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1996 Wild Blueberry CSREES Progress Reports/1996 Wild Blueberry Tax Reports

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A. FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
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1. TITLE: Factors affecting the quality of Individually Quick Frozen (IQF) wild blueberries

METHODS: Four samples (2.2 kg) were taken from three locations in the processing line (after winnowing, following sugar floatation and after chlorination). Samples were taken six times during the harvest (twice each at early, mid and late season). All samples were transported to the Department of Food Science and Human Nutrition on ice where they were analyzed for Total Aerobic Plate Count (TAP), yeasts, molds, coliforms, *E. coli,* and *Staphylococcus aureus*. Standard methods were used to analyze for TAP, yeasts and molds. FDA Bacteriological Analytical Manual methods were used for human pathogens.

RESULTS: Figures 1-3 demonstrate the effect of sugar floatation and chlorination on the total aerobes, yeasts and molds on wild blueberries. Chlorination was very effective in reducing the number of yeasts and molds associated with the fruit. Harvest season did not appear to be a factor in the reduction even though higher mold counts were seen in mid and late season berries. At each sampling period, a two to three log reduction in TAP, yeasts and molds were observed. Larger reductions occurred during freezing which would indicate that microorganisms which had been injured during chlorination were killed by freezing. The coliform count on wild blueberries was low at all harvesting seasons although a much higher number was found in the late season, winnowed berries (Fig. 4). Washing and chlorination effectively reduced the number of coliforms to less than 10/g. In addition, only one sample was positive for *E. coli* and none of the samples were positive for *S. aureus.*

CONCLUSIONS: Based on these results, it appears that the current processing methods, which include the use of chlorination, can significantly reduce the microbial load on wild blueberries. Not only are the processing methods effective against spoilage microorganisms, but potential pathogens would appear to be controlled.

RECOMMENDATIONS: With the recent outbreaks of food borne illness associated with *E. coli 0157:H7,* it is important for the wild blueberry industry to have a database on the microbiological quality of frozen berries. With deer feces having been implicated as a possible source of *E. coli 0157:H7*, all samples testing positive for coliforms should be analyzed for *E. coli 0157:H7* keeping in mind that this organism will not grow at the temperature used to enumerate *E. coli.* A second year of this study will look at both a sugar floatation and a water wash system.

Total Aerobes for Lowbush Blueberries Processed at Early, Mid and Late Season

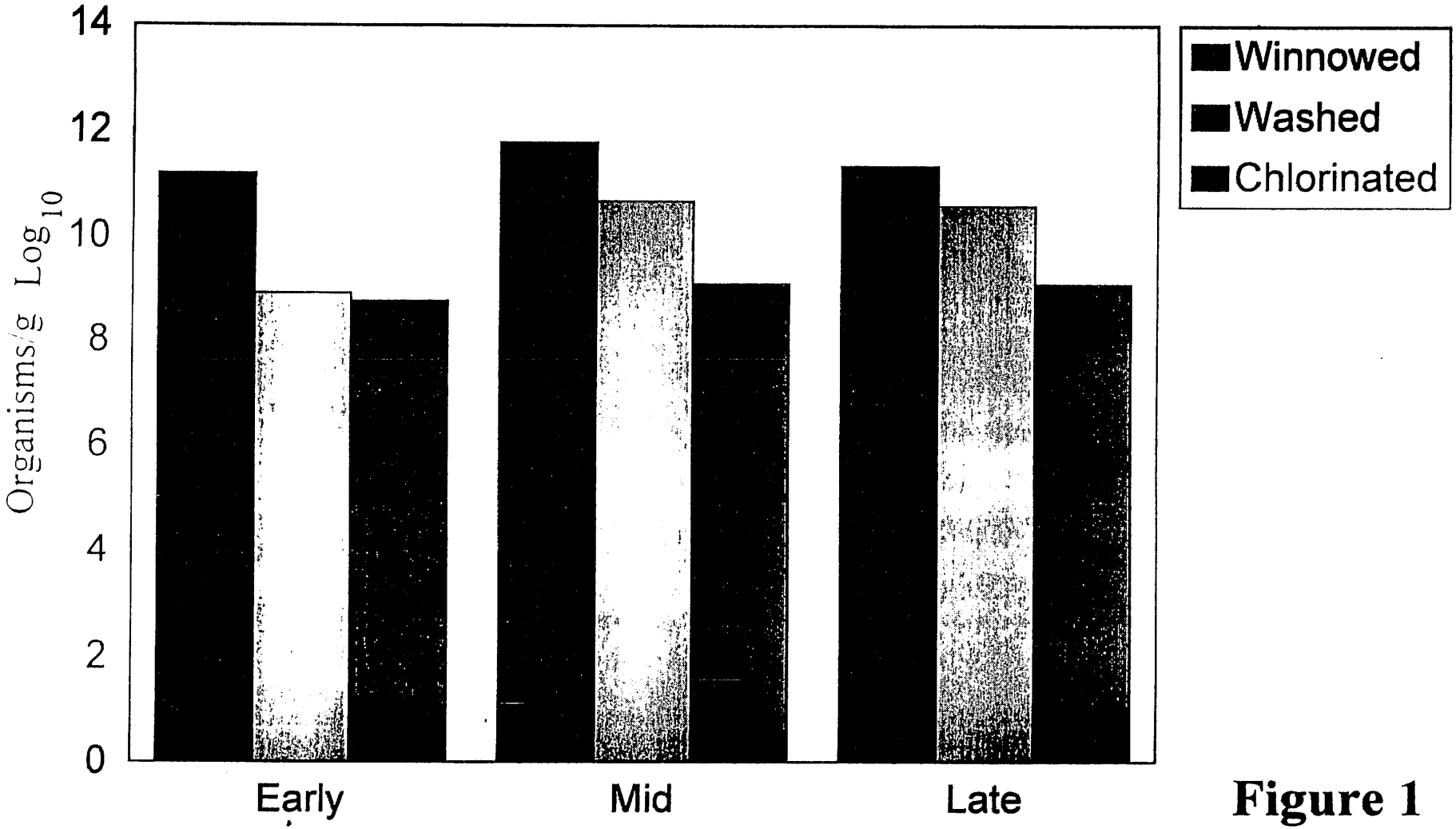


Figure 1

Yeasts for Lowbush Blueberries Processed at Early, Mid and Late Season

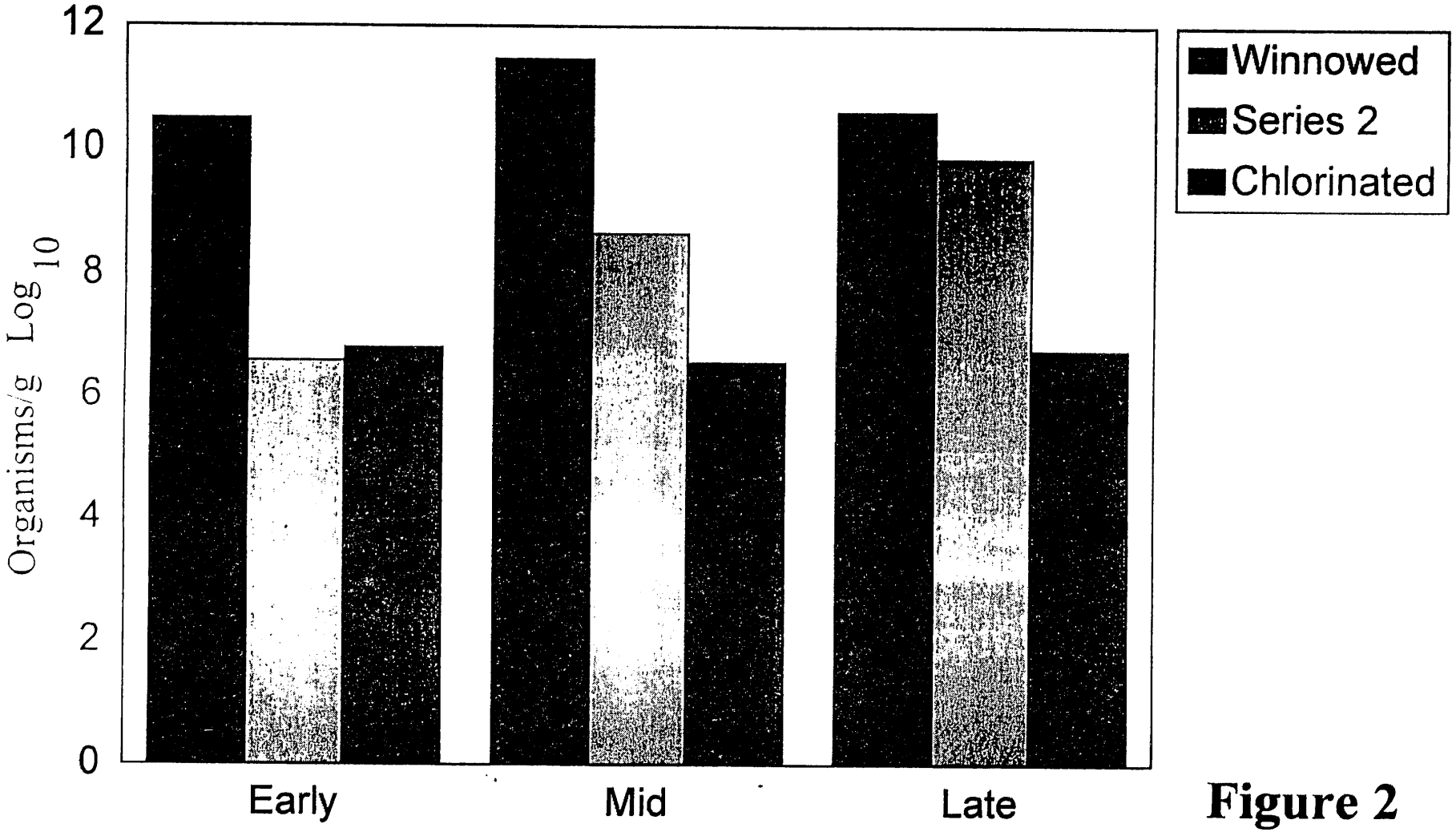


Figure 2

Molds for Lowbush Blueberries at Early, Mid and Late Season

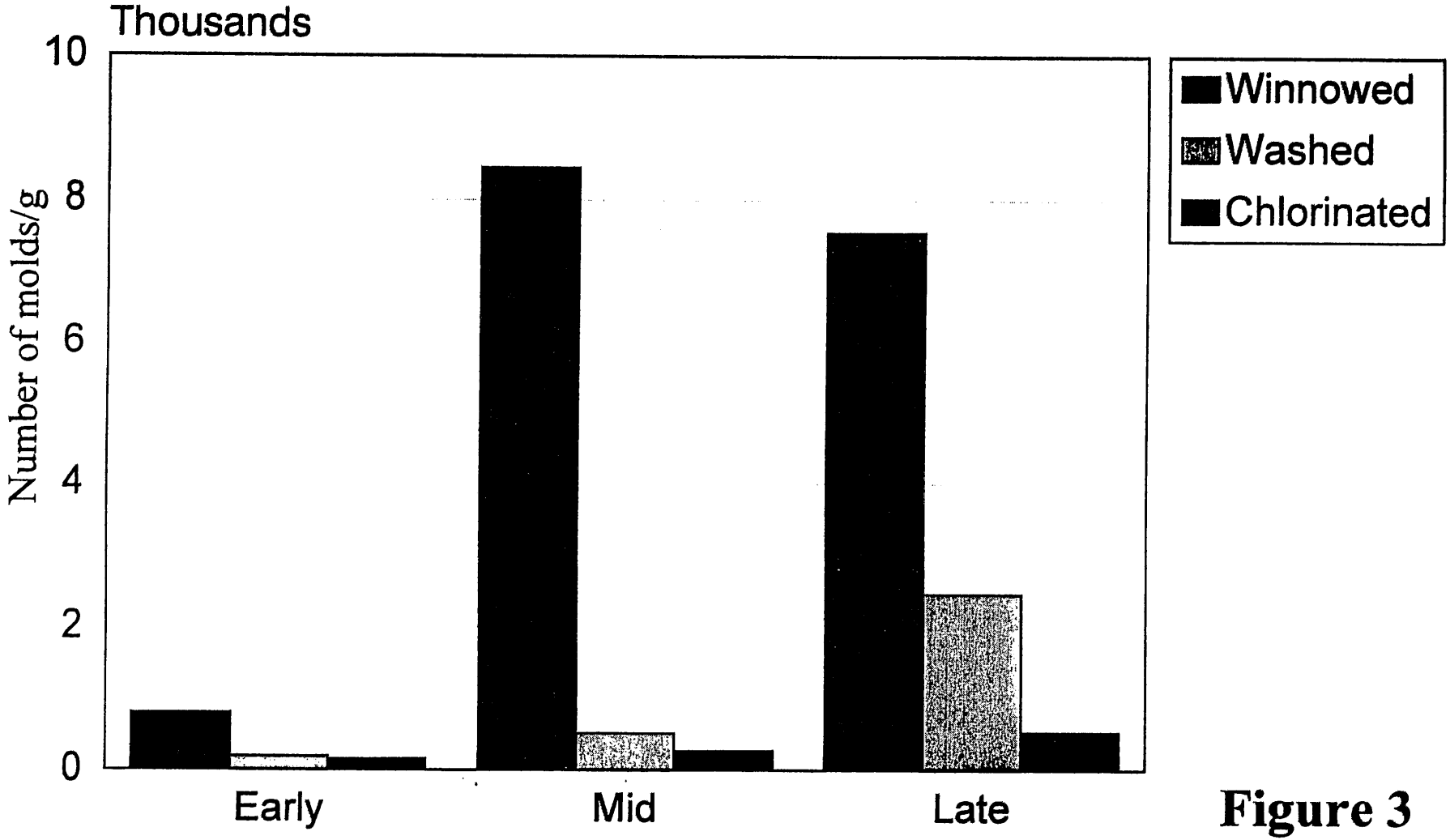


Figure 3

Coliform Counts for Lowbush Blueberries Processed at Early, Mid and Late Season

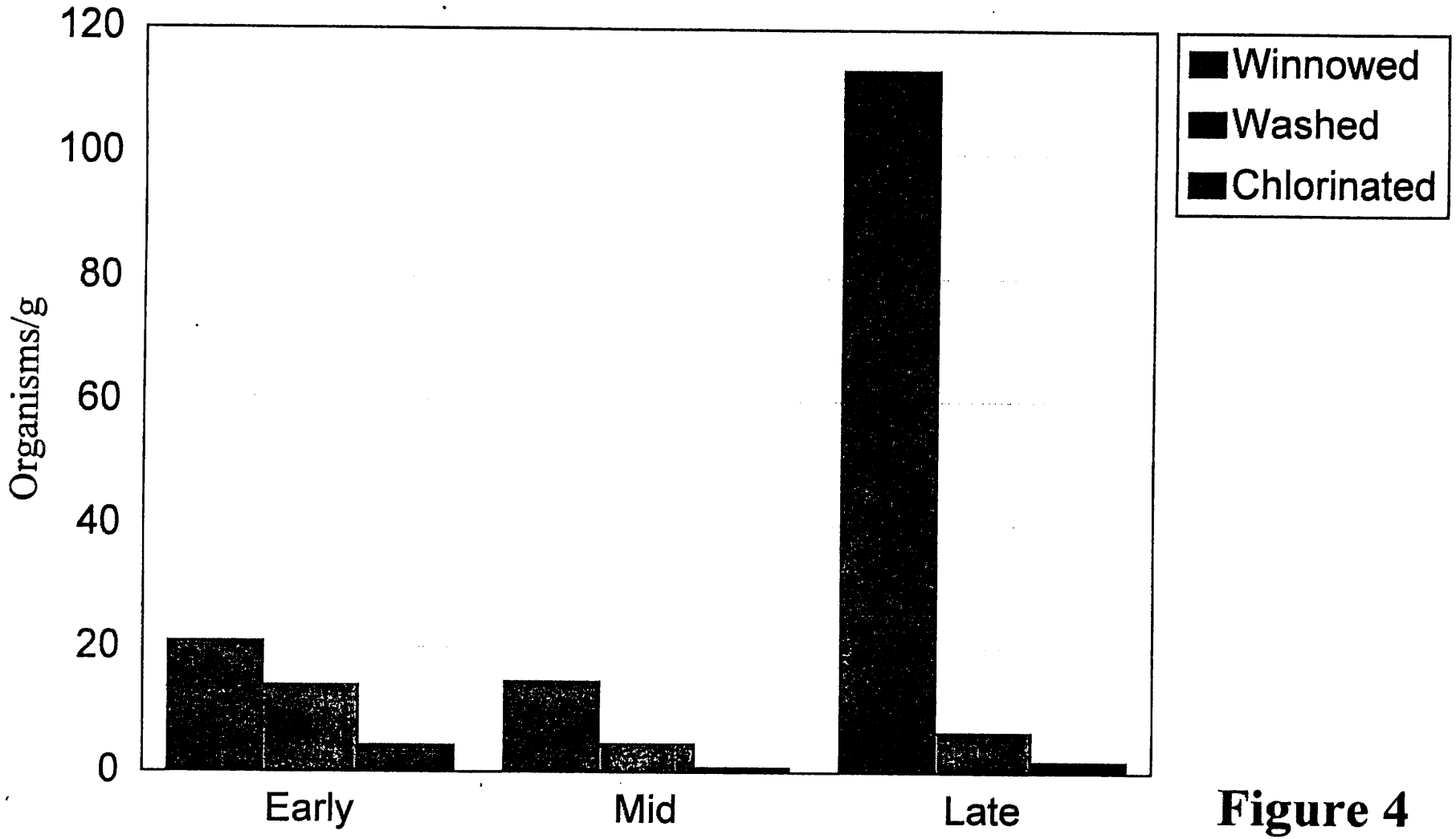


Figure 4

A. FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Robert Stark, Research Scientist
Huanli Zhang, Graduate Assistant

2. TITLE: Factors affecting physical and chemical properties of IQF blueberries

METHODS: A series of harvests (replicates) of wild blueberries from commercial growers were subjected to a range of treatment factors which were to simulate what occurs during commercial processing. All processing steps were performed at the Agriculture Canada Research Station at Kentville, Nova Scotia. Treatment factors included post harvest delay, drop, abrasion and compression damage to fresh berries, washing versus non washing, extent of freeze, drop, abrasion and compression damage to frozen berries and storage temperature. Two hundred and fifty two samples were processed and held at Kentville until physical and chemical analyses were to be performed. Samples were transported to the Department of Food Science and Human Nutrition in the frozen state by truck for physical and chemical analyses. Analyses included 50 g classification, textural evaluation, anthocyanin leakage, sugar migration, soluble solids, pH, titratable acidity and color. All analyses were performed in duplicate.

RESULTS: Preliminary analysis of the data has shown that harvest time, storage temperature, the extent of freeze and frozen abuse, tended to significantly ($P<0.01$) affect texture, sugar migration, anthocyanin leakage, Hunter values and percentage of intact berries. Later harvested berries tended to have higher sugar migration and anthocyanin leakage. Machine harvested berries were higher in sugar migration (17%), anthocyanin leakage (18.5%) and damaged berries (10.3%) than hand harvested fruit. Frozen berries subjected to compression and abrasion had significantly higher ($P<0.01$) sugar migration, anthocyanin leakage and damaged berries than non-abused fruit. Compression, abrasion and drop abuse of fresh berries seemed not to affect sugar migration, anthocyanin leakage and Hunter values, but berries undergoing drop and abrasion during processing were significantly ($P<0.01$) softer than non-abused and compressed fruit. Berries with the lowest post-freezing mass average temperature had significantly lower ($P<0.01$) sugar migration and anthocyanin leakage than semi-frozen berries. Delaying processing for 48 hrs. produced significantly softer ($P<0.01$) berries with higher sugar migration and anthocyanin leakage than those held 22 hrs prior to processing. The method of harvest, storage temperature, the extent of freeze and frozen abuse were major factors that had two and/or three way interactions.

CONCLUSIONS: Based on this extensive study, it is obvious that a number of factors influence wild blueberry quality. Harvest method was shown to influence the percentage of damaged fruit in a previous study and those results were confirmed in this study. Other factors that are of importance are storage temperature, the extent of freeze and abuse to the frozen berries. Drops and abuse to fresh berries did not appear to be as damaging.

RECOMMENDATIONS: The results from this study will be presented to the wild blueberry industry following further analysis of the data. Additional samples will be analyzed this year in order to clarify some of the observations made during last study.

A. FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Huanli Zhang, Graduate Assistant

3. TITLE: Preventing the bleeding of blueberry fruit in bakery products

METHODS: First run and rerun wild blueberries from the 1995 harvest were used in these experiments. Before berries were incorporated into muffin batter, IQF berries (used at 15% total weight) were placed in a single layer on a flat plate. Sodium carboxymethylcellulose, CMC (TIC Gums, Inc., MD) used at 10% berry weight, was spread on fruit and a thin film was formed on the fruit skin by shaking the plate. After coating, coated berries were immediately mixed with the batter. After berries were mixed into the muffin batter, batter color was measured (without berries) using a Hunter LabScan II Spectrocolorimeter. Hue angle and chroma were calculated from the a and b values.

Commercial muffin mix was used for determination of leakage area of individual berries in muffins. The mix was prepared following the "classic recipe" on the box (Gold Medal Muffin Mix, Minneapolis, MN). Four treatments included batter mixed with 1) uncoated first run (FR), 2) uncoated rerun (RR), 3) coated first run (CFR) and 4) coated rerun (CRR) wild blueberries. All muffins were baked in a convection oven for 30 min at 350 F. After cooling at room temperature, muffins were frozen and held at -26 C. Frozen muffins were cut horizontally to 0.5 cm thick slices and a image analyzer was used to measure the area of bleed surrounding each berry. Driploss and anthocyanin leakage were measured for each of the treatments.

RESULTS: Times through the destemmer and coating significantly ($P<0.05$) affected driploss and anthocyanin leakage in buffer (Table 1). Uncoated berries had significantly ($p<0.05$) higher driploss and anthocyanin leakage than coated berries. Uncoated rerun berries had significantly ($P<0.05$) higher driploss and anthocyanin leakage in buffer than first run berries. Increased physical damage to fruit passing through the reel destemmer twice could account for the differences noted.

Hunter L and b values of muffin batter with uncoated first run and uncoated rerun berries were significantly ($P<0.05$) different (Table 2). Batter containing uncoated berries was much darker than with coated berries. CMC coating on both types of berries increased the lightness of muffin batter (higher L and b value).

All Hunter a values were close to zero and there were significant ($P<0.05$) differences between uncoated, rerun and uncoated, first run berries (Table 2). Hunter a value that describes the change in color between red and green is not a proper indicator for color change in muffin batter.

Times through the destemmer significantly ($P<0.05$) affected hue angles and chroma for batter with uncoated berries. Hue angles for batter with coated, first run and rerun and uncoated, first run berries were close to yellow in the second quadrant. Hue angle (235.8°) for batter with uncoated rerun, berries was located in the third quadrant which indicated that batter color was more blue and dark (Table 2).

Table 1 - Effect of CMC coating of IQF blueberries on driploss, anthocyanin leakage in buffer and leakage of berries in muffins

Treatments	Driploss* g/100g	Anthocyanin leakage** mg/100g	Leakage area mm^2/berry***
Uncoated rerun berries	22.8b****	46.7b	49.07b
Uncoated first run berries	14.8a	7.2a	33.29a
Coated rerun berries	3.6c	9.7d	55.53b
Coated first run berries	1.5c	2.4c	30.53a

* n = 5. ** n = 12. *** n = 100. **** Different letters in the same column mean significant differences (P<0.05)

Table 2 - Effect of CMC coating blueberries on Hunter L, a, b, hue angle and chroma of muffin batter

Treatments	L*	a*	b*	Hue angle*	Chroma*
Uncoated rerun berries	56.4c**	-1.29b	-2.29c	235.8b	2.69c
Uncoated first run berries	69.8a	-0.45a	6.16a	94.5a	6.19a
Coated rerun berries	79.3b	-0.97ab	10.43b	95.3a	10.48b
Coated first run berries	77.8b	-0.82ab	10.37b	94.5a	10.41b

*n = 12. ** Different letters in the same column mean significant differences (P<0.05).

Coating caused significant (P<0.05) differences in hue angle and chroma between batter with rerun and coated, rerun berries, and between batter with first run and coated, first run berries. Coating of the berries with CMC was an effective means of reducing bleeding into muffin batter (Table 2) because a gum film on coated berries absorbed part of the anthocyanin on the surface of fruit and acted as a boundary interface between berry and batter. The film directly prevented anthocyanin on

the surface of fruit from adhering and diffusing to the batter during mixing.

Leakage area of individual berries in muffins was significantly affected by the times through the destemmer. The leakage area around individual berries in muffins baked with uncoated and coated, rerun berries were significantly ($P<0.05$) higher than those with coated, first run and uncoated, first run berries because rerun berries suffered more physical damage during the destemming process. There were no significant differences in leakage area between coated and uncoated, first run and between coated and uncoated, rerun berries. The film limited the diffusion of exuded juice to the crumb surrounding the berries and muffins with coated berries had lighter crumb even though there were no significant difference in the leakage area of individual berries with coated and uncoated fruit. Anthocyanin leakage into batter during mixing was a major contributor to the discoloration of the interior muffin crumb.

CONCLUSIONS: Repeated destemming of IQF blueberries affect driploss, anthocyanin leakage and Hunter L, a, b values and hue angle of muffin batter, as well as leakage area of berries in muffins. Coating first run and rerun fruit with CMC effectively reduced anthocyanin leakage into batter during mixing.

RECOMMENDATIONS: This research has shown that CMC can be used to prevent/reduce bleeding into bakery products. The next step is to determine the feasibility of applying the gum as part of the processing line. The logical point would seem to be following the destemmer. This research will be performed during the next year.

A. FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Mary Ellen Camire, Associate Professor of Food Science
Susan Cheney, Graduate Assistant

4. TITLE: Amylase test development

METHODS: Samples of frozen wild and highbush blueberries were purchased from a local supermarket and examined for their ability to hydrolyze a starch gel at both refrigeration and room temperatures. Degree of hydrolysis was determined using a Brookfield viscometer. Highbush and wild blueberries, fresh and frozen, were purchased from local supermarkets and growers, and microorganisms capable of producing alpha-amylase were isolated from the fruit.

RESULTS: The pH of wild and cultivated samples was not responsible for the loss of viscosity in food grade starch gels and blueberry pie fillings, but a bacterial alpha-amylase standard of 1.5% caused the complete hydrolysis of a 5% food grade starch gel. A mold, possibly an *Aspergillus species,* was isolated from cultivated blueberry samples and showed strong enzyme activity and starch hydrolysis over a nine day incubation period at 30C. Yeast isolated from the blueberry samples indicated alpha-amylase activity on alpha-amylase agar, but when grown in culture broth, no significant activity was seen. Bacterial isolates showed minimal enzyme activity and strong starch hydrolysis indicating an enzyme other than alpha-amylase.

The Ceralpha Assay for alpha-amylase can be used by processors or bakers for a rapid screening method for blueberry samples using a correction factor. Total plate counts, or yeast and mold counts, cannot be used to predict loss of viscosity.

CONCLULSIONS: The problem with loss of batter viscosity in the presence of blueberries is only observed occasionally making detection difficult. The results of this research has demonstrated that fruit pH is not responsible for the viscosity loss, but neither is the production of alpha-amylase the only enzyme involved in viscosity loss. Microorganisms isolated from blueberries can produce enzyme(s) capable of decreasing batter viscosity. Preliminary results indicate that the Ceralpha Assay could be used as a qualitative screen for lots of blueberries. The test takes about 30 min making it applicable to a processing facility or a bakery.

RECOMMENDATIONS: The Ceralpha Assay should be used during the next year to screen lots of blueberries from a commercial facility for the ability to decrease the viscosity of muffin batters and blueberry pie fillings. Based on these results, the Assay may be adopted by the industry as a screening method.

A. FOOD SCIENCE AND HUMAN NUTRITION

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

4. TITLE: Determination of pesticide residue levels in fresh and processed wild blueberries.

METHODS: Wild blueberry samples were gathered by Wyman's and Cherryfield Foods and brought to my laboratory for analysis in September and October. Samples arrived frozen and were placed in a freezer. They were analyzed by either immunoassay or GC-AED methods that had been developed earlier.

RESULTS: All 32 samples have been analyzed and the results are given in Table 1. None of the samples contained detectable levels of hexazinone and carbendazim. However, 9, 6 and 1 sample contained phosmet, guthion, and methoxychlor, respectively. Methoxychlor was shown to be present at 242 ppb, phosmet ranged from 7.6 to 680 ppb and guthion was observed at 13.3 to 345 ppb. All pesticides were below tolerance.

CONCLUSIONS: As mentioned above, all pesticide concentrations were below tolerance. Only 28% of the samples were positive for phosmet, 19% were positive for guthion, and 1% positive for methoxychlor.

RECOMMENDATIONS: To continue indefinitely with this project due to the importance of the public perception of pesticides in our diets.

FUTURE WORK: This project should be continued at some level for an unlimited time with the expansion of more chemicals.

Table 1. Blueberry Results for 1995

PESTICIDE CONCENTRATION IN BLUEBERRIES (ng/g)					
Sample #	Phosmet	Guthion	Methoxychlor	Carbendazim	Hexazinone
CO8189715	ND	ND	ND	ND	ND
103580921o5s	ND	345	ND	ND	ND
10908114t-1	ND	40	242	ND	ND
1090815t-11	ND	ND	ND	ND	ND
5963823t-1	ND	ND	ND	ND	ND
1063810t-3	ND	ND	ND	ND	ND
107448Rt-10	ND	ND	ND	ND	ND
1090813T-2	ND	ND	ND	ND	ND
1063870t-9	ND	ND	ND	ND	ND
4012816t-3	ND	29	ND	ND	ND
1099815t-4	ND	50	ND	ND	ND
5007817t	ND	ND	ND	ND	ND
1090815t-12	ND	ND	ND	ND	ND
1062810t-9	ND	334	ND	ND	ND
11118222t-3	ND	ND	ND	ND	ND
5022823t-3	ND	ND	ND	ND	ND
4032823t-12	ND	ND	ND	ND	ND
4012816t-18	ND	ND	ND	ND	ND
1111822t-14	418	ND	ND	ND	ND
5004815T-9	ND	ND	ND	ND	ND
1097815T-7	ND	ND	ND	ND	ND
1073912T-12	ND	ND	ND	ND	ND
106682t-8	ND	ND	ND	ND	ND
1882t-5#3	ND	ND	ND	ND	ND
1882t16#3	680	ND	ND	ND	ND
1010815T-13	316	ND	ND	ND	ND
C Foods A	100	ND	ND	ND	ND
C Foods B	19	13	ND	ND	ND
C Foods C	8	ND	ND	ND	ND
C Foods D	79	ND	ND	ND	ND
C Foods E	48	ND	ND	ND	ND
C Foods F	41	ND	ND	ND	ND

ND = none detected at the listed detection limits.
Phosmet: 1 ppb
Guthion: 1 ppb
Methoxychlor: 5 ppb
Carbendazim: 20 ppb
Hexazinone: 50 ppb

B. POLLINATION

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

1. TITLE: Sustainable pollination of wild blueberry.

OBJECTIVES:

1) To conduct field trials comparing the pollinator and cost effectiveness of commercially available bumblebees, *Bombus impatiens* and honeybees, *Apis mellifera.*

2)To evaluate leafcutting bees, honeybees, and bumblebees in foraging studies in the greenhouse.

3) To compare and evaluate the performance of native bumblebee species to commercially available pollinators: *Bombus ternarius, B. terricola,* and *B. vagans vagans.*

METHODS: Objective 1: To conduct field trials comparing the pollinator and cost effectiveness of commercially available *Bombus impatiens* and *Apis mellifera*. Six wild blueberry fields in Waldo County of similar size and management were used. Honeybees were stocked at three hives per acre in three of the fields and *B. impatiens* were stocked at two colonies per acre in the other three fields. The bumblebee fields were designated STAPLES (#1), MER. ORL (#2), and MER. PEN (#3). Honeybee fields were designated ALLEN (#1), BOY (#2), and HOME (#3).

Seventy-five meter (81.75 yds.) transects were established from each cluster of honeybee hives or colonies. (Three transects originated from each cluster.) For each transect, at distances of 15, 30, 45, 60 and 75 meters (16.35, 32.70, 49.05, 65.40, and 81.75 yds), ten wild blueberry stems were marked and the number of flowers recorded for each stem. Two weeks after bloom ceased the stems were reexamined and the number of developing fruits counted in order to determine percentage fruit set. Berries were harvested in late July and berry number, weight, size, and seeds per berry recorded. Regression analysis were used to determine if any relationship exists between distance from the hive/colony and the percentage fruit set and yield parameters. Percentage fruit set and yield were compared with descriptive and inferential statistics ($P < 0.05$).

Observations of bee foraging behavior were made during bloom. To measure bee abundance during bloom, 15 one m^2 (10.75 ft^2) plots were established and 1 minute counts of bees made during bloom in each field. Number of foraging bees were also recorded in each of the 75 meter transects. 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: To evaluate leafcutting bees, honeybees, and bumblebees in foraging studies in the greenhouse. Two measures of bee foraging efficiency on wild blueberry were examined in flight cage experiments in the greenhouse. Dormant cut wild blueberry stems and potted plants were maintained in cold storage at 4C (38F) for at least 1000 hours in order to break dormancy and induce

bud break. Plants and stems were brought into the greenhouse and allowed to flower as needed.

Generally, one species of bee and its nesting materials was maintained in the flight cage at a time. The honeybee hives contained a queen and two frames of bees. *Bombus impatiens* were greenhouse colonies, each colony contained approximately 60 workers. Only one hive or colony was in the flight cage at a time. Approximately 200 female alfalfa leafcutting bees, *M. rotundata*, from incubated leaf cells from Saskatchewan, Canada, were housed in Poli Surrounds, a commercial nesting material. Forty female native Maine blueberry bees, *Osmia atriventris*, reared from nests in 15.2 cm (6 in.) paper straws with a 6 mm (0.24 in.) inner tunnel diameter produced in trap nesting blocks set out around wild blueberry fields in Maine, were housed in wooden nesting blocks.

Bees in the flight cages were maintained on potted flowering buckwheat, *Fagopyrum esculentum* Moench, which served as a forage plant for all the bees and as a source of leaf material for the nesting *Megachile* and *Osmia* females. Sugar syrup and water were also provided. Several hours prior to the onset of a bioassay session the buckwheat plants were removed from the flight cage or covered with plastic or insect barrier cloth.

The procedure for the bioassay session was as follows: three cut wild blueberry stems were placed in a moistened floral styrofoam block. The block was placed in the flight cage approximately 1 meter (1.09 yds) from the bee domicile. Observations of bee foraging behavior, flower handling time and the number of bee visits to individual flowers were recorded. Stems were left in the cage for 1 hour or 10 visits to a single flower on one of the stems, whichever came first. Also, in order to obtain sufficient single visits to flowers, in some cases, an individual flower was excised from the stem after one visit and placed in a petri dish. Pollen tetrads on individual stigmas were counted under a dissecting microscope at 30x and the number of grains present per single visit recorded. The stigmas from three control flowers, which were handled in the same manner as visited flowers per bioassay session, were also examined microscopically and any pollen grains recorded.

Objective 3: To compare and evaluate the performance of native bumblebee species to commercially available pollinators: *Bombus ternarius, B. terricola,* and *B. vagans vagans*. Our 1995 bumblebee research indicated that three species of bumblebees looked promising due to their relative abundance in Washington County, ME, wild blueberry fields. Therefore, we examined their relative abundance in transects and m^2 plots in the six study fields used for comparing the commercial bumblebee to the honeybee. (See Objective 1 above for methods.)

Also, a field study examining the foraging efficiency of these native bumblebee species was conducted. During bloom, foraging behaviors, flower handling behavior and time and fidelity to the blooming crop were measured for each species for both workers and queens of the following species: *Bombus ternarius, B. terricola,* and *B. vagans vagans*. For comparisons with honeybees and the commercial bumblebee, *B. impatiens,* data for *B. terricola* and *B. vagans vagans* were pooled because of the difficulty of separating them in the field. Whereas *B. ternarius* is unmistakable (it is orange and yellow), *B. vagans vagans,* and *B. terricola* both can be confused if they are foraging in the field (both are yellow and black). Data were analyzed statistically to determine if differences existed among the species and between queens and workers for the native bumblebee studies. These findings were also compared to the findings from the field study comparing the honeybee and *B.*

impatiens in order to determine if the native bumblebees, honeybees, or the commercial bumblebee were the most efficient species.

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

Table 1 shows the average number of bumblebees (*Bombus impatiens*) and honeybees (*Apis mellifera*) per one m^2 (10.75 ft^2) plot and per transect at the six study sites. It should be noted that on only one occasion were honeybees found at any of the bumblebee sites, which suggests they had no role in pollination in two of the three bumblebee fields and probably a minimal role at best, in bumblebee field #1. On 11 June, honeybees were found in bumblebee field #1 (STAPLES); they had absconded from a field that had no bloom left; there was less than 1% bloom left in this bumblebee wild blueberry site. Interestingly, the number of bumblebees observed on 11 June in this field was 10 times less than usual, which may indicate competition with honeybees for very scarce floral resources.

For percentage fruit set, there was a significant effect for distance in bumblebee field #2 (MER. ORL) and honeybee fields #1 (ALLEN) and #3 (HOME). These findings are shown in Figures 1 and 2, respectively. In these fields, fruit set decreased with increasing distance from the colonies or hives. For berry weights, two of the bumblebee fields and two of the honeybee fields there was a significant effect of decreasing berry weight with increasing distance from the colonies or hives (Figures 3 and 4, respectively). Figures 5 and 6 show average percentage fruit set and yield in the individual bumblebee (*B. impatiens*) and honeybee (*A. mellifera*) fields, respectively. For data pooled across the two treatments (honeybees versus bumblebees), there were no significant differences in average percentage fruit set (Figure 7), average percentage yield (Figure 8), average berry weight (Figure 9) or average seeds per berry (Figure 10). These findings are noteworthy in that it demonstrates than one bumblebee is worth many, many honeybees, because a typical colony has 60 workers. In contrast, a honeybee bee hive contains 10,000--20,000 workers.

The importance of pollination is demonstrated in Figure 11, which shows that as the number of seeds per berry increases there is a significant increase in berry weight. In other words, more fertilized ovules from more pollen grains being deposited by bees results in greater berry weights.

Field observations of the commercial bumblebee and honeybee indicated that the bumblebee foraged in heavy rain whereas the honeybee did not. Also, all observations of *B. impatiens* (n = 100) were of pollen collecting as well as nectar foraging. In contrast, for the honeybee, only three observations (n = 100) were of pollen collecting from wild blueberry; the remaining 97 observations were of nectar collecting.

In 1996, the average price of honeybee hives was $45, which was an increase from 1995 of $10 per hive. The bumblebees were sold in units of four, termed "quads" because each quad contains four colonies. The price per bumblebee colony was $60 or $240 per quad. (This price was the multiple use rate because after wild blueberry bloom the bumblebees were transferred to Rhode Island to pollinate cranberry.) The nonmultiple use rate was $90 per colony or $360 per quad.

Objective 2: To evaluate leafcutting bees, honeybees, and bumblebees in foraging studies in the

greenhouse. Intraspecific differences existed for flower visitation behavior. For all bee species, some individuals visited only one flower per stem, whereas other individuals visited two to all available flowers per stem.

Flower handling time varied among the bee species, with the commercial bumblebee handling flowers the fastest with an average flower handling time of 1.5 sec (Table 2). The honeybee was the slowest at handling flowers with an average handling time of 13.2 sec. At these rates, in 1 minute, the bumblebee would visit and pollinate 40 flowers; whereas, the honeybee would visit only 4.5 flowers in the same amount of time.

Wild blueberry appears to be least preferred by honeybees based on the amount of time spent trying to observe and record 25 single flower visits to it (Table 3). This behavior was consistent with our observations in the field.

The only pattern observed for pollen deposition on stigmas was that honeybees, *A. mellifera,* consistently deposited the least per single visit with on average 11.6 tetrads deposited (Table 4). The Maine blueberry bee, *Osmia atriventris* deposited the most pollen per single visit on wild blueberry (Table 4). Wild blueberry has approximately 64 ovules on average. Thus, it would take the honeybee on average 6 visits to completely fertilize all ovules, 4 visits by the bumblebee, 3 visits by the alfalfa leafcutting bee, and only 2 visits by the wild native leafcutting Maine wild blueberry bee.

Objective 3: To compare and evaluate the performance of native bumblebee species to commercially available pollinators: *Bombus ternarius, B. terricola,* and *B. vagans vagans.* Native wild bumblebees, like the commercial bumblebee, foraged in heavy rains. Of 100 observations of floral preference, wild bumblebees were completely faithful to wild blueberry.

Bumblebee abundance varied from field to field with queens being far more abundant the workers (Table 5). A total of 41 queens were observed in transects with the "Orange-belted Queens," *B. ternarius,* comprising approximately 42% of the queens. Eight workers were observed in transects; none were *B. ternarius.*

Bombus ternarius queens handled flowers faster than other queens and faster than workers (Figure 13). When both commercially available bees and native bumblebees were compared, native *B. ternarius* queens handled flowers the fastest (Figure 14). All bumblebee species were faster than the honeybee. For example, based on these flower handling rates in the field, a *B. ternarius* queen would visit and pollinate 22 flowers in 1 minute compared to 11 flowers by the honeybee in the same amount of time.

RECOMMENDATIONS: The commercial bumblebee, *B. impatiens,* demonstrated that it is an excellent pollinator of wild blueberry both in the field and greenhouse studies. If it can be shown that its stocking density can be reduced by 50% from two colonies to one, than it truly will be cost competitive to the honeybee at the current rental prices for both bees. Based on its excellent flowering handling rate and the number of pollen grains it deposits per visit, we predict that this will be the case and recommend this study be continued for another field season in which a stocking density of one colony per acre is tested.

The superiority of the native leafcutting Maine blueberry bee over the honeybee in the flight cage studies demonstrates that growers should pursue steps to conserve and protect this native species. Likewise, the superiority of the native bumblebees as pollinators indicates that conservation efforts should be developed. Because so little is known about the biology and ecology of native bumblebees, we recommend developing methods to rear them in captivity.

Table 1. Average number of commercial bumblebees (*Bombus impatiens*) and honeybees (*Apis mellifera*) in transects and one m^2 plots at the six study sites in Waldo County during blueberry bloom.

	Bombus impatiens		*Apis mellifera*	
Site	Transect	m^2 plot	Transect	m^2 plot
Bumblebee Fields				
#1	7.6	0.67	5.0	0.533
#2	8.6	0.13	0	0
#3	4.75	0.03	0	0
Honeybee Fields				
#1	na	na	10.3	0.38
#2	na	na	36.0	1.13
#3	na	na	22.0	0.30

Table 2. Average flower handling time (sec) + S. E. M per individual wild blueberry flowers, *Vaccinium angustifolium* , by bees. Range is in parentheses.

Bee Species	Lowbush blueberry
Apis mellifera (honeybee)	13.2 ± 3.1 (2 - 48)
Bombus impatiens (bumblebee)	1.5 ± 0,2 (1 - 4)
Megachile rotundata (alfalfa leafcutting bee)	3.4 ± 0.1 (1 - 5)
Osmia atriventris (Maine blueberry bee)	1.9 ± 0.2 (1 - 5)

Table 3 . Time (min) elapsed observing bees in the flight cage in order to obtain 25 observations of a single visit to individual flowers.

Bee Species	Lowbush blueberry
Apis mellifera (honeybee)	293
Bombus impatiens (bumblebee)	45
Megachile rotundata (alfalfa leafcutting bee)	188
Osmia atriventris (Maine blueberry bee)	178

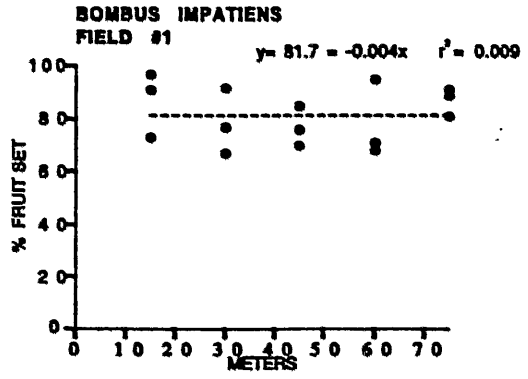
Table 4. Average number of pollen tetrads ± S. E. M. deposited on individual *Vaccinium angustifolium* , wild blueberry, stigmas by bees in single visits. Range is in parentheses.

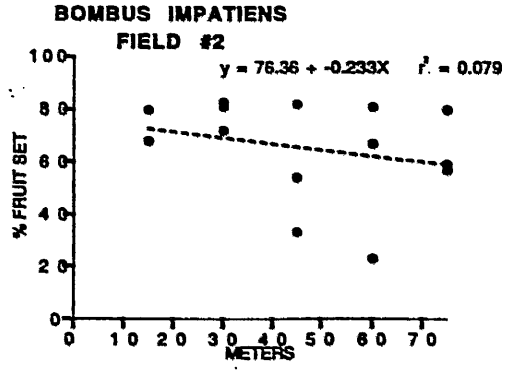
Bee Species	Lowbush blueberry
Apis mellifera (honeybee)	11.6 ± 3.1 (0 - 70)
Bombus impatiens (bumblebee)	16.0 ± 1.9 (0 - 41)
Megachile rotundata (alfalfa leafcutting bee)	23.1 ± 8.3 (0 - 89)
Osmia atriventris (Maine blueberry bee)	33.8 ± 8.5 (0 - 202)
Control	1.2 ± 0.4 (0 - 6)

Table 5. Average number of wild bumblebee Queens and workers in transects and one m^2 plots at six study sites in Waldo County during blueberry bloom.

	Bombus Queens		*Bombus* Workers	
Site	Transect	m^2 plot	Transect	m^2 plot
Bumblebee Fields				
#1	0.1	0	0	0.08
#2	1.7	0.06	0.4	0.03
#3	1.6	0.06	0.1	0.03
Honeybee Fields				
#1	0.3	0.1	0.3	0.03
#2	0.2	0	0	0
#3	0.2	0.03	0	0

Fig.1. Fruit set in fields with commercial bumble bees, *Bombus impatiens*. (Note 1 meter = 1.09 yds.)





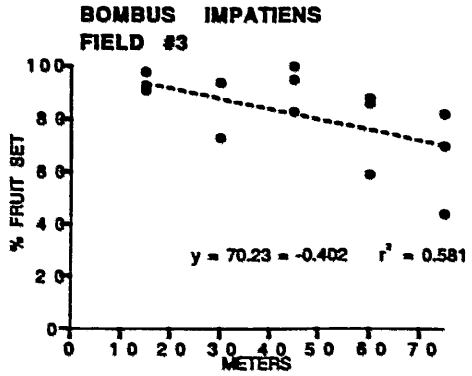


Fig. 2. Fruit set in fields with honeybees, *Apis mellifera*. (Note 1 meter = 1.09 yds.)

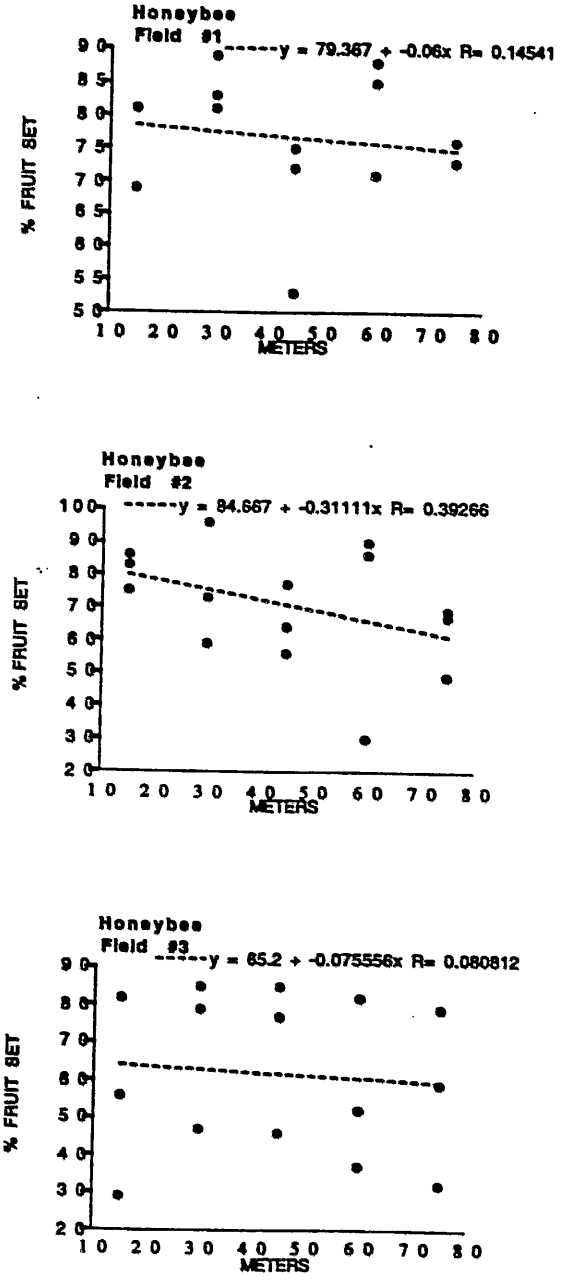
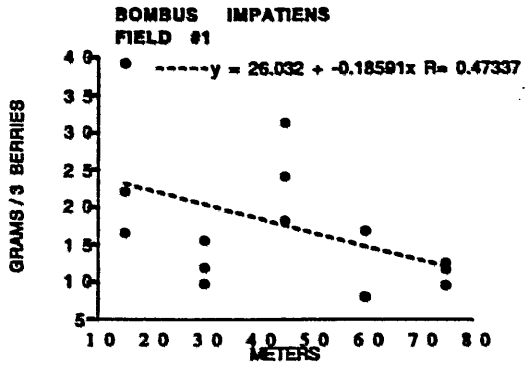
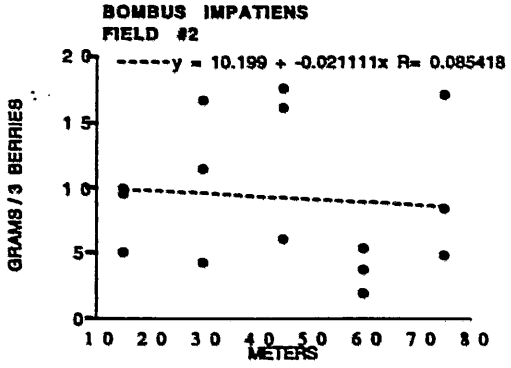


Fig. 3. Berry weight in fields with commercial bumblebees, *Bombus impatiens*. (Note 1 meter = 1.09 yds.)





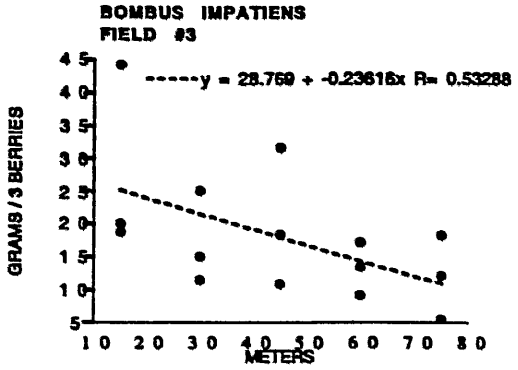


Fig. 4. Berry weight in fields with honey bees, *Apis mellifera*. (Note 1 meter = 1.09 yds.)

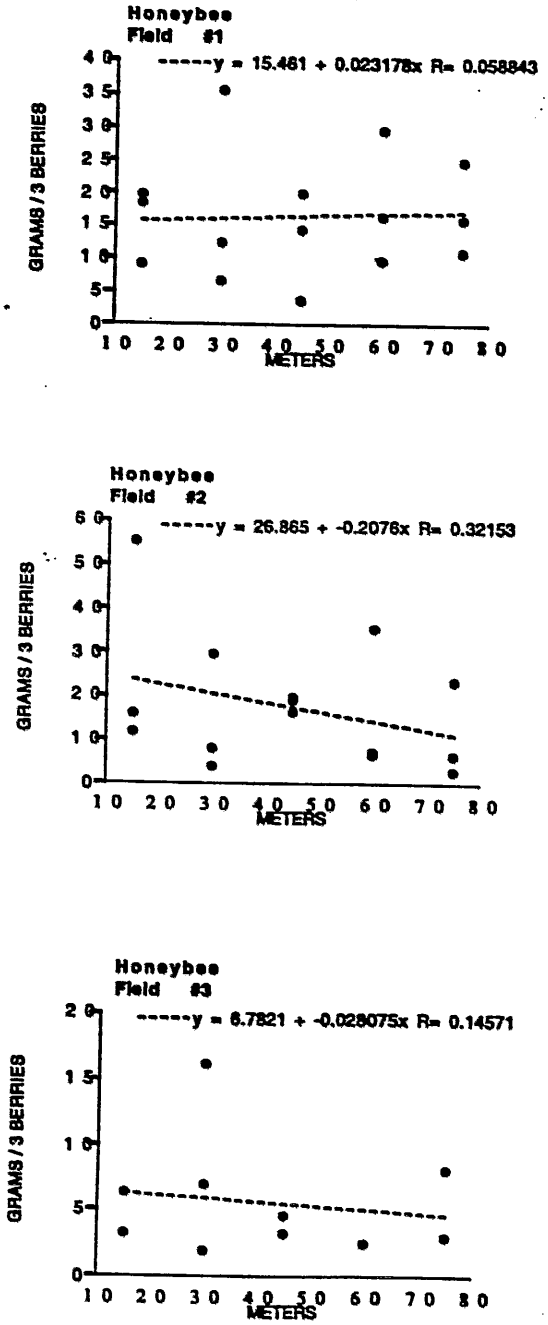
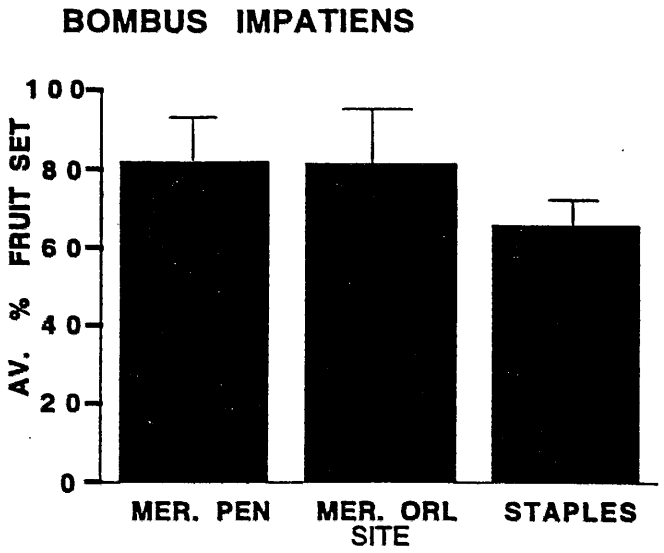


Fig. 5. Average percentage fruit set (A) and percentage yield (B) in individual fields with commercial bumblebees, *Bombus impatiens*. The bumblebee fields were designated STAPLES (#1), MER. ORL (#2), and MER. PEN (#3).

A



B

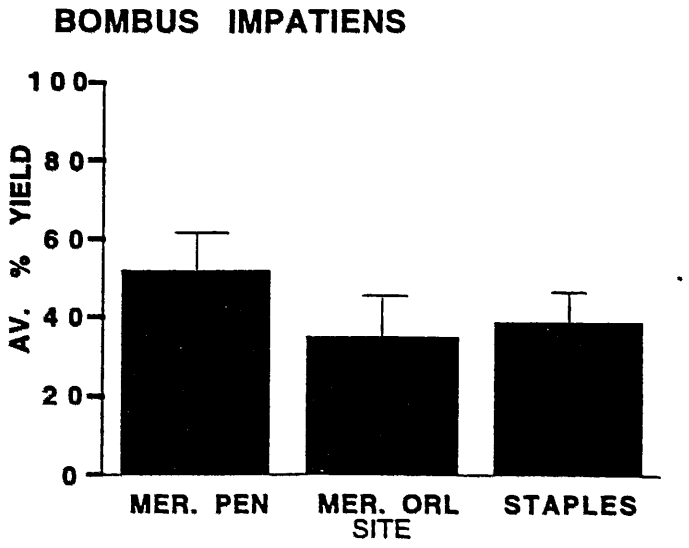
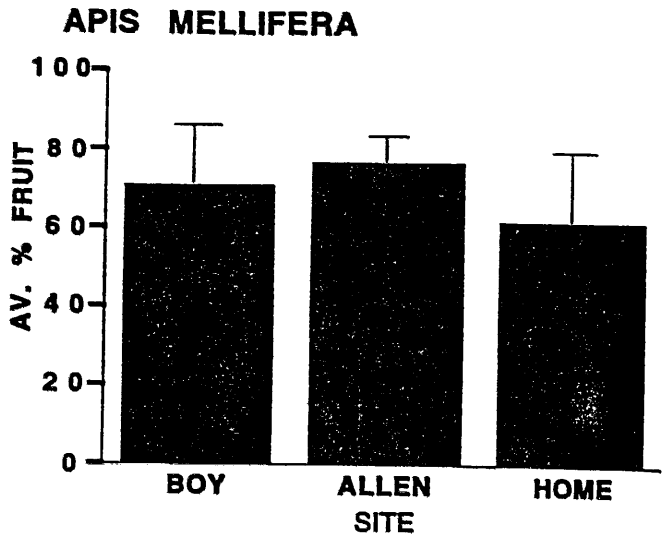


Fig. 6. Average percentage fruit set (A) and yield (B) in fields with honey bees, *Apis mellifera*. Honeybee fields were designated ALLEN (#1), BOY (#2), and HOME (#3).

A



B

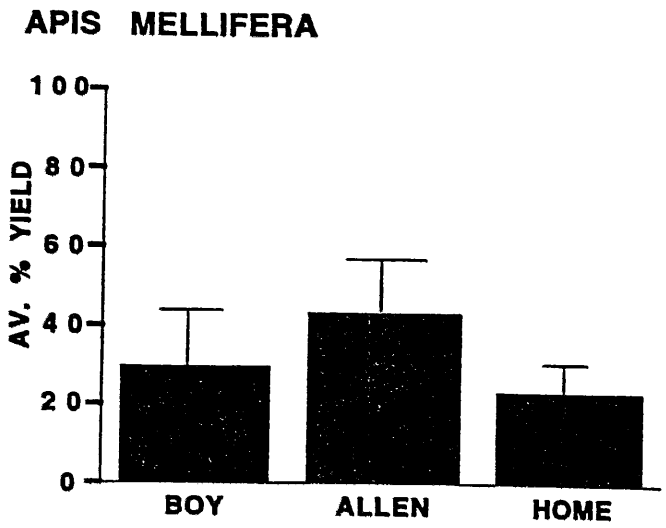


Fig. 7. Average percentage fruit set in fields with honeybees, ***Apis mellifera***, and bumblebees, *Bombus impatiens*.

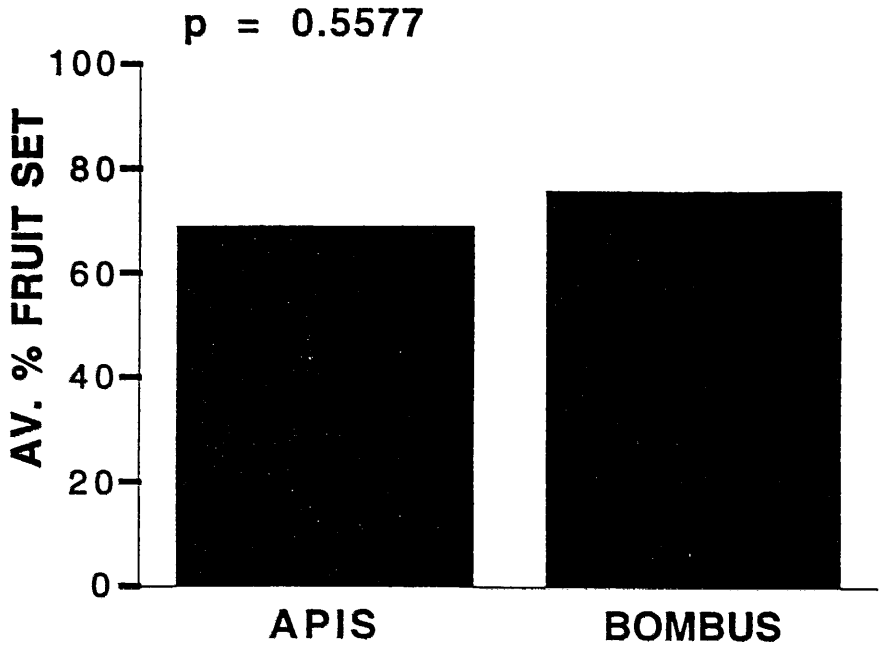


Fig. 8. Average percentage yield in fields with honeybees, *Apis mellifera*, and bumblebees, *Bombus impatiens*.

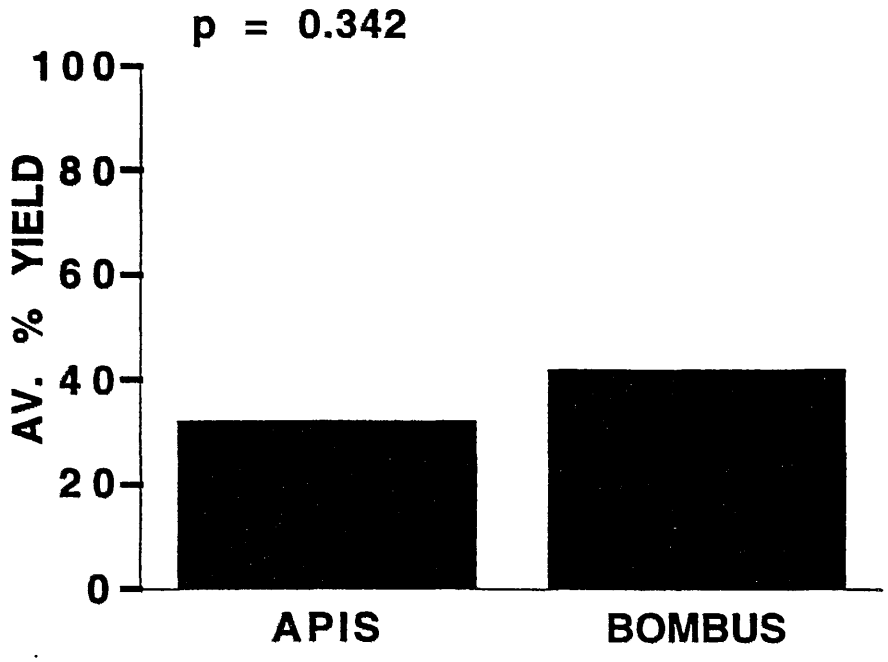


Fig. 9. Average berry weight in fields with honeybees, *Apis* ***mellifera,*** and bumblebees, *Bombus impatiens.*

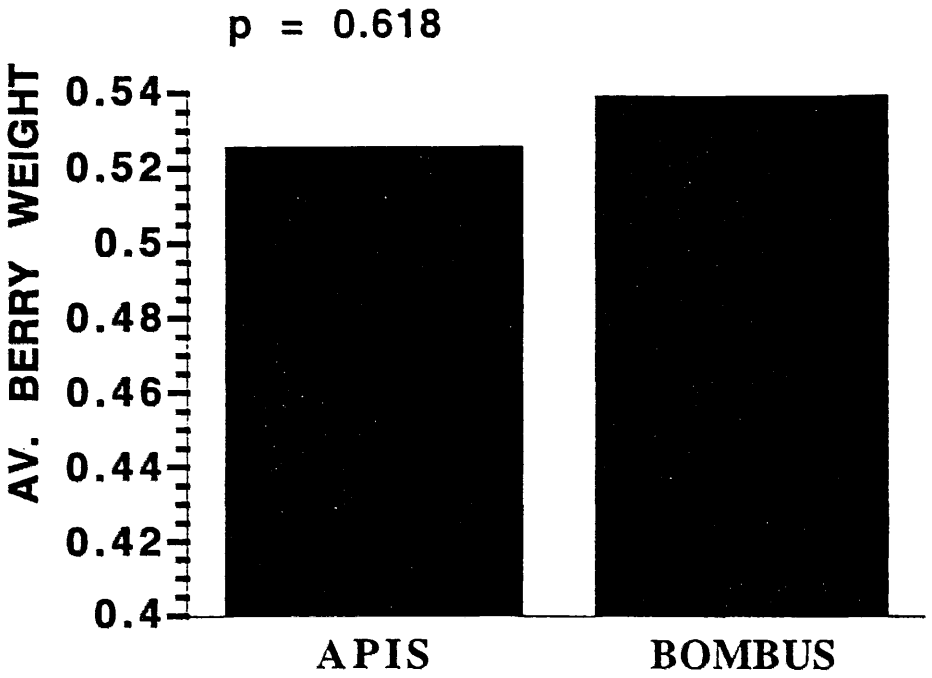


Fig. 10. Average seeds per berry in fields with honeybees, ***Apis mellifera,*** and bumblebees, *Bombus impatiens.*

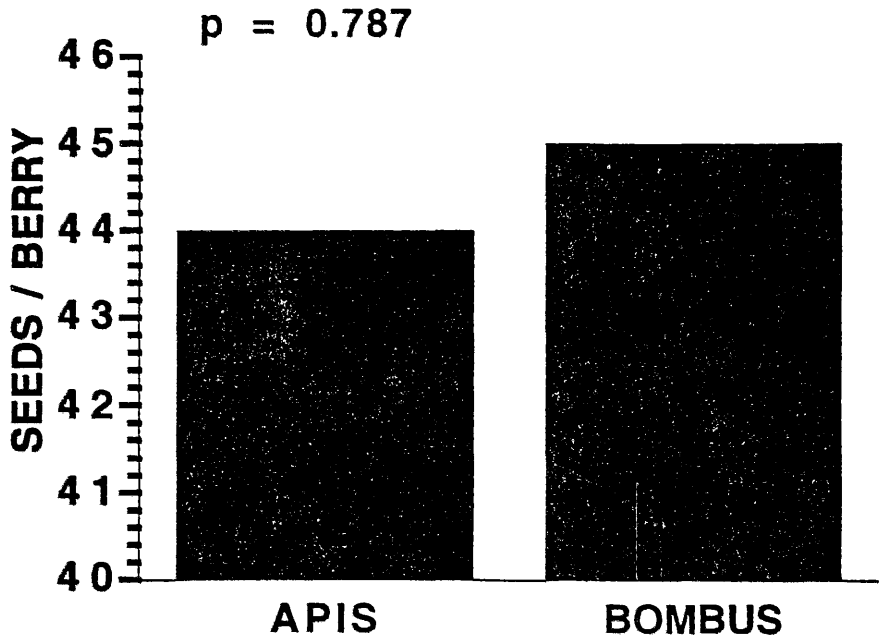


Fig. 11. The significant relationship between number of seeds per berry and berry weight.

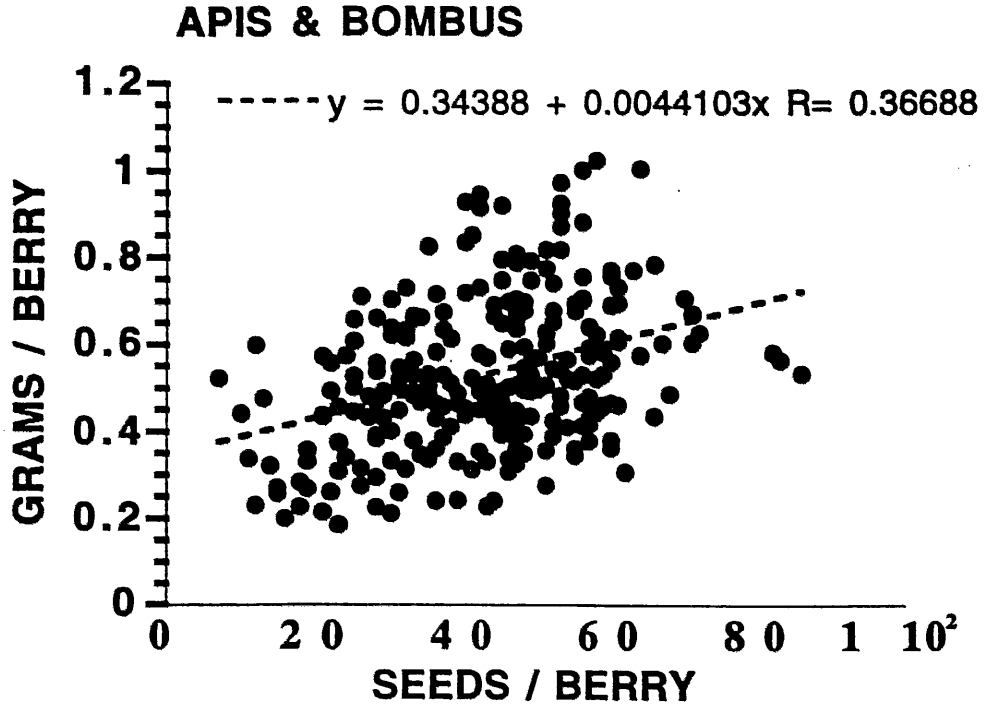


Fig. 12. Average flower handling time for honeybees (*Apis mellifera*) and commercial bumblebees (*Bombus impatiens*).

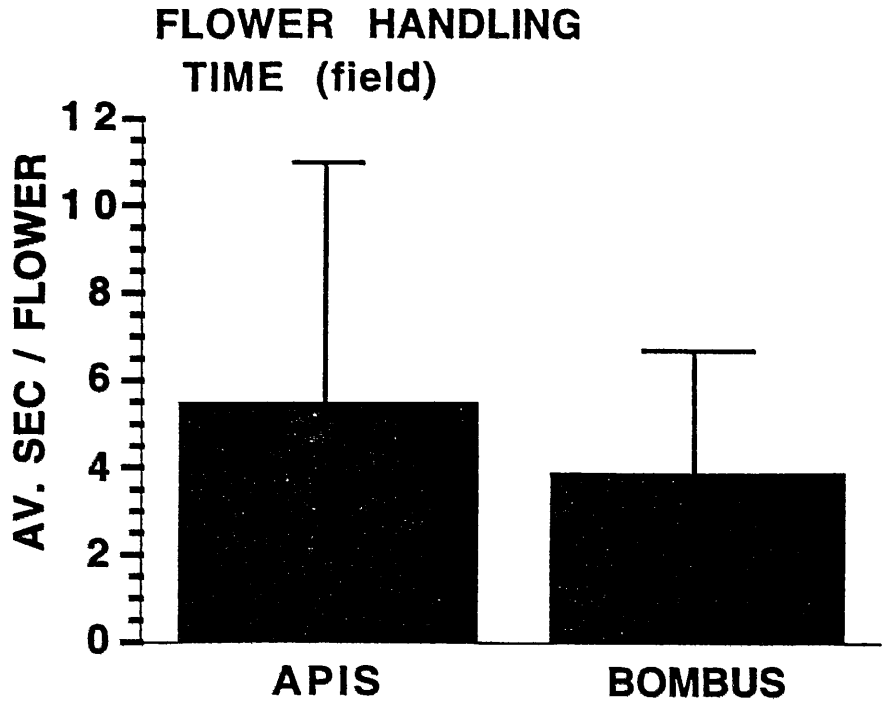


Fig. 13. Flower handling time by native bumblebee queens **and workers.** (**tern. Q** = *Bombus ternarius* queens; ter. W = *Bombus ternarius* **workers; spp. Q** = pooled *Bombus vagans* and *Bombus terricola* queens; **spp W** = **pooled** ***Bombus*** *vagans* and *Bombus terricola* workers.

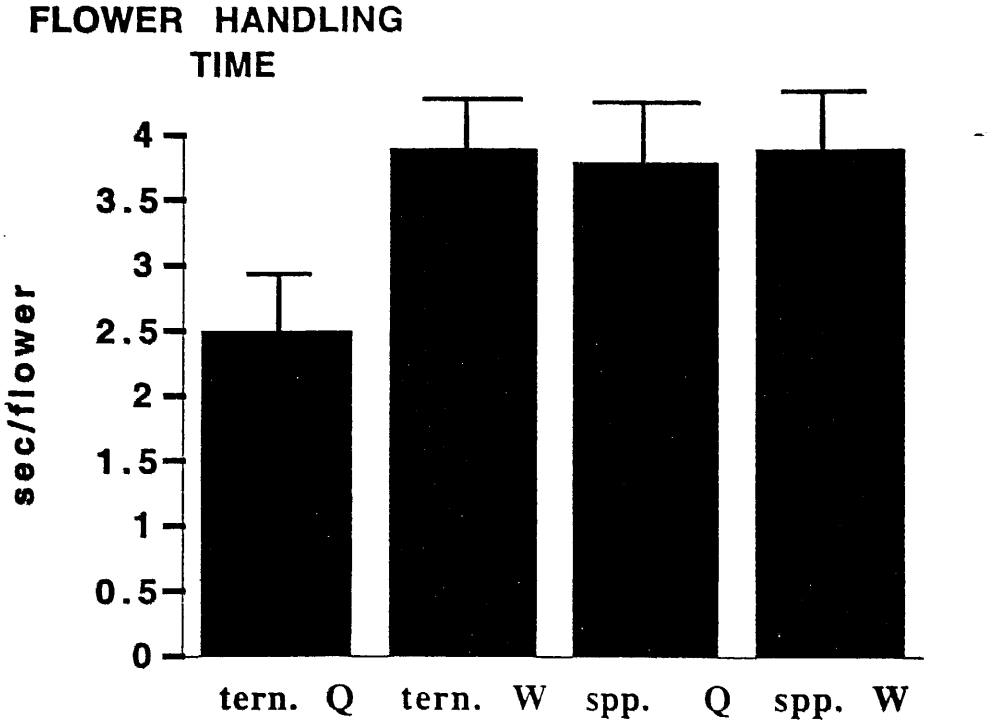
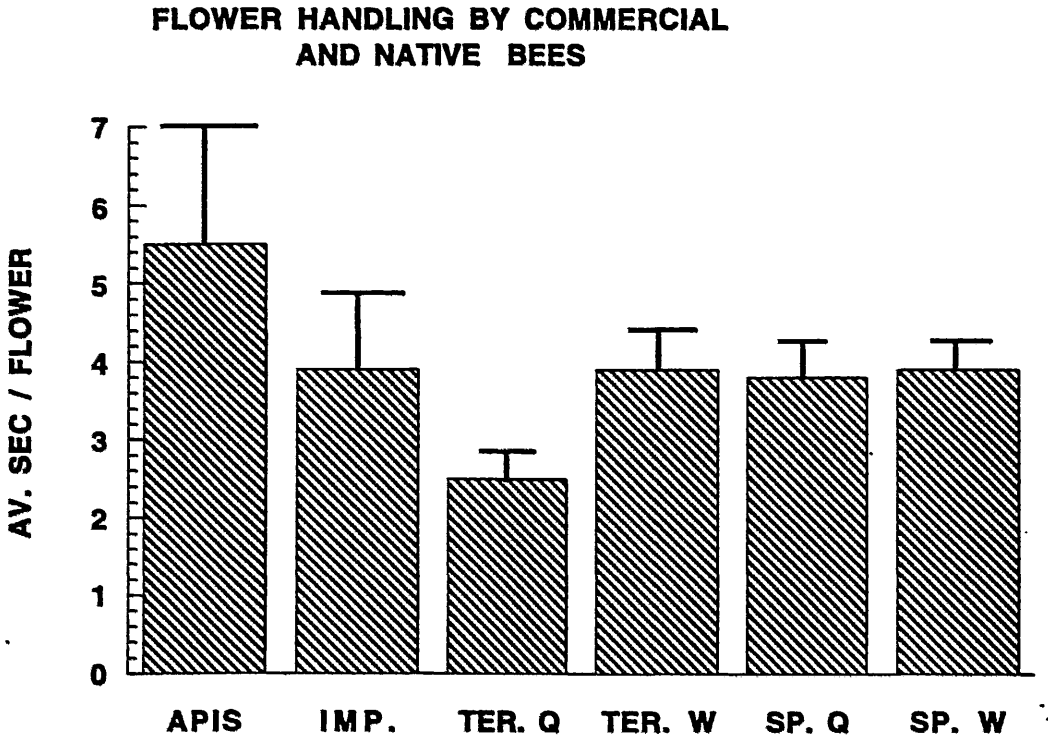


Fig. 14. Flower handling time by commercially available honeybees (Apis), commercially available bumblebees (imp) , and native bumblebee queens and workers. (tern. Q = *Bombus ternarius* queens; ter. W = *Bombus ternarius* workers; spp. Q = pooled *Bombus vagans* and *Bombus terricola* queens; spp W = pooled *Bombus vagans* and *Bombus terricola* workers.



C. INSECT CONTROL

INVESTIGATORS: F. A. Drummond, Associate Professor of Applied Ecology and Environmental Sciences
J. A. Collins, Assistant Scientist

TITLE: Potential for the biological control of insect pests of blueberry.

METHODS:

Laboratory control tests were conducted using a Burkard[R] computer controlled spray apparatus. For the tests with the fungal pathogen, *Beauveria bassiana*, insects were sprayed in filter-paper lined, 4-inch diameter petri dishes; blueberry foliage was added immediately after spray application. For all other tests, blueberry foliage was placed in the petri dishes prior to application. Foliage was changed every 2-3 days. The number of insects per dish depended on pest species and developmental stage and ranged from 4-10. Replicates ranged from 2-8, and the frequency of sampling dishes for the assessment of mortality was 1-5 days (see tables). Insects were determined dead if they did not move upon being touched with a laboratory dissecting needle. Dead insects were held in separate petri dishes for up to 2 weeks in order to detect symptoms of disease or parasitism. Statistical analysis was used to quantify the relationship between dose of control agent and mortality. The date selected for performing the analysis was usually 4 days after spraying; although, the criteria used to select the date was evidence of significant mortality across the dosages.

RESULTS:

Our studies indicate that *B. bassiana* shows potential for control of blueberry spanworm larvae (Tests 1, 2, 3), blueberry flea beetle larvae and adults (Tests 5, 6), grasshopper nymphs (Test 7), and leaf beetle adults (Test 8). Flea beetle adults (Test 6) appeared especially susceptible and feeding was almost not detectable 4 days postspray. *B. bassiana* did not look promising against red-striped fireworm (Test 4) within their leaf ties.

Results with the novel botanical neem (azadirachtin) on blueberry flea beetle (Tests 9 and 10) suggest this material may have potential for control against adults at high rates (Test 9), but not against larvae (Test 10).

A comparison of blueberry spanworm second and third instar susceptibility to Javelin® (*Bacillus thuringiensis kurstaki*) (Test 11) showed that larger third instar caterpillars are significantly more tolerant then are smaller instars.

Our research on M-Trak as a potential control for larval blueberry flea beetles (Test 12) suggests that this formulation of *Bacillus thuringiensis san diego* is not a viable control alternative to currently recommended insecticides.

CONCLUSIONS:

Research in 1996 identified several promising microbial biocontrol agents. Laboratory bioassays indicated that the fungal pathogen *Beauveria bassiana* shows potential for control of spanworm larvae, flea beetle larvae and adults, grasshopper nymphs, and leaf beetle adults. The novel botanical insecticide neem may have potential against flea beetle larvae and blueberry maggot.

RECOMMENDATIONS:

Research into nonchemical and environmentally friendly strategies of pest suppression should remain a high priority for the lowbush blueberry industry. In addition to *B. bassiana* and neem, work on other biocontrol agents such as the fungi, *Metarhizium anisopliae*, and the insect parasitizing nematode, *Steinernema carpocapsae*, should be completed. At least several years of data must be collected before any recommendations can be made concerning the use of these or other new materials as alternatives to control pest insects of lowbush blueberry. Our results with Javelin® lends support to the recommendation that if Javelin® is used for control of blueberry spanworm, targeting of small, early instar larvae is necessary for effective control.

Beauveria bassiana

Test 1: First Instar Blueberry Spanworm Larvae

Rate Conidia/Acre	% Mortality (SD)[a]		
	18 May	20 May	22 May[b]
2.80×10^{9}	5.0 (4.6)	35.0 (18.9)	50.0 (17.3)
2.80×10^{10}	0.0 (0.0)	35.0 (21.2)	60.0 (15.5)
2.80×10^{11}	10.0 (6.2)	45.0 (21.6)	90.0 (6.3)
2.80×10^{12}	14.0 (8.5)	54.0 (16.2)	87.0 (7.0)
2.80×10^{13}	15.0 (7.0)	60.0 (19.3)	97.0 (4.3)
0.01% Silwet, 2% Oil	0.0 (0.0)	15.0 (12.6)	25.0 (11.1)
H_2O	2.5 (4.6)	23.0 (11.4)	28.0 (9.9)
	25 May	29 May	31 May
2.80×10^{9}	75.0 (13.8)	85.0 (14.2)	85.0 (11.4)
2.80×10^{10}	70.0 (11.5)	84.0 (9.4)	90.0 (8.0)
2.80×10^{11}	90.0 (4.6)	93.0 (11.2)	97.0 (5.7)
2.80×10^{12}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
2.80×10^{13}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
Silwet, Oil	50.0 (22.4)	70.0 (13.7)	72.0 (18.4)
H_2O	43.0 (12.4)	48.0 (16.4)	60.0 (21.5)

[a] 3 replicates of ten larvae; 5 replicates of ten larvae for control. Sprayed on 16 May.

[b] $LD_{50} = 4.97 \times 10^{8}$, $LD_{95} = 3.52 \times 10^{12}$, $LD_{99} = 1.76 \times 10^{14}$; estimates based upon log dose - probit regression: $y = 1.317 + 0.412x$, $r^2 = 0.89$.

Test 2: Second Instar Blueberry Spanworm Larvae

Rate Conidia/Acre	% Mortality (SD)[a] 18 May	20 May	22 May[b]
2.80×10^{9}	3.3 (2.7)	16.7 (12.2)	46.7 (23.1)
2.80×10^{10}	0.0 (0.0)	20.0 (11.2)	56.7 (22.5)
2.80×10^{11}	0.0 (0.0)	20.0 (21.5)	73.3 (33.5)
2.80×10^{12}	3.3 (1.8)	16.7 (9.5)	86.7 (15.6)
2.80×10^{13}	3.3 (1.8)	16.7 (13.2)	90.0 (7.8)
0.01% Silwet, 2% Oil	0.0 (0.0)	3.3 (1.9)	16.7 (5.9)
H_2O	4.0 (0.0)	4.0 (3.0)	4.0 (1.1)
	25 May	29 May	31 May
2.80×10^{9}	90.0 (4.8)	93.3 (6.9)	96.7 (4.4)
2.80×10^{10}	90.0 (5.9)	96.7 (4.3)	100.0 (0.0)
2.80×10^{11}	96.7 (5.0)	96.7 (11.9)	100.0 (0.0)
2.80×10^{12}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
2.80×10^{13}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
Silwet, Oil	46.7 (28.8)	53.3 (34.6)	63.3 (19.5)
H_2O	10.0 (6.2)	18.0 (8.3)	24.0 (17.9)

[a] 3 replicates of ten larvae; 5 replicates of ten larvae for control. Sprayed on 16 May.

[b] $LD_{50} = 2.22 \times 10^{9}$, $LD_{95} = 1.11 \times 10^{14}$, $LD_{99} = 1.11 \times 10^{16}$; estimates based upon log dose - probit regression: $y = 1.301 + 0.347x$, $r^2 = 0.98$.

Test 3: Third Instar Blueberry Spanworm Larvae

Rate Conidia/Acre	% Mortality (SD)[a]		
	25 May	27 May	29 May[b]
2.80×10^9	0.0 (0.0)	0.0 (0.0)	40.0 (23.1)
2.80×10^{10}	0.0 (0.0)	20.0 (14.6)	80.0 (11.2)
2.80×10^{11}	10.0 (3.4)	16.7 (12.2)	84.0 (30.6)
2.80×10^{12}	0.0 (0.0)	22.0 (16.8)	93.7 (4.5)
0.01% Silwet, 2% Oil	0.0 (0.0)	0.0 (0.0)	10.0 (5.5)
H_2O	0.0 (0.0)	0.0 (0.0)	4.0 (2.4)
	31 May	1 Jun	3 Jun
2.80×10^9	43.0 (24.6)	100.0 (0.0)	100.0 (0.0)
2.80×10^{10}	90.0 (4.3)	100.0 (0.0)	100.0 (0.0)
2.80×10^{11}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
2.80×10^{12}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
Silwet, Oil	10.0 (6.7)	20.0 (7.2)	45.5 (23.1)
H_2O	4.0 (2.4)	7.6 (3.5)	53.3 (27.9)

[a] 3 replicates of ten larvae; 5 replicates of ten larvae for control. Sprayed on 23 May.

[b] $LD_{50} = 2.22 \times 10^9$, $LD_{95} = 2.22 \times 10^{12}$, $LD_{99} = 5.58 \times 10^{13}$; estimates based upon log dose - probit regression: $y = 1.057 + 0.527x$, $r^2 = 0.90$.

Test 4: Red-striped Fireworm Larvae

Rate Conidia/Acre	% Mortality (SD)[a]			
	7 Sep	9 Sep	11 Sep	13 Sep
2.80×10^{9}	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
2.80×10^{10}	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	12.0 (8.0)
2.80×10^{11}	0.0 (0.0)	4.0 (4.0)	4.0 (4.0)	16.0 (4.0)
2.80×10^{12}	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	14.0 (5.8)
2.80×10^{13}	0.0 (0.0)	6.7 (4.2)	10.8 (4.9)	26.0 (6.0)
H_2O	0.0 (0.0)	6.4 (4.2)	6.4 (4.2)	6.4 (4.2)

	15 Sep	17 Sep	19 Sep[b]
2.80×10^{9}	0.0 (0.0)	4.0 (4.0)	4.0 (4.0)
2.80×10^{10}	20.0 (12.6)	20.0 (12.6)	24.0 (14.7)
2.80×10^{11}	16.0 (4.0)	16.0 (4.0)	28.0 (8.0)
2.80×10^{12}	14.0 (5.8)	19.0 (9.3)	27.0 (5.8)
2.80×10^{13}	34.0 (6.0)	38.0 (4.9)	42.0 (2.0)
H_2O	6.4 (4.2)	15.0 (3.9)	15.0 (3.9)

[a] 5 replicates of five larvae; 6 replicates of five larvae for 2.80×10^{13} rate; 7 replicates of five larvae for control. Sprayed on 5 Sep.

[b] $LD_{50} = 2.22 \times 10^{13}$, $LD_{95} = 7.02 \times 10^{21}$, $LD_{99} = 2.80 \times 10^{25}$; estimates based upon log dose - probit regression: $y = 0.955 + 0.3117x$, $r^2 = 0.69$.

Test 5: Blueberry Flea Beetle Larvae

Rate Conidia/Acre	% Mortality (SD)[a]			
	6 Jun	8 Jun[b]	11 Jun	13 Jun
2.80×10^{9}	0.0 (0.0)	0.0 (0.0)	20.6 (10.8)	61.1 (10.2)
2.80×10^{10}	12.8 (9.4)	12.8 (9.4)	67.5 (11.1)	97.5 (2.5)
2.80×10^{11}	17.5 (10.3)	22.5 (10.3)	95.0 (5.0)	100.0 (0.0)
2.80×10^{12}	12.8 (6.3)	45.3 (12.5)	100.0 (0.0)	100.0 (0.0)
2.80×10^{13}	18.9 (12.5)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
0.01% Silwet, 2% Oil	0.0 (0.0)	2.5 (2.5)	7.5 (4.8)	20.0 (4.1)
H_2O	0.0 (0.0)	2.5 (2.5)	7.5 (4.8)	20.0 (7.1)

[a] 4 replicates of ten larvae. Sprayed on 4 Jun.

[b] $LD_{50} = 5.58 \times 10^{11}$, $LD_{95} = 8.84 \times 10^{12}$, $LD_{99} = 2.80 \times 10^{13}$; estimates based upon log dose - probit regression: $y = 1.240 + 1.339x$, $r^2 = 0.89$.

Test 6: Blueberry Flea Beetle Adults

Rate Conidia/Acre	% Mortality (SD)[a] 29 Jul[c]	31 Jul	4 Aug	% Feeding[b] 29 Jul
2.80×10^{9}	28.0 (10.9)	52.0 (22.8)	100.0 (0.0)	16.0 (7.4)
2.80×10^{10}	40.0 (46.9)	64.0 (32.0)	100.0 (0.0)	9.0 (5.5)
2.80×10^{11}	88.0 (17.9)	100.0 (0.0)	100.0 (0.0)	16.0 (5.7)
2.80×10^{12}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	0.0 (0.0)
2.80×10^{13}	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	2.0 (4.5)
0.01% Silwet, 2% Oil	0.0 (0.0)	0.0 (0.0)	32.0 (22.8)	20.0 (0.0)

[a] 5 replicates of five adults. Sprayed on 25 Jul.

[b] Reduction in feeding as a percent of control: 50% = 1.11×10^{11}, 90% = 1.76×10^{13}, 95% = 3.52×10^{13}; estimates based upon log dose vs. % reduction of control regression: $y = -19.45 + 18.5x$, $r^2 = 0.61$.

[c] $LD_{50} = 1.76 \times 10^{10}$, $LD_{95} = 3.52 \times 10^{11}$, $LD_{99} = 1.40 \times 10^{12}$; estimates based upon log dose - probit regression: $y = 0.335 + 1.244x$, $r^2 = 0.92$.

Test 7: Grasshopper Nymphs

Rate Conidia/Acre	% Mortality (SD)[a] 24 Jun	25 Jun[b]	28 Jun
2.80×10^{9}	0.0 (0.0)	30.1 (24.8)	95.8 (12.0)
2.80×10^{10}	3.1 (8.8)	26.9 (24.9)	100.0 (0.0)
2.80×10^{11}	0.0 (0.0)	46.6 (30.8)	100.0 (0.0)
2.80×10^{12}	0.0 (0.0)	81.1 (24.0)	100.0 (0.0)
0.01% Silwet, 2% Oil	0.0 (0.0)	8.0 (24.5)	53.6 (25.8)

[a] 8 replicates of four nymphs. Sprayed on 21 Jun.

[b] $LD_{50} = 1.40 \times 10^{11}$, $LD_{95} = 3.52 \times 10^{14}$, $LD_{99} = 1.11 \times 10^{16}$; estimates based upon log dose - probit regression: $y = 0.831 + 0.474x$, $r^2 = 0.80$.

Test 8: Blueberry Leaf Beetle Adults

Rate Conidia/Acre	% Mortality (SD)[a]			
	25 May	27 May	29 May	30 May
2.80×10^{9}	0.0 (0.0)	0.0 (0.0)	2.0 (2.0)	4.0 (2.4)
2.80×10^{10}	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
2.80×10^{11}	2.0 (2.0)	4.0 (2.4)	6.0 (4.0)	8.0 (3.7)
2.80×10^{12}	0.0 (0.0)	0.0 (0.0)	6.0 (4.0)	36.0 (5.1)
2.80×10^{13}	0.0 (0.0)	0.0 (0.0)	22.8 (7.9)	55.6 (7.8)
0.01% Silwet, 2% Oil	0.0 (0.0)	1.4 (1.4)	2.8 (1.8)	4.3 (2.0)
H_2O	4.0 (4.0)	4.0 (4.0)	8.0 (3.7)	10.0 (3.2)

	1 Jun	4 Jun	6 Jun[b]
2.80×10^{9}	4.0 (2.4)	6.0 (2.4)	10.0 (0.0)
2.80×10^{10}	2.0 (2.0)	4.0 (2.4)	12.0 (3.7)
2.80×10^{11}	20.6 (4.8)	34.8 (8.9)	43.2 (7.8)
2.80×10^{12}	58.0 (3.7)	78.0 (5.8)	88.0 (3.7)
2.80×10^{13}	67.6 (3.4)	92.0 (3.7)	96.0 (2.4)
0.01% Silwet, 2% Oil	7.1 (1.8)	7.1 (1.8)	7.1 (1.8)
H_2O	10.0 (3.2)	16.0 (6.0)	18.0 (7.3)

[a] 5 replicates of ten adults; 7 replicates of ten adults for H_2O control. Sprayed on 23 May.

[b] $LD_{50} = 1.11 \times 10^{11}$, $LD_{95} = 1.76 \times 10^{13}$, $LD_{99} = 1.76 \times 10^{14}$; estimates based upon log dose - probit regression: $y = 0.354 + 0.721x$, $r^2 = 0.93$.

Align Biological Insecticide (neem)

Test 9: Blueberry Flea Beetle Adults

Rate[a] Oz/A	% Mortality (SD)[b] 29 Jul	31 Jul[d]	4 Aug	% Feeding[c] 29 Jul
1.6	0.0 (0.0)	4.0 (8.9)	32.0 (10.9)	20.0 (0.0)
16	0.0 (0.0)	4.0 (8.9)	52.0 (22.8)	14.0 (5.4)
80	0.0 (0.0)	12.0 (10.9)	60.0 (20.0)	14.0 (5.4)
160	8.0 (10.9)	24.0 (16.7)	76.0 (35.8)	9.0 (2.2)
320	84.0 (21.9)	92.0 (17.9)	96.0 (8.9)	0.0 (0.0)
0.03% Triton	4.0 (8.9)	12.0 (10.9)	28.0 (22.8)	20.0 (0.0)

[a] 0.2 mls were sprayed into each petri dish.

[b] 5 replicates of five adults. Sprayed on 25 Jul.

[c] Reduction in feeding as a percent of control: 50% = 1.37, 90% = 171.8, 95% = 370 (oz/A); estimates based upon dose vs. % reduction of control regression: $y = 10.958 + 0.227x$, $r^2 = 0.94$.

[d] $LD_{50} = 2.28$, $LD_{95} = 36.68$, $LD_{99} = 37.03$ (oz/A); estimates based upon log dose - probit regression: $y = 3.168 * e^{0.002x}$, $r^2 = 0.98$.

Test 10: Blueberry Flea Beetle Larvae

Rate[a] Oz/A	% Mortality (SD)[b] 15 Jun	17 Jun[c]	19 Jun	21 Jun
1.6	2.0 (2.0)	16.0 (5.1)	31.2 (3.4)	52.8 (3.7)
16	2.0 (2.0)	18.0 (6.6)	34.0 (9.8)	44.0 (6.8)
80	0.0 (0.0)	12.0 (4.9)	28.0 (7.3)	46.0 (14.0)
160	12.8 (11.0)	26.3 (11.1)	38.0 (11.1)	48.8 (11.5)
320	6.7 (4.2)	20.0 (6.8)	33.3 (4.9)	45.0 (6.7)
0.03% Triton	0.0 (0.0)	6.0 (4.0)	26.0 (4.0)	54.0 (4.0)
H_2O	5.2 (2.9)	11.6 (4.2)	22.2 (3.7)	42.0 (7.1)

	24 Jun	25 Jun
1.6	60.8 (8.4)	66.6 (7.6)
16	50.0 (8.4)	52.0 (9.2)
80	56.0 (13.3)	56.0 (13.3)
160	49.8 (12.5)	53.2 (12.7)
320	55.0 (6.7)	60.0 (6.8)
Triton	60.0 (3.2)	62.0 (3.7)
H_2O	48.2 (6.6)	53.1 (7.2)

[a] 0.2 mls were sprayed into each petri dish.

[b] 5 replicates of ten larvae; 8 replicates of ten larvae for control. Sprayed on 12 Jun.

[c] No significant ($P > 0.05$) dose vs. mortality regression relationship.

Javelin WG

Test 11: Second and Third Instar Blueberry Spanworm Larvae

Rate[a] lb/A	% Mortality (SD)[b] 6 Jun	8 Jun[c]	11 Jun	13 Jun
Second Instar				
0.1	0.0 (0.0)	57.2 (12.9)	67.8 (12.2)	89.4 (0.6)
0.5	13.3 (6.7)	72.6 (2.6)	93.0 (3.5)	96.3 (3.7)
1.0	42.2 (2.2)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)
H_2O	3.3 (3.3)	16.7 (3.3)	40.0 (5.8)	46.7 (3.3)
Third Instar				
0.1	5.0 (5.0)	35.0 (5.0)	55.5 (5.0)	85.0 (5.0)
0.5	10.4 (5.8)	44.4 (5.6)	75.6 (4.4)	88.9 (11.1)
1.0	15.0 (5.0)	75.0 (5.0)	85.0 (5.0)	85.0 (5.0)
H_2O	0.0 (0.0)	13.3 (3.3)	36.7 (6.7)	50.0 (15.3)

[a] 0.2 mls were sprayed into each petri dish.

[b] Replicates ranged from 2 to 3 replicates of 10 larvae. Sprayed on 5 Jun.

[c] Dose - % mortality regression: second instar mortality = 50.777 + 47.852x, $r^2 = 0.97$; third instar mortality = 27.536 + 45.131x, $r^2 = 0.93$. Susceptibility of second instars is significantly greater than third instars (ANOVA: $F_{(1,11)} = 18.06$, $P = 0.001$).

M-Trak

Test 12: Blueberry Flea Beetle Larvae

Rate[a] lb/A	% Mortality (SD)[b] 6 Jun	9 Jun	11 Jun[c]	13 Jun
0.001	0.0 (0.0)	2.5 (2.5)	17.5 (11.8)	28.2 (10.4)
0.01	0.0 (0.0)	5.0 (2.9)	20.0 (4.1)	27.5 (4.8)
0.1	0.0 (0.0)	0.0 (0.0)	20.0 (7.1)	30.0 (7.1)
1.0	2.5 (2.5)	7.5 (2.5)	35.0 (10.4)	55.0 (8.7)
10.0	0.0 (0.0)	5.0 (5.0)	27.5 (10.3)	50.0 (7.1)
H_2O	8.0 (8.0)	8.0 (8.0)	16.0 (6.8)	32.0 (7.3)
	15 Jun	17 Jun	19 Jun	21 Jun
0.001	54.2 (5.9)	77.0 (2.4)	90.0 (4.1)	95.0 (2.9)
0.01	45.0 (2.9)	70.0 (7.1)	80.0 (7.1)	82.5 (6.3)
0.1	45.0 (6.4)	65.0 (8.7)	77.5 (8.5)	87.5 (7.5)
1.0	65.0 (11.9)	80.0 (12.2)	82.5 (11.8)	90.0 (10.0)
10.0	70.0 (7.1)	80.0 (7.1)	82.5 (7.5)	92.5 (4.8)
H_2O	50.0 (3.2)	68.0 (10.2)	78.0 (8.0)	88.0 (4.9)

[a] 0.2 mls were sprayed into each petri dish.

[b] 4 replicates of ten larvae; 5 replicates of ten larvae for control. Sprayed on 5 Jun.

[c] Log dose - probit regression not significant ($P = 0.11$).

D. COLD TEMPERATURE TOLERANCE AND FIELD COVER

INVESTIGATOR: Paul E. Cappiello, Associate Professor of Landscape Horticulture

1. TITLE: Effect of desiccation on wild blueberry winter survival and cold tolerance.

METHODOLOGY: The work for this project has been initiated as of September 1996. Initial results will not be available until early summer 1997. Below is a description of the methodology which has been/will be employed. The methodology is slightly altered from the initial proposal but follows the same reasoning.

Desiccation effects on winter survival of wild blueberry will be investigated by employing a series of laboratory and field studies. These studies will evaluate the potential benefits of physical wind-break measures and chemical antitranspirant applications.

Field studies on physical wind-breaks will employ strategies to block ambient wind from study plots. Twenty clones will be selected and one half of the clones will be surrounded with construction fencing to form an 8'-diameter plot encircling the center of the clone. Plots will be protected from wind by physical barriers consisting of 4'-high construction fencing. Throughout the dormant season, sample stems will be harvested from both the protected and unprotected plots. Buds will be excised and assessed for moisture content to determine percent moisture loss over the season. In addition, buds will be sectioned and examined microscopically to assess potential desiccation of the tissues. The same plots will be followed through full bloom and fruit set to evaluate interactions among wind protection treatments, tissue moisture levels, and yield potential. In controlled freezing studies, field-dug sod plugs will be exposed to varying wind/desiccation treatments to assess the degree of desiccation tolerance in wild blueberry.

The second series of studies will investigate potential benefits of moisture loss inhibitors in reducing desiccation damage in field and laboratory maintained plant material. Eight clones will be selected and 4 subplots established within each clone. Each subplot will receive one of the following antitranspirant treatments: 1) water control, 2) Wiltpruf®, 3) Cloud Cover®, 4) Leaf Shield®. Following field applications, treatment plots will be evaluated as described above. In addition, field-dug sod plugs will be similarly treated with the antidesiccant compounds and exposed to artificially imposed wind/desiccation treatments to further assess the potential benefits of these products.

Throughout the above studies, sample stems will be harvested over the dormant season and exposed to low-temperature tolerance treatments (same methodology as employed over the last several years in my lab) to assess potential interaction between moisture loss and low-temperature tolerance.

RESULTS None available at this time.

D. COLD TEMPERATURE TOLERANCE AND FIELD COVER

INVESTIGATOR: Paul E. Cappiello, Associate Professor of Landscape Horticulture

2. TITLE: Population variation in low-temperature tolerance of wild blueberry: effect of artificial warming on low-temperature tolerance.

METHODOLOGY: Five clones were selected for use in this study. On each of the following dates (11/11, 2/26, 3/18, 4/4, and 4/18) stems of each clone were harvested and subjected to incubation treatments at -5C, +5C, +10C, and +15C for approximately 72 hours. Control stems were evaluated for low-temperature tolerance immediately following harvest. Following sample stem incubation, stems were subjected to the low-temperature tolerance testing procedure. Fruit buds were rated for percent survival at each of the test temperatures.

RESULTS: For all five clones, warming treatments had a significant effect on flower primordia survival rates on all but the January sampling date (Fig 1.) On the January 11 date, there was no clear effect of warming across all five clones. In January, only the 10C incubation treatment resulted in decreased survival of flower primordia compared to controls. Although this was a statistically significant reduction in survival it amounted to only approximately a 5% reduction and is not likely biologically significant. On the remaining 4 dates, the 10C and 15C incubation treatments resulted in significantly reduced survival rates. In February and March, those treatments resulted in approximately 20% reduction in flower primordia survival. On the two April dates, the 10C and 15C incubation treatments resulted in more than 60% reduction in survival compared to control stems.

These results are in agreement with the little data that are available concerning low-temperature tolerance dynamics in wild blueberry. It has long been proposed that wild blueberry requires approximately 1000 hours of temperatures below 2C for satisfaction of bud dormancy but this has not been shown conclusively. In addition, earlier work had indicated the possibility that wild blueberry flower primordia would be most susceptible to both cold damage and to early warm spells starting in late March and early April. Examination of the data from this work indicates that the greatest increase in susceptibility to the warming trends occurred between the 3/18 and 4/4 sampling dates: the 2/26 and 3/18 sampling dates showing significantly lower susceptibility to the warm incubation.

In a Maine winter, it is typical to have in excess of 1000 hours below 2C by the end of January. It has also been observed that stems cut at this time do not always demonstrate satisfaction of dormancy requirements. It is typically not until mid or late March that most or all wild blueberry plants in the field show symptoms of having satisfied their dormancy requirement. If the susceptibility to warming treatments is tied to dormancy requirements, as we suspect, then one would expect little or no effect of warming in January, and little/variable effects in February and March. Further, if this scenario is correct, one would expect to see dramatic effects of warming treatments applied in April. This is exactly the case presented in Fig. 1.

While these results do not provide definitive proof of a direct tie between dormancy

requirement and susceptibility to warming trends, it does provide strong indications that this is the case. This work does add support to the hypothesis that wild blueberry buds are most susceptible to loss of low-temperature tolerance after late March. Regardless, a recommendation can be made for growers who wish to assess winter damage by forcing stems, to wait until late April to make that assessment. Any damage determinations made prior to that point will likely lead to an overestimation of crop potential.

Figure 1. Wild blueberry flower primordia survival percent as affected by incubation temperature.[z]

Incubation Trt.	Sampling Date[x]				
(C)	1/11	2/26	3/18	4/04	4/18
-5	53ab	72a	66ab	68a	45a
5	50ab	67b	68a	64a	42ab
10	49c	62c	64b	41b	38b
15	56a	57d	60c	23c	19c

[z] survival to be compared only within columns as different test temperature ranges were used on each date.
[x] values within columns followed by the same letter are not significantly a 5% level.
N=150

RECOMMENDATIONS: Further work on this topic should investigate the relationship among dormancy requirement, warming susceptibility, and damage potential. Ultimately, a goal should be to determine the range of chill requirements across the wild blueberry population. No funding for this project is being requested at this time.

D. COLD TEMPERATURE TOLERANCE AND FIELD COVER

INVESTIGATOR: Paul E. Cappiello, Associate Professor of Landscape Horticulture

3. TITLE: Influence of flower delaying sprays on seasonal variation of low temperature tolerance in wild blueberry.

METHODOLOGY: Six clones were selected and each was divided into four treatment plots. The rhizomes were physically severed with a spade along the treatment plot lines because previous studies have shown Etherel to have a weak, systemic effect. Within each clone, treatment plots received either 1000, 10,000, or 20,000 ppm of Etherel, or a water control. Treatments were applied in fall of 1995 prior to foliage coloration. Thirty stems from each clone/treatment plot were harvested on each of the following dates: 11/22/95, 12/17/95, 2/12/96, 3/28/96 and 4/18/96. Stems were harvested, packed on crushed ice, and transported to Orono for low-temperature tolerance testing.

RESULTS: All Etherel treatments resulted in decreased cold tolerance relative to control plots on all dates (Fig. 2). The decrease in cold tolerance followed a negative linear trend with respect to Etherel concentration applied to sample stems. The November, December and February sampling dates showed the greatest reduction in cold tolerance with an approximately 80% reduction in flower bud survival percent compared to controls. The last two dates showed a significantly lower reduction in survival but still yielded approximately 50% lower survival with 20,000 ppm applied Ethereal compared to survival of control buds. The lowest concentration applied (1000 ppm) resulted in between 23% and 30% reduction in flower primordia survival.

Figure 2. Wild blueberry flower primordia percent survival as affected by fall foliar sprays of Etherel.[z]

Etherel Conc.	Sampling Date[x]				
(ppm)	11/22	12/17	2/12	3/28	4/18
0	77a	73a	71a	77a	40a
1000	56b	51b	48b	59b	30b
10,000	35c	30c	27c	58b	25c
20,000	17d	11d	12d	44c	19d

[z] survival to be compared only within columns, as different test temperature ranges were used on each date.

[x] values within columns followed by the same letter are not significantly a 5% level. N=180

D. COLD TEMPERATURE TOLERANCE AND FIELD COVER

INVESTIGATOR: Paul E. Cappiello, Associate Professor of Landscape Horticulture

4. TITLE: Effect of various levels of disbudding on yield of wild blueberry.

METHODOLOGY: This study was designed to evaluate the ability of wild blueberry plants to compensate for partial winter damage to flower buds. Five clones were marked in an Ellsworth, ME field in late April 1996 and flower buds were manually removed to simulate partial winter injury. Clones were selected based on absence of any signs of winter damage to flower buds and only clones with 5 flower buds per stem were selected. On 4/29, stems received the following treatments with 20 stems per treatment per clone: 1) all of first (apical) four buds removed, leaving only bud #5; 2) only buds 4 and 5 remaining; 3) only buds 3, 4 and 5 remaining; 4) buds 2, 3, 4 and 5 remaining; 5) all five buds remaining on the stem. On May 24, flower counts were made for each bud on each stem. On July 9, initial fruit set determinations were made and on August 2, each of the stems were harvested and placed in frozen storage for further analysis. Berries were then weighed and diameters determined to determine yield responses to each of the treatments.

RESULTS: An initial evaluation of the data indicated there to be an inherent effect of bud position on fruit characteristics (Fig. 3). While bud position had little or no effect on initial or final fruit number, or initial and final fruit set, there was a significant trend of decreasing fruit size and weight from buds located in positions 4 and 5 (two lowest buds) on the stem.

Figure 3. Fruit number, set, weight and size characteristics as affected by bud position on the stem.

Bud position[z]	Initial Fr #	Initial Set %	Final Fr #	Final Set %	Berry Wt (g)	Berry Radius (cm)
Bud 1	3.2a	60a	2.1a	41a	.27a	.39a
Bud 2	3.3a	53b	2.0a	34b	.28a	.39a
Bud 3	3.3a	58ab	2.1a	38ab	.26a	.38a
Bud 4	3.2a	59ab	2.0a	37ab	.20b	.35b
Bud 5	3.0a	55ab	2.0a	36ab	.21b	.36b

[z] buds numbered 1-5 from apical to basal position

Disbudding treatments also had a significant effect on berry weight and size but did not influence fruit set or fruit number (Fig 4). Stems with 1, 2 or 3 buds left intact had the largest and heaviest fruit and were statistically similar. Stems with 4 and 5 buds intact yielded significantly smaller and lighter fruit.

Figure 4. Fruit number, set, weight and size characteristics as affected by disbudding treatment.

Buds intact[z]	Initial Fr #	Initial Set %	Final Fr #	Final Set %	Berry Wt (g)	Berry Radius (cm)
5	3.2a	58a	2.0a	38a	.30a	.40a
4, 5	3.1a	55a	2.1a	36a	.28a	.40a
3, 4, 5	3.2a	61a	2.0a	38a	.30a	.41a
2,3,4,5	3.3a	56a	2.0a	37a	.26b	.38b
1,2,3,4,5	3.1a	55a	2.0a	36a	.21b	.36c

[z] buds numbered 1-5 from apical to basal position

While the differences in berry size and weight are small, consideration should be made that bud 5 in control plants yielded significantly smaller fruit than did buds located closer to the tip of the stem. When the disbudding treatments were imposed, the plant compensated for lower fruit load by producing from bud 5, among the largest and heaviest fruit of any in the study.

These results follow a similar trend but to a different degree than work done in 1995. In the previous study, stems with 5, 4 and 3 buds left intact produced similar yield characteristics. In that year, the disbudding was done from the base of the stem up, such that the treatment with a single bud remaining had only a bud in the tip position. In the present study, that direction was reversed to more accurately mimic partial winter damage characteristics. Given that the more apically located buds yielded larger fruit in control plants, the difference in the two years' results are not surprising. The work still demonstrates a potential for wild blueberry to compensate fruit load following partial winter injury.

RECOMMENDATIONS: This study should be repeated for a third year with 3-5 clones. The work should follow the methodology used in the present study rather than the 1995 study. No funding is being requested for this work.

E. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Scott Dunham, Crop Technician
Walter Litten, Faculty Associate

1. TITLE: Effect of boron and the polyamine putrescine on wild blueberry fruit set and yield.

STUDY I - Fruit set, Yield and Potential Second Crop

OBJECTIVES: Determine the effect of fall foliar application of boron and spring blossom applied putrescine on wild blueberry fruit set, yield and flower bud formation.

BRIEF JUSTIFICATION:

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. When wild blueberry plants are unable to obtain adequate amounts of boron, applying boron through fall foliar leaf application could improve fruit set, and stimulate greater numbers of berries to develop. Larger berries may be produced due to more seed development within the fruit.

Polyamines are naturally found in the stigmatic exudate where pollen is deposited by insects. Polyamines have also been shown to promote pollen germination, pollen-tube elongation and receptivity of the ovule to fertilization. The polyamine putrescine increased fruit set and yield of "comice" pear and apple. Work with pears indicated that the effective pollination period was extended by putrescine treatment. Putrescine treatment resulted in significant increases in nitrogen and boron concentrations in flower tissue 12 days after anthesis (pollen shedding). In apple, fruit set and yield were increased by sprays of polyamines (spermine, spermidine, and putrescine) 9 days after full bloom. The polyamines not only increased the number of apples per tree, but also often increased the average weight of the fruits. Subsequent flower bud formation was also stimulated by the polyamines.

Therefore, it is possible that spraying wild blueberry blossoms with putrescine could improve fruit set and yield and could even increase a second crop yield by stimulating flower bud formation during the crop year.

METHODS: Nine clones in a commercial wild blueberry field located near Grassy Pond and owned by Northeast Blueberry Company are being used in this study. Twenty five clones were sampled in July 1995 to enable selection of clones which have low leaf boron concentrations (< 24 ppm). Clones of *V. angustifolium* (sweet low or nigrum) larger than 16 ft^2 in diameter showing little evidence of other clones growing into them were selected. Due to drought damage, many clones were rejected and clones not sampled in July were added to the study.

Sixteen 4ft x 4ft treatment plots were established in each of 9 selected clones providing 4 within-clone replicates. Plots receiving foliar application (to drip) of boron were treated on

September 16, 1995. Putrescine was applied in May 1996. A wooden shield was used to prevent spray drift. A hand held, pump-up, 2.5 gallon sprayer was used to apply the following treatments:

1. Control (no treatment)
2. 400 ppm boron (Solubor)
3. 10^{-6} M putrescine (in 0.01 M, pH 7 buffer)
4. 400 ppm boron plus 10^{-6} M putrescine

Twenty stems were sampled from each treatment plot in November 1995. The top 1.5 inches of stem tissue (including flower buds) were dried, ground and analyzed for nutrients to verify that a higher level of boron has been achieved. Crop-year leaf tissue samples were also taken in July 1996 to assess boron levels.

RESULTS: Boron concentrations in stem and bud tissue and in crop-year leaf tissue indicated that boron treatments were effective in raising boron levels (Table 1).

Table 1
Effects of boron and putrescine on boron concentrations in stem and crop-year leaf tissue and yield.

	Stem B (ppm)	Crop year leaf B (ppm)	Yield (lbs/acre)
Control	18.2 c	31.5 b	3008 a
Boron	27.4 a	41.0 a	2984 a
Putrescine	19.3 c	32.2 b	3229 a
B+Putre	26.2 b	39.6 a	2912 a

Fruit set, determined from each treatment plot by counting blossoms on 14 randomly sampled stems in the spring and berries on the same stems in August, has yet to be determined. Fruit characteristics such as color, size and weight are currently being evaluated on frozen samples. Plot yield taken in August 1996 was not affected by treatments (Table 1). Stems sampled in November 1996 will be examined to determine the effect of putrescine on flower bud formation for a potential second crop.

CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can be made at this time.

Study II - Extending the Receptivity of Wild Blueberry Blossoms

OBJECTIVES: Determine the effect of fall foliar application of boron and spring blossom applied putrescine on wild blueberry blossom receptivity.

BRIEF JUSTIFICATION: Boron and putrescine have been implicated in the pollination and fertilization mechanisms of many plants. Insufficient boron (B) concentration in flowers has resulted in low fruit set due to poor pollen germination, inadequate pollen growth through the style into the ovary or failure of the pollen tube gamete to fertilize the egg cell.

When the pollen grain is transferred to the stigma (see fig. 1), it is attached by the stickiness of the fluid produced on the stigma (stigmatic exudate). The stigmatic exudate serves several functions including: control of pollen adhesion, hydration and germination, protection of the pistil with its pollen from microbial infection and also as coating to prevent stigma dehydration, providing flower-visitor (insect) nutrition during pollination with its sugar content and in nutrition of the pollen tube as it grows through the stigma and style to the ovary. Substances in the stigmatic exudate

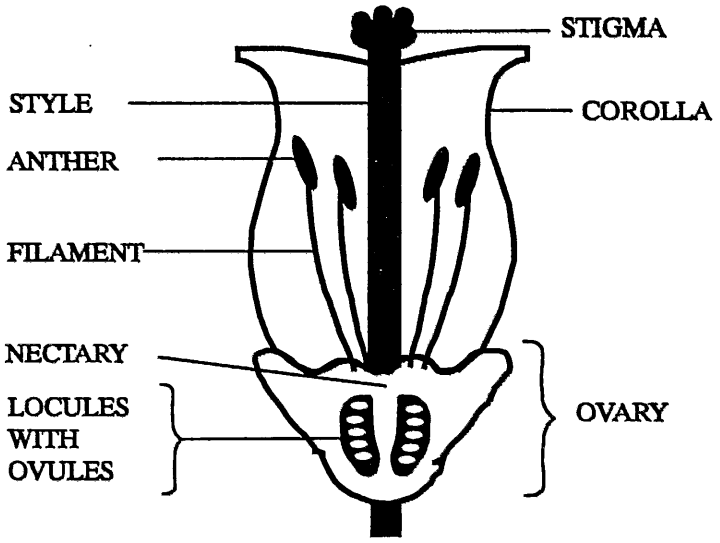


Figure 1

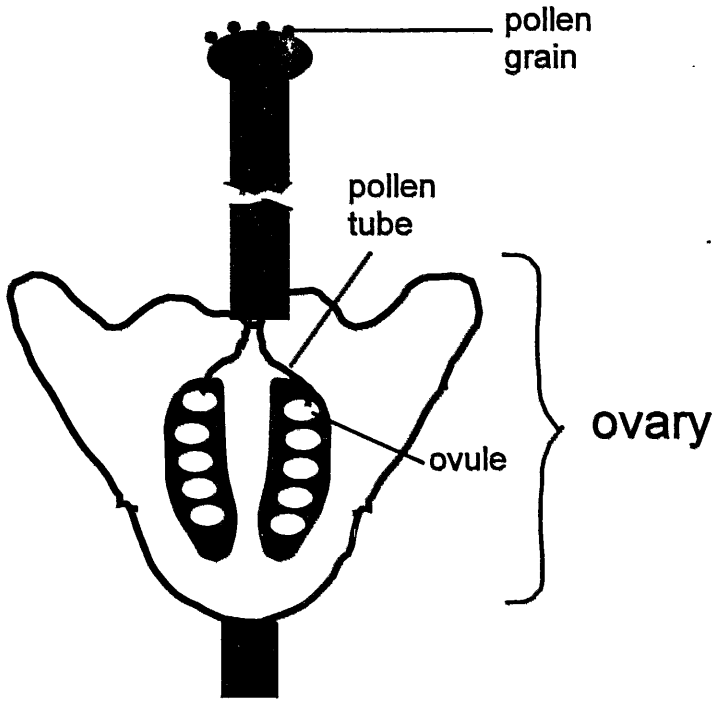


FIGURE 2

that may help achieve these functions include: sugars, nutrients such as B or calcium (Ca), and other organic compounds such as polyamines. Polyamines are thought to have growth regulator properties. Putrescine is a polyamine that has been naturally found in pollen and, following pollination, the polyamine content of sexual tissues is known to increase dramatically.

In the ovary, fertilization of the ovules by the male gametes of the pollen takes place (fig. 2) and seed development begins. Larger berries may be produced due to more seed development within the fruit. The period of ovule receptivity has been extended in pear and other crops when putrescine has been sprayed on the flowers. Boron concentration has also been raised in putrescine treated flowers of other crops.

Polyamines are naturally found in the stigmatic exudate where pollen is deposited by insects. Polyamines have also been shown to promote pollen germination, pollen-tube elongation and receptivity of the ovule to fertilization. The polyamine putrescine increased fruit set and yield of "comice" pear and apple. Work with pears indicated that the effective pollination period was extended by putrescine treatment.

Therefore, it is possible that spraying wild blueberry blossoms with putrescine could improve fruit set, yield and even increase the second crop yield by stimulating flower bud formation during the crop year.

METHODS: Twelve clones in a commercial wild blueberry field located in T32 MD (Sunkhaze Blueberry Farm) were used in this study. Twenty five clones were sampled in July 1995 to enable selection of clones which have low leaf boron concentrations (< 24 ppm). Clones of *V. angustifolium* Ait. (sweet low or nigrum) about 16 ft in diameter, showing little evidence of other clones growing into them, were selected.

Six pairs of 2ft x 4ft treatment plots were established in each of 12 selected clones, providing 6 within-clone replications. A boron plus putrescine treatment plot was paired with an adjacent control plot (Fig 3). Plots received foliar application (to drip) of a boron solution on September 19, 1995. Putrescine was applied during bloom in May

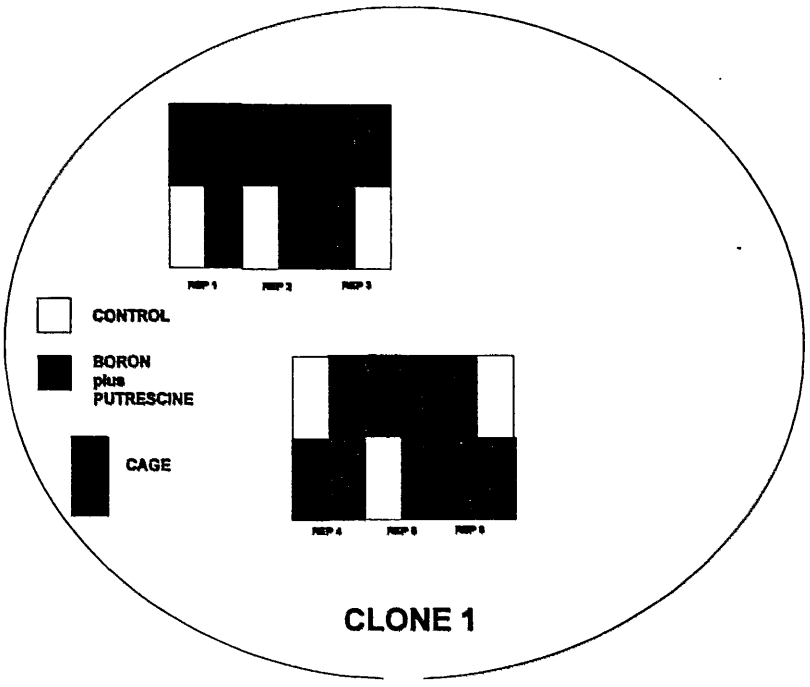


Figure 3

1996. A wooden shield was used to prevent spray drift between plots. A hand held, pump-up 2.5 gallon sprayer applied the boron and putrescine. To simulate poor pollination weather, half of each treatment plot was caged (see Fig 3) to prevent pollination by insects during the first half of the pollination period. Then the cages were removed to allow pollination. The unaged halves were compared to each other to determine the effect of B+putrescine on fruit set and yield during "good pollination conditions" and the caged halves were compared to each other to determine the effects under "poor pollination conditions".

Therefore, the treatments were:

1. Control (no treatment), unaged
2. Control (no treatment), caged
3. 400 ppm boron plus 10^{-6} M putrescine, unaged
4. 400 ppm boron plus 10^{-6} M putrescine, caged

To verify that a higher level of boron has been achieved, twenty stems were sampled from each treatment plot in November 1996. The top 2 inches of stem tissue (including flower buds) were dried, ground and analyzed for boron. Fruit set will be determined for each treatment plot by counting blossoms on 20, randomly tagged stems in the spring and berries on the same stems from frozen material. Fruit characteristics such as color, size and weight will be determined later on frozen the samples.

RESULTS: Stem tissue from boron treated plots contained 25.3 ppm compared to 18.6 ppm from the controls, verifying entry of boron. Other data are in various stages of analysis and interpretation.

CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can be made at this time.

E. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Scott Dunham, Crop Technician
Walter Litten, Faculty Associate

2. 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 it's pH adjusted toward the optimum pH 4.8 as 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 a high soil pH values (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 one of the treatment plots within each clone was treated 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 pH difference between the expected, based on previous samples, and those taken more recently troubled us. Soil samples taken in July 1993 as part of a phosphorus study indicated 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 samples were lower when sampled in October 1994 than in July when the ICM samples were taken. 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 spatial variability of 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

quadrates. The non-destructive counts will be made each prune cycle. 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 will be determined in August 1996, which will be repeated in 1998 and 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 sizable 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 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. Mn values not significantly different at 10% level.

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	4.8	328	58	69	18	315	0.1	13	34	1.8
3	4.8	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	4.8	294	51	53	19	322	0.08	15	37	2.2
7	4.8	197	47	39	18	344	0.09	13	27	1.3
8	4.7	276	51	58	18	257	0.1	12	36	1.9

Concentrations in mg/kg. Only values for Mg and P were significantly different among clones at 10% level.

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.

How did the pH vary over the growing season? Figure 5 illustrates the change in pH found during the growing season and reinforces the need to be consistent in the time that soil samples are taken. The current recommendations are that soil samples be taken at 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 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. No pH differences were found between the control and treatment plots in the NO 14 TWP field, while only a drop of 0.1 pH unit was found in the treatment plots at the Lamoine field. 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. Stems cut from randomly selected sub plots (destructive samples) for stem length and fruit bud counts also showed no difference between control and treatment plots. The average stem height ranged from 10 to 17 cm 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, stem average stem height ranged from 8.5 to 13 cm 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. This may explain why

the average yield recorded from these plots in 1994 was about 2000 lb/acre higher in NO 14 TWP field. These base line data will be valuable in assessing the effects of future soil pH changes.

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

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

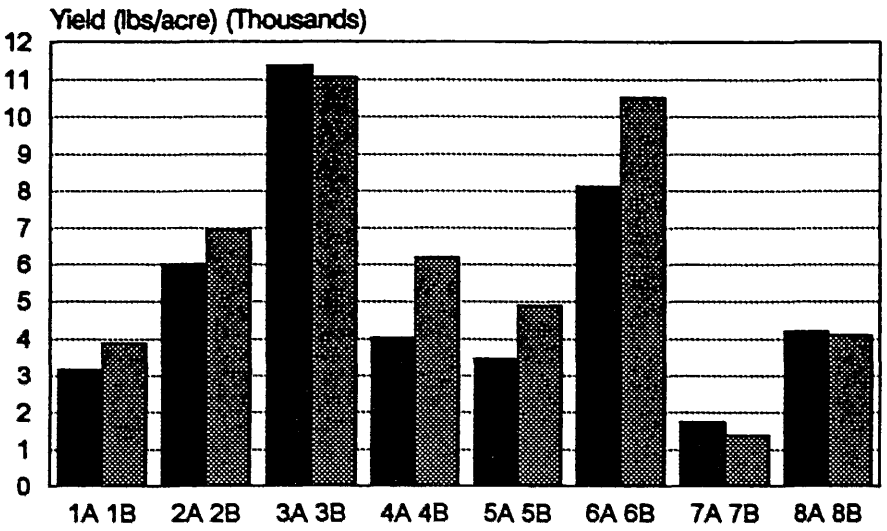
CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can made at this time.

Figure 1

YIELD DATA COMPARSION OF TREATMENT PLOTS

Lamoine

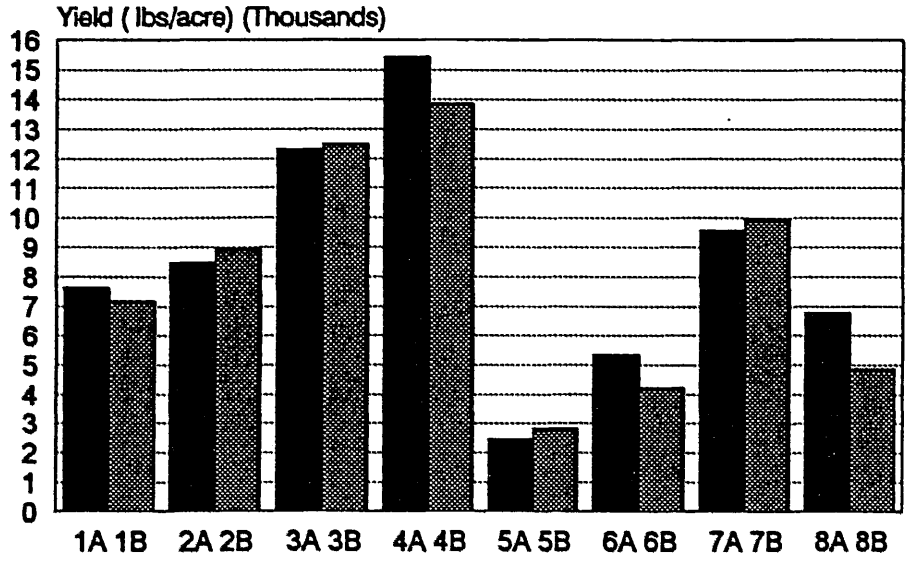


1994

Figure 2

YIELD DATA COMPARSION OF TREATMENT PLOTS

NO 14 TWP



1994

Figure 3

VARIATION OF pH AMONG CLONES

LAMOINE

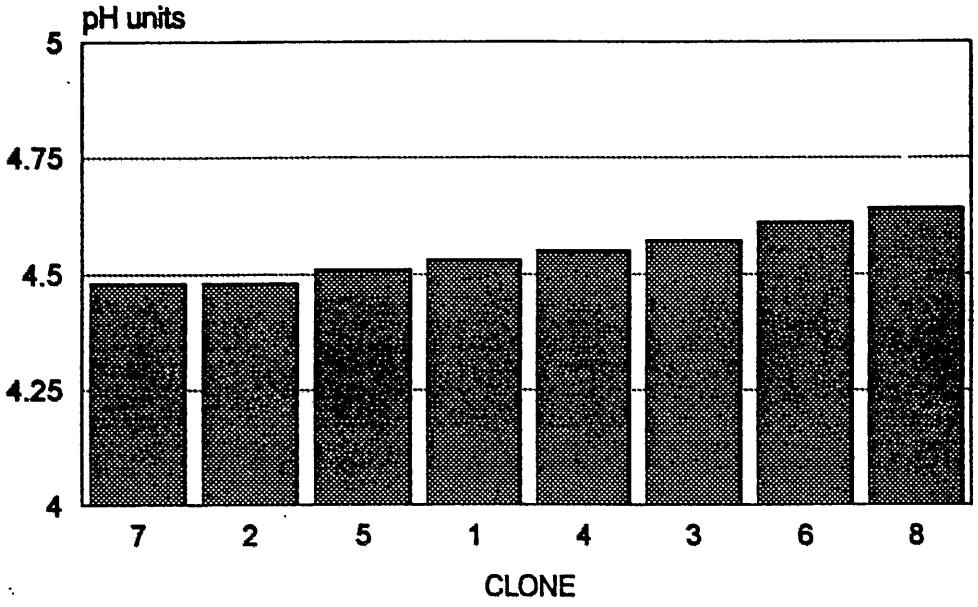


Figure 4

VARIATION OF pH AMONG CLONES

NO 14 TWP

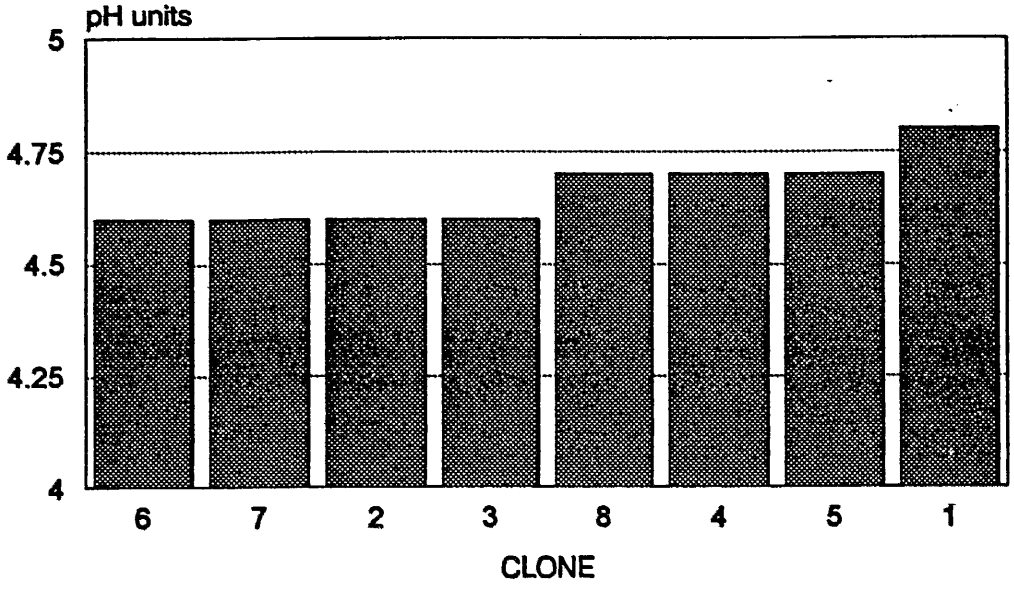


Figure 5

CHANGE IN pH DURING GROWING SEASON

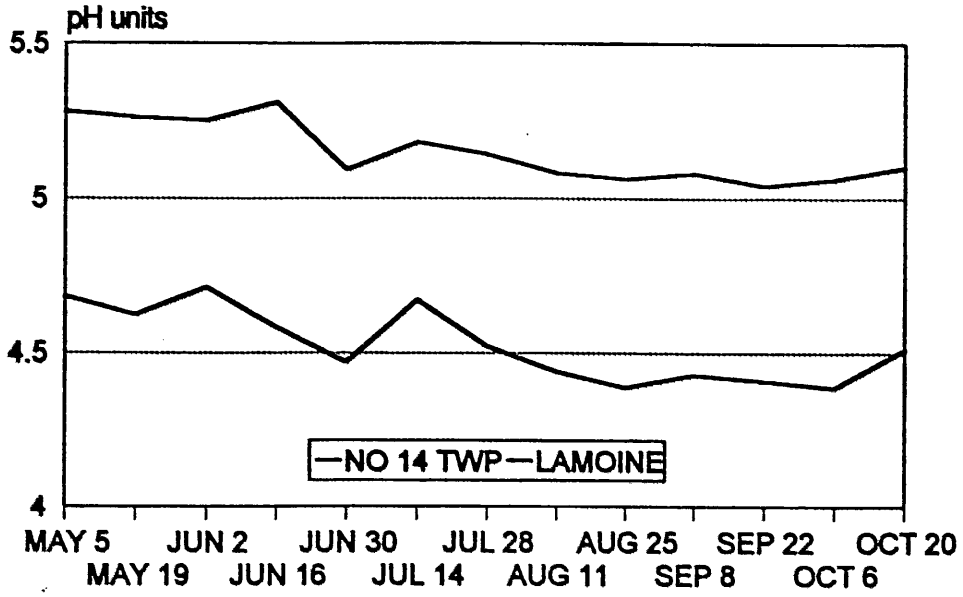
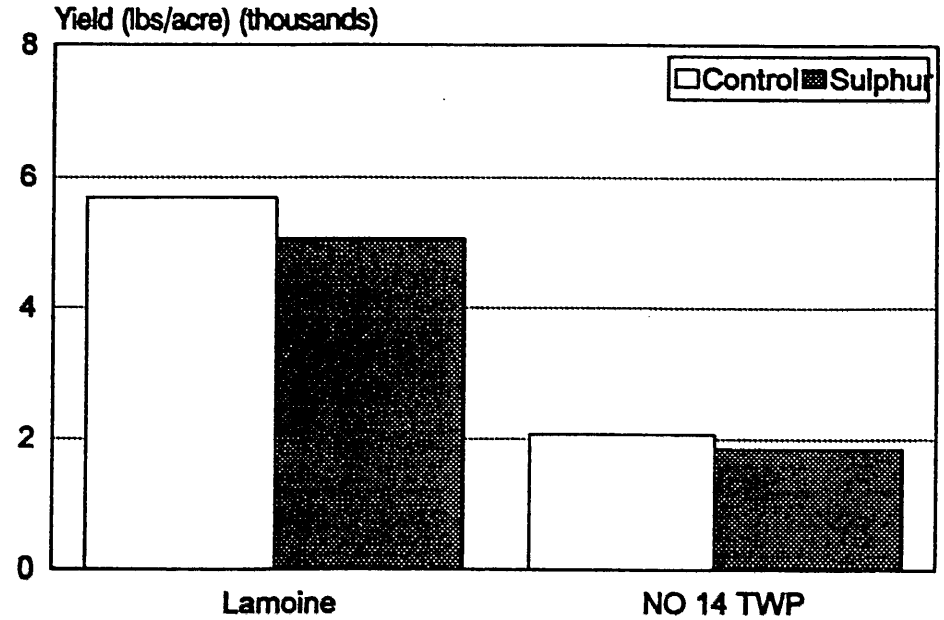


Figure 6

1996 Yield

Average Yield at Lamoine and NO 14 TWP



No significant difference between treatments at either location

E. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Scott Dunham, Crop Technician

3. TITLE: Phosphorus uptake

OBJECTIVES: To compare leaf tissue nutrient concentrations with stem and leaf tissue nutrient content for evaluating nutritional response of wild blueberries to fertilizers.

BRIEF JUSTIFICATION:

In previous studies, phosphorus fertilization has resulted in taller stems and may have also produced larger leaves or a greater number of leaves. Phosphorus uptake may be improved by fertilization but be masked by a dilution of the nutrient in the larger leaves resulting in only a small increase in P concentration or no increase at all. Measuring tissue content (concentration x dry wt) instead of concentration will indicate if this is happening.

METHODS: Treatment plots in a P/N ratio study were used in this investigation. Response to the treatments described below were assessed by taking all stems in three, 1/3 ft^2 quadrates per treatment plot. Plant biomass was determined by weighing all above ground tissue in each quadrate after it had been dried. Tissues were ground and analyzed for nutrient concentrations. Nutrient content of stem and leaf tissue were determined by multiplying concentration by dry wt and then correlated to leaf tissue nutrient concentration. Correlations were made between nutrient content and stem length, flower buds/stem, flower bud density and 1996 yield.

TREATMENT SUMMARY

1. control - no fertilization
2. phosphorus (60 lb P/acre) using triple superphosphate
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)).

RESULTS:

Phosphorus

Phosphorus leaf nutrient concentrations and contents showed similar response patterns to applications of TSP, MAP, and DAP; MAP and DAP were more effective in raising P concentration and content than TSP, compared to the controls (Tables 1 & 2).

Table 1
Leaf nutrient concentrations as affected by treatment.

	P	N	K	Mg	Mn	Zn
Control	.099 c	1.37 b	.462 b	.183 a	708 a	10.3 a
60 lb P/acre TSP	.108 b	1.38 b	.472 b	.183 a	723 a	10.4 a
60 lb P/acre MAP	.117 a	1.47 a	.492 a	.175 b	716 a	10.1 a
60 lb P/acre DAP	.116 a	1.49 a	.475 b	.169 c	714 a	10.1 a

Values within columns separated by Duncan's multiple range test, 5% level.

Table 2
Leaf nutrient contents (concentration x weight) as affected by treatment.

	P	N	K	Mg	Mn	Zn
Control	.31 b	4.24 b	1.43 b	.56 bc	2211 bc	31.7 b
60 lb P/acre TSP	.33 b	4.24 b	1.43 b	.55 c	2173 c	31.0 b
60 lb P/acre MAP	.41 a	5.12 a	1.69 a	.62 a	2421 ab	35.1 a
60 lb P/acre DAP	.42 a	5.36 a	1.70 a	.61 ab	2475 a	35.7 a

Values within columns separated by Duncan's multiple range test, 5% level.

Stem nutrient concentrations and contents also indicated that P was taken into blueberry stems more effectively when applied as MAP or DAP compared to TSP (Tables 3 & 4). Evaluation by concentration and content showed similar results.

Table 3
Stem nutrient concentrations as affected by treatment.

	P(%)	N(%)	K(%)	Mg(%)	Mn(ppm)	Zn(ppm)
Control	.095 c	.752 c	.390 b	.077 a	779 a	40.7 a
60 lb P/acre TSP	.109 b	.748 c	.392 b	.076 a	807 a	39.4 a
60 lb P/acre MAP	.117 a	.789 b	.424 a	.078 a	784 a	39.3 a
60 lb P/acre DAP	.119 a	.828 a	.425 a	.078 a	768 a	39.7 a

Values within columns separated by Duncan's multiple range test, 5% level.

Table 4
Stem nutrient contents (concentration x weight) as affected by treatment.

	P	N	K	Mg	Mn	Zn
Control	.147 b	1.17 b	.600 b	.118 ab	1215 a	61.8 a
60 lb P/acre TSP	.157 b	1.08 b	.568 b	.108 b	1176 a	55.7 a
60 lb P/acre MAP	.180 a	1.22 ab	.649 ab	.122 ab	1217 a	60.9 a
60 lb P/acre DAP	.197 a	1.36 a	.703 a	.128 a	1238 a	63.6 a

Values within columns separated by Duncan's multiple range test, 5% level.

Nitrogen

DAP was more effective than MAP in raising leaf N concentration but not content (Tables 1 & 2). However, both the N concentration and content of stem tissue was greater in samples taken from plots treated with DAP compared to MAP (Tables 3 & 4).

Other nutrients

Although TSP, MAP, and DAP contain only P or P and N, other nutrients were affected by these treatments. Leaf potassium (K) concentration and content was increased by MAP and DAP but not TSP (Tables 2 & 3). Leaf magnesium (Mg) concentrations were lowered by MAP and DAP but leaf magnesium content increased. This may indicate a dilution effect resulting from the effect of these treatments on growth.

Growth Measurements

The average dry weight of stem tissue was not affected by treatments but the average dry weight of leaves produced on stems cut from within three, 1/3 ft^2s quadrates per treatment plot increased due to MAP and DAP (Table 5). Biomass of aerial plant parts was increased by DAP, compared to the control.

Table 5
Treatment effect on weight of leaves and stems - all locations

	Dry weight of leaves (grams)	Dry weight of stems (grams)	Plant Biomass (grams)
Control	3.09 b	1.55 a	4.63 bc
60 lb P/acre (TSP)	3.05 b	1.44 a	4.49 c
60 lb P/acre (MAP)	3.51 a	1.54 a	5.05 ab
60 lb P/acre (DAP)	3.59 a	1.64 a	5.23 a

Values within columns separated by Duncan's multiple range test, 5% level.

To substantiate that larger or more leaves were produced on stems in plots receiving fertilizer containing both N and P requires further study.

No meaningful correlations were found between nutrient content and stem length, flower buds/stem, flower bud density or the 1996 yield.

CONCLUSIONS: Evaluation of wild blueberry nutritional status using leaf nutrient concentrations is valid.

RECOMMENDATIONS: Continue to encourage growers to base their fertilizer needs on the nutrient concentrations of leaf tissue samples collected at the tip-dieback stage of development.

E. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Scott Dunham, Crop Technician

4. TITLE: Correcting boron deficiency

OBJECTIVES: To determine the effect of boron foliar applications on wild blueberry leaf boron concentrations.

METHODS: Two locations that had a previous history of low leaf boron concentrations were used in this study. Three, 5 ft x 200 ft treatment plots were replicated 10 times at each of these locations in a Randomized Complete Block Design. A 200 ft plot was used to cover a large number of clones. Boron (Solubor®) was applied as a foliar spray in June 1996 at 0, .05, or 0.1 kg/ha^{-1}. Leaf samples were taken the first week of July (at 90% tip dieback) to determine the effectiveness of spring foliar boron sprays in raising leaf boron concentrations.

RESULTS: At both locations, spring foliar boron sprays increased leaf boron concentrations (Table 1). However, concentrations did not reach the standard (24 ppm) established by Trevett in 1972. To reach this standard, concentrations higher than 0.1 kg/ha^{-1} will probably be necessary. As illustrated in Figure 1, the trend drawn from data points generated in this study suggest that the boron rate would have to be in the range of 0.25 kg/ha to raise concentrations to about 24 ppm.

Table 1
Boron concentrations as affected by treatment

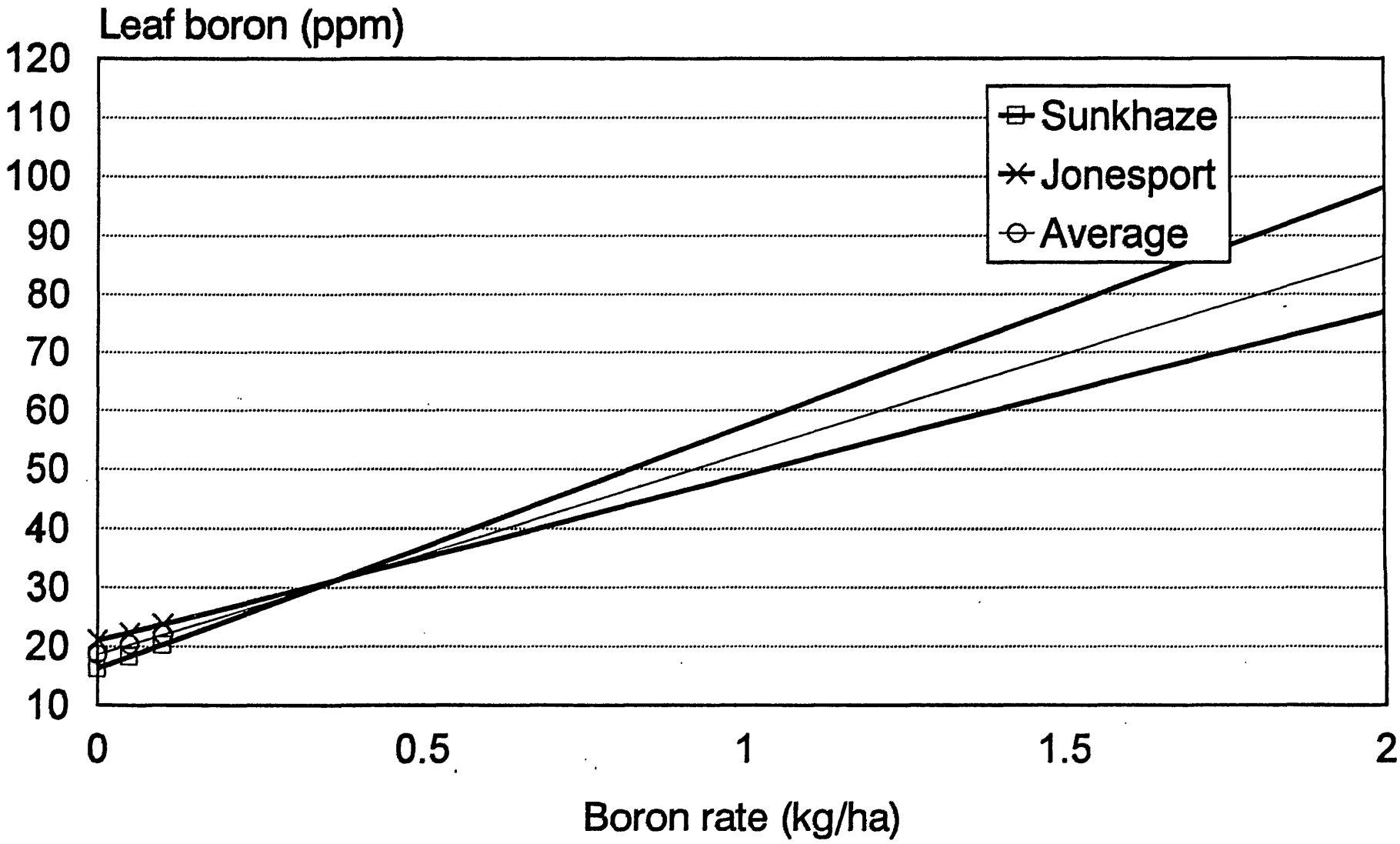
	Location 1	Location 2	Average of both locations
Control	16.2 c	21.0 c	18.6 c
.05 kg B/ha	18.3 b	22.3 b	20.3 b
.10 kg B/ha	20.3 a	23.8 a	22.0 a

Values within columns separated by Duncan's multiple range test at 5% level.

CONCLUSIONS: Spring foliar boron sprays using Solubor® are effective in raising leaf boron concentrations in wild blueberry leaves. Higher boron rates should be tested to identify the proper rate to increase leaf boron concentrations to the standard concentration.

RECOMMENDATIONS: Continue to study correction of wild blueberry boron deficiency comparing soil and foliar applications. Establishing the critical, high level to document toxicity levels and symptoms on wild blueberry would be extremely important.

Figure 1



Rates used in 1996 study were 0, .045, and .09 lbs B/acre.

F. WEED CONTROL AND PRUNING

INVESTIGATOR: David E. Yarborough, Cooperative Extension blueberry specialist

COOPERATOR: John Jemison, Cooperative Extension water quality specialist

1. TITLE: Hexazinone groundwater survey

METHODS: Sixteen wells and five streams or ponds adjacent to or in wild blueberry fields in four counties were sampled in 1996 at 0, 1, 2, 3, 4 and 5 months after hexazinone application. Five of the wells were test wells 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. In addition, surface water was sampled from seven ponds or streams adjacent to the well sites; the number associated with the surface sample corresponds to that of the well (Table 1). Fields may be grouped to hexazinone treatment: sites 4 and 11 received Velpar® L preemergence; sites 5, 13 and 23 received Velpar® L impregnated on diammonium phosphate (DAP) fertilizer; sites 7, 12 and 34 received Pronone® 10G applied in April; sites 29, 31, 32 and 33 received Pronone® 10G applied in June and site 9 was not treated. Residue analysis of the water was performed at the University of Maine Food Science & Human Nutrition Department with a high pressure liquid chromatograph which has a detection limit of 0.1 parts per billion (ppb). The objective of this study was to survey wells with different treatments to determine if the Best Management Practices (BMP's) followed reduced intrusion of hexazinone into groundwater.

RESULTS: Test well 9 continued to decrease from a previous high of 29 ppb in 1993 (Figure 1) to 8.9 ppb in October 1996 (Table 1). The liquid hexazinone/DAP treatments showed a trend of decreasing hexazinone in the early part of the summer but 2 of the 3 wells had an increase from August to October (Figure 2). Several wells in fields that received the granular hexazinone applications had an increase in hexazinone levels in August and two of the four wells had higher levels at the end of the season than at the beginning (Figure 3). Precipitation was very uneven in 1996; July and September had unusually high levels and August was well below normal (Figure 4). The reduced rates used on the liquid hexazinone treatments resulted in little change in groundwater levels but resulted in higher detection levels in the irrigation pond associated with well 11 (Table 1).

CONCLUSION: Hexazinone is a very soluble herbicide and, if used on sandy loam soils, it has a high potential to leach into groundwater. Use of best management practices may reduce the intrusion of hexazinone into groundwater. Excessive rainfall may result in some movement of the granular forms of hexazinone. Wells will be resampled in May, 1997 to determine if levels increase from the previous years application.

RECOMMENDATIONS: Continue to sample wells to obtain longer term information and expand

information on site history, well depth and distance from the field. Continue to vary management practices to determine how they influence hexazinone movement in wild blueberry soils. Set up site specific study to determine the effect of soil texture and formulation on leaching of hexazinone. Continue to emphasize best management practices to growers in educational programs and increase awareness of solubility of hexazinone and potential for well water contamination.

Table 1. 1996 Hexazinone Test Result Summary
University of Maine Well Water Survey
Hexazinone in parts per billion

Site #	May	June	July	August	September	October
WELLS						
4 drill	-	0.5	1.7	0.7	0.6	0.8
5 test	-	2.2	1.8	1.6	1.1	1.0
7 test	-	1.9	0.3	4.5	2.3	2.4
9 test	15.4	13.4	13.9	10.5	11.2	8.9
11 test	6.9	7.4	4.2	5.8	5.5	4.3
13 drill	2.2	1.8	0.3*	0.2	0.6	1.4
12 test	2.2	4.0	3.2	1.2	3.3	3.1
23 drill	2.3	1.9	2.3	0.3	1.3	1.5
25 drill	0.4	0.4	ND	0.7	0.3	ND
29 drill	0.6	0.5	0.8	4.0	0.4	0.5
31 drill	3.9	3.9	3.7	11.4	3.8	5.6
32 drill	9.7	7.8	6.5	ND	10.7	11.8
33 drill	0.2	2.7	ND	ND	ND	ND
34 drill	-	ND	0.1	ND	ND	-
SURFACE						
4 stream	-	1.0	2.7	1.3	1.3	1.4
4 lake	-	ND	0.6	ND	ND	ND
7 pond	-	13.2	ND	ND	ND	ND
11 pond	10.5	ND	ND	13	12	9
12 stream	3.9	-	3.5	ND	3.3	3.8
13 pond	0.3	3.8	ND	0.8	ND	ND
33 stream	0.3	ND	0.5	3.2	ND	ND

Liquid - 4,11 Liquid/DAP - 5,13,23 Granular/early - 7,12,34 Granular/late - 29,31,32,33, Untreated - 9

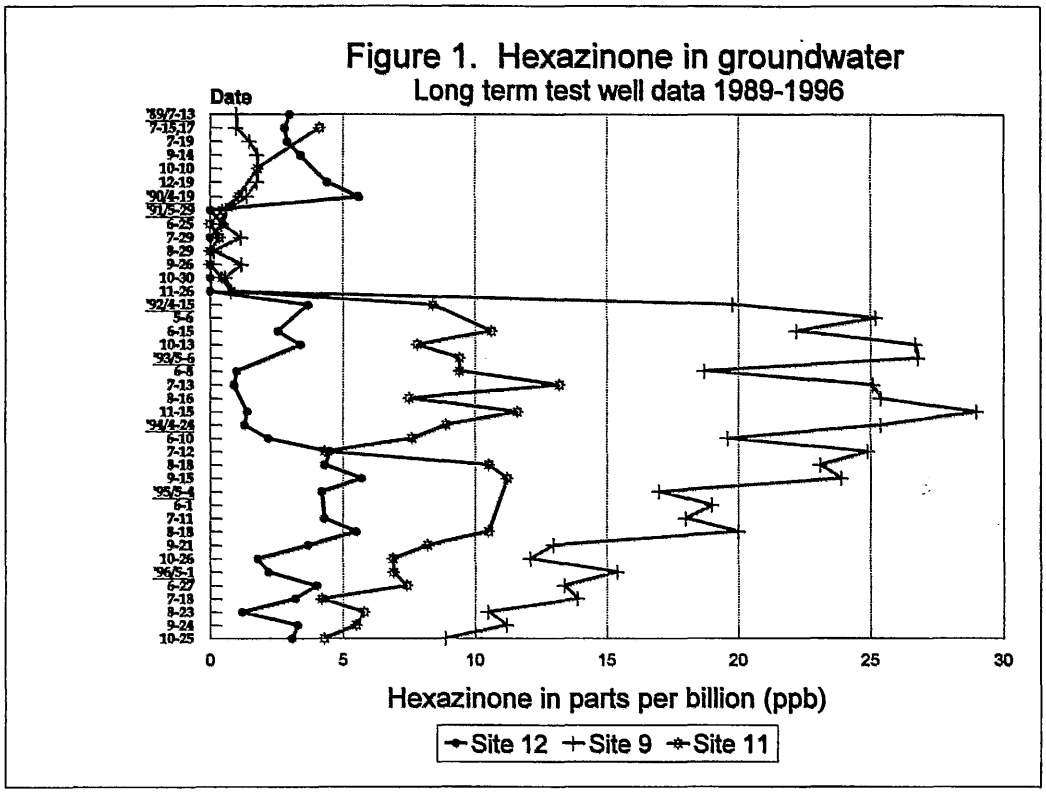


Figure 1. Hexazinone in groundwater
Long term test well data 1989-1996
Date
0
5
10
15
20
25
30
Hexazinone in parts per billion (ppb)
Site 12
Site 9
Site 11

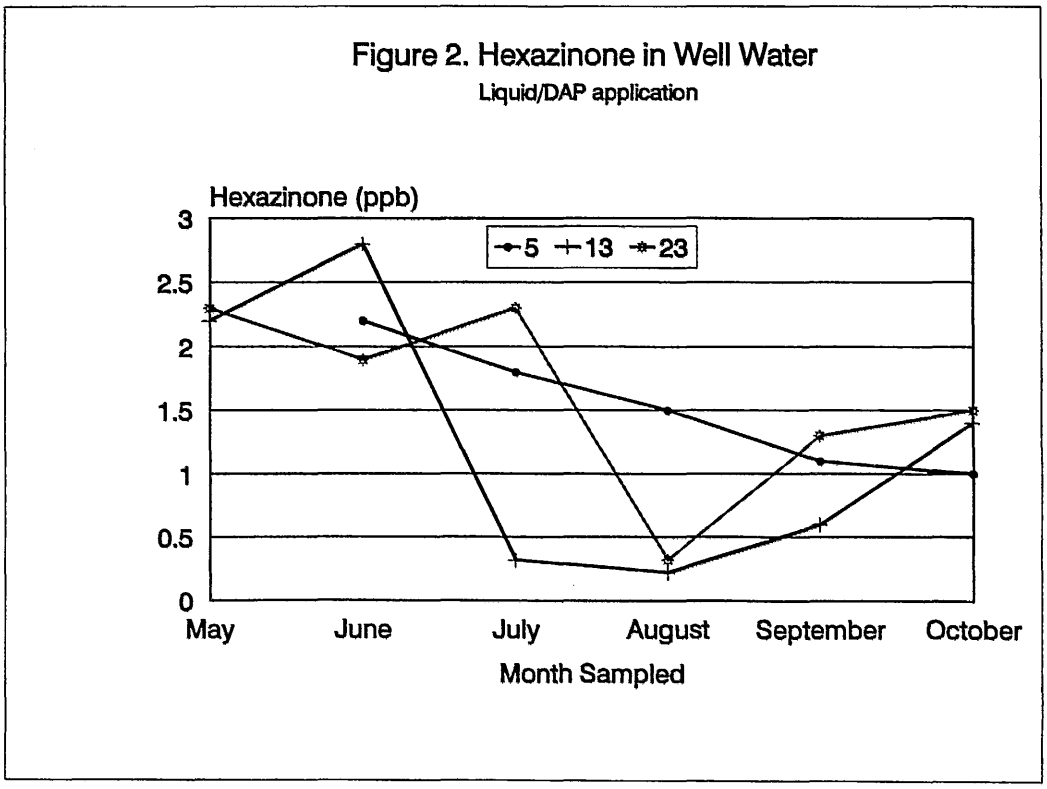


Figure 2. Hexazinone in Well Water
Liquid/DAP application
Hexazinone (ppb)
3
2.5
2
1.5
1
0.5
0
5
13
23
May
June
July
August
September
October
Month Sampled

Figure 3. Hexazinone in Well Water

Pronone 10G application

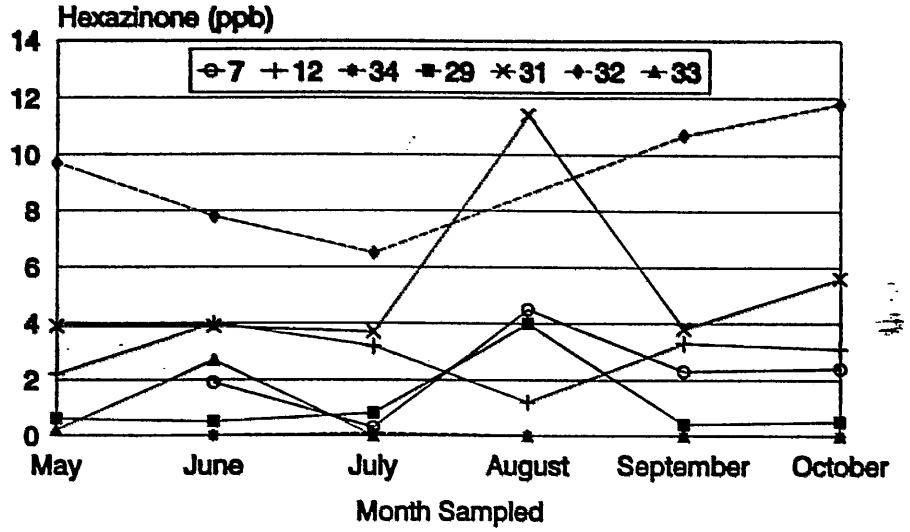
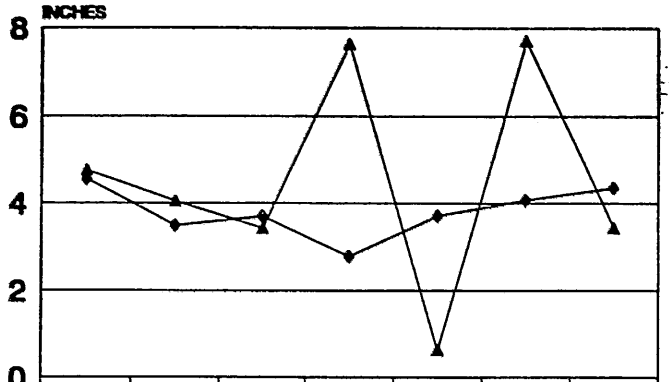


Figure 4. Precipitation
Blueberry Hill Farm



	April	May	June	July	Aug	Sep	Oct
4 Year Average	4.6	3.5	3.7	2.8	3.7	4.1	4.4
1996	4.8	4.1	3.4	7.6	0.6	7.7	3.5

F. WEED CONTROL AND PRUNING

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

2. TITLE: Effect of time of fall pruning on growth and productivity of wild blueberries..

METHODS: A plot at Blueberry HIll Farm, Jonesboro, ME was established and harvested on August 26, 1991 to provide pretreatment yield data. Pruning times in 1991, 1993 and 1995 were: late August, immediately after harvest; mid September, before frost; or late October, after frost. The randomized complete block experiment has 3 dates and 6 replications for a total of 18 plots. Plot size is 6 X 40 feet with two, 1 ft^2 subplots per plot. Stem samples were cut in October 1992, 1994 and 1996. Plots will again be pruned after harvest in 1997.

RESULTS: Pruning time has not significantly affected wild blueberry development or yield in this study.

CONCLUSION: No conclusion can be made until 1997 harvest.

RECOMMENDATIONS: Continue with experiment through harvest in 1997.

F. WEED CONTROL AND PRUNING

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

3. TITLE: Evaluation of Pronone® spot treatments for control of St. Johnswort, dogbane, bracken fern, witch grass/fall panicum and bunchberry.

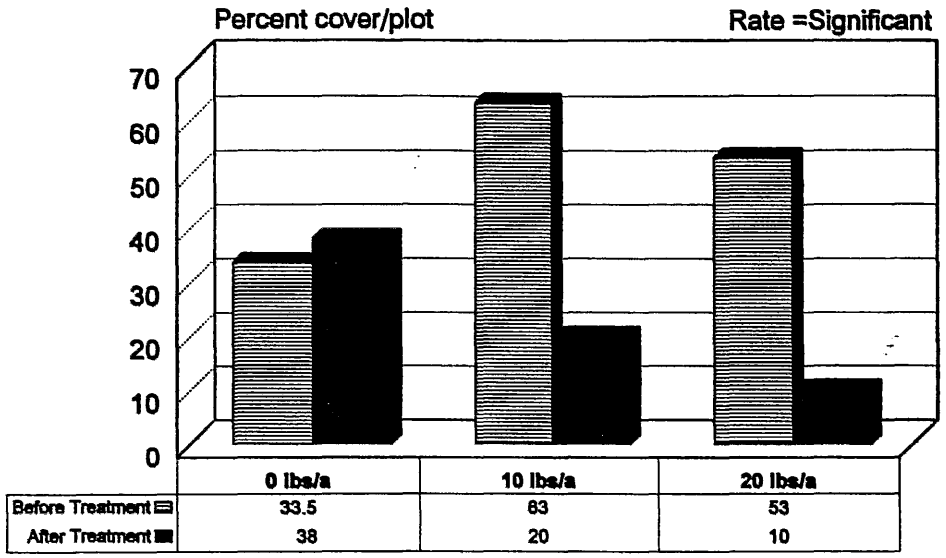
METHODS: For each weed species resistant to hexazinone applications, ten, one yard^2 plots were established and treated with either 0, 10 or 20 lbs/a Pronone® (30 plots per species for a total of 150 plots). Treatment dates were: 6-27-96 for St. Johnswort, bunchberry and bracken fern and 7-12-96 for dogbane and witch grass/fall panicum. Cover was evaluated on 7-25 and 9-17-96. Weed and blueberry cover will be assessed in June 1997.

RESULTS: Dogbane and bracken fern were controlled at both rates of Pronone® with the 20 lbs/a rate being most effective (Figures 1 and 5). St. Johnswort, witch grass/fall panicum and bunchberry was unaffected by either rate (Figures 2, 3 and 4). Heavy rainfall after treatment dates, including over 3" of rainfall on 7-13-96, may have influenced hexazinone movement and effectiveness.

CONCLUSIONS: Carryover effects need to be conducted in June 1997 before any conclusions can be made.

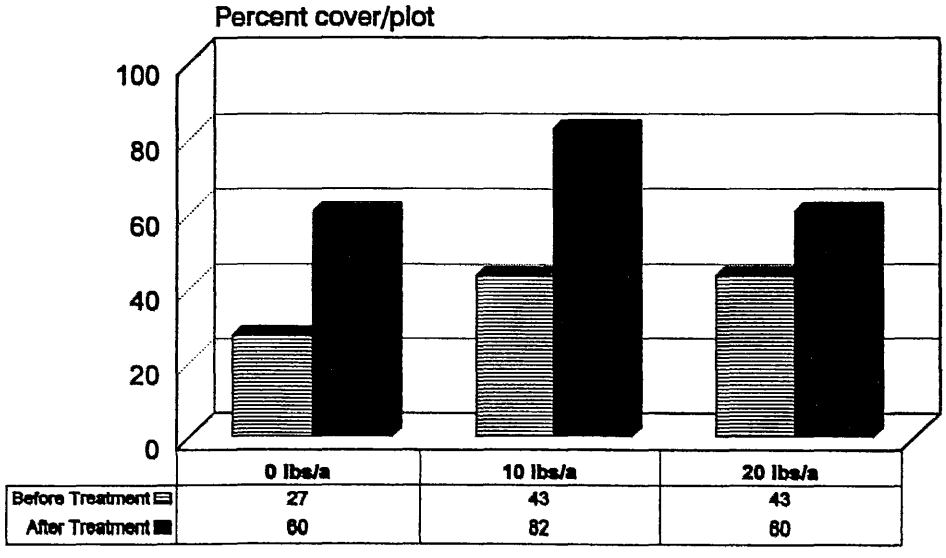
RECOMMENDATIONS: Continue project until carryover effects are evaluated.

Figure 1. Effect of Postmergent Pronone 10MG on Bracken Fern



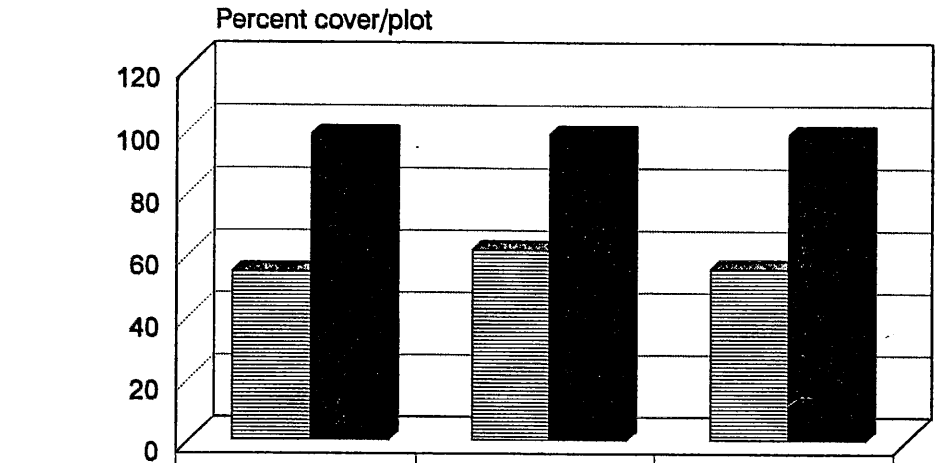
	0 lbs/a	10 lbs/a	20 lbs/a
Before Treatment	33.5	63	53
After Treatment	38	20	10

Figure 2. Effect of Postmergent Pronone 10MG on St. Johnswort



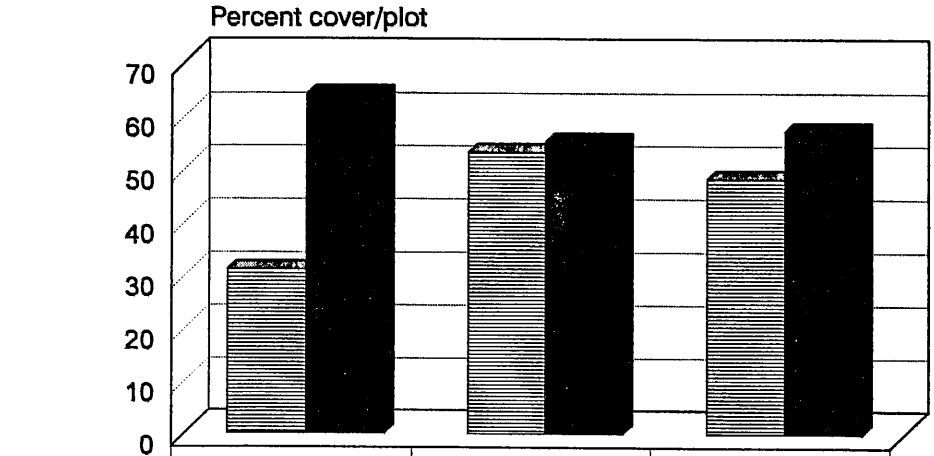
	0 lbs/a	10 lbs/a	20 lbs/a
Before Treatment	27	43	43
After Treatment	60	82	60

Figure 3. Effect of Postmergent Pronone 10MG on Fall panicum/witch grass



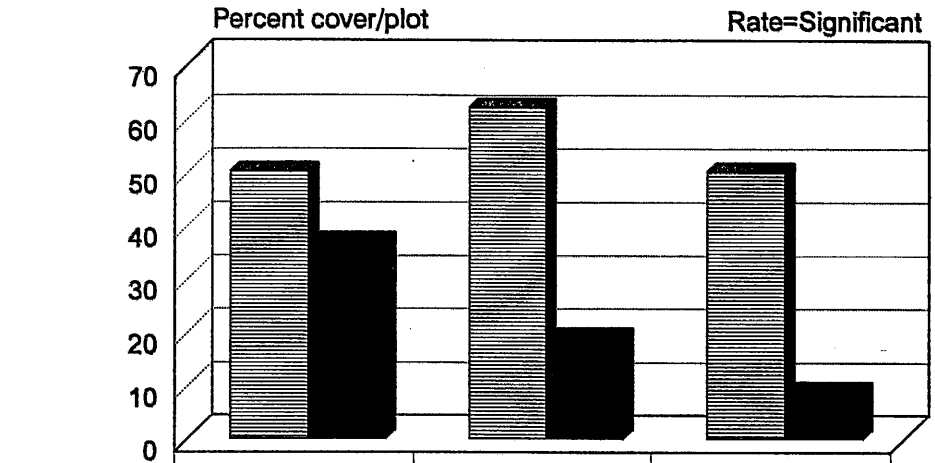
	0 lbs/a	10 lbs/a	20 lbs/a
Before Treatment	54	61	55
After Treatment	98	98	98

Figure 4. Effect of Postmergent Pronone 10MG on Bunchberry



	0 lbs/a	10 lbs/a	20 lbs/a
Before Treatment	31	53	48
After Treatment	64	55	57

Figure 5. Effect of Postmergent Pronone 10 MG on Dogbane



	0 lbs/a	10 lbs/a	20 lbs/a
Before Treatment	50	62	50
After Treatment	37	19	9

F. WEED CONTROL AND PRUNING

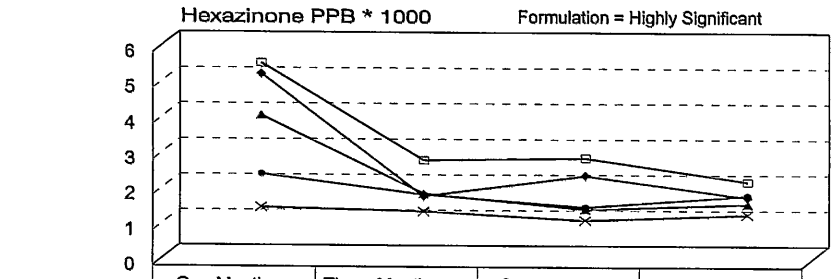
INVESTIGATORS: David E. Yarborough, Associate Professor of Horticulture
Timothy M. Hess, Research Associate
Brian Perkins, Research Scientist

4. TITLE: Effect of hexazinone formulation on movement through the soil profile.

METHODS: A randomized complete block design trial to study the effect of hexazinone formulation on soil movement and weed control was established and treated with one lb ai/a Velpar® L, Pronone® 10G, Pronone® 10MG, Velpar/DAP or left untreated May 25, 1995. Each treatment also received 200 lbs/a diammonium phosphate (DAP). Plot size was 10 X 20 ft with 10 ft alleyways, 3 blocks and 5 treatments for a total of 15 plots. Soil was sampled on 6-25-95, 8-25-95, 11-25-95 and 5-24-96 one, three, six months and one year post treatment, from 0-2", 2-6" and 6-10". Carryover effects to wild blueberries and weeds was evaluated in mid June 1996.

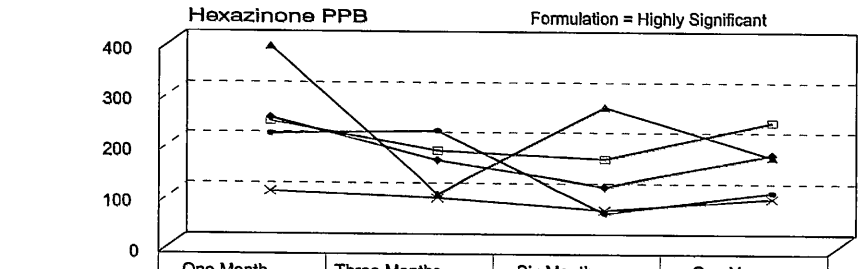
RESULTS: The Velpar/DAP formulation had the highest concentration over time at the 0-2" (0-5 cm) depth and the untreated control had the lowest (Figure 1). One year after application the Velpar/DAP formulation had the highest concentration of hexazinone at the 2-6" (5-15 cm) depth (Figure 2) followed by the Pronone® formulations. A similar fluctuation occurred at the 6-10" (15-25 cm) depth with Velpar/DAP, Pronone® 10G and Pronone® 10MG formulation retained in the soil at higher concentrations (Figure 3). Most of the hexazinone was retained at the 0-2" (0-5 cm) level one year later (Figure 4). Even though the untreated control did not receive any hexazinone treatment in 1995, hexazinone was still detectable from the treatment in May 1993 (Figure 4). Precipitation was well below normal for the summer of 1995 compared to the average (Figure 5).

Figure 1. Effect of Velpar Formulation on Hexazinone Movement through the Soil Profile at 0-2 inches



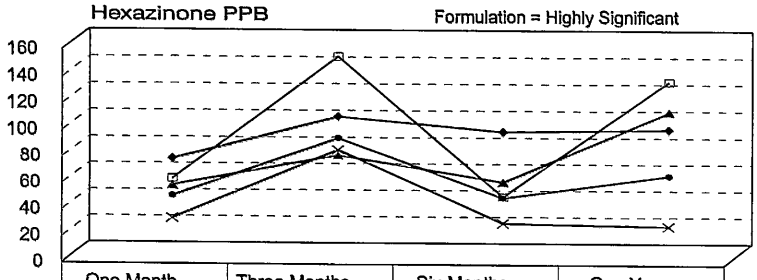
	One Month	Three Months	Six Months	One Year
Velpar L	2	1.423	1.083	1.41
Pronone 10G	4.812	1.383	1.966	1.35
Pronone 10MG	3.656	1.45	1.019	1.173
Velpar/Dap	5.126	2.4	2.466	1.8
Untreated	1.069	0.954	0.716	0.88

Figure 2. Effect of Velpar Formulation on Hexazinone Movement through the Soil Profile at 2-6 inches



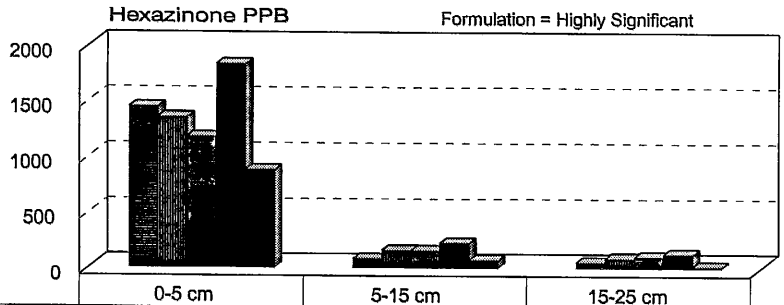
	One Month	Three Months	Six Months	One Year
Velpar L	198	202	41	82
Pronone 10G	228	144	93	156
Pronone 10MG	370	78	250	151
Velpar/Dap	221	163	147	220
Untreated	84	71	47	70

Figure 3. Effect of Velpar Formulation on Hexazinone Movement through the Soil Profile at 6-10 inches



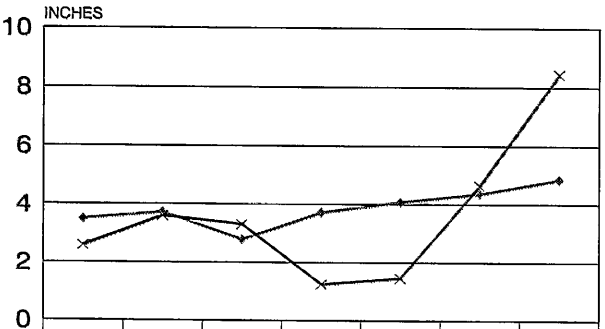
	One Month	Three Months	Six Months	One Year
Velpar L	35	79	34	51
Pronone 10G	63	95	84	86
Pronone 10MG	43	66	46	99
Velpar/Dap	48	140	35	122
Untreated	18	70	15	13

Figure 4. Comparison of Formulation on Hexazinone Movement After One Year



	0-5 cm	5-15 cm	15-25 cm
Velpar L	1443	82	51
Pronone 10G	1350	157	86
Pronone 10MG	1173	152	99
Velpar/DAP	1833	220	122
UTC	880	70	13

Figure 5. Precipitation
Blueberry Hill Farm



	May	June	July	Aug	Sep	Oct	Nov
1995	2.6	3.6	3.3	1.2	1.5	4.6	8.4
4 Year Average	3.5	3.7	2.8	3.7	4.1	4.4	4.8

CONCLUSION: If hexazinone leaching and groundwater is a concern at a particular site, this research indicates the Velpar/DAP formulations of hexazinone is retained in the soil profile the longest and will thus, be least likely to leach into groundwater, followed by Pronone® formulations. Velpar® L was the most likely to leach out of all soil horizons.

RECOMMENDATIONS: This experiment should be reevaluated with the Velpar® DF formulation with irrigation to insure there is adequate moisture to move the hexazinone through the soil profile.

F. WEED CONTROL AND PRUNING

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

5. TITLE: Effect of plant source and density on spread of wild blueberry.

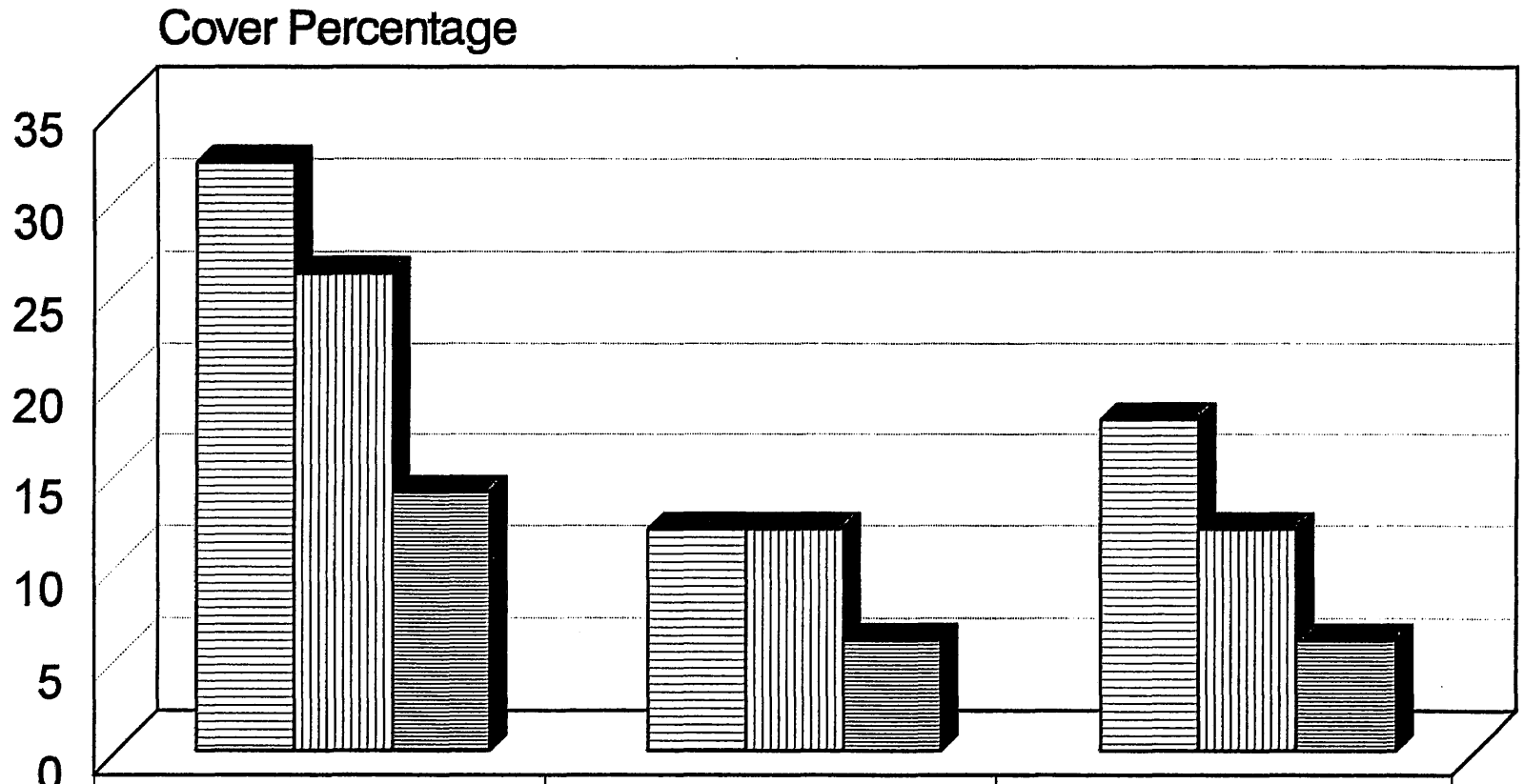
METHODS: A randomized, complete block design trial was established on June 13, 1996 and spread with 6" of bark mulch. Each 0.6 by 3m plot had three different plant sources (tissue culture, sod plug or seedling) planted at 4 different spacings (0, 0.25, 0.5 or 1m) and replicated 4 times for a total of 48 plots. Plant spread will be assessed each September until 2002. In addition, each block was established on the edge of an existing clone so the effect of no treatment and clonal spread alone will also be able to be tabulated.

RESULTS: After one growing season, tissue culture plants at the 0.25m spacing covered the most area with sod plugs at 0.5 and 1m spacing covering the least (Figure 1).

RECOMMENDATION: Continue evaluating each September until 2002.

CONCLUSION: No conclusions can be made at this time.

Figure 1. Percentage Blueberry Cover After First Season



	0.25 m	0.5m	1m
Tissue Culture	32	12	18
Seedling	26	12	12
Sod	14	6	6

1996 WILD BLUEBERRY TAX REPORTS

A. DISEASE CONTROL

INVESTIGATOR: David Lambert, Associate Professor of Plant Pathology

1. TITLE: Control of Wild Blueberry Diseases

Septoria Brown Spot

METHODS: A trial was established to confirm the effects of propiconazole (Orbit) on *Septoria* brown spot. Individual 2½ m x 3 m plots were replicate nine times. In three treatments, Orbit® 3.6 E at 6 oz/A, 30 gal/A, and 30 psi was applied with a 3-nozzle backpack sprayer on a standard 2 X schedule with sprays on May 7 and 22. In addition, sprays were applied on May 31 and June 13 in certain treatments. In one treatment, Captan® 50WP was applied at the 5 lb/A rate on the latter two dates. Each plot was photographed in mid-July, and the numbers of spots on twenty leaves per plot were counted and averaged.

RESULTS: Table 1. *Septoria* brown spot lesions as affected by number and timing of Orbit® applications. (6 oz/A, 30 gal/A, 30 psi)

Treatment	Spots/leaf	Yield-lb/plot
None	5.3 B§	6.9 A
Orbit® 2X - May 7, May 22	3.5 AB	-
Orbit® 2X + May 31	3.3 AB	-
Orbit® 2X + June 13	4.3 AB	7.9 A
Orbit® May 31 only	1.4 A	-
Orbit® June 13 only	3.7 AB	-
Captan® - May 31, June 13	5.0 AB	-
Combined Analysis		
Orbit® - May 31	2.4 A	
Orbit® - June 13	4.0 B	
Others	4.6 B	

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

CONCLUSIONS: The most effective period for brown spot control in 1996 was early June. This suggests that this is a peak period for fungal infection. Late application of Orbit®, which has some effect against the secondary (fruit infection) stage of *Monilinia,* also will reduce severity of brown spot. However, artificial inoculation with 10^6 and 10^9 *Septoria* spores/m^2 on 29 May (1996) at

Blueberry Hill under conditions favorable for disease did not result in substantial amounts of brown spot.

RECOMMENDATIONS: None at this time.

Stem Dieback

METHODS: Stems showing symptoms of dieback were collected from several locations (in 1994 and 1996), and fungi were isolated from the margins of discoloration in the woody stems.

RESULTS: *Phomopsis vaccinii* was found in a number of cases. This fungus was also found in blueberry fruit in a previous study. The fungus is sensitive to Orbit® by agar dish assay.

CONCLUSIONS: *Phomopsis vaccinii* is confirmed as a major cause of dieback and fruit rot on lowbush blueberry. When Orbit® is registered for *Monilinia* control, it may have some secondary value in reducing *Phomopsis.*

Field Sanitizer

METHODS Ten areas 6m X 7m in size were mowed with the sanitizer in the spring of 1995, and five were also heat sanitized. Mummies were counted immediately and again on May 22, 1996, and foliar disease was rated in June 1996.

RESULTS: Table 2. Effect of heat sanitation on mummy survival and blossom infection - 3rd trial, Montegail Pond.

Treatment	1994		1996		
	Mummies/m^2		Mummies/m^2		% Blossom Infection
	Whole	Broken	Germinated	Nongerminated	
Control	23.2 A§	0.0 A	0.0 A	32.5 B	11.4 A
Treated	31.1 A	3.9 B	0.1 A	10.7 A	10.7 A

§ Means in the same column followed by the same letter do not differ at P = 0.05

DISCUSSION: Sanitizer treatment reduced intact mummies from 33 to 11 per square meter, but did not substantially reduce blossom infection. Trials of the effectiveness of a gas-fired field sanitizer for control of mummy berry disease *(Monilinia vaccinii-corymbosi)* was consistent with previous experience.

CONCLUSIONS: The sanitizer is not likely to substantially reduce mummy berry disease, and is less effective in this regard than burning.

B. INSECT CONTROL

INVESTIGATORS: F. A. Drummond, Associate Professor of Applied Ecology and Environmental Sciences
J. A. Collins, Assistant Scientist

1. TITLE: Control of lowbush blueberry pest insects.

METHODS:

Field Trials:

Field trials were conducted to evaluate conventional and biorational controls for spanworm larvae (5/22, 5/27, 6/3), flea beetle larvae (6/6), red-striped fireworm larvae (8/19), and blueberry maggot (7/17, 7/24, 7/30). Effectiveness of materials against spanworm and flea beetle populations was measured by taking pre- and post-treatment sweep-net samples. In the control test on red-striped fireworm, populations were monitored by counting the number of infested stems in square foot samples. Evaluation of the effectiveness of insecticides against blueberry maggot was based on sampling ripening berries in selected areas and processing for maggots.

IR4 Residue Trial:

Treatments were applied (5/31, 6/12, 6/24) and residue samples collected (8/21) to aid in the registration of Cryolite®.

Evaluation of Sprayer Coverage:

A preliminary investigation of crop penetration and drift associated with two different application methods (airblast and conventional boom) was completed (8/23). Each sprayer was calibrated to simulate the gallons per acre typically used in lowbush blueberry production. Water and oil sensitive paper was used to monitor spray-droplet density at various distances from the sprayers. The two sprayers evaluated were:

Airblast: CIMA^{R} P55D Atomizer L.V. sprayer mounted on an Agco Allis^{R} 6670 tractor operating at 40 psi, driven at ca. 1.8 mph, and calibrated to deliver 20 gallons water-mixture per acre.

Boom: 13-ft boom equipped with eight, 80015LP TeeJet^{R} nozzles; 20-inch nozzle spacing; boom height = 2 ft; mounted on a Wheelhorse^{R} garden tractor driven at 2 mph and delivering 23.5 gallons of water-mixture per acre.

RESULTS:

Field Trials:

Secondary pest insects: Spanworm and flea beetle larvae were controlled very effectively using different formulations of Imidan® (phosmet). The unregistered pyrethroid Asana® (esfenvalerate) provided excellent control of spanworm; Marlate® (methoxychlor) was also effective. Mavrik® (tau-fluvalinate), another unregistered pyrethroid performed well against both spanworm and flea beetle. Cryolite® (an unregistered inorganic sodium aluminofluoride) worked well against

spanworm but not flea beetle. Tests with Javelin®, Able®, and Agree®, all formulations of *Bacillus thuringiensis*), were mixed and underscore the need to target small instars of blueberry spanworm to obtain effective control with these materials. M-Trak® (*B. thuringiensis san diego*) did not significantly reduce populations of flea beetle larvae.

Imidan®, Cryolite®, and Asana® all seemed to be effective in controlling red-striped fireworm larvae. Javelin®, Agree®, and neem, an unregistered novel botanical insecticide, were ineffective (Table 1).

Blueberry maggot control: Although the number of maggots found in processed fruit was generally low, some significant findings were obtained. Imidan®, Mavrik®, and neem + Nulure® significantly reduced the number of maggots found in fruit. The results with neem are very interesting since there are currently no biological materials registered for blueberry maggot control. Results obtained using Asana® 4.8 oz were mixed; at one site Asana® seemed to be effective, but at a second site there was no significant reduction in maggot numbers. The higher 9.6 oz rate of Asana® gave more consistent results. One application of Imidan® 70 WP did not significantly reduce population numbers (Table 2).

IR4 Residue Trial:

Although IR4 is continuing its projects, registration of new materials is essentially on hold until EPA and the chemical industry decide how to meet the requirements of the new Food Quality Protection Act recently passed by Congress. Lowbush blueberry registrations affected by this delay are: Asana®, Mavrik®, Cygon® (dimethoate), and Cryolite®.

Evaluation of Sprayer Coverage:

Airblast: According to the manufacturer, the maximum effective range of the model sprayer tested is between 75 and 100 ft. In the trial, the most complete coverage was observed on cards placed 5, 25, or 50 ft from the sprayer. There was a significant decline in droplet density between 50 and 100 ft among cards placed a) above the canopy, b) within the canopy, and c) cards pooled over both canopy heights. A comparison of droplet density between cards at the two canopy heights showed no significant difference at any distance from the sprayer (Table 3). This last finding is especially reassuring considering that the applications were made late in the season when foliage was at peak levels.

Boom: Cards located beneath the 13-ft length of the spray boom and directly within the coverage area were saturated with too many droplets to count. No significant drift was observed and there was no significant difference in droplet density between cards at the two canopy heights at any distance from the sprayer (Table 4).

CONCLUSIONS:

Field Trials:

Accurate identification of pests and monitoring of insect numbers and growth stage to determine the best times to spray are critical for achieving effective, economical control with any insecticide.

Evaluation of Sprayer Coverage:

Sprayers are important tools for nearly all growers. Boom and/or airblast sprayers are used to apply herbicides, insecticides, fungicides, fertilizers, and other materials. Underdosing (too little product) and overdosing (too much product) are common problems.

It is very easy to underdose when using airblast sprayers. With insecticides, underdosing might not kill the pest. Overdosing is a problem more commonly associated with boom sprayers. It has been suggested that the pattern observed from the boom sprayer, where cards placed within the coverage area of the boom were essentially saturated, represents overdosing which is a waste of product and which with herbicides may result in crop damage. Since proper selection, calibration, use, and maintenance of both airblast and boom sprayers are essential to maximize control with any material as well as for the protection of the environment, further investigation into this area of research is warranted.

RECOMMENDATIONS:

Recommendations for control of blueberry pest insects will remain essentially unchanged from 1996.

Table 1: Summary of Field Trials for Secondary Pest Insects.

Material	Classification	SW	FB	RSFW
Registered				
Imidan 2.5 EC	Phosphate	VG-E	VG-E	
Imidan 50 WP	Phosphate	VG-E		
Imidan 70 WP	Phosphate	VG-E	VG-E	G
Marlate 50 WP	Chlor. Hydro.	G		
Javelin WG	Bt	F		P
Agree 50 WP	Bt	P		P
Unregistered				
Able 50 WP	Bt	G		
Neem	Botanical			P
Asana .66 XL	Pyrethroid	VG-E		G
Mavrik 22% AF	Pyrethroid	G	VG-E	P
Cryolite 96% WDG	Inorg. fluorine	G	P	G
M-Trak	Bt		P	

Table 2: Summary of Field Trials for Blueberry Maggot.

Material	Rate	Applications	Maggot
Registered			
Imidan 2.5 EC	24 oz	2	G
Imidan 2.5 EC	48 oz	1	G
Imidan 2.5 EC	48 oz	2	G
Imidan 70 WP	23 oz	1	P
Unregistered			
Mavrik 22% AF	6 oz	2	G
Asana .66 XL	4.8 oz	2	?
Asana .66 XL	9.6 oz	2	G
Neem + Nulure	21 oz	2	G

P = not significantly different from control
F = Slightly, but not significantly, different from control
G = Significantly different from control
VG-E = Highly significantly different from control

Table 3: Evaluation of Airblast Sprayer; droplets per card.

Distance from sprayer (ft)	Avg. Droplets per 1/4 cm^2 Above canopy	Within canopy	Pooled	% Difference Above:Within
5	671.5	560.9	616.2	-16.5
25	577.8	404.0	490.9	-30.1
50	668.2	528.4	598.3	-20.9
100	79.1	101.7	90.4	+22.2
150	27.3	45.8	36.5	+40.4

Table 4: Evaluation of Boom Sprayer; droplets per card.

Distance from end of Boom (ft)	Avg. Droplets per cm^2 Above canopy	Within canopy	% Difference Above:Within
0	TNC	TNC[a]	-
5	3.3	3.2	-3.0
10	1.6	1.0	-37.5
20	0.4	0.5	+20.0

[a] TNC = Droplets too numerous to count.

B. INSECT CONTROL

INVESTIGATORS: F. A. Drummond, Associate Professor of Applied Ecology and Environmental Science
J. A. Collins, Assistant Scientist

2. TITLE: Biology and action thresholds of secondary blueberry pest insects.

METHODS:

Effects of Red-striped Fireworm Infestation: A preliminary study of the relationship between red-striped fireworm infestation (based on infested stems per sq ft) and yield was completed in 1996. Also, a final year of data was collected to evaluate the hypothesis that feeding by fireworm larvae increases the susceptibility of flower buds to winter injury.

Status of Secondary Pest Insects: Personal observation, grower, and scouting reports were used to gather information on the status of secondary pest insects in 1996.

RESULTS AND CONCLUSIONS::

Effects of Red-striped Fireworm Infestation: Analysis revealed no significant difference in mean numbers of flower buds between infested and uninfested stems. Although it has been reported by researchers in Canada that red-striped fireworm larvae reduce the number of flower buds on lowbush blueberry, this apparently is only an occasional occurrence in Maine. Currently, the major concern of larval fireworm infestations is their appearance on field machinery and processing lines during harvest.

Statistical analysis of the relationship between yield and previous infestation by red-striped fireworm was not significant (Tables 1 and 2). From the results of our study on infestation and yield, it would be premature to conclude that infestation by red-striped fireworm does not reduce yields under a wide range of infestation levels and growing conditions.

Clonal variations or other factors may have overshadowed infestation effects in both studies and must be taken into account in any future study.

Status of Secondary Pest Insects: Blueberry spanworm was abundant again in 1996. Commercial fields were closely monitored using sweep-net counts. Feeding damage was reported, and insecticides were used to control this insect in both pruned and crop fields. Adults were seen in large numbers in many areas in late June and early July. Growers may anticipate continuing problems for 1997. Blueberry sawfly and flea beetle were generally not a problem in 1996. One sawfly infestation was reported from South Paris and a few isolated flea beetle infestations were found in Washington Co. Red-striped fireworm populations decreased. First leaf-tying activity did not occur until early August. There was one report of an isolated outbreak of leaf beetle adults in Jonesboro.

Fact Sheets: Six fact sheets were developed in cooperation with the University of Maine Cooperative Extension. The guides, which illustrate life history and economic damage of blueberry spanworm, thrips, flea beetle, grasshoppers, strawberry rootworm, and leaf beetle were included in the 1996 update to the Lowbush Blueberry Growers Guide.

RECOMMENDATIONS:

Development and refinement of monitoring systems and action thresholds to make management of pests more ecologically and economically sound has been and should remain a continuing priority. Preliminary and tentative action thresholds based on sweep-net counts have been developed for spanworm, flea beetle, and sawfly in crop fields and will continue to be the basis for control recommendations. However, to be effective, action thresholds must incorporate economic costs and benefits. Conversion of existing action thresholds to economic thresholds and development of new economic thresholds will allow growers to make more informed management decisions and should be a focus of future research.

Yellow sticky traps remain an effective tool for monitoring blueberry maggot populations. Little is actually known about the within field movement of this insect. Data need to be developed to establish the movement patterns of blueberry maggot files within a field. To be most effective, any management strategy requires a basic knowledge of the target pests dispersal, migration, environmental preferences, and host associations.

Table 1: Summary of flower-bud development.

Clone number	Mean number of live flower buds[a]	
	Infested	Uninfested
1	4.2	5.5
2	4.1	4.4
3	5.6	6.6
4	3.4	3.2
5	2.2	2.4
6	2.6	3.2
Overall mean	3.7 a	4.2 a

[a] Means infested and uninfested stems followed by the same letter are not significantly different (ANOVA, $P = 0.05$, $Pr > F = 0.364$).

Table 2. Analysis of average yield and seasonal density.[a]

Plot no.	Seasonal density	Yield (lbs)
1	2.0	16.14
2	2.6	16.23
3	1.8	14.38
4	1.6	16.41
5	1.8	17.68
6	0.6	19.49
7	0.6	14.38
10	0.6	14.86
11	1.5	19.89
13	1.1	20.82
14	1.5	18.57
15	0.8	23.33
16	2.2	24.56
17	0.7	24.65
18	1.0	17.73

[a] Regression analysis, $Pr > F = 0.679$.

C. PLANT NUTRITION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Scott Dunham, Crop Technician

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 have a known history of leaf nutrient concentrations (low leaf phosphorus) and yield consistency, they were expanded to include four 5 ft x 20 ft treatment plots. The treatments are:

1. Control - no fertilization

2. Phosphorus (60 lb P/acre),using triple superphosphate

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, was evaluated by analyzing composite leaf samples taken from 30 stems randomly selected across each treatment plot in July 1995. Growth characteristics (including stem height and flower bud formation) were assessed on stems cut at ground level in four 1/4 ft^2 quadrates/treatment plot in October 1995. Yield was determined in August 1996 by hand harvesting the plots, winnowing the berries and recording the weight.

RESULTS:

Leaf Tissue Nutrient Concentrations

Leaf phosphorus concentrations in control plots at the three locations averaged 0.100%, considerably less that the new 0.13% standard (Fig. 1). All fertilizers raised the leaf phosphorus concentrations, compared to the controls. However, phosphorus concentrations were not raised to the standard (0.13%) at the rate used (60 lb P/acre). Using logical contrasts to statistically analyze differences among treatments (Table 1), all fertilizers raised leaf phosphorus concentrations but those containing nitrogen (NP) were more effective than the one containing only phosphorus (P), TSP. We also note that there was no difference between MAP and DAP in raising the leaf phosphorus concentration when the three locations are averaged. Differences among locations did exist 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 phosphorus concentrations from plots receiving DAP to the control plots was similar for locations 1 and 2 (1.16), 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.

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

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

Soil Nutrient Concentrations

Soil phosphorus concentrations averaged across locations showed a similar pattern to that found for leaf phosphorus concentrations among treatment plots; all fertilizers raised soil phosphorus concentrations, compared to the controls (Fig. 9). However, MAP or DAP did not raise soil phosphorus concentrations higher than TSP, according to logical contrasts to statistically compare among the fertilizer treatments (Table 2).

That leaf phosphorus concentrations were slightly higher in plots treated with DAP or MAP suggests an interaction of nitrogen and phosphorus in the plant's ability to absorb and translocate phosphorus.

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 quadrates per treatment plot; there were 576 bags containing stems from each 1/4 ft^2 of plot area to process. The density of stems was increased by MAP and DAP, but not by TSP (Table 3). 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 (Figure 10).

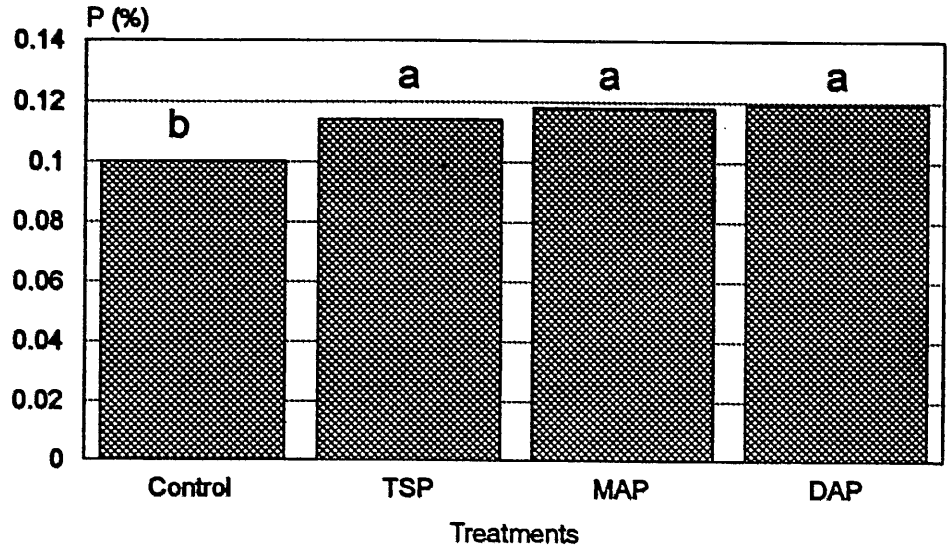
CONCLUSIONS: No conclusions can be made until the study is completed and all the data is completely analyzed and interpreted.

RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1

P/N Ratio Study

Phosphorus leaf concentrations*



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

Table 1

P/N Ratio Study

Phosphorus leaf concentrations

Treatments	P (%)
Control	0.1
TSP	0.114
MAP	0.118
DAP	0.119
Contrasts	SIGN LEVEL
Fert vs Control	1%
NP vs P	5%
MAP vs DAP	ns

Figure 2

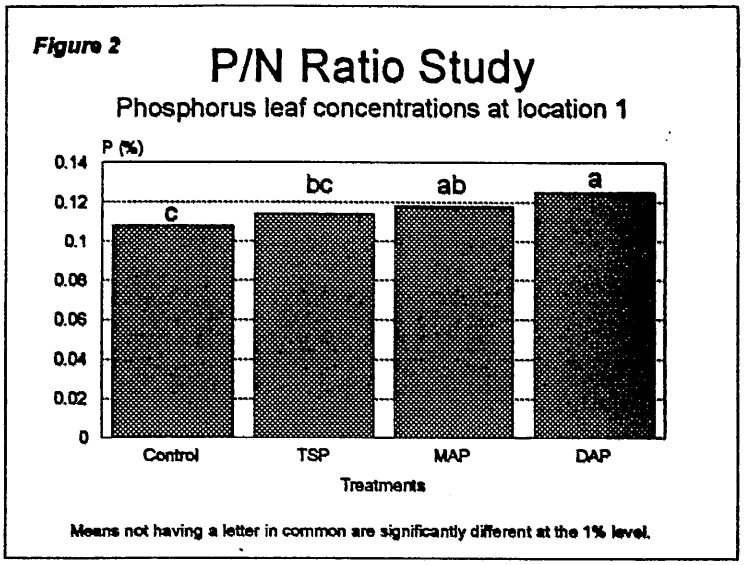


Figure 3

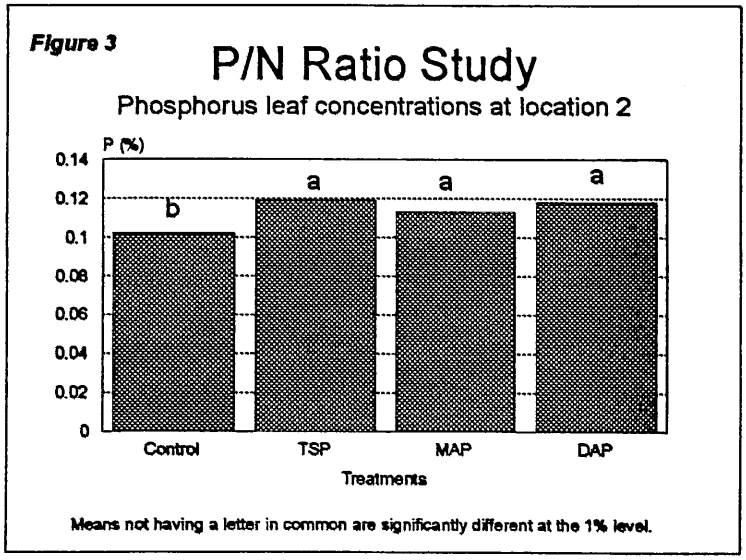


Figure 4

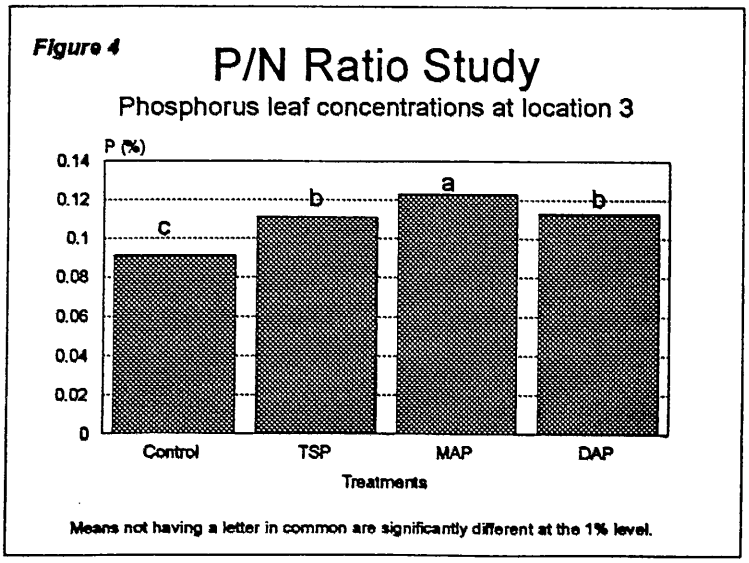
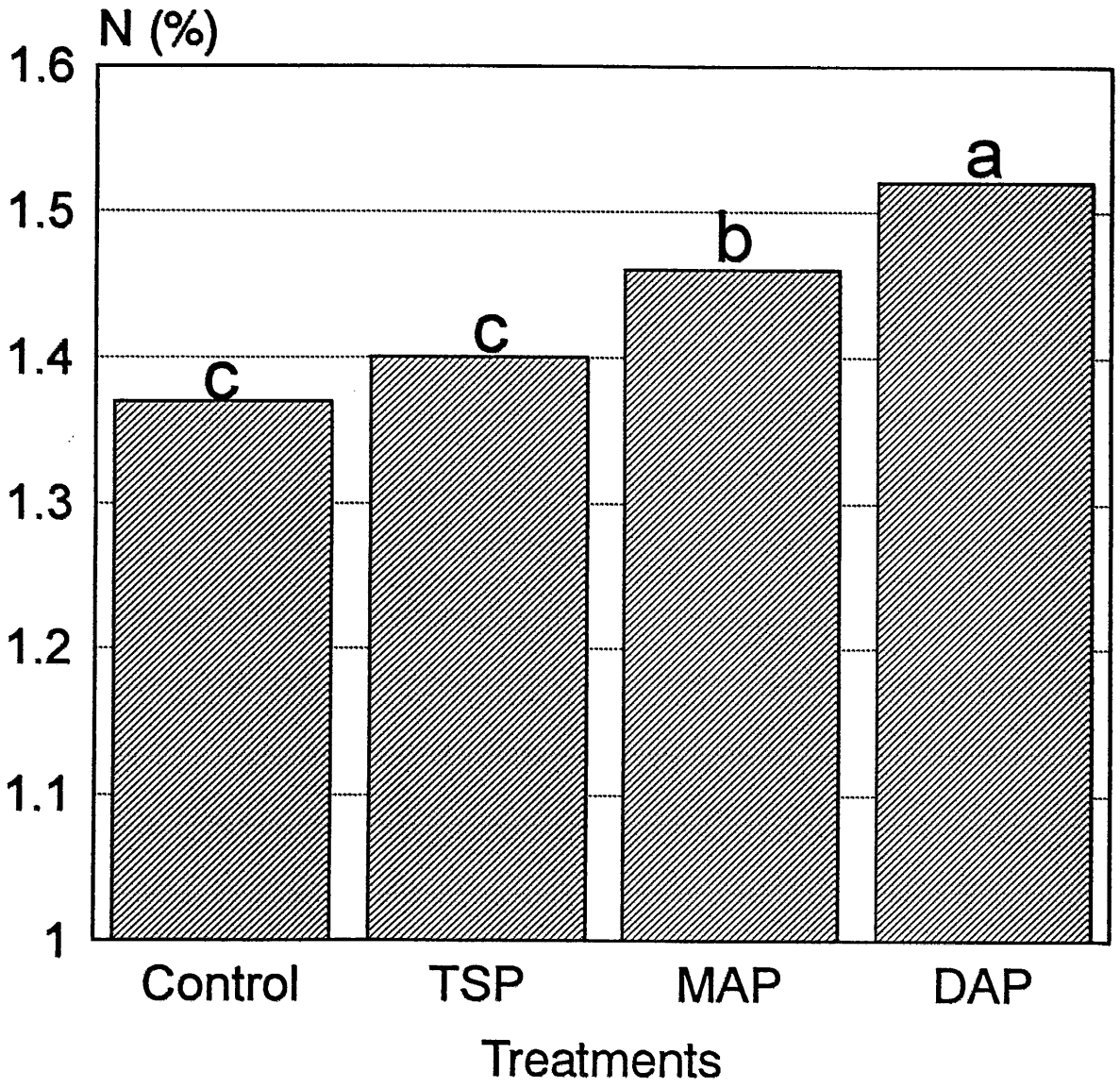


Figure 5

P/N Ratio Study

Nitrogen leaf concentrations*

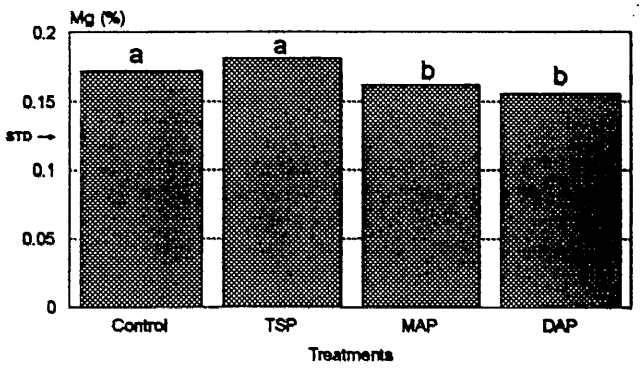


*Values are average of three locations. Means not having a letter in common are significantly different at the 1% level.

Figure 6

P/N Ratio Study

Magnesium leaf concentrations*

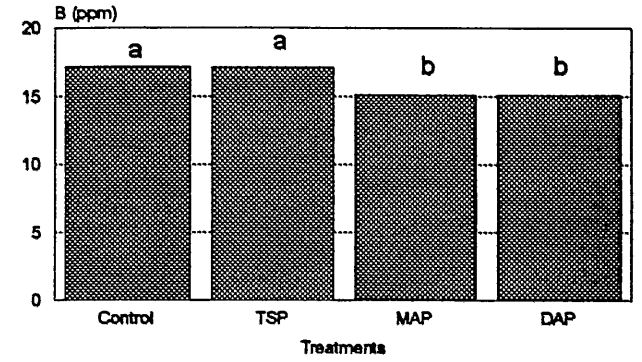


*Values are average of three locations. Means not having a letter in common are significantly different at the 1% level.

Figure 7

P/N Ratio Study

Boron leaf concentrations*

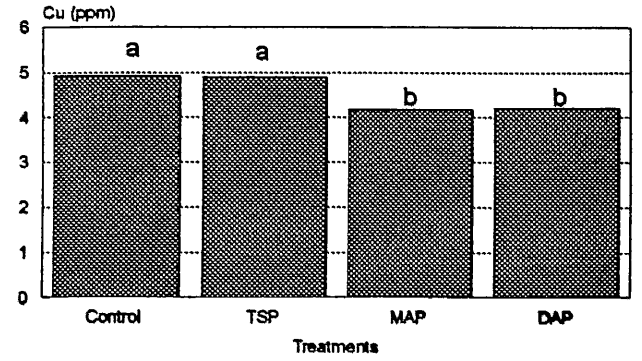


*Values are average of three locations. Means not having a letter in common are significantly different at the 1% level.

Figure 8

P/N Ratio Study

Copper leaf concentrations*

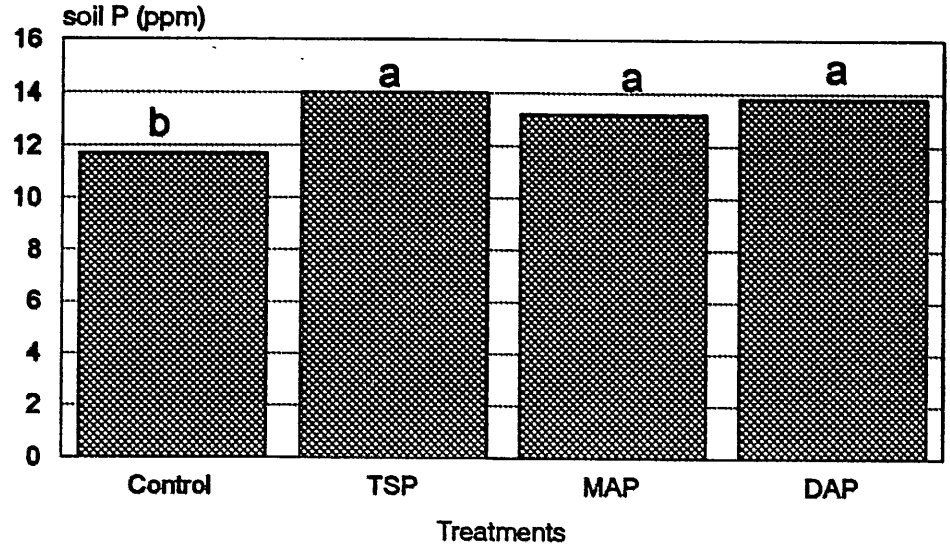


*Values are average of three locations. Means not having a letter in common are significantly different at the 1% level.

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.

Table 2

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 3

P/N Ratio Study

Stem characteristics

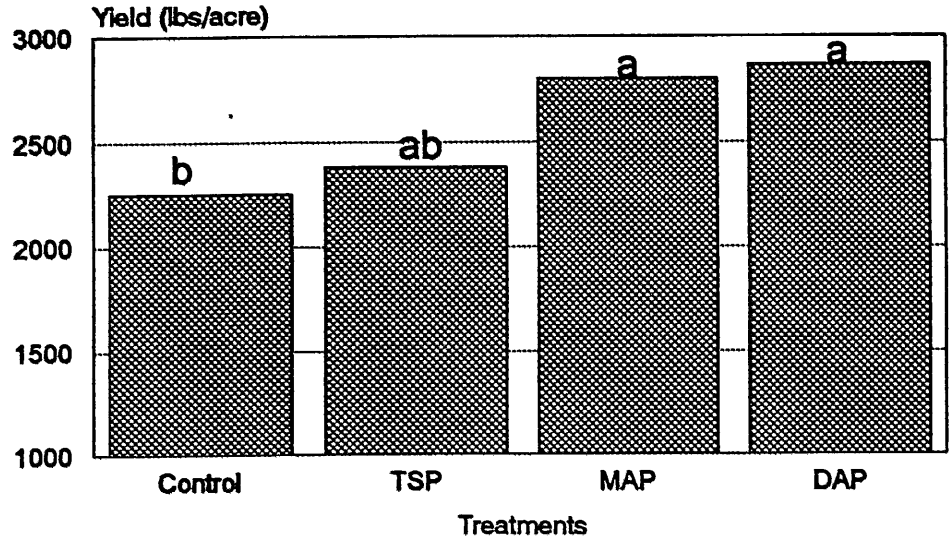
Treatment	Stems per 1/4 sq ft	Stem length (in)	Flower buds per stem	Flower buds per 1/4 sq ft
Control	21.3 b	2.91 c	1.82 c	37.1 b
TSP	22.5 ab	3.00 c	1.92 bc	41.3 b
MAP	24.0 a	3.33 b	2.12 b	49.5 a
DAP	24.0 a	3.50 a	2.40 a	54.6 a

Means within columns followed by different letters are significantly different at the 5% level

Figure 10

P/N Ratio Study

Yield*



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

D. WEED CONTROL AND PRUNING

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

1. TITLE: Effect of surfactant and ammonium sulfate on glyphosate activity

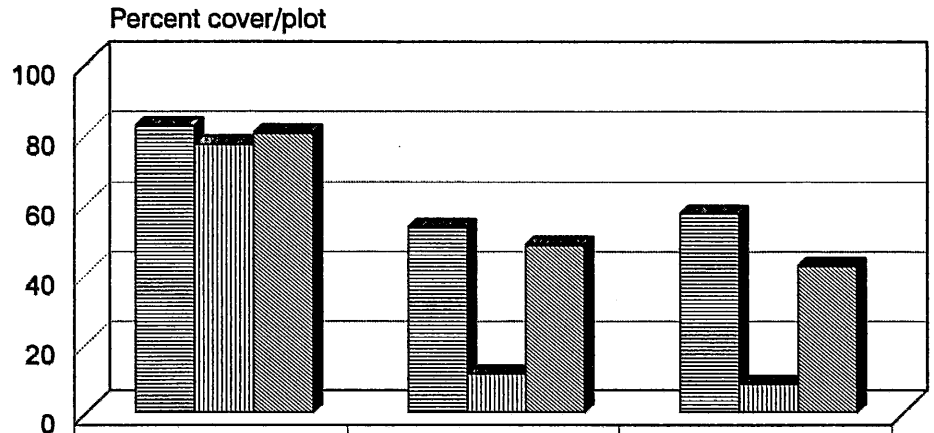
METHODS: A completely randomized block experiment was established in Eastbrook to determine the effect of surfactant and ammonium sulfate on glyphosate activity. Each weed species (dogbane, bracken fern and bunchberry) had 1 by 3 yard plots split in three by treatment date. Treatment times were 7-10, 7-31 or 8-28-96. Bracken fern and dogbane were wiped with a 10% wipe amended with 0.1% surfactant (LI700®) and 18 mgs ammonium sulfate/gallon of solution. Bunchberry plots were sprayed with a 2% spray amended with same surfactant and ammonium rates. An additional bunchberry experimental site was established comparing treating with 2% glyphosate with and without the same surfactant and ammonium sulfate rates. Twenty completely randomized, one yard^2 plots were established and treated either with amended 2% solution or unamended solution on 8-28-96. Phytotoxicity was taken 9-6-96.

RESULTS: For dogbane, the middle treatment date had the most effective suppression (Figure 1). For controlling bracken fern, all three treatment dates proved equally effective (Figure 2). Treatments for bunchberry took longer to take effect with the later date being most effective. No difference was noticed in amended and unamended applications to the late August bunchberry trial

CONCLUSION: Continue evaluating with carryover effects and repeat in spring of 1997.

RECOMMENDATIONS: Preliminary conclusions and recommendations from the first year trial will be available in winter, 1997.

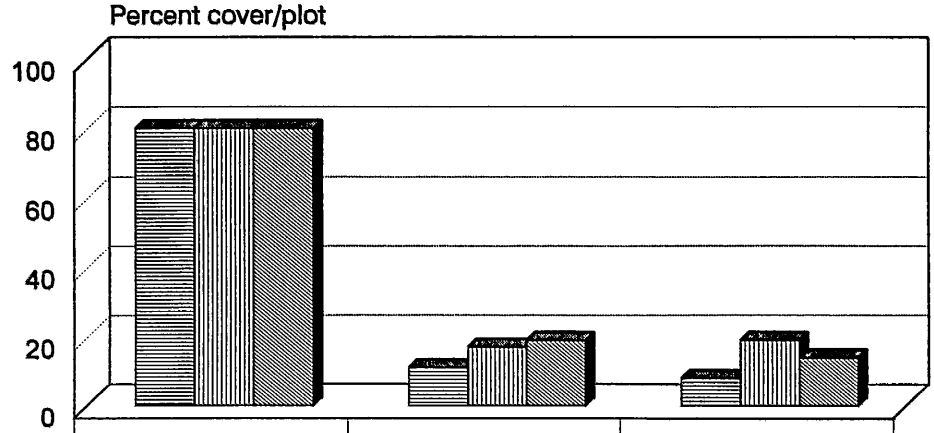
Figure 1. Effect of Surfactant and Ammonium sulfate Enhanced Glyphosate on Dogbane



	Before Treatment	1 Month later	2 Months later
Early	82	53	57
Mid	77	11	8
Late	80	48	42

Timing=Highly Significant

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



	Before Treatment	1 Month later	2 Months later
Early	80	11	8
Mid	80	17	19
Late	80	19	14

Timing=Not significant

E. EXTENSION

PRINCIPLE INVESTIGATOR: David E. Yarborough

TITLE: Blueberry Extension Education Program Base

METHODS: Conduct an educational program that will stress the use of best management practices in an integrated crop management program which will improve the efficiency of culture and minimize the use of unnecessary pesticides and fertilizers. Conduct Spring grower meetings and field days to introduce and reenforce the use of best management practices, integrated crop management and sound business management principles. Provide management information through the blueberry newsletters, fact sheets in the wild blueberry growers guide, telephone and correspondence, and conduct field visits as appropriate. Cooperate with County Educators and provide support for blueberry initiatives requested by County offices. Cooperate with the Blueberry Research Advisory Committee, Maine Blueberry Commission and Wild Blueberry Association of North America on blueberry related matters. Cooperate with county (Soil and Water Conservation Districts), state (Department of Agriculture, Board of Pesticides Control) and federal agencies (USDA, IR-4) on blueberry related matters. Needs were 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, ICM, 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 reenforced those previously identified but also added the need for blueberry quality and groundwater concerns.

RESULTS: Educational Activities:

The Blueberry Integrated Crop Management program consists of three field demonstration sessions conducted in three counties. This program has been conducted over the past four 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.

Participated in meetings for the Agricultural Working Group of the Atlantic Salmon Listing task force created by executive order by Governor King. Provided pesticide use information on blueberry and cranberry production in Maine. The conservation plan is being proposed as the basis for Maine to manage the salmon.

Provided a Blueberry/Cranberry training session the Agricultural Trade Show in Augusta on January 11, 1996.

Discussed wild blueberry budgets at the Agricultural Trade Show on January 11 with Vern Pierce, Farm Management Specialist.

Presented 'Leaf samples determine nutrient needs in wild blueberries' at annual meeting of Maine Plant Food and Educational Society on January 31, 1996 in Bangor.

Met with Maine Blueberry Advisory Committee on February 13 in Orono to summarize Blueberry Extension education program and propose program for 1996.

1996 Spring Blueberry Meetings held in South Paris, April 1, in Union, April 2, in Ellsworth, April 4, and in Machias, April 6. Topics presented by Extension, Experiment Station, and Pesticide board personal. 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 blueberries. Updated sixteen Wild blueberry fact sheets for growers guide. Presented 'Results of Groundwater Testing program', 'Use of On-Farm Plots and 'Weed Mapping to Determine Velpar/Pronone Rates' and lead a discussion on the Needs and Future of the Wild Blueberry Industry.

Provided blueberry growers training for blueberry pesticide license exam on April 6, 1996 in Machias.

Participated in Wild Blueberry Research and Extension Workers Conference in Moncton New Brunswick on April 10-11, 1996. Presented 'Economic Weed Thresholds for Wild Blueberries' and 'Results of 1995 Hexazinone Groundwater Survey in Maine' and presented an Extension report on status of Maine Wild Blueberries. This meeting provides for exchange of current research information and for interaction of research and Extension workers between Maine and Canada. Shared information reduces duplication of effort and improves knowledge base for both Maine and Canadian industry.

Gave guest lecture on "Mode of action of herbicides" in Orono for AES 570 on February 26th, 1996.

Gave guest lecture on "Wild Blueberry Culture" in Orono for AES 101 on March 28th, 1996.

Gave guest lecture on "Upland Cranberry Management" in Orono for AES 101 on April 16th, 1996.

Presented 'Water use in wild blueberries and upland cranberries in Maine' at Water Use Resources Conference in Lewiston on May 10, 1996.

Provided a summary of the Food Science Research and received input for future direction of new research projects on May 24 and October 15 in Ellsworth.

Presented Blueberry IPM information at IPM Technology Day at Lakeside Orchards on May 24, 1996.

1996 field training sessions were offered at four locations to demonstrate and discuss Integrated Crop Management (ICM) field scouting techniques in Wild Blueberry Fields. The first session demonstrated equipment calibration, Velpar® rate needs, in-field experiments for herbicide management, and blight identification in Jonesboro, Appleton and Orland on April 30, May 1 and 2. The second session was given in South Paris, Union and Orland and Jonesboro on May 13, 14, 15, and 16 and included insect sweeping techniques, insect identification and life cycles and spot treatment of Pronone®. The third session dealt with scouting techniques for weed management, weed mapping, fruit fly trap placement and sampling for plant nutrition on June 25, 26 and 27 in Appleton, Orland and Jonesboro.

Held annual summer field day and crop guesstimate at Blueberry Hill Farm in Jonesboro on July 17. This session gives researchers and Extension faculty an opportunity to review programs and discuss programs and to get grower input.

Held 6th International Vaccinium Conference in Orono, Maine on August 11-21, 1996. This meeting was attended by 125 scientists from 15 countries. Two days of tours of Maine Blueberry fields and operations, two days of presentations, a two day tour of cranberry operations in Massachusetts and a three day tour of Québec Blueberry and Cranberry operations comprised the symposium. I presented 'Production Trends in the Wild Blueberry Industry in North America', 'Economic Weed Thresholds for Wild Blueberries' and 'Developing Best Management Practices to Reduce Hexazinone in Ground Water'.

Explained Maine wild blueberry production to hundreds of attendants of the Big E Agricultural Fair in Springfield, Mass. on September 14-15.

Participated in the IR-4 annual meeting in Colorado Springs, CO on October 1-4 to establish priorities for Maine for minor use pesticide trials.

Met with Maine Blueberry Advisory Committee on October, 22-23 to summarize Extension education program and propose program for 1997.

Met with Blueberry Advisory Committee to finalize Extension and Research projects on November 13 in Orono.

Met with Blueberry Commission on November 19 in Ellsworth to report on Extension and research activities.

Met with blueberry growers in Union on November 21 to discuss research programs funded for 1997.

Professional Improvement Activities:

Participated in the Northeastern Weed Science Society meetings on January 3-5 in Williamsburg, VA. Presented 'Economic Thresholds for Weeds in Wild Blueberry Fields'. Learned of most recent research activities and met with weed specialists to discuss problems and solutions for the Maine Blueberry and cranberry industries.

Attended Weed Science Society of America's Annual Meeting on February 5-8 in Norfolk, VA. Session on 'Pandering to Fear: The Media Crisis Mentality', and symposiums on 'Role of Weed Science in Sustainable Agriculture', 'Remediation of Herbicide-Contaminated Sites', and Teaching and Extension section provided valuable incites and discussion which I will use in dealing with these issues in blueberry and cranberry culture in Maine.

Attended 'On Farm Research Workshop' with Dr. Chuck Francis at UMaine on March 1, 1996. Workshop helped define on farm research definitions and goals which I have used in Integrated Crop Management Field sessions at three locations to demonstrate the minimum hexazinone rates to be used on wild blueberry fields.

Attended 1996 Annual Cranberry Research and Extension Update in Taunton, MA on March 13, 1996. Information of weed management and pH from meeting was presented to Maine Cranberry Growers at their April 16th meeting.

Attended 1996 Wisconsin Cranberry School on March 19-20 in Stevens Point, WI. Article on 'Weed Competition Effects on Cranberry: When and How Serious?' written for Maine Cranberry Newsletter.

Pesticide applicator training by UMCE pest management, in Brewer on March 26, 1995 - Provided training on how to communicate on pesticide issues and pesticide safety. These principles are stressed at all field days which deal with pesticide use.

Attended 'Toxicology' and 'Environmental Risk Assessment' short courses given by University of Maine Chemical Engineering Department in Orono on September 12 and 26, 1996.
These courses added to my understanding of these subjects and will help me to answer questions I get in these areas.

Attended Nova Scotia Blueberry Growers meeting in Truro, NS on November 15-16, 1996. Grower issues, concerns and research efforts were discussed.

Other Activities:

I am on the Research and Development Committee of the Wild Blueberry Association of North America. The purpose of the committee is to determine research and development 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. Two IR-4 projects were done in Maine in 1996.

I am coordinator for the CSREES special research grant 'Lowbush blueberry production and processing technologies' which is granted by the USDA; $205,613 was awarded for 1997. I coordinate proposals and reports from the researchers involved.

I have reviewed manuscripts for the *Canadian Journal of Plant Science, HortTechnology, HortScience* and *The Journal of Small Fruit and Viticulture.*

CONCLUSION: Growers are participating in ICM programs in the four primary blueberry growing counties, Washington, Hancock, Knox and Lincoln. The skills survey results indicate that growers are learning new skills and making positive changes in their management practices.

Participation in this program has increased from 1993 in Hancock, there was a slight decrease in the Washington County and Knox/Lincoln counties program but this was from Cherryfield Foods offering growers their program. 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 blueberry culture by reducing unnecessary pesticides and fertilizers.

The hexazinone groundwater survey I have conducted from 1992 to 1996 continues to provide information on the movement of this herbicide into the groundwater. Over the four summers I have sampled test and drilled wells and surface water in blueberry fields. 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.

The survey indicates that growers need the information provided by the meetings, fact sheets and newsletters. It also indicates that many growers are using integrated management techniques. Adoption of best management practices enable growers to improve the efficiency of blueberry culture by reducing unnecessary pesticides and fertilizers. More efficient management will results in greater returns and a stable, sustainable industry.

RECOMMENDATIONS: Continue to support Extension educational program.