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A. FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Therese M. Work, Food Scientist
Huanli Zhang, Graduate Student

1. TITLE: Factors Affecting the Quality of IQF Blueberries.

METHODS: Blueberries were obtained from a grower immediately after harvest and transported to the Agriculture Canada Research Station at Kentville, Nova Scotia for processing. Fifteen replications were conducted on hand harvested berries. Berries were winnowed and mixed with a sample being removed to assess fresh berry quality, as a measure of inherent quality characteristics of each replicate or run. A sample went immediately into frozen storage to serve as zero time frozen sample. Preprocess delay was imposed on a portion of berries at low (10 C) and high (30 C) temperature for 48 hr. Immediate processing samples (no delay) were put through the following treatments (1) compression (2) drop damage (3) abrasion treatments prior to freezing. Delay/temperature samples proceeded to compression/drop/abrasion treatments followed by freezing. Freezing was performed in -25 C air at constant air-flow to provide: (1) completely frozen berry, -20 C mass average temperature (2) crust frozen berry, -1 C mass average temperature. Frozen berries were immediately subjected to compression/drop/abrasion treatments. These treatments were performed in a freezer environment. Samples were placed at -20 or -5 C for long term storage. Samples will be transported to the Department of Food Science & Human Nutrition at the University of Maine in January of 1996 for quality analysis. The following analyses will be performed on the 256 samples: (1) 50 g classification (2) texture (3) anthocyanin leakage (4) sugar migration (5) soluble solids (6) pH (7) titratable acidity.

RESULTS: Results will not be available until the quality characteristics of the blueberries have been determined in February of 1996.

CONCLUSIONS: Conclusions will be developed upon analysis of the data generated from the quality measurements.

RECOMMENDATIONS: Recommendations will have to await completion of the research.

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

2. TITLE: Preventing the Bleeding of Blueberry Fruit in Bakery Products

METHODS: Before rerun blueberries were incorporated into muffin batter, IQF berries (used at 15% total batter weight) were placed in a single layer on a flat plate, then sodium carboxymethylcellulose (CMC), gum arabic, guar gum and gellan gum were used as coating materials and applied at 10% berry weight. The gum was spread on the 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. Commercial muffin mix (Gold Medal Blueberry Muffin Mix) was prepared following the "classic recipe" on the box. Muffins were baked one day before the sensory test, and stored in the refrigerator at 5-6 C. Twelve members from the Department of Food Science & Human Nutrition were trained for a total of 2 hr in two training sessions. During the training session, panelists discussed the sensory attributes of muffins (color, texture and flavor). Muffin color was determined to be different among the samples, so interior batter color of muffins was evaluated by using a seven point intensity scale from 1 (no color) to 7 (highly colored). Each panelist received half a muffin per treatment per test. Samples with unevenly distributed berries were not evaluated. Three sessions were conducted under normal fluorescent light. Muffin batter color was measured using a Hunter LabScan II Spectrocolorimeter. Twelve readings of each treatment were averaged. Hue angle was calculated as:

$$\text{Hue angle} = \tan^{-1} b/a$$

Driploss was measured by placing 50 g of frozen blueberries into a plastic container with three sheets of paper towels. Samples were thawed at room temperature for 4 hr, then taken out of the container and drained berry weight was recorded. Percent driploss was calculated as:

$$\% \text{ Driploss} = \frac{(\text{unthawed sample wt} - \text{drained sample wt})}{\text{unthawed sample wt}} \times 100$$

Anthocyanin (ACN) leakage was measured by the method of Sapers and Phillips. Total ACN leakage of blueberries was calculated in terms of malvidin-3-glucoside by Lambert-Beer's Law.

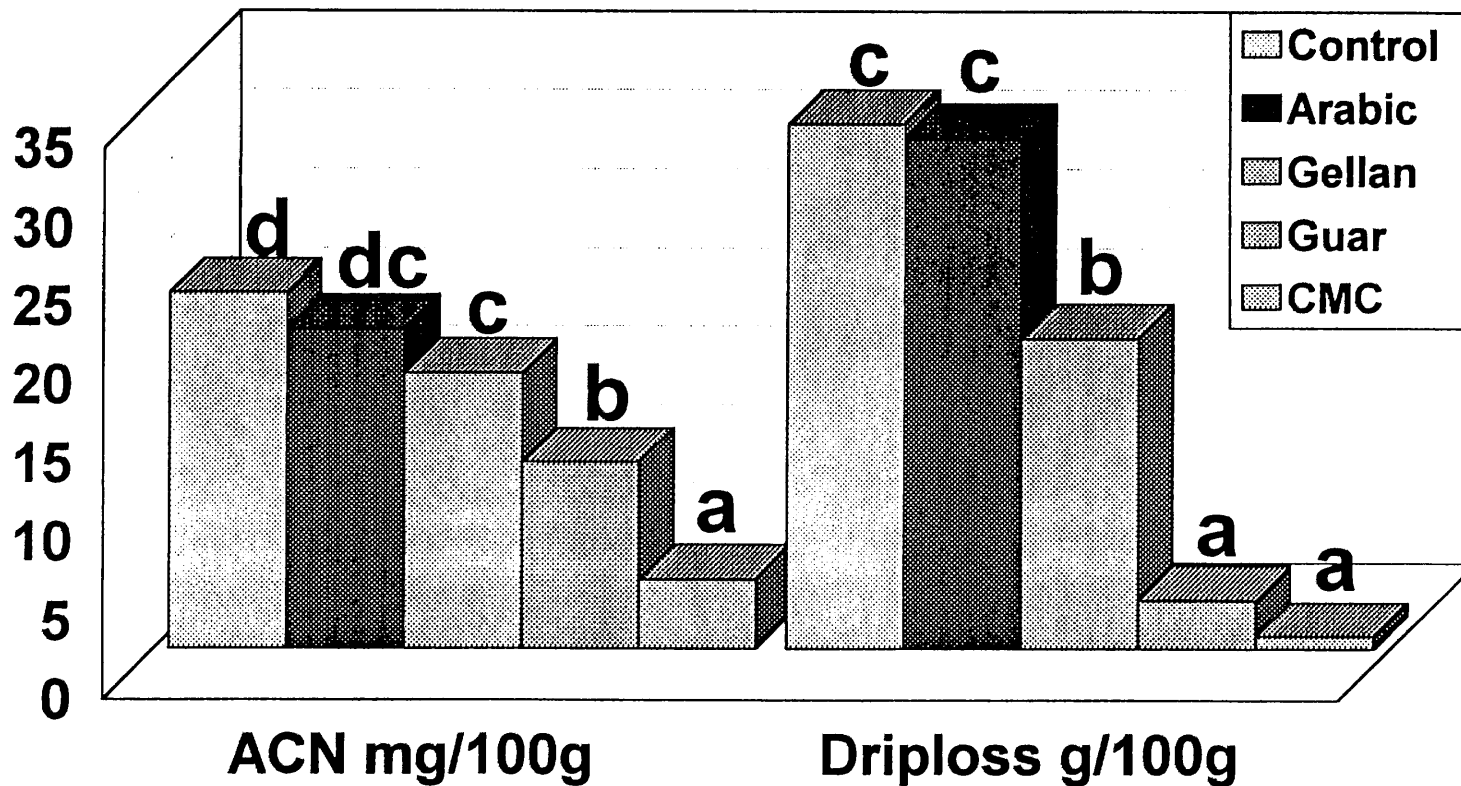
RESULTS: There were significant ($P \leq 0.05$) differences in both ACN leakage and driploss between uncoated berries (control) and coated berries except gum arabic coated berries (Fig. 1). Uncoated berries and berries coated with gum arabic had significantly ($P \leq 0.05$) higher ACN leakage and driploss than berries coated with gellan, guar gum and CMC. Gum arabic did not form a firm film due to its high solubility. Berries coated with CMC had lower ACN leakage and driploss than fruit treated with other gums. Hunter L-, a-, and b-values for batter with all coated berries were significantly ($P \leq 0.05$) different from the control. Batter with berries coated with gum arabic had higher L-values (Fig. 2) than the control, but lower L-values than the other three gums. Batter with Berries coated with CMC and guar gum had higher L-values, 74.76 and 73.01, respectively. Hunter a- and b-values showed no significant differences for batter with berries coated with gellan, guar gum and CMC (Fig. 3 and 4). Hue angle for batter without blueberries was 91.63 which was close to the b-axis in the second quadrant and the batter appeared light yellow. Hue angles for batter with berries coated with gellan, guar gum and CMC

were not significantly different, 101.24, 99.46 and 97.93, respectively (Fig. 5). All these values were close to the b-axis in the second quadrant which indicated that batter color was close to yellow. Hue angle for batter with berries coated with gum arabic was significantly ($P \leq 0.05$) higher than other gum treatments, it was also in the second quadrant, but close to green. Batter with uncoated berries had significantly ($P \leq 0.05$) higher hue angle which shifted to the third quadrant and indicated the batter color was close to blue. Chroma of muffin batter with uncoated berries was significantly ($P \leq 0.05$) lower than that of coated berries (Fig. 6). Batter with CMC coated berries had a higher chroma value than fruit treated with other gums. Muffins with coated berries had significantly ($P \leq 0.05$) different sensory scores than those with uncoated berries (Fig. 7). Among the treatments, gum arabic coating had significantly ($P \leq 0.05$) higher sensory scores than gellan, guar gum and CMC coatings. There were no significant difference in sensory scores for muffins with gellan, guar gum and CMC coated blueberries, 2.51, 2.32, and 2.17, respectively. The lower sensory scores indicated that gellan, guar gum and CMC coating of IQF blueberries prevented ACN leakage from rerun fruit and muffins with coated berries had a lighter color.

CONCLUSIONS: It can be concluded that coating IQF blueberries with gum arabic, guar, CMC and gellan gums improved the sensory quality of blueberry muffins. Sensory scores were correlated with Hunter L-, a- and b-values, chroma and hue angle (Table 1). Gellan, guar and CMC coatings were more effective than gum arabic coating. CMC was the most promising coating material because it forms a firm film.

RECOMMENDATIONS: No recommendations will be made until research is completed this year on industrial application of the gums, cost analysis and the possibility of incorporating the gums into the batter rather than coating the berries.

Fig.1 Effect of coating on driploss and ACN leakage of IQF blueberries



Different letters on the top of bars mean significant difference among treatments at alpha=0.05 level using Tukey's HSD Test.

Fig.2 Effect of coating of IQF blueberries on Hunter L-values of muffin batter

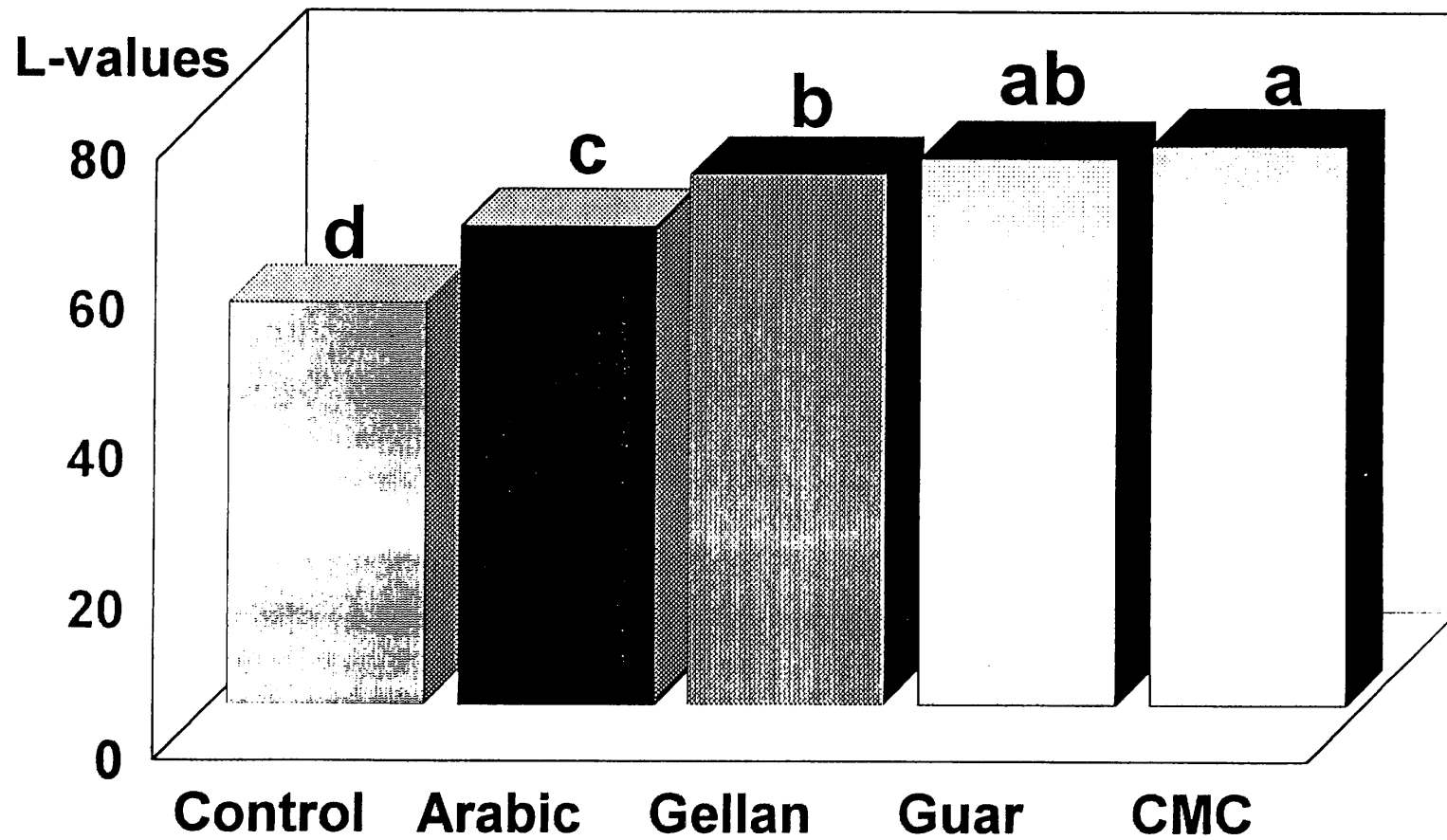


Fig.3 Effect of coating of IQF blueberries on Hunter a-values of muffin batter

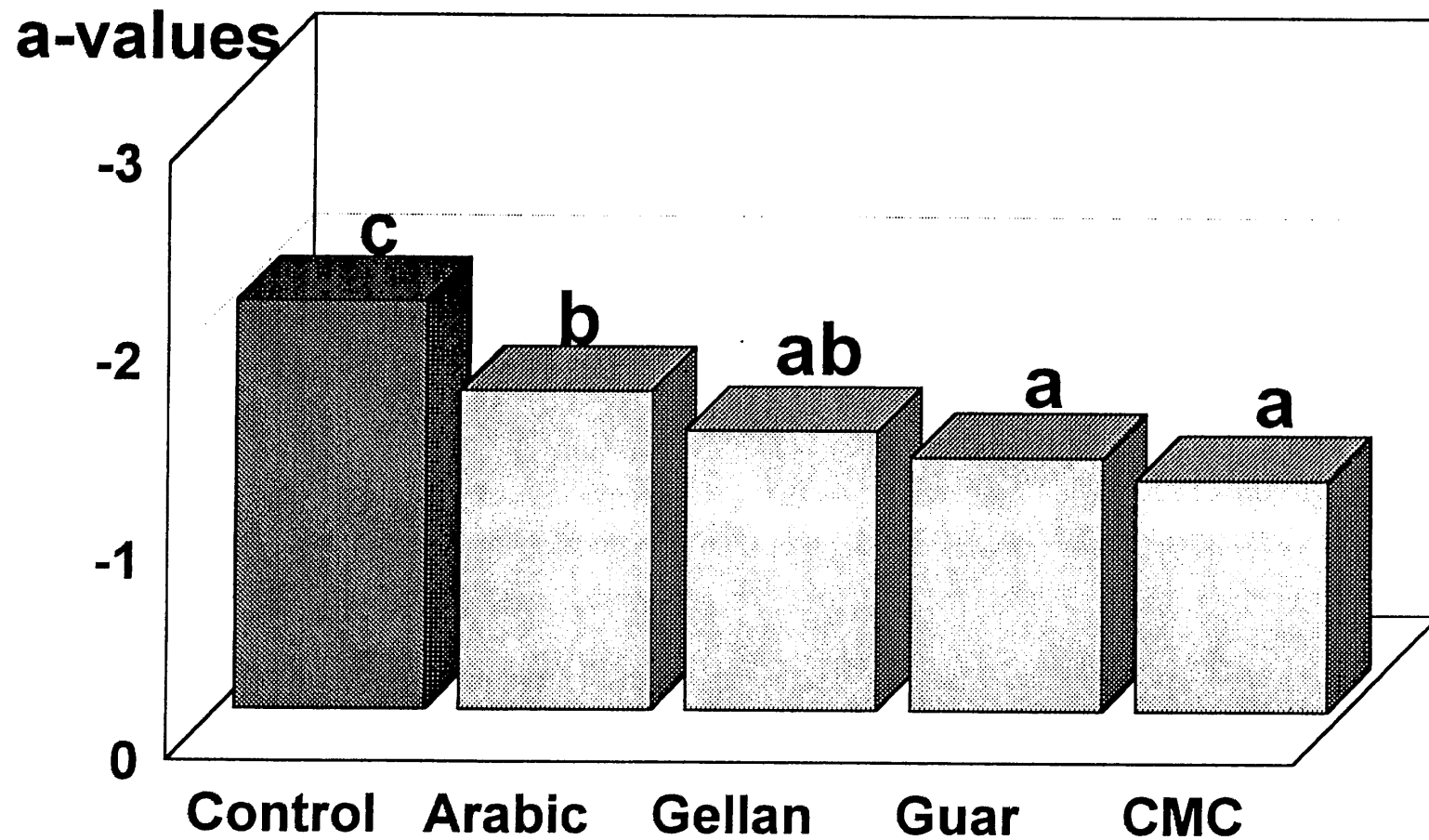


Fig.4 Effect of coating of IQF blueberries on Hunter b-values of muffin batter

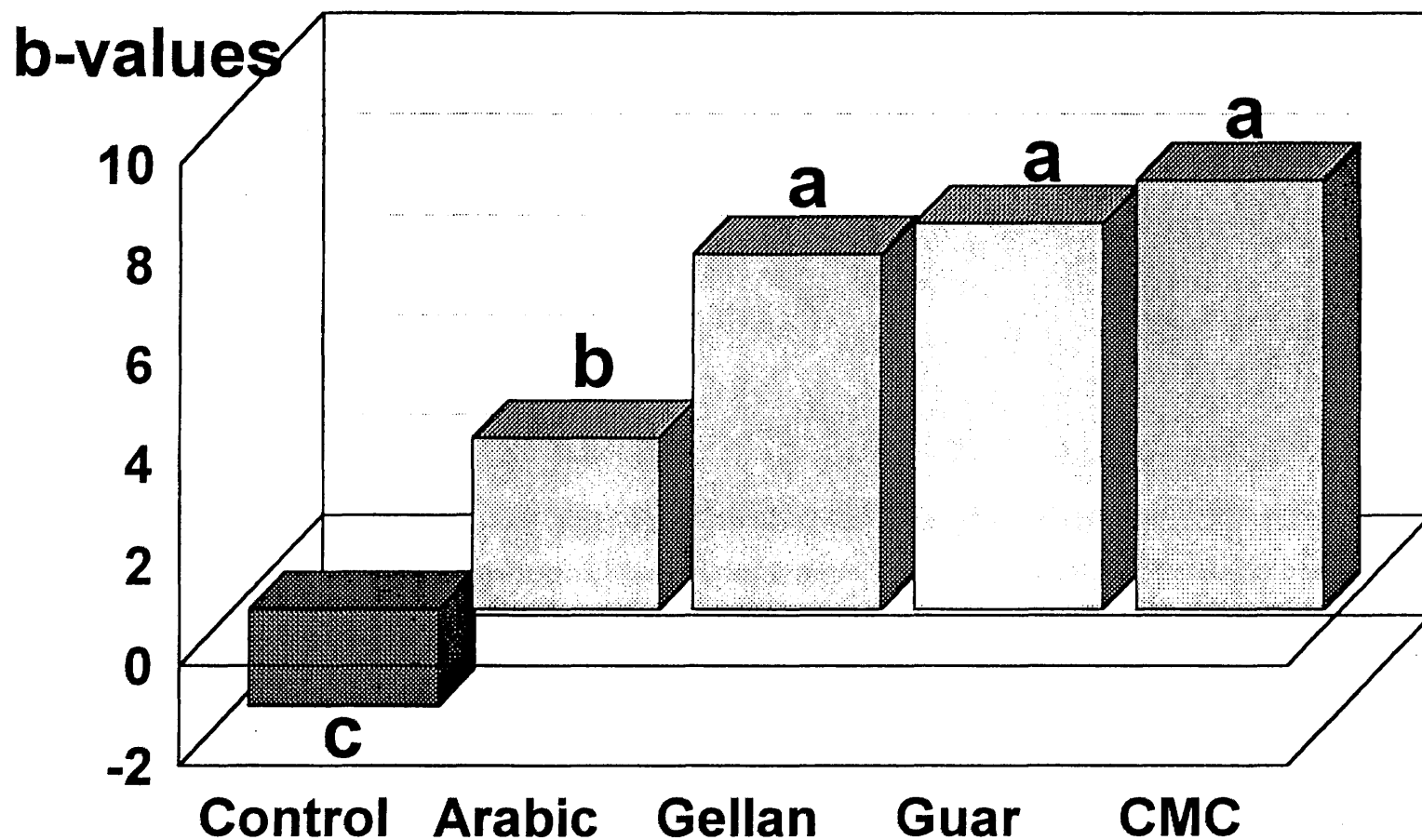


Fig.5 Effect of coating of IQF blueberries on hue angles of muffin batter

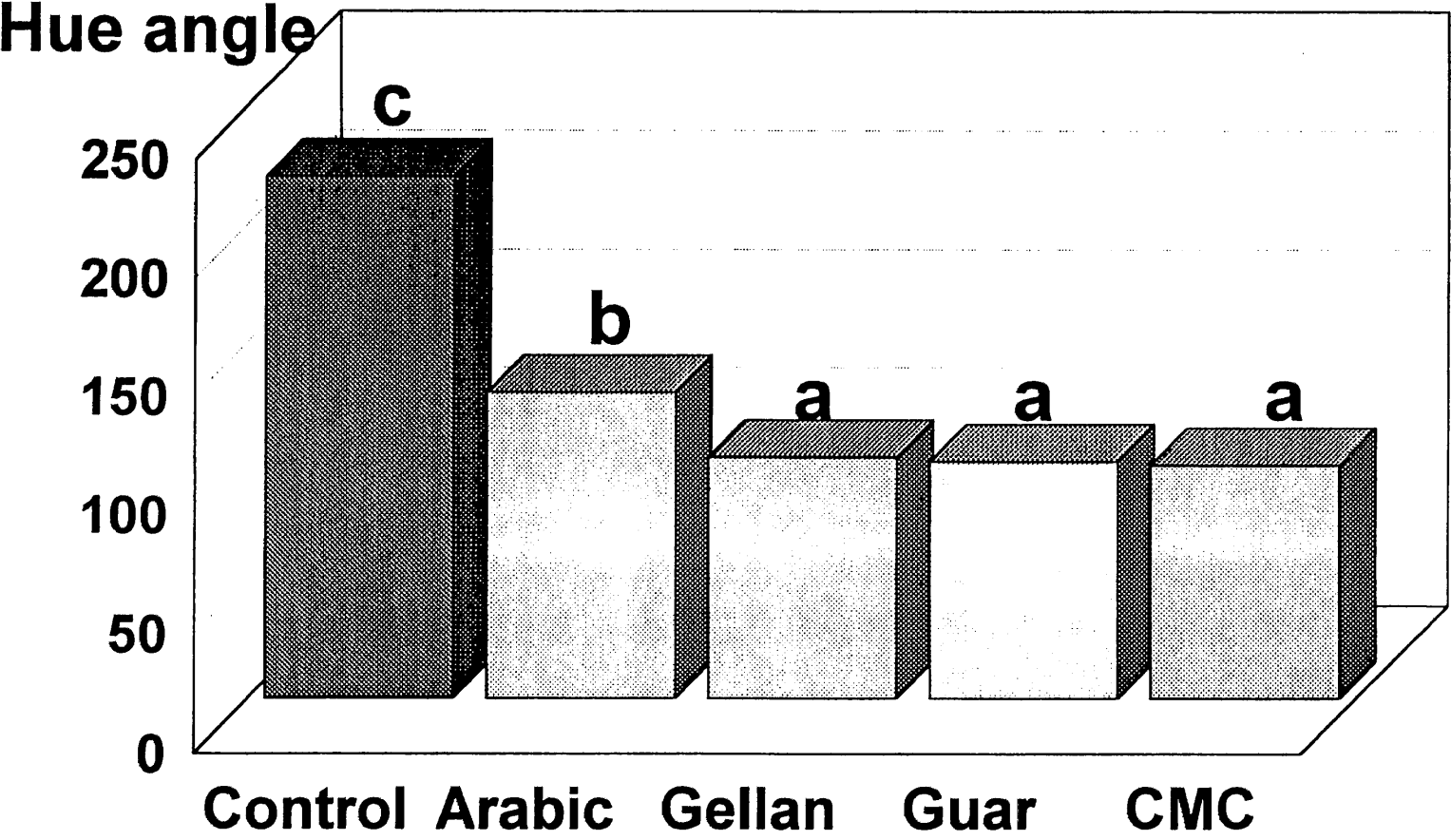


Fig.6 Effect of coating of IQF blueberrie on chroma of muffin batter

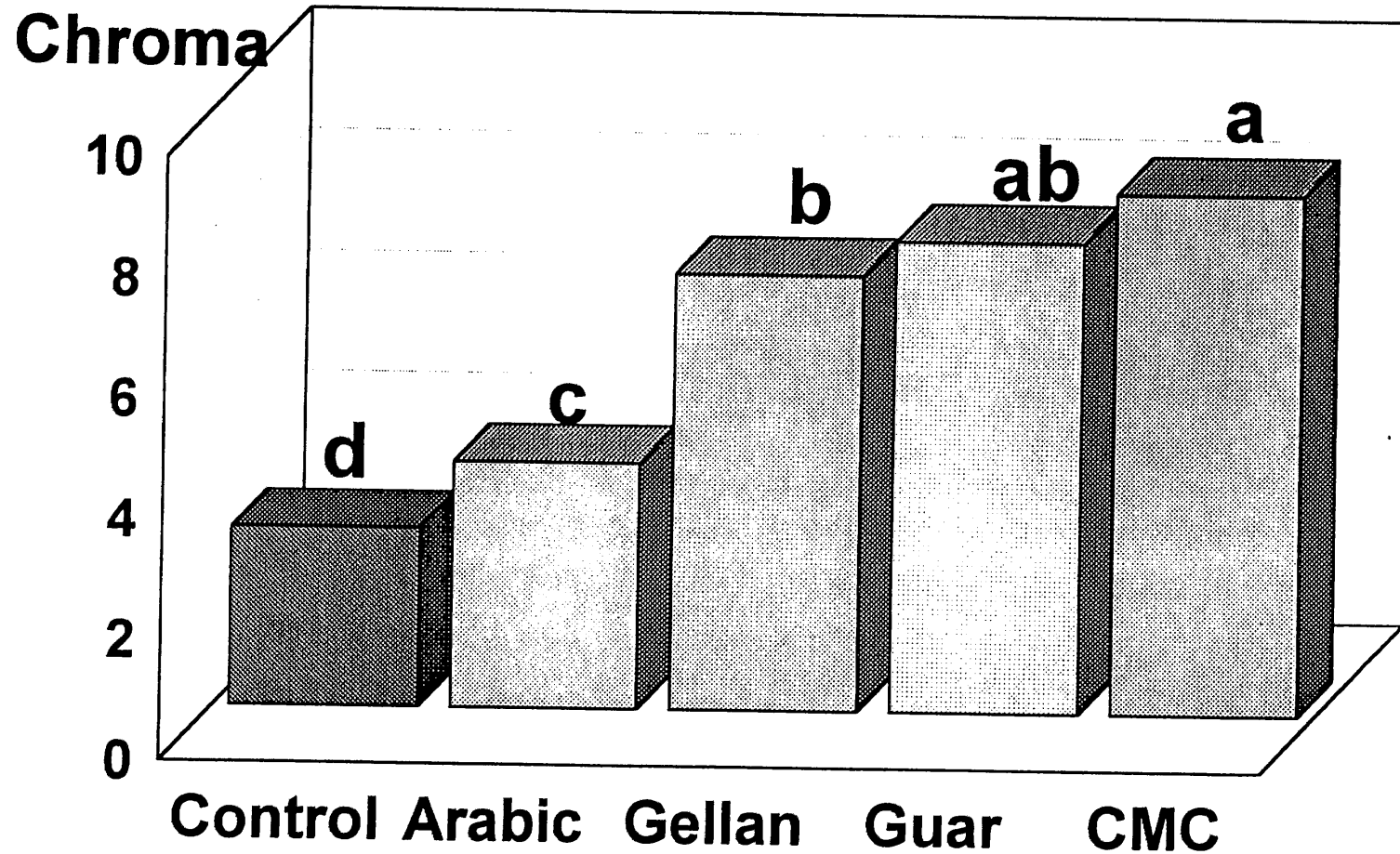
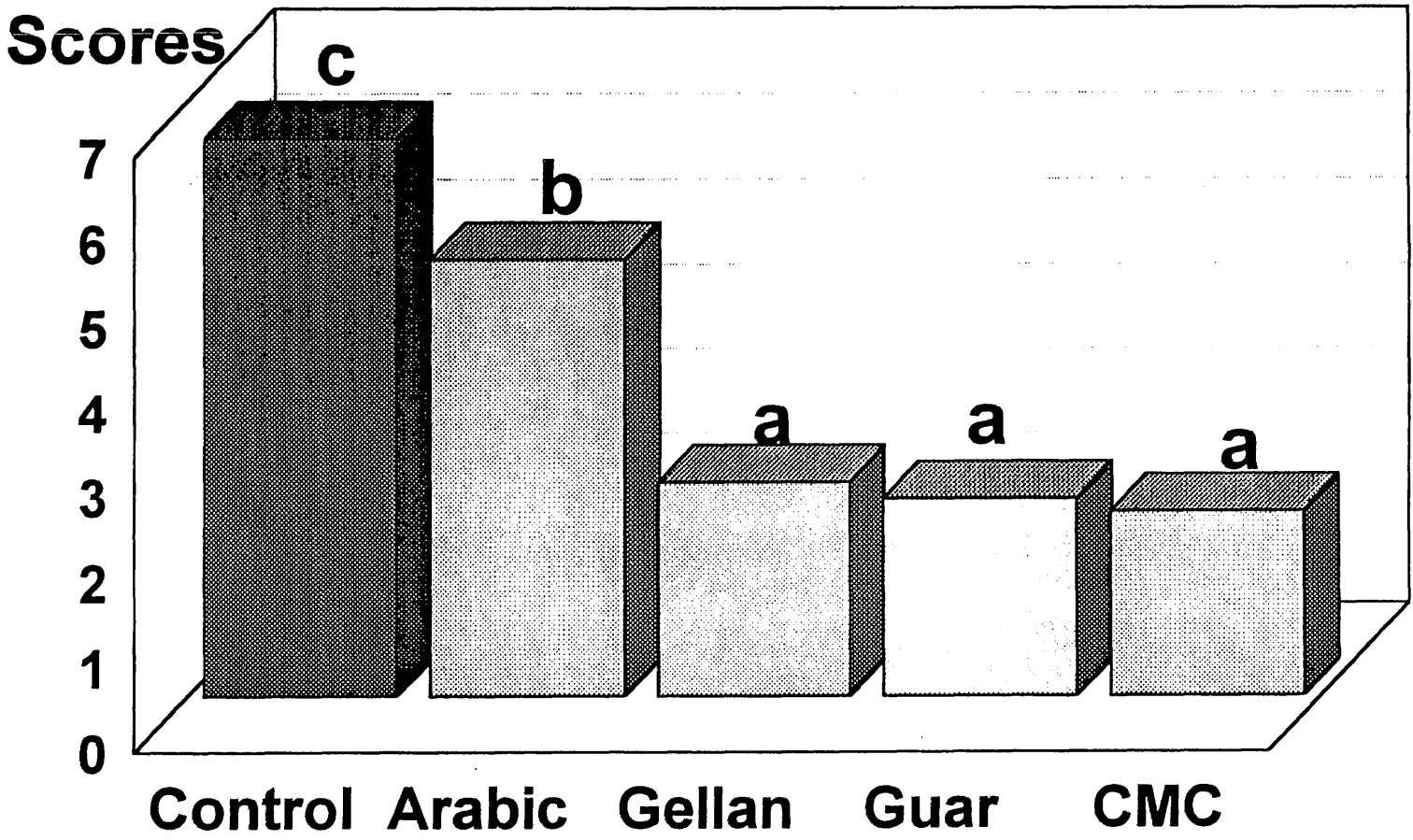



Fig.7 Effect of coating of IQF blueberries on sensory scores of muffins





Chroma of muffin batter with uncoated berries was significantly ($P \leq 0.05$) lower than that coated berries. Batter with CMC coated berries had a higher chroma value than fruit treated with other gums.

Muffins with coated berries had significantly ($P \leq 0.05$) different sensory scores from those with uncoated berries. Among the coating treatments, gum arabic coating had significantly ($P \leq 0.05$) higher sensory scores than gellan, guar gum and CMC coatings.

There were no significant difference in sensory scores for muffins with gellan, guar gums and CMC coated blueberries, 2.51, 2.32, and 2.17, respectively. The lower sensory scores indicated that gellan, guar and CMC gum coating of IQF blueberries prevented the ACN leakage and muffins with coated berries had a lighter color.




Table 1. Correlation of sensory scores for muffins with instrumental measurement of batter colors

| | L | a | b | Chroma | Hue | Sen. Scores |
|--------------------|--------------|--------------|--------------|---------------|-------------|--------------------|
| L | 1 | | | | | |
| a | 0.73 | 1 | | | | |
| b | 0.98 | 0.78 | 1 | | | |
| Chroma | 0.91 | 0.74 | 0.94 | 1 | | |
| Hue | -0.96 | -0.70 | -0.97 | -0.84 | 1 | |
| Sen. Scores | -0.91 | -0.75 | -0.94 | -0.93 | 0.87 | 1 |

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Raoul Pelletier, Adjunct Assistant Professor of Food Science

3. TITLE: Removing Water from Blueberries Before Freezing: An Analysis on the Effect on Freezing Efficiency and Product Quality

METHODS: During the past year research was undertaken on the design of a field unit to be used for removing water from blueberries harvested early in the morning by fresh packers.

RESULTS: The design of a prototype forced air dryer has been completed, and the dryer is currently being fabricated at Blueberry Hill Farm in Jonesboro, ME. Field trials will be performed during the 1996 harvest season in order to determine the effect of the dryer on moisture removal, shelf life and sensory and physical characteristics of the fruit. Trials will be performed early, mid and late season to determine if fruit maturity affects berry quality.

CONCLUSIONS: No conclusion can be drawn until field trials have been completed.

RECOMMENDATIONS: No recommendations will be made until the field trials have been completed at the end of the 1996 harvest season.

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

4. TITLE: Determination of Pesticide Residue Levels in Freshly Harvested and Processed Lowbush Blueberries.

METHODS: Extraction of blueberries was done using methanol. Five grams of blueberries along with 20 ml of methanol was polytroned for 3 minutes. Samples were concentrated using C18 Sep Paks and then injected into a GC-AED or analyzed by ELISA.

RESULTS: Only 6 of the 30 samples have been analyzed thus far. The others are being processed now. Of these 6 samples, only one has something out of the ordinary in it. We are now trying to determine what it might be.

CONCLUSION: Unable to make any conclusions until all of the samples are analyzed.

RECOMMENDATIONS: To continue this project for several years. The consumer values this information.

INVESTIGATORS: Mary Ellen Camire, Associate Professor of Food Science and Human Nutrition
Michael Dougherty, Scientific Technician

5. TITLE: Industrial Ingredients from Cull Blueberries

METHODS: Optical sorter-rejected blueberries were pureed by a blueberry processor. Puree was frozen for storage. Thawed puree was drum-dried and ground to form a flour-like material. Proximate composition, water absorption capacity, color, particle size and bulk density were measured.

RESULTS: Drying reduced moisture content from 88% to 4%. Dried berries contained about 0.3 g lipid per 100 g, and ash content was 3%. Hydration capacity was approximately 7.5 mL/g; powder bulk density was 0.7 g/cc. These values are comparable to other high-fiber materials. The Department freeze drier was recently repaired and we will dry some puree by that method for comparison. During the spring of 1996 baked goods containing dried blueberry flour will be prepared. These products will be tested against similar products containing commercially-available sources of dietary fiber for physical characteristics and consumer acceptability.

CONCLUSION: Dried berries could be used as a source of added fiber for healthier baked goods, but color may be a problem.

RECOMMENDATION: No recommendations can be made until consumer testing is completed and an economic evaluation of the cost of the process versus the possible selling price for the material can be determined. No additional funds are requested for this project.

B. ENTOMOLOGY AND POLLINATION

INVESTIGATORS: H. Y. Forsythe, Jr., Professor of Entomology
J. A. Collins, Assistant Scientist

1. TITLE: Application of Heat as a Method of Controlling Secondary Pest Insects on Lowbush Blueberry: a feasibility study.

METHODS: Evaluation of a field sanitizer: Three sites were treated using a prototype field sanitizer in the fall of 1994; an additional five sites were treated in the spring of 1995 (total eight sites). Comparisons were made between the number of insects collected weekly in sanitizer treated areas and in adjacent untreated (mowed only) control areas. Blueberry plant growth and development was monitored by taking measurements of stem height, number of stems, and number of flower buds (Study 1). An additional eight fields which received a sanitizer treatment in the spring of 1994 were evaluated in 1995 to verify the long-term effects of sanitizer treatment on blueberry plant growth and development (Study 2).

RESULTS: Evaluation of a field sanitizer: Study 1: Conditions at the three sites treated in the fall of 1994 were most representative of conditions expected to be encountered by growers since no site was mowed prior to the sanitizer treatment. Mowing the field in the fall as part of the treatment seemed to improve litter pick-up. For most previous treatments and for the five sites treated in the spring of 1995, the fields had already been mowed, and litter and debris were packed down making it more difficult for the sanitizer to pick up the material. There were no mechanical difficulties during any treatment. All sites had heavy flights of spanworm moths in 1994.

The sanitizer was apparently effective in suppressing spanworm larval populations. More spanworm larvae were found in mowed-only, nonsanitized areas at all eight sites; the difference was statistically significant at two sites. Slightly higher numbers of grasshoppers were found in mowed-only, nonsanitized areas at six of the eight sites sampled. Only a minimal number of flea beetle larvae and sawfly larvae were present at any site; therefore, no evaluation of control of these insects was possible.

There was a delay in blueberry plant growth due to spanworm larval feeding at four sites before insecticides were applied by the grower to control the outbreak. The insecticide treatment made it difficult to determine what, if any, effect the sanitizer had on plant growth and development at these sites. Growth seemed to be slightly delayed on three of the remaining four sites as measured by average number of stems per 0.25 ft² and average stem height. However, a comparison of blueberry plant growth in October indicated no apparent adverse affect by the sanitizer on blueberry plant growth.

Study 2: In the study to verify the long-term effects of sanitizer treatment on blueberry plant growth and development, a comparison of stem length, number of flower buds, and number of leaf buds on sites treated in the spring of 1994 seemed to indicate that the sanitizer did not cause

any consistent adverse effect on blueberry plant growth. The apparent effect varied widely from site to site.

CONCLUSIONS: Between 1990 and 1995 a large volume of research data has been accumulated on the ability of a prototype field sanitizer to control wintering populations of blueberry pest insects. Laboratory studies have focused on determining the temperature required to kill blueberry spanworm and flea beetle eggs with short (<1 sec) exposures to heat. A temperature of ca. 175 to 200°F was found to kill spanworm eggs in spring and fall. Work has also been done to establish conditions needed for successful laboratory rearing of wintering stages, i.e. relative humidity and temperature. Attempts have been made to evaluate the use of heat, but without burning, to control the wintering stages of secondary insect pests in the field by treating areas of previously infested fields and monitoring post-treatment insect populations. The most definitive results were obtained in 1995 when the sanitizer was very effective in suppressing spanworm larval populations. Overall, results seem to indicate that pest insect populations can be successfully reduced by the application of heat but without burning and that this process has no consistent and significant adverse effect on blueberry plant growth.

RECOMMENDATIONS: This study is now complete. We believe that the project has successfully demonstrated the feasibility of reducing pest insect populations by the application of heat but without burning.

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

2. TITLE: The Phenology and Biology of Bumble Bees, *Bombus* spp., that Pollinate Lowbush Blueberry, *Vaccinium* spp., in Maine

METHODOLOGY: Bumble bee populations in 20 fields in Knox, Waldo, and Washington counties were sampled. The phenology of queens, workers, males, and new queens was determined using transects, malaise traps, mark and recapture techniques, and individual live catches in petri dishes. Also some growers provided phenological information by calling in sightings via the Bumble Bee Hot Line.

In each study field (n = 20) three 100 meter (328 ft.) transects were sampled prior and during blueberry bloom. Mark and recapture of bumble bees began with blueberry bloom. The number of queens and workers in the transects were recorded for each sampling period. In order to ascertain the fidelity of bumble bees to blueberry as well as the importance of alternate forage, we made observations on floral preference in the transects for each sampling period.

After blueberry bloom sampling procedures were modified because in many fields floral resources were very limited. Therefore, after bloom each field was sampled for 20 min. During the 20 min period all bees seen on flowers were captured in individual petri dishes. Each field was also ranked as to forage abundance with 0 = no forage, 1 = very sparse, 2 = sparse, 3 = moderate, 4 = plentiful. The distribution of forage was also noted as being either random, patchy (clumped), or evenly distributed. Malaise traps were set up in three fields after bloom to ascertain the relative abundance of bees in relation to alternate forage.

Observations of the phenology of two native bumble bee colonies were also made during September and October until the natural demise of the colonies.

RESULTS: The first sighting of a *Bombus* queen was on 25 April in Penobscot county, approximately three weeks before the onset of blueberry bloom. Table 1 summarizes bumble bee phenology through 29 Sept. Prior to bloom, the orange belted bumble bee queens, *B. ternarius*, were seen on willow (*Salix*) in Hancock and Washington counties. The first workers were sighted on 30 May in both Hope, and Lincolnville Center. Males began appearing in mid July and on 19 Sept. a mating pair (queen and male *Bombus vagans*) were captured in Camden.

During blueberry bloom, the most *Bombus* sighted in a 100 m transect were at Gardener Lake on 9 June (Table 2). This was a site with abundant alternate forage during and after bloom. During bloom, bumble bees appeared to be quite faithful to the blooming crop, as only six bees (n = 533) were sighted on alternate forage. After bloom, bees were most abundant in fields that had plentiful alternate forage and the most important forage in 20 minute walks were the following: lambkill, golden rod, and meadowsweet. However, spatial distribution of the forage (clumped, random, or even) was not a factor for bumble bee abundance. Workers and males were sighted in Washington County as late as 24 October.

Malaise trap sampling indicates that meadowsweet and fireweed are important forage plants after bloom (Table 3). Emergence of *Bombus vagans* males and new queens is shown in Fig. 1 as well as the decline (demise) of the worker bees.

RECOMMENDATIONS: Much new information as been gathered about the phenology and biology of our native bumble bees, but there are still major gaps in our knowledge, which need to be filled. The importance of forage plants before and after bloom has been demonstrated by the fact that queens emerge before bloom and that workers, males, and new queens emerge after blueberry bloom. Growers should encourage the presence of alternate forage such as willow, lambkill, golden rod, and meadowsweet along their field borders.

Table 1. *Bombus* phenology (first sighting of each caste) in 1995.

| <u>Date</u> | <u>County</u> | <u>Species</u> | <u>Caste</u> |
|-------------|---------------|--|--------------|
| 4 /25 | Penobscot | <i>Bombus</i> sp | Queen |
| 4/26 | Waldo | <i>Bombus</i> sp. | Queen |
| 4/27 | Waldo | <i>B. ternarius</i> | Queen |
| 5/1 | Hancock | <i>B. ternarius</i> | Queen |
| 5/2 | Knox | <i>B. ternarius</i> , <i>B. vagans</i> | Queen |
| 5/3 | Waldo | <i>B. vagans</i> | Queen |
| 5/8 | Hancock | <i>Bombus</i> sp. | Queen |
| 5/10 | Washington | <i>B. ternarius</i> , <i>B. vagans</i> | Queen |
| 5/14 | Washington | <i>B. fervidus</i> , <i>B. terricola</i> | Queen |
| 5/15 | Waldo | <i>B. terricola</i> | Queen |
| 5/21 | Penobscot | <i>B. ternarius</i> , <i>B. vagans</i> | Queen |
| 5/23 | Waldo | <i>B. ternarius</i> , <i>B. vagans</i> | Worker |
| 5/30 | Knox | <i>B. ternarius</i> , <i>B. vagans</i> , <i>B. terricola</i> | Worker |
| 6/2 | Washington | <i>B. ternarius</i> , <i>B. vagans</i> , <i>B. terricola</i> | Worker |
| 7/11 | Washington | <i>B. ternarius</i> | Male |
| 7/22 | Knox | <i>B. terricola</i> | Male |
| 8/8 | Knox | <i>B. ternarius</i> , <i>B. vagans</i> | Male |
| 9/11 | Penobscot | <i>B. vagans</i> | Male |
| 9/16 | Knox | <i>B. vagans</i> | New Queen |
| 9/21 | Penobscot | <i>B. vagans</i> | New Queen |
| 9/29 | Penobscot | <i>B. terricola</i> | New Queen |

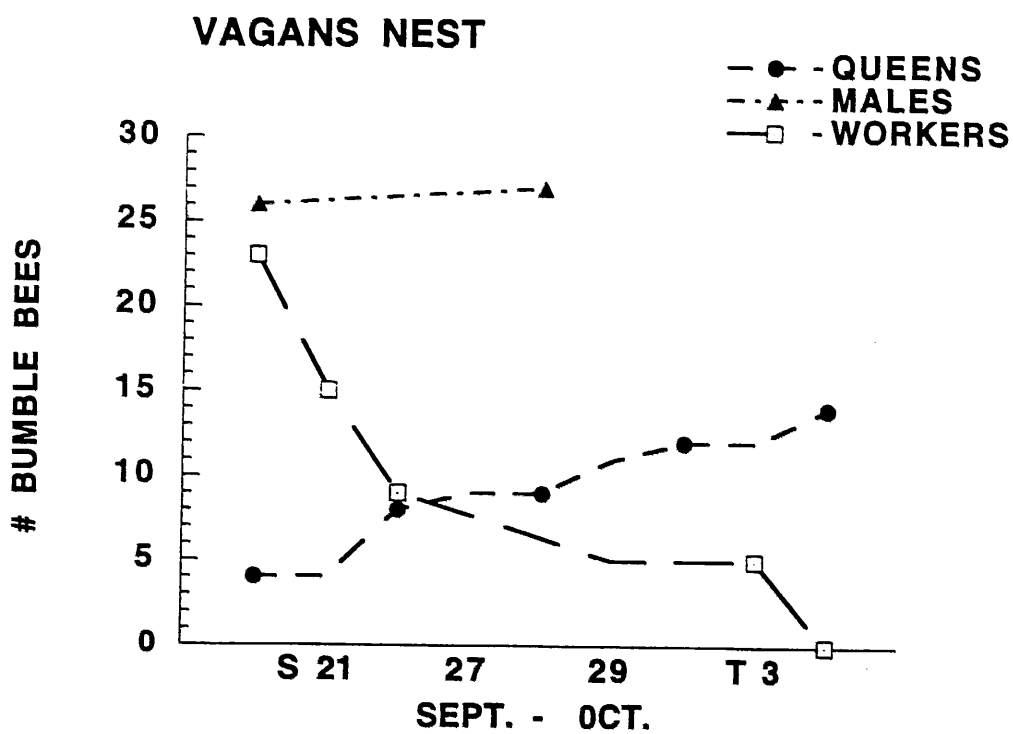
Table 2. Fields with the most bumble bees sighted in a 100 m transect during blueberry bloom.

| <u>Field</u> | <u>Location</u> | <u>Date</u> | <u>Number of Bumble bees</u> |
|---------------|-----------------|-------------|------------------------------|
| Gardener | Gardener Lake | 9 June | 12 |
| Breshnahan | Hope | 30 May | 9 (all Queens) |
| Kelly Bog | Jonesport | 8 June | 9 (2 Queens + 7 workers) |
| Kelly Bog | Jonesport | 16 June | 9 (1 Queens + 8 workers) |
| Cameron Mt.#1 | Lincolnville C. | 30 May | 8 (all workers) |
| Masuco #2 | Jonesport | 6 June | 8 |
| Cameron Mt.#2 | Lincolnville C. | 30 May | 7 |
| Gardener | Gardener Lake | 9 June | 7 |
| Kelly Bog | Jonesport | 9 June | 7 |

Table 3. Malaise trap catches of native worker bumble bees on various wild flowers after blueberry bloom.

| <u>Flower (Common Name)</u> | <u>Scientific Name</u> | <u>Number of bees</u> |
|-----------------------------|------------------------------|-----------------------|
| blackberry | <i>Rubus allegheniensis</i> | 1 |
| butter & eggs | <i>Linaria vulgaris</i> | 1 |
| fireweed | <i>Epilobium americanum</i> | 23 |
| golden rod | <i>Solidago</i> spp. | 1 |
| honeysuckle | <i>Lonicera japonica</i> | 0 |
| lambkill | <i>Kalmia angustifolium</i> | 5 |
| meadowsweet | <i>Spirea</i> spp. | 50 |
| St. John's wort | <i>Hypericum praetense</i> . | 6 |
| yellow clover | <i>Trifolium agrarium</i> | 0 |

Figure 1. The emergence of *Bombus vagans* males, new queens, and the decline in numbers of workers, in Sept. and October, 1995, Penobscot county.



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

3. TITLE: Pollination Ecology of Lowbush Blueberry in Maine

Methods: Objective 1) Increase *Osmia* bee numbers so large field releases can be conducted. Two hundred fifty-seven *Osmia* nests from trap nests produced in 1994 were dissected (127 were from the three Greenfield shelters; 130 from Knox, Washington, and Oxford counties) screened for parasites and disease. A total of 1117 viable cells containing adult bees were available for release. Prior to release a wooden nesting shelter was set up in a 16 acre field in Deblois and 20 nesting blocks were affixed to trees along the perimeter of each field to catch any dispersing bees. Bees were released 18 May when bloom was approximately 3%. Shelters and perimeter nesting blocks were checked weekly to monitor nesting behavior. Emergence trays were collected 16 June and nonemerged cells counted. Nesting materials were collected 4 August. Nesting straws were removed from all nesting blocks in order to assess nest production at both the shelter and in the perimeter nesting blocks.

Objective 2) Compare the pollination efficiency of honey bees, alfalfa leafcutter bees, *Osmia* bees, and bumble bees. Three greenhouse and two field studies were conducted in 1995. *Greenhouse Study 1: Pollen deposition by bumble bees, honey bees, and leafcutters.*-- Cut blueberry stems were placed in floral foam and either honey bees, *B. impatiens*, alfalfa leafcutting bee, or the Maine blueberry bee, *Osmia atriventris* were allowed to visit the flowers. Bees had access to individual stems until at least one flower received 10 visits or 1 hr elapsed. Excised stigmas were examined under a dissecting microscope and the number of pollen grains deposited on the stigma counted. For each set of observations stigmas from three control flowers were also examined in order to determine if handling the flowers resulted in pollen deposition on the stigma.

Greenhouse Study 2: Travel/Trip Efficiency.-- Potted flowering blueberry plants were set up in front of either a honey bee hive, *B. impatiens* hive or an alfalfa leafcutting bee poli surround in the following array: three rows of five pots with each pot spaced 30 cm (~ 12 in.) apart starting at the front of the bee domicile. Number of visits per pot/bee/unit time were recorded for individual bees.

Greenhouse Study 3: The effect of age and stem position on pollen availability.-- Pollen availability was assessed in flowers ranging in age from one to four days. Flower position was also evaluated (top, mid, and bottom of stem). For assessing whether there are differences in pollen availability in flowers of different ages one anther was chosen at random/flower. In order to investigate the effect of position on the stem one anther from a flower at the top, mid, and bottom of an individual stem was chosen. Individual anthers were excised, held with forceps and tapped lightly over a glass microscope slide until no more pollen was released. Then the number of pollen grains released were counted under a dissecting microscope using a grid.

Field Study 1: Effect of pollinators on fruit set, yield, berry weight and seeds/berry.-- Fifteen lowbush blueberry fields located in Washington County were sampled using transects to estimate the absolute abundance of the major bee species. The sampling consisted of three random 100 m (328.3 ft.) length by 1 m (3.27ft.) width transects along the edges of each

blueberry field, three times during bloom. Prior to measuring bee abundance 50 random stems near each transect were marked (10 stem at each sampling station at 20, 40, 60, 80, 100 m (or 65.6, 131.3, 261.6 and 327 ft. respectively), and the number of flowers/stem recorded. The number of honey bees, bumble bees, leafcutters, andrenids, and "other" bees were recorded for each transect for each sample date. In mid-June, after bloom, the number of berries were counted and percent fruit set calculated for each transect. Just prior to commercial harvest in each field, the berries from marked stems were counted and then harvested from each transect. Number of berries, berry weights, and seeds/berry were measured. Linear regression analyses were performed to evaluate the relationships between bee abundance, fruit set, yield, and the number of seeds/berry.

Field Study 2: Foraging behavior of native bumble bees, sand bees (andrenids), and the honey bee.-- Floral visitation time, number of flowers visited per stem, travel distance to the next flower, flower handling time, and whether the bee was collecting pollen, nectar or both were measured.

Objective 3) Evaluate blueberry management practices on native leafcutting *Osmia* spp. populations. From 1992-1994 wooden trap nest blocks were placed in 36 fields (located in Washington, Hancock, Waldo, Oxford, Penobscot, and Knox counties) prior to bloom. After bloom the number of *Osmia* nesting tunnels were counted in each nest block. Both prior to bloom and after bloom, visual estimates of alternative flowering resources in each blueberry field were made. Participating growers (n = 36) were sent a management questionnaire in order to evaluate the effect of cultural practices and field characteristics on native leafcutting bees. Results from the three years of trap nesting data (1992 - 1994) and the responses of the growers to the questionnaire were used to determine if relationships existed between fields with high *Osmia* abundance and the following lowbush blueberry management practices: pesticide use (insecticide, herbicide, fungicide); pruning method; irrigation; fertilization; use of honey bees; as well as the following field characteristics: size, isolation, availability of alternate forage, yield. We, also, investigated if a relationship existed between bee numbers and yield.

Objective 4) Assess the potential for increasing native leafcutter bee populations in blueberry fields by providing artificial nesting sites. Six blueberry fields were selected in 1993 for this study. In each of 3 fields, 50 wooden trap nests were placed along the field border. No nesting blocks were placed in the three control fields. Prior to blueberry bloom, traps were checked to determine any overwintering changes to the number of completed nest tunnels. At peak bloom, fifteen 10.8 ft² (1 m²) quadrat samples/field and 15 sets of 5 sweeps were taken three times in each field in order to estimate the number of native leafcutter bees (*Osmia* spp.). In September of each year the number of nest produced by *Osmia* spp. were measured as well as the number of straws occupied by other organisms.

In 1995 we also conducted an additional preliminary study to those we proposed. We examined the performance of *Bombus impatiens*, a commercially available bumble bee.

Additional Objective 5) Assess the potential of *Bombus impatiens* as a commercially available alternative to honey bees. Thirty-six *Bombus impatiens* hives, which were rented by Ms. G.

Gaffney were set out in her Stockton Springs blueberry field in three clusters. Each cluster of 12 hives was placed at least 100 yds away from each other. One 120 ft transect was established from each cluster and three stems were tagged and the number of flowers counted at the following distances: 10, 20, 40, 80 and 120 ft. After bloom the percentage fruit set was measured by dividing the number of fruits produced by the original number of flowers/stem. Berries were harvested from stems in late July and berry weights, and number of seeds/berry counted.

A transect was also established at a nearby field (Allens), which was less than 1/4 mi away and that had 24 honey bee hives. One transect was established from the honey bee cluster. The same protocol as described above was carried out for this field. Regression analyses were used to determine if any trend existed between fruit set, berry weight and seeds/berry. Ninety-five percent confidence intervals were estimated to determine if significant differences existed between the two fields for fruit set, berry weight, and seeds/berry.

Observations of foraging behavior were also made on 8 June and 13 June of *B. impatiens* foraging behavior. We recorded type of pollen collected-by color with the assumption that pale yellow pollen was blueberry. Flower handling in terms time elapsed for nectar or pollen collection was also observed and recorded.

RESULTS: Objective 1) Increase *Osmia* bee numbers so large field releases can be conducted. Dissections of nesting straws prior to release indicated that 69.5% of the straws contained bees and 31.5% of the straws with leaf plugs were false nests. A total of 1266 cells were produced and 93.6% contained viable adult bees, 2.1% contained dead bees and 4.3% were non viable cells that did not develop past the egg stage. The average number of bees/straw was 4.6 ± 3.4 /straw (range = 1 - 15 bees/straw). Parasitism was 5.9%. Only 14 non-emerged cells were collected from the emergence trays on 16 June. Overall 98.2% of the bees successfully emerged. Only three females were observed using the nesting materials in the shelter. Twelve new nests were produced at the nesting shelter and 17 in the nesting blocks around the field perimeter. Figure 1 shows nest production in terms of dissected nests for 1994 and 1995. Based the 2 yr average of nests dissected (1994-1995), we project that nine nests will be false, one will be diseased and 20 will contain *Osmia* with 168 viable cells available for release in 1996.

Objective 2) Compare the pollination efficiency of honey bees, alfalfa leafcutter bees, *Osmia* bees, and bumble bees. *Greenhouse Study 1: Pollen deposition by bumble bees, honey bees, and leafcutters.*-- For single visits to flowers, both *Osmia atriventris* and *Bombus impatiens* delivered more pollen grains/single visit than the honey bee (Fig. 2). For multiple visits the mean number of grains deposited decreased for *B. impatiens* and the honey bee. The mean number of pollen grains on control flowers was 1.3 grains. Based on the mean number of grains deposited/min, *B. impatiens* was the most efficient and the honey bee the least efficient (Fig.3).

Greenhouse Study 2: Travel/Trip Efficiency.-- Individuals of all three species tended to visit adjacent pots (patches), but only *M. rotundata* exhibited a tendency to forage on pots closest to their domicile upon first exiting the domicile. The honey bee visited the most number of flowers per m traveled per trip (39.4 in) with 0.1 flowers visited per m (39.4 in) traveled, the alfalfa leafcutting bee visited .07 flowers/m (39.4 in) traveled/trip and *B. impatiens* visited 0.05

flowers/m (39.4 in) traveled/trip from their hive.

Greenhouse Study 3: The effect of age and stem position on pollen availability.-- Flowers at the top of the stem had an average of 350 ± 115 pollen grains, mid stem flowers had 285 ± 137.3 , and basal flowers had 323 ± 90.4 pollen grains per anther. These means were not significantly different ($P = .2938$ ANOVA), which means that whether bees have a preference for visiting lower, mid or top flowers will not affect the number of pollen grains collected. One day old flowers had a mean of 284 grains ± 126.5 grains/anther, two day old flowers had 351.8 ± 117.3 , three day old flowers had 331 ± 90.1 , and four day old flowers had 358 ± 132.7 grains/anther. Flower age did not affect pollen grain availability ($P = .3959$ ANOVA), which means that bees have the potential to collect the same number of pollen grains regardless of flower age.

Field Study 1: Effect of pollinators on fruit set, yield, berry weight and seeds/berry.-- No significant relationship existed for fruit set, nor the number of seeds/berry and the number of bees present. However, as the number of bees increased, berry weight increased (Fig. 4). This relationship was significant at $P < 0.0001$, which demonstrates the importance of having sufficient numbers of pollinators in order to obtain good yields.

Field Study 2: Foraging behavior of native bumble bees, sand bees (andrenids), and the honey bee.-- Both bumble bees (*Bombus*) and sand bees, (*Andrena*) tended to visit 1-2 flowers/stem. Because cross pollination is important in *V. angustifolium*, this is a desired behavior. In contrast, the honey bee visited on average 4 flowers/stem (Fig. 5). Also, both *Bombus* and *Andrena* handled individual flowers much more quickly than honey bees, which suggests they would be pollinating more flowers/unit time in the field. Pollen collection varied among species; 100% of the bumble bees and andrenids observed collected blueberry pollen, whereas 77% of the honey bees collected blueberry pollen.

Objective 3) Evaluate blueberry management practices on native leafcutting *Osmia* spp. populations. In 1992 and 1993 no significant relationships existed between management practices and field characteristics and *Osmia* populations (Table 1). In 1994 there was a significant relationship between insecticide use and *Osmia* populations; nesting populations decreased with increasing insecticide use (Fig. 6). Pruning method did not effect *Osmia* numbers (Mann-Whitney U, $P = .3637$). The importance of native leafcutters on increasing lowbush blueberry yield is shown in Figure 7, which show that as native *Osmia* numbers increased yield increased. Floral surveys indicated that the maximum number of forage plants in flower was four, during bloom 13 and after bloom 22 species. The most important alternate forage plant species, based on their presence in fields that had more than 20% *Osmia* nest production are listed in Table 2.

Objective 4) Assess the potential for increasing native leafcutter bee populations in blueberry fields by providing artificial nesting sites. In 1995, native leafcutter *Osmia* spp. densities were higher in two of three fields that had nesting blocks (Fig. 8). This suggests that in two out of every three fields with blocks provided *Osmia* spp. populations will increase. Nest production increased in one of three of the fields with nesting blocks over 1994 levels. There appears to be competition for nesting sites with other organisms. Utilization of nesting straws by other organisms, especially spiders, increased with the passage of time and this appears to be an

important limiting factor to continued increased nesting by *Osmia* (Fig. 9).

Additional Objective 5) Assess the potential of *Bombus impatiens* as a commercially available alternative to honey bees. Percent fruit set was significantly higher at the field with bumble bees than at the one with honey bees (Figure 10). No relationship between distance from the hive and fruit set, berry weights, and seeds/berry were shown (Fig. 11) for either bumble bees or honey bees. Figure 12 shows that average berry weight and seeds/berry was higher at the bumble bee site, but not significantly so. This, in part, may be due to the small number of samples. Pollen collecting took longer than nectar collecting. Although there was a diversity of alternate forage in the field during bloom, approximately 89% of the pollen appeared to be blueberry that was brought back to the bumble bee colonies.

RECOMMENDATIONS: Our findings for this field season again demonstrate that *Osmia* and other native bees are more efficient than honey bees. No further trap nesting and releases of *Osmia* for population build-up, however, are recommended. Although the bee is an excellent pollinator, it does not appear to have commercial potential. The best approach to using this bee is population build-up within individual growers' fields through habitat manipulation (providing nest blocks and protecting alternate forage.) Growers are advised to provide the alternate forage listed in Table 2. It is important to ascertain the best management practices (based on sound ecological principles) for the nesting blocks in order to maximize native leafcutting population build-up. The preliminary field trial with *B. impatiens* suggests that it is a good pollinator of blueberry. However, more research needs to be conducted at more study sites with a focus on the economics of using bumble bees as compared to honey bees.

Table 1. Effects of management practices and field characteristics on leafcutting *Osmia* populations.

*P ≤ 0.1 indicates a significant relationship.

| <u>Management Practice or Field Characteristic</u> | <u>Year</u> | <u>r²</u> | <u>Probability</u> | |
|--|--------------|----------------------|--------------------|------------|
| Pesticide Use | Fungicides | 1992 | 0.044 | P = .5899 |
| | | 1993 | 0.003 | P = .4419 |
| | | 1994 | 0.001 | P = .5694 |
| | Herbicides | 1992 | 0.000 | P = .8622 |
| | | 1993 | 0.100 | P = .1953 |
| | | 1994 | 0.002 | P = .4778 |
| | Insecticides | 1992 | 0.059 | P = .4984 |
| | | 1993 | 0.100 | P = .2197 |
| | | 1994 | 0.200 | *P = .0331 |
| Fertilizer | 1992 | NA | | |
| | 1993 | 0.000 | P = .4586 | |
| | 1994 | 0.000 | P = .6438 | |
| Field Size | 1992 | 0.000 | P = .9763 | |
| | 1993 | 0.002 | P = .5001 | |
| | 1994 | 0.100 | P = .1721 | |
| Bearing Acres | 1992 | 0.009 | P = .7660 | |
| | 1993 | 0.000 | P = .7822 | |
| | 1994 | 0.000 | P = .7106 | |
| Nearest bearing field | 1992 | 0.015 | P = .7353 | |
| | 1993 | 0.100 | P = .1597 | |
| | 1994 | 0.003 | P = .3547 | |
| Honey bee hives/acre | 1992 | 0.086 | P = .4796 | |
| | 1993 | 0.000 | P = .6956 | |
| | 1994 | 0.200 | *P = .0331 | |

Table 2. Recommended forage plants for enhancing populations of *Osmia* spp.

| <u>Common Name</u> | <u>Genus</u> |
|------------------------|-----------------|
| maple | <i>Acer</i> |
| aster | <i>Aster</i> |
| birch | <i>Betula</i> |
| dogwood, bunchberry | <i>Cornus</i> |
| sheep laurel, lambkill | <i>Kalmia</i> |
| honeysuckle | <i>Lonicera</i> |
| poplar, aspen | <i>Populus</i> |
| cherry | <i>Prunus</i> |
| oak | <i>Quercus</i> |
| willow | <i>Salix</i> |

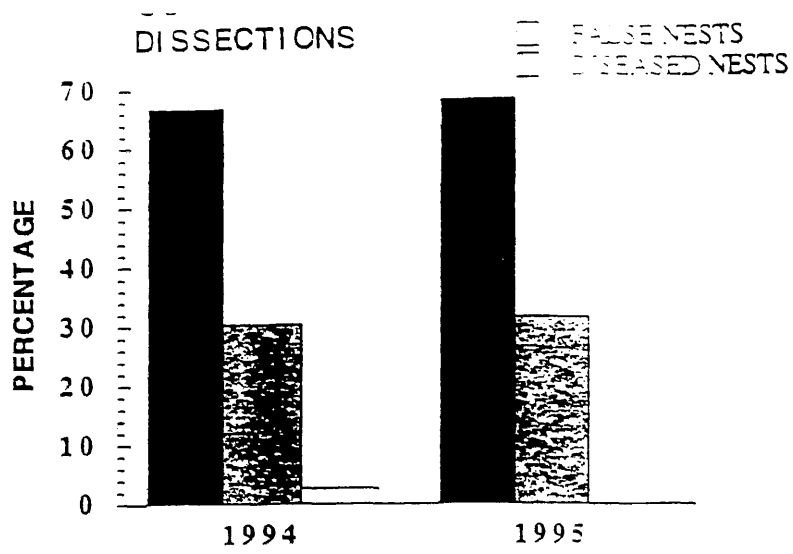


Fig. 1. *Osmia* nest dissections in 1994 and 1995.

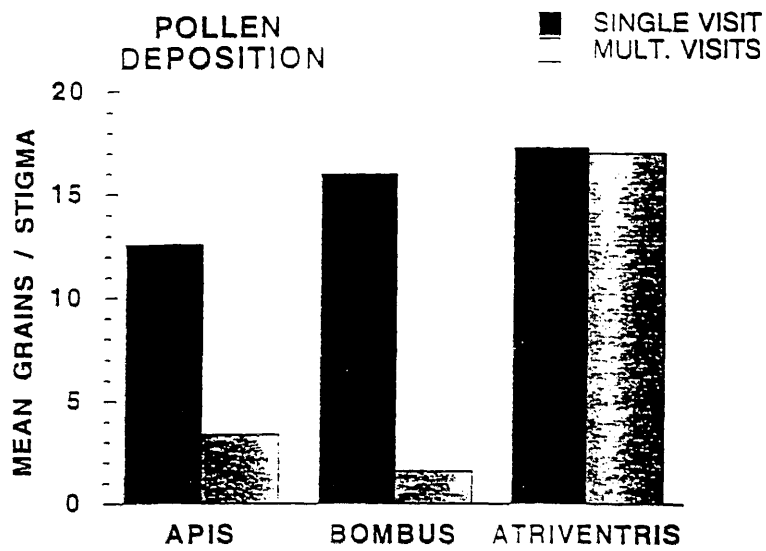


Fig. 2. Pollen grain deposition on stigmas by honey bees, bumble bees, and *Osmia atriventris*.

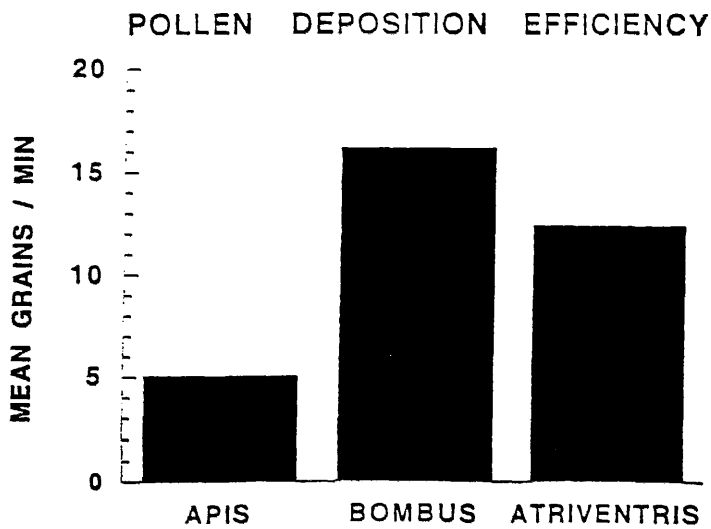


Fig. 3. Honey bee, bumble bee, and *Osmia atriventris* pollen grain deposition efficiency.

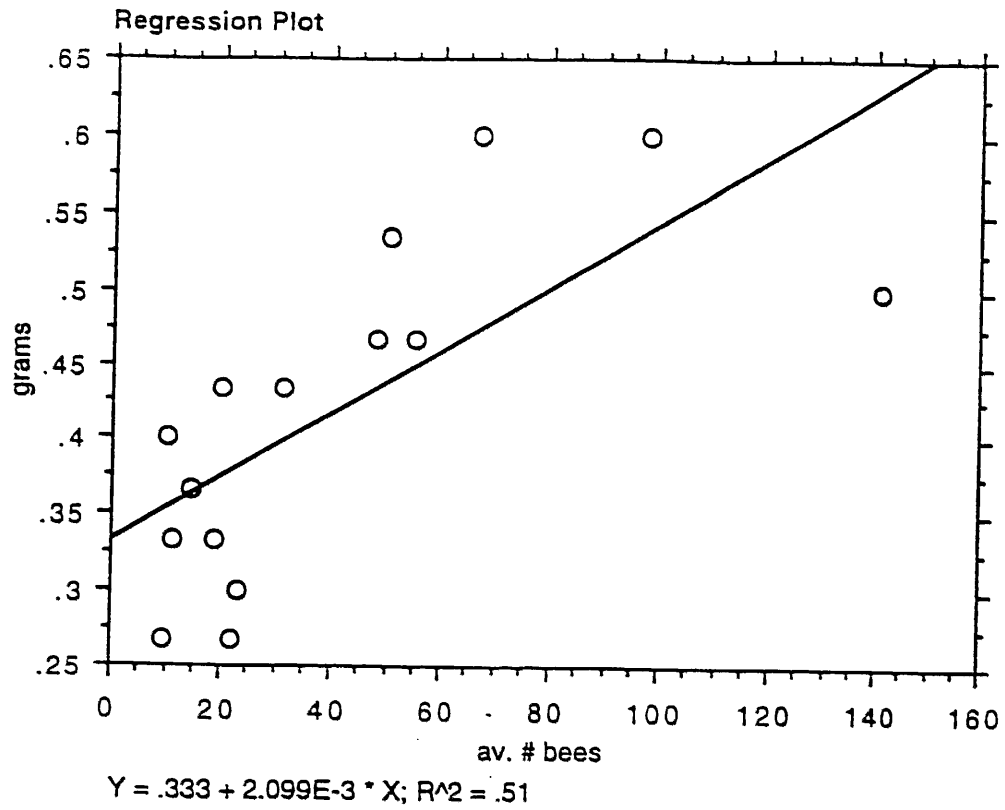


Fig. 4. The effect on bee abundance on blueberry yield.

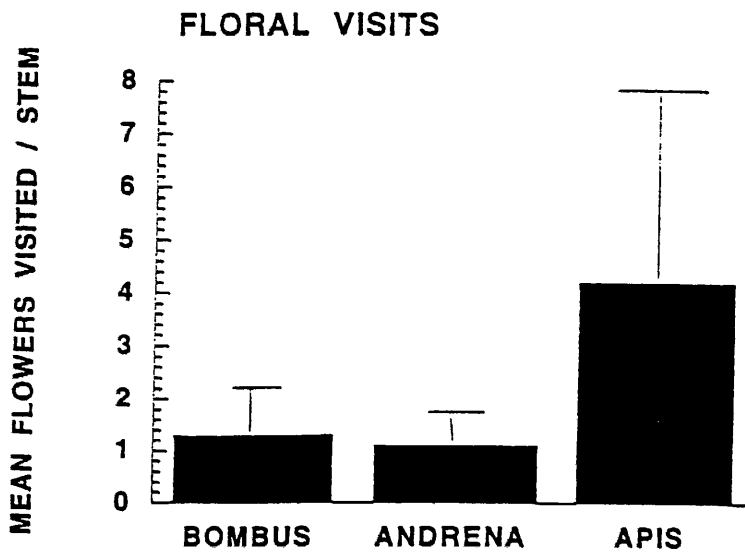


Fig. 5. Flower visitation by bumblebees, sand bees, and honey bees.

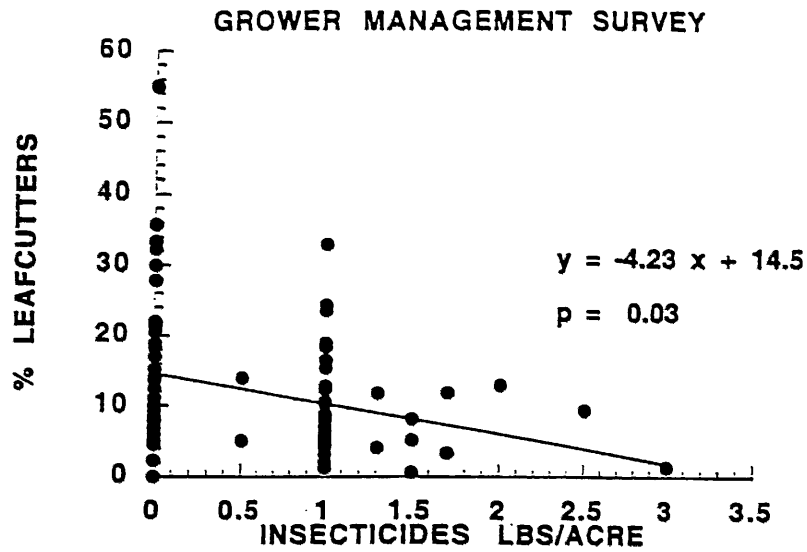


Fig. 6. The effect of insecticides on native leafcutting bees.

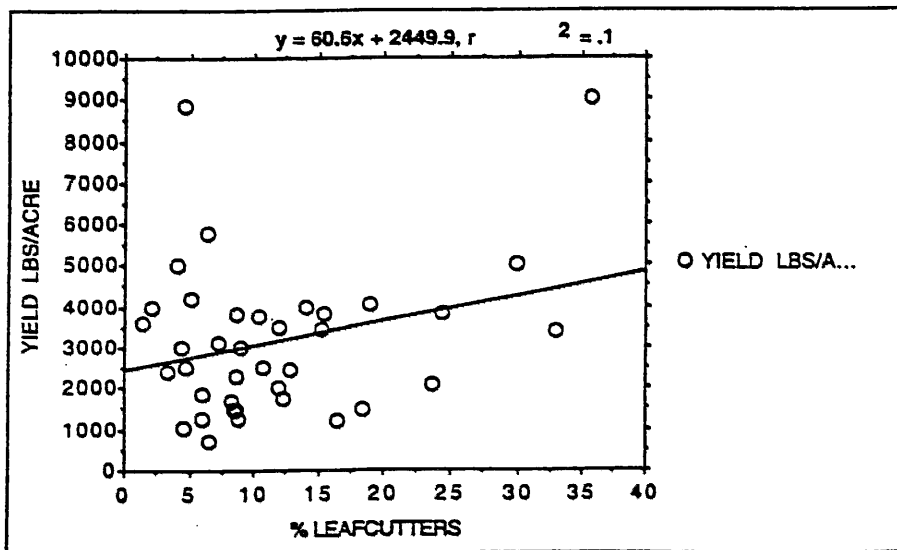


Fig. 7. The effect of native leafcutting bees on blueberry yield in 1994.

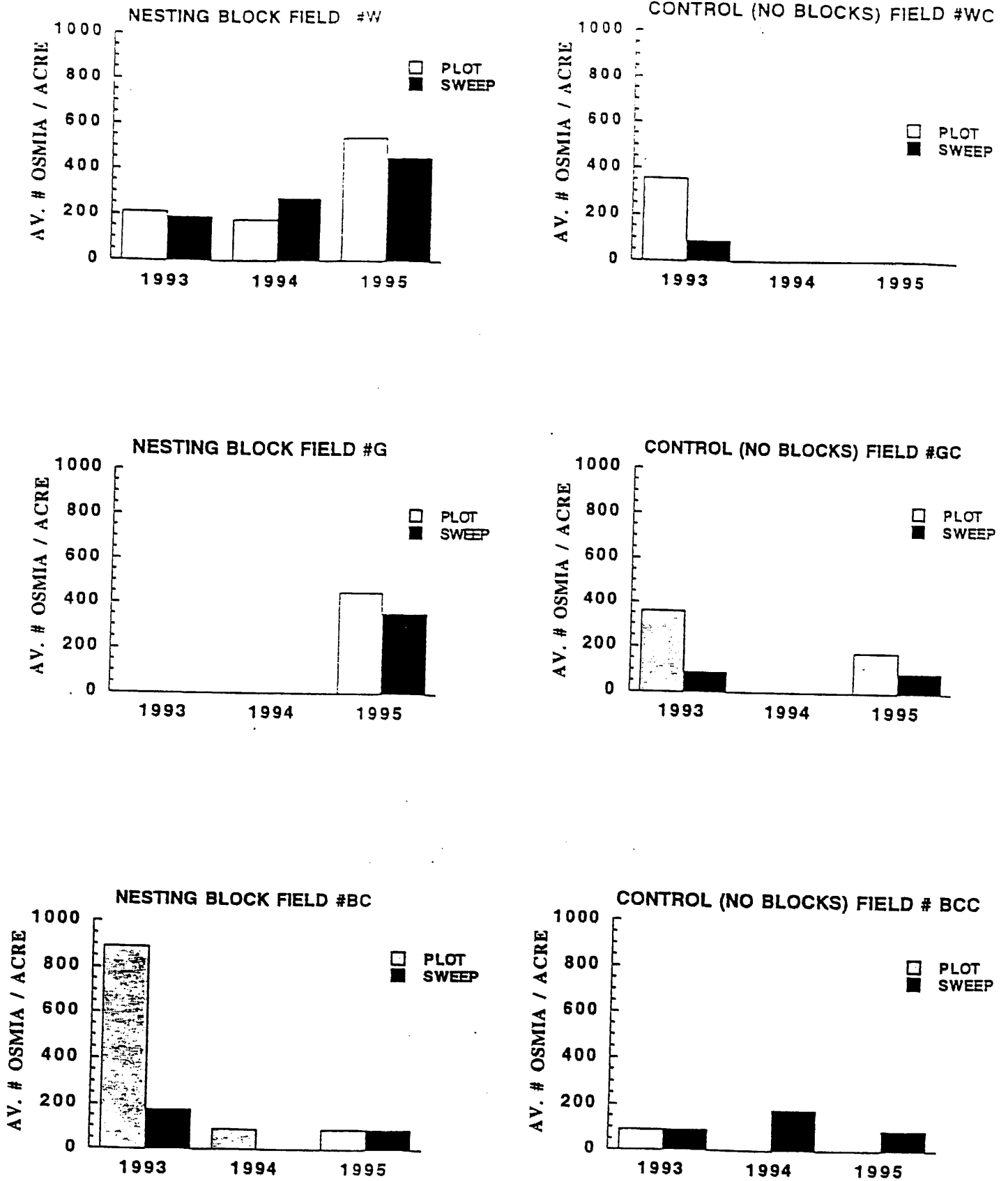


Fig. 8. Population increase of native leafcutting bees in 2 of 3 fields with nesting blocks.

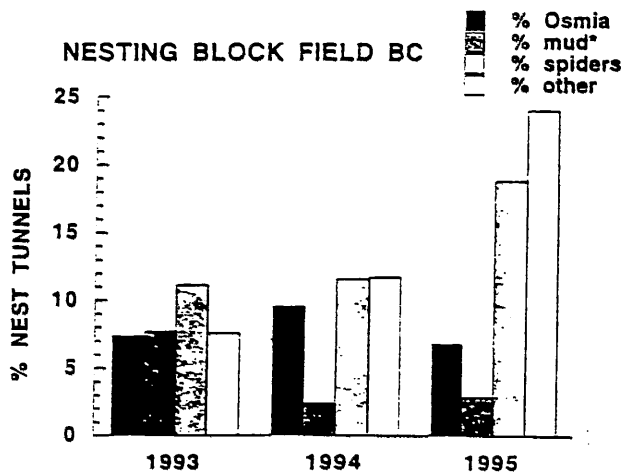
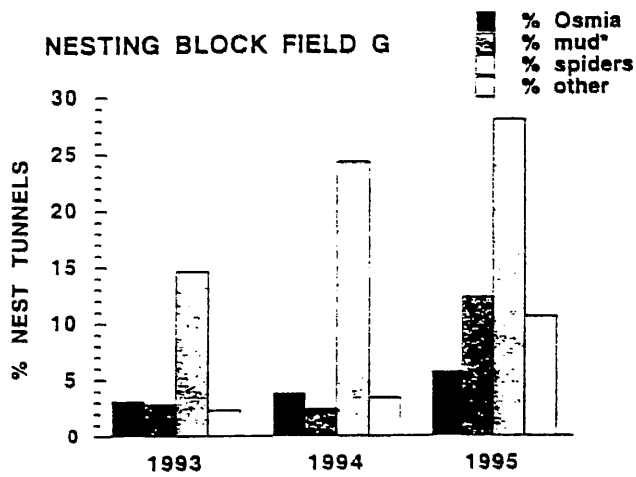
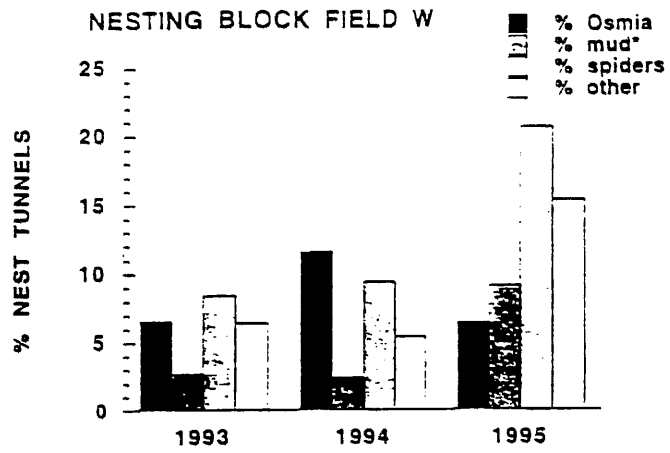


Fig. 9. Increase in nesting block use by spiders and other organisms over time.

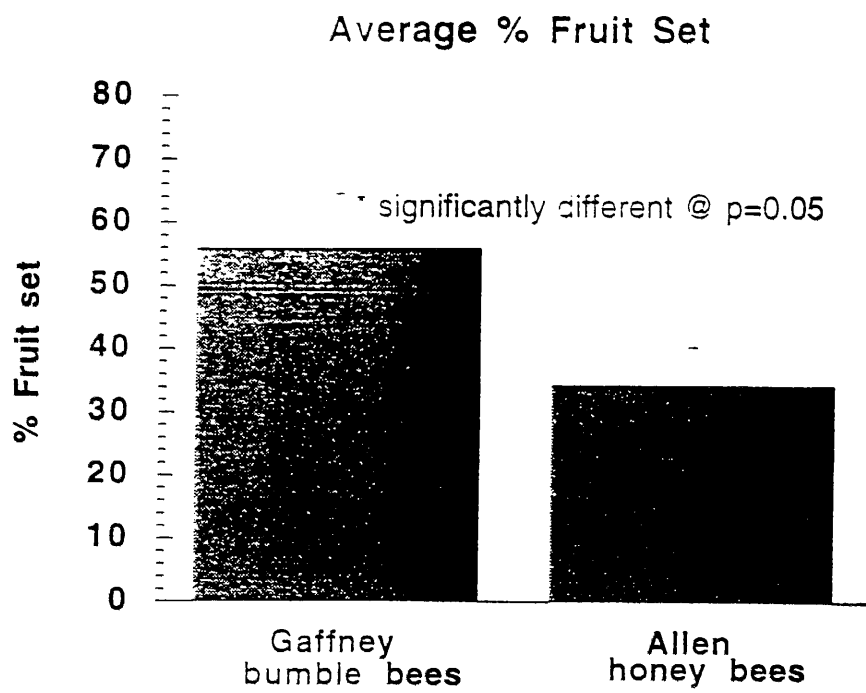


Fig. 10. Average percentage fruit set by *Bombus impatiens* and *Apis mellifera* in two fields in Frankfort.

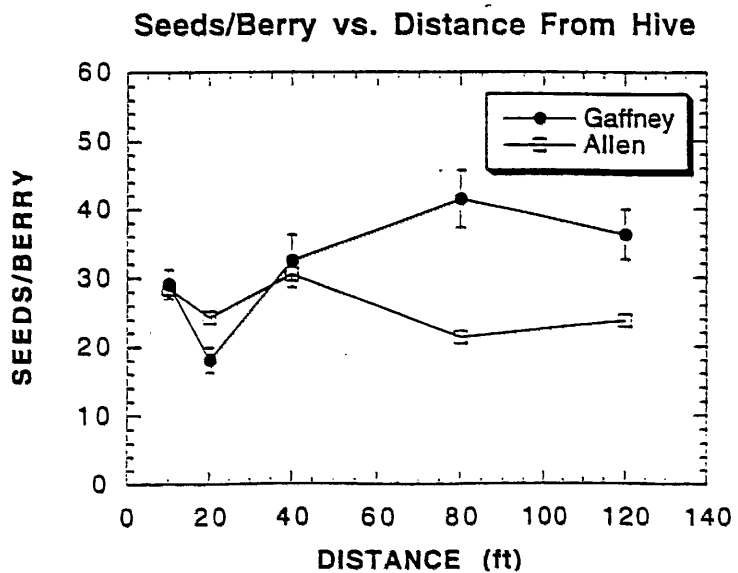
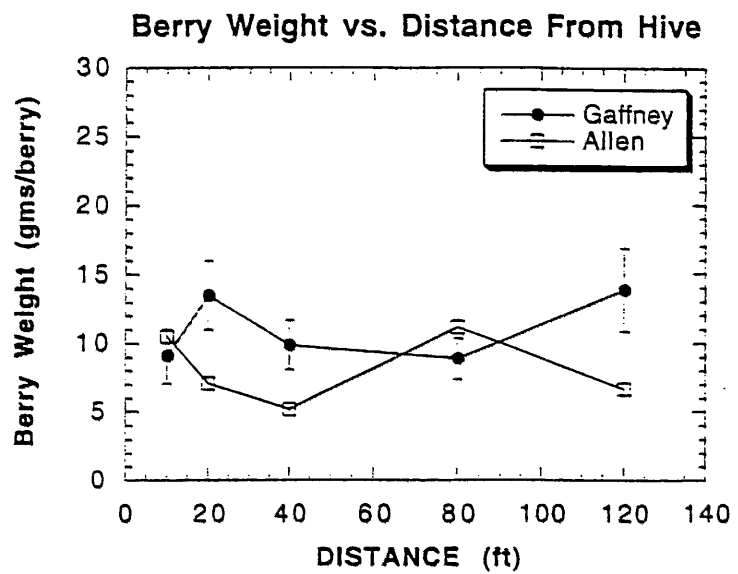
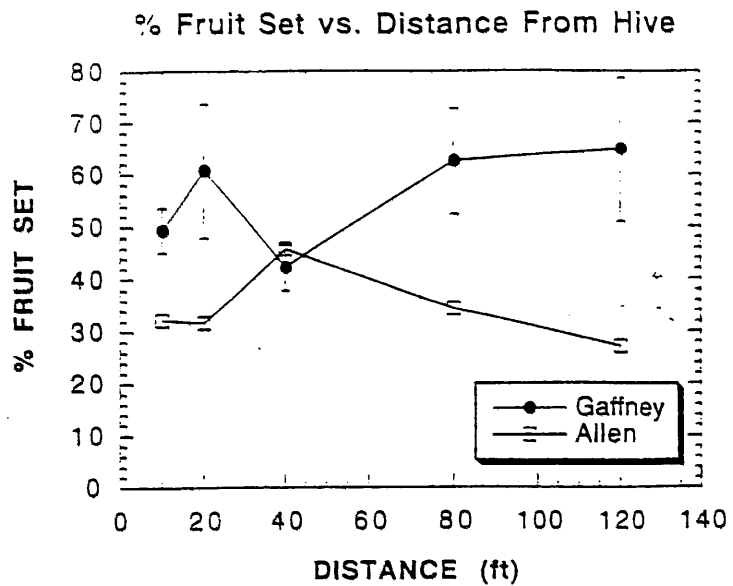


Fig. 11. Percentage fruit set, berry weight, and seeds per berry versus distance from bumble bee and honey bee hives.

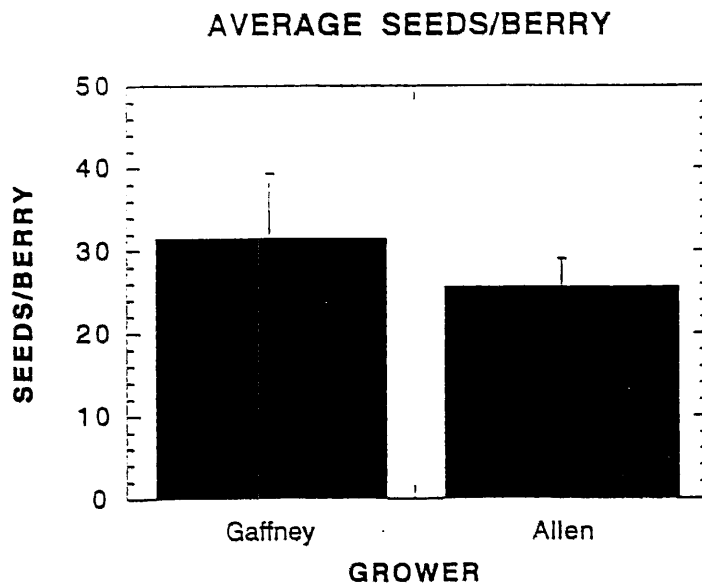
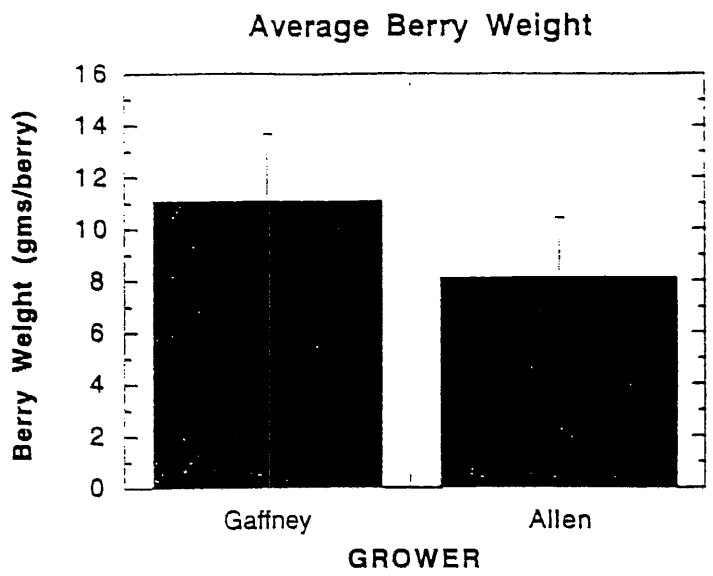


Fig. 12. Average berry weight and seeds per berry at fields with bumble bee and honey bee hives.

C. IRRIGATION

INVESTIGATORS: H. Y. Forsythe, Jr., Professor of Entomology
J. A. Collins, Assistant Scientist

1. TITLE: Effects of Irrigation on Lowbush Blueberry Yield

METHODS:

Eight, 25- by 75-ft plots were established for each of the following treatments.

- A) Control - no irrigation
- B) Irrigation in prune and crop year (1995 & 1996)
- C) Irrigation in prune year only (1995)
- D) Irrigation in crop year only (1996)

To reduce the influence of topography, blocks of four adjacent treatments were established and the location of each treatment within a block selected randomly. The amount of rainfall was determined weekly and irrigation was applied to treatments B (irrigation in prune and crop year) and C (irrigation in prune year only). Irrigation was applied at weekly intervals from 24 June to 8 September; the goal was 1-inch of water (irrigation + rainfall) per week. The entire study area was managed as a commercial crop, on a two-year cycle. The area was flail mowed in the fall of 1994. Insect, weed, and disease control and fertilizer application were made to the entire study area when appropriate.

Moisture blocks: Percent available soil moisture was determined by placing one gypsum moisture block in the center of each plot at a depth of 6 inches. Blocks were placed in the field on 10 June. Soil moisture was recorded for each plot using a digital soil moisture tester at ca. weekly intervals from 14 June to 21 August.

Blueberry plant growth: Blueberry plant growth and development within each plot was monitored and compared among the four treatments. Plant growth was determined in October by placing six, sq ft frames within each plot. All blueberry stems within each frame were cut, placed in paper bags, brought into the laboratory, and examined to determine stem density, branching, length, and flower bud numbers. Plant growth was then compared among the four treatments.

COMMENTARY ON EXISTING IRRIGATION SYSTEM:

It is important that we discuss some problems we encountered and our observations before stating any conclusions concerning the results from year one (1995) of the irrigation study. In early summer, when an initial investigation of the irrigation plots was undertaken, we found an underground system which, in our opinion as nonengineers, was not designed well for the type of study planned. The underground system developed numerous leaks and the sprinklers were not of the best quality for a research study.

Because of the spray pattern of water from widely spaced sprinklers, we believe that round plots would have been better than square for this study; water can be gauged more accurately from one sprinkler in a round pattern than from eight quarter or half round patterns in a square plot. Measurements of simulated rainfall under the present system would simply be averages with wide variation.

The test site was not leveled adequately before installation of the system. Because of an uneven area, exposure to weather and pressure stresses on both the piping, and more particularly the joints, frequently resulted. This unevenness caused problems with the sprinkler heads; not only were they of differing heights, many were tilted at various directions and degrees.

Numerous repairs of leaks had to be made during the season. Joints and end-caps were frequent casualties, leading to several major leaks necessitating upwards of 50 hours to repair. Some time was also required to repair minor leaks.

Nine plots (just short of one-fourth of the study area) were unusable because of sprinkler heads not receiving water due to holes not being drilled in the feeder pipes. Lack of time prevented further investigation and repair of these feeder pipes.

Many of the sprinkler heads initially supplied for this project did not operate correctly. New sprinkler heads were purchased which enabled all plots to be watered, albeit at different speeds, heights, and pressures.

Additional problems we experienced included a lack of a way to regulate water pressure in the system and a lack of a safety shutoff for the pumps in the event of a leak. Thus the system required constant supervision.

RESULTS AND CONCLUSIONS: Because of the problems and difficulties of the irrigation setup, it was not possible to attain reliable and objective research evidence for the value of irrigation. However, a listing of difficulties and problems does not completely nullify any conclusions; although the conclusions must be very broad.

Moisture blocks: Average available soil moisture for each treatment is in Table 1. Average available soil moisture remained between 85 and 90% for plots receiving ca. 1-inch of water (irrigation + rainfall) per week (Prune only; Crop & Prune). For nonirrigated plots (Crop only; Control), available soil moisture dropped below 70% on 5 and 12 July and again on 21 August. However, the soil did apparently hold moisture fairly well. For example, although no significant rainfall was recorded between 17 June and 14 July (average weekly rainfall = .25 inches), available soil moisture did not drop to dangerous levels (<70%) in nonirrigated plots until some time between 30 June and 5 July.

Blueberry plant growth: Collection of data and analysis of stem samples has not yet been completed; however, stem samples tentatively indicate that the plants in the plots that were irrigated are faring better than those plants not receiving irrigation water. The purchase and use

of moisture blocks also added to our broad observations and conclusions that plants receiving water are doing better.

RECOMMENDATIONS: In spite of the problems, we feel the project is worth continuing for a second season following which yields will be determined. We suspect that the original objective of applying 1-inch of water per week will demonstrate the need for irrigation.

Table 1. Moisture block data summary.

| Treatment | Available Soil Moisture (%) | | | | | | | | | | | |
|--------------|-----------------------------|------|------|------|-----|------|------|------|------|-----|------|------|
| | 6/14 | 6/21 | 6/27 | 6/30 | 7/5 | 7/12 | 7/19 | 7/24 | 7/31 | 8/7 | 8/15 | 8/21 |
| Crop only | 85 | 85 | 85 | 75 | 50 | 30 | 85 | 90 | 90 | 85 | 70 | 47 |
| Prune only | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 90 | 90 | 85 | 85 | 85 |
| Crop & Prune | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 90 | 85 | 85 | 85 |
| Control | 85 | 85 | 85 | 85 | 60 | 43 | 85 | 90 | 90 | 85 | 80 | 53 |

D. COLD TEMPERATURE TOLERANCE

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

1. TITLE: Effect of Brief Warming Treatments on Late Winter Low-Temperature Tolerance of Native Lowbush Blueberry.

METHODOLOGY: On 3/2, 3/31, and 5/1, stems were field collected from each of three clones. Sample stems were sealed individually in glass culture tubes and exposed to one of 4 warming treatments (-5C, +5C, +10C, +15C) for 72 hours. Following this incubation, stem samples were subjected to laboratory low-temperature tolerance analysis. Following freeze stress exposure and a 10-day incubation at 21C, samples were evaluated for damage to flower primordia.

RESULTS: There was no significant clonal difference in LST estimates. All three clones responded similarly to the warming treatments. There was, however, a significant effect of bud position on LST estimates (Fig. 1). On 3/2, there was no significant effect of bud position, however on 3/31, bud #4 showed a significantly lower LST estimate than buds in position 1, 2, and 3. On 5/1, buds in positions 1, 2, and 3 had significantly higher LST estimates than did bud #4. For this reason, all data discussed below represent analysis of bud #4 only.

On all three dates, warming treatment resulted in a significant effect on low-temperature tolerance (LTT) (Fig. 2). Control stems incubated at -5 for 72 hours and not subjected to freezer treatment showed high mortality rates indicating that those stems were damaged during the incubation at -5. A possible explanation for this is that the stems may have warmed sufficiently during processing in the lab that transfer to a -5C chamber may have been too extreme for the tissue to sustain. Future studies will employ initial incubation at +5 followed by gradual temperature decrease to -5C for the 72 hr. incubation.

On each of the three sampling dates, warming regime had a significant effect on lowest survival temperature (LST) estimates (Fig. 2). On each of the dates, the warmest incubation resulted in a significantly higher LST. The greatest difference in LST between the highest and lowest incubation treatments was on 3/31. On this date, the +15C incubated stems had an LST of -9C and those incubated at +5 were able to withstand -24C with no apparent damage to flower primordia. On 5/1 there was only a 3C spread in LST estimates. This is likely due to the nearly complete dehardening of the buds as they approached opening.

RECOMMENDATIONS: The data indicate clearly that 3/31 stems were more susceptible to short-term warming trends than were 3/2 stems. It is likely that this pattern is tied in some way to the depth of bud dormancy at these two dates. A series of studies planned for 1996 will include the following features to investigate any potential interaction of bud dormancy and susceptibility to spring warming: 1) expand 1995 study design to include sampling dates beginning in January and continuing through March; 2) increase from 3 to approximately 6 clones; 3) on each sampling date, collect additional stems from each clone and subject to forcing treatments to assess level of bud dormancy; and 4) alter the -5C warming treatment protocol to eliminate problems noted above.

Figure 1.

Low temperature tolerance of lowbush blueberry buds at different stem positions

| Bud position | Date | | |
|---------------------|----------------|-----------------|--------------|
| | March 2 | March 31 | May 1 |
| 1 | -30a | -21a | -9a |
| 2 | -30a | -21a | -9a |
| 3 | -30a | -24ab | -9a |
| 4 | -30a | -27 b | -12 b |

values within columns followed by the same letter are not significantly different

N=3

Figure 2

Lowest survival temperature of lowbush blueberry buds following artificial warming

| Warming Trt. (C) | Date | | |
|---------------------|---------|----------|-------|
| | March 2 | March 31 | May 1 |
| 15 | -24a | -9a | -3a |
| 10 | -24a | -18 b | -3a |
| 5 | -30 b | -24 c | -6 b |

values within columns followed by the same letter are not significantly different

N=3; warming treatment for 72 hours.

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

2. TITLE: Correlation of Late-winter/Early-spring Cold Hardiness with Date of Flowering

METHODOLOGY: Eighteen clones of *Vaccinium angustifolium* were field collected on 3/24 and subjected to low-temperature tolerance testing in the lab as described previously. Lowest survival temperatures (LST) were determined for each clone on this date. In addition, on two dates during peak of flowering, all 18 clones were assigned classification as either early, mid., or late flowering.

RESULTS: Figure 3 lists the clonal differences in LST estimates for stems of the 18 clones collected on 3/24. There was significant clonal difference in LST with the least tolerant showing an LST of -15C (2 clones) and three clones able to tolerate as low as -30C. Table 1 lists the 18 clones with their flowering time ranking and LST estimates. While there was no strong relationship immediately evident relating higher March cold tolerance with later flowering, there was a statistically significant but relatively weak correlation among the two ($R^2 = 0.31$). This indicates that while there is a tendency for those clones with better late winter cold tolerance to flower later in the season, the relationship is not sufficiently strong to warrant further investigation.

Table 1. Flowering time classifications and lowest survival temperature (LST) estimates for 18 clones of *Vaccinium angustifolium* collected on March 24, 1995.

| | Clone # | | | | | | | | | | | | | | | | | |
|----------|---------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Clone | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| Fl. Date | M | E | E | M | M | M | M | L | L | M | L | E | M | L | E | L | E | L |
| LST (-F) | 11 | 11 | 17 | 23 | 23 | 17 | 17 | 23 | 17 | +5 | 11 | 11 | 11 | 17 | 17 | 11 | +5 | 17 |

=====

each value represents a mean of 3 observations

RECOMMENDATIONS: As stated above, it does not seem advisable at this point to pursue this line of research. The guiding hypothesis for this study was that lateness of flowering could be exploited as a means of field selection of clones with significantly improved late season cold tolerance. The weak nature of the relationship indicated above, indicates that this would not be a more economical method than the more traditional freeze tolerance screening used prior to this study.

Frequency distribution of lowest survival temperature ratings for 18 lowbush blueberry clones collected on 3/24

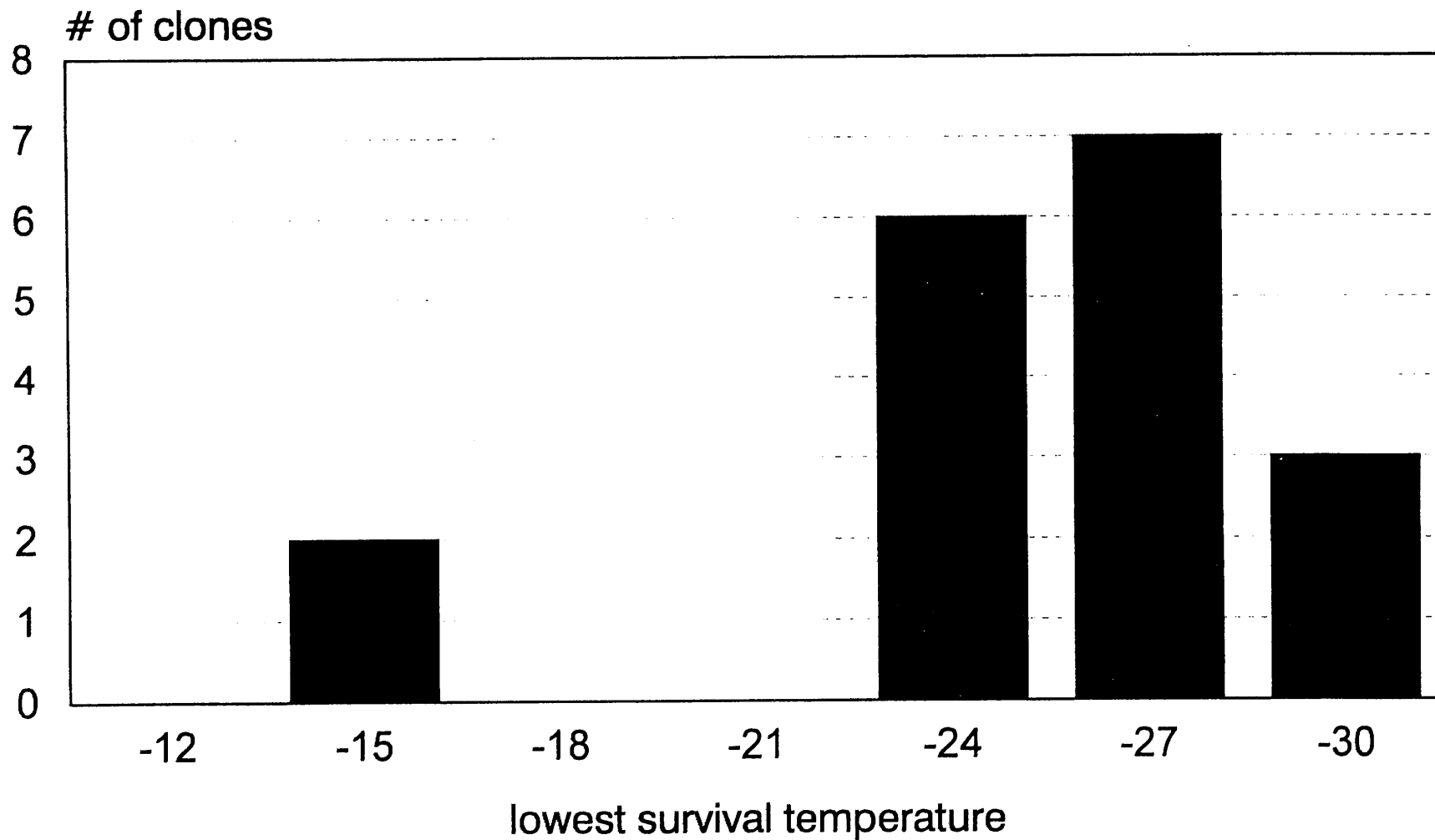


Figure 3

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

3. TITLE: Evaluation of Cold Tolerance of Opening Flowers of Lowbush Blueberry

METHODOLOGY: Twenty eight *Vaccinium angustifolium* clones were selected for evaluation. Sample stems were collected on 5/21. Stems collected had a mixture of buds fully open, partially open, and mostly closed. Stems were seeded with crushed ice and wrapped individually and placed in the freezer apparatus at +3C. The temperature of the chamber was decreased (2C/hour) to a minimum of -6C with three replicate samples removed from the freezer at +1, -1, -2, -3, and -4C. Treated stems were allowed to thaw gradually and were evaluated for damage 48 hours after thawing.

RESULTS: Results of this study are concerned more with methodology and equipment limitations than with the plant material. A major equipment limitation was encountered in that the freeze chamber was not able to maintain sufficient consistency in temperature in order to adequately apply the treatments. The chamber temperature at or around the freezing point tended to fluctuate up to 1C from the set point. Considering the possibility that the plant tissue mass in the freezer was too great for the unit to accommodate, a second run was conducted with 8 clones rather than the original 28 clones. Rather than improving the situation, this exasperated the temperature fluctuation to a maximum of 1.2C from the set point. The study therefore, produced little useable data.

RECOMMENDATIONS: This study has not been selected for continuation for reasons cited above and due to the high expense of additional equipment needed to conduct a more appropriate study. Two proposals have been submitted to other agencies for related projects which require such equipment. Should those proposals prove successful and the equipment purchased, this study will be repeated, however further funds will not be requested for this work.

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

4. TITLE: Influence of Flower Delaying Sprays on Seasonal Variation of Low Temperature Tolerance in Lowbush Blueberry.

METHODOLOGY: Ethrel has been used successfully on several woody fruit crops to delay flowering. This study was conducted to determine if the same effect could be realized on lowbush blueberry and to determine the effect of such treatments on seasonal patterns of cold-tolerance. On each of two September dates in 1994, six clones were treated with 0, 40000, 60000 and 80000 ppm of Ethrel by spraying on leaves to the point of run-off. On 11/9, 2/14, and 4/24, stems were collected from each treatment plot of each clone. Stems were subjected to low-temperature tolerance testing to determine if Ethrel treatment had any affect on the seasonal pattern of cold tolerance.

RESULTS: On each sampling date, Ethrel treatment resulted in a decrease in cold tolerance of flower primordia. The greatest difference in LST estimate occurred in November where there was a 9C difference between the control and 80000ppm-treated stems. In mid February, there was only a 3C difference across all treatments, while in April, only the control stems were able to tolerate the lowest test temperature.

RECOMMENDATIONS: Given the performance of Ethrel treated stems, it is recommended that a final year of study look at a lower range of concentrations. Should this prove to provide no positive results, this study should be discontinued in favor of other more promising studies.

Figure 4

Lowest survival temperature for lowbush blueberry plants treated with Ethrel

| Ethrel Trt. (ppm) | Sampling Date | | |
|----------------------|---------------|---------|----------|
| | Nov. 9 | Feb. 14 | April 24 |
| 0 | -30a | -36a | -9 |
| 40000 | -24 b | -33b | ns |
| 60000 | -24 b | -33b | ns |
| 80000 | -21 c | -33b | ns |

values within columns followed by the same letter are not significantly different.
 ns=no survival at highest test temperature (-6); values represent means of 12 clones.

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

5. TITLE: Effect of Various Levels of Disbudding on Yield of Lowbush Blueberry

METHODOLOGY: In spring, prior to bud swell, three clones with 6 fruit buds each were selected for evaluation. Only clones that displayed no winter damage were used for this study. Within each clone, stems were manually disbudded such that there were 20 stems each with 1, 2, 3, 4, 5, or 6 fruit buds that remained on each stem. At peak flowering, flower number was determined for each bud. In early July, initial fruit set was determined for each bud on each of the stems. Final fruit set, fruit size and total stem yield were determined in mid August.

RESULTS: Of the three clones selected and tagged for the study, two sustained significant early summer damage due to an unidentified disease or physiological disorder. As a result, the following results are based on the one remaining clone. Calculated on a per stem basis, disbudding had a significant effect on blossom number, initial fruit number, and final fruit number (Figure 5). All three factors were significantly reduced with progressive bud removal. The reverse case was true when average fruit diameter and total fruit weight/stem were compared across disbudding treatments (Figure 5). Fruit diameter was greatest on stems with 1, 2, and 3 buds. Total fruit weight/stem was not significantly different on stems with 3, 4, 5, and 6 buds. Only disbudding to leave 1 or 2 buds resulted in a significant loss of yield. Initial fruit set (83%) and final fruit set (53%) were unaffected by disbudding treatment. It appeared from the data that regardless of initial fruit set rate, most stems demonstrated abscission of initial fruit to approximately 50% final fruit set. This may indicate a limited fruit load capacity for lowbush blueberry and may have implications for future work on methods to increase fruit set efficiency.

RECOMMENDATIONS: Based on preliminary results of this partial disbudding (simulated winter injury), it is recommended that this project be continued and expanded to evaluate a larger number of clones. The results have potentially important implications for future work in terms of fruit quality, pollinator efficiency, etc. This expanded work has been proposed and tentatively approved for 1996.

Flowering and fruiting characteristics for disbudded lowbush blueberry plants

Figure 5

| # buds on stem | Flowers/ Stem | Initial Fruit # | Final Fruit # | Fruit Diam. (mm) | Yield/ Stem(g) |
|----------------|------------------|--------------------|------------------|------------------------|-------------------|
| 1 | 6d | 5c | 4c | 6ab | 0.7c |
| 2 | 10c | 9c | 6c | 6.1ab | 0.9bc |
| 3 | 16b | 14b | 8b | 6.5a | 1.5ab |
| 4 | 17b | 15b | 9b | 5.4bc | 1.2abc |
| 5 | 29a | 24a | 15a | 5.2cd | 1.8a |
| 6 | 32a | 24a | 15a | 4.6d | 1.6ab |

values within columns followed by the same letter are not significantly different

E. FERTILITY

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

1. TITLE: Effect of Boron and Calcium on Lowbush Blueberry Fruit Set and Yield

STUDY 1 - B, Ca, B+Ca Study

OBJECTIVES: To determine the effect of fall foliar applications of boron, calcium and a mixture of boron and calcium on lowbush blueberries having low leaf boron concentration.

METHODS: Twelve clones (*V. angustifolium* Ait.) having low leaf boron concentrations (<20 PPM) were selected in a field managed by Northeast Blueberry Company. Within each clone, four 8 ft x 8 ft plots were established and sprayed to the point of dripping with the following treatment solutions on September 20, 1993:

1. Control (water)
2. 400 ppm boron (BORTRAC-1, SHIELD-BRITE Corp.)
3. 4000 ppm calcium (STOPIT-6, SHIELD-BRITE Corp.)
4. 400 ppm boron and 4000 ppm calcium (BORTRAC-1+STOPIT-6)

RESULTS:

ENTRY OF BORON AND CALCIUM INTO STEM/BUD TISSUE

To verify entry of boron and calcium into lowbush blueberry stem and bud tissue, twenty stems were sampled from each treatment plot on November 5, 1993 after leaves had dropped. The top 1.5 inches of stem tissue (including flower buds) were analyzed for boron and calcium concentrations. Foliar application of boron or boron plus calcium raised the stem tissue boron concentrations compared to the control and calcium treatment (Fig. 1). The calcium treatments did not affect the concentration of calcium in the stem tips (Fig. 2); however, it may be worth noting that stems from treatment plots receiving foliar calcium and boron had the highest mean calcium concentration.

POLLEN GERMINATION STUDIES

Boron and calcium are micro nutrients that have influenced fruit set of several crops but the way in which they have their effect is not clear. Is the applied nutrient having its effect on the male part of the flower (pollen) or on the female part of the flower (the stigma/style)? The following two experiments attempt to answer this question.

When the treatment plots were sprayed with the treatment solutions, a 1 ft x 4 ft strip outside each treatment plots was also treated. Two 5 inch sod pieces were taken from each of these strips, placed in 5 inch standard plastic pots, transported to the University of Maine cold storage facility and stored at 37° F for 1,000 hours to satisfy the bud dormancy requirement. In March, the potted sod pieces were transferred to greenhouse conditions for one week and then to a growth chamber where

they blossomed. Two experiments were performed at this time.

The first experiment was designed to determine the effect of boron and calcium treatments on the male part of the flower (pollen). In other words, does pollen from plants with higher levels of boron or calcium have a greater ability to germinate? This study was done *in vitro* (in glass, or out of the living organism). The second experiment tested the ability of higher levels of boron and calcium in the female part of the flower to stimulate greater germination of pollen *in vivo* (within the living organism).

Pollen Experiment I (*in vitro*)

In the first experiment pollen grains were removed from flowers as each clone came into full bloom. Fifteen pollen grains from each treatment subplot were placed on a semi-solid agar solution containing 12% lactose for energy and placed in an incubator set at 72° F. Pollen germination was evaluated after twenty hours. A pollen grain was considered to have germinated if the length of the tube produced by the grain was greater than the diameter of the grain. Pollen germination is presented in figure 3 as the percent of fifteen pollen grains that germinated. Surprisingly, pollen from plants receiving treatments containing boron had a lower percent germination than pollen from the control or the calcium treatment. These data suggest that raising levels of boron in pollen may not be as important to good fruit set of the lowbush blueberry as raising the level of boron in the female flower parts.

Pollen Experiment II (*in vivo*)

To test the importance of having adequate boron in female flower parts to ensure good pollen germination, development and fruit set, a second experiment was initiated. As each clone blossomed, fifteen pollen grains from boron deficient control plot flowers of a different clone were transferred to pollinate the stigma of blossoms from each treatment of the blossoming clone. Ten blossoms were hand pollinated for each treatment. The potted sod pieces were then put back into the growth chamber for three more days to allow pollen germination and growth down the style to the ovary. The style of each treated blossom was removed and given a chemical treatment designed to soften its tissue. The style was then stained with Aniline Blue to make the pollen tubes fluoresce under ultra violet light and thus easier to see and count with the aid of a fluorescent microscope. The effect of foliar treatments with boron and calcium on pollen germination was determined by counting the number of pollen tubes growing into the style. *In vivo* pollen grain germination was calculated by dividing the number of tubes produced by 15, the number of pollen grains transferred. The styles from boron deficient control plot flowers had a significantly lower number of tubes produced than any other treatment (Fig. 4). These data suggest that boron and calcium nutrition is perhaps more important as it effects the female flower parts, the stigma, style and ovary than the male flower parts, the pollen. Having an adequate boron or calcium concentration in the female flower parts does, however, influence the germination and growth of the male pollen tetrad which will fertilize the egg and influence fruit set and berry development.

BLOSSOM/FRUIT CHARACTERISTICS

Twenty stems were tagged in each treatment plot in April 1994 to determine the effect of foliar boron and calcium treatments on fruit set and berry characteristics. Only stems with a specific number of flower buds were used to reduce treatment response variability among stems due to the number of buds. Stems with four flower buds were tagged in treatment plots in 10 clones and due to a scarcity of these stems in the two remaining clones, stems with only three flower buds were chosen. As flower buds began to open, winter injury damage was noted in the plots and some of the tags were transferred to stems on which all flower buds were swelling and no winter injury was apparent. Blossoms produced at each bud were counted on all tagged stems in late May. In August, before plots were harvested, tagged stems were cut, carefully placed in plastic bags with their tags and transported on ice to Orono where they were stored in a freezer for subsequent fruit number, fruit set (number of fruit/total number of blossoms), fruit diameter, fruit weight, and fruit color measurements.

The number of flowers and fruit that developed at each bud position averaged across all treatment plots and clones (Fig. 5) indicated that the terminal bud produced the fewest blossoms and fruit, but fruit set was the same at each bud (66 to 68%). On average, each bud had 4.7 flowers and produced 3.2 berries. Ca treatment reduced the number of blossoms and fruit per bud compared to the stems in the control plots (Fig. 6). While B treatment slightly reduced the number of fruit produced per bud, there was no effect of any treatment on fruit set (Fig 7). Calcium treatment slightly increased the diameter and weight of individual berries (Fig.8).

SEED COUNT

Successful pollination leads to fertilization of the egg cell in the ovary of the flower and the development of seeds (Fig. 9). As seeds develop they produce growth regulators that stimulate the flower to develop into the fleshy part of the fruit.

To determine if foliar boron or calcium treatments influenced pollen germination, pollen tube development and ultimately fertilization of the eggs in the ovary, seeds were extracted from fruit that developed at the third bud. Preliminary studies indicated that seed number and size distribution was similar among fruits from all buds. For practical reasons, only fruit developing at bud three of ten randomly selected stems from each treatment plot were evaluated. Extraction was done on an individual berry basis so correlations can be made between berry diameter and weight and seed number and seed size. When seeds of varying sizes were germinated to determine their viability or ability to germinate, only seeds with diameters greater than .6mm² had germination percentages of 50% or above (Data not shown).

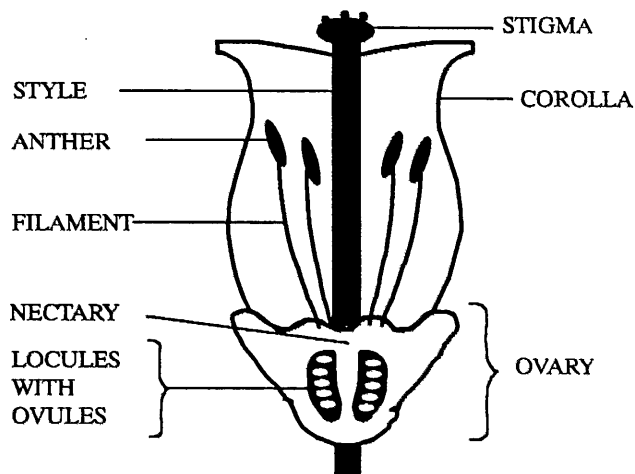


Figure 9

There was a significant correlation between both berry diameter and weight and the number of seeds per berry (Table 1). The correlation was stronger between both berry diameter and weight and the number of seeds with seed area greater than 0.6 mm² than the number of total seeds per berry. The larger the seed area, the stronger the correlation. Averaged across all treatments, the greatest coefficient of correlation (R=0.572) was found with the correlation between berry diameter and the number of seeds with and the number of seeds with an area greater than 0.8 mm². Boron and Ca treatment had a significant influence on seed number per berry (Table 2). The number of total seeds per berry and the number of nonviable seeds (<0.6mm²) per berry were increased by B treatment, however, the number of viable seeds per berry was not affected. Ca treatment also resulted in an increased number of nonviable seeds per berry. The B and Ca treatments seem to be affecting the pollination process with an increased number of ovules being fertilized but the plants during this particular growing season were unable to sustain the development of the seeds to full maturity.

YIELD

Winter injury was a major problem in this field and may have affected treatment plots differently and resulted in inconsistent yield response to the boron and calcium treatments (Fig. 10). While some clones seemed to respond positively to boron and calcium treatments (clones 4,5,6), others seemed to respond negatively (clones 9,10,12). Averaged across all clones, yield of fruit/plot, expressed as kg/ha, was decreased by Ca treatments (Fig. 11) but this could have been due to the random effect of winter injury to the plots because this was not found when weight of fruit produced on tagged stems is used to measure yield (Fig. 12). Perhaps a clearer picture of how the treatments would have influenced yields without winter injury is seen by looking at the weight of fruit produced per stem, since only stems without winter injury were tagged. No effect of treatment was found when yield was determined on a stem basis.

BLUEBERRY FIRMNESS

Calcium is a micro nutrient that is found in the material holding plant cells together and is therefore thought to be important in fruit firmness. Blueberry firmness was measured using an Instron Universal Testing Machine (Model 1122) in the Department of Food Science and Human Nutrition. Preliminary tests indicated greater sensitivity in measuring firmness of fresh berries could be achieved if a single layer of uniform-sized berries were pressed through the Instron's sheer plate. The resistance to being squeezed through the sheer plate indicates berry firmness. Therefore, berries harvested from each treatment plot were presorted to provide a subsample of uncrushed berries with a 7 to 9 mm diameter. Thirty five grams of fruit provided a single layer of berries on the bottom of the sheer plate. Firmness (grams of force) was determined from the compression peak height recorded. The berries from the boron treatment proved to be less firm than from other treatments (Fig. 13).

BLUEBERRY FRUIT CHARACTERISTICS

The following tests were run in triplicate using one-hundred gram blended fruit samples from each treatment plot, with the exception of elemental analysis which was run on one sample.

Elemental Analysis

A two-gram blended sample of blueberries from each treatment plot was dry ashed, taken up in HCl and analyzed for nutrient elements, using plasma emission spectroscopy in the University of Maine Analytical Laboratory. Boron concentrations were raised in fruit samples from treatment plots receiving foliar boron and calcium application (Fig. 14) , but fruit calcium concentrations were unaffected by treatments supplying calcium (data not shown).

Titrateable Acidity

To determine the effect of foliar boron and calcium treatments on fruit acidity , a mixture of ninety milliliters of water and ten grams of blended berries was titrated with drops of .1N NaOH to achieve a pH of 8.1. The number of milliliters needed to reach the desired pH was used to calculate the titrateable acidity. There was no effect of any treatment on fruit acidity (titrateable acidity) which ranged from .51 to .52 % (expressed as citric acid).

Soluble Solids

A refractometer was used to estimate the sugar content of a mixture of two grams of blended berries and eight milliliters of water. Soluble solids of fruit ranged from 10.3 to 10.7% and was not affected by treatments.

Sugar/Acid Ratio

The sugar/acid ratio was measured by dividing soluble solids by titrateable acidity. This ratio changes at different stages of berry ripeness and therefore is useful in determining an effect of treatments on berry ripeness. Boron and calcium treatment had no effect on the sugar/acid ratio.

STUDY II - Source Study

OBJECTIVES: Experiment 1- To compare response of clones with different boron concentrations to two sources of boron.

Experiment 2 - To evaluate the response of clones with different boron concentrations to two sources of boron plus calcium.

METHODS: Six clones were selected at the same field owned by Northeast Blueberry Company. Two clones had adequate boron levels (24 ppm), two with low boron levels (20 ppm), and two with very low boron levels (15 ppm). Each clone was divided into four treatment plots (2 sets of paired plots). The first set of paired plots received treatments comparing boron sources (Solubor at 400 ppm boron vs BORTRAC-1 at 400 ppm boron). The second set of paired plots received treatments comparing boron plus calcium sources (Sorba-Spray CAB at 400 ppm boron and 4000 ppm calcium vs a combination of BORTRAC-1 and STOPIT-6 at 400 ppm boron and 4000 ppm calcium). A foliar

application of these treatments was applied on September 22, 1993.

RESULTS:

ENTRY OF BORON AND CALCIUM INTO STEM/BUD TISSUE

Experiment 1 - boron sources

Twenty stems were sampled from each treatment plot on November 5, 1993 to assess effectiveness of sources of foliar boron in raising stem/bud tissue boron concentrations. The top 1.5 inches of stem tissue (including fruit buds) were analyzed for boron concentrations. The source of boron had no effect on stem/bud tissue boron concentrations or on crop year leaf tissue (Fig.15).

The leaf boron concentrations before and after treatment and the stem boron concentrations after treatment for each clone is illustrated in figure 16.

Experiment 2 - boron plus calcium sources

Stems samples from treatment plots receiving two different sources of a combination of boron and calcium had comparable concentrations of boron and calcium (Fig.17). The variation among clones of leaf boron concentrations before and after treatment and the concentrations in stem tissue after treatment is presented in figure 18.

BLOSSOM/FRUIT CHARACTERISTICS:

Twenty stems in each treatment plot were tagged in April 1994. To eliminate differences due to number of fruit buds per stem, stems with four fruit buds were tagged in five clones and stems with two fruit buds per stem were tagged in the sixth clone. Blossom counts were made in May for use in determining fruit set. Before plots were harvested in August, tagged stems were cut, transported on ice and stored in a freezer for determination of fruit number, fruit set, fruit diameter and fruit weight. There was no effect of boron source (Bortrac vs Solubor) on number of blossoms or fruit per stem (18.7 vs 18.9 blossoms and 11.4 and 11.9 fruit), fruit set (59 vs 61%), fruit diameter (7.53 vs 7.45mm) or fruit weight (0.24 vs 0.23g).

Similar results were found comparing sources of a combination of boron and calcium. There was no effect of source (Bortrac + Stopit vs Sorba spray) on number of blossoms or fruit per stem (18 vs 18 blossoms and 10.7 vs 10.5 fruit), fruit set (58 vs 57%), fruit diameter (7.78 vs 7.92 mm) or fruit weight (0.27 vs 0.27g).

YIELD:

There was no effect of difference sources of boron or sources of boron plus calcium on yield expressed on a plot basis (Fig. 19) or on a per stem basis (Fig.20). It appears that the treatments providing only boron had higher average yields for the six clones in this study, however, due to the experimental design used (paired plots) the plots receiving boron can not be statistically compared to the plots receiving boron plus calcium.

CONCLUSIONS: Boron deficiency, detected by leaf tissue analysis can be corrected by fall foliar B application. In these experiments, B increased the *in vivo* pollen germination on the stigma but not *in vitro* pollen germination. This suggests that the B treatment was more effective in stimulating pollen germination by increasing the B concentration in the female flower parts, the stigma, style and ovary, rather than in the male flower part, the pollen. That more seeds began to develop when B deficiency was corrected suggests a potential for increasing yields under the right growing conditions. Additional studies are needed to test this hypothesis.

RECOMMENDATIONS: No recommendations can be made until additional studies verify a positive response under field conditions.

Figure 1 STEM TIP BORON CONCENTRATION

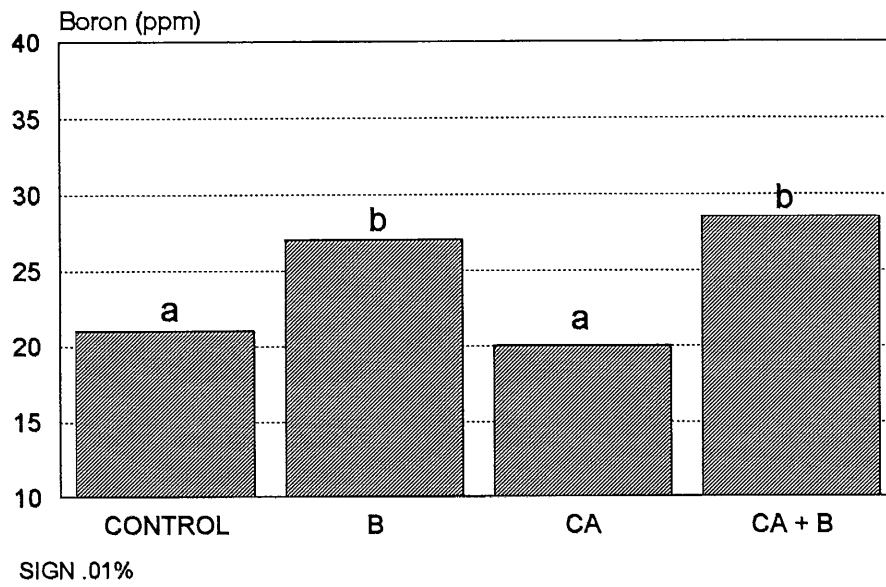


Figure 2 STEM TIP CALCIUM CONCENTRATION

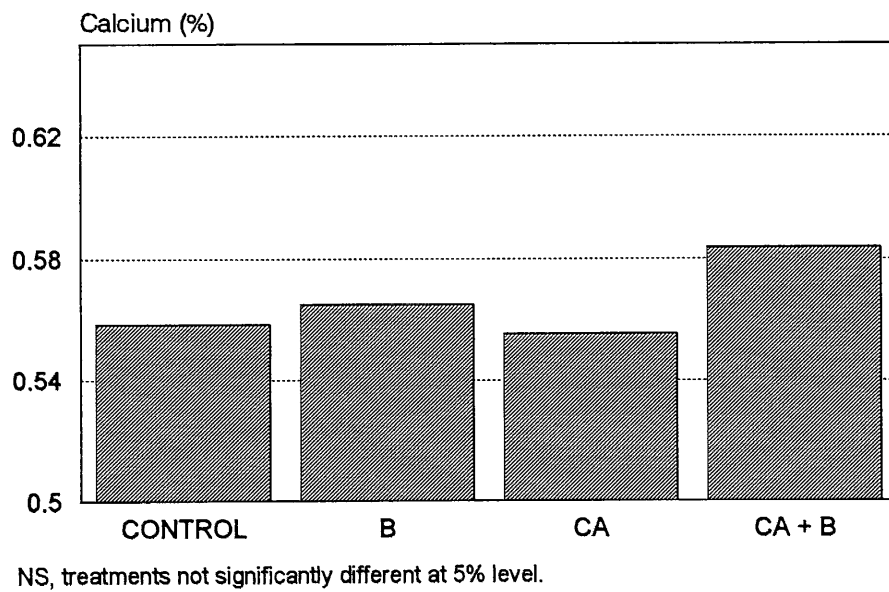
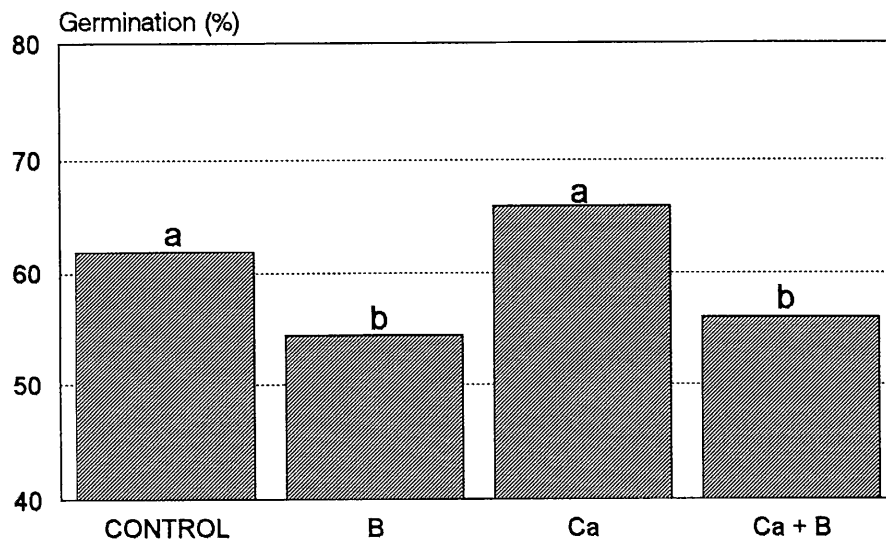


Figure 3

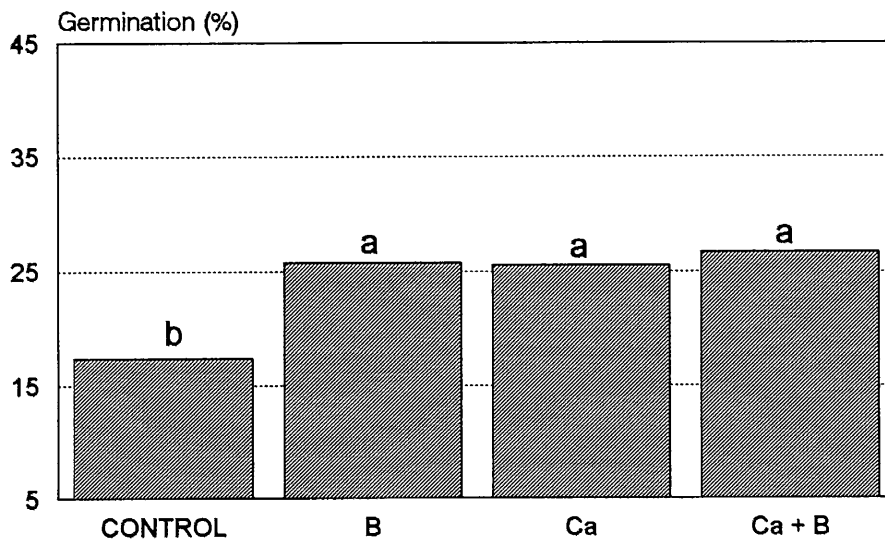
POLLEN GERMINATION in vitro*



* Pollen germinated on agar
SIGN 1%

Figure 4

POLLEN GERMINATION in vivo*



* Pollen germinated on flower stigma,
SIGN 5%

Figure 5

BLOSSOMS AND FRUIT PER BUD

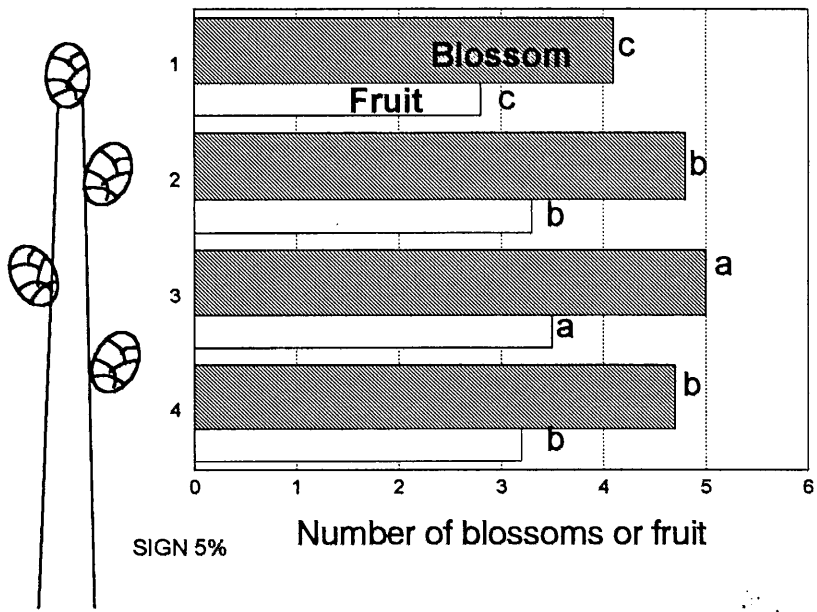


Figure 6

FRUIT SIZE AND WEIGHT

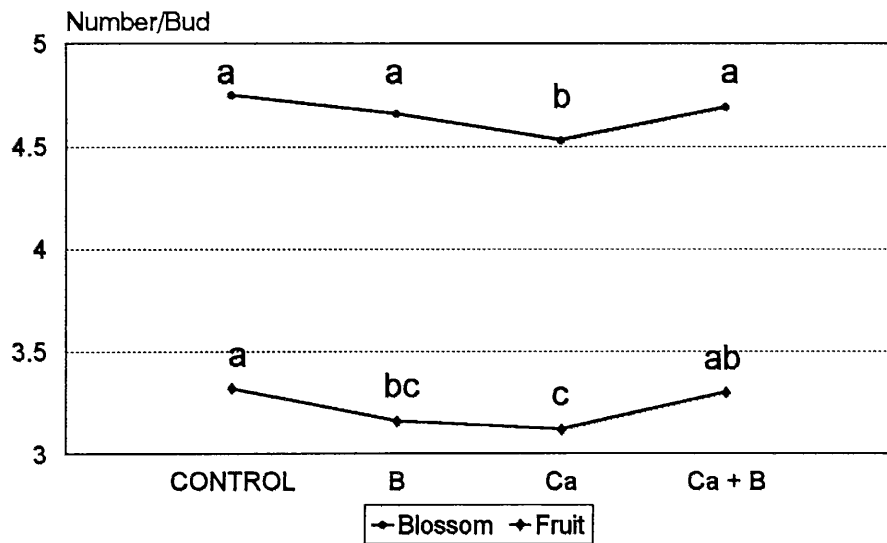


Figure 7 EFFECT OF B AND Ca ON FRUIT SET

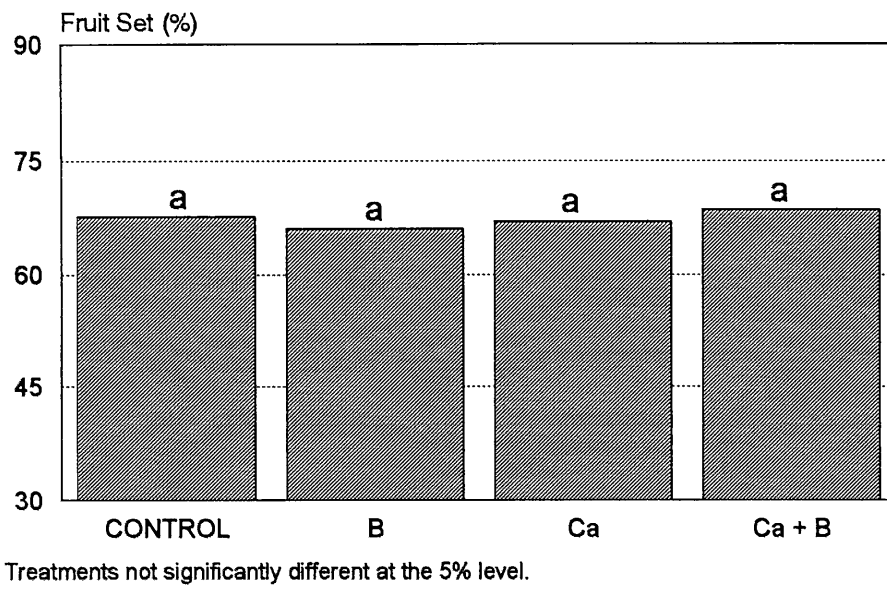


Figure 8 FRUIT SIZE AND WEIGHT

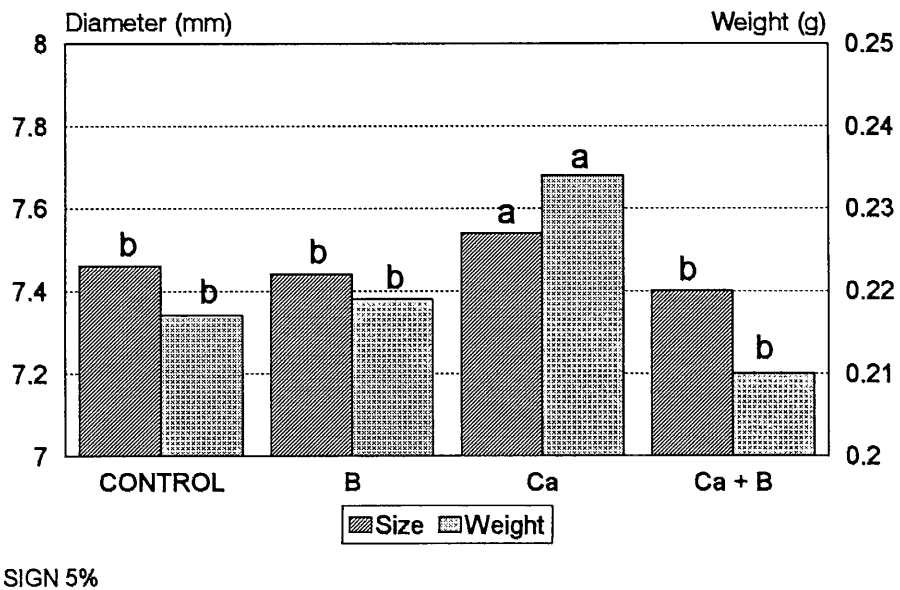


Table 1. Correlation of the number of total seeds and different-size seeds per berry with the berry diameter and weight for *Vaccinium angustifolium* Ait..

| Seed size | Coefficient of correlation (R) | |
|-------------------------|--------------------------------|--------------|
| | Berry Diameter | Berry Weight |
| Total seed | 0.358 ^z | 0.280 |
| Area>0.6mm ² | 0.499 | 0.434 |
| Area>0.7mm ² | 0.526 | 0.471 |
| Area>0.8mm ² | 0.572 | 0.528 |

^z Each R represents the correlation between the number of seed and berry diameter or weight from 5 clones tested.

Table 2. The number of nonviable seeds, viable seeds and total seeds per berry of *Vaccinium angustifolium* Ait. as affected by fall foliar applied B and Ca.

| Treatment | Seeds per berry | % seeds per berry |
|-------------------|------------------------------------|-------------------|
| | <i>Nonviable seeds^z</i> | |
| Control | 31.06 b ^x | 72.86 b |
| B(400ppm) | 34.19 a | 74.57 ab |
| Ca(4000ppm) | 34.90 a | 76.98 a |
| B+Ca(400+4000ppm) | 31.49 b | 74.11 ab |
| Average | 32.94 | 74.55 |
| | <i>Viable seeds^y</i> | |
| Control | 11.88 a | 27.14 a |
| B(400ppm) | 11.94 a | 25.43 ab |
| Ca(4000ppm) | 10.17 a | 23.02 b |
| B+Ca(400+4000ppm) | 11.69 a | 25.89 ab |
| Average | 11.49 | 25.45 |
| | <i>Total seed</i> | |
| Control | 42.95 b | -- -- |
| B(400ppm) | 46.13 a | -- -- |
| Ca(4000ppm) | 45.08 ab | -- -- |
| B+Ca(400+4000ppm) | 43.19 b | -- -- |
| Average | 44.43 | -- -- |

^z Nonviable seeds are seeds with seed area less than 0.6 mm².

^y Viable seeds are seeds with seed area greater than 0.6 mm².

^x Each value represents mean seed number averaged across 5 clones from berries of 20 stems with 4 flower buds/stem. Values within columns followed by different letters are significantly different at the 5% level according to Duncan's multiple range test.

Figure 10

YIELD

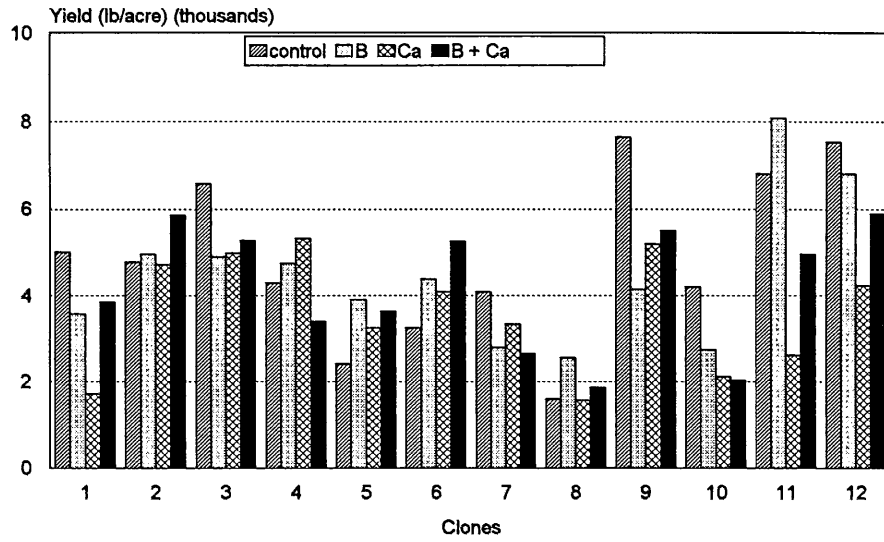


Figure 11

YIELD

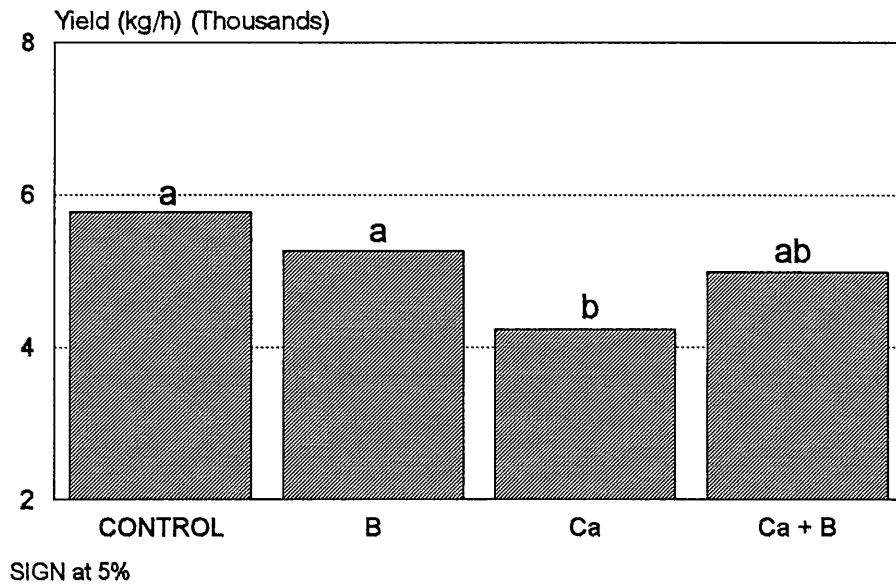
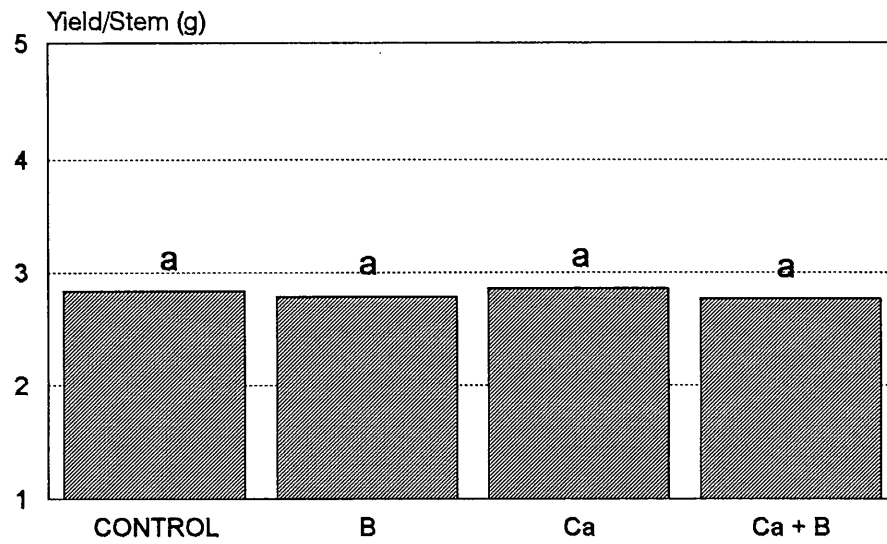


Figure 12

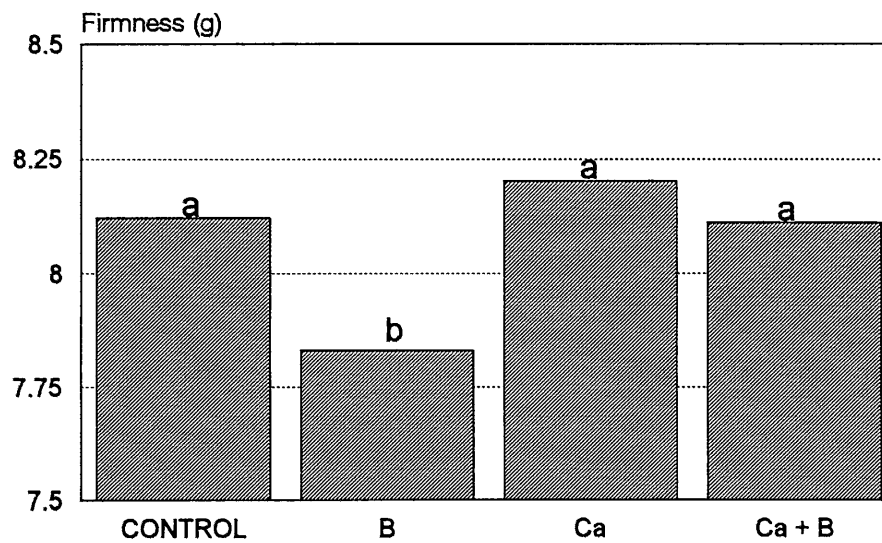
YIELD PER STEM



Treatments not significantly different at the 5% level.

Figure 13

BLUEBERRY FIRMNESS



Firmness expressed as hrams force per grams of berries. SIGN 5%

Figure 14 FRUIT BORON CONCENTRATION

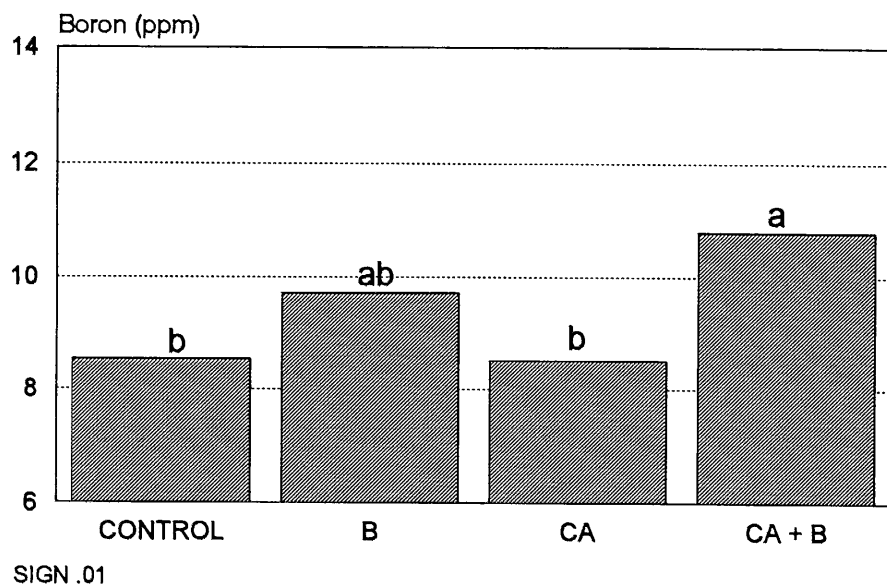
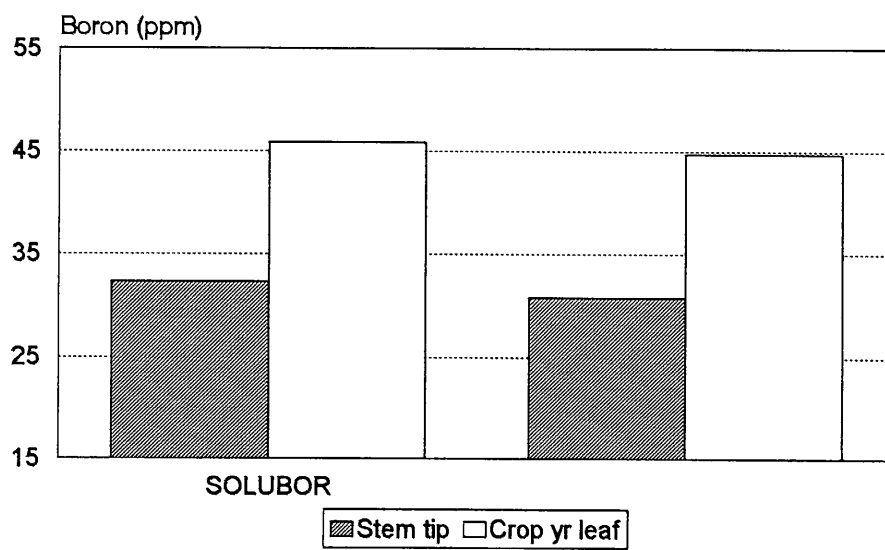


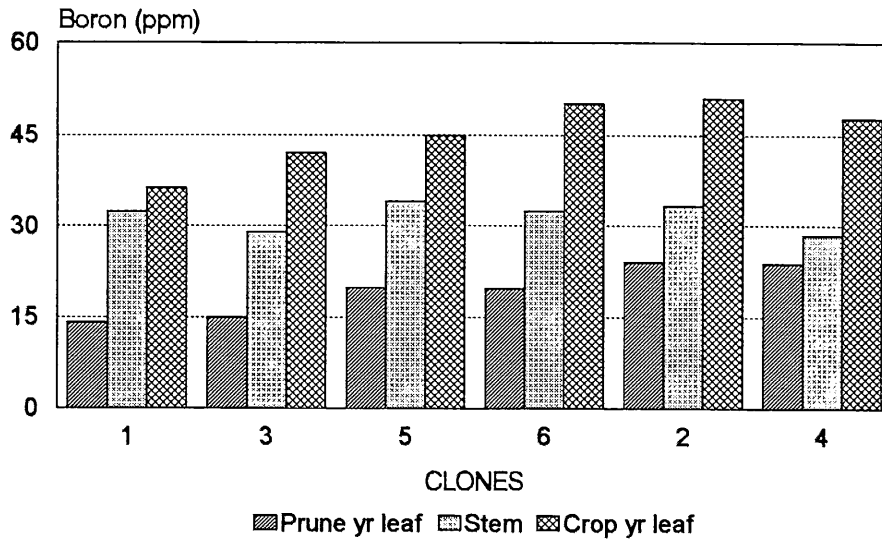
Figure 15 STEM TIP AND CROP YEAR LEAF BORON CONCENTRATION



Treatments not significantly different.

Figure 16

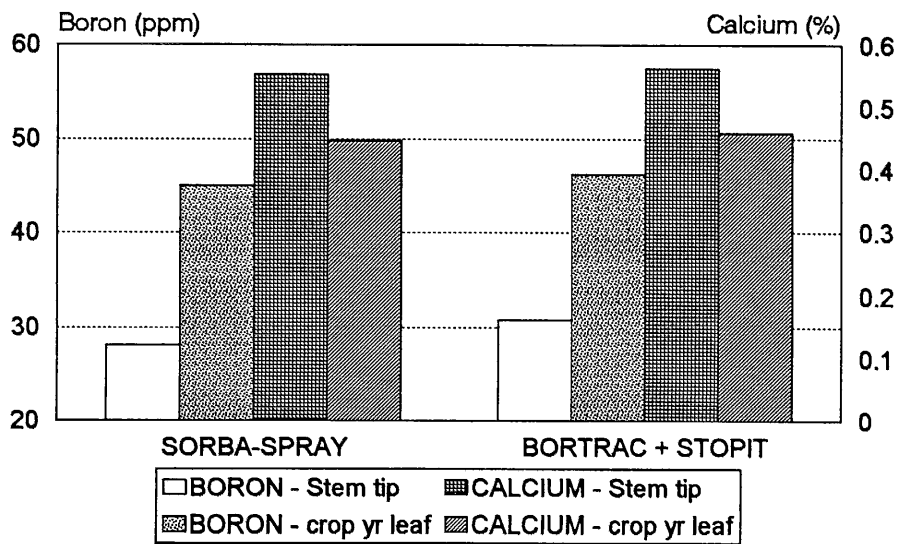
LEAF AND STEM BORON CONCENTRATIONS



Prune leaf tissue sampled July 1993, stem tissue November 1993, crop year July 1994

Figure 17

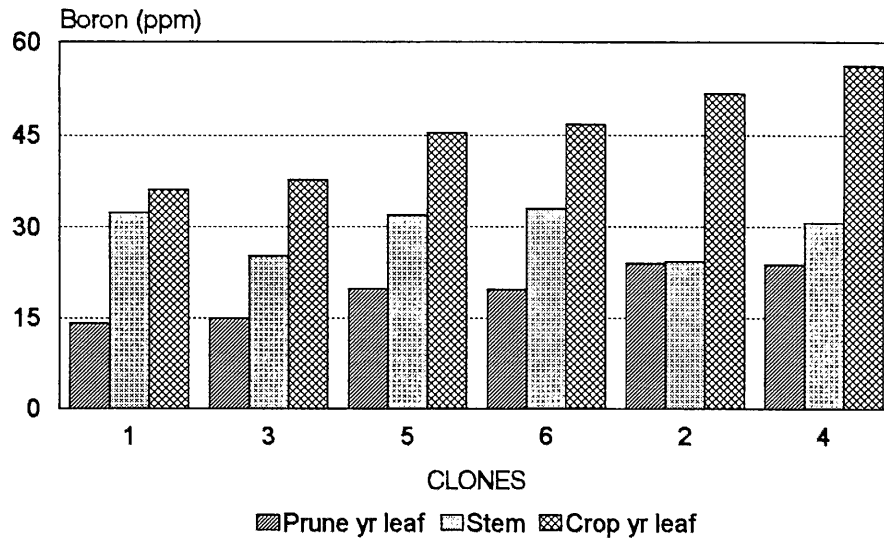
BORON AND CALCIUM



Treatments had no effect on boron or calcium concentrations.

Figure 18

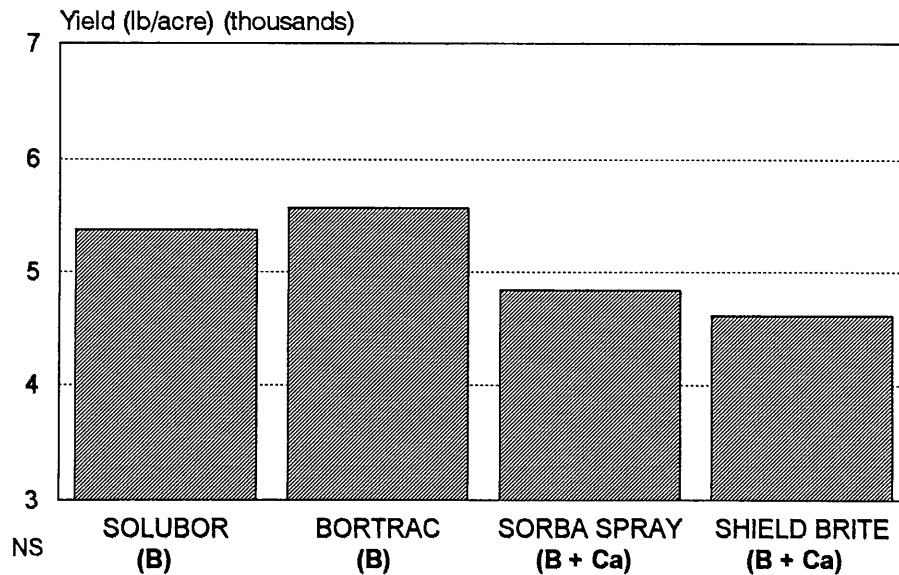
LEAF AND STEM BORON CONCENTRATIONS *



*Tissue samples from plots comparing boron and calcium sources.
 Prune leaf tissue sampled July 1993, stem tissue November 1993, crop year July 1994

Figure 19

YIELD



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

2. TITLE: Effect of Boron and the Polyamine Putrescine on Lowbush 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 lowbush 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 lowbush 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 lowbush 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: Nine clones in a commercial lowbush 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 ft² 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 will be applied in May 1996. A wooden shield was used to prevent spray drift. A hand held pump-up 2.5 gallon sprayer will 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

RESULTS: Twenty stems were sampled from each treatment plot in November 1995. The top 1.5 inches of stem tissue (including flower buds) have been dried, ground and are being analyzed for nutrients to verify that a higher level of boron has been achieved. Fruit set will be determined from each treatment plot by counting blossoms on 20 randomly sampled stems in the spring and berries on the same stems in August. Fruit characteristics such as color, size and weight will be determined later on frozen samples. Plot yield will be taken in August. Stems will be sampled before the field is pruned to determine the effect of putrescine on flower bud formation.

CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can be made at this time.

Study II - EXTENDING THE RECEPTIVITY OF LOWBUSH BLUEBERRY BLOSSOMS

OBJECTIVES: Determine the effect of fall foliar application of boron and spring blossom applied putrescine on lowbush 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

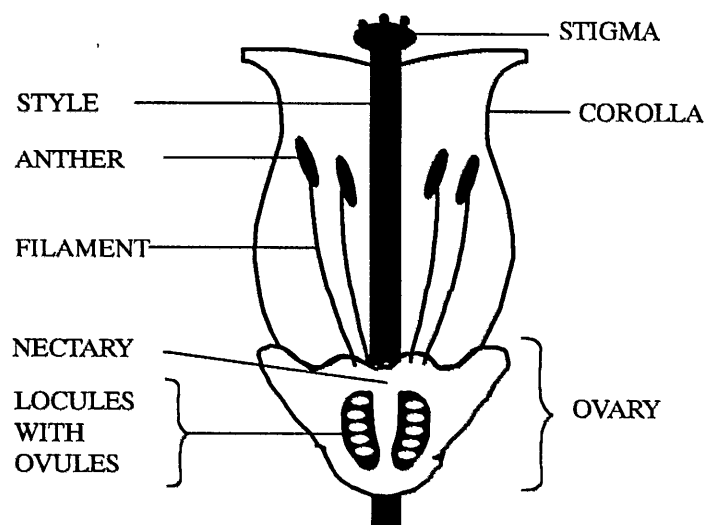


Figure 1

the ovary. Substances in the stigmatic exudate 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.

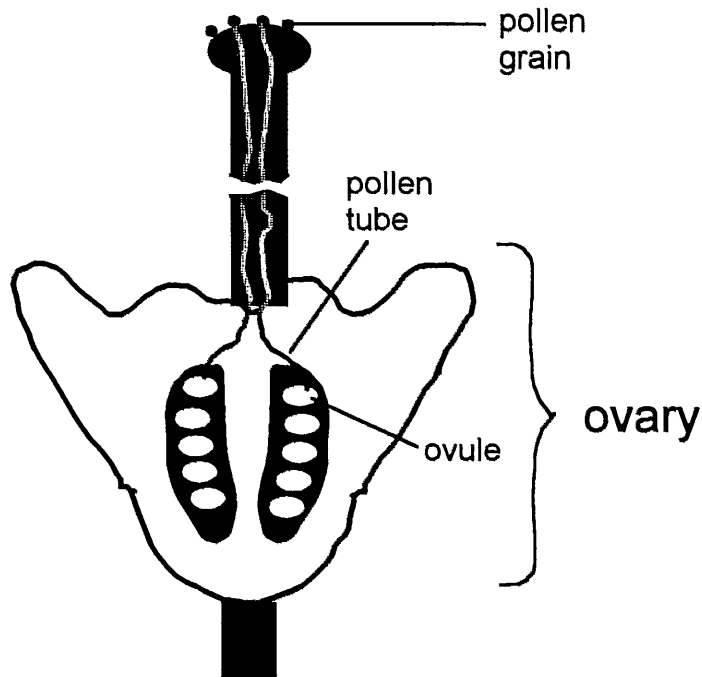


FIGURE 2

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 lowbush 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 lowbush blueberry field located in T32 MD (Sunkhaze Blueberry Farm) 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* 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 will be paired with an adjacent control plot (Fig 3). Plots received foliar application (to drip) of a boron solution on September 19, 1995.

Putrescine will be applied during bloom in May 1996. A wooden shield was used to prevent spray drift between plots. A hand held pump-up 2.5 gallon sprayer will apply the boron and putrescine. To simulate poor pollination weather, half of each treatment plot will be caged (see Fig 3) to prevent pollination by insects during the first half of the pollination period.

Then the cages will be removed to allow pollination. The uncaged halves will be compared to each other to determine the effect of B+putrescine on fruit set and yield during "good pollination conditions" and the caged halves will be compared to each other to determine the effects under "poor pollination conditions".

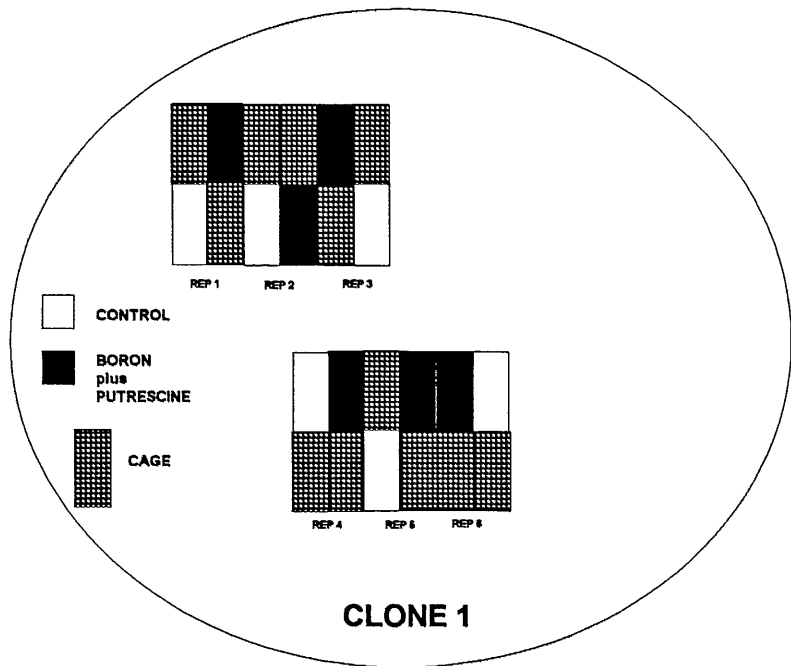


Figure 3

Therefore, the treatments will be:

1. Control (no treatment), uncaged
2. Control (no treatment), caged
3. 400 ppm boron plus 10^{-6} M putrescine, uncaged
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 1995. The top 2 inches of stem tissue (including flower buds) will be 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 in August. Fruit characteristics such as color, size and weight will be determined later on frozen samples. Plot yield will be taken in August.

RESULTS: Stem samples to verify entry of boron have been collected and prepared for analysis but results are not available at this time.

CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can be made at this time.

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

3. TITLE: Effect of Soil pH on Nutrient Uptake

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

METHODS: An experiment to determine the effect of soil pH adjustment on nutrient uptake, plant growth, and yield was established at two locations in 1994. Eight clones were selected at a field in Lamoine that had shown a history of low soil pH (3.9) and 8 clones were also chosen at a field in (NO 14 TWP) with a history of high soil pH (5.3). Within each clone two 4 ft x 8 ft plots were established. One of these plots was a control while the other plot was to have its pH adjusted toward the optimum pH 4.8 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 their 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 the extent of variability in pH within a clone two 3-inch cores were taken every 2 feet along a straight line in an East-West direction across the clones outside the plots in Lamoine.

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

Stem length measurements and flower bud counts were made on stems cut from within one randomly selected 4 inch 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 inch 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, 1998 and 2000. The pre-treatment harvest data will be used to adjust the 1996 yields and better determine true effects of treatments.

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 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. Only values for Mn not sign 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 | 4.6 | 328 | 58 | 69 | 18 | 315 | 0.1 | 13 | 34 | 1.8 |
| 3 | 4.6 | 368 | 45 | 67 | 17 | 293 | 0.08 | 13 | 36 | 1.6 |
| 4 | 4.7 | 329 | 50 | 54 | 18 | 289 | 0.12 | 12 | 30 | 1.8 |
| 5 | 4.7 | 271 | 44 | 45 | 15 | 314 | 0.08 | 11 | 34 | 1.8 |
| 6 | 4.6 | 294 | 51 | 53 | 19 | 322 | 0.08 | 15 | 37 | 2.2 |
| 7 | 4.6 | 197 | 47 | 39 | 18 | 344 | 0.09 | 13 | 27 | 1.3 |
| 8 | 4.7 | 276 | 51 | 56 | 18 | 287 | 0.1 | 12 | 36 | 1.9 |

* Concentrations in mg/kg. Values for Mg and P sign different at 10% level.

The soil pH at each location varied from clone to clone but was more variable at the low pH Lamoine field. Leaf tissue samples have not been analyzed at this time.

That pH varies beneath the clones in blueberry fields (Figs 3 & 4), reinforces the need for blueberry growers to take a large number of samples to get a true representation of the pH in their field.

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

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.

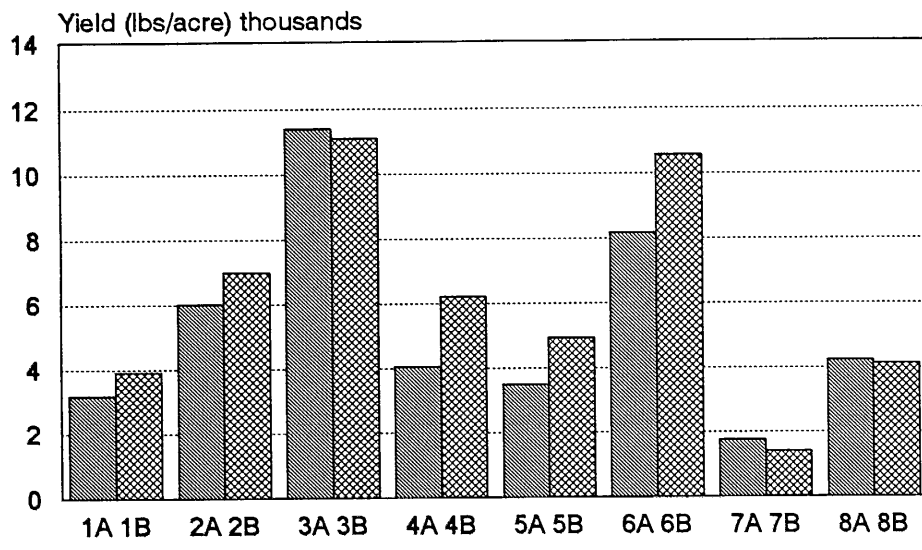
Destructive and non-destructive stem samples characterized the clones used in this study but no changes in stem characteristics were brought about by pH adjustment treatments. This was expected as pH adjustment in an unplowed soil is slow. No pH differences were found between the control and treatment 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/ft² among the clones in the NO 14 TWP field and 131 to 192 stems/ft² 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 .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 1984 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.

CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can made at this time.

Figure 1

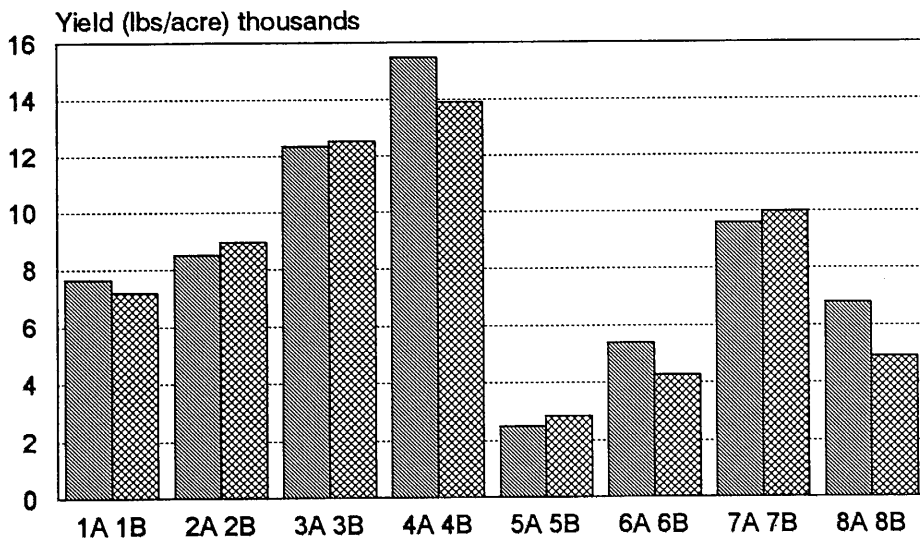
YIELD DATA COMPARISON OF TREATMENT PLOTS LOW pH FIELD



1994 yield. 1a and 1b are treatment plots in clone 1.

Figure 2

YIELD DATA COMPARISON OF TREATMENT PLOTS HIGH pH FIELD



1994 yield. 1a and 1b are treatment plots in clone 1.

Figure 3

VARIATION OF pH AMONG CLONES

LAMOINE

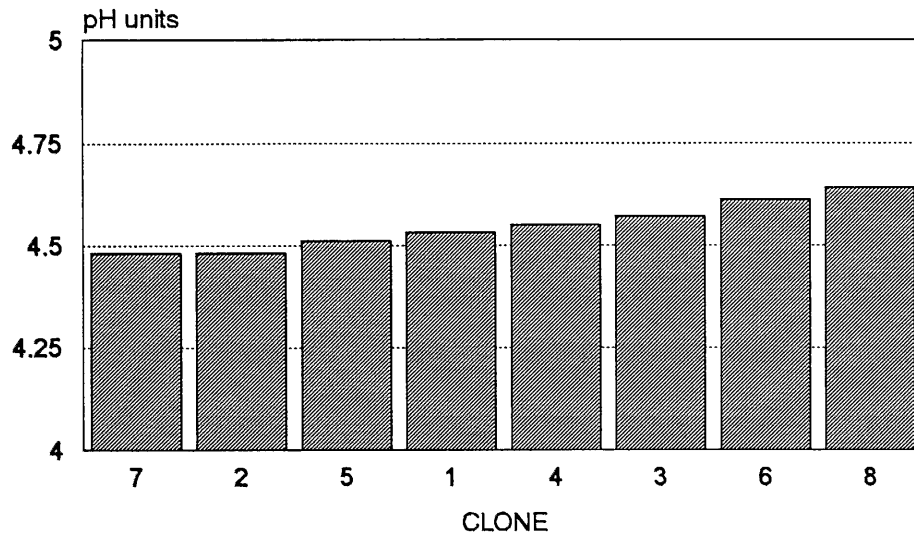


Figure 4

VARIATION OF pH AMONG CLONES

NO 14 TWP

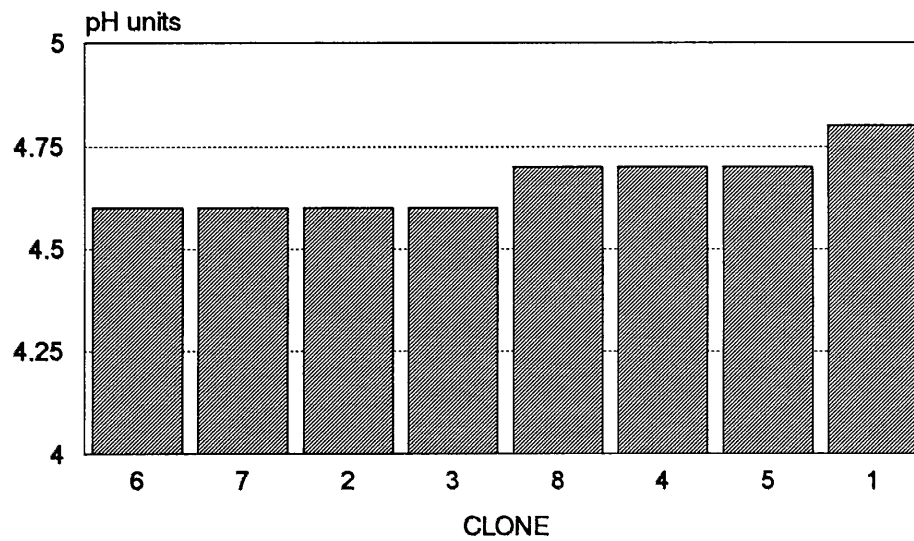
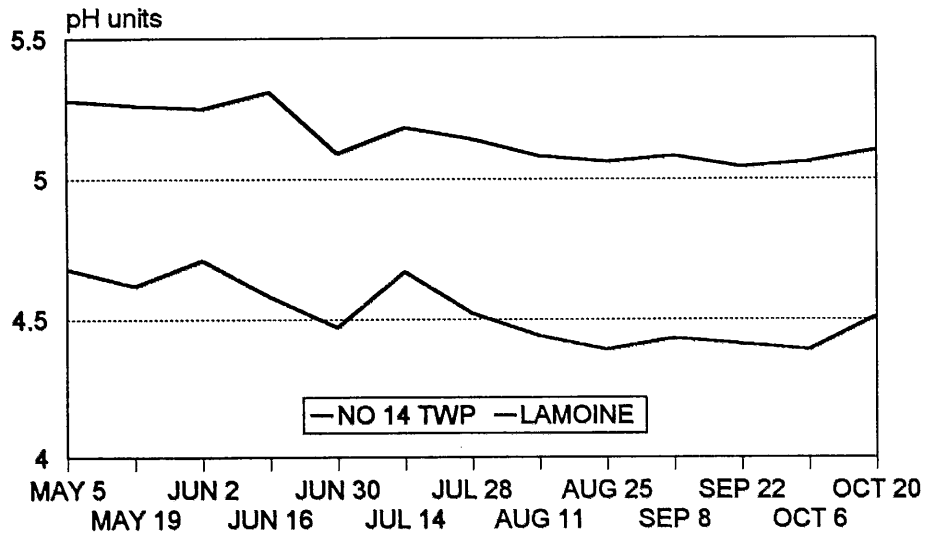


Figure 5

CHANGE IN pH DURING GROWING SEASON



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

4. TITLE: Phosphorus Uptake

OBJECTIVES: To compare leaf tissue nutrient concentrations with stem and leaf tissue nutrient content for evaluating nutritional response of lowbush 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 the p/n ratio study will be used in this investigation. Response to the treatments described below will be assessed by taking all stems in three 1/3 ft² quadrates per treatment plot. Plant biomass will be determined by weighing all above ground tissue in each quadrate after it has been dried. Tissues will be ground and analyzed for nutrient concentrations. Nutrient content of stem and leaf tissue will be determined by multiplying concentration by dry wt and then correlated to leaf tissue nutrient concentration as determined in the p/n ratio study. Correlations will also be 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 lbP/acre) using triple superphosphate
3. phosphorus + nitrogen (60 lbP/acre + 28.8 lbN/acre using monoammonium phosphate (MAP)).
4. phosphorus + nitrogen (60 lbP/acre + 54 lbN/acre using diammonium phosphate (DAP)).

RESULTS: Samples have been collected and are in various stages of analysis. No results can be reported at this time.

CONCLUSIONS: No conclusions can be made until the data is completely analyzed.

RECOMMENDATIONS: No recommendations can be made at this time.

F. WEED CONTROL

INVESTIGATORS: David Yarborough, Assistant Professor of Horticulture
Timothy M. Hess, Research Associate
Brian Perkins, Assistant Research Food Chemist

1. TITLE: Evaluation of Hexazinone Formulation on Soil Movement and Weed Control.

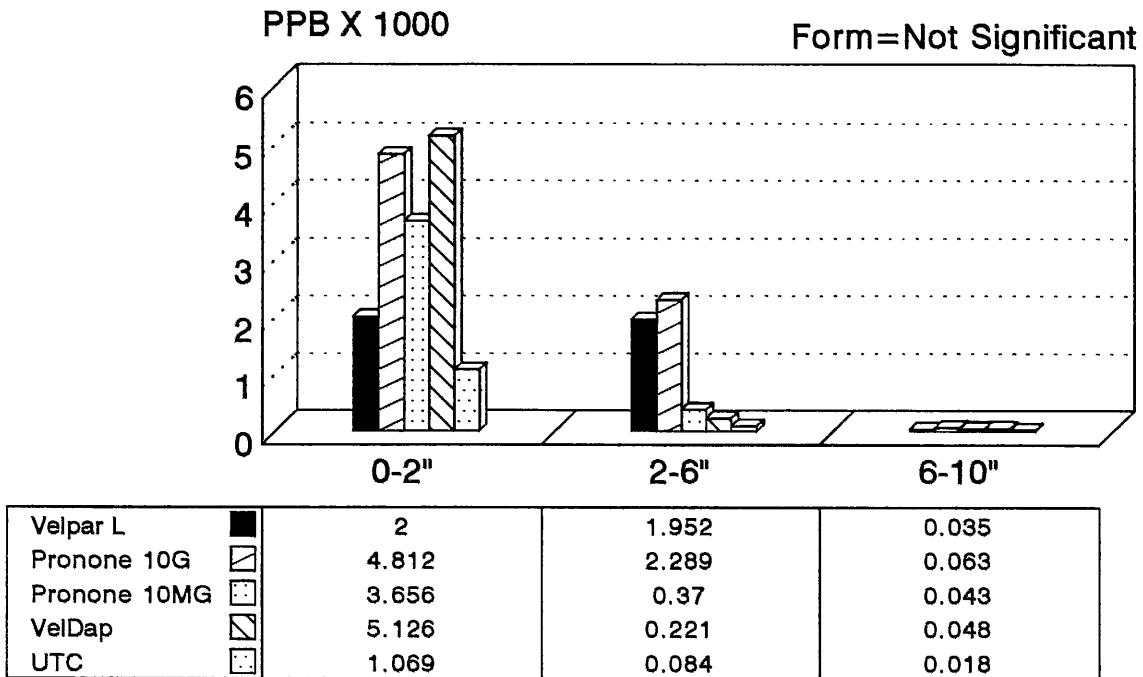
METHODS: A randomized complete block design trial, established to study the effect hexazinone formulation on soil movement and weed control, was established and treated with one lb ai/a Velpar L[®], Pronone 10G[®], Pronone 10MG[®], Velpar/DAP or left untreated May 25, 1995. Each treatment also received 200 lbs/a DAP. Plot size is 10 X 20 ft with 5 ft alleyways with 3 blocks and 5 treatments for a total of 15 plots. Soil was sampled on 6-25-95 and 8-25-95, one and three months post treatment, from 0-2", 2-6" and 6-10". Blueberry and weed phytotoxicity and weed cover were assessed on 7-2-95 and 8-15-95. Soils were again sampled late November 1995, 6 months post treatment and a final sample will be taken on May 25, 1996, one year post treatment. Carryover effects to blueberries and weeds will be reevaluated in June, 1996 and yields will be taken in August, 1996.

RESULTS: For the first two sample dates, the formulation of hexazinone applied did not significantly affect amount of hexazinone found at the three sample depths (Figures 1 and 2). No significant differences in blueberry phytotoxicity or weed cover were found.

CONCLUSION: No conclusions can be made at this time.

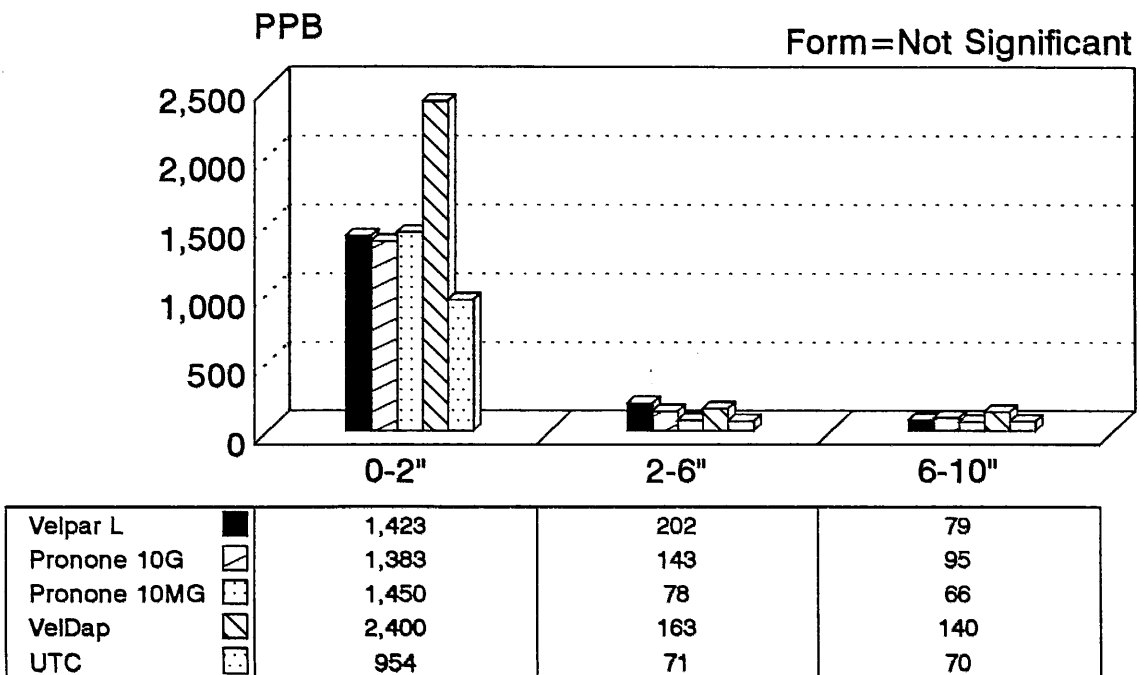
RECOMMENDATIONS: Evaluate carryover effects on blueberries and weeds and determine soil hexazinone level results from six and 12 month soil samples to assess need for further research.

Figure 1. Soil Hexazinone PPB
One Month Post Treatment-June 1995



veldis1

Figure 2. Soil Hexazinone PPB
Three Months Post Treatment-Aug. 1995



veldis2

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

2. TITLE: Effect of Time of Fall Pruning on Growth and Productivity of Blueberries.

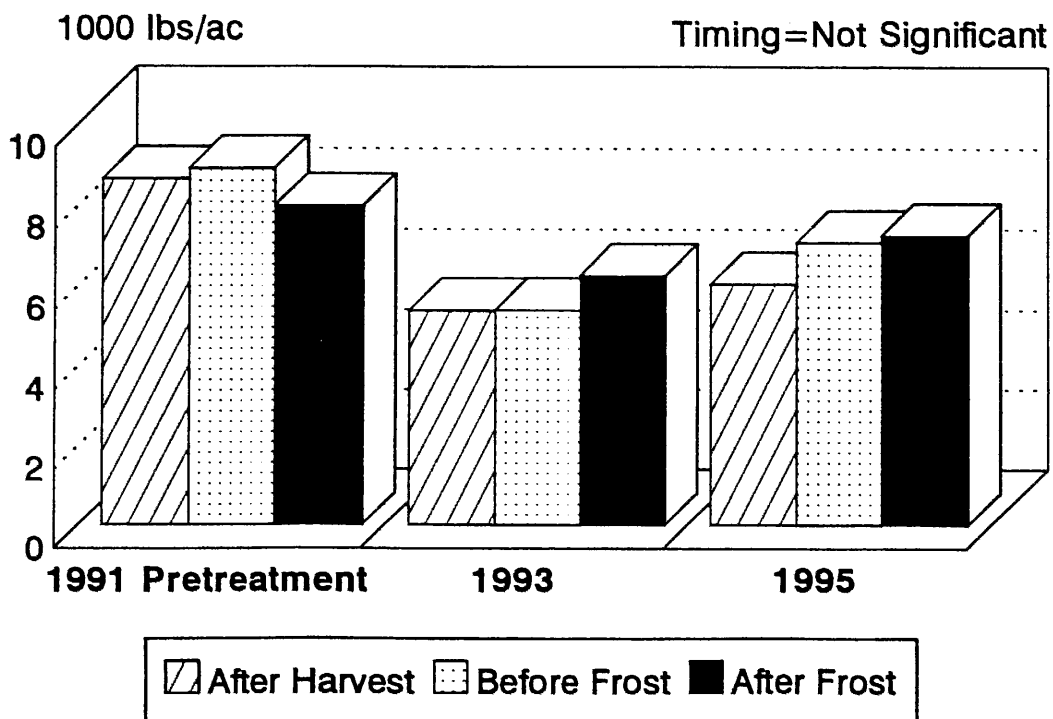
METHODS: A plot at Blueberry Hill Farm, Jonesboro, ME., was established and harvested on August 26, 1991 to provide pretreatment yield data. Pruning times in 1991, 1993 and 1995 were; late August, immediately after harvest; mid September, before frost; or late October, after frost. The randomized complete block experiment has 3 dates and 6 replications for a total of 18 plots. Plot size is 6 x 40 feet with two, 1 ft² subplots per plot. Stem samples were cut in October 1992, 1994 and will be cut again in 1996. Plots will again be pruned after harvest in 1997.

RESULTS: Although there is a trend of lower yields with the earlier harvest no significant differences in yields may be attributed to pruning date (Figure 1).

CONCLUSION: Pruning should be repeated over several cycles before conclusions may be made.

RECOMMENDATIONS: Continue with experiment through harvest in 1997.

Figure 1. Effect of Pruning Time on Yield



prunyld

INVESTIGATOR: David E. Yarborough, Cooperative Extension blueberry specialist

COOPERATORS: John Jemison, Cooperative Extension water quality specialist

3. TITLE: Hexazinone ground water survey

METHODS: Sixteen wells and five streams or ponds adjacent to or in blueberry fields in four counties were sampled in 1995 at 0, 1, 2, 3, 4 and 5 months after hexazinone application. Three of the wells were test wells put in by the Maine Department of Conservation in 1986 and the others were drilled or dug wells. Well sites were chosen on the basis of a high probability of finding hexazinone. In addition, surface water was sampled from five 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 2, 11 received Velpar L preemergence; sites 13, 16, 17, 22 and 23 received Velpar L impregnated on Diammonium Phosphate (DAP) fertilizer; site 12 received Pronone 10G applied in April, sites 28, 29, 30, 31, 32, and 33 received Pronone 10G applied in June and sites 9 and 25 were 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). Samples with an M have been analyzed but misplaced and were not available when the report was written. The objective of this study was to survey wells with different treatments to determine if the Best Management Practices (BMP's) followed reduced the potential intrusion of hexazinone into groundwater.

RESULTS: The water tested in 1995 varied from no detects up to a high level of 20 ppb on site 9 (Table 1). This site has not been treated since 1992. The hexazinone groundwater level in the 50' test well in a blueberry field was measured at 29 ppb in 1993 (Figure 1). The site specific BMP was to use alternative herbicides, i.e. Sethoxydim and Glyphosate. The level at the last reading in October 1995 was 12 ppb. This indicates that hexazinone will be dissipated over time if applications are suspended. Site 11 is a test well treated with Velpar L which had over 10 ppb hexazinone, but decreased to 6.9 ppb in October.

The wells in fields receiving the Velpar/DAP treatment did not show a trend for increasing hexazinone from May through October (Table 1). On site 16 in 1993 the level for the 270' drilled well was 6 ppb. Because of a steep slope above the well, the recommended BMP's were to not treat the adjacent 2.5 acres with hexazinone. In addition, the field above the setback but still sloping toward the well as treated with 1 lb/a Velpar L and the portion of the field sloping away from the well was treated with 2 lb/a Velpar L in 1993. In 1995, the level decreased to 1.7 ppb so the recommendation was to treat the entire field after emergence with 1 lb/a Velpar/DAP with the 50' well buffer. The level in 1995 was in the 2.0 to 2.2 range, within the normal fluctuation seen and not increasing. The level declined to 0 when a new well was drilled to 500' in 1995. The old well was originally drilled in 1956 and was re-drilled 15 years ago because of a ledge intrusion into the casing. The old well casing was not intact and vulnerable to leakage from the side. The new well indicates the hexazinone is not in the groundwater but in the layers above the aquifer.

On site 13 the highest level from the drilled well was at 8.9 in 1993 after liquid application of

1.5 lb/a Velpar L. The site specific BMP was to apply Velpar/DAP at 1 lb/a with the 50' to well buffer in 1995. The hexazinone in the groundwater was at 2.1 ppb prior to treatment and at 1.8 ppb on the October sample date. Applying hexazinone by the BMP resulted in no increase in the hexazinone groundwater detection.

The treatment with Pronone 10G had an increase in hexazinone in August on three sites and in October on well 31. The year 1995 was regarded as a hot and dry. Summer precipitation was low but was higher in October (Figure 3). The next sample taken in May will determine if levels will increase or decline from this treatment. The levels of hexazinone in the surface water did roughly correspond to the wells for site 11, 12 (with the exception of a low reading in August) and 33, but not for site 9 or 13.

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 in the groundwater. Wells will be resampled in 1996 to determine if levels increase from the previous years application.

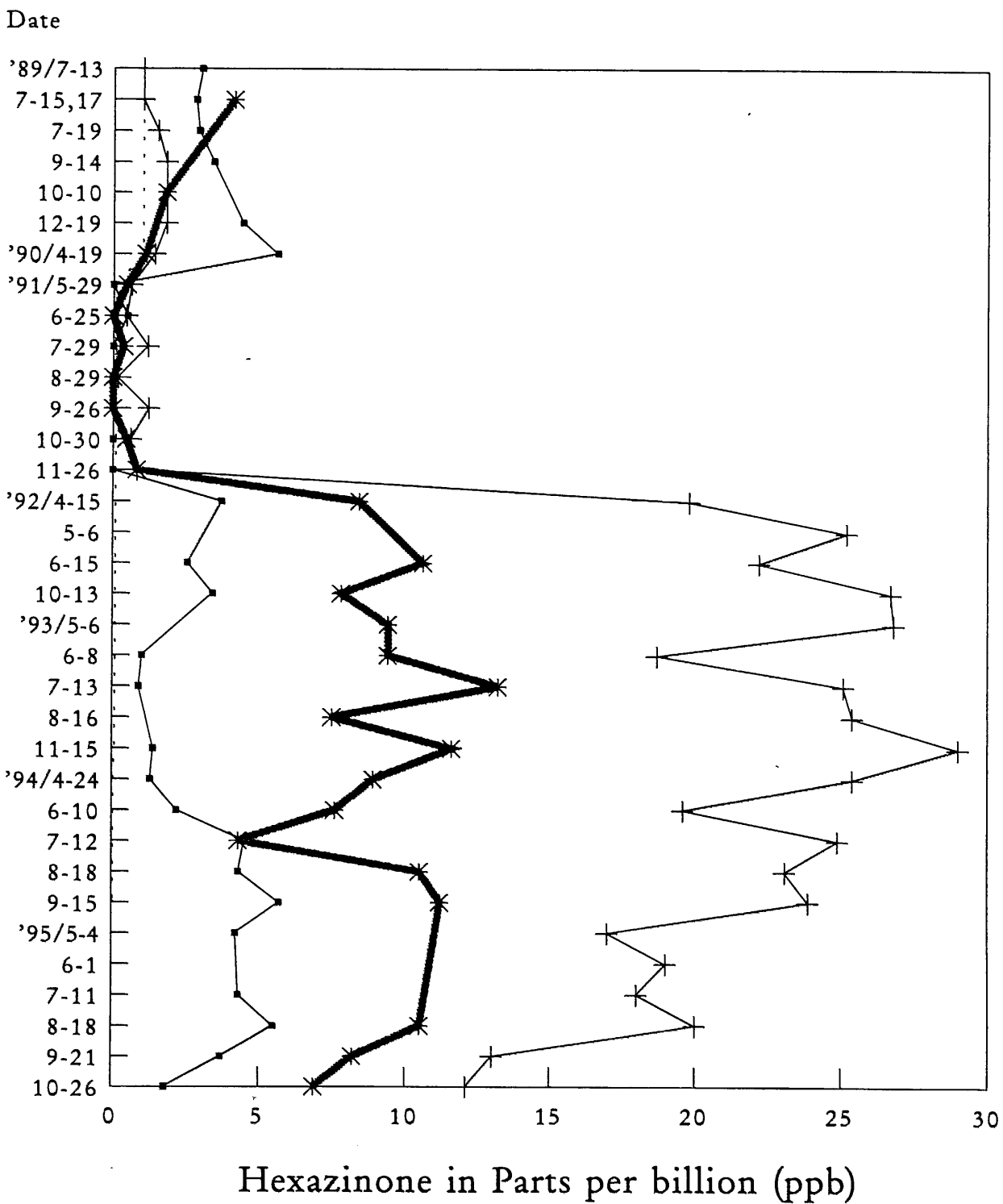
RECOMMENDATIONS: Continue to sample wells to obtain longer term information and expand information on site history, well depth and distance from the field. Continue to vary management practices to determine how they influence hexazinone movement in blueberry soils. Set up site specific study to determine 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. 1995 Hexazinone Test Result Summary
University of Maine Well Water Survey
Hexazinone in parts per billion

| Site # | May | June | July | August | September | October |
|----------------|-----------|------|------|--------|-----------|---------|
| WELLS | | | | | | |
| 2 drill | 0.3 | M | 0.4 | 0.5 | 0.4 | - |
| 9 test | 17 | 19 | 18 | 20 | 13 | 12.1 |
| 11 test | 10 | M | M | 10.5 | 8.2 | 6.9 |
| 12 test | 4.2 | M | 4.3 | 5.5 | 3.7 | 3.3 |
| 13 drill | 2.1 | M | 2.2 | 2.4 | 1.9 | 1.8 |
| 16 drill | 1.7 | 2.0 | 2.2 | 2.2 | *ND | *ND |
| 17 drill | - | 0.3 | 0.2 | 0.2 | 0.2 | 0.1 |
| 22 dug | - | 0 | 0 | DRY | DRY | DRY |
| 23 drill | - | M | 2.0 | 2.6 | 2.0 | 1.5 |
| 25 drill | 0.5 | 0.5 | 0.6 | - | 0.4 | 0.5 |
| 28 drill | 2.0 | - | 2.1 | 5.5 | 2.1 | 1.9 |
| 29 drill | - | 1.2 | 1.4 | 1.5 | 1.2 | 0.7 |
| 30 dug | - | M | 0 | 1.5 | DRY | DRY |
| 31 drill | - | 3.9 | 3.9 | 4.8 | 3.3 | 8.8 |
| 32 drill | - | 5.6 | 4.5 | - | 4.5 | 3.6 |
| 33 drill | - | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 |
| SURFACE | | | | | | |
| 9 stream | 0 | M | 1.2 | 1.0 | 1.0 | ND |
| 11 pond | 7.3 | M | 9.2 | 5.5 | 6.7 | 4.2 |
| 12 stream | 4.4 | M | 5.2 | 0.3 | 4.3 | 3.3 |
| 13 pond | 0.2 | M | 0 | M | 0 | ND |
| 33 stream | - | M | 0.4 | 0.4 | 0.1 | ND |
| | | | | | | |
| | *New well | | | | | |

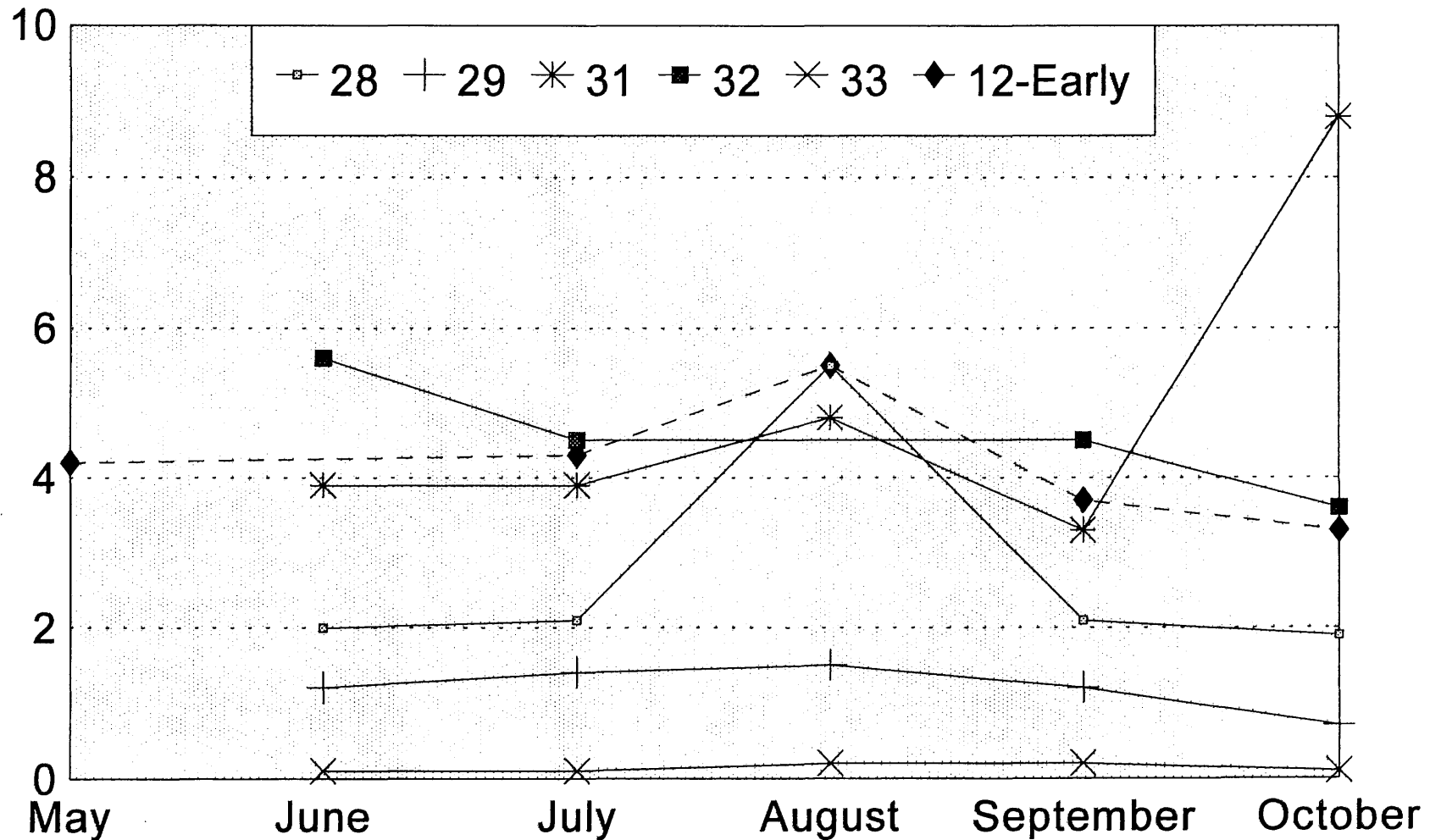
Liquid - 2,11 Liquid/DAP -13,16,17,22, 23 Granular/early - 12 Granular/late 28,29,30,31,32,33 Untreated - 9,25

Figure 1. Hexazinone in ground water 1989-1995
 Long term test well data



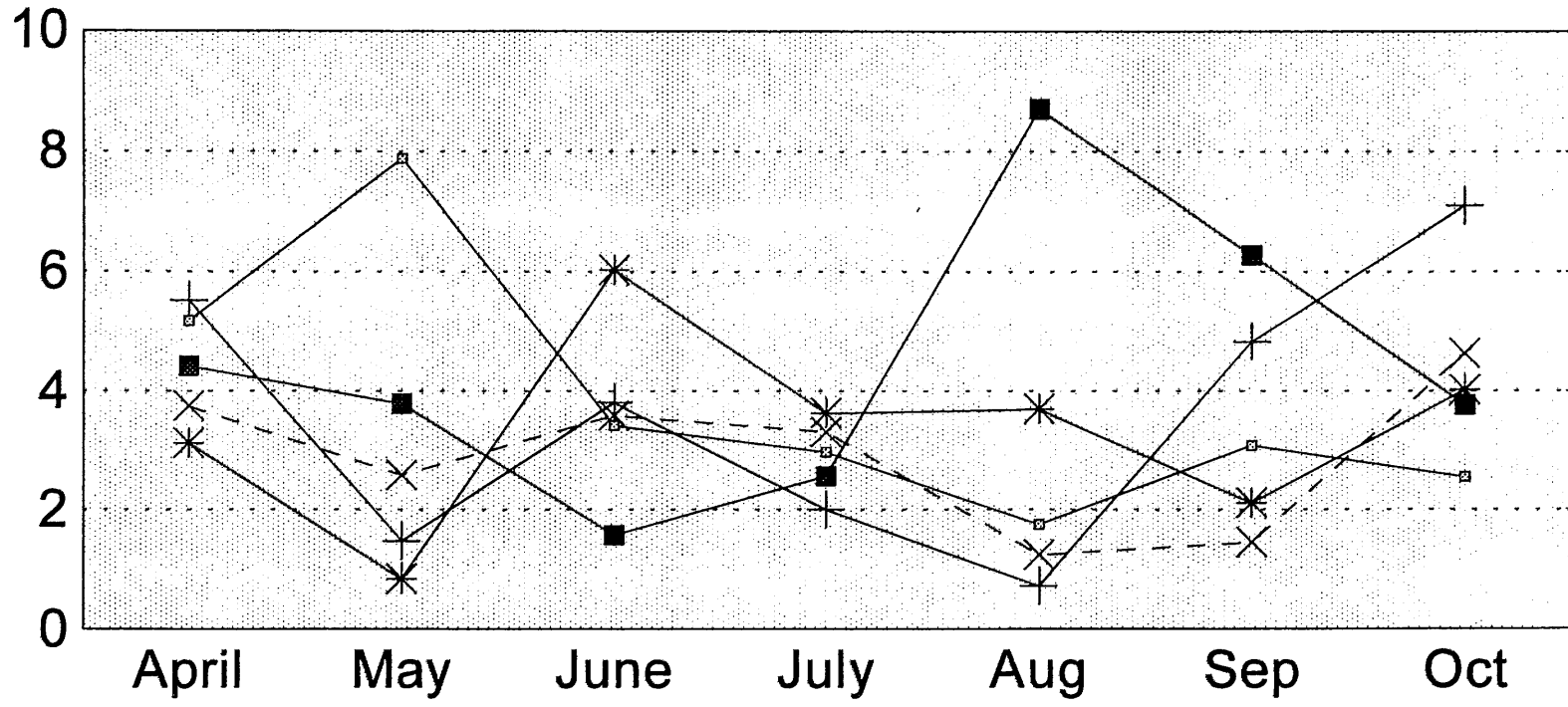
—■— Site 12 + Site 9 * Site 11 - - - Detection Limit

Figure 2. Hexazinone in Well Water Pronone 10G application



Pronone 10G applied on 4-28 or 6-27-95

Figure 3. Precipitation Blueberry Hill Farm



| | April | May | June | July | Aug | Sep | Oct |
|--------|-------|------|------|------|------|------|------|
| 1994 □ | 5.18 | 7.88 | 3.42 | 2.97 | 1.75 | 3.08 | 2.55 |
| 1993 + | 5.52 | 1.47 | 3.81 | 2 | 0.72 | 4.83 | 7.1 |
| 1992 * | 3.12 | 0.84 | 6.03 | 3.63 | 3.7 | 2.11 | 4.02 |
| 1991 ■ | 4.42 | 3.79 | 1.57 | 2.56 | 8.71 | 6.28 | 3.77 |
| 1995 × | 3.75 | 2.58 | 3.59 | 3.31 | 1.24 | 1.45 | 4.63 |

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).

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.

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

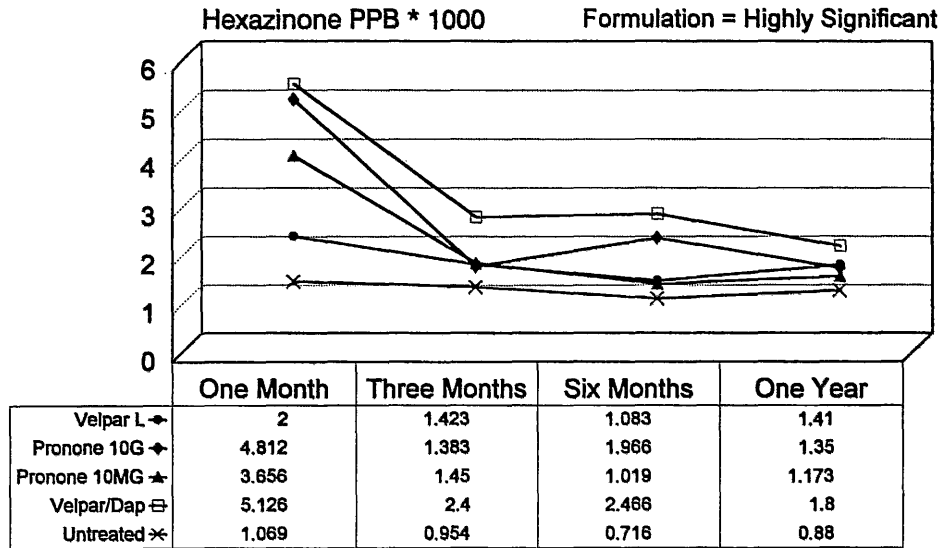


Figure 2. Effect of Velpar Formulation on Hexazinone Movement through the Soil Profile at 2-6 inches

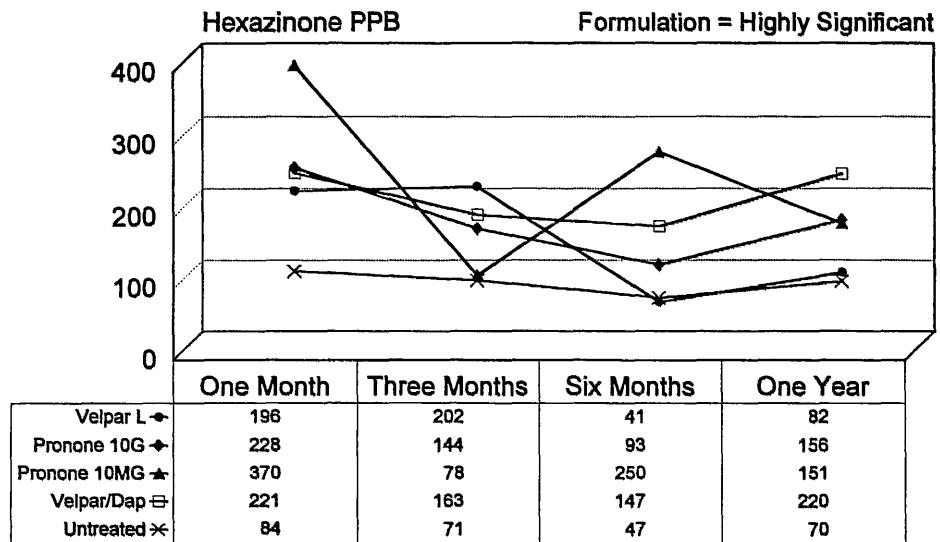


Figure 3. Effect of Velpar Formulation on Hexazinone Movement through the Soil Profile at 6-10 inches

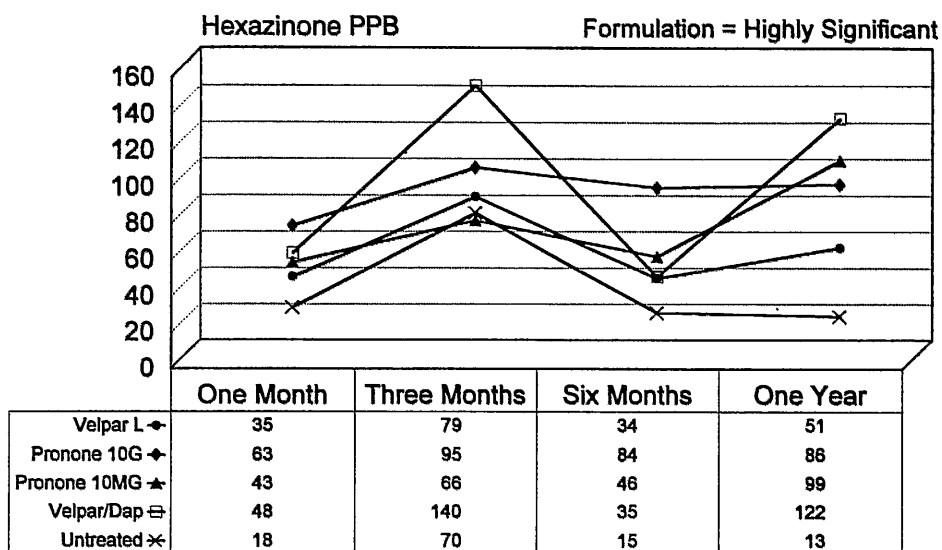
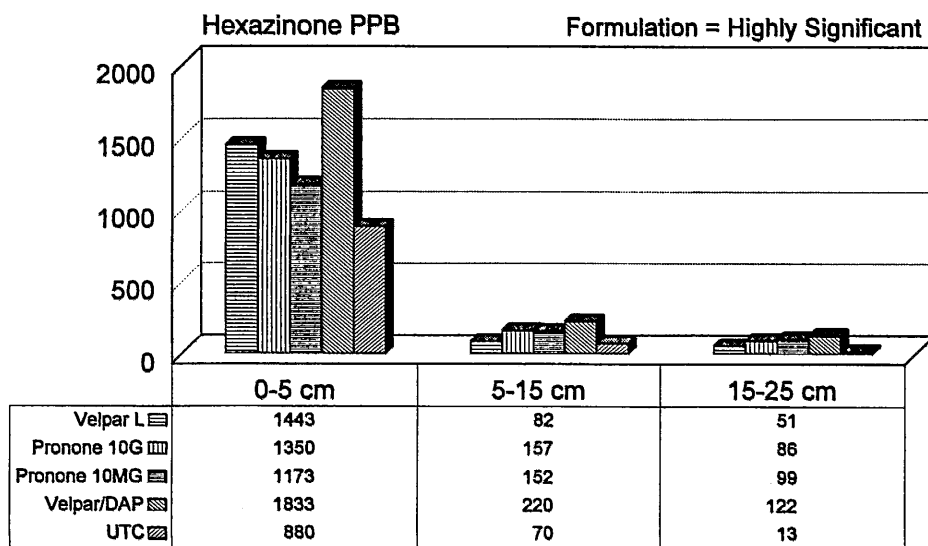
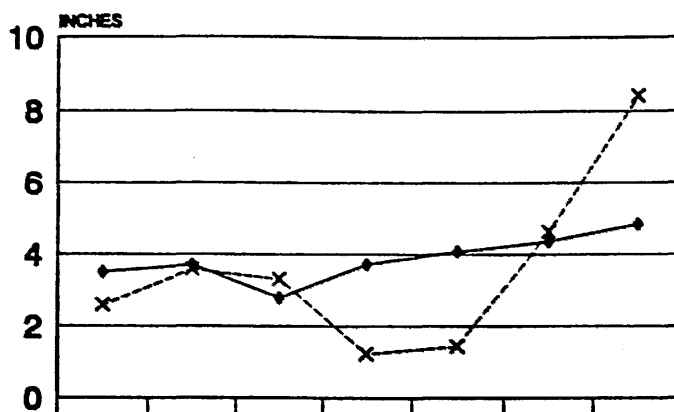


Figure 4. Comparison of Formulation on Hexazinone Movement After One Year



**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 |

E. WEED CONTROL

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

1. TITLE: Evaluation of Tribenuron Methyl for Bunchberry Control

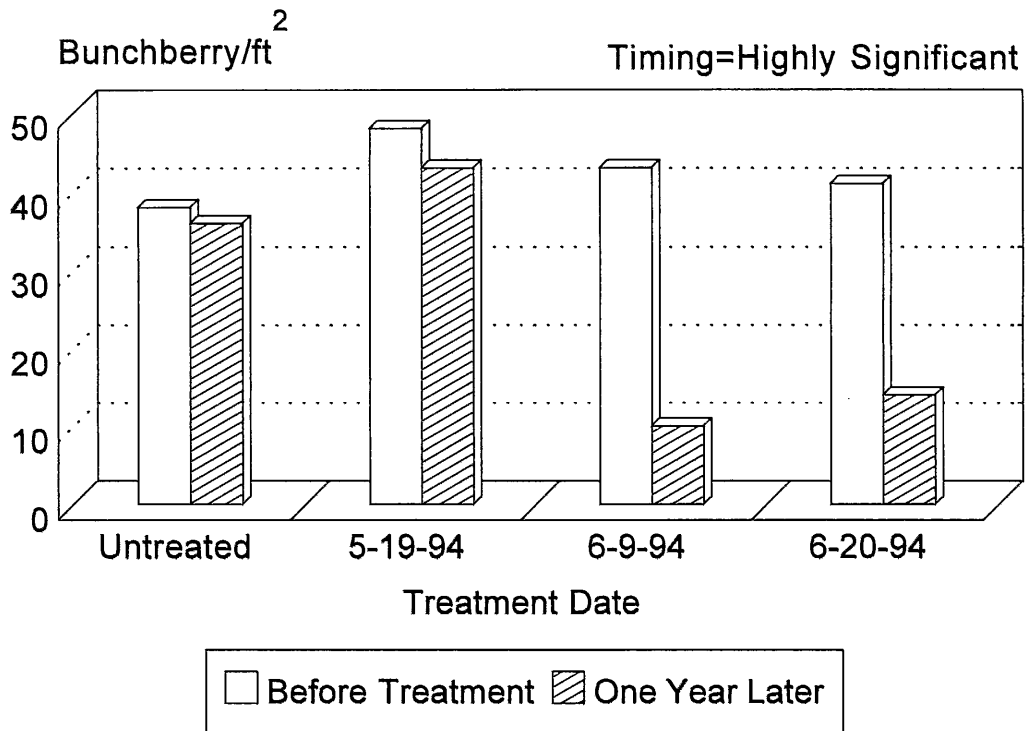
METHODS: An RCB design trial, established to study the effect of timing of tribenuron methyl for bunchberry control and blueberry phytotoxicity, was treated with 0.28 oz ai/a on either May 19, 1994, before blueberry or bunchberry emergence; June 9, after bunchberry but before blueberry emergence; on June 24, after both fully emerged or left untreated. Plot size was 6 X 45 ft with 2 ft alleys, 6 blocks and 4 treatment dates for a total of 24 plots. Each plot had 2, 1 ft² count plots and counts of bunchberry were made after the second application. Phytotoxicity was evaluated on July 29 and blueberry stems were cut on October 20, 1994. Bunchberry counts and blueberry phytotoxicity were reevaluated in June 1995. Yields were not taken because of poor blueberry cover.

RESULTS: Best suppression of bunchberry was observed with the treatment applied on ⁶⁻⁹~~5-19~~ 94 after bunchberry and before blueberry emergence (Figure 1). In previous trials, blueberry bud and lateral number increased with rate. In this trial, they increased with a later date of application (Figure 2).

CONCLUSION: For the timing study, tribenuron methyl applied at 0.28 oz ai/a before blueberry emergence provided the best control.

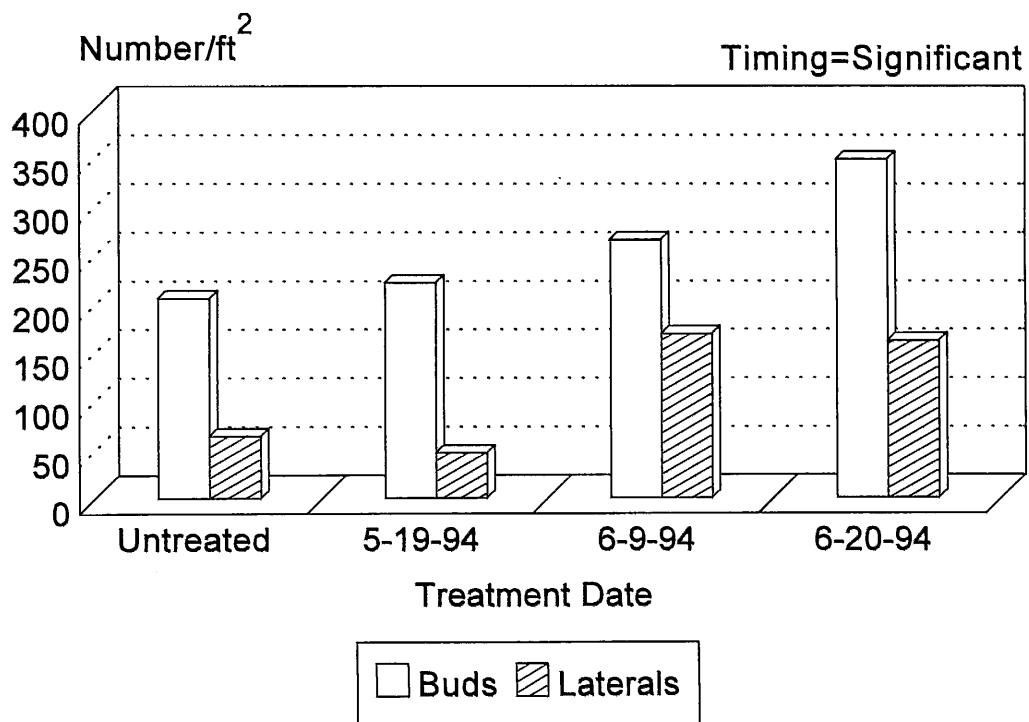
RECOMMENDATIONS: Terminate trial.

Figure 1. Effect of 0.28 oz ai/a Tribenuron Methyl on Bunchberry Number



exp1

Figure 2. Effect of 0.28 oz ai/a Tribenuron Methyl on Blueberry Buds and Laterals



exp2

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

2. TITLE: Evaluation of Tribenuron Methyl Commercial Applications for Bunchberry Control

METHODS: Two trials were initiated to study the efficacy of commercial applications. At Blueberry Hill Farm, a one acre plot was treated June 2, 1994 with 0.56 oz ai/a, with an adjacent, untreated one acre plot serving as a control. Each treatment had 15, 1 yd² count/cover plots with 80-100% bunchberry cover and 0-20% blueberry cover. Bunchberry cover and counts and blueberry cover were taken 2 weeks, 1 month and 2 months after application. Blueberry stems were cut from 15, 1 ft² plots per treatment on October 20, 1994. Carryover effects were evaluated in June 1995. The plots were not harvested.

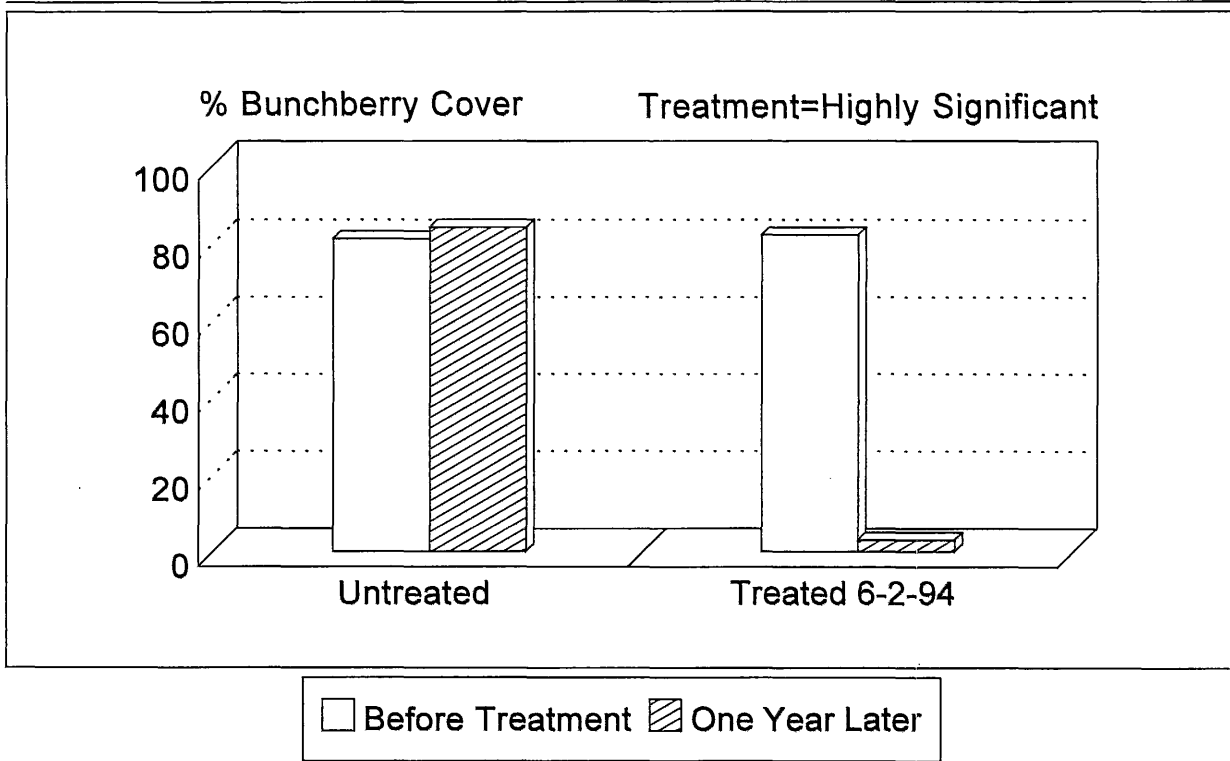
A second site, on a commercial field in Waldoboro, was established and treated with 0.28 oz ai/a on June 10, 1994. Counts and cover were taken 2 weeks and 1 month after application. In the same field, a 1/8 acre plot was treated with 0.56 oz ai/a. Both of the Waldoboro sites, and an untreated control, had 15, 1 yd² count/cover plots for a total of 45 plots.

RESULTS: In the Blueberry Hill Farm commercial application, bunchberry cover was significantly reduced one year after treatment (Figure 1). Annual grasses were observed to invade areas left bare from bunchberry control. Blueberry cover on the treated plot increased compared to the untreated plot but was not statistically significant (Figure 2). There was no significant treatment effect on bunchberry at the Waldoboro site.

CONCLUSION: A 0.56 oz ai/a tribenuron methyl rate applied before blueberry and after bunchberry emergence effectively controlled bunchberry in a commercial application. The treatment on the Waldoboro site as applied too late in the season to provide effective control.

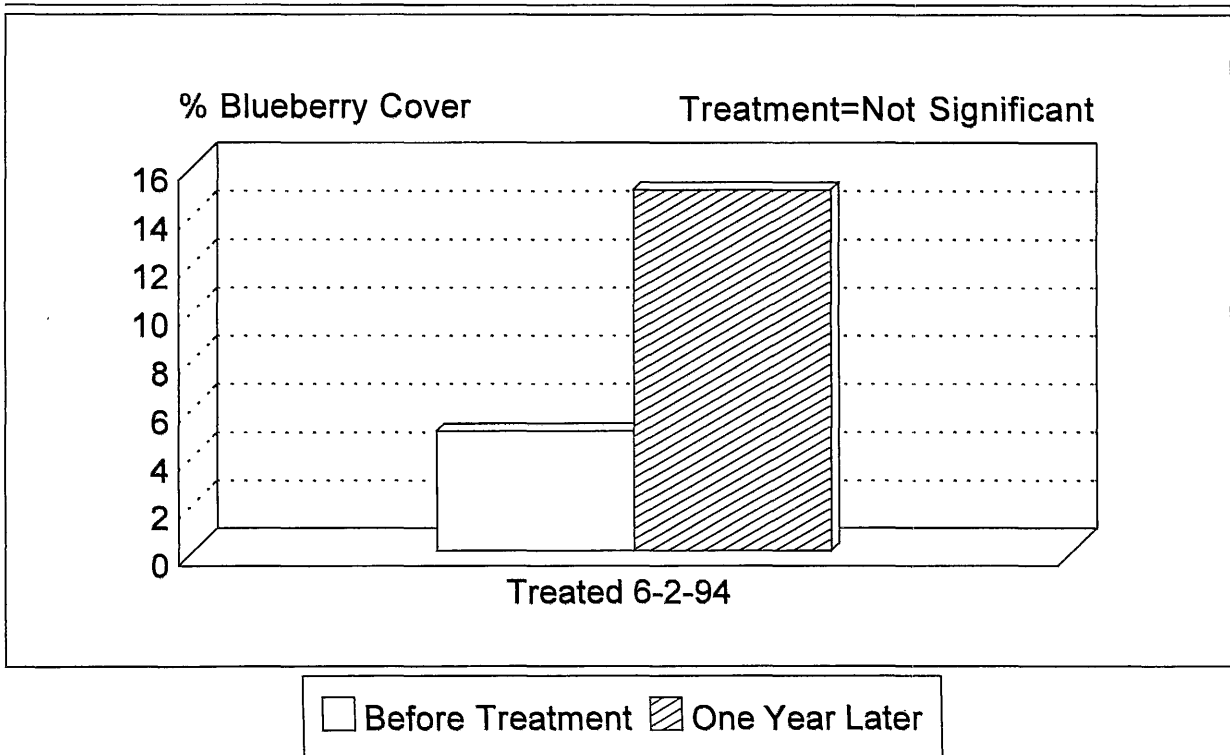
RECOMMENDATIONS: Maintain yard squared plots at Blueberry Hill Farm one more year to evaluate weed species shifts. Discontinue trial at Waldoboro site.

Figure 1. Effect of 0.56 oz ai/a
Tribenuron Methyl on Bunchberry Cover



comm1

Figure 2. Effect of 0.56 oz ai/a
Tribenuron Methyl on Blueberry Cover



comm2

INVESTIGATORS: David E. Yarborough, Extension Blueberry Specialist

2. TITLE: Effectiveness of Resin-Exchange Columns to Determine Efficacy in Removing Hexazinone from Well Water.

METHODS: Ambersorb® 563, a synthetic carbonaceous adsorbent, was obtained from Rohm and Haas Co. and will be assessed for its ability to remove hexazinone from well water. This material has several advantages over more commonly used granular activated carbon in that it can be regenerated on site, has 5-10 times the capacity of carbon for adsorbing pollutants, allows for a much higher flow rate and resists bacterial fouling. Ambersorb® 563, commonly used in commercial groundwater remediation, will be installed in-line with water being tested for hexazinone content before and after filtration. Due to the unique qualities of the filtrate, a special filter with a fine enough mesh to house the material, a Rusco® 500 mesh filter, had to be located and purchased. The experiment will be initiated in late January 1996.

RESULTS: No results are available at this time.

CONCLUSION: Use of this filtering material has been effective at filtering out other classes of pesticides and groundwater pollutants. It is expected to be more effective than activated carbon in removing hexazinone from well water.

RECOMMENDATIONS: Continue with experiment to evaluate hexazinone concentrations in filtered water.

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

3. TITLE: Effect of Clopyralid for Vetch Control

METHODS: An experiment was originally designed to evaluate the effect of clopyralid for control of vetch in wild blueberries. Dry conditions at the Addison field where the experiment was to be initiated made the vetch unsuitable for treatment. Inability to find additional fields with an adequate vetch population resulted in the experiment not being carried out.

Two additional fields with sufficient vetch cover will be assessed in late May 1996 and new trial initiated to study effect of timing on control of vetch. A randomized complete block experiment will be established with plot size being determined by area covered with vetch. Rate will be 0.25 lb ai/a applied at two week intervals beginning in July and commencing in mid August with a total of 3 applications.

RESULTS: No results from the 1995 field season are available.

CONCLUSION: Clopyralid, applied at 0.25 lb ai/a in mid to late summer, before vetch senescence, has proven effective in previous trials compared to manual pulling. This experiment will further refine application timing.

RECOMMENDATIONS: Continue with experiment through harvest in 1997.

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

4. TITLE: Evaluation of Tribenuron Methyl/Velpar® Tank Mix for Bunchberry Control

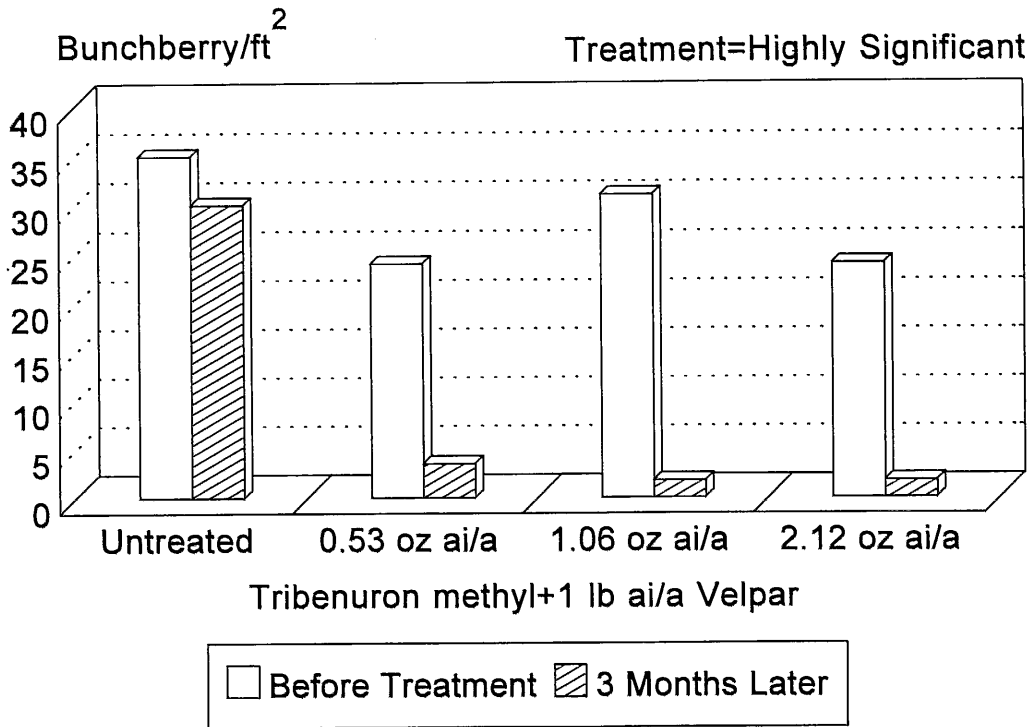
METHODS: An RCB design trial, established to study the effect of rate of a tribenuron methyl/Velpar® tank mix for bunchberry control and blueberry phytotoxicity, was treated with one lb ai/a Velpar® and 0.53 oz ai/a, 1.06 oz ai/a or 2.12 oz ai/a tribenuron methyl or untreated May 23, 1995, before blueberry but after bunchberry emergence. A 0.2% v/v surfactant was included in all treatments. Plot size is 6 by 27 ft with 3 ft alleyways, 4 blocks and 4 treatments for a total of 16 plots. Each plot has 2, 1 ft² count plots and counts of bunchberry were made on June 2, 1995. Phytotoxicity was evaluated on June 22 and bunchberry counts reevaluated August 23, 1995. Blueberry stems were cut on October 25, 1995. Bunchberry counts and blueberry phytotoxicity will be reevaluated in June 1996 and yields will be taken in August 1996.

RESULTS: All rates of tribenuron methyl reduced bunchberry numbers significantly in the initial year of the study (Figure 1). Late blueberry emergence and blueberry phytotoxicity (as evidenced as reddening and drying of leaves) was noted early in the season, but plants recovered by mid summer. Phytotoxicity to the blueberries increased with rate (Figure 2). Bud number increased significantly, but stem length and lateral numbers were unaffected (Figure 3).

CONCLUSION: Precise timing, before blueberry and after bunchberry emergence, could allow these two materials to be tank mixed and applied in one application. Effects on yields and blueberry plant growth need to be assessed.

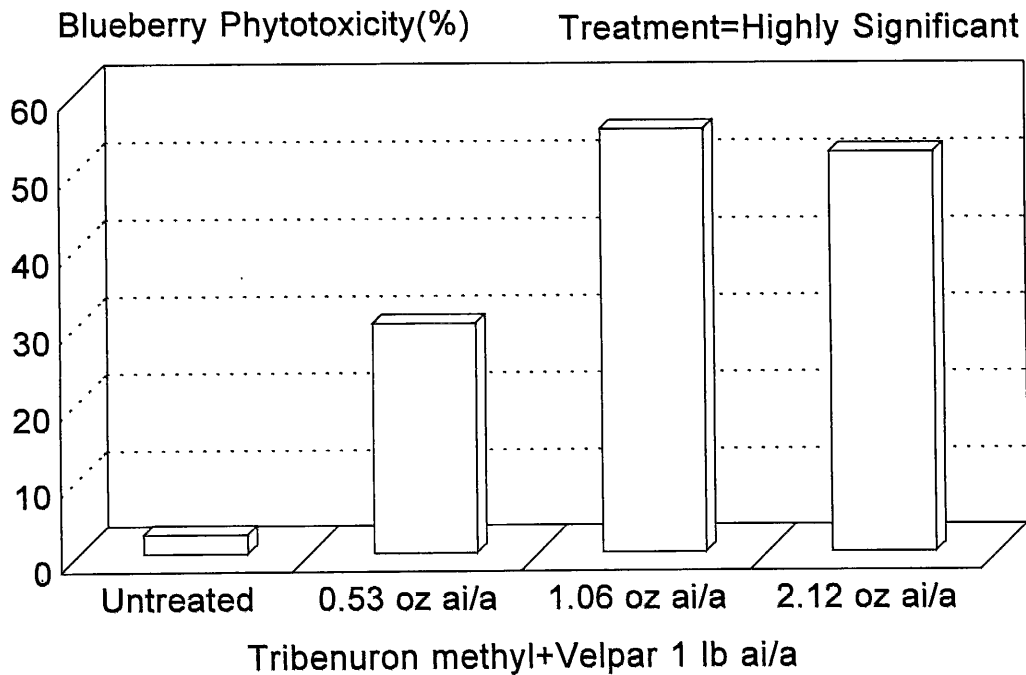
RECOMMENDATIONS: Evaluate carryover effects and take yields in 1996.

Figure 1. Effect of Tribenuron Methyl/Velpar Tank Mix on Bunchberry Numbers



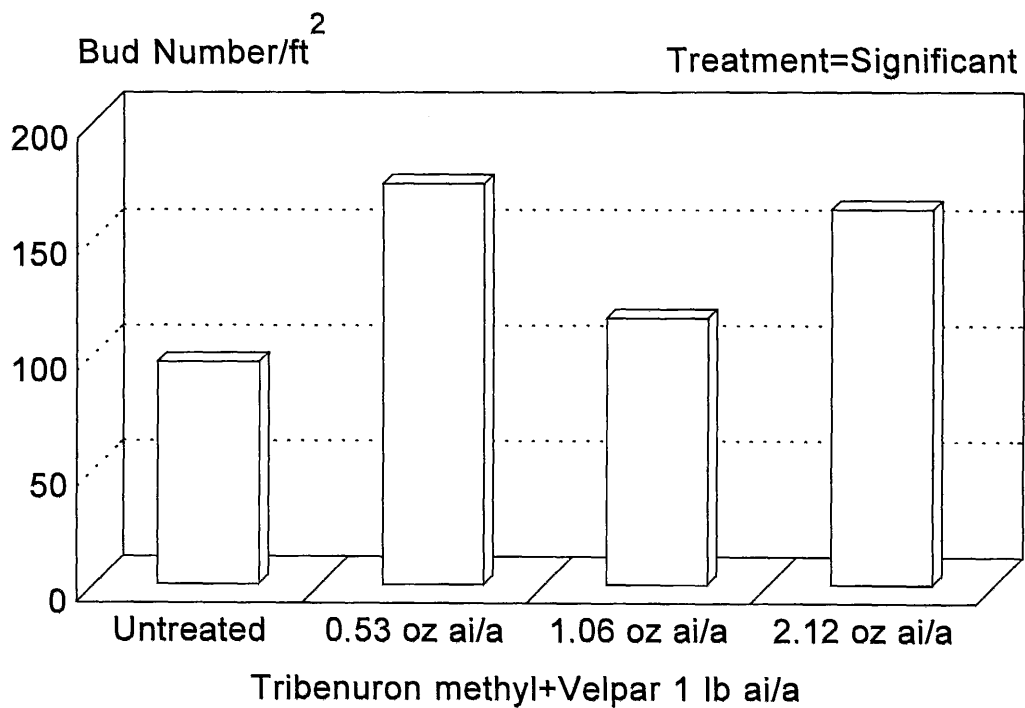
velex1

Figure 2. Effect of Tribenuron Methyl/Velpar Tank Mix on Blueberry Phytotoxicity



velex2

Figure 3. Effect of Tribenuron Methyl/Velpar Tank Mix on Blueberry Bud Number



velex3

F. EXTENSION

PRINCIPLE INVESTIGATOR: David E. Yarborough, Extension Blueberry Specialist

1. 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, through fact sheets in the wild blueberry growers guide, telephone and correspondence, and conduct field visits as appropriate. Cooperate with County Educators and provide support for blueberry initiatives requested by the County office. Cooperate with the Blueberry Research Advisory Committee, 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 three 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.

Field training sessions were offered at three 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, Union and Blue Hill on May 2, 3 and 4.

The second session was given in Appleton, Hancock and Jonesboro on May 16, 17, and 18 and included insect sweeping techniques, insect identification and insect life cycles. The third session dealt with scouting techniques for weed management, weed mapping, fruit fly trap placement and sampling for plant nutrition on June 20, 21 and 22 in Union, Eastbrook and Jonesboro.

Conducted first Blueberry Best Management Practices meetings in February 25, 28, March 1 and 2 in Ellsworth, Union, Machias and South Paris. These meetings stressed physical and

chemical factors affecting the movement of hexazinone in groundwater. Presentations were made by Extension Specialists, District Conservationists, Department of Agriculture, and the Board of Pesticides Control. I provided revised fact sheets and handouts at meetings and introduced a brochure with Washington County Soil and Water Conservation District. Information from these meetings helped growers make more informed decisions on the use of hexazinone and how it affects groundwater.

1995 Spring Blueberry Meetings were held in Ellsworth, March 23, in South Paris, March 22, in Union, March 21, and in Machias, March 25. Topics presented by Extension, Experiment Station, and Pesticide board personnel. These meetings provide growers with information on current topics and allow for discussion of projects and needs with Extension, State and University personnel working with blueberries. Presented need to use enterprise budget to remain competitive.

Summarized needs of organic growers and determined that weed management was their highest priority. Conducted field demonstration of cultural management techniques for weeds on farm experiments in Sedgewick on June 13 and in Beddington on July 13, 1995. Demonstrated management strategies and set up on-farm experiments which allowed growers to assess the effectiveness of different control techniques on their own farm.

Participated with Board of Pesticides Control committee to develop State Management Plan for Hexazinone use in Maine on January 27, February 17, March 17, April 7 and June 23, 1995 in Ellsworth, ME. The goal of this committee is to develop the first specific state groundwater management plan for the use of the herbicide hexazinone in Maine. The third draft has been completed and will be discussed in upcoming meetings of the Board of Pesticides Control before it goes to public hearing. Adoption of this plan will ensure that growers will have the tools they need to remain competitive and minimize the potential for movement of hexazinone into the groundwater.

Presented 'Blueberry ICM and Cranberry IPM' program to Blueberry and Cranberry Growers for pesticide recertification credits at Augusta Trade Show on January 12.

Gave guest lecture on "Blueberry Management" on January 31 and on "Cranberry Management" on April 25 for PSE101 in Orono.

Presented 'Results of blueberry harvester trial', '1994 hexazinone groundwater survey', 'Wild blueberry enterprise budget' and moderated Extension reports session, on March 29-30, 1995 at North American Blueberry Research and Extension Workers meeting in Bangor.

Participated in Department of Agriculture committee to develop Best Management Plan for Velpar® use in Maine on January 19, and February 15 1995 in Augusta, ME. Developed Best Management Practices for Hexazinone. Presented information at grower meetings and revised BMP's were incorporated into *Wild Blueberry Fact Sheet* No. 250.

Held Annual summer field day and crop guesstimate at Blueberry Hill Farm in Jonesboro on July 19. This session gives researchers and Extension faculty an opportunity to review programs

and discuss programs and to get grower input.

Met with representatives of the Federal Crop Insurance Corporation in Ellsworth on May 10 and Jonesboro on August 22 to develop criteria for a wild blueberry crop insurance program.

Explained Maine wild blueberry production to hundreds of attendants of the Big E Agricultural Fair in Springfield, Mass. on September 23-24.

Met with blueberry growers in Union, Maine on September 13 to discuss program needs.

Participated in the IR-4 annual meeting in Newport, RI on October 9-11 to establish priorities for Maine for minor use pesticide trials.

Participated in 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. Group met on October 23, November 7 and December 4-5. Report used as basis for Maine Conservation plan to manage the salmon.

Met with Maine Blueberry Advisory Committee on October 30-31 to summarize Extension education program and propose program for 1996.

Met with Blueberry Commission on November 16 in Ellsworth to report on Extension and research activities.

Met with Blueberry Advisory Committee to finalize Extension and Research projects on December 7 in Ellsworth.

I published a monthly newsletter to announce upcoming meetings and workshops, and to remind growers of proper management practices.

Updated four and revised two *Wild blueberry fact sheets* for the growers guide.

I continue to respond to calls and letters on blueberry, cranberry and weed related matters through my office. Requests range from basic to technical. This past year there was a large increase in questions on the use of hexazinone and how that related to human safety.

I continue to contribute to numerous TV, radio and newspaper interviews.

Other Activities:

I am the chairman of 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 and to help coordinate programs, and to enhance communication among researchers and WBANA members. Food Science research projects are being coordinated in this committee to reduce duplication and foster cooperation on projects between Maine and Canada.

I am IR-4 liaison for the state of Maine. IR-4 is a federal agency which facilitates the registration of pesticides on minor use crops. Assistance is given for registration when the need is demonstrated but the chemicals are not economically feasible for companies to register. This allows for the use of materials needed in IPM programs that would have been lost. Two IR-4 projects were done in Maine in 1995.

I am coordinator for the CSREES special research grant 'Lowbush blueberry production and processing technologies' which is granted by the USDA; \$206,747 was awarded for 1996. I coordinate proposals and reports from the researchers involved.

I have reviewed manuscripts for the *Canadian Journal of Plant Science*, *HortTechnology*, the *Journal of Small fruit and Viticulture* and the *Canadian Field-Naturalist*.

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 (see graph of 1995 skills). 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. More efficient management will result in greater returns and a stable, sustainable industry.

I specifically surveyed the larger companies on their use of Velpar[®] since they also service many small growers (see graph on hexazinone use). The result is a steady decline in the use of Velpar[®] over the past four years. The shift from liquid to granular hexazinone will also result in better efficacy against weeds and less potential leaching of herbicides into the groundwater.

The hexazinone groundwater survey I conducted from 1992 to 1995 has provided information on the movement of this herbicide into the groundwater. Over the past three 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 making decisions about the continued use of hexazinone in Maine.

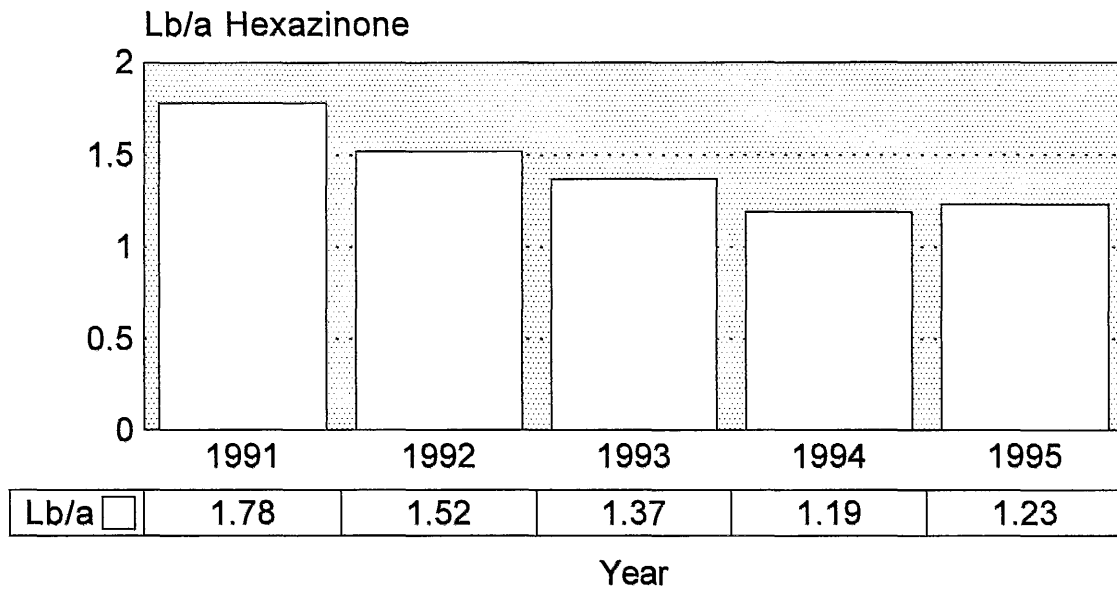
I did a survey of grower practices in 1992 and 1995 (see graphs at end of report). Over 60% of the blueberry land is in Washington County followed by Hancock, with about 20% and 15% in Knox and Lincoln Counties. These three areas have had the focus of most of the blueberry programs. Eighty percent of the growers have farms under 50 acres and 75% of them farm part time. All programs, except the annual field day at Blueberry Hill Farm, were held in the evening or on weekends to accommodate the part time growers. The use of Velpar[®] and Guthion[®] decreased as growers incorporated cultural practices or less toxic chemical alternatives. More growers used the fungicide Funginex[®] to control mummyberry disease and use of

Benlate®, a less effective alternative, decreased. More growers mowed their fields which is less costly and preserves the soil organic matter. Fertilizer use increased as growers used their leaf sample results. Although the integrated pest management practices were not as high as those participating in the ICM program, a slight increase in fly trapping, sweep netting and leaf sampling was seen from 1992 to 1995. Most growers still wanted information on weeds, general management and economics of blueberry production.

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 enables growers to improve the efficiency of blueberry culture by reducing unnecessary pesticides and fertilizers. More efficient management will result in greater returns and a stable, sustainable industry.

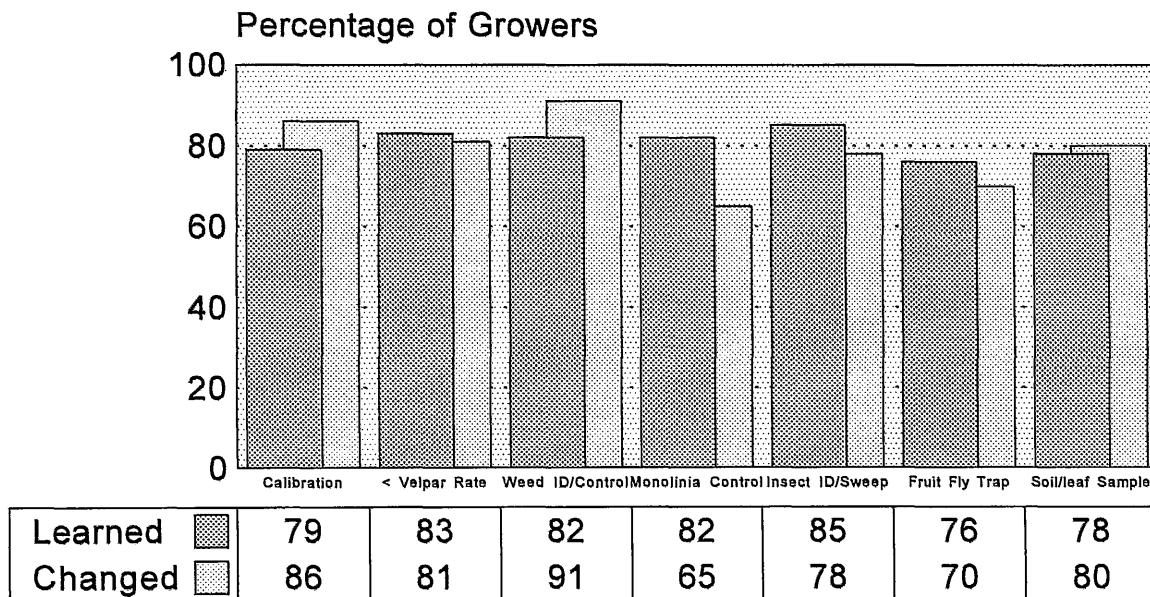
RECOMMENDATIONS: Continue to support Extension educational program.

Industry Survey of Hexazinone Use Averages of 8 processors



1994- 4% of acres applied granular
1995- 36% of acres applied granular

1995 Skills Survey Results (for 3 yrs) Wild Blueberry ICM Educational Program



Integrated Crop Management Skills

87 Growers in 4 counties on 23834 acres (44% return)
44% do pesticide applications and 58% have pesticide license

1995 Wild Blueberry Survey Results

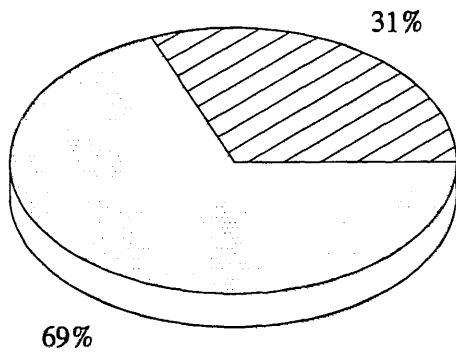
Information compiled from 278 growers and processors responding to a survey form the *Wild blueberry Newsletter* in 1995.

Distribution of blueberry acres by county:

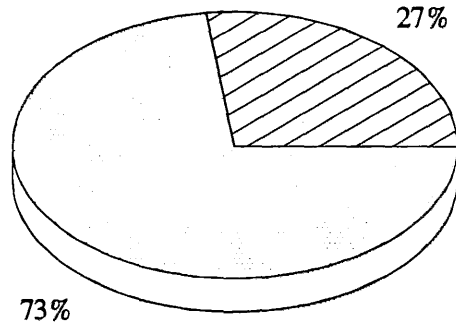
| <u>County</u> | <u>% of Acreage</u> |
|---------------|---------------------|
| Androscoggin | <1 |
| Cumberland | <1 |
| Franklin | <1 |
| Hancock | 17.5 |
| Kennebec | <1 |
| Knox | 15.2 |
| Lincoln | 1.2 |
| Oxford | 2.6 |
| Penobscot | <1 |
| Piscataquis | <1 |
| Sagadahoc | <1 |
| Waldo | 1.1 |
| Washington | 60.8 |
| York | <1 |

Maine - Five year average yield - 64.5 million pounds

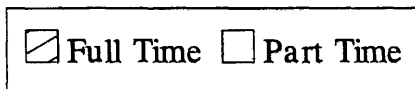
Grower Occupation



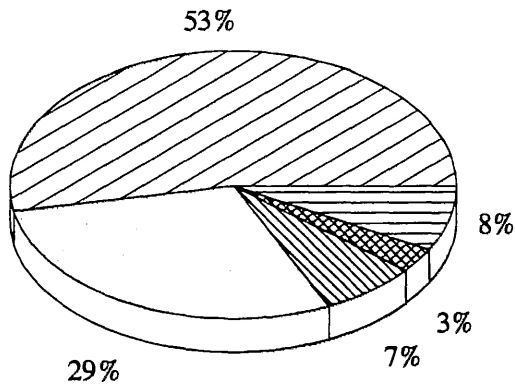
1992



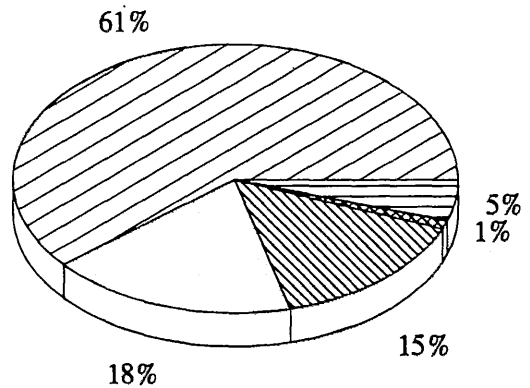
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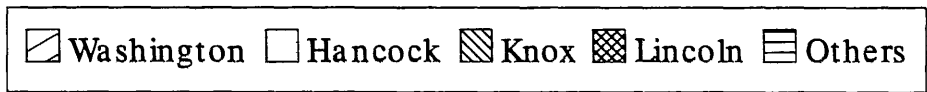
Blueberry land by county



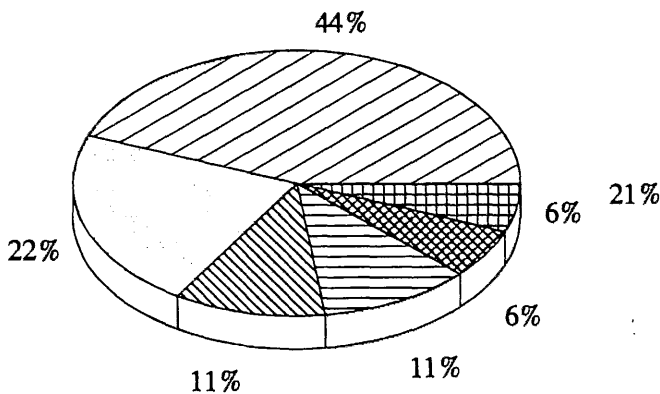
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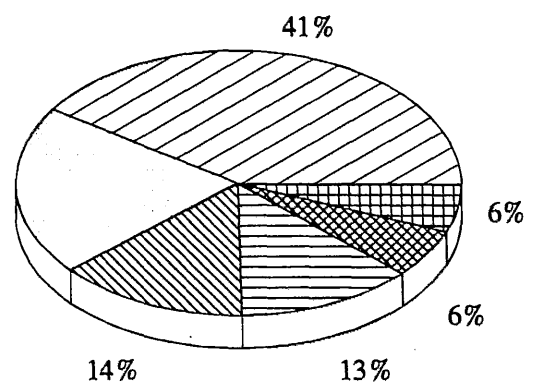
1995



Grower distribution by county



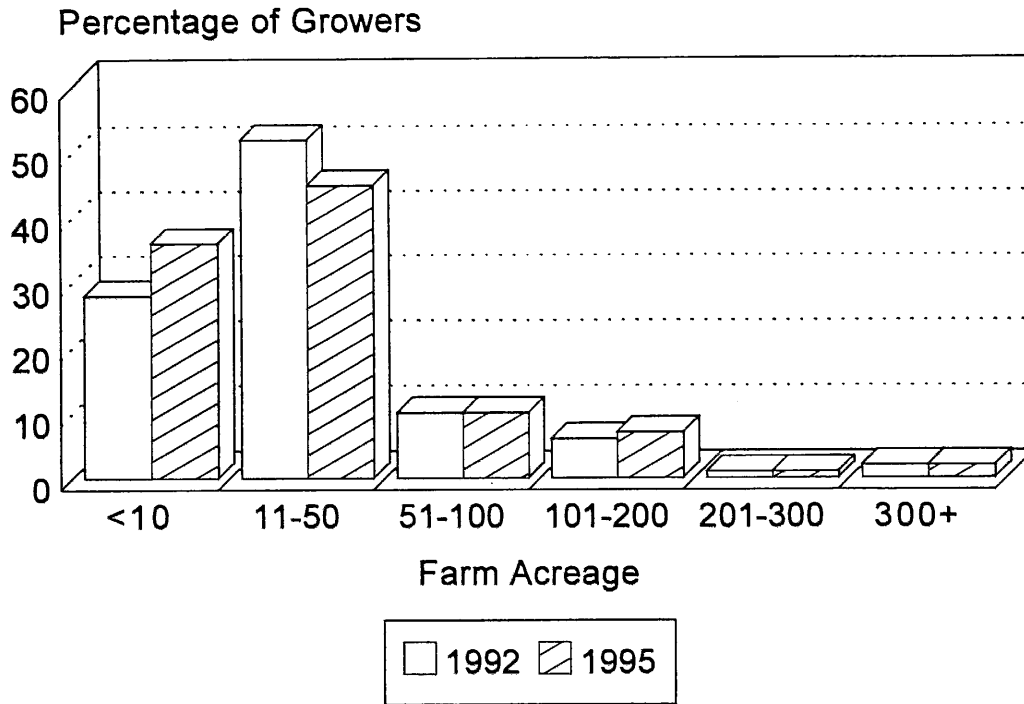
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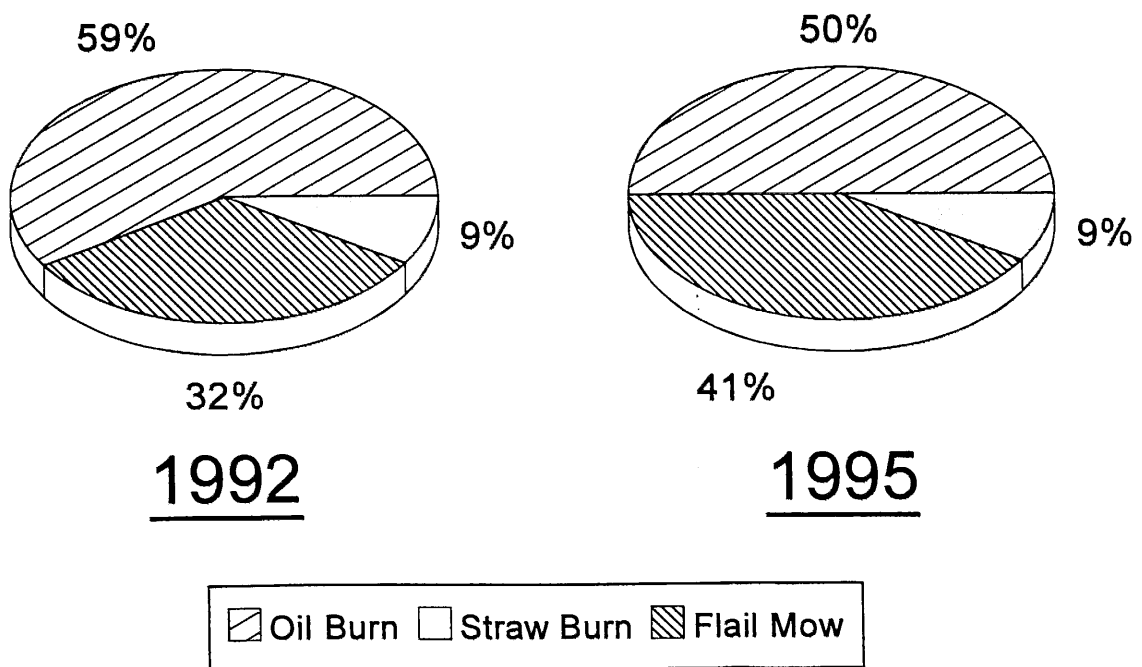
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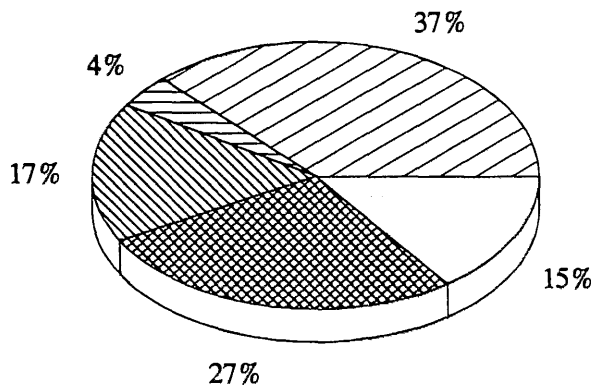
Farm Size in acres



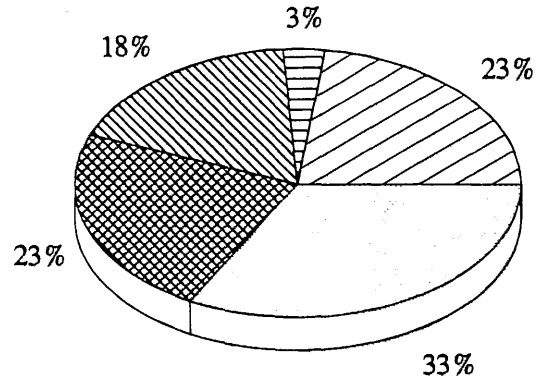
Pruning Methods percentage of acreage



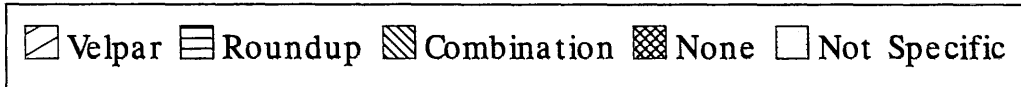
Herbicide use by Growers



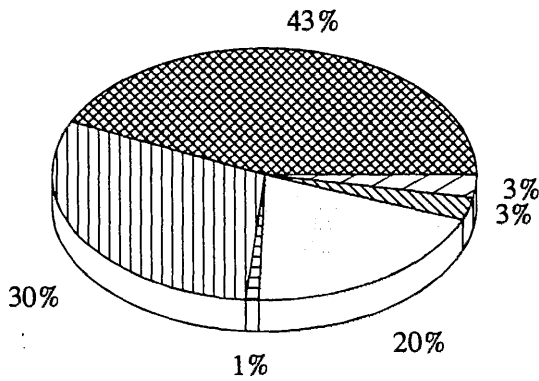
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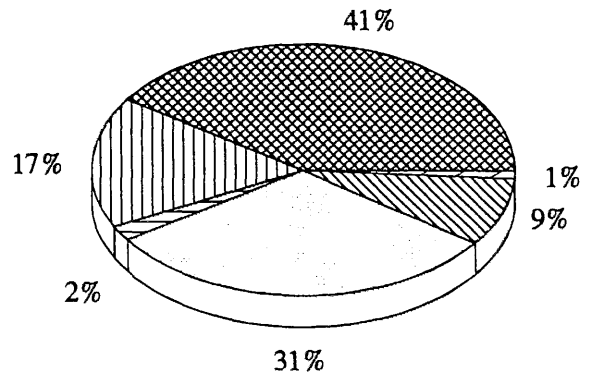
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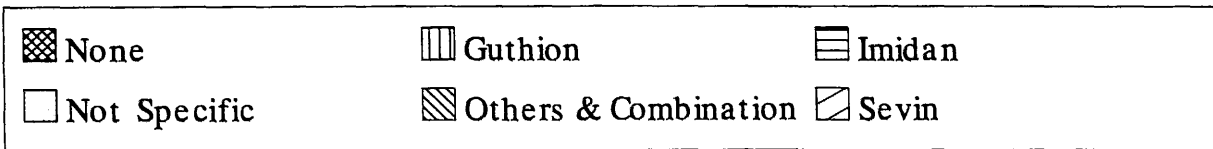
Insecticide Use by Growers



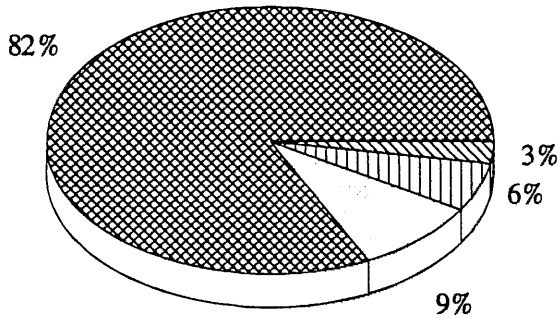
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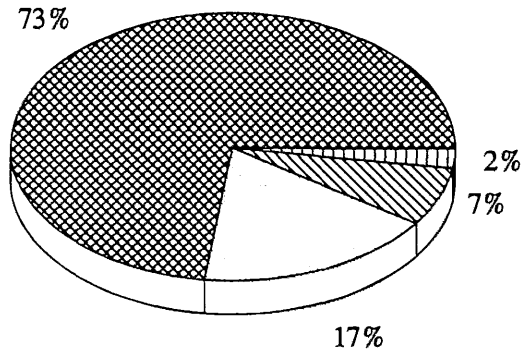
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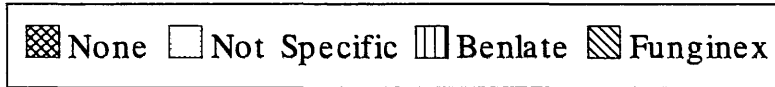
Fungicide use by Growers



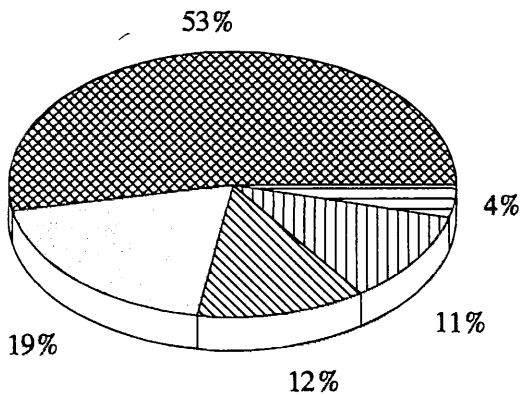
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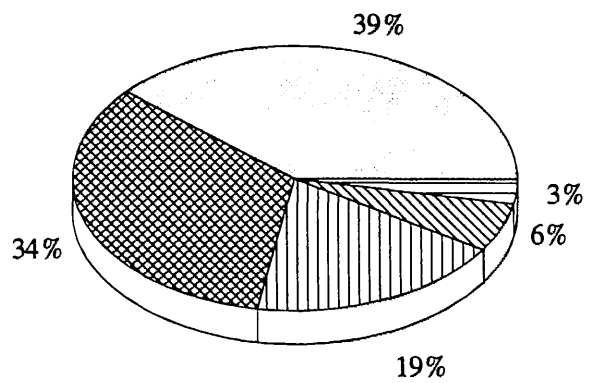
1995



Fertilizer Use by Growers



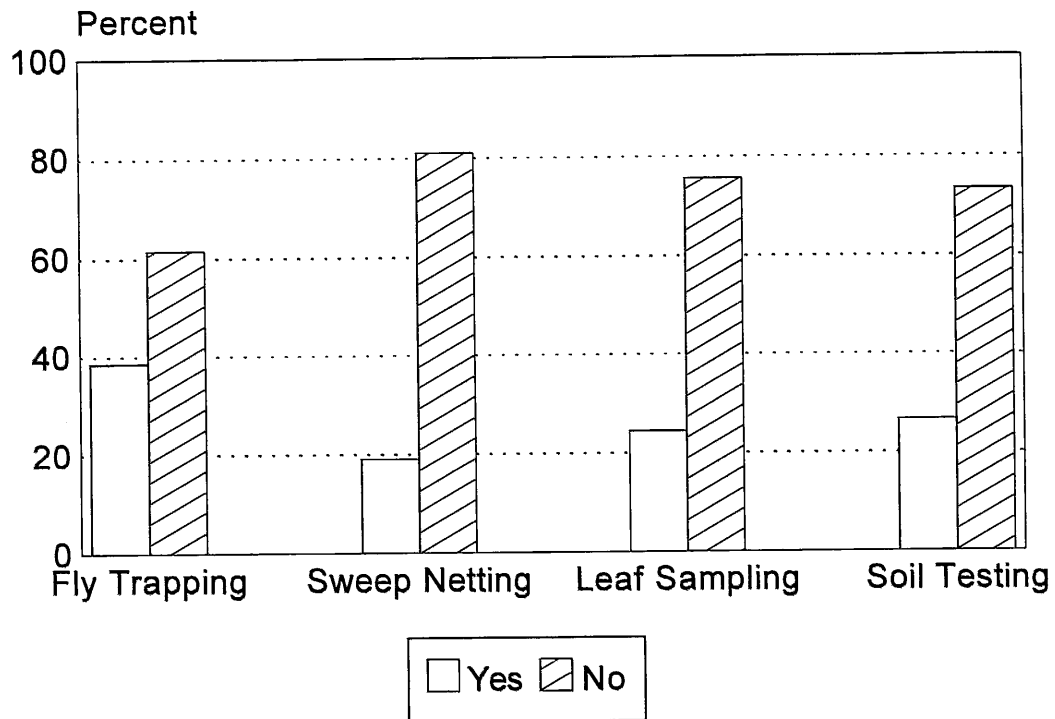
1992



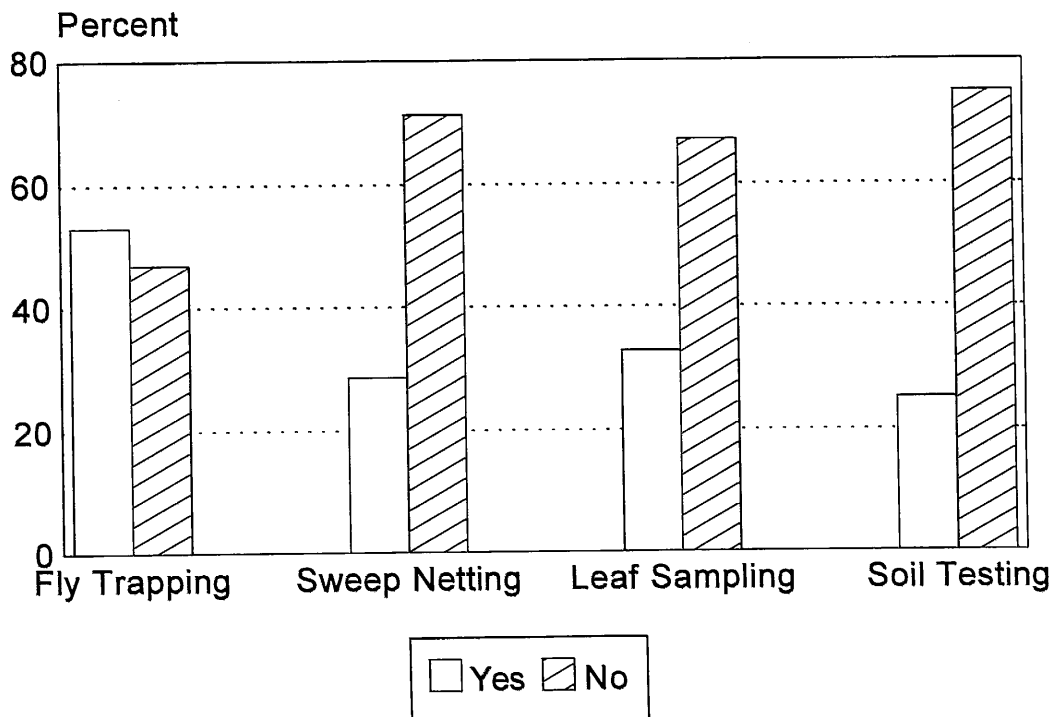
1995



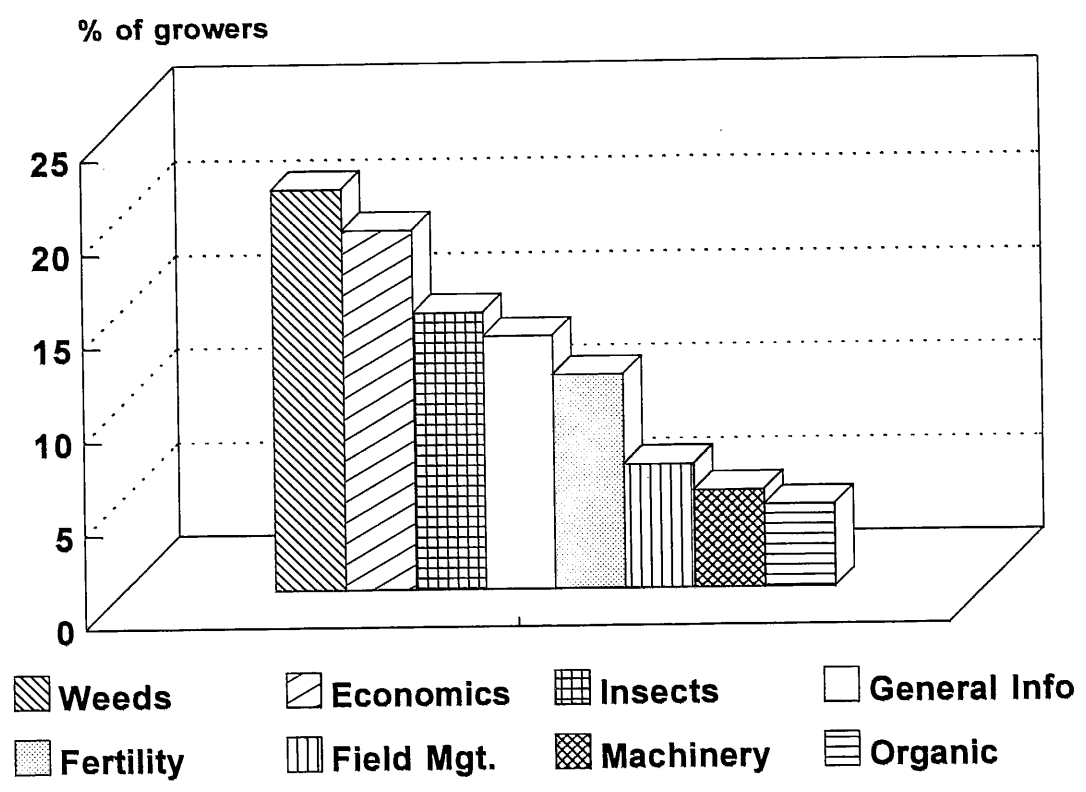
Integrated Pest Management percent using-1992



Integrated Pest Management percent using-1995



Questions Asked by Growers-1992



Questions Asked by Growers-1995

