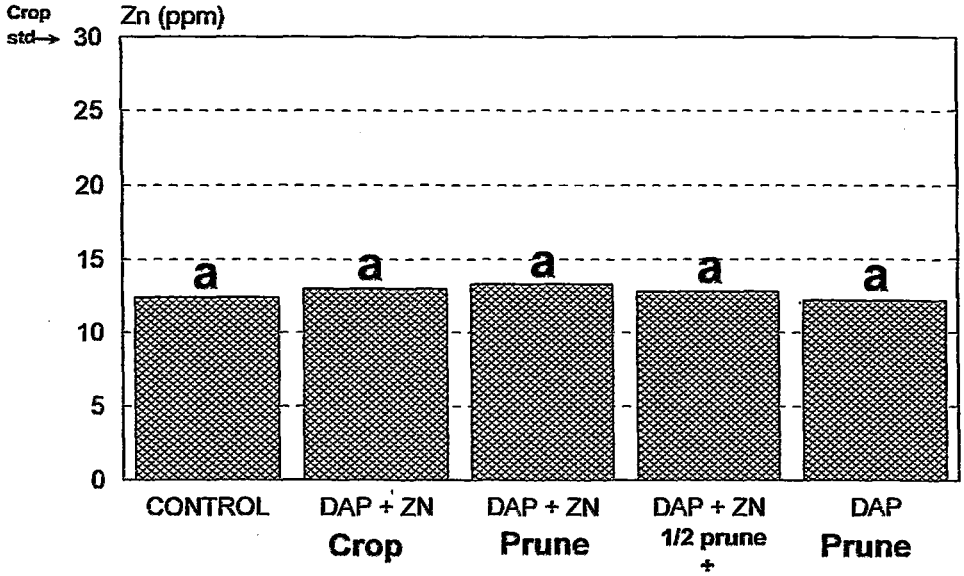
Sign = .2% level

Figure 11 Crop Year Fertilization Study
1998 Leaf Magnesium



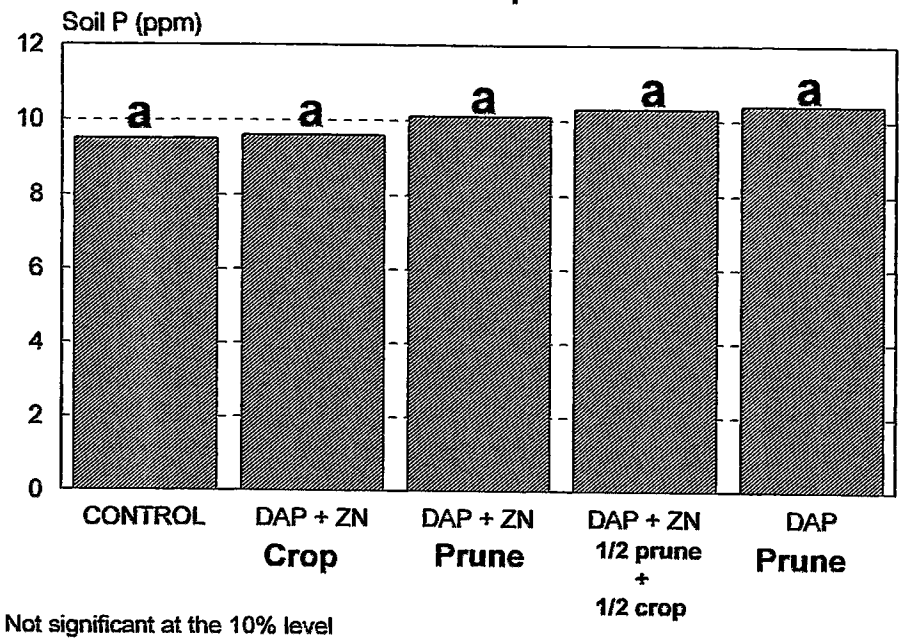
Sign = .2% level

Figure 12 Crop Year Fertilization Study
1998 Leaf Zinc



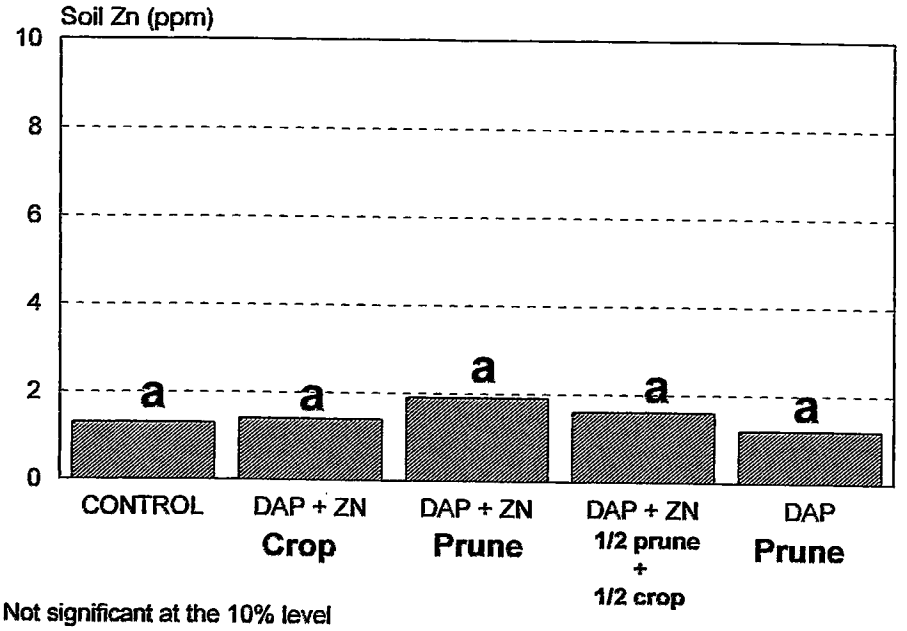
Not significant at the 5% level

Figure 13 Crop Year Fertilization Study
1997 Soil Phosphorus



Not significant at the 10% level

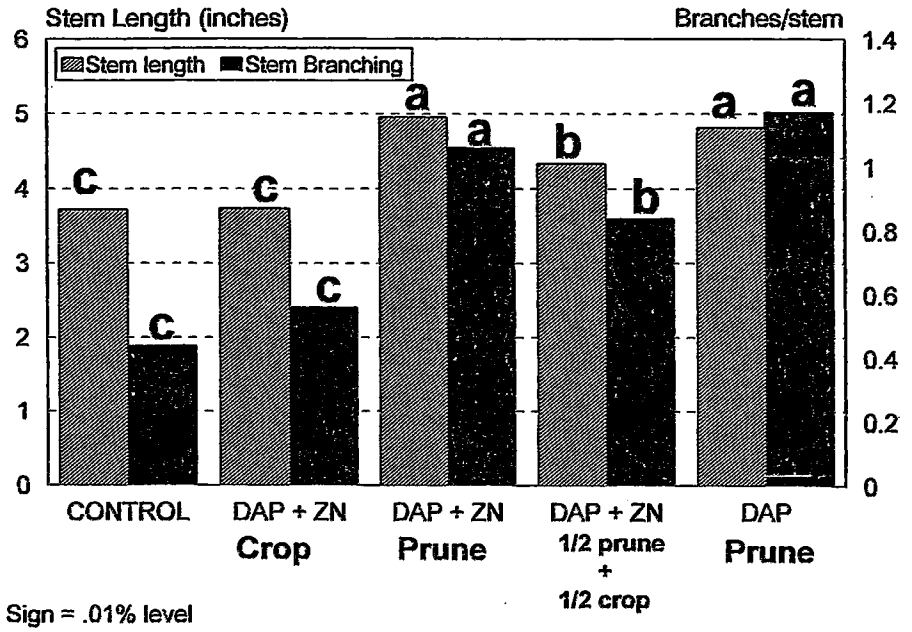
Figure 14 Crop Year Fertilization Study
1997 Soil Zinc



Not significant at the 10% level

Figure 15 Crop Year Fertilization Study

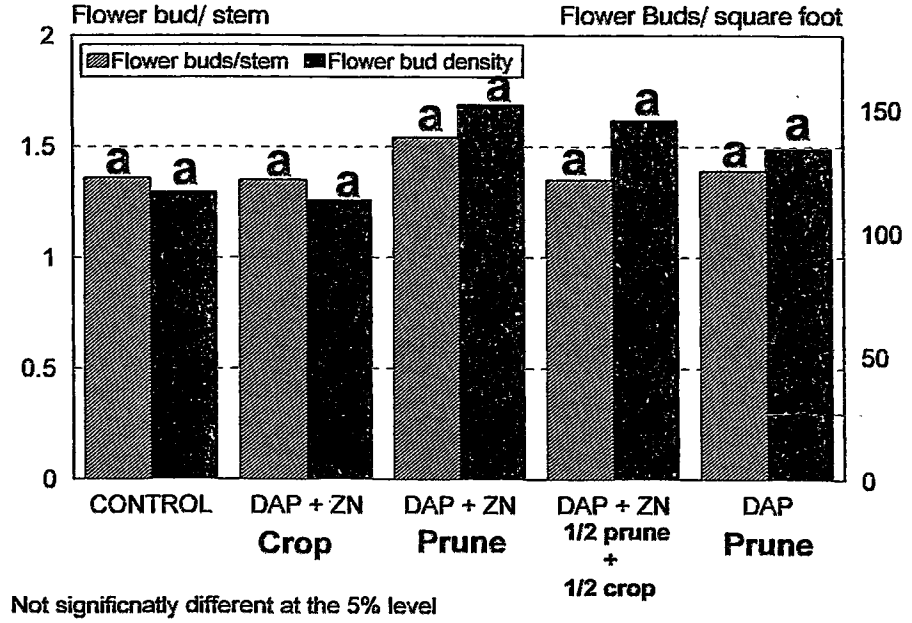
1997 Stem Characteristics



Sign = .01% level

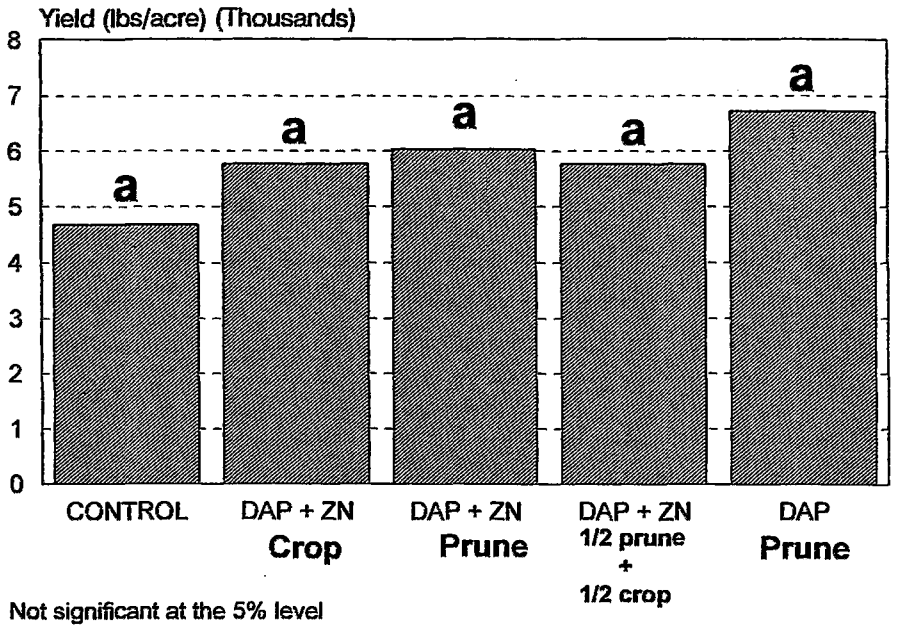
Figure 16 Crop Year Fertilization Study

1997 Flower Bud Characteristics



Not significnatly different at the 5% level

Figure 17 Crop Year Fertilization Study



Not significant at the 5% level

D. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Andrea Southworth, Research Assistant
Walter Litten, Faculty Associate

6. TITLE: Effect of Fertilizer Timing on Wild blueberry Growth and Productivity.

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

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 on May 19, June 2, June 16 or June 30, 1988. 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.

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. Stems were sampled in October 1998 to determine treatment effects on stem length and flower bud formation. Yield will be collected 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 indicated nitrogen was not deficient resulting 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.

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).

Location 2

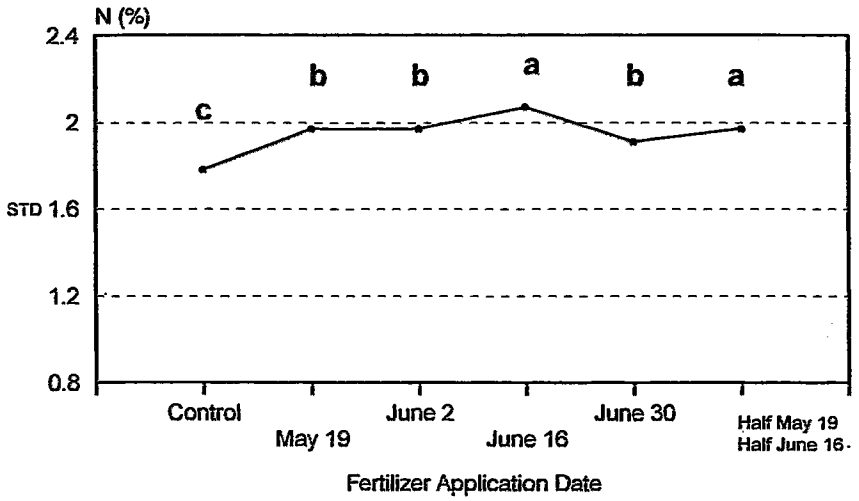
On the sandy soil of Location 2, leaf nitrogen was below the standard (1.65%) in leaves sampled from the control plots (Fig. 8). The leaf N concentrations were raised above the standard by DAP fertilizer at all application dates; the highest concentration resulted from fertilizing on June 2 and June 16 and from the split application on May 19 and June 16. Leaf P concentrations were also affected by date of fertilizer application (Fig. 9); 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 (Trevett, 1972). That we have raised yields in response to P fertilization when leaf concentrations were at the 0.125% suggests the standard should perhaps be 0.130%. Stem density was not influenced by fertilization (Fig. 10). Stem length was increased by early fertilization on May 19 or June 2, compared to other dates and the control (Fig. 11). 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. 12). 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. 13). Flower bud density was also increased by fertilization at all dates, including the split application, compared to the control (Fig. 14).

CONCLUSIONS: No conclusions can be made until the study is completed.

RECOMMENDATIONS: We recommend that a second study begin in 1999 that includes a preemergent application date along with postemergent application dates.

Figure 1

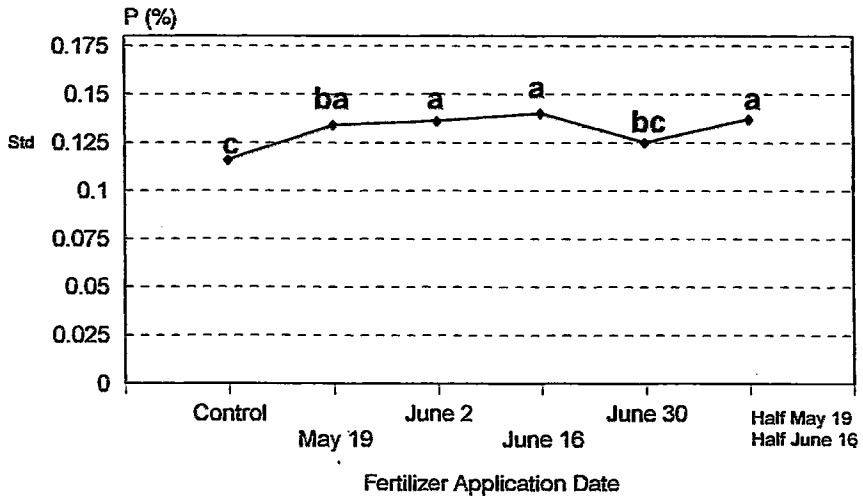
Effect of Fertilizer Timing on Leaf Nitrogen



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

Figure 2

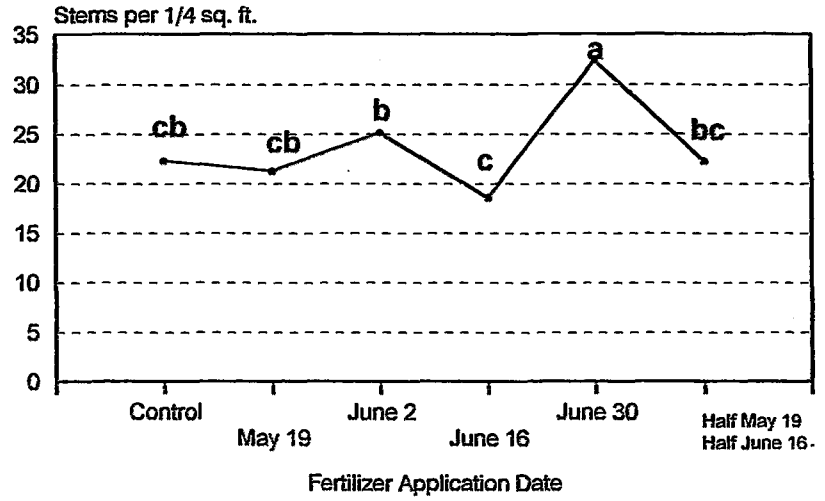
Effect of Fertilizer Timing on Leaf Phosphorus



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

Figure 3

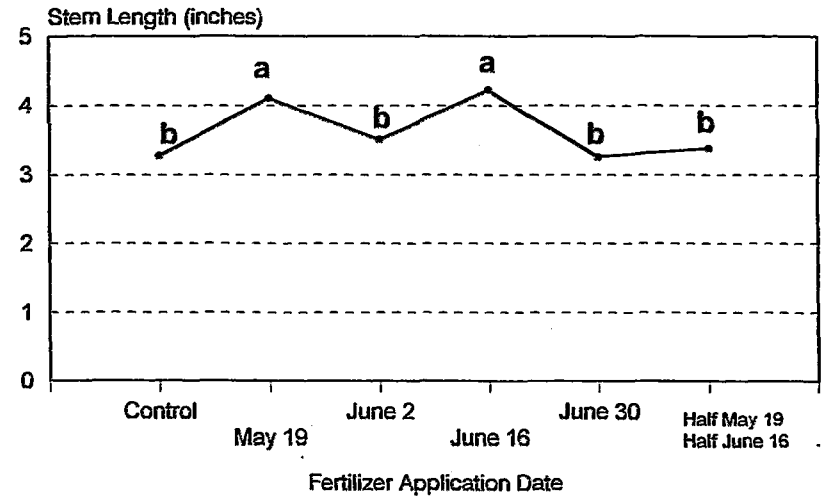
Effect of Fertilizer Timing on Stem Density



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

Figure 4

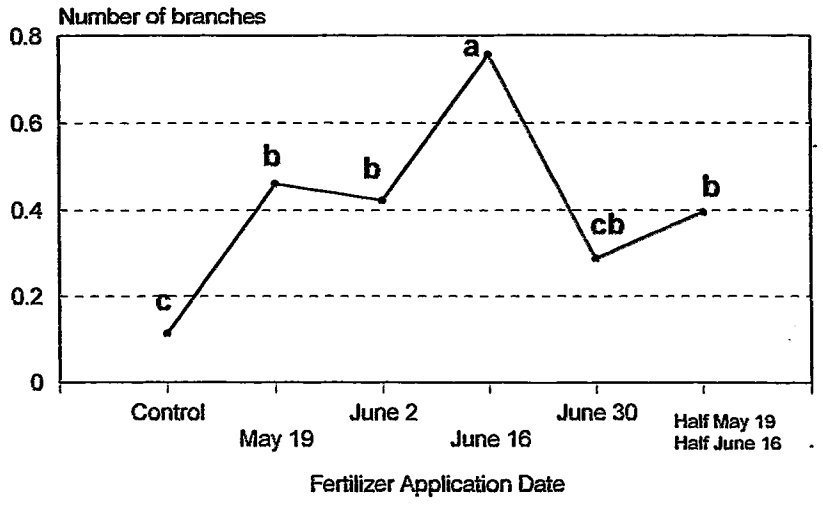
Effect of Fertilizer Timing on Stem Length



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

Figure 5

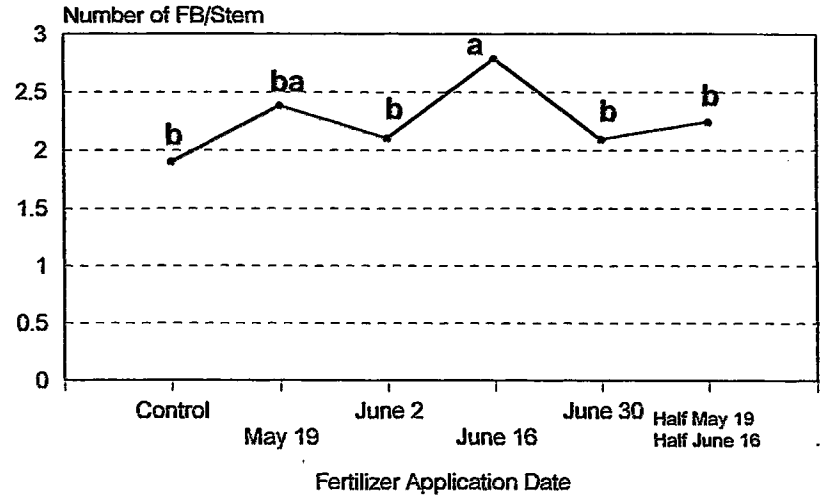
Effect of Fertilizer Timing on Stem Branching



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

Figure 6

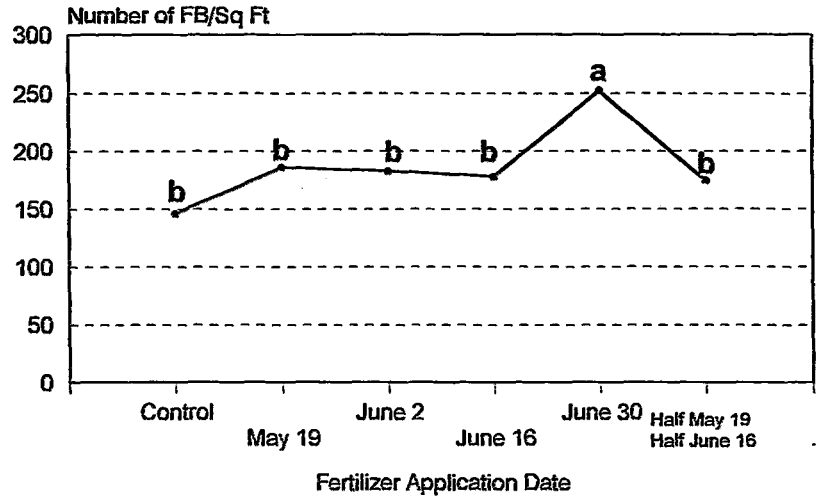
Effect of Fertilizer Timing on Flower Bud Formation



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

Figure 7

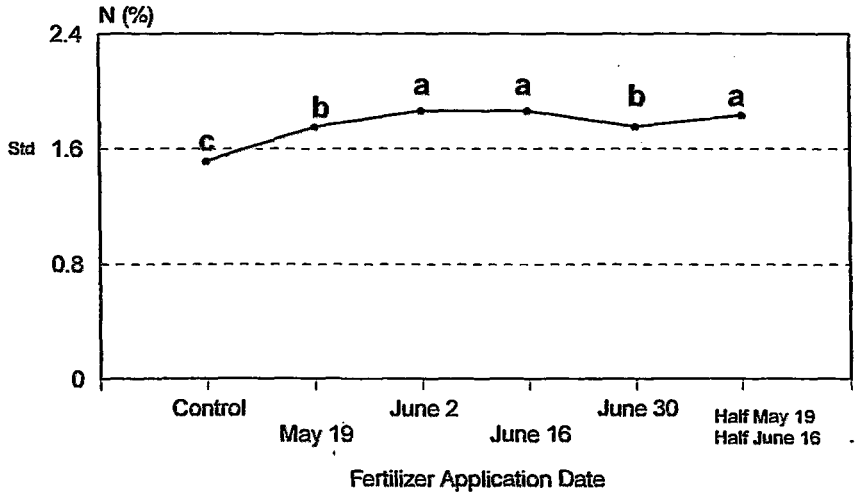
Effect of Fertilizer Timing on Flower bud Density



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

Figure 8

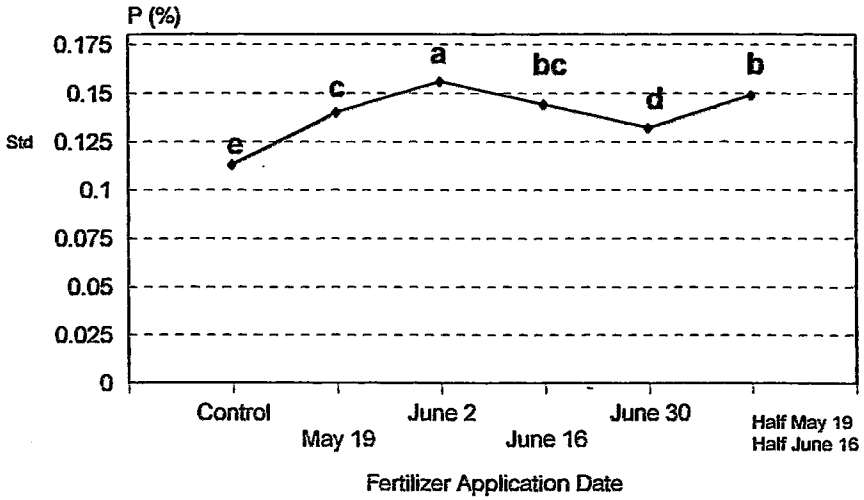
Effect of Fertilizer Timing on Leaf Nitrogen



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

Figure 9

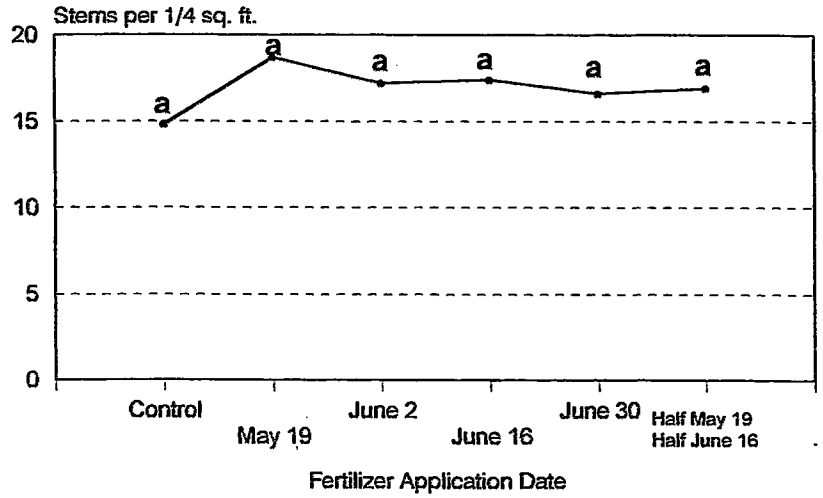
Effect of Fertilizer Timing on Leaf Phosphorus



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

Figure 10

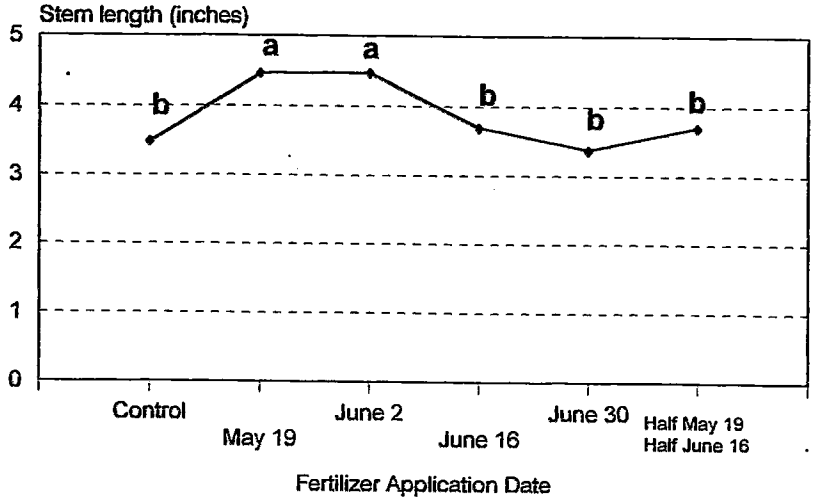
Effect of Fertilizer Timing on Stem Density



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

Figure 11

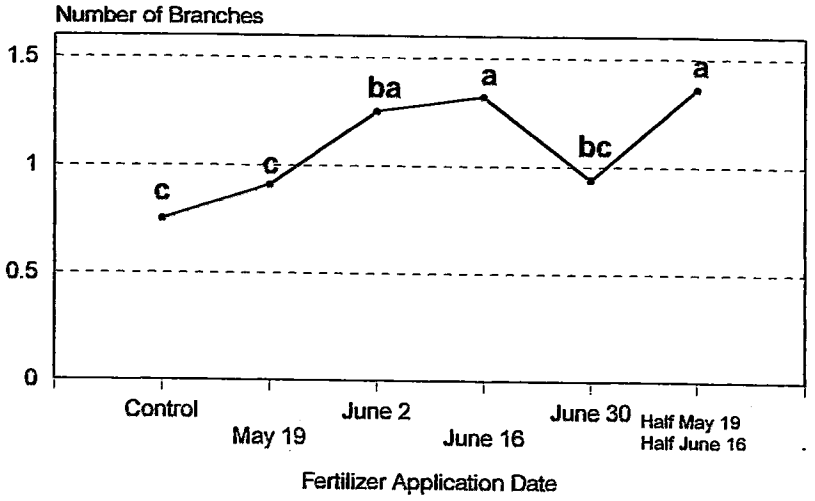
Effect of Fertilizer Timing on Stem Length



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

Figure 12

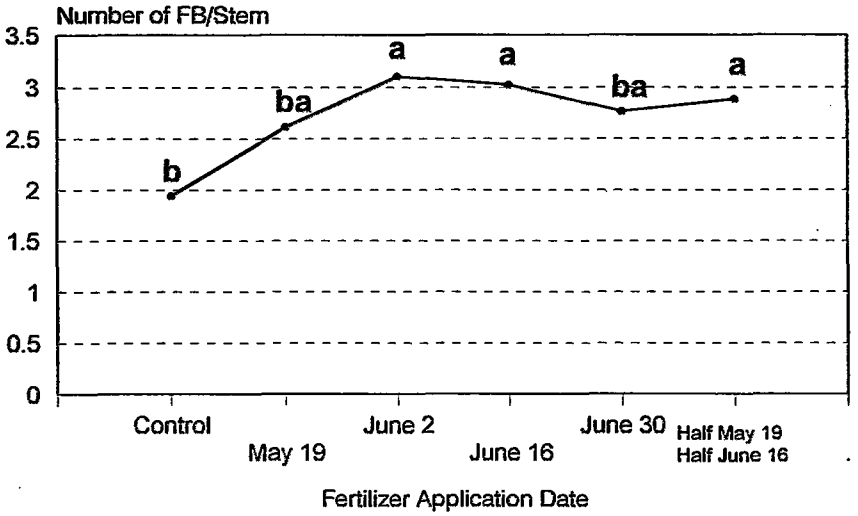
Effect of Fertilizer Timing on Stem Branching



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

Figure 13

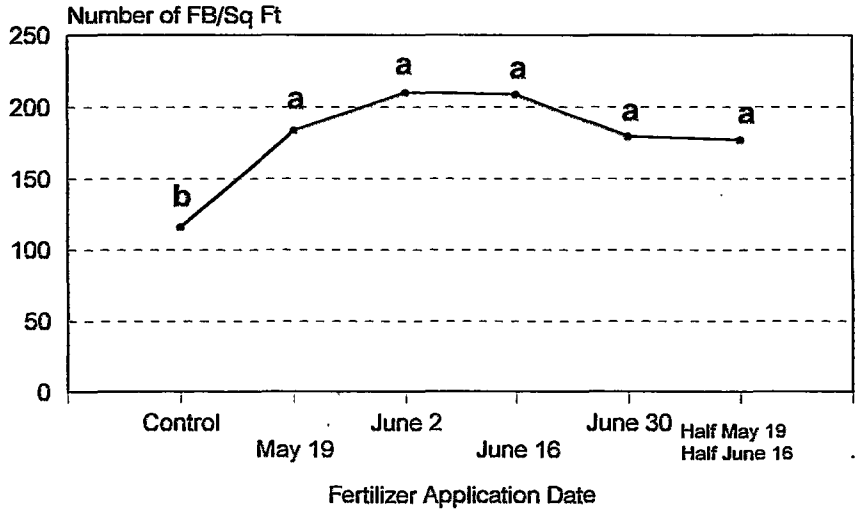
Effect of Fertilizer Timing on Flower Bud Formation



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

Figure 14

Effect of Fertilizer Timing on Flower bud Density



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

E. 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: A randomized, complete block design trial was initiated to study the effectiveness of registered pre and postemergence herbicide applications, and to evaluate Prism® (12.6% clethodim), an unregistered, grass herbicide at the time. The trial was established adjacent to a field in Wesley that was inundated with fall panicum/witchgrass during the summer of 1996 to the point where the field was unharvestable. Treatments for the 6' by 40' plots were either preemergence on May 30, 1997 with Velpar DF® at 1.3 or 2.7 lbs product/ac, Sinbar 80 WP® at 2 or 3 lbs/ac, or Princip 4L® at 2 or 4 quarts/ac. Postemergence treatments applied on July 23, 1997 consisted of Pronone MG® at 10 or 20 lbs/ac, Poast® at 1.5 or 2.5 pts/ac or Prism® at 13 or 17 oz/ac, or an untreated control. Each treatment was replicated 4 times, with plots being evaluated for grass and broadleaf weed cover September 4, 1997. Carryover effects were evaluated June 22 and plots harvested on August 13, 1998, at which point project was terminated.

A second experiment was initiated in the spring of 1998 on adjacent to the above 1997 trial. The field was treated preemergence with Velpar DF® at 1.3 lb product/a except for the untreated controls. Treatments consisted of either Pronone MG® 10 or 20 lbs/ac in mid June, Pronone MG® 10 or 20 lbs/ac in mid June plus Select® (26.4% clethodim, a newly labeled, grass-specific, postemergence herbicide) at 6 or 8 oz/ac or a later (mid July) application of 10 lb/ac Pronone MG®. Plots were established June 10, treated with Pronone® June 22 and with Select® on August 5, 1998 to 6' X 40' plots (6 treatments, 4 reps and 2 pruning methods = 48 plots). A third trial was conducted at BBHF in Section 12, lower field with same size plots and rates. The farm site was established and treated with Pronone MG® on July 6 and Select® on July 7, 1998. Efficacy ratings were assessed September 10, 1998 at both sites. Carryover effects will be assessed in June 1999 and project will terminate in August 1999 after harvest.

RESULTS: For the 1997 trial, uneven initial weed and wild blueberry cover affected carryover effects and produced variable results. Best overall weed control was achieved with Velpar® and Sinbar® (Figures 1 and 2). Yields were not significantly different but, because of excessive variation in cover and yields ranged from 5326 lbs for the 2 lbs/ac Sinbar® rate to 2486 lbs for the 10 lb Pronone MG ® rate (Figure 3). The best grass suppression in the cropping year was obtained by the preemergence treatemts at the low rate (Figure 4 and 5). In the 1998 trial, both treatments with Select® controlled grasses best (Figure 6).

CONCLUSION: In general, the preemergence treatments provided yields greater than the control. A combination of post and preemergence treatments would be required to adequately

control the weeds present. Pronone MG® treatments require adequate rainfall to be effective when grasses are treated late in the season and this does not always occur. Postemergence grass treatments remain the most effective option for both annual and perennial grass control. Further exploration of new, preemergence herbicides, may provide control of both grass and broadleaf weeds with a single preemergence treatment

RECOMMENDATIONS: Continue research with the new herbicides identified.

Figure 1. Effect of Postemergence and Preemergence Low Application Rates-One year later

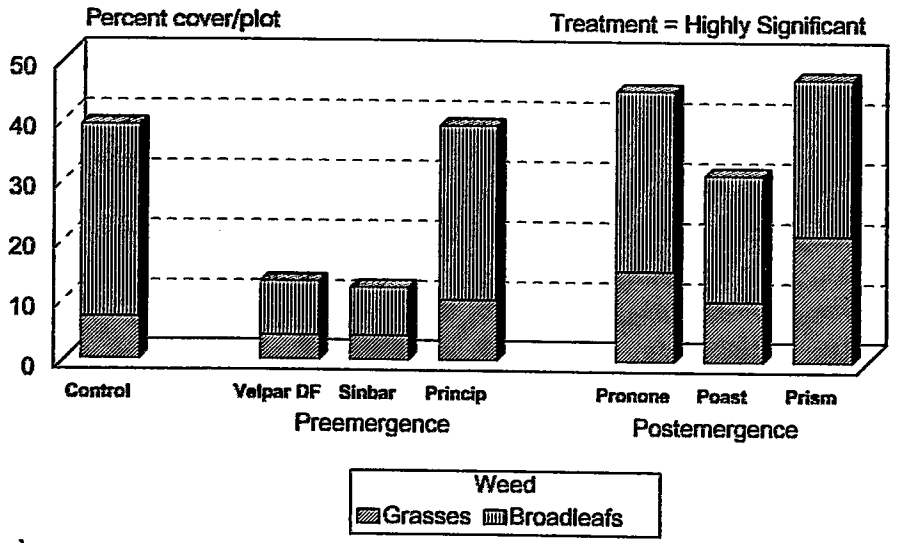


Figure 2. Effect of Postemergence and Preemergence High Application Rates-One year later

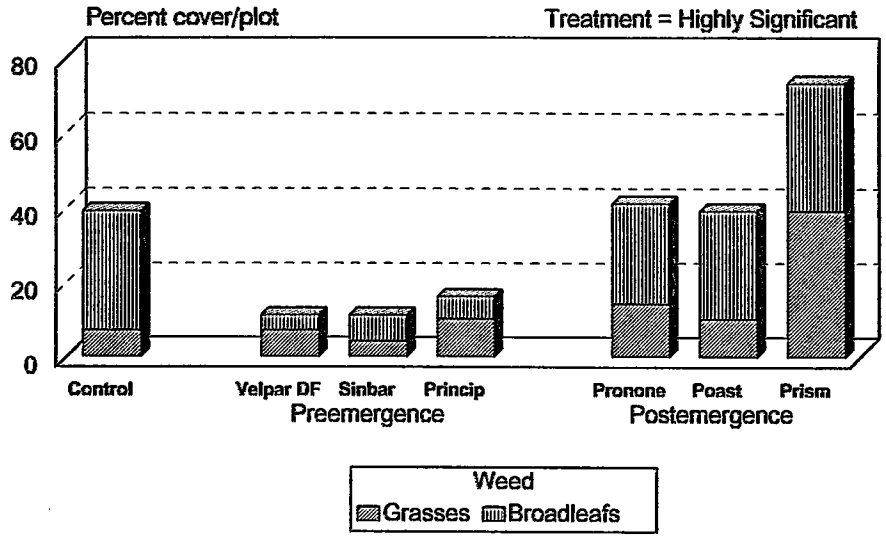


Figure 3. Effect of Grass Alternatives Treatments Rate on Wild Blueberry Yield

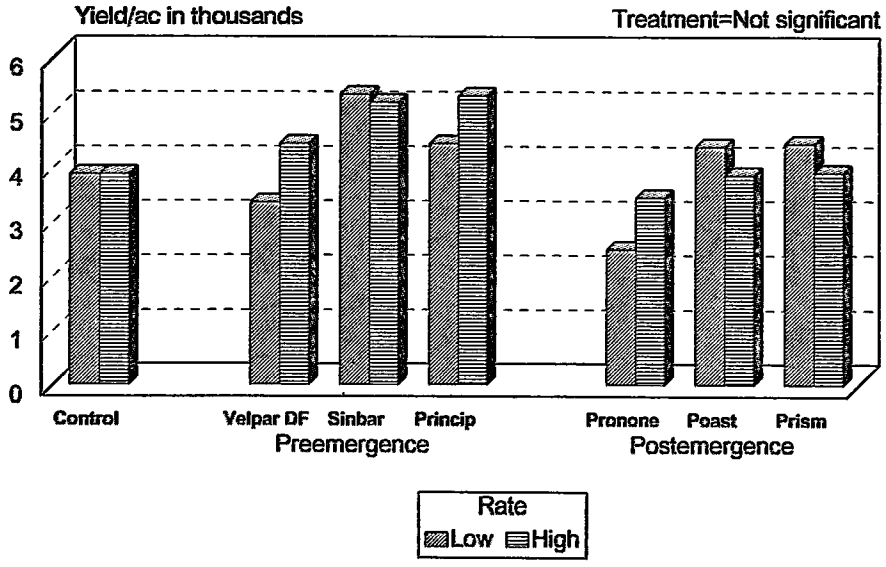


Figure 4. Effect of Postemergence and Preemergence
Low Application Rates on Grass Cover

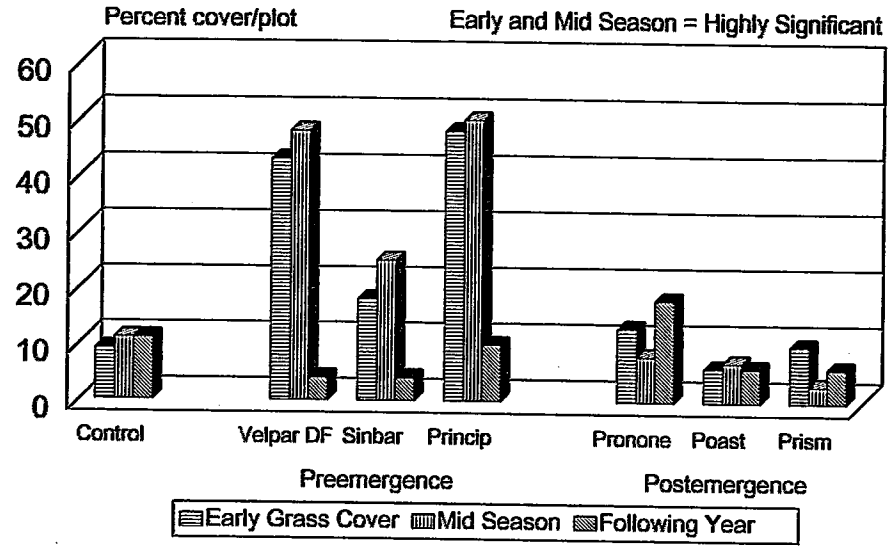
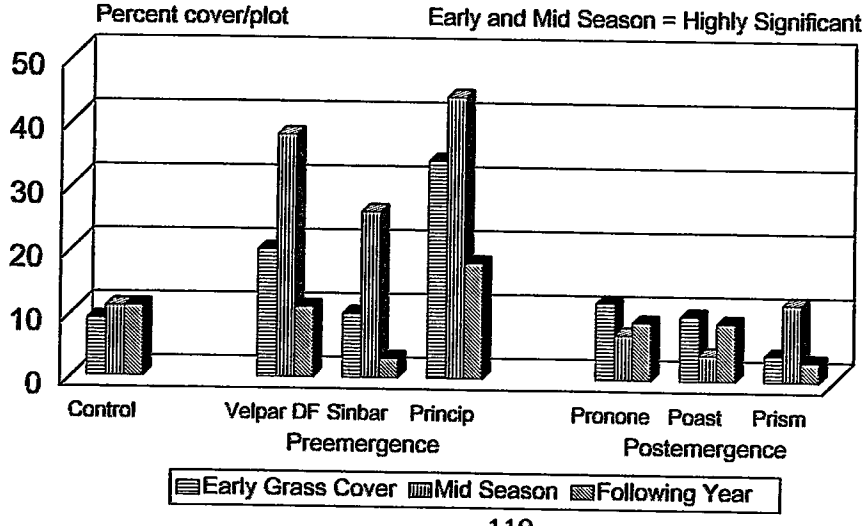
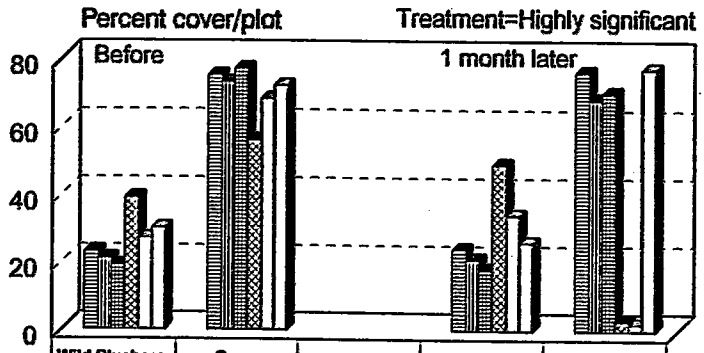


Figure 5. Effect of Preemergence and Postemergence
High Application Rates on Grass Cover



Figrue 6. Effect of Treatment on Grass and Wild blueberry Cover-1 month post treatment



	Wild Blueberry	Grass		Wild Blueberry	Grass
UTC	23	75		24	76
10 lb Pronone MG	21	73		21	68
20 lb Pronone MG	19	77		18	70
10 lb MG+Select	39	56		49	3
20 lbs MG+Select	27	68		34	2
10 lbs Pronone MG Late	30	72		26	77

All Plots except controls treated with 1.3 lb Velpar DF preemergence

E. 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: Several fields with high pH's in Knox-Lincoln, Hancock and Washington Counties have been identified and the experimental sites will be established in 1999. A two-factor, split-block design will be used with pH levels adjusted to >5.0, 4.5, or <4.5 with granular sulfar 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.

Azefenidin-A trial was initiated in April 1998 in Sections 6 & 7, lower field at Blueberry Hill Farm (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 azefenidin +Velpar DF® 1.3 lb/a, 10 oz /a azefenidin +Velpar DF® 1.3 lb/a, 10 oz/a azefenidin + Velpar DF® 2.6 lb/a, 30 oz /a azefenidin alone and an untreated control. Cover assessments were made one and two months post treatment. Stems were cut October 5, 1998 and buds and stems will be counted and measured this winter. Carryover effects will be assessed in June and plots harvested in August of 1999.

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 stems and buds will be measured counted this winter. Carryover effects will be conducted in June and plots harvested in August of 1999.

Pendimethalin-This trial 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 October 5, 1998. Bud number and stem length and number will be measured this winter. Carryover effects will be assessed in June and plots harvested in August 1999.

Prosulfuron- Sixteen 6' X 30' plots were established and treated on 5-14-98 with either 0, 0.5, 1.0 or 1.5 oz product/a and replicated with 4 blocks. Plots were evaluated for phytotoxicity to weeds and wild blueberries on 6-23-98.

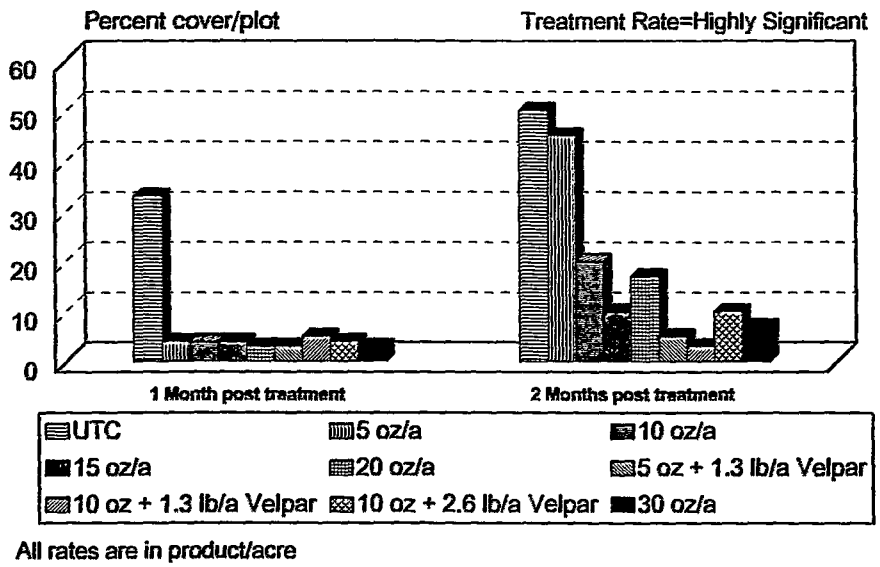
RESULTS: Excellent control of both grass and broadleaf weeds was observed from application of azefenidin and rimsulfuron (Figures 1 and 2). At two months post treatment, pendimethalin also controlled both grass and broadleaf weeds (Figure 3). Prosulfuron produced unacceptable phytotoxicity so trial was canceled.

CONCLUSION: Preliminary results indicate these materials are potential alternatives to hexazinone for broad spectrum weed control but carryover effects, phytotoxicity and yields for residue analysis need to be assessed in June and August 1999 before any conclusions can be made.

RECOMMENDATIONS: Continue project until carryover effects and yields are assessed. Several new trials have been initiated this fall and will continue next spring evaluating timing,

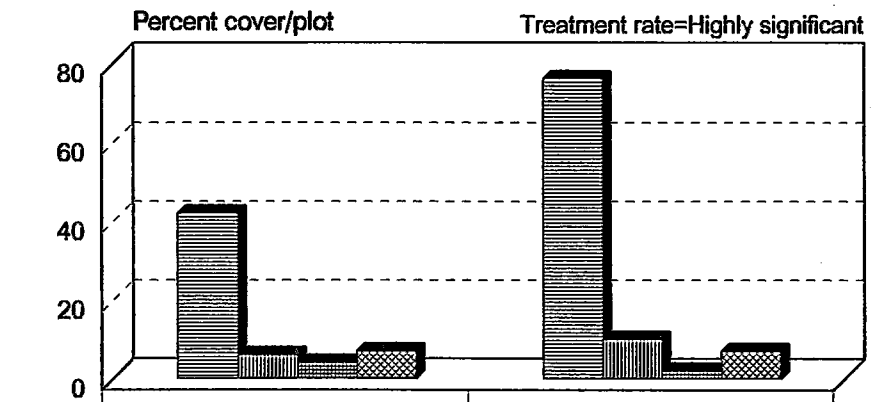
Several new trials have been initiated this fall and will continue next spring evaluating timing, weed control composition and possible herbicide combinations.

Figure 1. Effect of Azefenidin
on Grass and Broadleaf Weeds



All rates are in product/acre

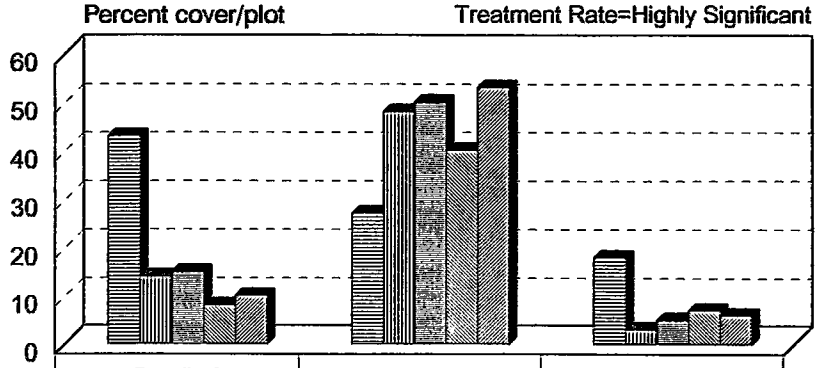
Figure 2. Effect of Rimsulfuron on Grass and Broadleaf Weeds



	1 Month post treatment	2 Months post treatment
UTC	42	76
0.5 oz/a	6	10
1.0 oz/a	4	2
2.0 oz/a	7	7

Rimsulfuron applied 5-14-98

Figure 3. Effect of Pendimethalin on Grass, Broadleaf and Wild blueberry Cover



	Broadleaf	Wild blueberry Cover	Grass
UTC	43	27	18
1.4 pts/a	14	48	3
2.8 pts/a	15	50	5
5.6 pts/a	8	40	7
11.2 pts/a	10	53	6

Pendimethalin applied 5-8-98

E. WEED MANAGEMENT AND FIELD COVER

INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate
Rod Bushway, Professor Food Science and Human Nutrition
Brian Perkins, Research Scientist, Food Science and Human Nutrition

4. TITLE: Evaluation of Hexazinone Applications in the Cropping Year.

METHODS: A completely randomized block experiment was established at BBHF to determine the effect of crop year application of hexazinone on yield, weed control and residue on wild blueberries. Twenty eight, 15' by 50' plots were established and treated preemergence with commercial equipment with Velpar DF® at 1.3 or 2.6 lbs product/a on April 17, 1998. Postemergence treatments applied April 30 included Pronone MG® at 10 or 20 lbs/a or Velpar DF® 1.3 or 2.6 lbs/a impregnated on 200 lbs MAP/a and an untreated control. All plots received 200 lbs MAP/a and were replicated 4 times. Efficacy was evaluated June 11 and plots were harvested on August 12, 1998. Berries were analyzed for residue with the Food Science and Human Nutrition Department at the University of Maine.

RESULTS: No significant difference in weed control between treatments was observed. No residue on berries was detected for any treatment to a 0.1 ppm limit.

CONCLUSION: Earlier trials tracking hexazinone movement through the soil profile indicate little residual hexazinone remains in the soil two years after application. Thus, lack of yield effect may be due to the fact that wild blueberry buds are formed in the first year when most competition occurs and wild blueberries are more competitive in the cropping year or, that there was little weed pressure in the cropping year to limit wild blueberry yield. No residue was detected when hexazinone was applied 104 days before harvest.

RECOMMENDATIONS: Hexazinone may be used the cropping year without detectable residues in the fruit. However, other than reducing weeds that interfere with harvest, little yield increases can be expected.

E. WEED MANAGEMENT AND FIELD COVER

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

5. TITLE: Effect of Surfactant and Ammonium Sulfate on Glyphosate Activity

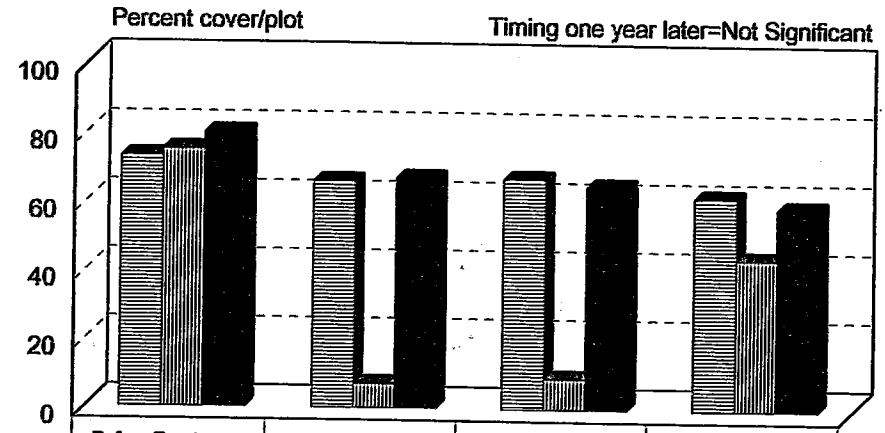
METHODS: A completely randomized block experiment was established in BBHF to determine the effect of surfactant and ammonium sulfate on glyphosate activity. Each weed species evaluated, dogbane, bracken fern and bunchberry, had 1 by 3 yard plots split in three by treatment dates. Bracken fern and dogbane were wiped on 6-25 (early), 7-31(mid) or 8-22-97 (late) with a 10% wipe amended with 0.1% surfactant (LI700®) and 18 mgs. ammonium sulfate/gallon of solution. Bunchberry plots were sprayed on 7-22-97 with a 2% spray amended with same surfactant and ammonium sulfate rates. Carryover effects for all plots were evaluated on 6-23-98 at which point project terminated.

RESULTS: The 7-31-97 (mid) treatment date gave the best suppression of dogbane, but plants recovered one year later (Figure 1). No significant effect of timing was found for bracken fern cover (Figure 2). Bunchberry cover was not reduced by either amended or unamended glyphosate treatments (Figure 3).

CONCLUSION: Dry conditions in 1997 may have influenced effectiveness of treatments since past trials have produced significant results. Dry conditions will affect efficacy of glyphosate treatments.

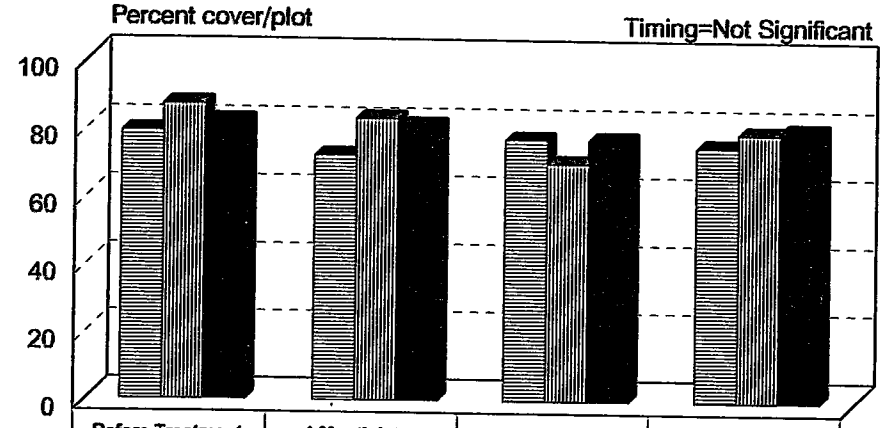
RECOMMENDATIONS: Timing is not a critical function in weed control when plants are stressed.

Figure 1. Effect of Surfactant and Ammonium sulfate Enhanced Glyphosate on Dogbane-1997 Study



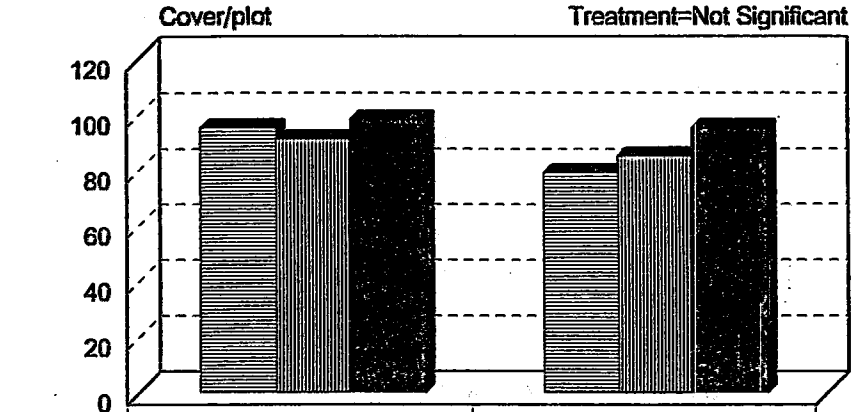
	Before Treatment	1 Month later	2 Months later	One year later
Early	73	66	67	62
Mid	75	7	9	44
Late	80	67	65	59

Figure 2. Effect of Surfactant and Ammonium sulfate Enhanced Glyphosate on Bracken Fern-1997 Study



	Before Treatment	1 Month later	2 Months later	1 Year later
Early	79	72	77	75
Mid	87	83	70	79
Late	82	81	77	80

Figure 3. Effect of Glyphosate Solution on Bunchberry



	Initial cover	One year later
Ammended	95	79
Unammended	91	85
Untreated	98	95

E. WEED MANAGEMENT AND FIELD COVER

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

6. TITLE: Evaluation of Pronone MG® Spot Treatments for Control of St. Johnswort, Dogbane, Bracken Fern, Witch Grass/Fall Panicum and Bunchberry.

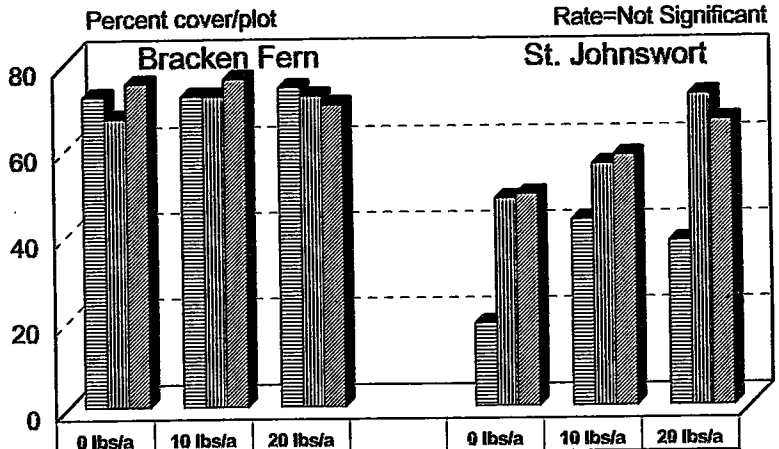
METHODS: For each weed species, ten one yard^2 plots were established and treated with either 0, 10, or 20 lbs/a Pronone MG® (30 plots per species for a total of 150 plots). Treatment date was June 25, 1997. Treatment efficacy was evaluated July 25 and September 4, 1997. Carryover effects were assessed June 16, 1998 at which point project terminated.

RESULTS: In this dry year, none of the rates adequately suppressed any of the weeds (Figures 1 and 2).

CONCLUSION: Granular hexazinone relies on rainfall to activate which is unpredictable in the summer and so results in sporadic control.

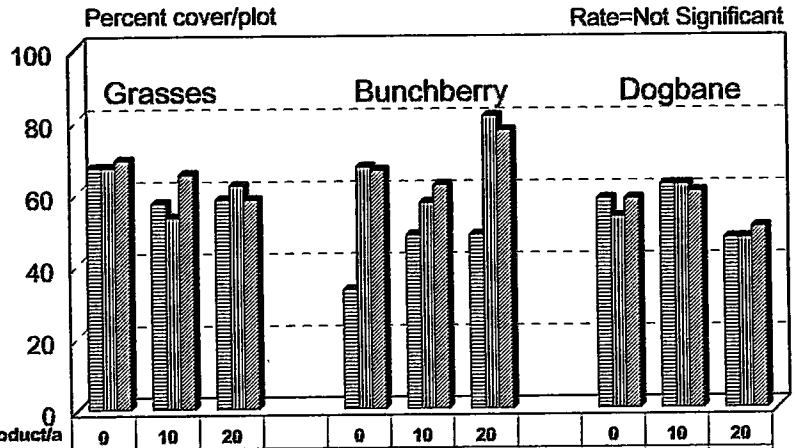
RECOMMENDATIONS: Discontinue postemergence granular hexazinone trials.

Figure 1. Effect of Postmergence Pronone® MG on Weeds-1997



	0 lbs/a	10 lbs/a	20 lbs/a		0 lbs/a	10 lbs/a	20 lbs/a
Before Treatment	72	72	74		19	43	38
After Treatment	67	72	72		48	56	72
1 Year later	75	76	70		49	58	66

Figure 2. Effect of Postmergence Pronone® MG on Weeds-1997 Study



Rate lbs product/a	0	10	20		0	10	20		0	10	20
Before Treatment	67	57	58		33	48	48		58	62	47
After Treatment	67	53	62		67	57	81		53	62	47
1 year later	69	65	58		66	62	77		58	60	50

F. EXTENSION

INVESTIGATOR: David E. Yarborough, Cooperative Extension blueberry specialist

COOPERATOR: John Jemison, Cooperative Extension water quality specialist

1. TITLE: Hexazinone Groundwater Survey

METHODS: Eight wells and 4 streams or ponds adjacent to, or in wild blueberry fields, in three counties were sampled in 1998 in May, June, July, August, September 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 to 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 by 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 1998, no increase in the levels of hexazinone was found. The one exception, site 32, was previously reviewed by the Board of Pesticides Control and was determined to be a point source contamination. The 1998 monitoring data are consistent with past results with seasonal changes, but no increase in levels under current use patterns. Figure 1 gives the long-term trends over 9 years and 50 sampling dates. Site 12 was treated with granular hexazinone from 1993 through 1996 and has the lowest level of hexazinone. Site 11 was treated with a liquid and has higher levels while site 9 was not treated with hexazinone after 1993 but alternative herbicides were used and the hexazinone level has been declining over the years from 27 ppb to less than 10 ppb.

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

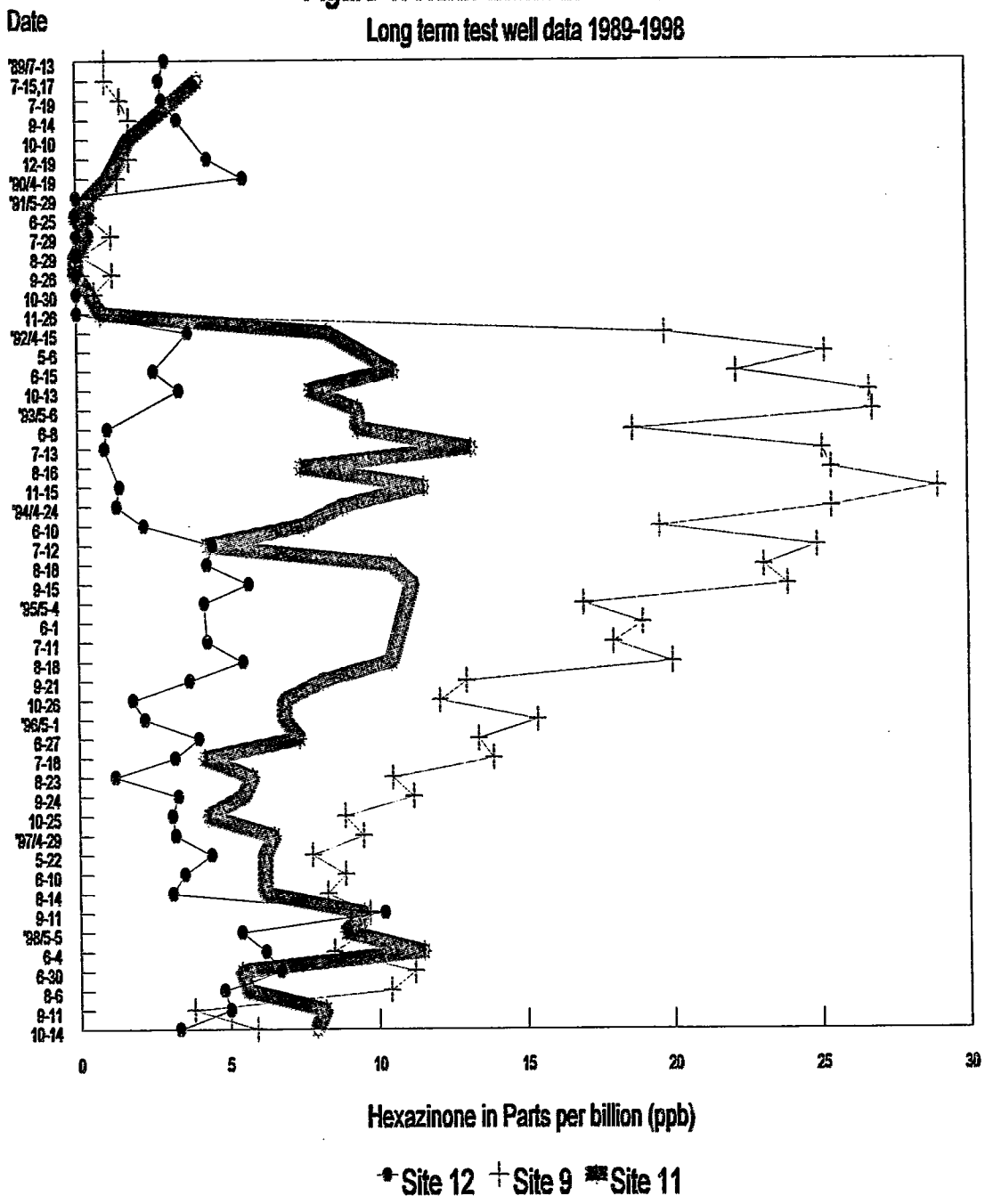
RECOMMENDATIONS: Continue to sample wells to insure best management practices do not result in hexazinone detections above the health advisory limit (HAL). Continue to vary management practices to determine how they influence hexazinone movement in wild blueberry soils and review and update practices 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. 1998 Hexazinone Test Result Summary
University of Maine Well Water Survey
Hexazinone in parts per billion

Site/Treatment	May	June	July	August	September	October
Wells						
9 test/untreated	9.5	8.5	11.2	10.4	3.8	5.9
11 test/liquid	8.9	11.5	5.4	5.6	8.2	7.9
12 test/liquid	5.4	6.2	6.7	4.8	5.0	3.3
13 drill/untreated	2.4	6.4	2.4	2.0	1.8	1.5
23 drill/liquid+DAP	2.3	1.6	1.7	-	1.3	0.5
31 drill/granular	2.8	2.4	6	-	5.4	4.3
32 drill/granular	46	36	44.6	32.7	12.3	15.4
36 drill/granular	-	8.1	12	8	2.6	9.2
Surface						
9 stream/untreated	ND	ND	ND	ND	0.2	ND
11 pond/liquid	11.3	8.8	7.8	6.5	3.3	5.2
12 stream/liquid	5.6	6	4.4	5.4	4.1	3.7
13 pond/untreated	ND	ND	ND	ND	0.2	ND
ND = No Detect - = missing sample						

Figure 1. Hexazinone in Groundwater

Long term test well data 1989-1998



F. EXTENSION

PRINCIPLE INVESTIGATOR: David E. Yarborough

2. TITLE: Wild Blueberry / Cranberry Extension Education Program in 1998

METHODS: Conduct an educational program that will stress the use of best management practices in an integrated crop management program which will improve the efficiency of culture and minimize the use of unnecessary pesticides and fertilizers. Conduct Spring grower meetings and field days to introduce and reinforce the use of best management practices, integrated crop management and sound business management principles. Provide management information through the wild blueberry newsletters, 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 wild blueberry initiatives requested by the County office. Cooperate with the Wild 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 (USDA, IR-4) agencies on wild 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:

The Blueberry Integrated Crop Management program was continued in 1998, and consists of three field demonstration sessions conducted in three counties. This program has been conducted over the past six years. During that time the program requirements have been better defined and new fact sheets and better examples have been provided, such as the weed mapping and explanation of in-field experiments and granular calibration.

Presentations:

Gave guest lecture on 'Wild Blueberry Culture' and 'Upland Cranberry Management' in Orono for AES 101 on January 27.

Presented 'Cranberry Culture in Maine' to prospective growers in Farmington, on January 27. Discussed Food Quality Protection Act and its effect on wild blueberry and cranberry growers at the Augusta Agricultural Trade Show on February 5.

Organized 'Introduction to Alfalfa Leafcutter Bee Management' course at Wyman's C&D in Deblois on February 12.

Met with Maine Wild Blueberry Advisory Committee on February 26 in Orono to summarize Blueberry Extension education program.

Led discussion on 'Wild Blueberry IPM' and 'Cranberry IPM' at a forum on 'Integrated Pest Management in Maine: Past, Present and Future' on March 3 in Orono.

1998 Spring Blueberry Meetings held in South Paris, March 23, in Union, March 26, in Ellsworth, March 25, and in Machias, March 28. Topics presented by Extension, Experiment Station, and Pesticide board personnel. These meetings provide growers with information on current topics and allow for discussion of projects and needs with Extension, State and University personnel working with wild blueberries. Updated five wild blueberry fact sheets and produced a new fact sheet, *Calibration of granular applicators for Pronone and Velpar impregnated or Pronone mixed fertilizer applications,* for the growers guide. Presented 'Grass Control in Wild Blueberries'.

Presented Wild blueberry Culture to EPA/OPP in Washington, DC on April 1.

Participated in the University of Maine new faculty bus tour at Blueberry Hill Farm and Wyman's C&D in Deblois on May 15.

Talked on cranberry IPM and weed management at Cherryfield RC&D on June 11.

Presented 'Cranberries for Maine' at Highmoor Farm Fruit and Vegetable Field Day on June 9.

For 1998 hexazinone groundwater survey I surveyed four drilled wells, 3 test wells and 4 from adjacent surface sites. Water samples were taken each month from April - October to evaluate the difference in liquid vs granular formulations. In 1998, no increase in the levels of hexazinone was found. The one exception, previously reviewed by the BPC, was determined to be a point source contamination. The 1998 monitoring data are consistent with past results, with seasonal

changes but no increase in levels, under current use patterns. In addition, I requested information of the Pesticide Board's efforts in re-sampling the wells that were sampled in 1994 for hexazinone. Bob Battessee informed me that 11 of the 42 wells (26%) had a detectable level with the maximum detection level at 5.9 ppb. The 1995 report released by the Pesticides Board indicated that 75% of the wells had detectable levels and the maximum level was 5.97 ppb. The levels detected are two orders of magnitude below the HAL (health advisory limit) level of 210 ppb. These data further substantiate that current use patterns are not resulting in any increase in hexazinone levels in the groundwater.

Discussed wild blueberry research and Extension program with members of the Wild Blueberry Commission on June 10, in Orono and November 19 in Ellsworth.

Conducted tour of wild blueberry fields in Grey and lingonberries in Gorham for IR-4 group on July 14.

Held annual summer field day and crop guesstimate at Blueberry Hill Farm in Jonesboro on July 15. A review of new weed management plots and effect of pH reduction as a cultural weed management tool was discussed. This annual meeting gives researchers and Extension faculty an opportunity to review and discuss programs and to get grower input.

Conducted tour of wild blueberry fields and production in Deblois for a Chinese researcher group on July 27.

Participated in several meetings with the Navy to use P-3 aircraft and multiband sensors to map wild blueberry barrens and field set up on July 28.

Participated in WBANA Wild Blueberry Research Summit on Health Effect of Wild Blueberries on July 31- August 1 in Bar Harbor.

Conducted tour of wild blueberry fields, cranberry and apple production in Deblois for USDA/FAS program visitors from Latvia and Estonia on September 13-16.

Explained Maine wild blueberry production to hundreds of attendants of the Big E Agricultural Fair in Springfield, MA on September 18-19.

Participated in the IR-4 annual meeting in Phoenix, AZ on October 7-10 to establish priorities for Maine for minor use pesticide trials.

Met with Maine Wild Blueberry Advisory Committee on October 20-21 and in Ellsworth on November 12 to summarize wild blueberry research and Extension education program and proposed a program for 1999.

Discussed grass control measures with growers in Meddybemps on October 29.

Presented 'Wild blueberry Culture' and 'Upland Cranberry Production' to Blue Hill grade school on November 2 and to Cumberland-North Yarmouth 3rd grade on November 13.

Gave Public testimony:

To Board of Pesticides Control on:

January 30, Results of water sampling program for hexazinone
June 3, 24-C for Velpar in crop year
November 20, Hexazinone performance concerns

Gave interviews to:on

AgVentures Magazine: March 24
Associated Press: August 27
Bangor Daily News: January 21, July 15
Currier Gazette: July 17
Ellsworth American: February 9, May 7, July 15, August 25
Kiss& the Bear Radio: August 27
Maine Public Radio: August 19
New England Agriculturalist: July 23
New England International: July 15
Portland Press Herald August 11
TV CH 2: January 21
UM Public Affairs: January 27
Weekly Packet (Blue Hill): May 12

Professional Improvement Activities:

Participated in the Northeastern Weed Science Society meetings on January 5-8 in Washington, DC. Presented 'Spot treatment of granular hexazinone for weed control in wild blueberries' and 'Effect of formulation on soil movement of hexazinone'. Learned of most recent research activities and met with weed specialists to discuss problems and solutions for the Maine wild blueberry and cranberry industries.

Attended Food Quality Protection Act Workshop sponsored by the USDA in St. Louis, MO on

February 18-19 to learn of implications of this act on wild blueberry growers.

Attended 'Good Laboratory Practices Training Workshop' in San Francisco, CA sponsored by the IR-4 Program on March 19-20.

Attended 1998 Wild Blueberry Research and Extension Workers Conference in Halifax, Nova Scotia on April 15-16. Presented 'Effect of Time of Fall Prunning on Wild Blueberry Growth and Yield', 'Best Management Practices to Reduce Hexazinone in Groundwater in Wild Blueberry Fields', 'Spot Treatment of Granular Hexazinone in Wild Blueberries' and 'Effect of Formulation on Soil Movement of Hexazinone'.

Attended 8th North American Blueberry Research and Extension Workers Conference. Wilmington, North Carolina on May 27-30. Presented 'Effect of Time of Fall Prunning on Wild Blueberry Growth and Yield' and 'Effect of Formulation on Soil Movement of Hexazinone'.

Attended University of Massachusetts Cranberry Station Annual Field Day in East Wareham, MA to learn of most current research on August 18.

Attended Maine Cranberry Growers Association Annual Meeting in Jonesboro, to learn of grower needs on August 22.

Attended 'Best Management Practices for Cranberry' sponsored by New Brunswick Department of Agriculture on December 1 in Dieppe, NB.

Other Activities:

I am on the Health committee of the Wild Blueberry Association of North America. The purpose of the committee is to evaluate health research needs of the wild blueberry industry, 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 conducted in Maine in 1998.

I am coordinator for the CSREES special research grant 'Wild 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* and *The Canadian Journal of Plant Science.*

CONCLUSION: Growers are participating in IPM programs in the four primary wild 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 Velpar 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 wild blueberry culture by reducing unnecessary pesticides and fertilizers.

The hexazinone groundwater survey I have conducted from 1992 to 1998 continues to provide information on the movement of this herbicide into the groundwater. I have sampled test and drilled wells and surface water in wild blueberry fields over 7 years. This information has been used by the Department of Agriculture in developing Best Management Practices and by the Board of Pesticides Control in deciding to continue use of hexazinone in Maine and to approve a new 24-C crop-year label for Velpar. 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 wild 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.