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1994 CSRS Research Reports/1994 Blueberry Tax Reports

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1994 CSRS Research Reports

A. FOOD SCIENCE AND HUMAN NUTRITION

INVESTIGATORS: Mary Ellen Camire, Assistant Professor of Food Science
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1. TITLE: Potential Uses for Green and Red Cull Blueberries

MATERIALS & METHODS: Optical sorter rejects, or cull IQF lowbush blueberries, stored at -18°C were provided by Jasper Wyman and Son, Cherryfield ME. Preliminary work was conducted using puree made from these berries, but the complete replicated experiment has been delayed due to equipment problems at the company. A new puree machine has been installed at Jasper Wyman's and puree has been made from the sorter rejects. A scale-up extraction using a 50 liter vessel will be attempted this month. Concentration of the pigment from the alcohol extract was planned to be conducted using ultrafiltration equipment from the Department of Chemical Engineering, but that particular piece of equipment was unavailable. Final concentration will be performed with steam distillation to remove the majority of the ethanol and water.

Anthocyanins

Anthocyanins were extracted from the filtrate, and absorbance at 535 nm was used to measure anthocyanin concentration. Stirring time and speed were found to have little effect on pigment recovery

Pectin colour

Pectin was extracted from the alcohol treated puree with hot water. The pectin retained some pigment, rendering it unusable for industry. Several treatments with sodium metabisulfite were evaluated for potential in removing this residual colour.

Total dietary fiber

Dietary fiber constituents were analyzed by a chemical method (AACC method 32-25) in order to further characterize this material for functional characteristics and potential health benefits.

RESULTS & DISCUSSION: This project has faced several equipment related setbacks during the past year. Although the graduate student involved is now working on a different project he will complete the scale up duplicate by the end of February, 1995

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

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

METHODS: Two thirty pound boxes of IQF blueberries were obtained from Jasper Wyman & Son. One of the boxes was first run berries while the second contained rerun fruit which had been put through the reel destemmer twice. The amount of anthocyanin leakage from the two samples was measured by mixing a 30 g sample of blueberries with 100 ml of phthalate buffer pH 3.0 The mixture was stirred for 5 min. In all cases the stirring bar was separated from the fruit to prevent mechanical damage. The color of the extract was measured in a Beckman Spectrophotometer at 525nm.

Blueberries from each of the samples were treated with various concentrations (0.1 to 10%) of sodium carboxymethylcellulose(CMC) , guar gum and gum arabic. The degree of anthocyanin leakage was measured as described above for each of the treatments. Further samples of rerun blueberries were treated with CMC (10% by wt.) and these berries were used in muffins in order to evaluate the affect of treatment on bleed in muffins. Batter color was measured before baking using a Hunter LabScan II Spectrocolorimeter. Interior color of the muffins was evaluated by a trained panel to determine degree of anthocyanin leakage into the batter. A seven point hedonic scale from 1 (no color) to 7 (highly colored) was used.

RESULTS: Rerun berries had a significantly ($P < 0.01$) higher driploss and demonstrated significantly ($P < 0.01$) greater anthocyanin leakage than first run berries. These results indicate that passing the blueberries through the reel destemmer for a second time causes severe abrasion which results in loss in quality if the fruit is to be used in bakery products (e.g. muffins, cakes).

Sensory scores were highly correlated with Hunter L, a and b values. Muffins with first run and rerun berries coated with CMC had the lowest sensory scores, 1.5 and 1.3, respectively. However, muffins with uncoated rerun berries were significantly ($P < 0.01$) darker in color and had a higher sensory score (6.5). First run berries without coating bled slightly, and received a sensory score of 4.0. CMC effectively reduced anthocyanin leakage of rerun IQF frozen blueberries in muffins. Guar gum and gum arabic also reduced anthocyanin leakage of IQF blueberries.

CONCLUSIONS: Chemical treatment can affectively reduce anthocyanin leakage in IQF blueberries. This reduction can be used to improve the color of muffins.

Recommendations: Complex carbohydrates and gums offer possibilities for reducing anthocyanin leakage from both first run and rerun blueberries.

Future Work: The next phase of this research needs to examine the procedures that can be used commercially to coat the blueberries with CMC. In addition, effect of freezing tunnel or method on anthocyanin leakage in blueberries will need to be examined.

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Therese M. Work, Associate Food Scientist
Dick Work, Scientific Technician

3. TITLE: The Effect of Fertilization and Irrigation on Blueberry Fruit Quality

METHODS: Blueberries were harvested from Jack Smagula's plots at Blueberry Hill Farm at the time of fruit maturity using traditional methods. Four treatments were examined and each treatment included irrigated and non-irrigated blueberries (Treatment 1 = 2 year cycle; Treatment 2 = 3 year cycle; Treatment 3 = 3 year cycle with velpar, urea; Treatment 4 = velpar, NPK). Blueberries were transported on ice to the Department of Food Science and Human Nutrition for analysis. Chemical and physical analyses were performed on replicates of each treatment. Texture of the blueberries was measured on 100 g samples using an Instron Universal Food Testing Machine equipped with an extrusion cell. Titratable acidity, pH, Brix and moisture were measured using AOAC methods. A composite sample was taken from each replicate from each treatment for sugar analysis. The samples for sensory evaluation were presented in a randomized complete block design. A sensory panel consisting of 40-60 judges were used to rank samples in order of preference for flavor and texture and to check whether or not each sample was acceptable. The ranked data for preference was transformed to scores according to Fisher and Yates for normalizing ranked data and was analyzed by the variance method. The Waller-Duncan Test at K-ratio = 100 was used to determine significant differences among sample scores.

In a second experiment samples from six irrigated and six non-irrigated clones were obtained from Fred Olday at Jasper Wyman & Son. Chemical and physical analyses of each clone was performed as described above.

RESULTS: The results of the Blueberry Hill Farm experiments are shown in Table 1 and 2. For the irrigated samples there were no significant differences among treatments for any of the characteristics examined. For the non-irrigated samples berries from Treatment 4 were significantly ($P<0.05$) softer than those from Treatment 1 and 3. The moisture content of the blueberries from Treatment 1 was significantly ($P<0.05$) lower than berries from the other treatments. Figures 1 to 3 point out significant differences between irrigated and non-irrigated blueberries. Although differences were noted, they were not consistent across treatments which would indicate that other factors (clones) may be involved. It should be noted that significant rainfall occurred prior to harvest which was late in the season. No significant differences were found between irrigated and non-irrigated blueberries for any of the sensory characteristics.

The results from Wyman's irrigation study are shown in Table 3 and Figures 4 to 7. Significant ($P<0.05$) differences were observed between irrigated and non-irrigated fruit for moisture, texture, size, glucose, fructose and total sugars. The irrigated blueberries were higher in moisture, larger, softer and contained less glucose, fructose and total sugar. It should be noted that these berries were harvested by clone, early in the harvest season and at a time of little

rainfall.

CONCLUSIONS: Based on six years of data from the Blueberry Hill Farm research and two years of data from Wyman's study, it is evident that many factors affect the chemical and physical characteristics of blueberries. In years when rainfall is low, irrigation can be used to increase berry size, but there are clonal differences. As the industry looks toward the fresh market, irrigation may be a means of producing larger fruit to compete with the cultivated blueberry.

RECOMMENDATIONS: Irrigation may be a valuable tool in the production of larger fruit for the fresh market, particularly if sizing of the berries is performed prior to packaging.

FUTURE WORK: This should be the end of this research project.

Table 1: Jonesport Irrigation Study 1994
Blueberry Hill Experiment Station

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
pH	3.43 a	3.28 a	3.35 a	3.42 a
Brix %	9.28 a	9.55 a	9.40 a	9.60 a
Titrat. Acidity %	0.32 a	0.34 a	0.33 a	0.30 a
Moisture %	87.10 ab	87.79 a	87.01 ab	87.05 ab
Texture Kg-F	0.490 c	0.500 bc	0.55 abc	0.490 c
Greens*	0.30 a	0.23 a	0.10 a	0.23 a
Reds*	0.10 a	0.13 a	0.18 a	0.23 a
Debris*	0.23 abc	0.10 c	0.35 a	0.13 c
Blues*	99.38 ab	99.55 ab	99.38 ab	99.25 b
Crush g/100g	7.78 a	7.38 a	7.58 a	8.75 a
Size #/50g	108 a	130 a	125 a	116 a

Irrigated

Table 2: Jonesport Irrigation Study 1994 Blueberry Hill Experiment Station

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
pH	3.31 a	3.24 a	3.62 a	3.58 a
Brix %	8.90 a	10.08 a	9.13 a	9.85 a
Titrat. Acidity %	0.40 a	0.42 a	0.39 a	0.28 a
Moisture %	85.76 c	87.10 ab	87.76 a	86.74 b
Texture Kg-F	0.600 a	0.520 abc	0.590 ab	0.49 c
Greens*	0.15 a	0.28 a	0.05 a	0.08 a
Reds*	0.05 a	0.13 a	0.00 a	0.25 a
Debris*	0.28 ab	0.13 c	0.15 bc	0.18 bc
Blues*	99.53 ab	99.48 ab	99.80 a	99.63 ab
Crush g/100g	4.95 b	6.90 ab	8.03 a	7.90 a
Size #/50g	128 a	122 a	134 a	105 a

Not Irrigated

Table 3: Wyman's Irrigation Study 1994

	Irrigated	Not Irrigated
pH	3.43	3.34
Brix %	9.39 a	10.04 a
Tit. Acidity %	0.30 a	0.36 a
Moisture %	87.04 a	84.84 a
Texture Kg-F	0.848 b	1.072 a
Size #/50g	78 b	137 a
Glucose*	4596.4 b	5193.3 a
Fructose*	4604.4 b	5305.6 a
Sucrose*	0 a	15.13 a
Total Sugars*	9200.8 b	10514.1 a

* mg/100g

Jonesport Irrigation Study 1994
Debris

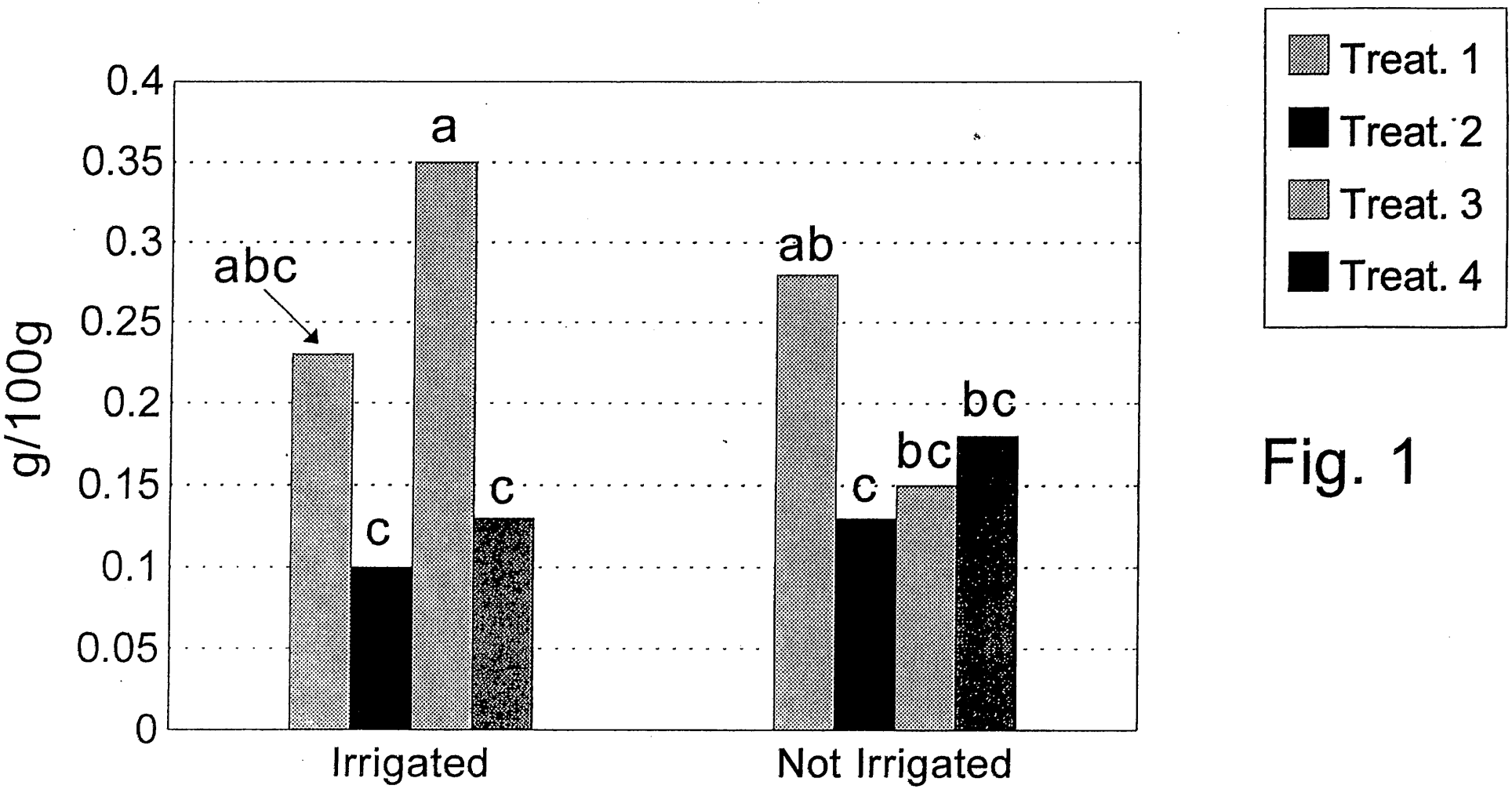


Fig. 1

Those bars with the same letter indicate no difference at the 95% confidence level

Jonesport Irrigation Study 1994
Texture

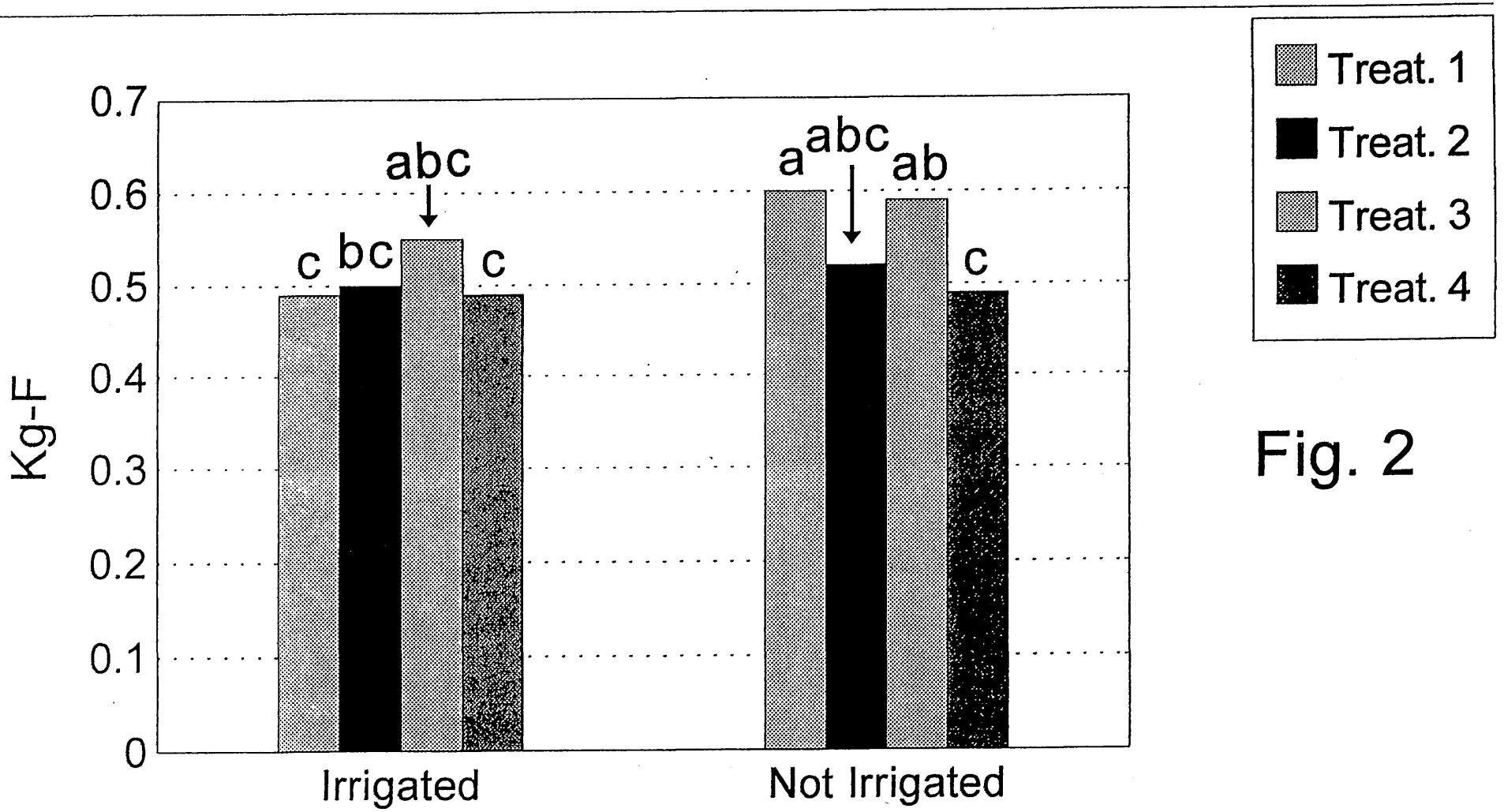


Fig. 2

Those bars with the same letter indicate no difference at the 95% confidence level

Jonesport Irrigation Study 1994 Moisture

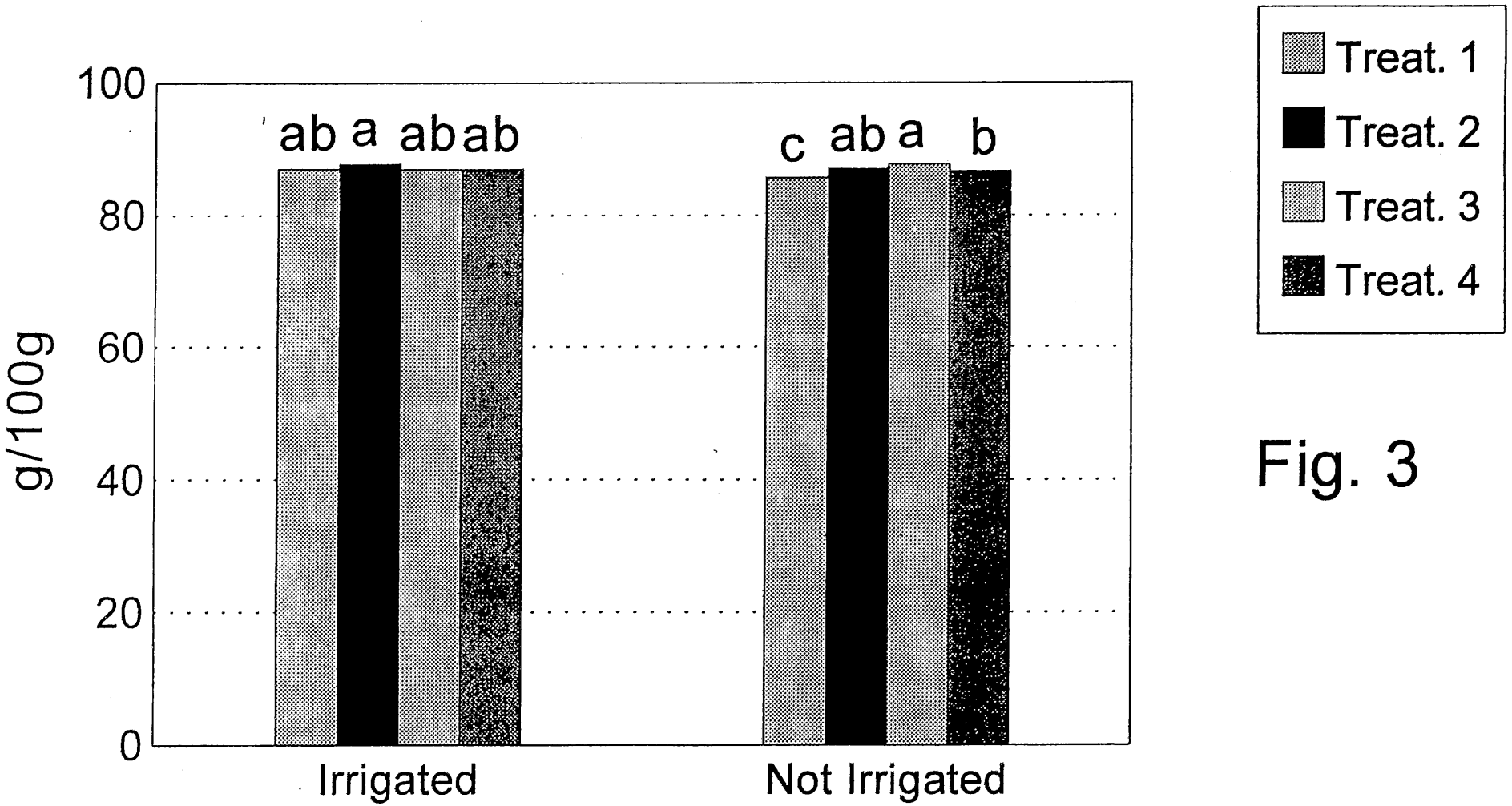


Fig. 3

Those bars with the same letter indicate no difference at the 95% confidence level

Wyman's Irrigation Study 1994
Moisture content

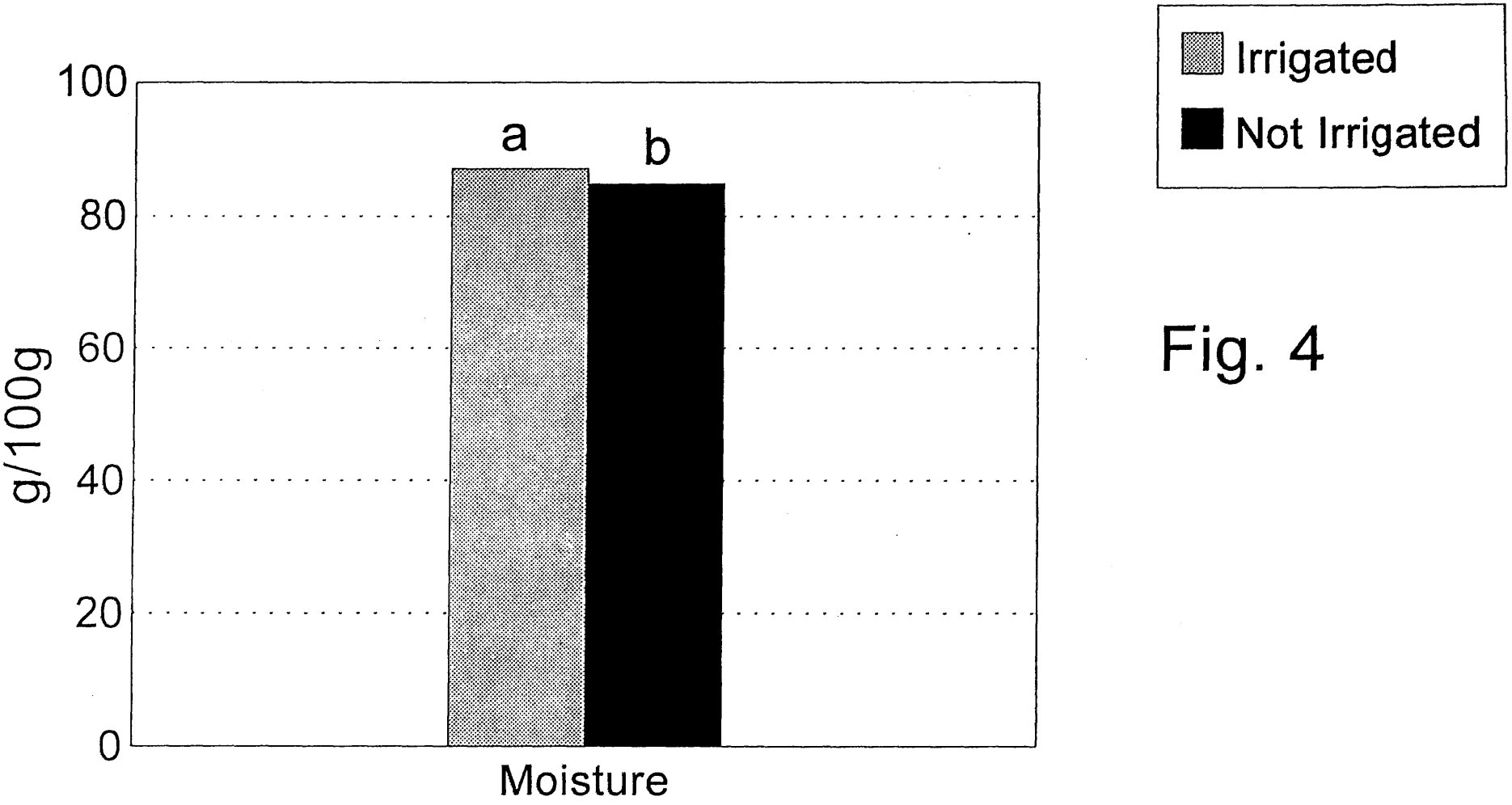


Fig. 4

Those bars with the same letter indicate no difference at the 95% confidence level

Wyman's Irrigation Study 1994 Texture

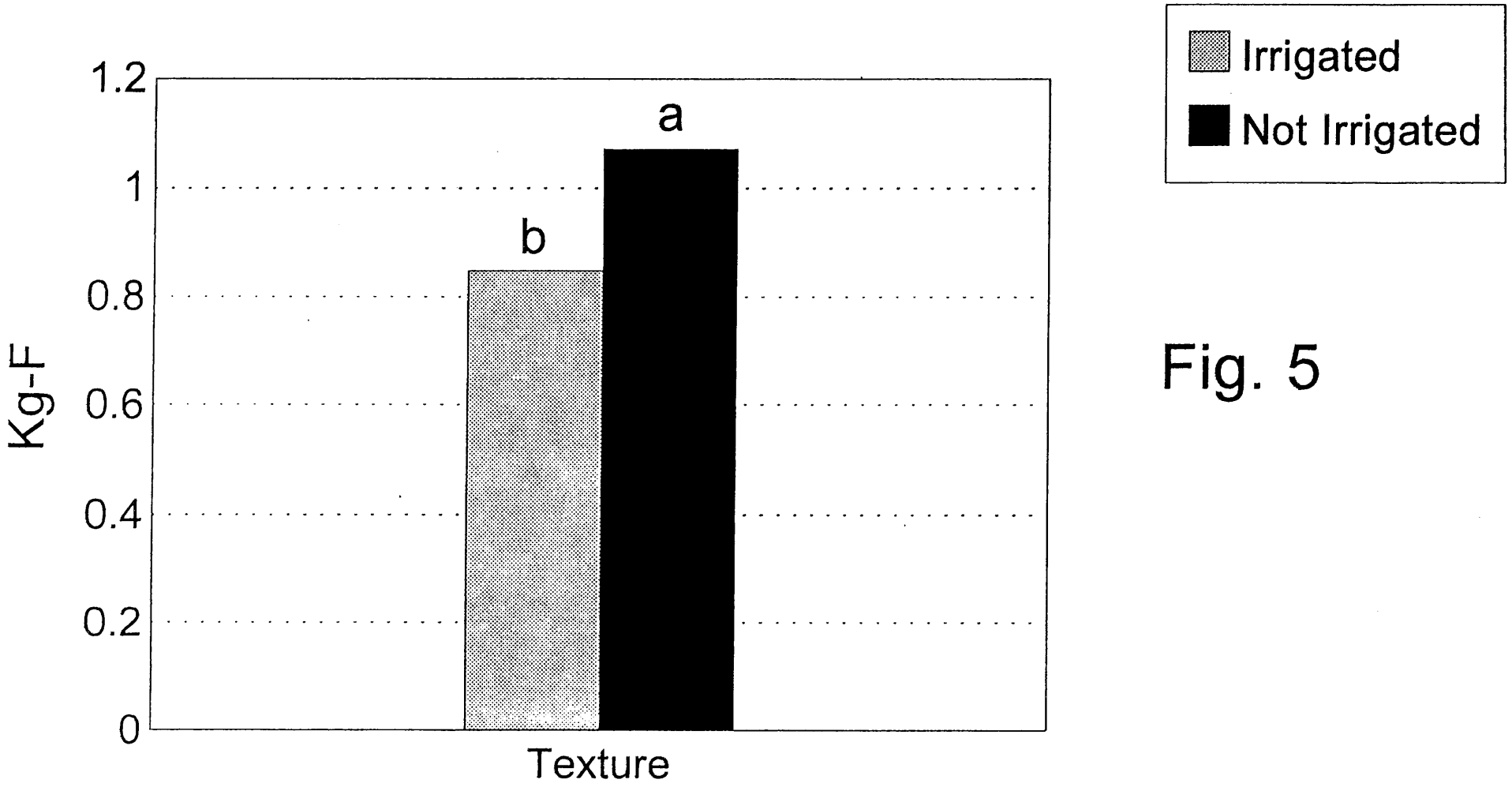


Fig. 5

Those bars with the same letter indicate no difference at the 95% confidence level

Wyman's Irrigation Study 1994 Size

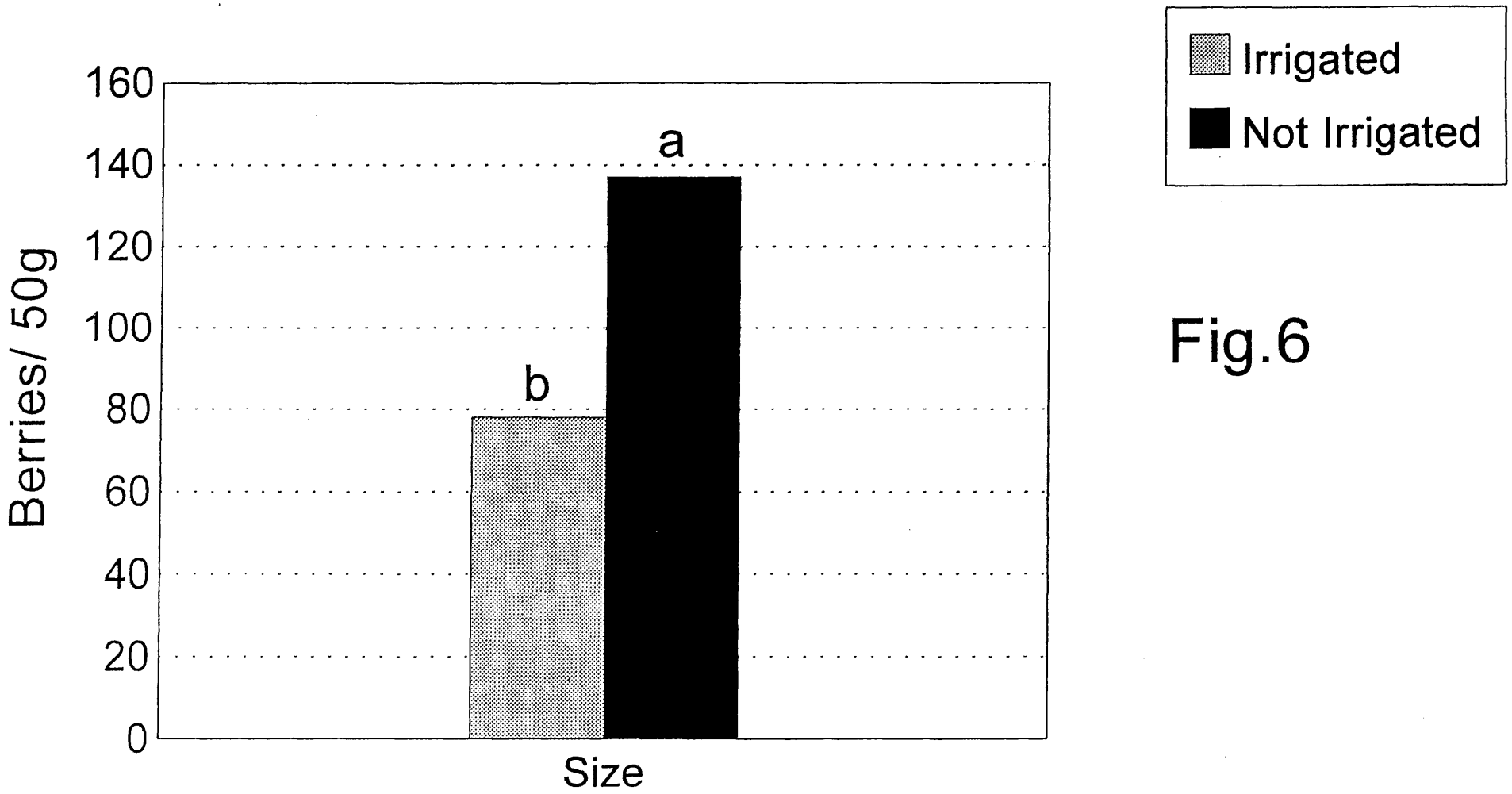


Fig.6

Those bars with the same letter indicate no difference at the 95% confidence level

Wyman's Irrigation Study 1994
Sugars

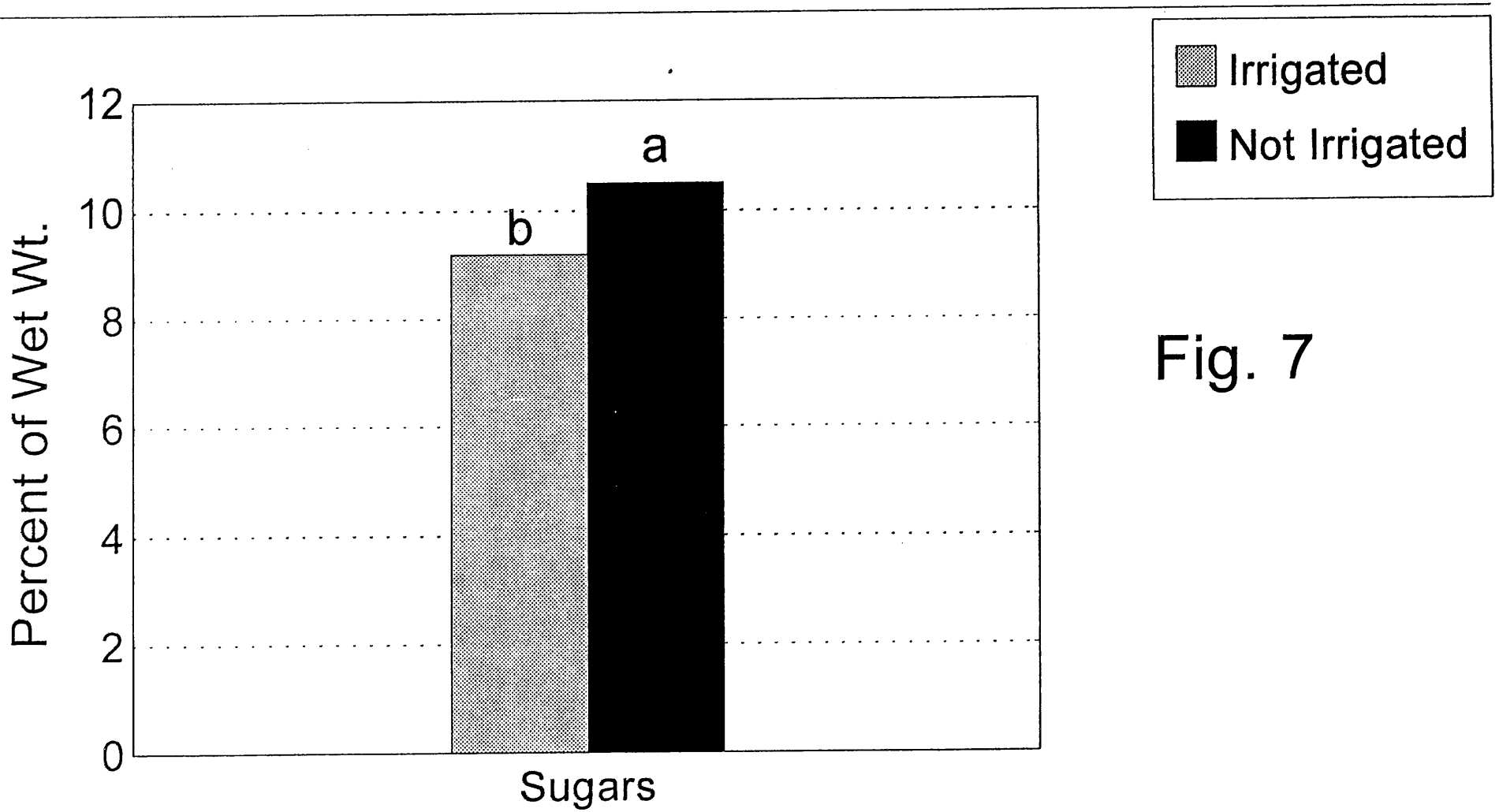


Fig. 7

Those bars with the same letter indicate no difference at the 95% confidence level

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

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

METHODS: Blueberry samples were gathered by Fred Olday and brought to my laboratory for analysis in September. Samples arrived in the frozen state and were placed in a freezer. Samples were analyzed by either immunoassay or GC-AED methods that had been developed earlier.

RESULTS: All samples have been analyzed. Results are given in Table 1. None of the samples contained detectable levels of methoxychlor. However, 16 samples contained guthion, 5 samples had imidan, and 21 were shown to have carbendazim (degradation product of benomyl) present. Carbendazim was found the most frequently and at the highest level, 0.336 ppm, but far below the tolerance of 7 ppm. The organophosphates, guthion and imidan were demonstrated to be present in the berries at less frequency and less concentration. The highest level of guthion observed was 0.092 ppm while the highest amount for imidan was 0.053 ppm. All organophosphate concentrations were well below the 5 ppm tolerance.

CONCLUSIONS: As far as tolerance levels, these berries contain low levels of pesticides. My only concern is the frequency and amount of carbendazim that was present. This fungicide has been under attack for years and is on the EPA hit list.

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

Future Work: This project should be continued at some level for an unlimited time with the expansion of more chemical analyses

Table 1. Blueberry Results.

	Pesticide conc. in blueberries (ng/g)			
Sample #	Guthion	Imidan	Methoxychlor	Carbendazim
BLB1	4.7965	0.0000	0.0000	336.0000
BLB2	5.7989	0.0000	0.0000	208.0000
BLB3	0.0000	0.0000	0.0000	44.5000
BLB4	3.2842	0.0000	0.0000	211.0000
BLB5	21.7626	0.0000	0.0000	160.0000
BLB5A	22.0951	0.0000	0.0000	336.0000
BLB5B	15.0529	0.0000	0.0000	301.0000
BLB5C	15.0524	0.0000	0.0000	262.0000
BLB6	11.1287	0.0000	0.0000	0.0000
BLB7	0.0000	2.2158	0.0000	0.0000
BLB8	0.0000	5.1437	0.0000	7.0000
BLB10	0.0000	53.0751	0.0000	0.0000
BLB11	11.1317	0.0000	0.0000	221.0000
BLB12	0.0000	0.0000	0.0000	109.0000
BLB13	0.0000	3.1159	0.0000	34.7000
BLB14	0.0000	0.0000	0.0000	0.0000
BLB15	10.6868	0.0000	0.0000	270.0000
BLB16	0.0000	0.0000	0.0000	34.7000
BLB17	77.1032	0.0000	0.0000	12.5000
BLB18-1	92.7687	0.0000	0.0000	44.6000
BLB18-2	75.8078	0.0000	0.0000	47.9000
BLB19	0.0000	0.0000	0.0000	0.0000
BLB20	0.0000	0.0000	0.0000	11.7000
BLB21	0.0000	0.0000	0.0000	0.0000
BLB22	0.0000	0.0000	0.0000	0.0000
BLB23	0.0000	0.0000	0.0000	
BLB24	3.6525	0.0000	0.0000	232.0000
BLB25B	0.0000	0.0000	0.0000	0.0000
BLB25F	0.0000	0.0000	0.0000	
BLB26	5.4472	0.0000	0.0000	173.0000
BLB*	20.5819	7.6333	0.0000	57.6000

*Cherryfield Foods

1995 ME Advisory committee report, UMM Orono

INVESTIGATORS: Alfred A. Bushway, Professor of Food Science
Dick Work, Scientific Technician
Jack M. Smagula, Professor of Horticulture
Dave E. Yarborough, Blueberry Specialist
Tim M. Hess, Research Associate
Michele C. Marra, Associate Professor of Agric. & Res. Econ.

5. TITLE: The Effect of Mechanical Harvesting on Blueberry Fruit Quality

METHODS: The project was coordinated by Michele Marra and Dave Yarborough and was designed to examine the effect of hand harvesting and three types of mechanical harvesters (unmodified and modified Brag, NIMCO) on yield, fruit loss and berry quality. Trials were performed on two consecutive days at two locations (Spring Pond and T-19 Montegail Pond). Eight replicates of each treatment (harvester method) were performed at each site. Samples were taken from each replicate and analyzed for % crushed berries, % debris and berry texture (using an Instron with an extrusion cell; 100g sample).

RESULTS: At the Spring Pond location, there were no differences in texture or % debris, but the handraked and NIMCO harvested blueberries had significantly ($P < 0.05$) less crushed fruit (Table 1). The land at this location was not leveled and blueberry plants were short (6-8in). Moss and dirt clods were found in all samples harvested with mechanical harvesters. Using a five point ranking system with one having the least and 5 having the most , the harvesters were rated as follows.

NIMCO 1
Brag 3
Modified Brag 3

At T-19, Montegail Pond, the NIMCO harvested berries were softer than fruit harvested with the modified Brag harvester. There were no differences in % debris, but the handraked and NIMCO harvested blueberries had significantly ($P < 0.05$) less crushed fruit (Table 2). The field had been leveled with tall blueberry plants (8-12in). No moss or dirt clods were observed in any of the samples.

Analysis of the data comparing locations vs harvester method showed that the only significant ($P < 0.05$) difference was on the texture of the fruit harvested with the NIMCO harvester (Table 3).

In all cases blueberries from the Brag and modified Brag harvesters were wet. All berries were field winnowed prior to sampling.

CONCLUSIONS: The type of harvester will affect fruit quality and in particular the % of crushed berries. Environmental factors such as plant height, land condition, etc. may also be factors. These results must be analyzed in conjunction with yield data, harvesting time, cost, etc. in order to determine if some quality loss can be off set by other economic factors.

RECOMMENDATIONS: Recommendations cannot be made until all data from the study are examined. The NIMCO harvester produces excellent quality fruit, but as presently designed is much slower than the Brag harvesters.

FUTURE WORK: Until further modifications are made in mechanical harvesters, this should be the end of this study.

Table 1: Blueberry Harvester Trial Location Spring Pond

Treatment	Texture	% Crushed	% Debris
Hand	0.676 a	2.00 b	0.88 a
NIMCO	0.712 a	1.75 b	1.25 a
Brag	0.683 a	5.00 a	1.25 a
Brag Mod.	0.747 a	4.50 a	1.31 a

Table 2: Blueberry Harvester Trial Location T-19

Treatment	Texture	% Crushed	% Debris
Hand	0.634 ab	2.28 b	2.10 a
NIMCO	0.586 b	0.90 b	1.44 a
Brag	0.665 ab	5.69 a	1.99 a
Brag Mod.	0.711 a	4.69 a	2.38 a

Machine leveled land

Table 3: Blueberry Harvester Trial By Location

Treatment	Texture	% Crushed	% Debris
Loc T-19 Hand	0.634 bc	2.28 b	2.10ab
Loc SPRPD Hand	0.676abc	2.00 b	0.88 b
Loc T-19 NIMCO	0.586 c	0.90 b	1.44ab
Loc SPRPD NIMCO	0.712ab	1.75 b	1.25ab
Loc T-19 Brag	0.665abc	5.69a	1.99ab
Loc SPRPD Brag	0.683abc	5.00a	1.25ab
Loc T-19 Brag Mod.	0.711ab	4.69a	2.38a
Loc SPRPD Brag Mod.	0.747 a	4.50a	1.31ab

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

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

METHODS: Those who appreciate that preliminary testing should be done in order to establish the study criteria will appreciate that, lacking fresh berries, dry peas dipped in water and spread out on a screen served rather well in setting the initial air volumes and temperature ranges that should be used in the actual trials. It was decided to use forced warm air convection drying to dry blueberries. As will be seen from the very first data and observations, warm air and fresh blueberries do not interact well. The basic method, therefore, was simply to force a small volume of ambient air through a thin bed of wet berries and to dry the berries until the bloom re-appeared on the berry surface.

Samples were collected from two processing facilities at two stages of product maturity. The samples were gathered at the entrance to the freezing tunnels. A total of 18 samples were run. The wet berries were weighed and spread out on a 1/6 mesh screen, attempting to limit doing any damage to the berry. The first trials were made using forced warm air at 17 cubic feet per minute. The berries dried very rapidly and did not hold up well for more than a minute. The wet, shiny berry first dries into a dull appearance during which the bloom returns. Continued drying causes the berry to bleed, therefore returning to its original shiny appearance due to the syrupy liquid on its surface.

The objective of the test, therefore, became one of drying the berry to its original dry bloom stage and to determine the weight loss at that point.

Results: The test data are shown in the attached tables. Test data A were recorded on August 11, 1994. Data A, subset 1 established quickly that heat cannot be used to dry blueberries. Data A, subset 2 during which berries were dried with room air for ten minutes, also indicated that this was a severe treatment and caused bleeding to the surface of the berry. Test data A, subset 3 helped to set the conditions for the next trial which was run two weeks later.

Test data B were recorded on August 25, 1994. Data B, subset 1 verified the need for minimal drying time and temperature. Subsets 2, 3 and 4 were run with drying air provided by a 13 inch room fan at ambient temperatures for two minutes.

Results indicate that an average of more than 2.5% of the weight of the blueberry entering a freezing tunnel can be removed by drying with a low volume of ambient temperature air at 50% relative humidity.

Several observations made during this abbreviated testing period show some interesting results. Some are already accepted by most blueberry processors and others are less obvious:

1. Warm air and blueberries do not go well together.

2. Too much water is entrained into the freezer and this condition must affect freezing tunnel performance.

3. Degree of blueberry maturity can severely affect freezer performance if bleeding is severe. The berries tested on August 25 were quite mature and exhibited heavy bleeding almost immediately after drying.

4. A wet berry dries to its original bloom when bleeding does not occur.

5. Entrained water can be removed at a rate of more than 2.5% of the total berry weight.

6. The amount of water removed can be accurately controlled by adjusting the treatment time and air relative humidity.

Recommendations: It was the intent of this study to minimize observing the operations of any one processor's facility. In this consideration, it is suggested that these data be analyzed by the individual plants and to draw conclusions as may be appropriate for r that facility. However, the data from this study support the need for further work. Several different applications for drying blueberries should be considered. Generic recommendations include the following:

1. Building a prototype forced air dryer to be used in one processing facility which is now experiencing short or abbreviated production runs due to entrainment of water into the freezer.

2. Constructing a prototype dryer that can be used in the field to dry berries for the fresh market.

3. Use the drying process to enable the pre-treatment of berries with an anti-mycotic agent (in the field if appropriate) thereby increasing its fresh shelf life (shelf life studies to be performed).

4. Plan next year's study to include shelf life, sensory and other physical quality parameters.

Future Work: This project should continue with the next phase as outlined in the recommendations. Also, the potential for removing moisture from berries for fresh pack lines should be investigated.

Table 1. Test data A.

Run #	1	2	3	4	5	6	7
Berry Temp.							
Start	54.5	54.3	54.0	54.0	72.1	77.4	---
Stop	79.5	68.5	65.5	65.0	76.0	77.8	70.7
Berry Weight							
Start	1442.3	1559.7	637.0	593.3	675.6	668.0	776.5
Stop	1350.9	1500.0	617.1	573.5	651.3	639.0	760.3
Drying Air							
Temp.	130	78	74	74	79.4	80.5	---
Rh	49	49	35	39	39	39	40
Time (min)	25	4	10	10	10	5	3
Loss							
gms.	91.4	59.7	19.9	19.8	24.3	29.0	16.2
%	6.34	3.83	3.12	3.34	3.60	4.34	2.08

Table 2. Test data B.

Run #	1	2	3	4	5	6	7	8	9	10	11
Berry Temp.											
Start	68.5	68.5	68.5	*	*	64.5	64.5	---	---	---	---
Stop	---	---	---	*	*	---	---	---	---	---	---
Berry Weight											
Start	572.6	445.0	371.0	344.3	430.6	426.1	318.6	329.4	337.9	313.0	309.7
Stop	537.8	431.8	363.3	330.2	419.0	418.6	311.5	321.8	329.5	303.5	299.9
Drying Air											
Temp.	77	78.5	78.9	74.3	77.3	77.1	77.7	77.6	77.5	77.5	---
Rh	54	50	51	47	41	47	49	---	---	---	---
Time (min)	7.5	3	2	2	2	2	2	2	2	2	2
Loss											
gms.	34.8	13.2	7.7	14.1	11.6	7.50	7.12	7.60	8.40	9.50	9.80
%	6.08	2.97	2.08	4.10	2.69	1.76	2.23	2.31	2.49	3.03	3.16

* = cold water dip

B. ENTOMOLOGY

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: Treatments were applied at nine sites in the spring of 1994 (Study 1) and four sites in the fall of 1994 (Study 2). Three fields which received a sanitizer treatment in the spring of 1993 were evaluated in 1994 to determine the long-term effects of sanitizer treatment on blueberry plant growth and development (Study 3). Comparisons were made between the number of insects collected in sanitizer treated areas and in adjacent untreated (mowed only) control areas at weekly intervals. Blueberry plant growth and development was monitored by taking measurements of stem height, number of fruit buds and number of leaf buds.

Tolerance of blueberry flea beetle eggs and spanworm eggs to brief exposures of heat: Blueberry flea beetle and spanworm eggs were collected during the summer of 1994. The eggs will be treated at various temperatures then held through overwintering diapause until spring 1995.

RESULTS AND CONCLUSIONS:

Evaluation of a field sanitizer:

Study 1: Mechanical problems were encountered on three of the nine sites treated in the spring of 1994. Vibration during treatment of the first site accounted for significant damage to the sanitizer requiring extensive repairs. Minor difficulties were experienced at sites 2 and 3; however, these were easily corrected and treatment proceeded without further problems. The sanitizer performed very well on the remaining six sites. It was generally estimated that 80 to 85% of the litter material was picked up and treated; temperatures within the machine were $>500°F$.

Blueberry plant growth seemed to be delayed early in the season (late May) on six of nine sites as measured by average number of stems per 0.25 ft^2 and average stem length; however, a comparison of blueberry plant growth in September indicated no apparent adverse affect by the sanitizer on blueberry plant growth. Stem length, leaf budset, and fruit budset were generally either significantly greater in sanitizer treated plots or showed no significant difference in comparison with untreated (mowed only) areas.
Insect populations were generally low throughout the season; however, there were indications that the sanitizer offered some control of grasshoppers and spanworm larvae.

Study 2: The four sites treated in the fall of 1994 will be evaluated in 1995 for insect control and blueberry plant growth. In addition to using an adjacent mowed area for comparison, one

site also has an adjacent burned area which will be monitored and compared. All sites had heavy flights of spanworm moths in 1994. This work was 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 improved litter pick-up. For most previous treatments 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

Study 3: A comparison of stem length, number of fruit buds, and number of leaf buds yielded some interesting results. Stems in sanitizer treated areas were significantly longer than untreated (mowed only) stems at all three sites. There were significantly more fruit buds at two of the three sites evaluated. It is unclear why blueberry stems were longer or what affect this may have on production; however, these results would seem to indicate that the field sanitizer has no significant adverse effect on blueberry plant growth.

RECOMMENDATIONS: The accumulation of several years research data seem to indicate this project is worth continuing; however, additional data on insect control is needed before firm recommendations can be made. Additional work is needed to improve the sanitizer; possible improvements include a diesel engine and larger fan. The current equipment is working at its maximum capacity; modifications should improve litter pick up and subsequently increase the potential for insect control.

INVESTIGATORS: F. A. Drummond, Associate Professor of Entomology
H. Y. Forsythe, Professor of Entomology
C. S. Stubbs, Post-Doctoral Research Scientist
J. A. Collins, Assistant Scientist

2. TITLE: Evaluation of the Effectiveness of Eumenid Wasps for Biocontrol of Blueberry Pests: A Feasibility Study

METHODS: Artificial nesting blocks were placed along the perimeter or within 36 lowbush blueberry fields in six counties (Washington, Waldo, Hancock, Penobscot, Oxford, and Knox). Aspect and tree species were recorded for each nesting block to ascertain if the wasps have a preference for a particular aspect or tree species or for hardwoods versus softwoods. Beginning with the onset of blueberry bloom nesting blocks were checked for first generation eumenid nests. Nesting blocks were checked throughout the summer and a total of 108 eumenid nests were collected and dissected for caterpillar larvae, which eumenids used to feed their offspring. Number of cells, caterpillars/cell, and predators were recorded. Caterpillars were preserved in alcohol and later examined for identification purposes. Eumenid adults were reared from some nesting blocks and field collections were also made. Adults were pinned, identified, and representative specimens sent to the Smithsonian for verification.

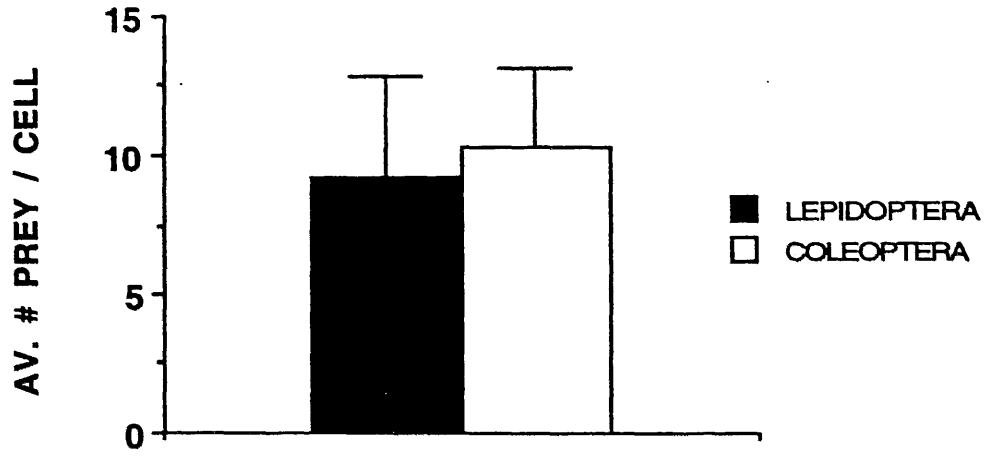
RESULTS: Eumenids were trap nested in all fields that had nesting blocks, which indicates they have a wide distribution. No nesting preference was demonstrated for tree species or aspect. Six species of eumenids were collected (Table 1). Of the 6 species identified, we know that 4 species definitely used the nesting blocks. Red-striped fireworm were found in a nest collected at Blueberry Hill Experimental Farm, Jonesboro, which demonstrates eumenids have potential as a biocontrol agent for this pest. No spanworm were found in dissected nests, which may be due to the fact that possibly spanworm were not present in the fields studied. The average number of cells/straw was 2.4 + 1.9 (range 1-9). Prey caterpillars included both lepidoptera (moth) and coleoptera (beetle) larvae, with eight times more lepidoptera larvae collected than coleoptera. On a per cell basis, eumenids collected slightly more beetle larvae than lepidoptera larvae (Figure 1).

RECOMMENDATIONS: Given we have ascertained that these eumenid wasps collect red striped fireworm, we think there is great potential for developing them into effective biocontrol agents. We are grateful to the Blueberry Advisory Board and Commission for their initial seed money. We will be pursuing extra mural funding to continue this very essential area of research, which could lead to a significant reduction in insecticide use.

TABLE 1. Species of Eumenidae collected 1992-1994. Species with an asterisk indicate trap nested.

Species	Counties
**Ancistrocerus antilope antilope*	Hancock, Oxford, Penobscot, Washington
**Ancistrocerus adiabatus adiabatus*	Waldo
**Ancistrocerus waldenii waldenii*	Penobscot
Eumenes crucifera nearcticus	Penobscot
**Euodynermus foraminatus foraminatus*	Penobscot, Washington
Parancistrocerus pensylvanicus pensylvanicus	Knox
Paranortia symmorpha	Penobscot, Hancock

FIGURE 1: Average number of Lepidoptera, moth, and Coleoptera, beetle, prey per nest cell provisioned by eumenid wasps. (Error bars indicate the standard deviation of the mean.)



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 the numbers of trap nested native leafcutter bees, *Osmia atriventris*, for large scale experiments and develop management practices for blueberry pollination. Two hundred seventeen *Osmia* nests from trap nests produced in 1993 were dissected and screened for parasites and disease. A total of 1814 viable cells containing adult bees were available for release in three fields in Greenfield, Maine. A nesting shelter was set up in each field and 5 nesting blocks were affixed to trees along the perimeter of each field to catch any dispersing bees. Shelters and perimeter nesting blocks were checked weekly to monitor nesting behavior. Nesting materials were collected in August. Nesting straws were removed from all nesting block in order to assess nest production at both shelters and in perimeter blocks.

Objective 2) Evaluate blueberry management practices on native *Osmia* spp. populations. 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 to ascertain their cultural practices for the years 1989 - 1994 for all fields that were sampled for native leafcutter bees with nesting blocks. Results from the three years of data (1992 - 1994) are being used to determine if relationships exist between fields with high *Osmia* abundance; and lowbush blueberry management practices and specific field characteristics (such as size, isolation, pesticide use, etc.).

Objective 3) Develop a field sampling methodology for bees and then evaluate contribution of the honey bee to pollination in the field and compare to wild bees. We are providing some background information for this objective, some of which was presented at the Spring 1994 Blueberry Meetings. Much of our pollination research depends upon sampling bees in the field and specific questions such as the relative contribution that honey bees compared to wild bees have on yield can not be answered without an efficient sampling plan. We have analyzed bee sampling data from Nova Scotia (the data are from a published report entitled "Pollinator Studies in 1991" by Dr. L. J. Eaton and cooperators: A. King, D. McIsaac, R. Nash, and J. Sibley). We found that there is good evidence that sampling bee populations during bloom and then relating those densities to percent fruit set can allow us to obtain a measure of bee pollination efficiency for lowbush blueberry. We found that in Nova Scotia, a relationship exists between percent fruit set and bee density during bloom (% fruit set = 13.7 + 0.11*honey bee density + 0.16*wild bee density) suggesting that it takes on the average 1.4 honey bees to set as much fruit as a single wild bee. Therefore, on an individual bee basis one might conclude that wild bees are more efficient than honey bees. These data can also be used to estimate the number of bees per acre necessary for a desired level of fruit set. For instance, under Nova Scotia

conditions (assuming that 1991 was representative of an average season) if a desired fruit set was 60% then we estimated from the above relationship that 14,684 honey bees are needed per acre (3.0/square yard) or 10,603 wild bees per acre (2.4/square yard). In order to develop similar relationships for Maine growing conditions and bee communities, we needed to develop a cost effective sampling methodology.

To develop a cost effective sampling methodology four methods of estimating bee abundance were evaluated in 1994: malaise traps, 5.4 ft^2 (0.5 m^2) screen emergence cages covered with black plastic, 1 min plot counts in 10.8 ft^2 (1 m^2) quadrats, and 15 sets of 5 sweepnet samples. Study sites were University of Maine Blueberry Hill Research Farm, University of Maine Crowley Organic Research Field, and a field in Addison. Number of malaise traps and cages varied so we are providing Table 1, which gives for each field: the sampling dates, the number and type of measurements, and the total number of observations. Measurements were made on the hour. Number and genus of bees were recorded for each sampling method. All sampling was conducted on sunny days with temperature and wind speed monitored. Sometimes bees died in the malaise traps, in which case they were kept for identification to species. Labor involved and cost of materials were also noted for each sampling method. Statistical analysis of variance was used to assess sampling precision and costs.

Objective 4) Compare the pollination efficiency of honey bees, alfalfa leafcutter bees, *Osmia* bees, and bumble bees. Preliminary greenhouse studies were conducted in order to assess the relative efficiency of the native *Osmia* leafcutter bee to the alfalfa leafcutter bee, and commercial bumble bee, *Bombus impatiens*. Bees foraged on potted or cut stems of flowering lowbush blueberry in a 33 ft x 7 ft x 6 ft screen flight cage in the greenhouse. Foraging behavior, handling time, and resulting pollen grains delivered to the stigma/visit were observed and recorded. Control flowers were handled exactly as the experimental flowers, but bees were not allowed visitation to the control flowers. An individually based foraging model is currently being constructed in cooperation with Dr. Larry Latour and graduate student, Ms. Wendy Curry of the Department of Computer Science at the University of Maine.

Objective 5) Test migratory techniques for establishment of strong alfalfa leafcutter bee congregations at time of initial blueberry bloom. On 26 April 1994, 120,000 alfalfa leafcutter bees were established in 3 bee domiciles (n= 40,000 bees/domicile) at the University of Rhode Island Agricultural Experiment Station Peckham Farm. These "early release" bees foraged on flowering plants in RI, such as crab apple, rhododendron, highbush blueberry, lilac, and blue holly until the onset of blueberry bloom in Washington county. Bees, nesting materials, and polidomes were transported (at night) to three blueberry fields (1 domicile with "early release" bees/field) in Washington county. Additionally, one new domicile with 40,000 "non-early release" bees were set out in each of the fields the following day. Total number of nests and foraging bees were counted at each domicile during bloom and number of flowers/10 randomly chosen blueberry stems counted in 10.8 ft^2 (1 m^2) study quadrats at 3.28 , 16.42, 32.83, 65.6, 131.33, and 196.80 ft (1, 5, 10, 20, 40, 60, and 80 m). At the end of bloom, nests and foraging bees were assessed again, as well as, percent fruit set in the study quadrats. Percent fruit set, total nests, and foraging force were compared for "early release" bees and "non-early release" bees. Bees were then moved to cranberry and foraged there until the end of cranberry

bloom. Then bees were moved to crimson clover at the University of Maine Roger's Farm where they remained and were observed until no bees continued to forage.

Objective 6) 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 three year study. In each of 3 fields, 50 wooden trap nests were placed along the field border. Prior to bloom, traps were checked to determine any overwintering changes to number of completed nest tunnels. At peak bloom, fifteen 10.8 ft^2 (1 m^2) quadrat samples/field and 15 sets of 5 sweeps were taken in order to estimate the number of native leafcutter bees (*Osmia* spp.). 1993 served as the base-line population census. 1994 was used to assess the potential for increasing *O. atriventris*. Number of *Osmia* leafcutter nests made in the trap nests were recorded at the end of bloom and again in September. Numbers of nesting bees was then compared to numbers of bees nesting in 1993.

In 1994 we also conducted an additional study to those we proposed. We examined the performance of a commercially available honey bee attractant, Fruit Boost.®

Objective 7) Assess the commercially available honey bee attractant, Fruit Boost.®. A honey bee attractant is a synthesized chemical which mimics the honey bee queen mandibular pheromone. In 1994, we tested Fruit Boost® a honey bee attractant produced by PheroTech Inc. This attractant has been shown to increase honey bee activity and yield in pears, apple, cherry, almond, and plum. A randomized complete block ANCOVA design (Analysis of Covariance) with four replicates (plots were 1/4 acre in size) was set up at the University of Maine Blueberry Hill Research Farm in Jonesboro, Maine. Four rates of Fruit Boost® (0, 40, 200, and 400 queen equivalents per acre) were applied at peak bloom on 2 June. Honey bee and wild bee densities were recorded on a per square meter basis for 2 minutes in each plot 2 hrs before spraying Fruit Boost®, and 1 hr, 1, 2, and 4 days after spraying. Fruit set, yield, seeds per berry, and berry weight were recorded and used as additional measures of Fruit Boost® performance. Covariates (distance of each plot from the nearest honey bee hives, stem and floral density, and initial pre-spray bee density) were included in the ANCOVA to minimize experimental error.

RESULTS: Objective 1) Build up a colony of the native leafcutter bee, *Osmia atriventris*, for large scale experiments and develop management practices for blueberry pollination. Dissections of nesting straws prior to release indicated that 66.1% of the straws contained bees, 30.7% of the straws with leaf plugs were false nests, and 3.2% contained leaf cells destroyed by fungi, *Aspergillus* spp. The average number of bees/straw was 12.2 bees/straw (range = 1 - 27 bees/straw). Emergence from leaf cells commenced within 1 week of putting the cocoons into the shelters. Emergence varied among shelters although the 3 fields were within 1000 ft. (910 m) of each other. At shelters 1 and 2 (A. SF and A. BF) approximately 50% emergence occurred within 1 week of setting out the leaf cells. Whereas, at the third shelter (WAT) emergence was less than 5% for the same period. Overall percent emergence was less at Shelter 3. Counted leaf cells at the end of June indicated that 95% of the cells emerged at Shelters 1 and 2, but that only 66% emerged from Shelter 3. Differences in emergence may be due to the fact that shelter 3 was more exposed to wind than the other two shelters and/or those leaf cells

were of a less hardy stock. Nesting continued past the end of blueberry bloom at all sites with the last new nest produced 26 July.

Figure 1 shows nest production at the 3 fields for shelters and perimeter blocks. The difference in emergence success may account for shelter 3 (WAT) having lower overall nest production both at the shelter and in perimeter blocks. Also 6 nests were destroyed by bird predation at shelter 3. A total of 127 nests were produced. It should be noted that mummy berry, *Monilinia*, destroyed much of the bloom in two of the three field, which may have resulted in reduced nesting due to a severe reduction in blueberry bloom for the bees to forage on. Based on our 1994 spring dissections we project that 38 nests will be false nest, 4 will be diseased and 85 will be viable with a total of 1066 cells available for release in 1995.

Objective 2) Evaluate blueberry management practices on *Osmia* populations. The percentage of traps and nesting straws with completed nesting straws was slightly higher than in 1992 or 1993 (Fig. 2). In 1994 the percentage of known completed leafcutter nests produced in nesting blocks along the edges of Maine blueberry fields ranged from 0 - 35.7%. Because some bees produce mud plugs the exact percentage will not be known until spring 1995 when we rear out the bees and wasps from the 1994 trapping. This will also allow us to complete our analysis of the effects of management practices on native leafcutter bees.

Some summary data from the growers who have responded thus far (n = 20 respondents) to the management questionnaire include the following: average field size = 24.1 acres (range 4.9 - 80 acres), 89% of the growers use pesticides, most common alternate bee forage plants reported by growers were cherry, golden rod, and aster. Three of the five fields with the most leafcutters are organic; two are not. All fields with less than 5% nesting success are nonorganic. Only one field
(n = 56) had no leafcutters. The only available tree species for this field was red pine, which would not be a suitable source for leaves to construct nest leaf plugs. Also this field was in the nonbearing phase.

Objective 3) Develop a field sampling methodology for bees and then evaluate contribution of the honey bee to pollination in the field and compare to wild bees. The results of the sampling study in 1994 suggest that plot counts, screen emergence cages and the sweepnet all sample the total bee community with generally similar biases (Fig. 3). Interestingly, however, the malaise trap method tends to collect a lower proportion of honey bees than the other three methods and collects a higher proportion of digger bees (andrenids) and "other" insects. It is doubtful, whether any of these methods is completely without bias. The sweepnet, for example, may not be efficient at sampling extremely fast fliers which can avoid the net, the screen emergence cage will not be efficient at sampling insects lacking a strong positive photo-tactic response (tendency to fly toward the light), and the plot count even though it is the only method in which the plots are visually observed for a length of time (1 minute), may underestimate extremely small fast flying bees. However, the similar frequency distributions of the sampled bee community for three of the four methods suggest that a major bias is not present in at least three sampling methods.

An analysis of sampling variation allows optimal sampling plans to be constructed. Our analysis indicates that in general all of the groups of bees that we sampled were found to be

distributed in the field randomly (slopes of Taylor regressions were not significantly different from 1.0). This is in sharp contrast to the way in which most agricultural pest species are distributed (clumped or aggregated). This observed spatial randomness also suggests that bees are not aggregating to specific clones due to differences in nectar and or pollen availability.

Figure 4 shows the necessary number of samples for each of the four methods, three levels of precision (10% = very high, 20% = high, and 30% = acceptable for most field studies) and a range of expected total bee densities. In Figure 4 we have depicted the 1994 average number of bees as a relative density of 1. Thus, if in any year the bee density is one-half of what was observed in 1994 then the necessary sample size can be determined by evaluating the x-axis at 0.5. These graphs indicate that if a precision of 0.3 is accepted then the necessary sample size for the densities which we observed in 1994 would be 119 cages per field, 39 sets of sweeps per field, 12 plot counts per field, and 14 malaise traps per field. Initially, the plot counts and the malaise traps appear to be the best methods for sampling bees. However, when the cost (materials and labor at $5.00/hr) of sampling a field (four times during bloom) is taken into account, the better sampling methods appear to be the plot counts and the sweepnet method. The malaise trap method becomes prohibitively expensive (Fig. 5) because each trap costs $200.00.

A further analysis of the sampling data will compare transect sampling to the four methods investigated in 1994. We are continuing to investigate transect sampling in 1995. This further analysis will evaluate an optimal sampling plan based upon the "presence or absence sampling method" (where instead of counting bees one simply records samples as being either a sample with or without bees. From these presence/absence data, the proportion of samples with bees is converted into a bee density estimate.

Objective 4) Compare the pollination efficiency of honey bees, alfalfa leafcutter bees, *Osmia* bees, and bumble bees. The results of our greenhouse flight cage studies have focused on the pollen foraging behavior of *Bombus impatiens* (a bumble bee species that is commercially available), *Megachile rotundata* (alfalfa leafcutter bee) and *Osmia atriventris* (the Maine blueberry bee). We attempted to assess the foraging behavior of honey bees on lowbush blueberry, but we were not successful in getting honey bees to collect pollen from lowbush blueberry flowers under our experimental conditions. We will attempt to study honey bee foraging on lowbush blueberry in 1995 under starvation conditions in order stimulate foraging.

In 1994 we found that bee flower visitation behavior while foraging for pollen was different for *B. impatiens* compared to the two leafcutter bee species (Fig. 6). Bumble bees foraged on a lowbush blueberry stem by visiting the lowest flowers on the stem first and then foraging up the stem. In many cases, bumble bees visited every flower on the stem and in most cases visited at least six flowers on a stem before moving on to a new stem. This type of foraging behavior by bumble bees has been reported by other researchers before for other species of plants. Although this type of foraging behavior is certainly an optimal foraging behavior for the bee to maximize its pollen collection, our future modeling efforts (with Latour and Curry) will allow us to assess the effectiveness of this type of behavior on cross pollination. The two leafcutter bees had very different foraging behavior. In general, it can be seen that leafcutter bees tended to initiate a visit to a stem at a flower in the middle of the stem and either

work sequentially up or down the stem for 2-4 flowers before leaving the stem (Fig. 6).

The number of pollen grains deposited by each of the three bee species is shown in Figure 7. Alfalfa leafcutter bees tend to deposit more pollen grains in a single visit to a flower (mean = 49.7 grains deposited per visit; range 7 - 122) than *B. impatiens* (mean = 7.8 grains deposited per visit; range 0 - 154). It should be noted that the sample size is quite small for the alfalfa leafcutter bee. We were only able to collect one observation of a single flower visit made by an *O. atriventris* that was not contaminated by another bee species visits. In this one case the number of pollen grains deposited was 202. Research in 1995 will focus on adding to these results to better quantify the efficiency that these bees exhibit in depositing pollen on the lowbush blueberry stigma.

Figure 8 shows that as bees visits to a particular flower increases, the number of grains deposited on the stigma generally increases in a linear manner. Because of this relationship, we expect that increased visits to a particular flower by bees result in more ovules per berry being pollinated and thus larger fruit size. We will be assessing how sequential visits and increasing pollen deposition relates to fruit set and yield in 1995.

Objective 5 Test migratory techniques for establishment of strong alfalfa leafcutter bee congregations at time of initial blueberry bloom. The number of alfalfa leafcutter bees observed in study plots was greater for the non early start bees than the bees that went to RI. It should be noted though that in these plots most of the bees were males, which probably do not contribute to pollination. Fruit set was high in all study plots and did not diminish in the plots at 198.6 ft. (80 m). Overall, average fruit set was 92.3% in transects with RI bees (range 80 - 100%). In transects with nonmigratory bees average fruit set was 88.4% and the range was 76-100%. Fruit set was significantly greater ($p < 0.001$, paired student *t* test) in transect plots for bees that went to RI (Fig 9).

There were no completed nest tunnels for either group of bees at the end of blueberry bloom. Figure 10 shows cumulative nesting on cranberry for both groups of bees. More nests were produced by migratory RI bees, but this difference was not significant. Bees continued to forage on crimson clover until 16 October. Overall, a total of 17051 nesting tunnels were completed. Total reproductive return from 24 gallons of bees was less than 2 gallons of bees. Parasitism was 26% (n = 500 dissected cells). The sex ratio was 4.2 males for each female (n = 1000 cells). Approximately 3.1% of the cells (n = 1000 cells examined) contained *Megachile relativa*, a conspecific that is native to North America.

Objective 6 Assess the potential for increasing native leafcutter bee populations in blueberry fields by providing artificial nesting sites. Winter losses occurred at all sites with the greatest losses at the Wass field due to logging. Despite the fact that 24 nest blocks were destroyed at the Wass field, nesting was greater in 1994 than 1993 at all sites (Fig 11). Plot counts and sweep net samples, however, were consistently higher only for the Wass site (field with blocks) than its corresponding control field (without nesting blocks.), which are shown in Fig. 12 and Table 2.

Objective 7) Assess the commercially available honey bee attractant, Fruit Boost.® In general, there was a trend for higher densities in honey bees in plots with higher rates of Fruit Boost,®

except at the highest level of Fruit Boost® (400 QE/acre). The highest level of honey bee activity was observed in plots with 200 QE/acre (Fig. 13). The effect of Fruit Boost® attracting honey bees, however, only appears to last for 1 day, by day 2 only 61% of bee activity observed on the day of spraying was observed. By day 3 activity had dropped to ~ 50% of that observed on the first day (Fig. 14).

There were no Fruit Boost®effects on yield, percent fruit set, weight per berry, or seeds per berry. We did find significant covariate effects with distance of the hive from plots. Plots closer to hives tended to have higher honey bee densities than plots far from honey bee hives. This has important implications for future lowbush blueberry pollination work. Hive distance from plots should be taken into account to reduce confounding error. In general, we found that Fruit Boost® can increase bee activity on lowbush blueberry, but this increased activity does not translate into increased yields as has been seen with other fruit crops.

RECOMMENDATIONS: At the present time, we still continue to consider the best two short term solutions for a large scale alternative pollinator to honey bees to be the alfalfa leafcutter bee and the native leafcutter Maine blueberry bee, *Osmia atriventris*. If the number of alfalfa leafcutter cells produced can be increased significantly so that growers or beekeepers can produce alfalfa leafcutter bees here in Maine, then it will be very cost effective. Cost effectiveness of the alfalfa leafcutter bee will depend on cost of the bee, increase in yield, and the price the grower gets for the berries.

Encouraged by the increased nesting by native leafcutter bees in 1994, we also recommend continuation of three year population study for its final year in order to determine if providing artificial nesting blocks will increase native leafcutter populations.

Based on our results from the Fruit Boost® study we do not recommend that growers apply Fruit Boost® to lowbush blueberry as it did not improve either fruit set or yield.

TABLE 1. Sampling methodology for bees.

Field	Dates	Type of Sampling	N/field	# Observations
Blueberry Hill	6/3; 6/4; 6/7;	screen cage	5	90
	6/8; 6/9; 6/16	malaise trap	4	71
		plot counts	15	285
		sweep nets	15 sets of 5	285
Crowley	6/3; 6/4; 6/7;	screen cage	5	90
	6/8; 6/9; 6/16	malaise trap	4	66
		plot counts	15	345
		sweep nets	15 sets of 5	345
Addison	6/9; 6/10	malaise trap	3	42
		plot counts	15	45
		sweep nets	15 sets of 5	45

TABLE 2. Average number of Osmia bees for the 3 yr. population study plot and sweep counts for 1993-1994 in fields with and without nesting blocks.

Site	Year	Blocks	Av. # Bees/plot	Av. # Bees/sweep
Burnt Camp	1993	yes	0.200	0.044
	1994		0.022	0
B. C. Control	1993	no	0.022	0.022
	1994		0	0.045
Gardener	1993	yes	0	0
	1994		0	0
Gar. Control	1993	no	0.089	0.022
	1994		0	0
Wass	1993	yes	0.052	0.044
	1994		0.044	0.067
Wass Control	1993	no	0	0
	1994		0	0

FIGURE 1: Maine Blueberry Bee, *Osmia atriventris*, nesting at three fields in Greenfield, ME. Codes: WAT indicates reproductive output from leaf cells placed at Shelter 1. A. SF and A. BF indicate reproductive output from leaf cells placed at Shelters 2 and 3.

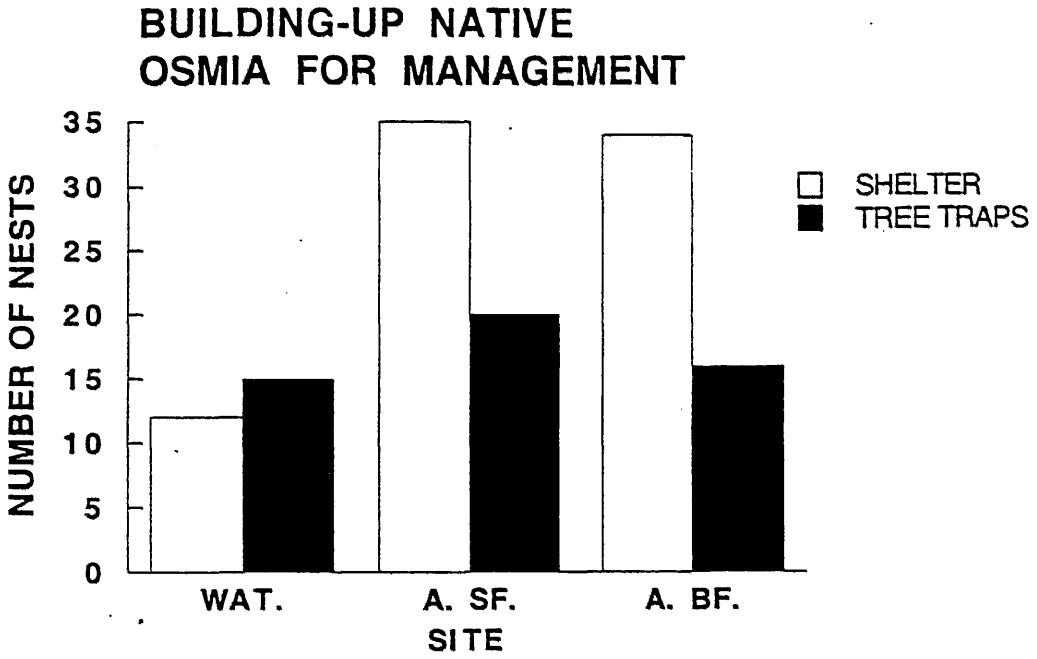


FIGURE 2: Native leafcutter bee nesting in wooden blocks affixed to tree trunks.

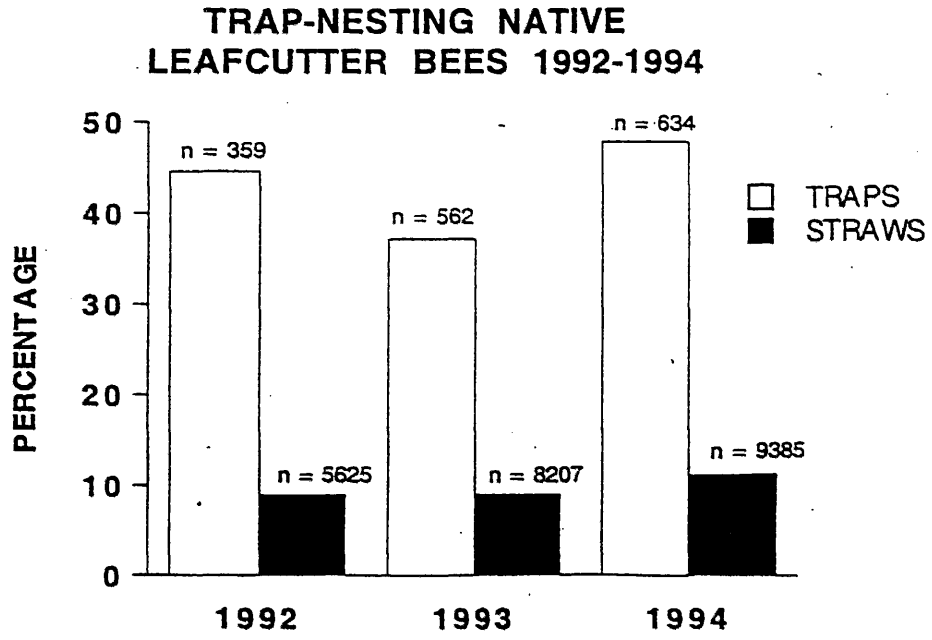
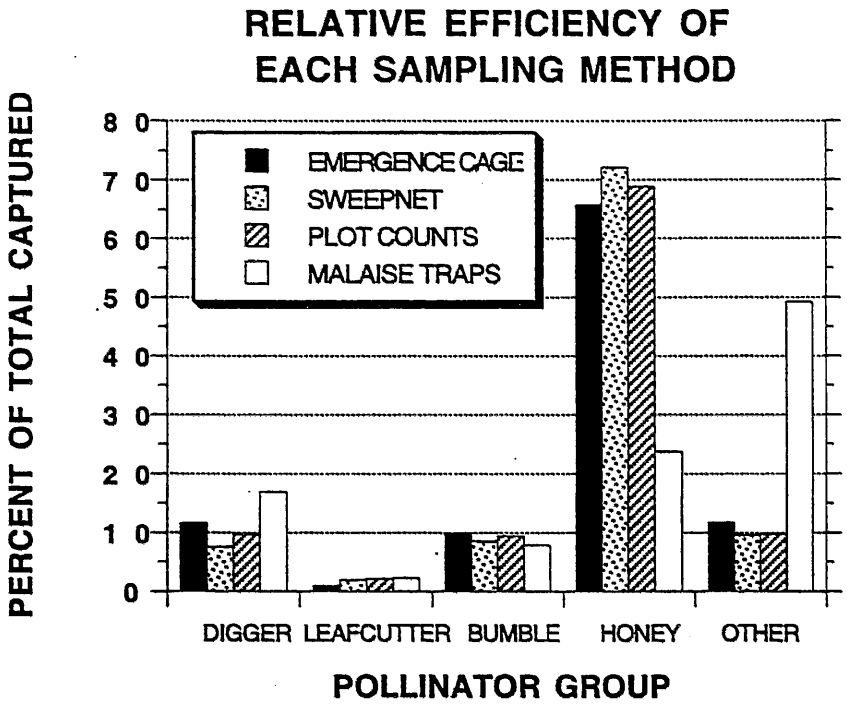
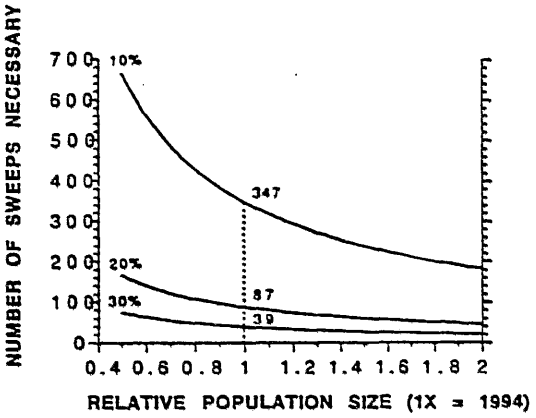
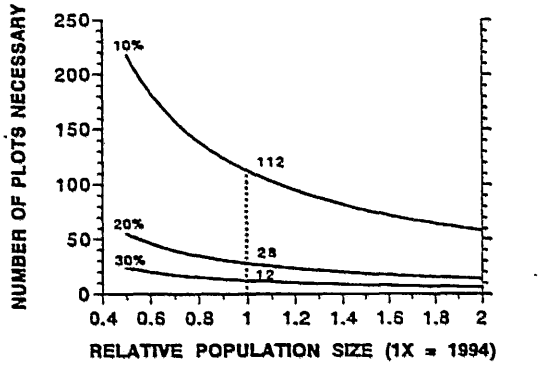
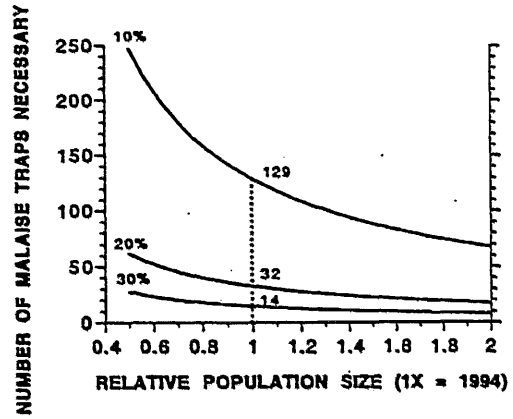


FIGURE 3: Percentage of bees captured (screen emergence cage, sweepnet, malaise traps) or observed (plot counts).









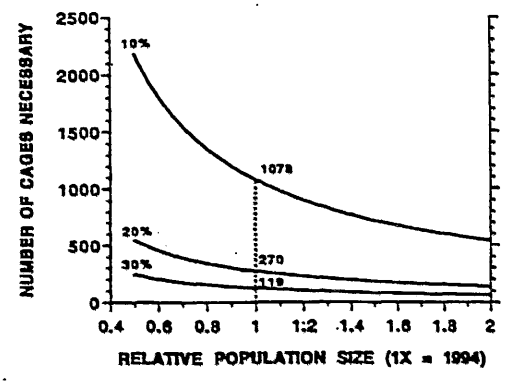


FIGURE 4: Number of samples required for each sampling method to attain a sampling precision of 10% (very high), 20% (high) or 30% (acceptable for most field studies).

FIGURE 5: Relative costs for four sampling methods to estimate pollinator abundance

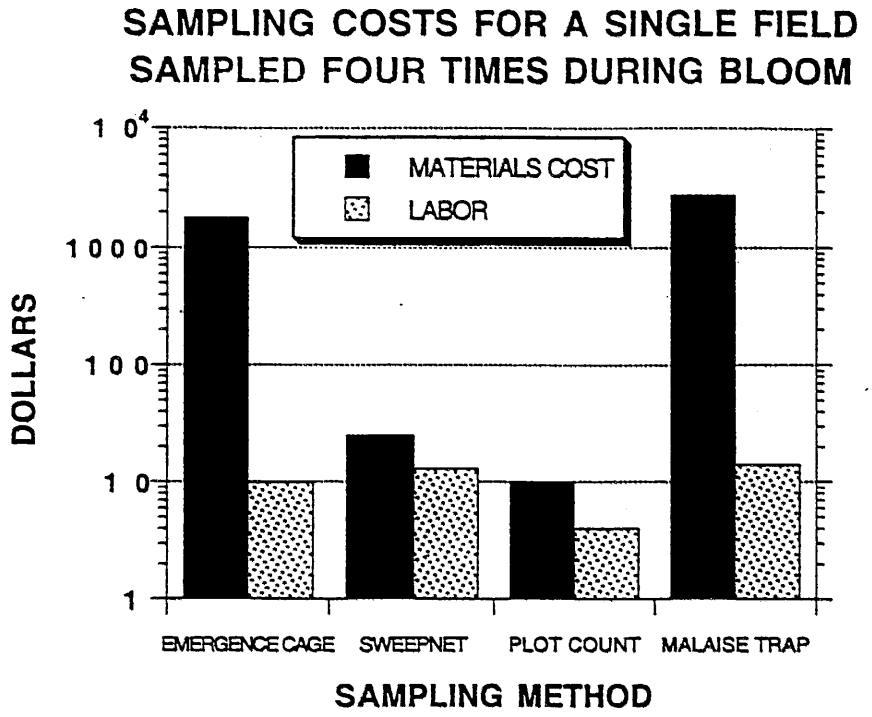


FIGURE 6: Within stem foraging behavior of three species of bees on lowbush blueberry. #1 flower position on stem is the lowest flower on stem.

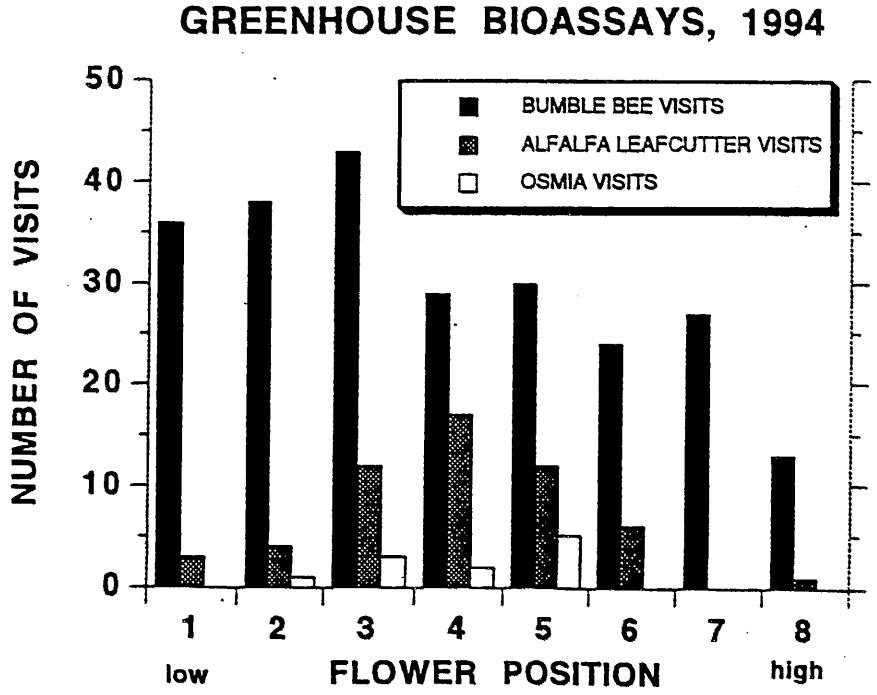


FIGURE 7: Average number of pollen grains deposited on a lowbush blueberry stigma by a single visit for bumble bees, alfalfa leafcutter bees, and the Maine blueberry bee, *Osmia atriventris*.

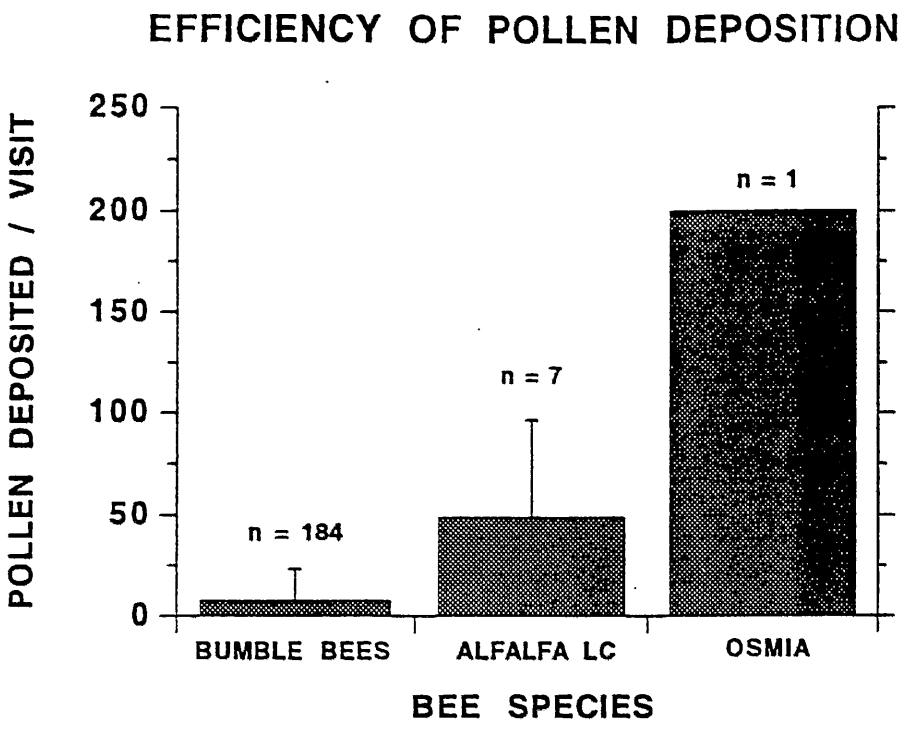


FIGURE 8: Relationship between number of bumble bee visits to a single flower and the number of pollen grains deposited on the stigma.

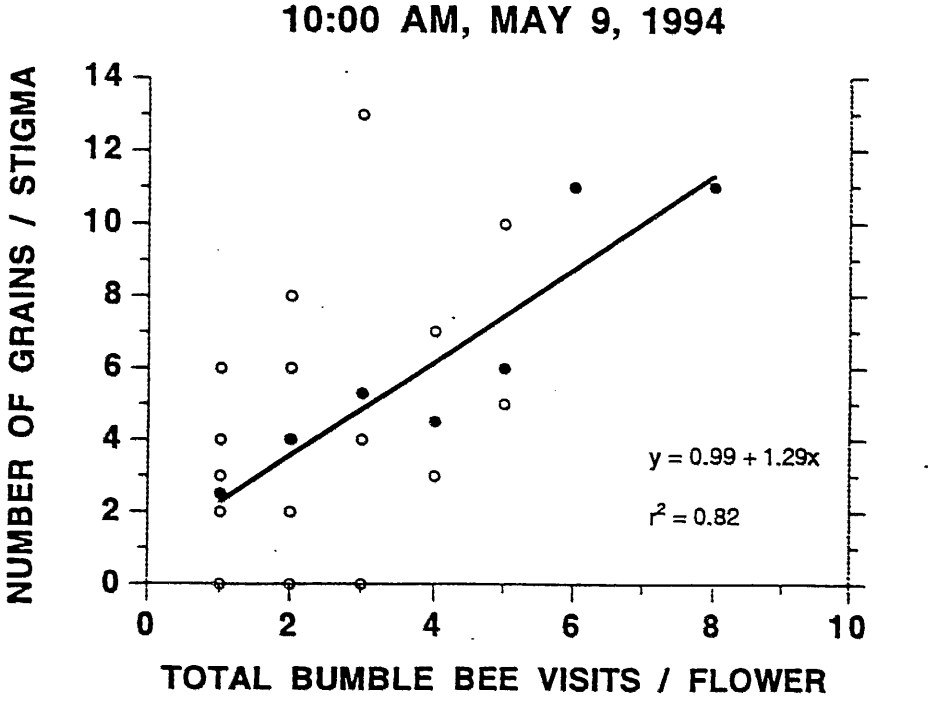


FIGURE 9: Average percentage fruit set by the alfalfa leafcutter bee. Codes: Control indicates fruit set in nonmigratory bee transects and RI indicates fruit set in transects by migratory bees that got an early start by foraging in RI for a month prior to lowbush blueberry bloom in Maine.

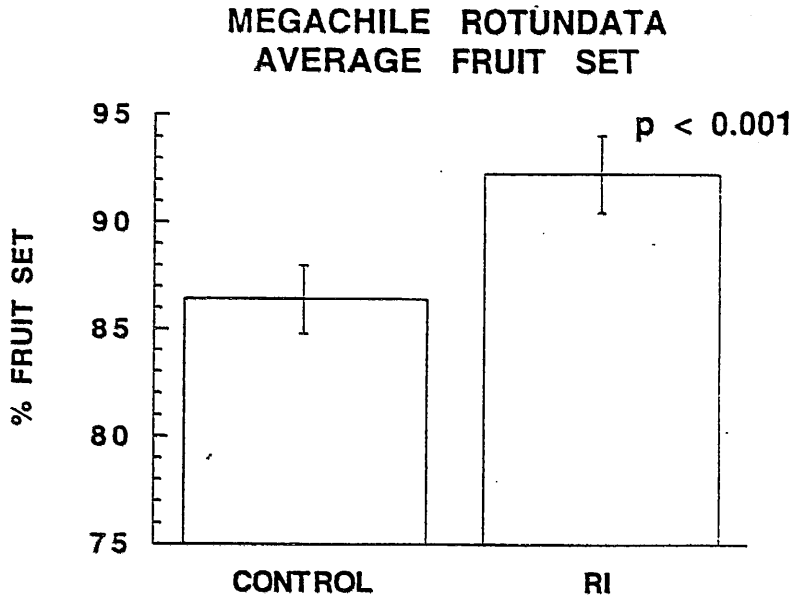


FIGURE 10: Alfalfa leafcutter bee nesting on cranberry. Codes: Control indicates nesting by nonmigratory bees and RI indicates nesting by migratory bees that got an early start by foraging in RI for a month prior to lowbush blueberry bloom in Maine.

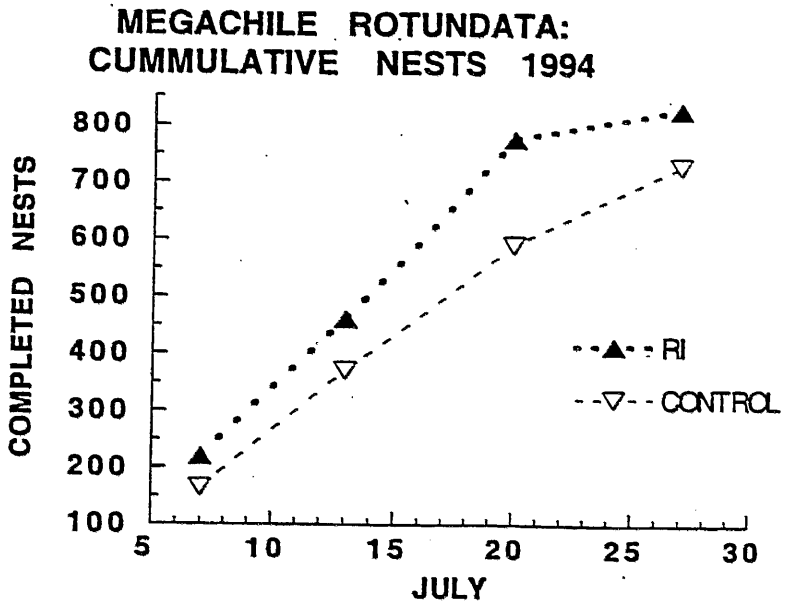


FIGURE 11. Three year population study of native leafcutter bees. Providing artificial nesting blocks to build-up leafcutter populations.

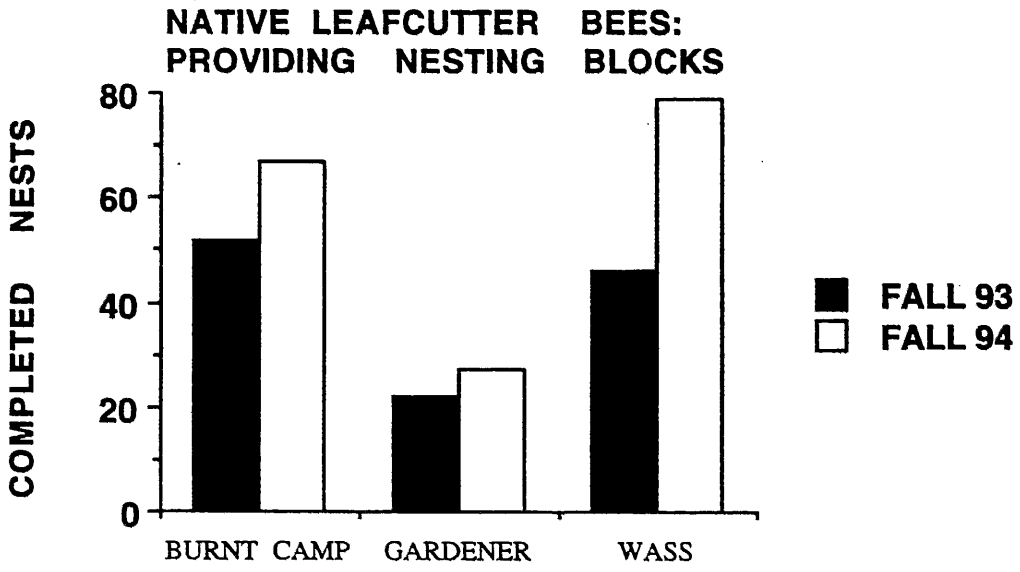
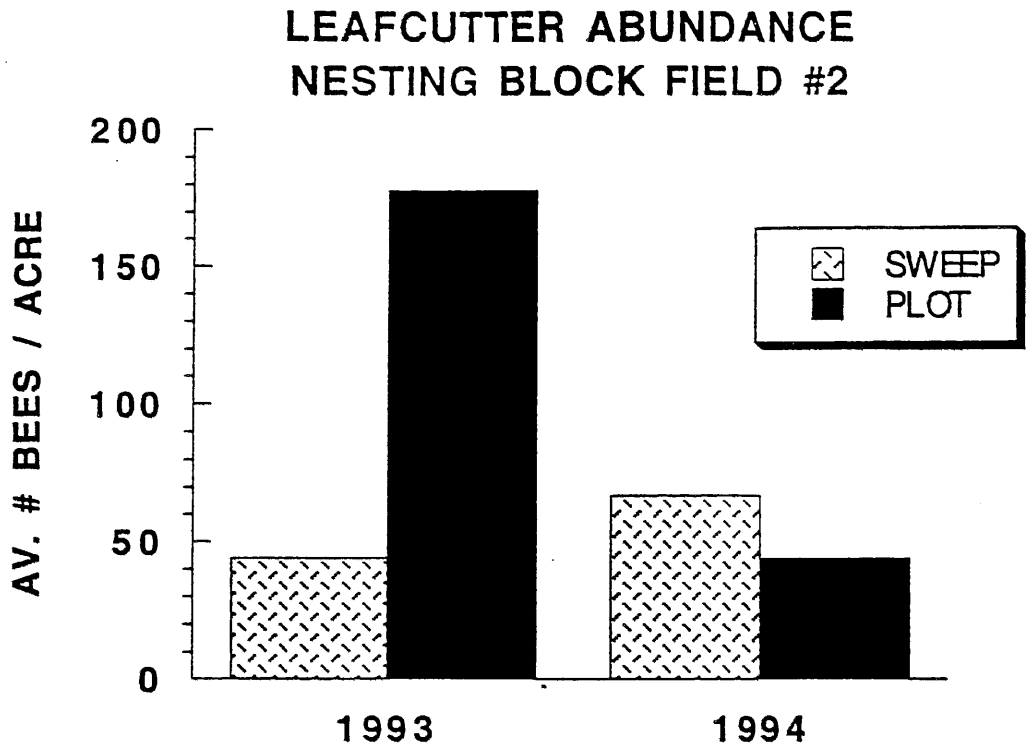


FIGURE 12: Native leafcutter bee abundance in a field with nesting blocks provided and in a field without (control) nesting blocks provided.



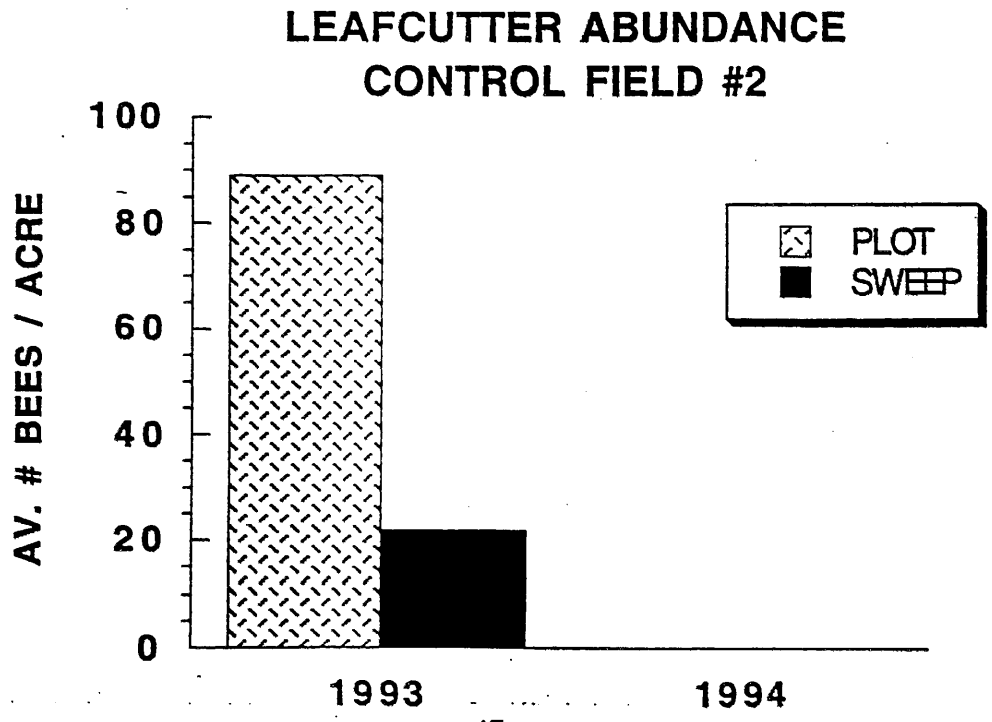


FIGURE 13: Honey bee activity in relation to amount of Fruit Boost® applied.

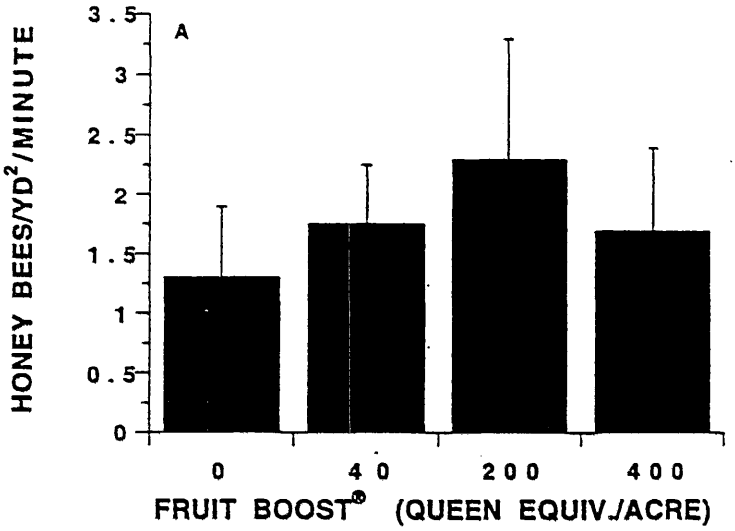
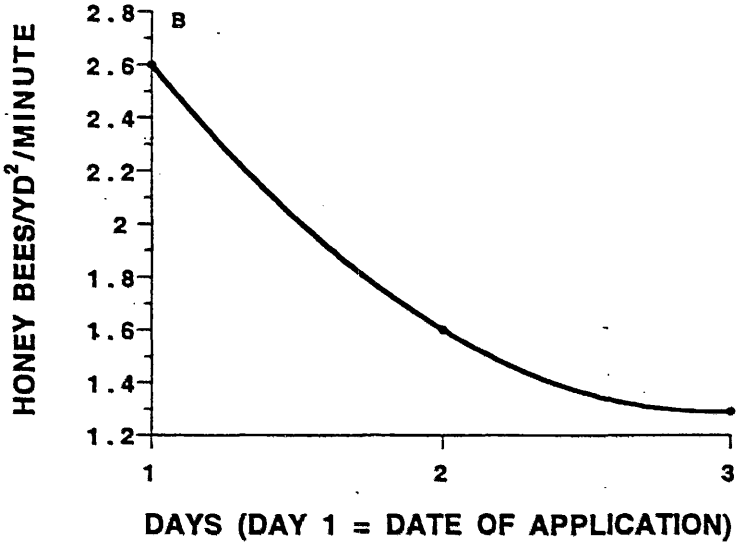


FIGURE 14: Honey bee activity in Fruit Boost® plots in relation to the passage of time. Day 1 was the day Fruit Boost® was sprayed.



C. DISEASE CONTROL

INVESTIGATOR: David H. Lambert, Associate Professor of Plant Pathology

1. TITLE: Fungicide Treatment for Control of Monilinia Blight.

METHODS: The effectiveness of fungicide treatments for control of primary (ascospore) infection by Monilinia was evaluated. Treatments were: a nontreated control, Funginex (triforine) 1.6E @ 24 oz/A, Orbit (propiconazole) 3.6E @ 4 oz/A, Orbit 1.6E @ 6 oz/A, Ziram (zinc dimethyldithiocarbamate) @ 1.0 lb/A, and TD 2350-1 50DF @ 0.5 lb/A. Fungicides were applied on May 10 and May 20 with a wheelbarrow sprayer at 50 gal/A and 30 psi. Plots, located in Twp 19, Washington Co., ME, were 3' by 15', separated by non-treated strips, and replicated six times. Occurrence of blight was rated for 25 blossoms at ten points along the center of the plot (250 blossoms/plot). Stage of bloom also varied with clone, with the first application at budbreak of the latest clones.

RESULTS/CONCLUSIONS:

Disease varied within the test area from moderate to severe. Data are analyzed to include all six blocks "**All Blocks**" or to exclude the last two severely affected blocks "**Four Blocks**".

PRODUCT	**RATE**	**% FLOWER BUD BLIGHT**	
		All Blocks	**Four Blocks**
Funginex 1.6E	24 oz/A	15.1 A	4.8 A
Orbit 3.6E	4 oz/A	11.9 A	4.4 A
Orbit 3.6E	6 oz/A	14.9 A	3.5 A
TD 2350-1	0.5 lb/A	43.1 B	28.4 B
Ziram	1.0 lb/A	40.4 B	30.4 B
Control	-	35.8 B	26.8 B

RECOMMENDATIONS: Orbit (propiconazole) at 4 oz is as effective as Funginex at 24 oz/A. This material appears to be an acceptable alternative to Funginex.

PROJECTED RESEARCH: This trial (Funginex vs Orbit) will be repeated in 1995. Effectiveness of propiconazole against secondary infection will be also be assessed.

INVESTIGATOR: David H. Lambert, Associate Professor of Plant Pathology

2. TITLE: Field Sanitation for Control of Monilinia Blight

METHODS: A field sanitizer designed to vacuum, heat and/or crush lowbush blueberry prunings and ground litter was evaluated for its ability to destroy sclerotia of the mummy berry pathogen Monilinia vaccinii-corymbosi, and to thereby reduce blight loss.

At the Montegail Pond site, plots 17' X 17', replicated five times, were treated in November of 1992. At the Long Pond site, 17' X 20' plots, replicated three times, were treated in April 1993. At the second site, eight 19" X 19" subplots per plot were surveyed after treatment for numbers of intact or broken sclerotia. This site was surveyed in the same manner in May 1994 for numbers of germinating and nongerminating sclerotia. Both plots were surveyed for disease in July 1994 by counting the numbers of infected fruit in eight sets of 100 berries per plot.

RESULTS: At the Long Pond site, sanitizer treatment appeared to reduce numbers of intact sclerotia by about one third, and surviving and germinating sclerotia by about half (Table 1). Fruit bud infection was 20% lower in treated plots. None of these differences were significant at $P = 0.05$. At Montegail Pond, infection was 10% lower in treated areas, and this difference was likewise non-significant.

RECOMMENDATIONS: The relatively low degree of inoculum destruction and disease control in these trials appears to result from incomplete pick-up of sclerotia. Subsequent changes in the sanitizer to improve pick-up may increase the effectiveness of disease control.

PROJECTED RESEARCH: This trial will be repeated in 1995.

Table 1. Effects of field sanitation on mummy berry survival, germination, and infection at two sites.

Treatment	Sclerotia		% Infected Fruit		
	April - 1993[1]		May - 1994		July - 1994
	Intact	Pieces	Total	Germinated	
Long Pond					
Control	24 A	0 A	15.0 A	1.5 A	4.8 A
Sanitized	17 A	7 A	7.8 A	0.8 A	4.0 A
Montegail Lake					
					18.2 A
					16.4 A

D. COLD HARDINESS

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

1. TITLE: Cold-hardiness of Native Lowbush Blueberry

METHODOLOGY: Twenty four clones of V. angustifolium and twelve clones of V. myrtilloides were selected for the study. Clones selected were divided equally between fields in Ellsworth and Jonesboro. V. angustifolium clones selected represented both green stem and red stem forms.

Stems were collected on 4 dates from November 1993 through March 1994 for determination of low-temperature tolerance. Stems were field collected, packed in crushed ice and transported to Orono for analysis. Treatment of stems was as follows: 1) seal stems in glass culture tubes; 2) place tubes in freezer at 30F; 3) gradually lower chamber temperature to -42; 4) remove stems at three 3C intervals; 5) incubate for 14 days and evaluate for stem and flower bud damage.

RESULTS: There was no significant difference in low temperature tolerance among V. angustifolium forms (red vs. green stem) and V. myrtilloides. As a result, all clones were analyzed together for the remainder of the tests.

As with previous studies, there was a significant difference between cold-hardiness of stems and flower buds. Flower buds were consistently at least 5F less tolerant than were stems. This was consistent when evaluated based on individual clones and on an estimated population basis.

There was consistent clonal variation on each sampling date with both stems and buds. On the November sampling date, there was the greatest variation, with estimated LST ranging from -38 to +5F for stems and from -33 to +5F for buds (Figs 1&2). There appeared to be less variation in among clones at the Ellsworth site than for clones at the Jonesboro site.

For stems sampled in December, there was far less variation in cold tolerance of both buds and stems in comparison to results from the November sampling date (Figs 3&4). December stem data showed the least variation of the entire study. There appeared to be a slight difference between the December stem data and stem data for February; however this difference is likely artificial. The February stems were the only samples exposed to the -43.5 temperature (on the other dates it was not possible to achieve that temperature in the chambers). Some of the December stems given an LST rating of -38, would likely have made it at -43.5. The greatest change in low-temperature tolerance occurred between the February 7 and March 7 dates. Both stems and buds showed a 10F loss of tolerance over this time span.

Finally, a weak but significant negative correlation was demonstrated among March cold hardiness and time of bloom. This indicates that there may be a pattern which shows up as later flowering clones retaining better cold tolerance later in the spring.

RECOMMENDATIONS: An obvious recommendation would be to repeat this study a second season to confirm these findings. That has been approved and the work is proceeding currently. With data on an additional number of clones it would be valuable to compare LST distribution

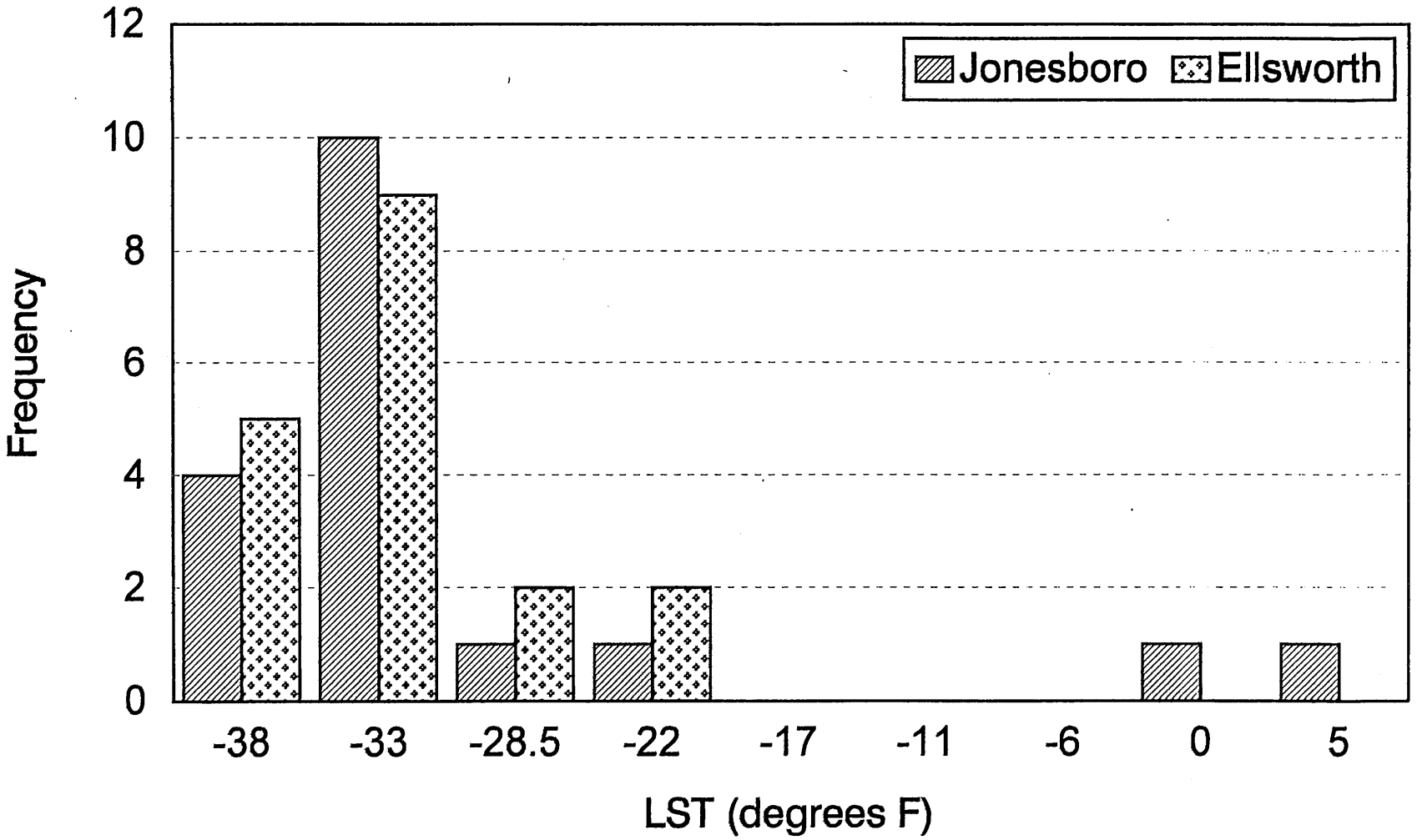
numbers with recorded temperature minima. A correlation of recorded, field damage with predicted damage would provide a measure of validity for the lab-determined figures.

With this work completed, it would be valuable to assess the following characteristics of the cold-hardiness of lowbush blueberry: 1) relationship of chill hour requirement to pattern of spring deacclimation; 2) determination of specific cold tolerance of carious tissues within the blueberry flower bud; 3) interaction among stem diameter, flower bud number, and cold tolerance; and 4) interaction of wind and low temperature as they relate to winter damage.

Figure 1

Stem LST frequency distribution

November 18, 1993

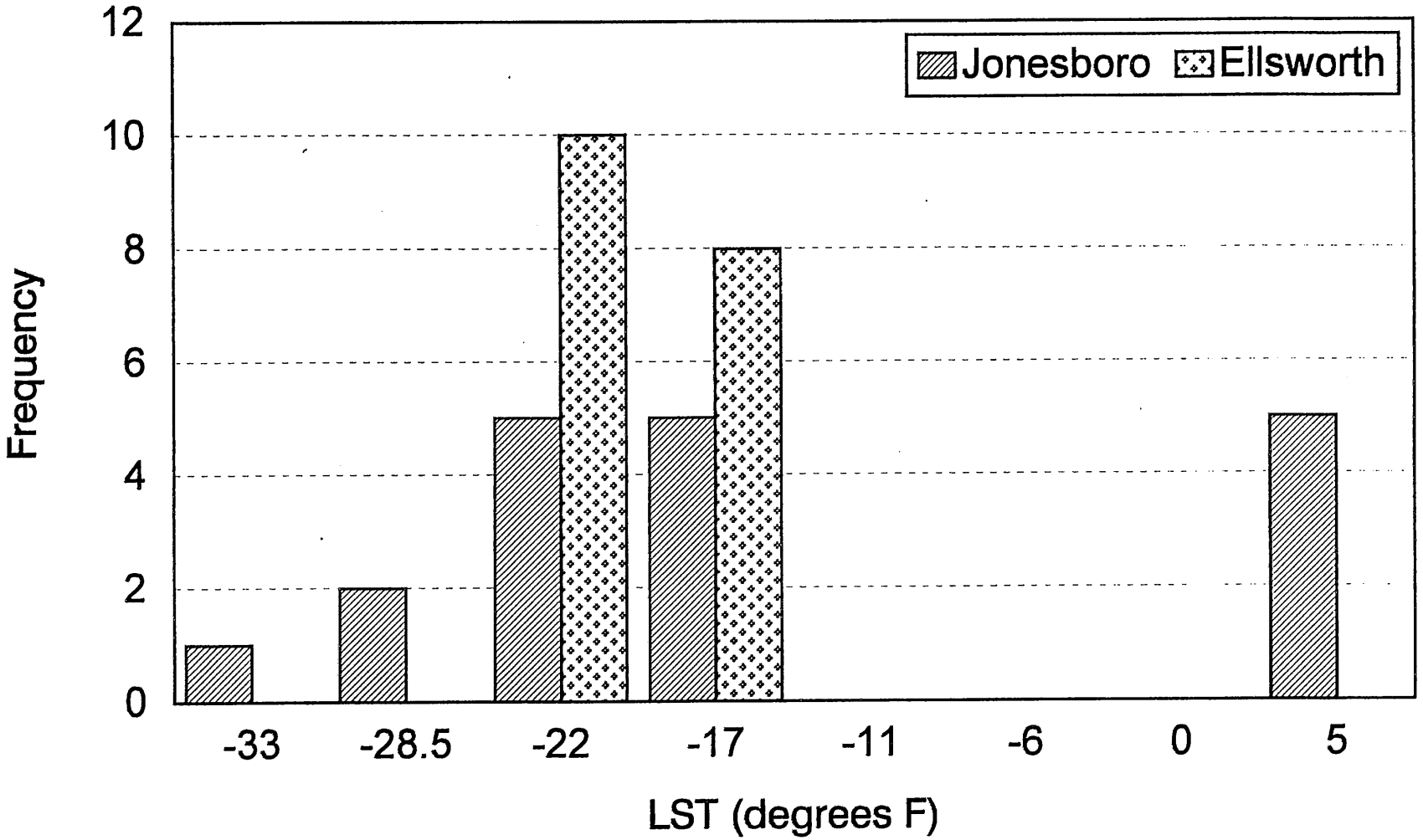


LST = lowest temperature resultling in 100% survival

Figure 2

Bud 4 LST frequency distribution

November 18, 1993

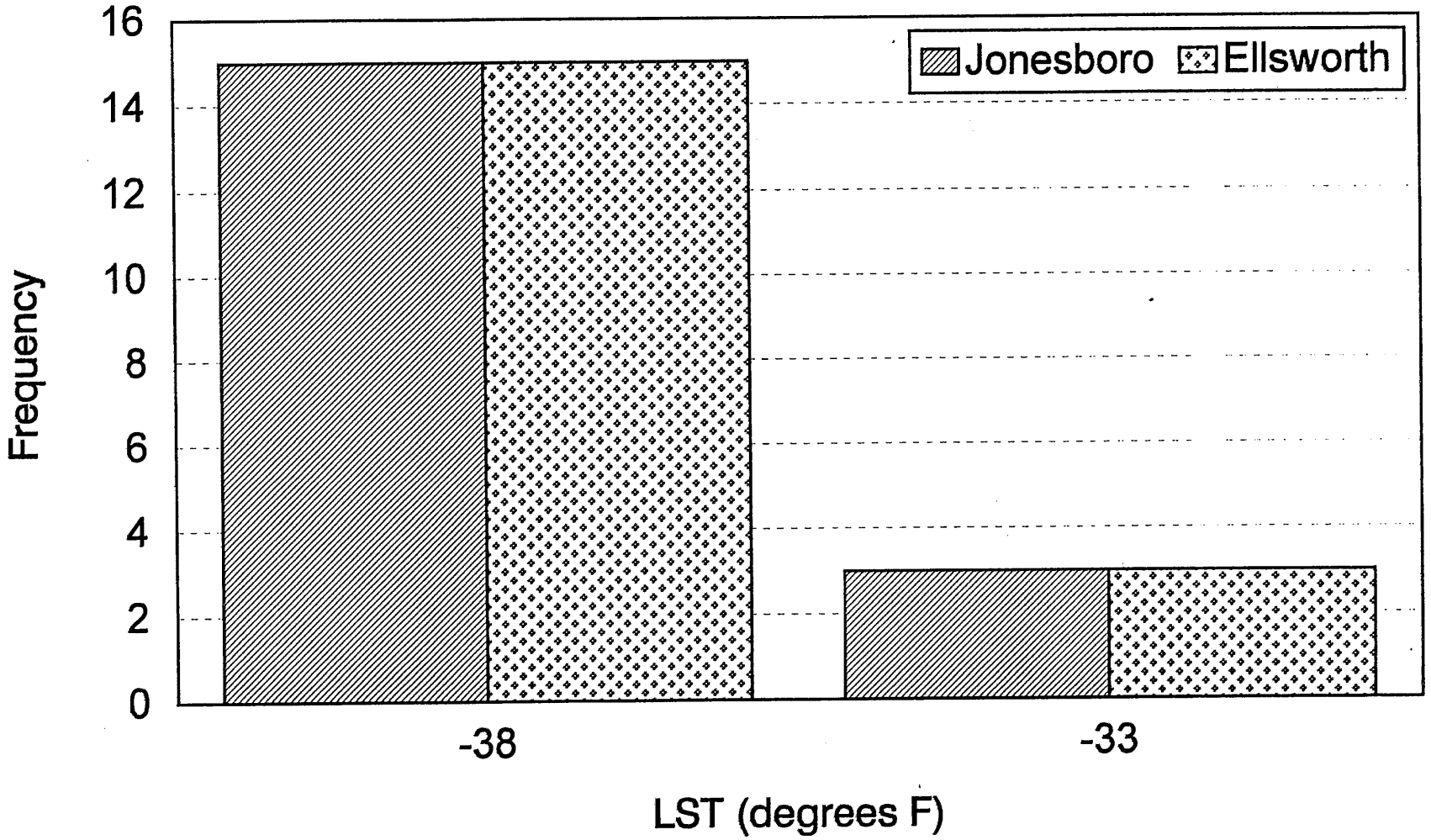


LST = lowest temperature resultling in 100% survival

Figure 3

Stem LST frequency distribution

December 22, 1993

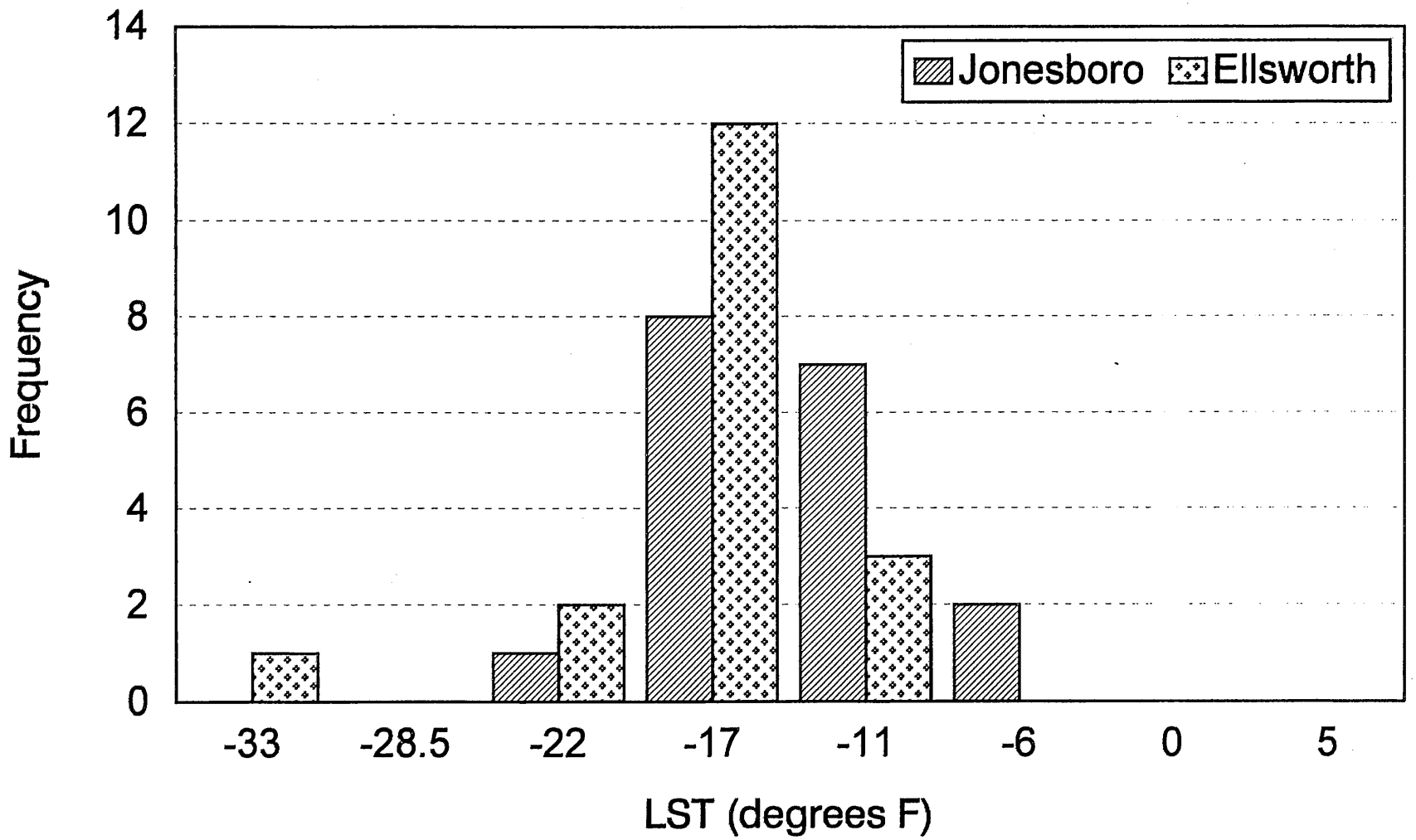


LST = lowest temperature resultling in 100% survival

Figure 4

Bud 4 LST frequency distribution

December 22, 1993

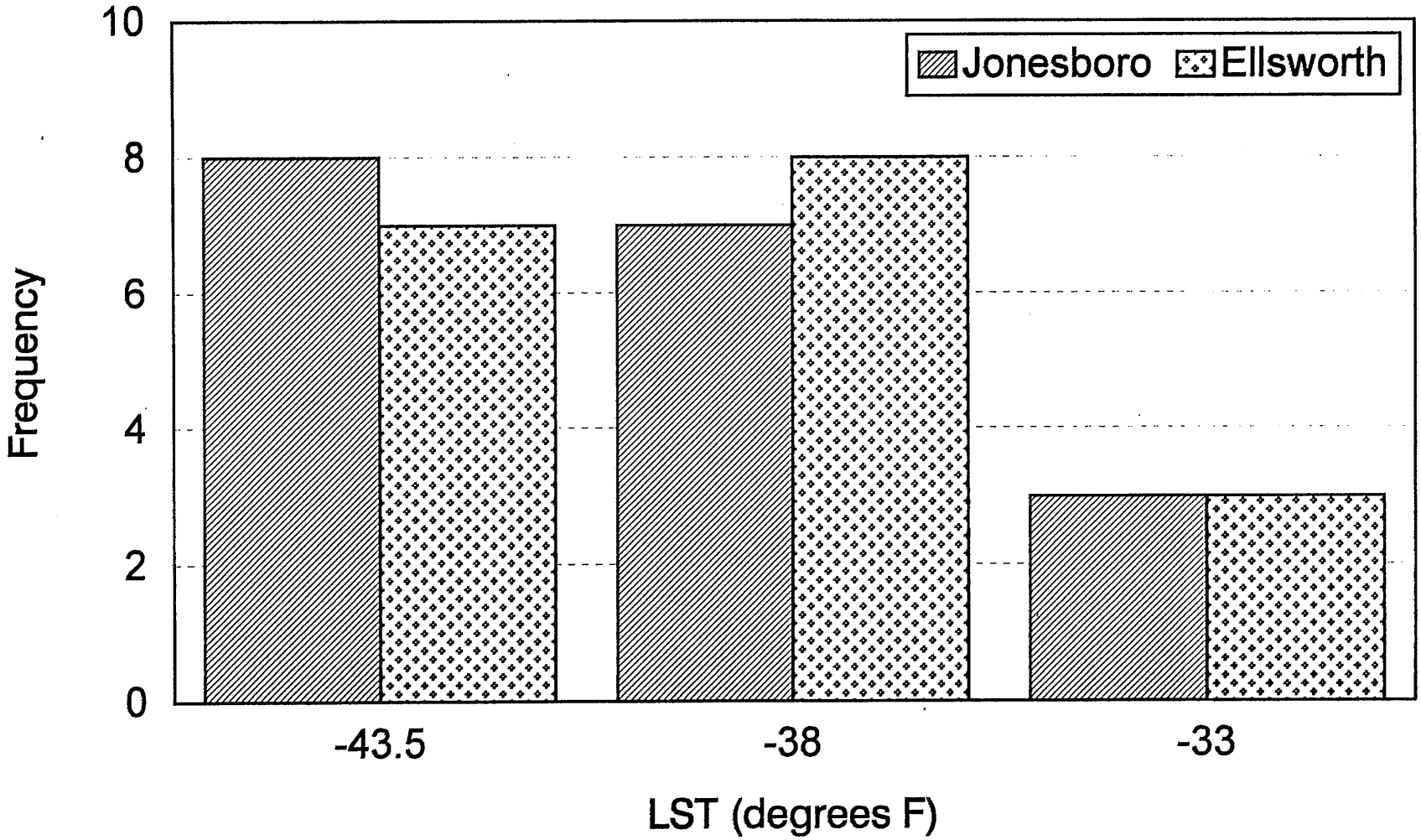


LST = lowest temperature resultling in 100% survival

Figure 5

Stem LST frequency distribution

February 7, 1994

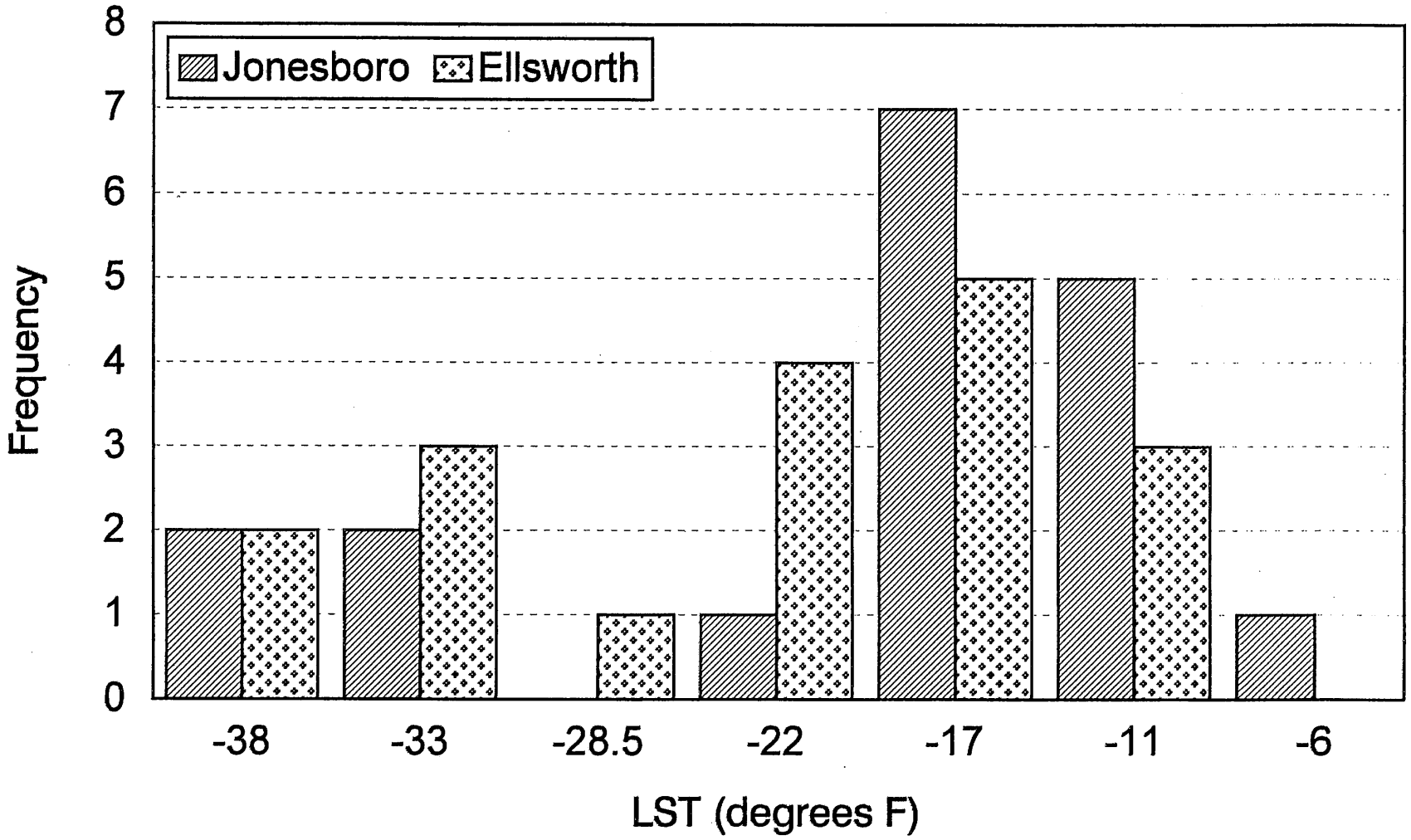


LST = lowest temperature resultling in 100% survival

Figure 6

Bud 4 LST frequency distribution

February 7, 1993

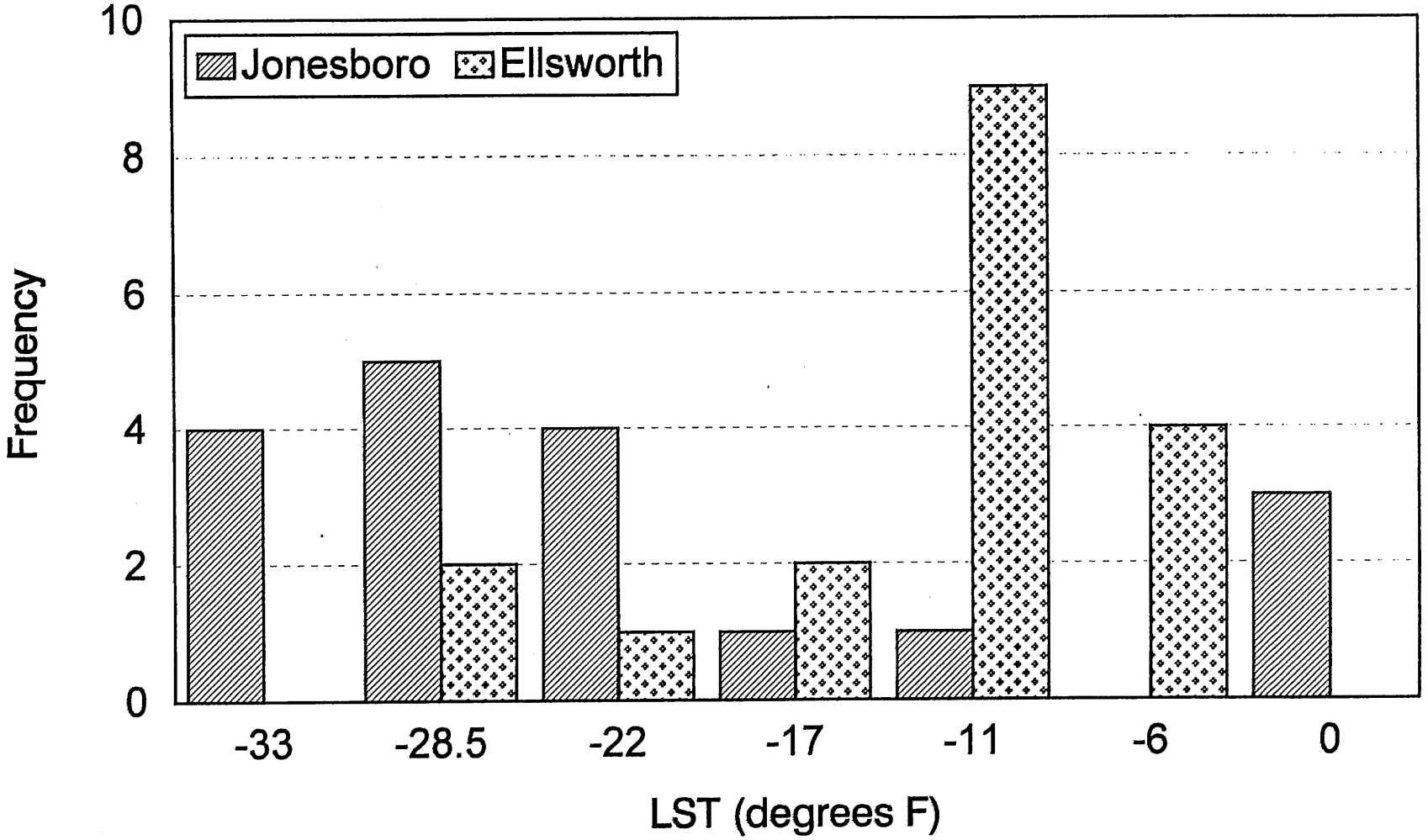


LST = lowest temperature resultling in 100% survival

Figure 7

Stem LST frequency distribution

March 7, 1994

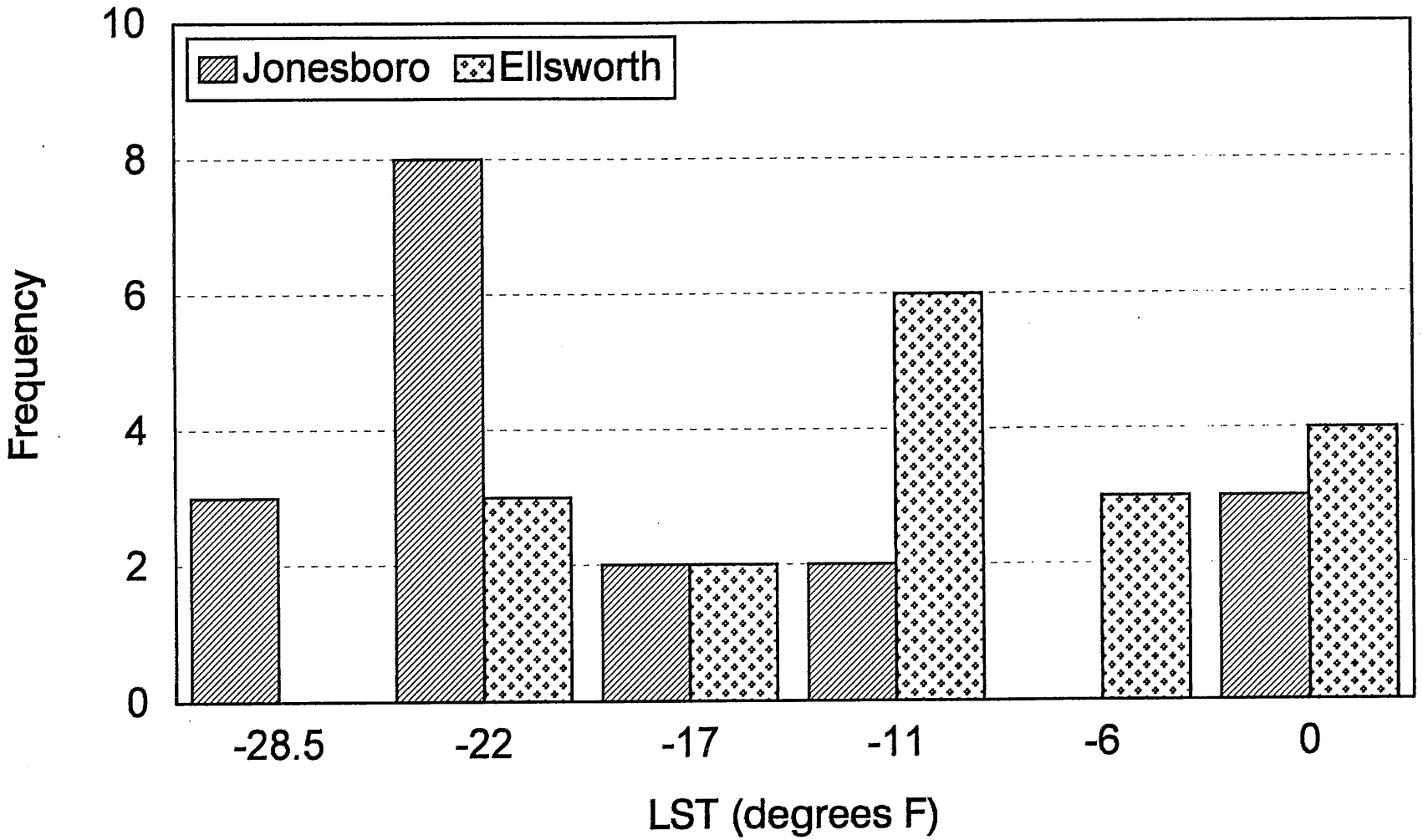


LST = lowest temperature resultling in 100% survival

Figure 8

Bud 4 LST frequency distribution

March 7, 1993



LST = lowest temperature resultling in 100% survival

E. FERTILIZATION

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Scott Dunham, Crop Technician
Cooperator: Delmont Emerson, Blueberry Hill Farm Manager

1. TITLE: Phosphorus Dose/ Response Curve

METHODS: Liquid phosphorus (23% phosphoric acid) was applied preemergent at 0, 20, 40, 60, or 80 lb P/acre to 9 commercial blueberry fields: 3 commercial blueberry fields having plants with very low (<.115%), 3 low (.115-.125%), and 3 adequate (>.125%) leaf phosphorus concentrations. Years of application (1989, 1989+1991, and 1989+1991+1993) were assigned in a split block RCB design with 4 replications at each location.

RESULTS:

FERTILIZER EFFECTS ON PLANT AND SOIL NUTRIENTS

LEAF PHOSPHORUS

Leaf phosphorus concentrations increased linearly with increasing rates of phosphorus (Fig 1). Consistent with both 1989 and 1991 leaf data, the fields with very low phosphorus levels showed the greatest response (Fig. 2). Over all fields, application of phosphorus for three consecutive prune cycles (1989+91+93) resulted in higher levels of phosphorus than for only one or two applications (1989, 1989+91) (Fig 3). Figure 4 illustrates this response and also indicates a carry-over effect. For example, treatment plots receiving 80 lb P/acre for two consecutive prune cycles (1989+91) still had adequate phosphorus in the last cycle without receiving the 1993 application. The treatment plots receiving only one application of phosphorus in 1989 still show an increase compared to the control but are below the standard. The response of individual fields to phosphorus averaged across treatment is illustrated in figures 5, 6, and 7 for very low, low, and high phosphorus fields, respectively.

SOIL PHOSPHORUS

Soil analysis indicated a significant linear increase in soil phosphorus with increasing rate of phosphorus application (Fig. 8). The very low, low, and high phosphorus fields all showed a similar positive increase to the phosphorus fertilizer (Fig. 9). The response of the individual fields in the very low, low, and high phosphorus categories is presented in figures 10, 11, and 12. Soil pH was unaffected by three consecutive prune-year applications of phosphoric acid (Fig. 13), indicating a high soil buffering capacity.

LEAF NITROGEN

The nitrogen concentrations in 1993 leaf tissue was not influenced by phosphorus

application (Fig. 14) in direct contrast to the 1991 leaf tissue samples which showed a linear increase associated with increasing rate of phosphorus application.

OTHER ELEMENTS

The only other leaf elements to be influenced by phosphorus application were manganese and aluminum. Leaf manganese showed a linear increase with an increasing rate of phosphorus application (Fig. 15). Leaf aluminum was influenced by each new phosphorus application which resulted in lower leaf aluminum (Fig. 16).

The soil elements most effected by phosphorus application were magnesium and aluminum. Increasing rates of phosphorus caused a linear decrease in the soil availability of aluminum and magnesium (Fig. 17, 18). Each additional prune-year application of phosphorus again decreased the availability of aluminum (Fig 19).

FERTILIZER EFFECTS ON PLANT CHARACTERISTICS

Phosphorus fertilization rate had no **meaningful** effect on stem density, length or branching. Flower buds per stem and flower bud density each showed a (linear?) (general?) increased with rising rates of phosphorus (Fig. 20, 21). The fields containing adequate phosphorus levels did not show an increase in flower bud density (Fig. 22). The fields low in phosphorus showed the best response to the phosphorus fertilizer gaining approximately 7 flower buds per 1/4 square foot (Fig. 23). The best response of an individual field was at a low P field which showed an significant increase of approximately 15 flower buds per 1/4 square foot (Fig 24).

Multiple phosphorus fertilizer application had no significant effect on any stem characteristics.

FERTILIZER EFFECTS ON YIELD

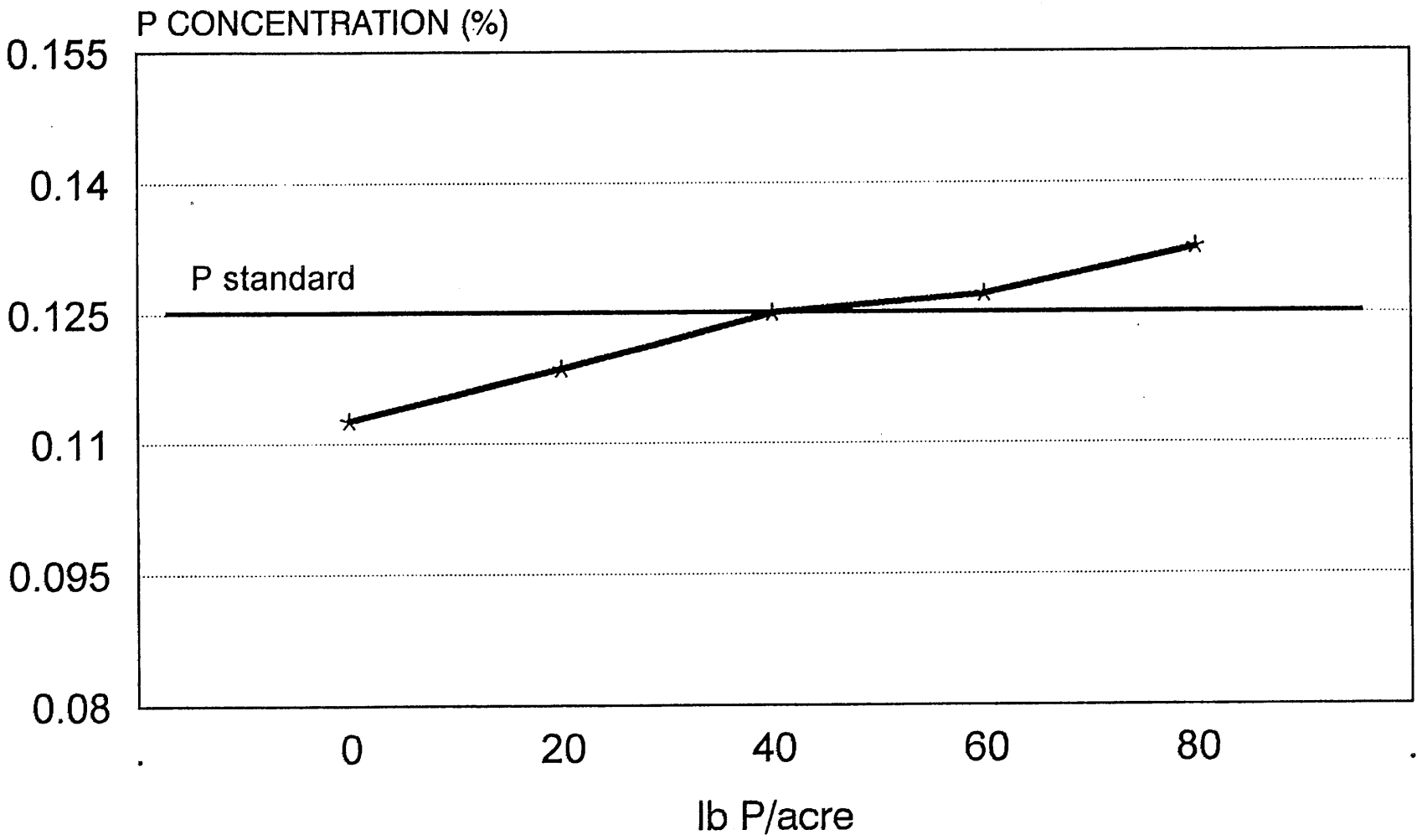
Phosphorus fertilizer rate and multiple phosphorus application had no significant effects on yield (Figs. 25 & 26).

CONCLUSIONS: Analysis of data is not complete. No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1

LEAF PHOSPHORUS CONCENTRATIONS
ALL FIELDS

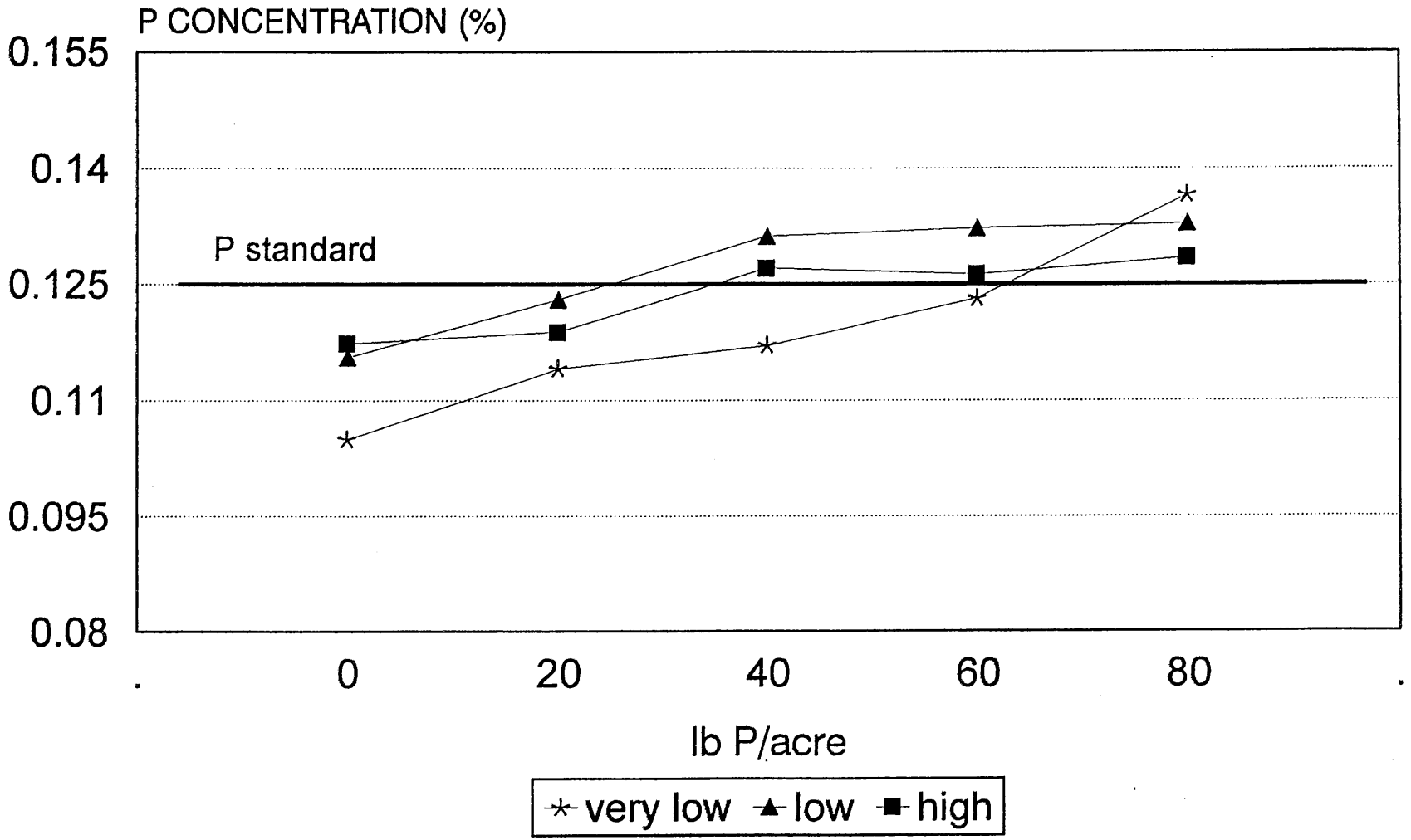


1993, L

Figure 2

LEAF PHOSPHORUS CONCENTRATIONS

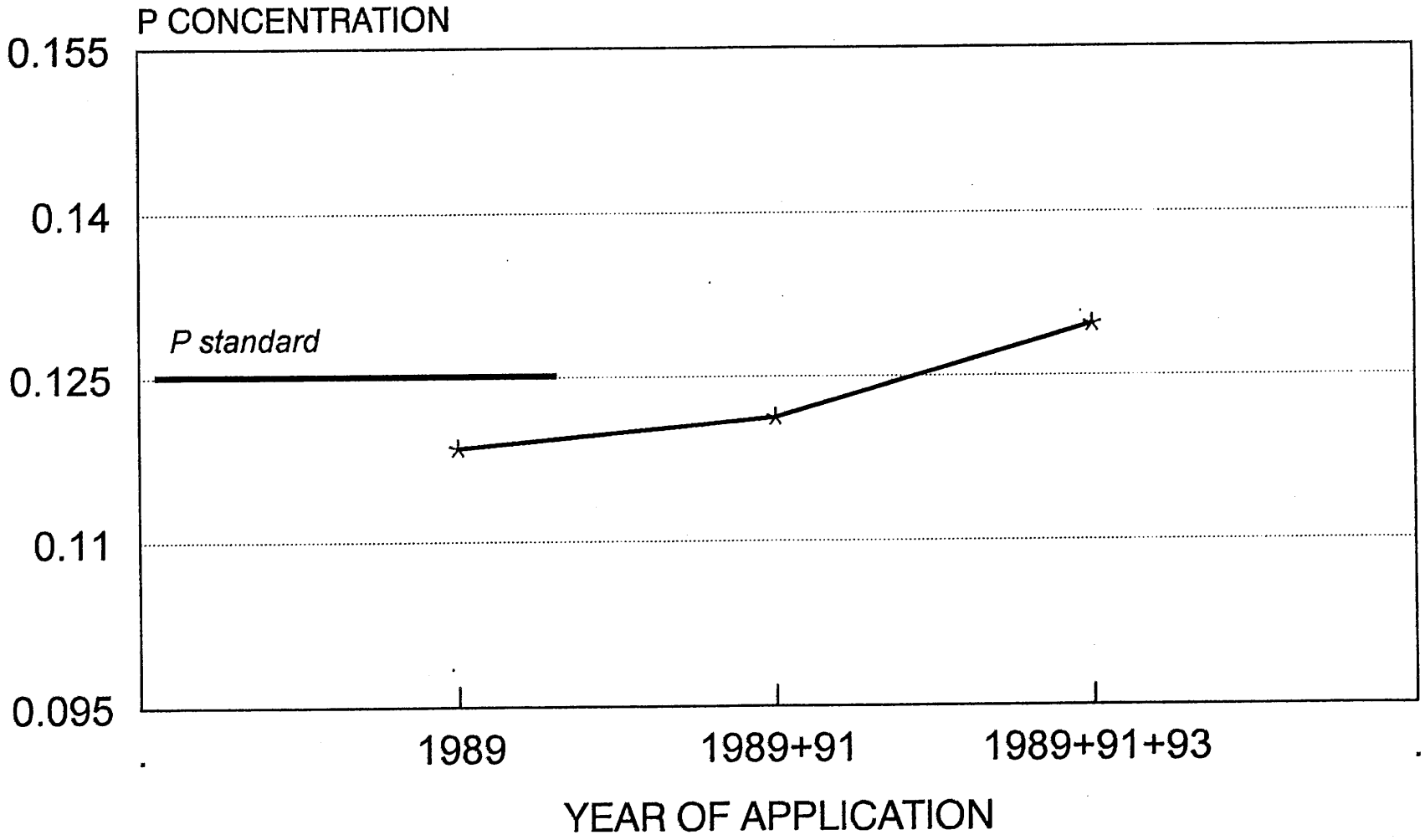
VERY LOW, LOW, AND HIGH PHOSPHORUS FIELDS



1993

Figure 3

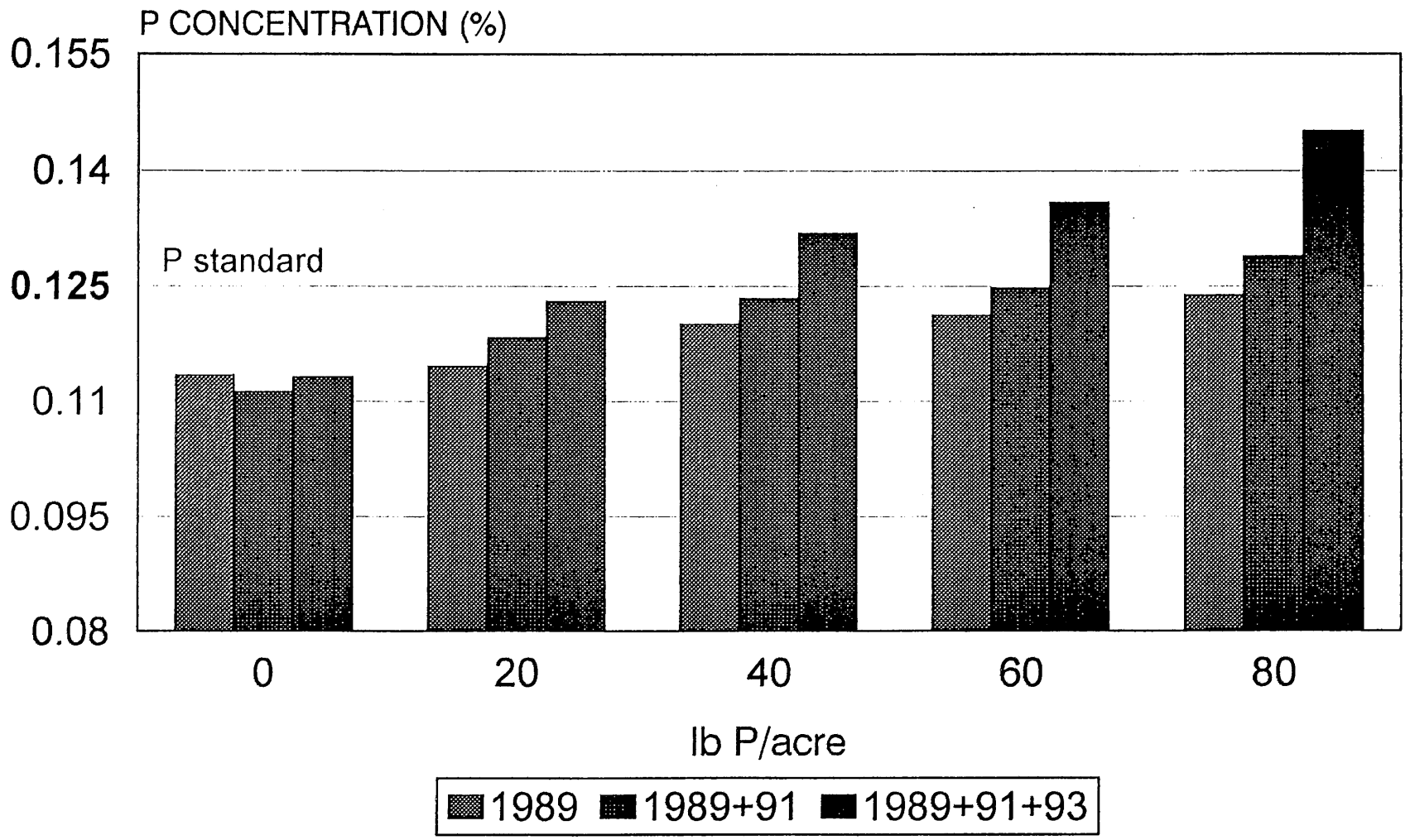
LEAF PHOSPHORUS CONCENTRATIONS
ALL FIELDS



1993

Figure 4

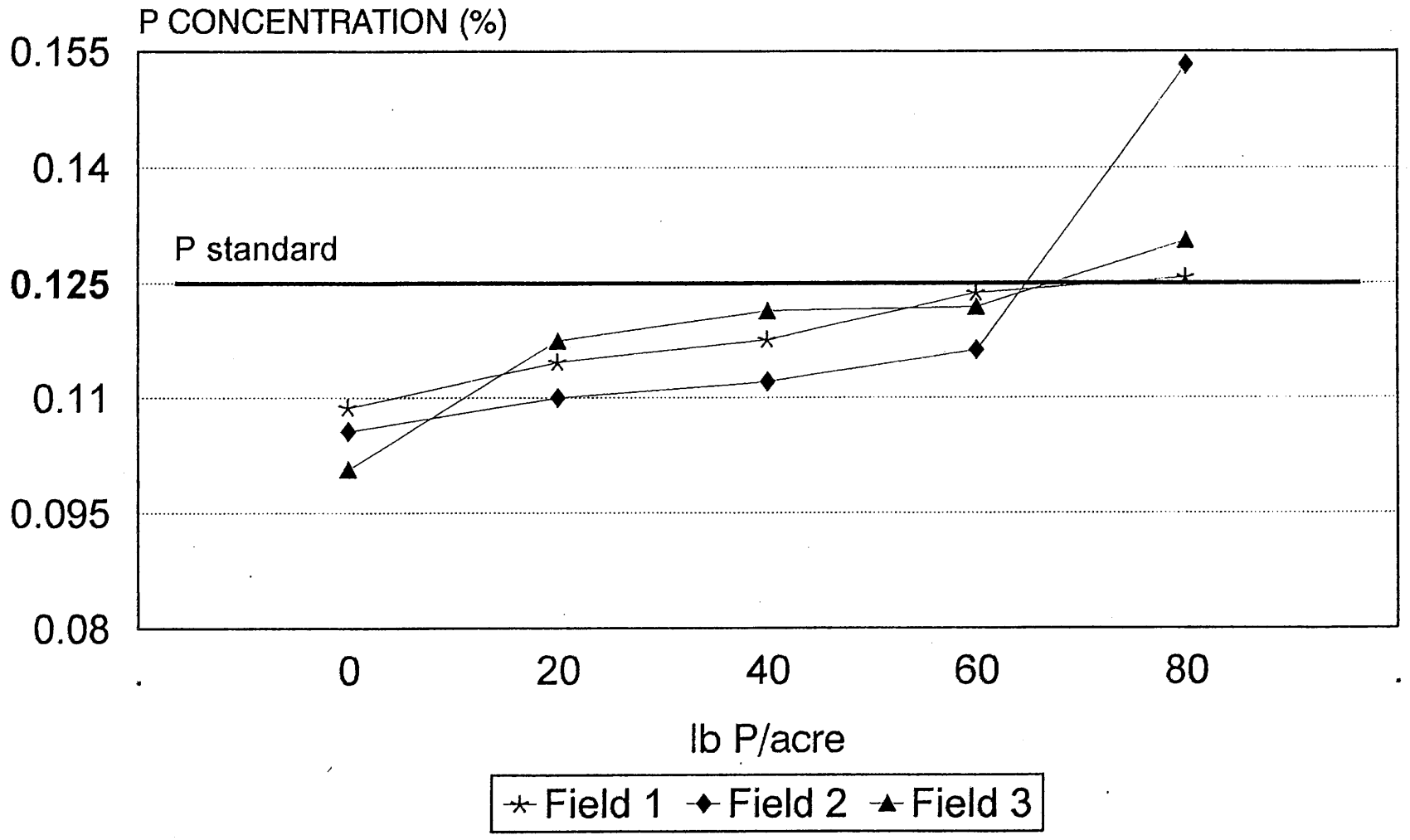
LEAF PHOSPHORUS CONCENTRATIONS
ALL FIELDS



1993

Figure 5

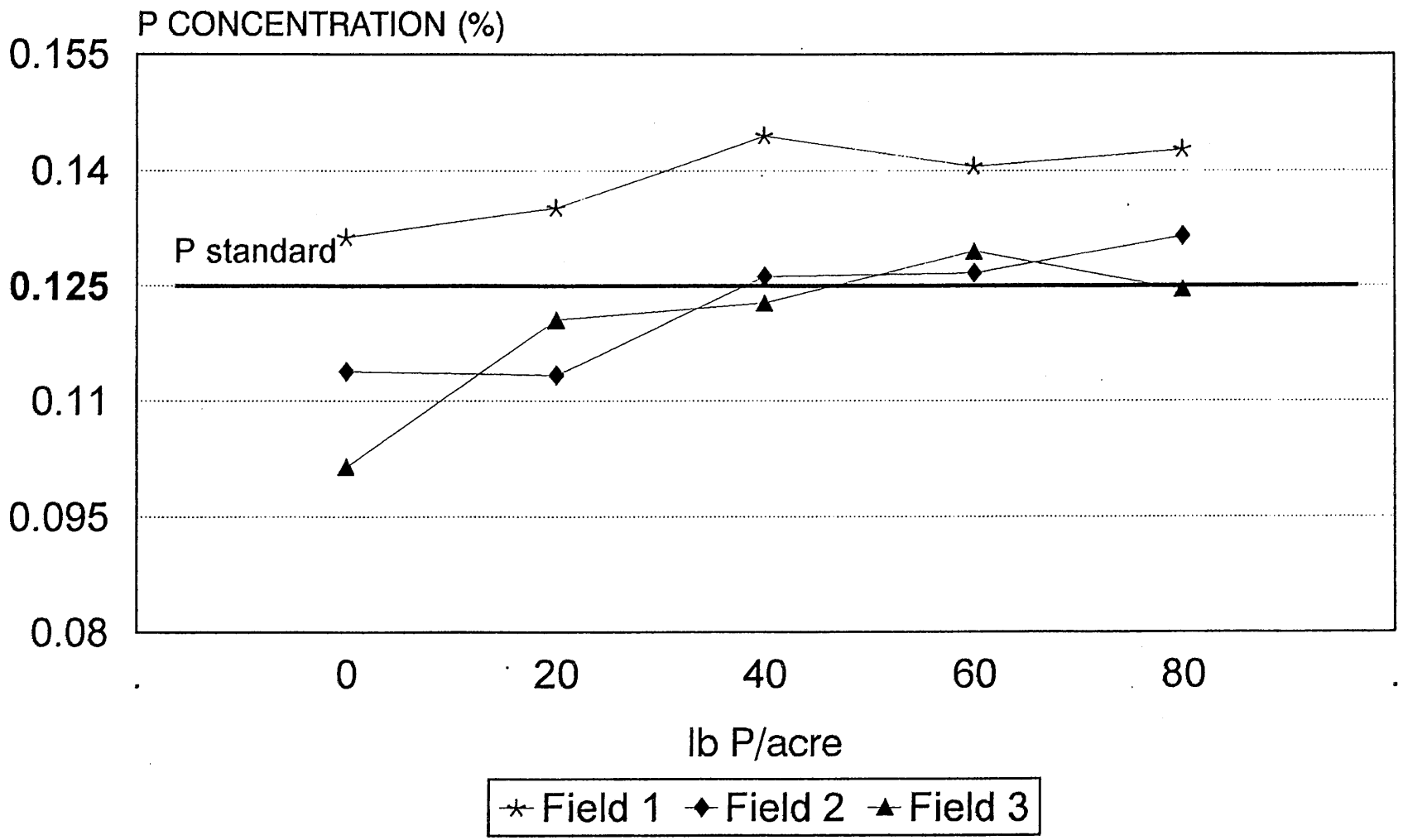
LEAF PHOSPHORUS CONCENTRATIONS
VERY LOW P FIELDS



1993

Figure 6

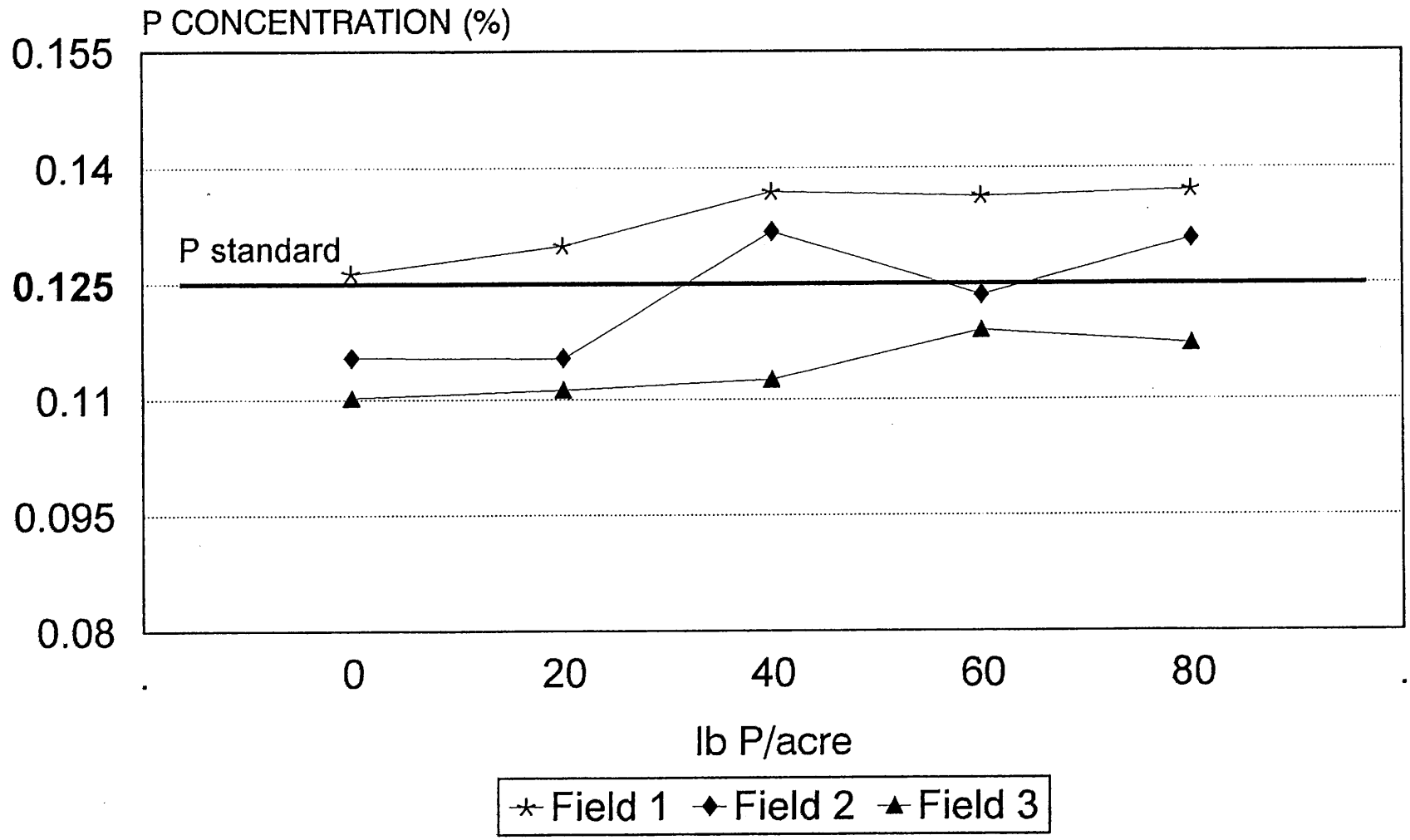
LEAF PHOSPHORUS CONCENTRATIONS
LOW P FIELDS



1993

Figure 7

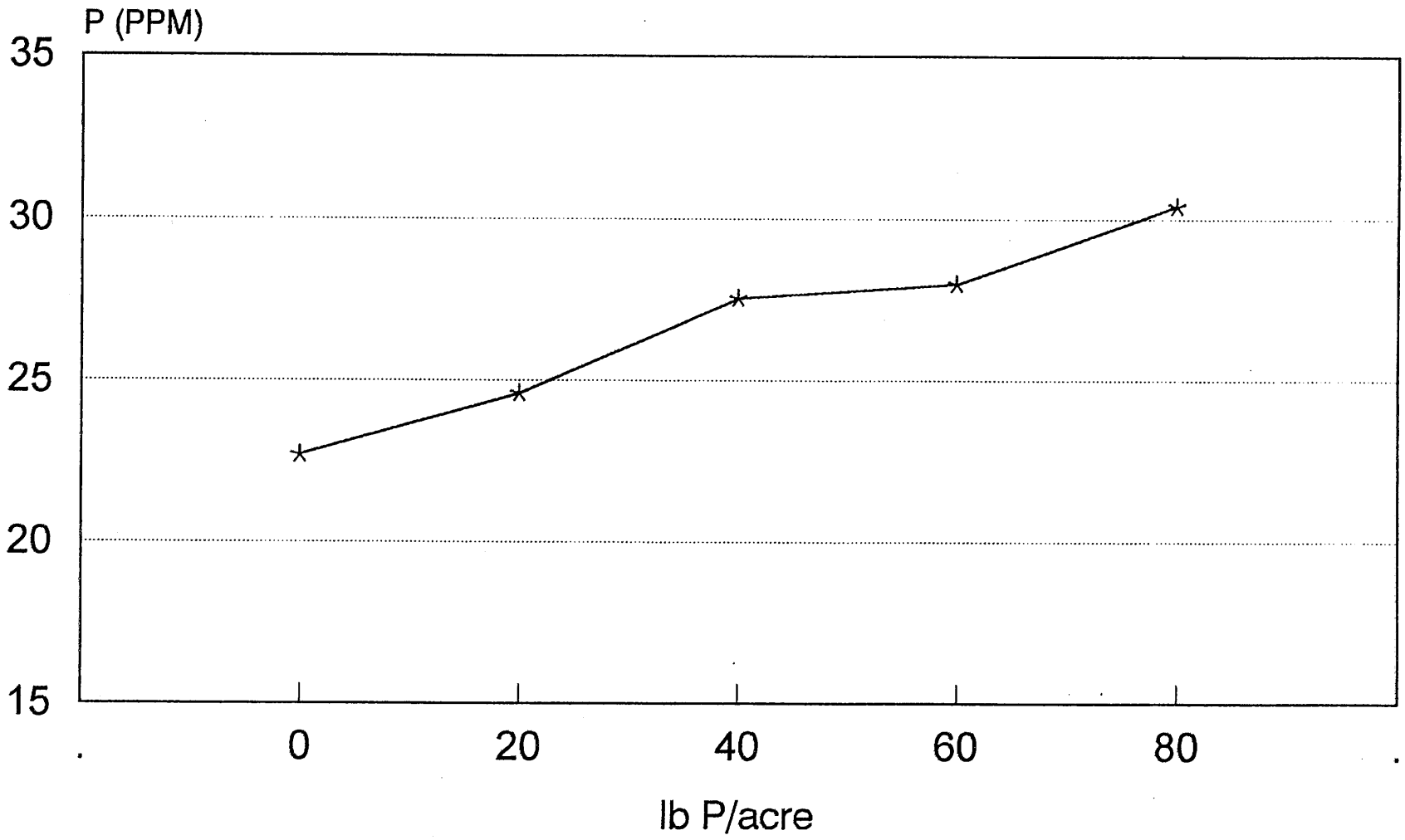
LEAF PHOSPHORUS CONCENTRATIONS
HIGH P FIELDS



1993

Figure 8

SOIL PHOSPHORUS CONCENTRATIONS
ALL FIELDS

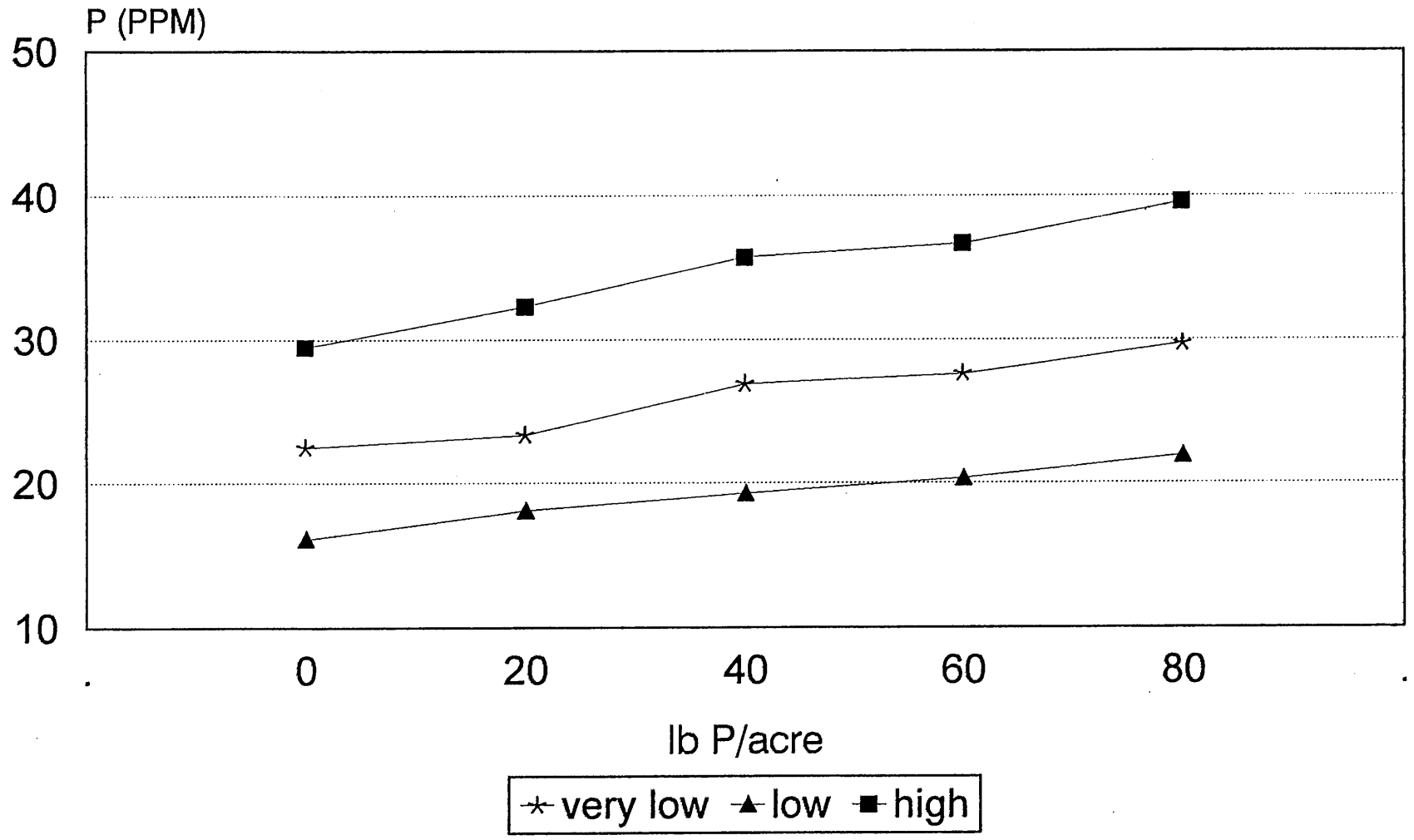


1993

Figure 9

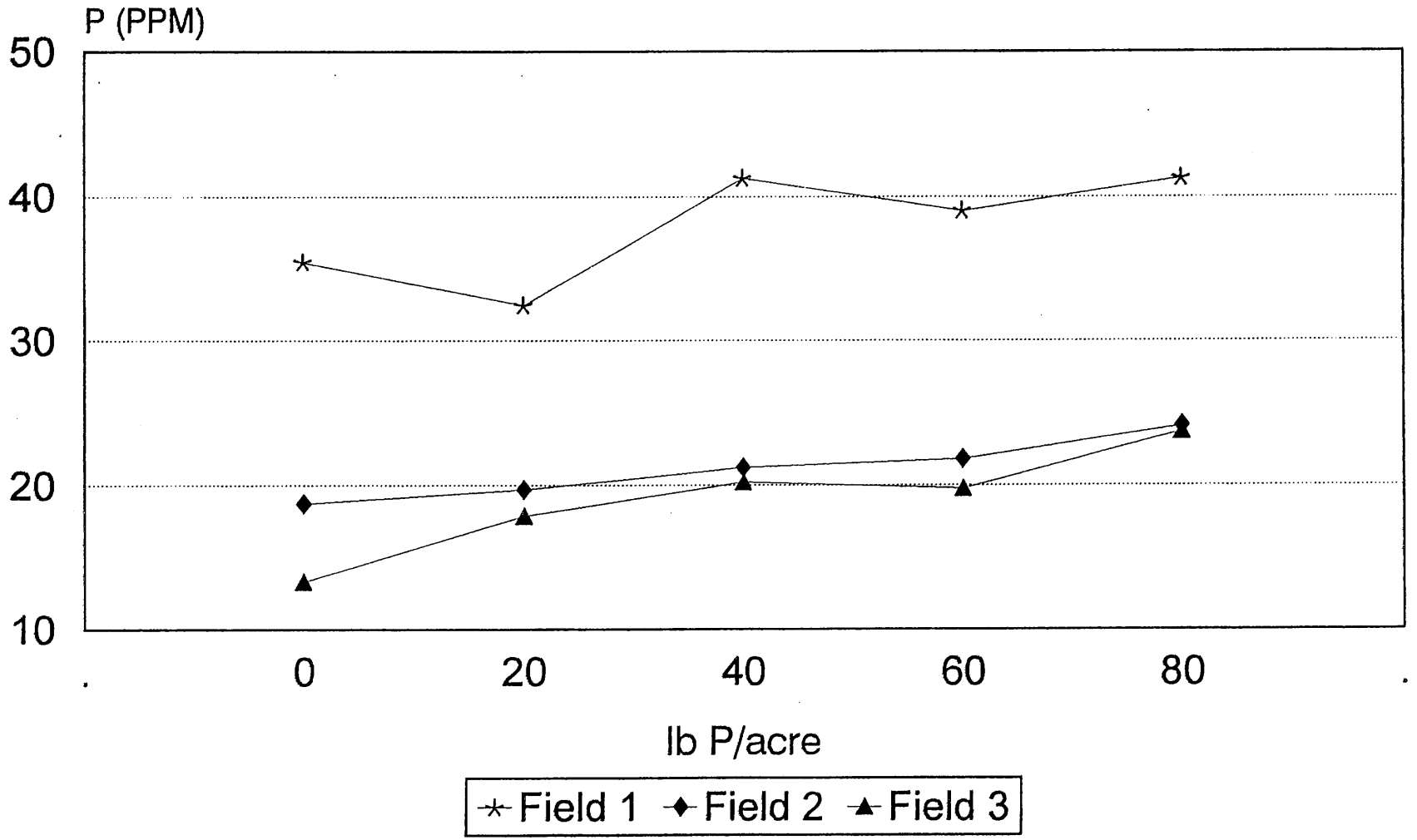
SOIL PHOSPHORUS CONCENTRATIONS

VERY LOW, LOW, AND HIGH PHOSPHORUS FIELDS



1993

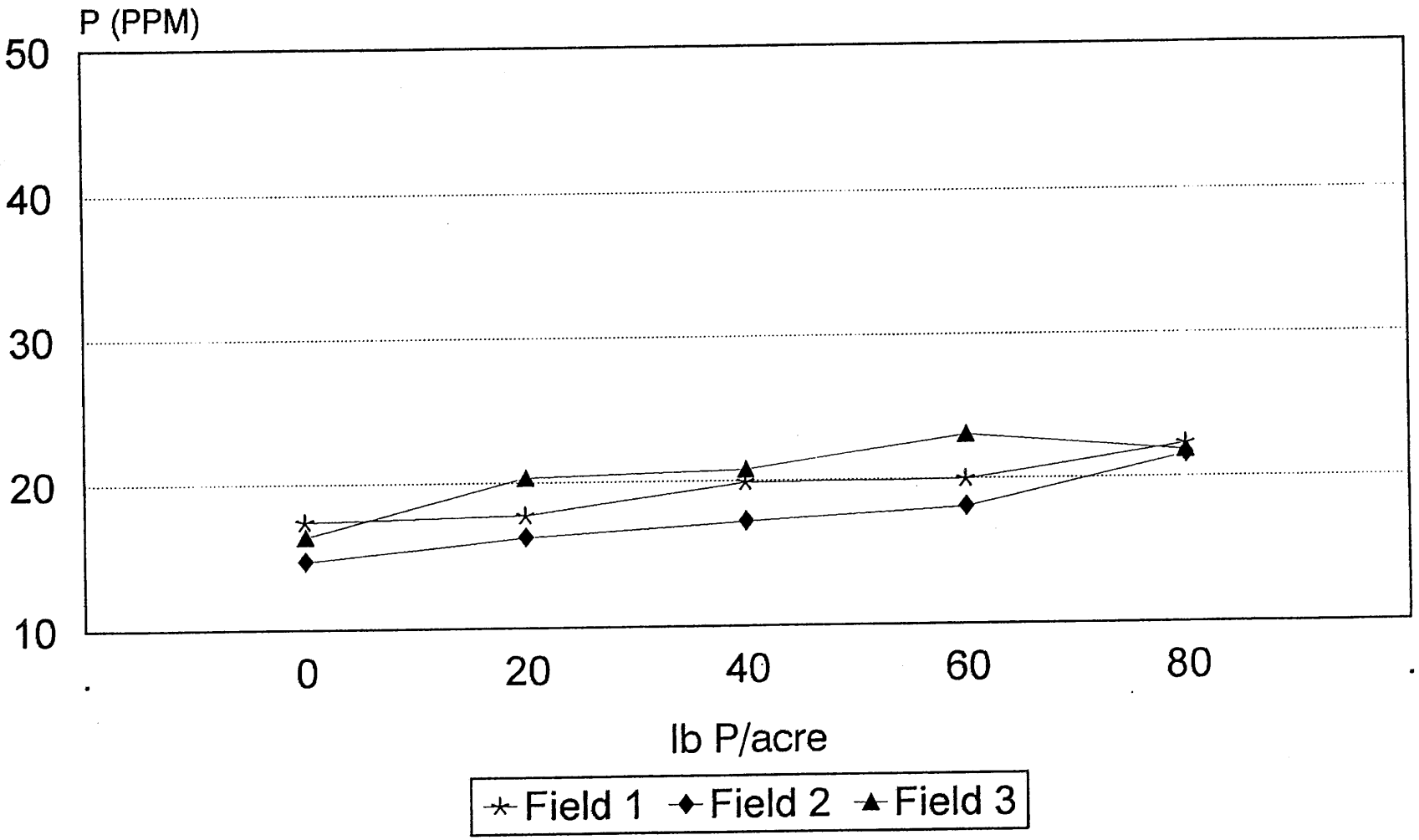
Figure 10 SOIL PHOSPHORUS CONCENTRATIONS
VERY LOW P FIELDS



1993

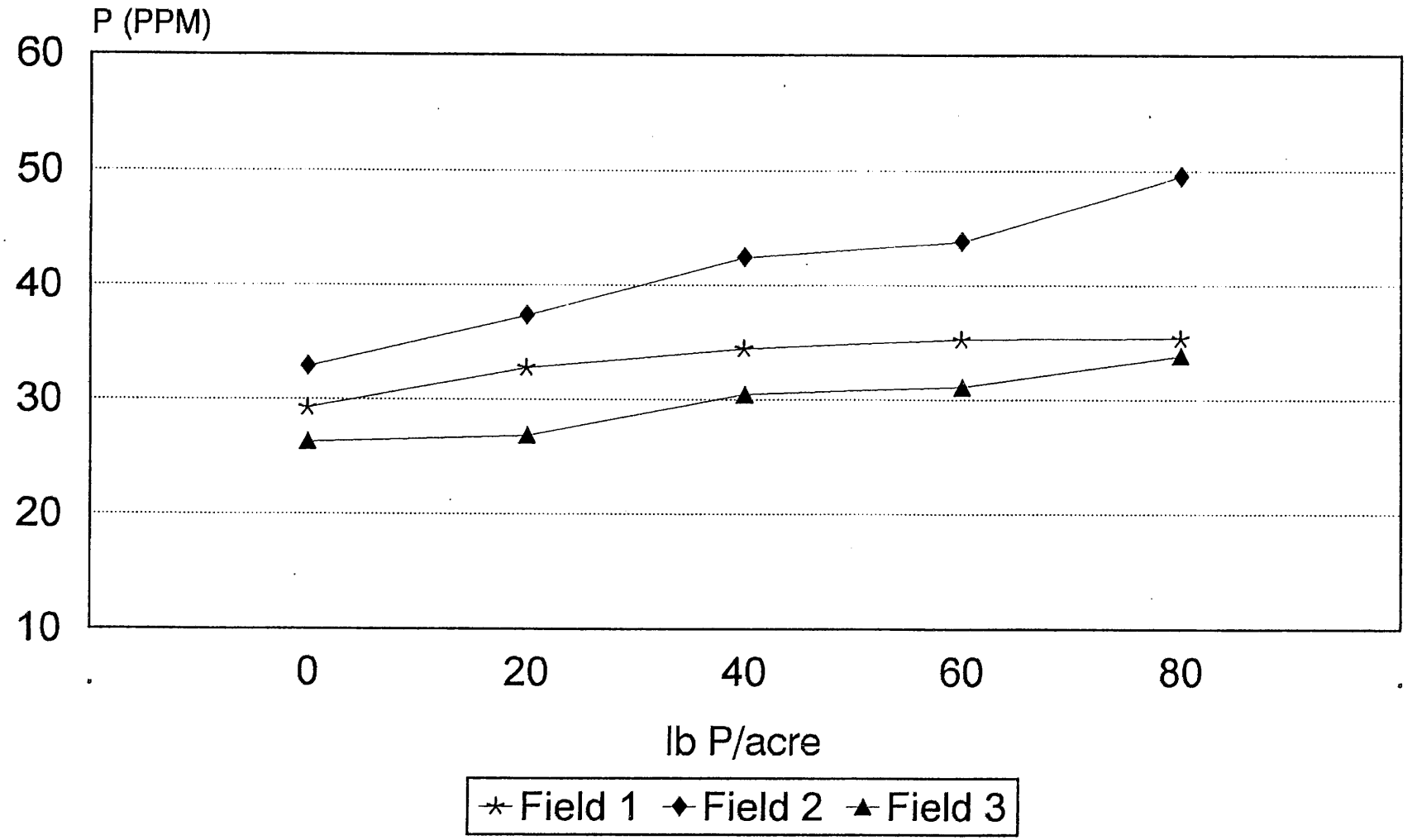
Figure 11

SOIL PHOSPHORUS CONCENTRATIONS
LOW P FIELDS



1993

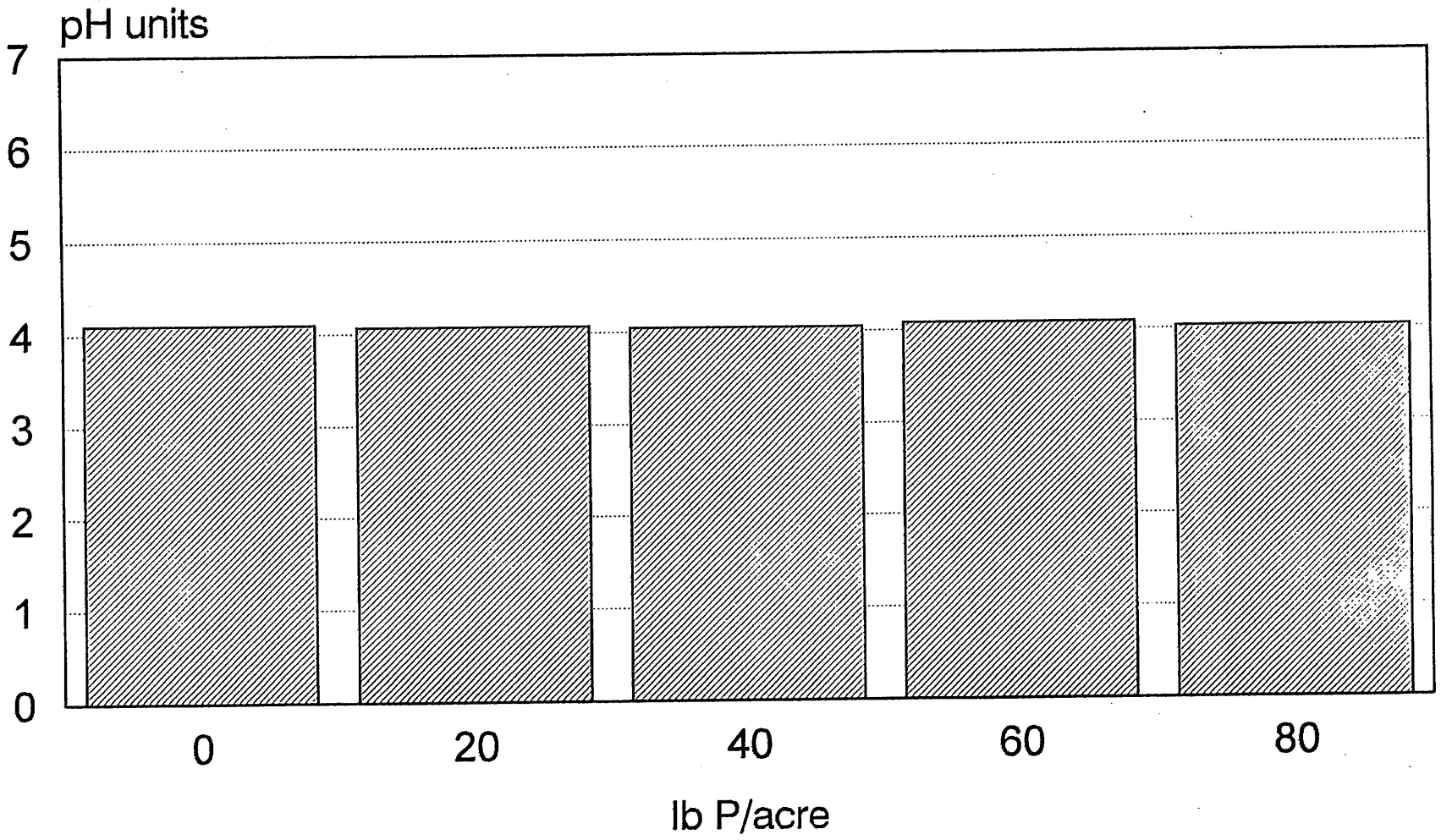
Figure 12 SOIL PHOSPHORUS CONCENTRATIONS
HIGH P FIELDS



1993

Figure 13

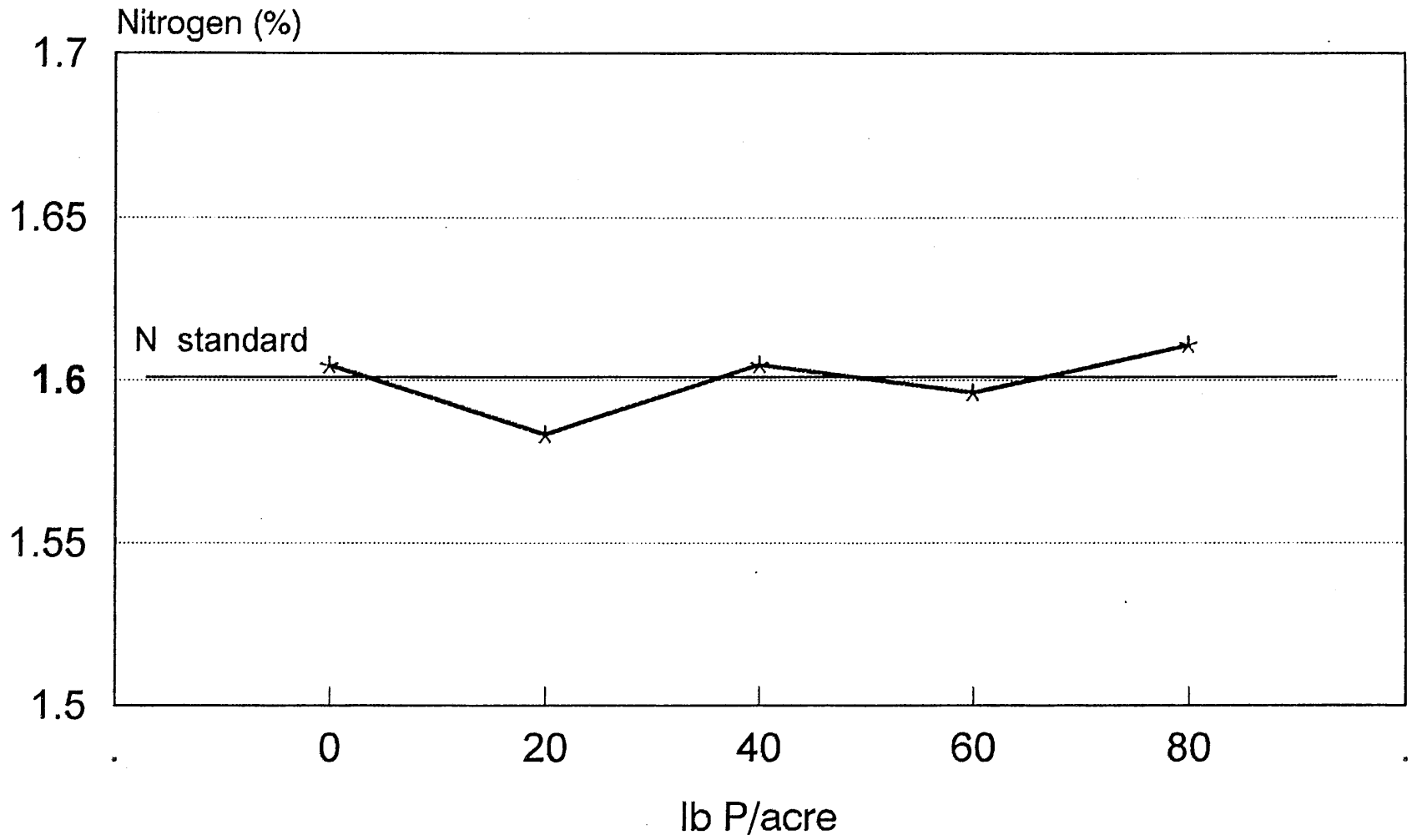
SOIL pH
AVERAGE ALL FIELDS



1993, P applied in 1989 +'91 + '93

Figure 14

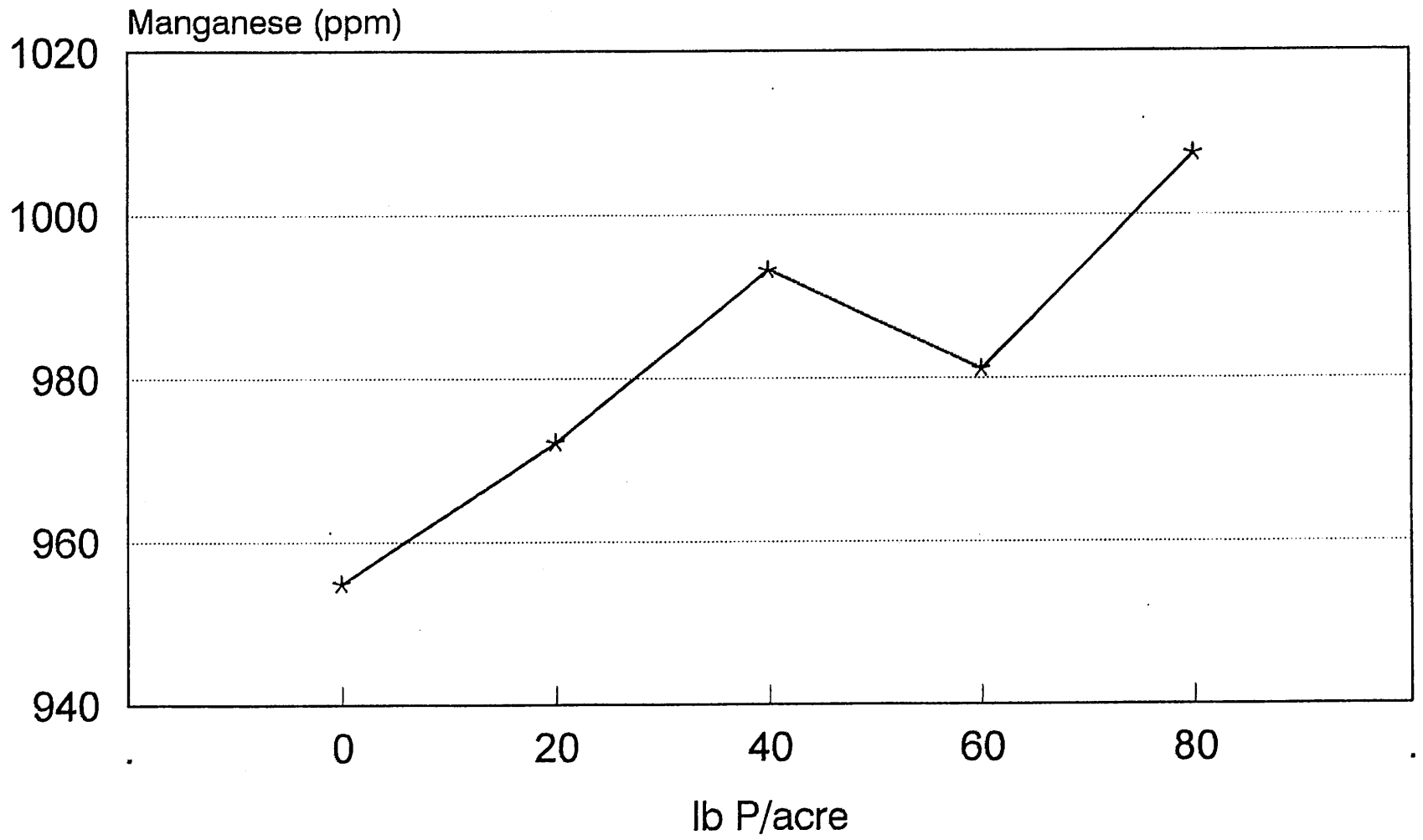
LEAF NITROGEN CONCENTRATIONS
ALL FIELDS



1993, NS

Figure 15

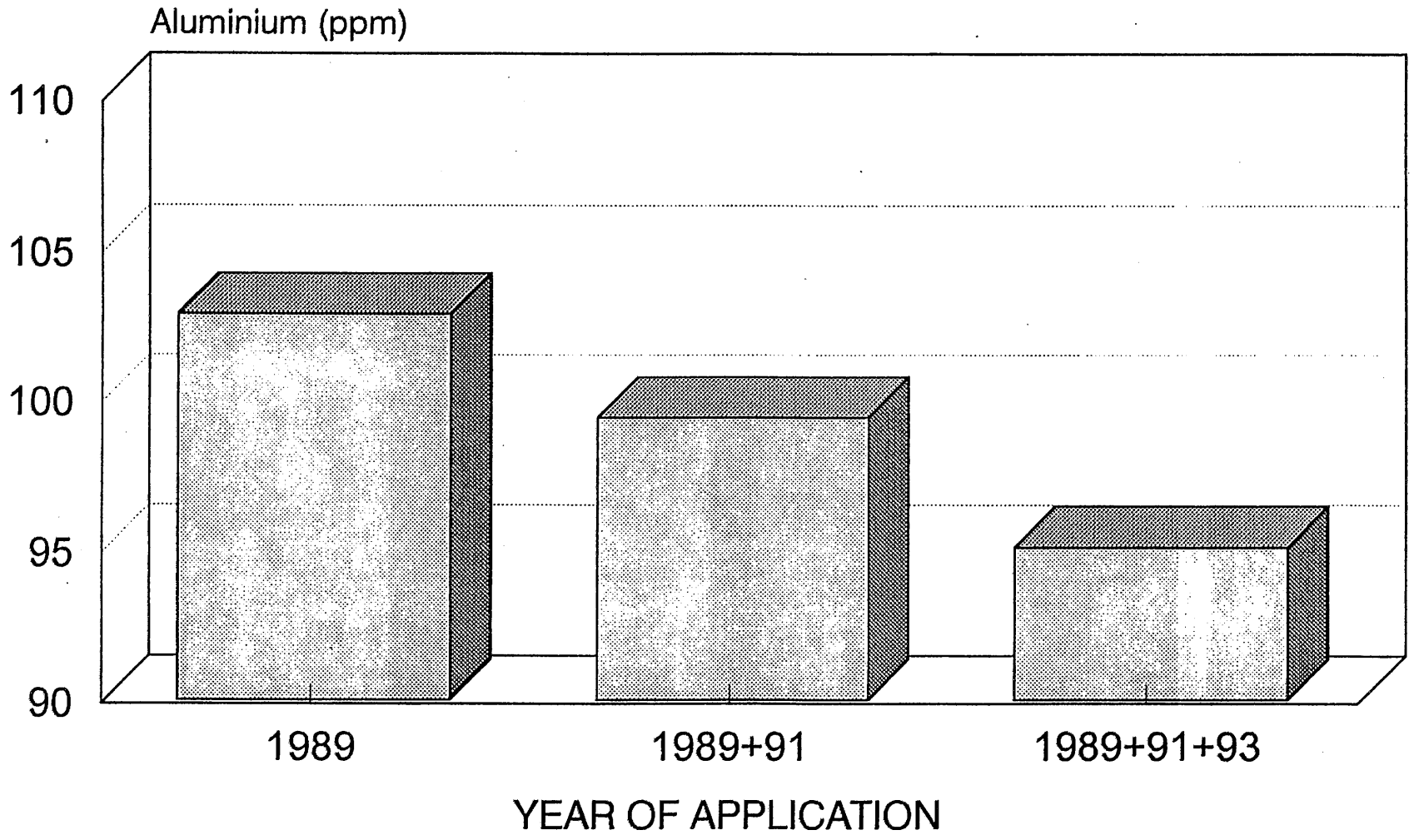
LEAF MANGANESE CONCENTRATIONS
ALL FIELDS



1993, sign linear .1%

Figure 16

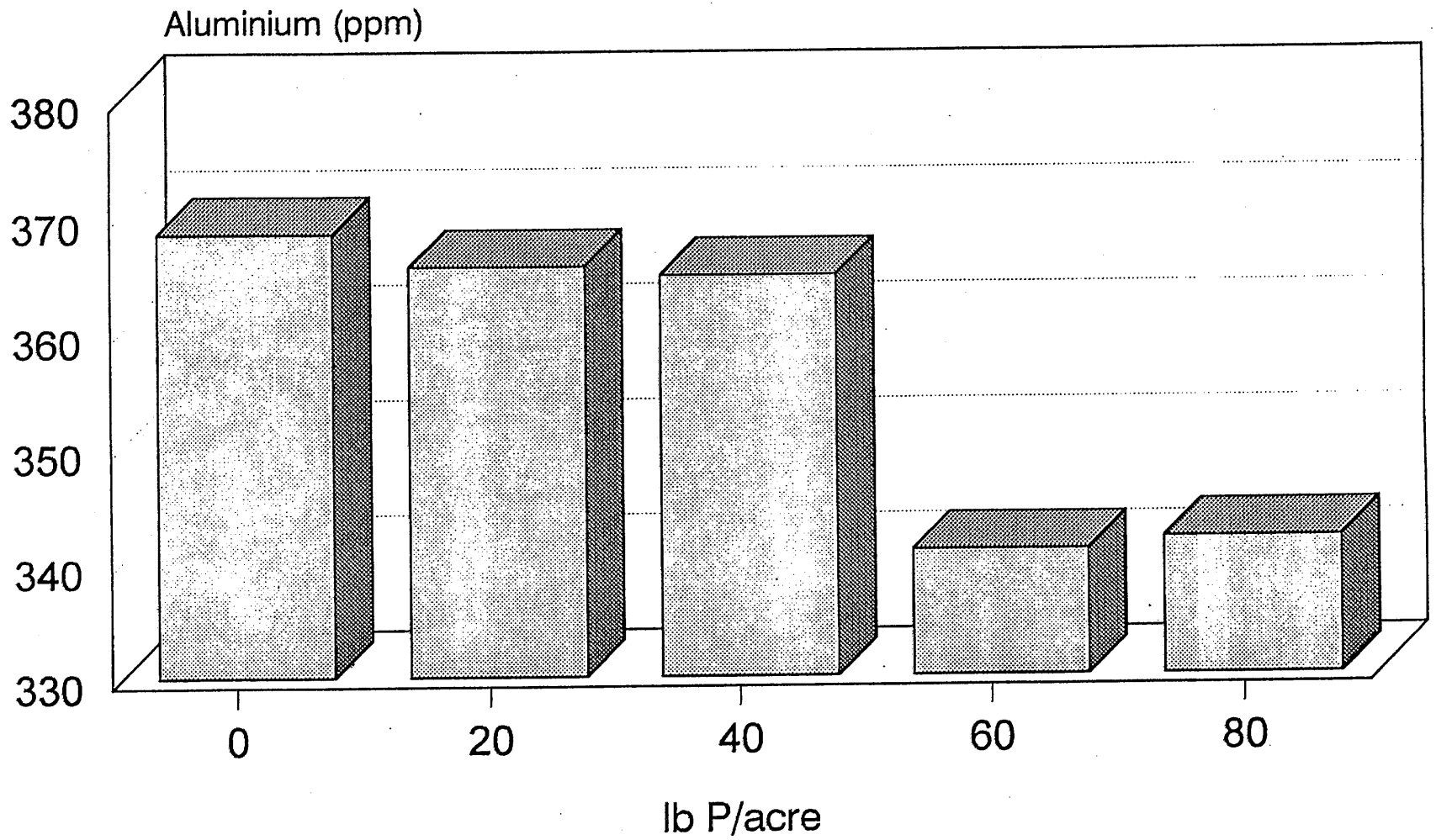
LEAF ALUMINUM CONCENTRATIONS
ALL FIELDS



1993, L .001%

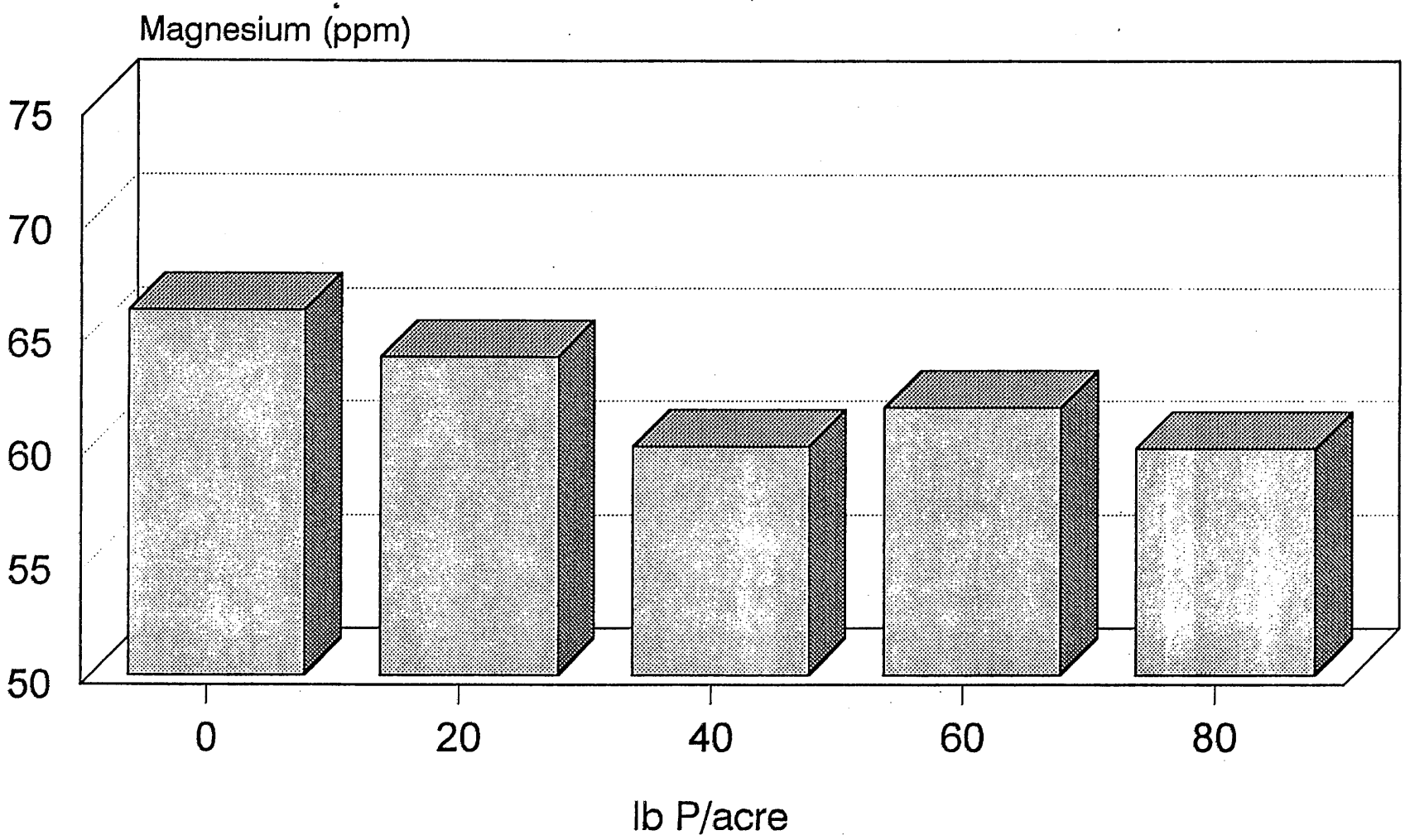
Figure 17

SOIL ALUMINUM CONCENTRATIONS
ALL FIELDS



1993, sign linear decrease

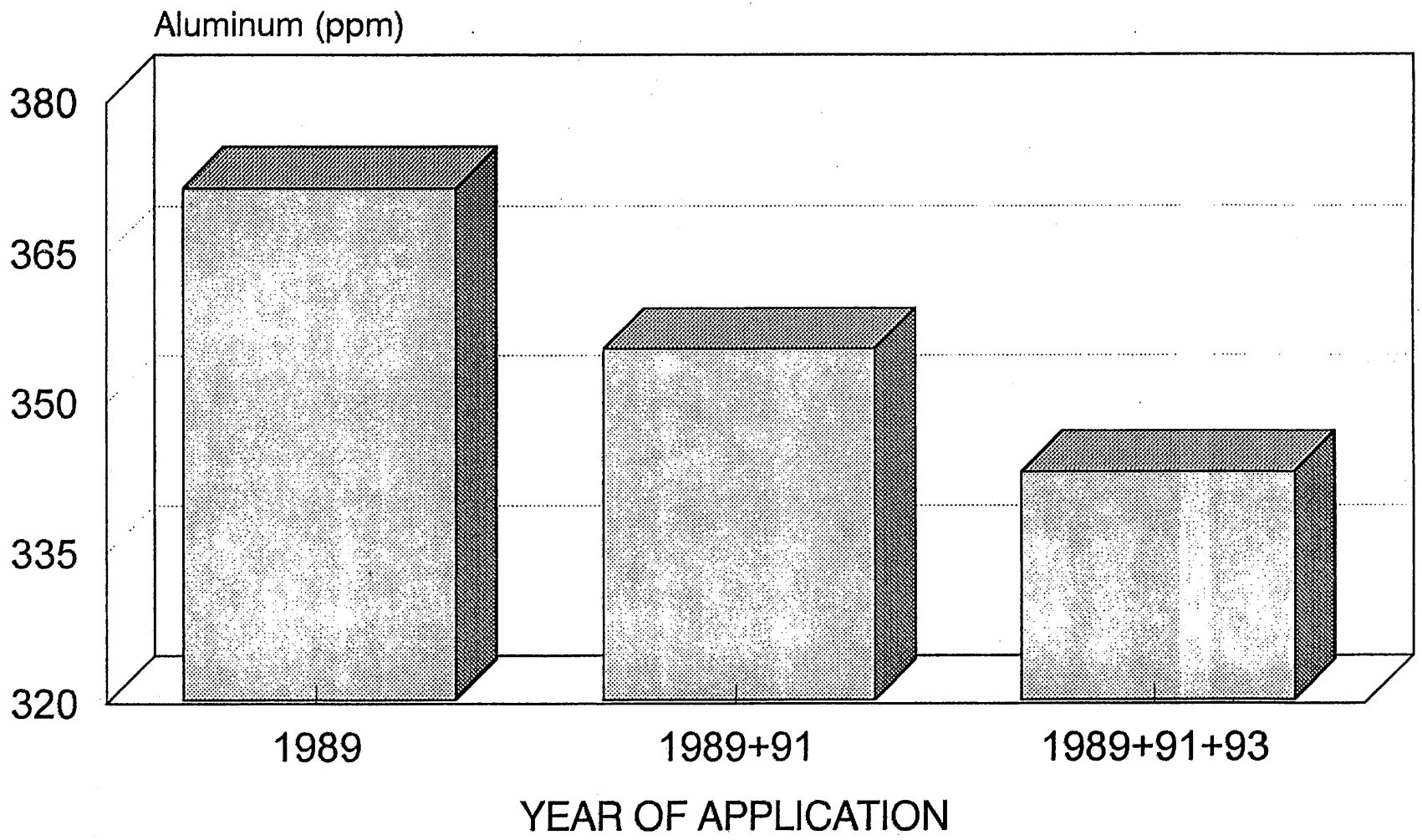
Figure 18 SOIL MAGNESIUM CONCENTRATIONS
ALL FIELDS



1993, sign linear decrease

Figure 19

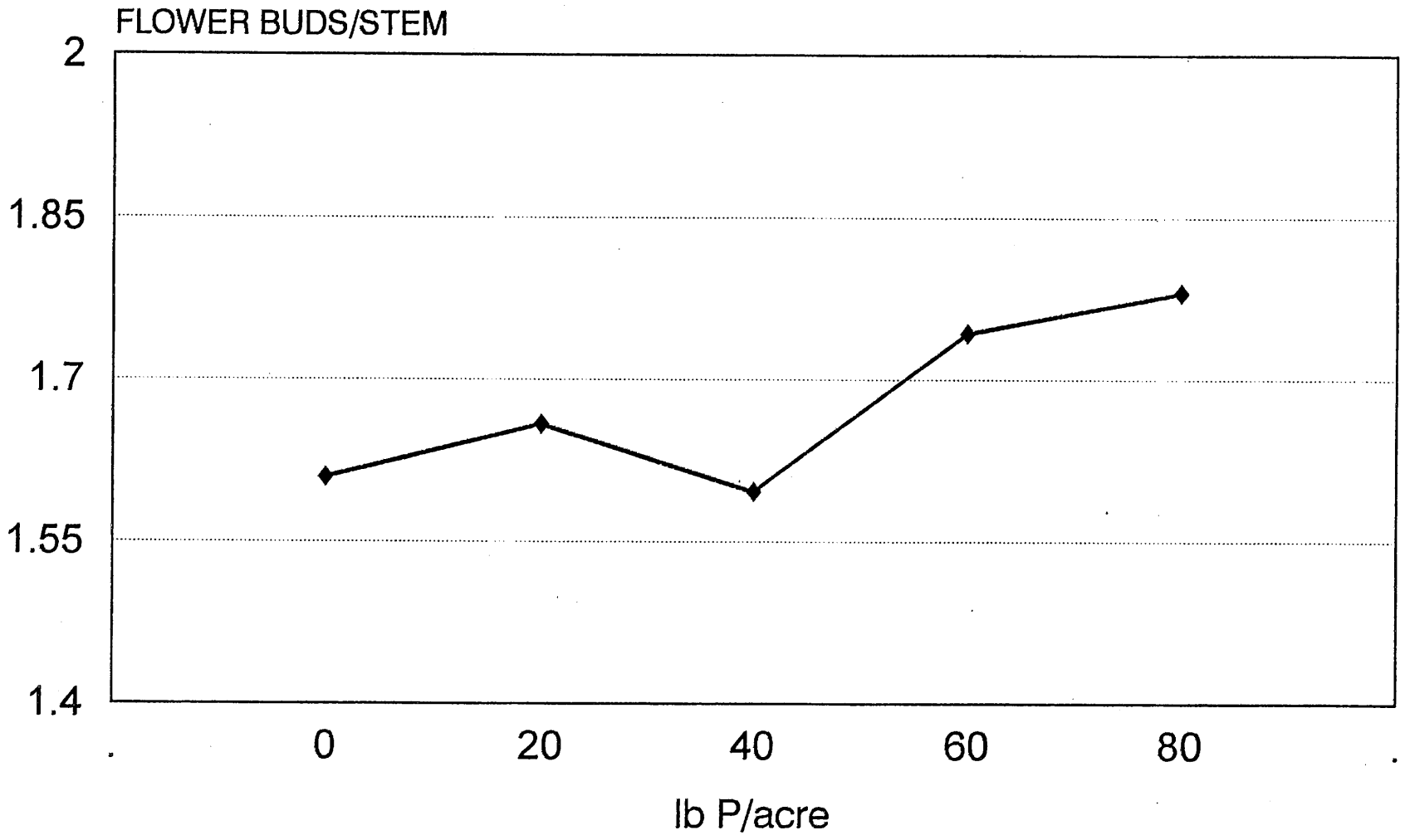
SOIL ALUMINUM CONCENTRATIONS
ALL FIELDS



1993, sign linear decrease

Figure 20

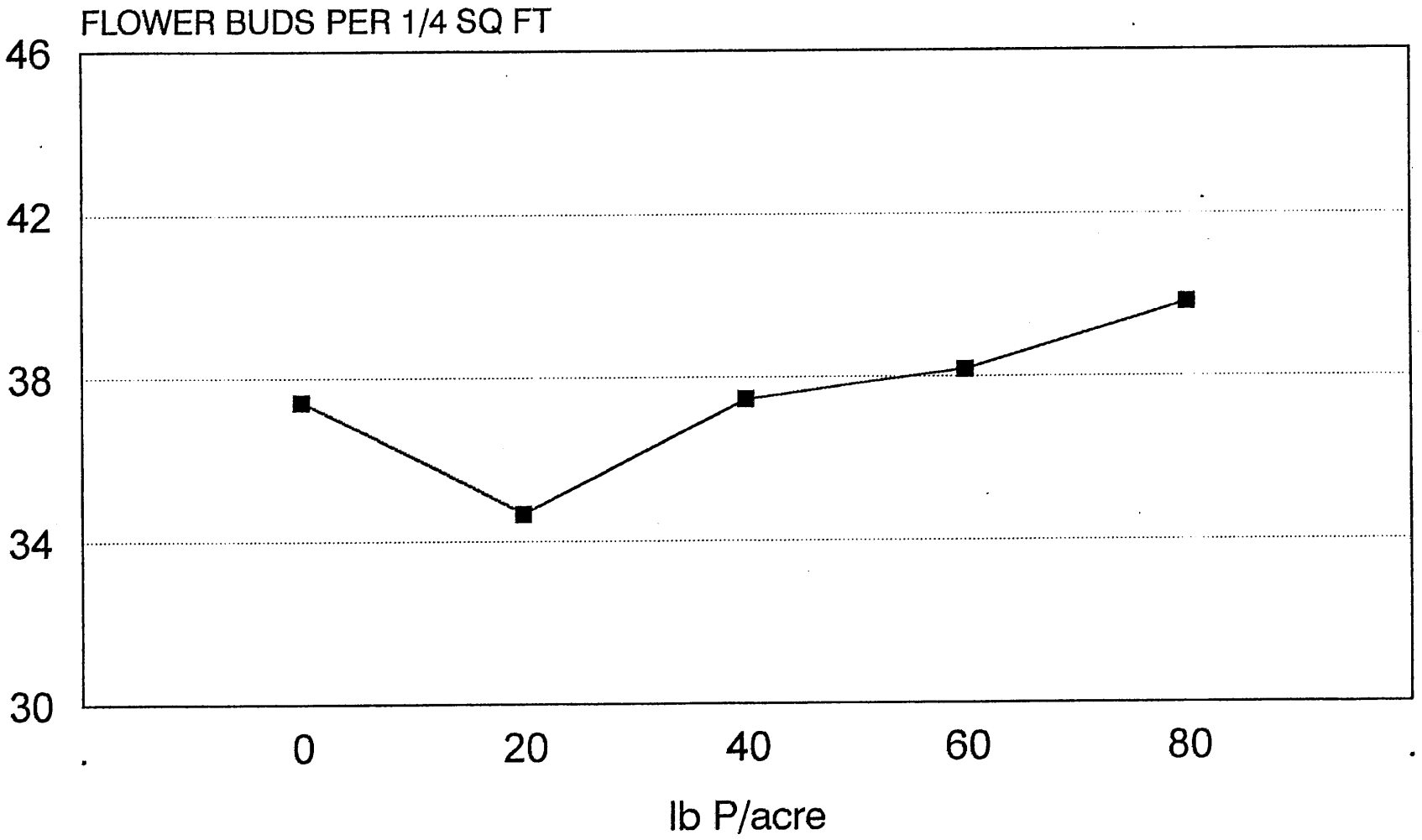
FLOWER BUD FORMATION
ALL FIELDS



1993, significant linear increase

Figure 21

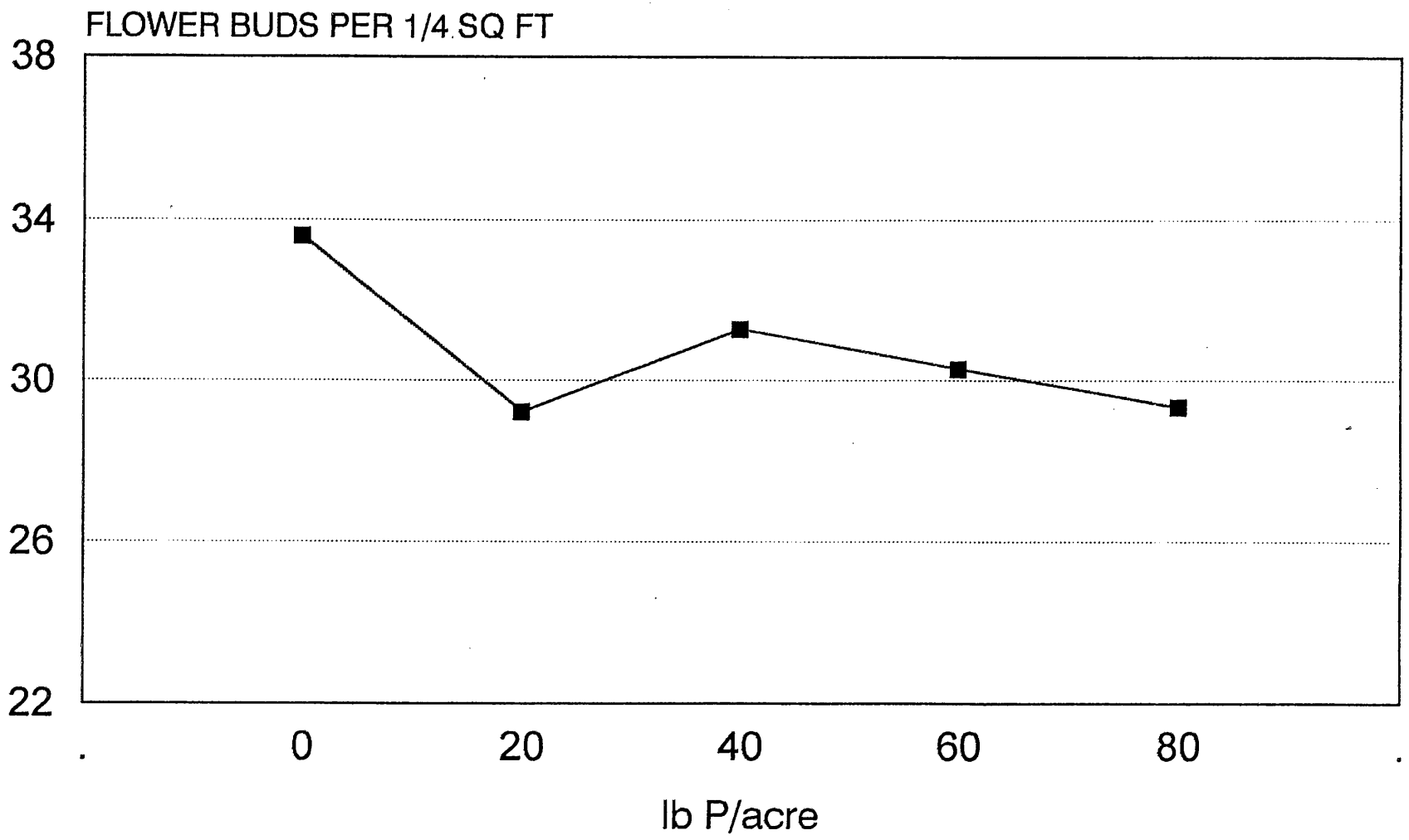
FLOWER BUD FORMATION
ALL FIELDS



1993,L

Figure 22

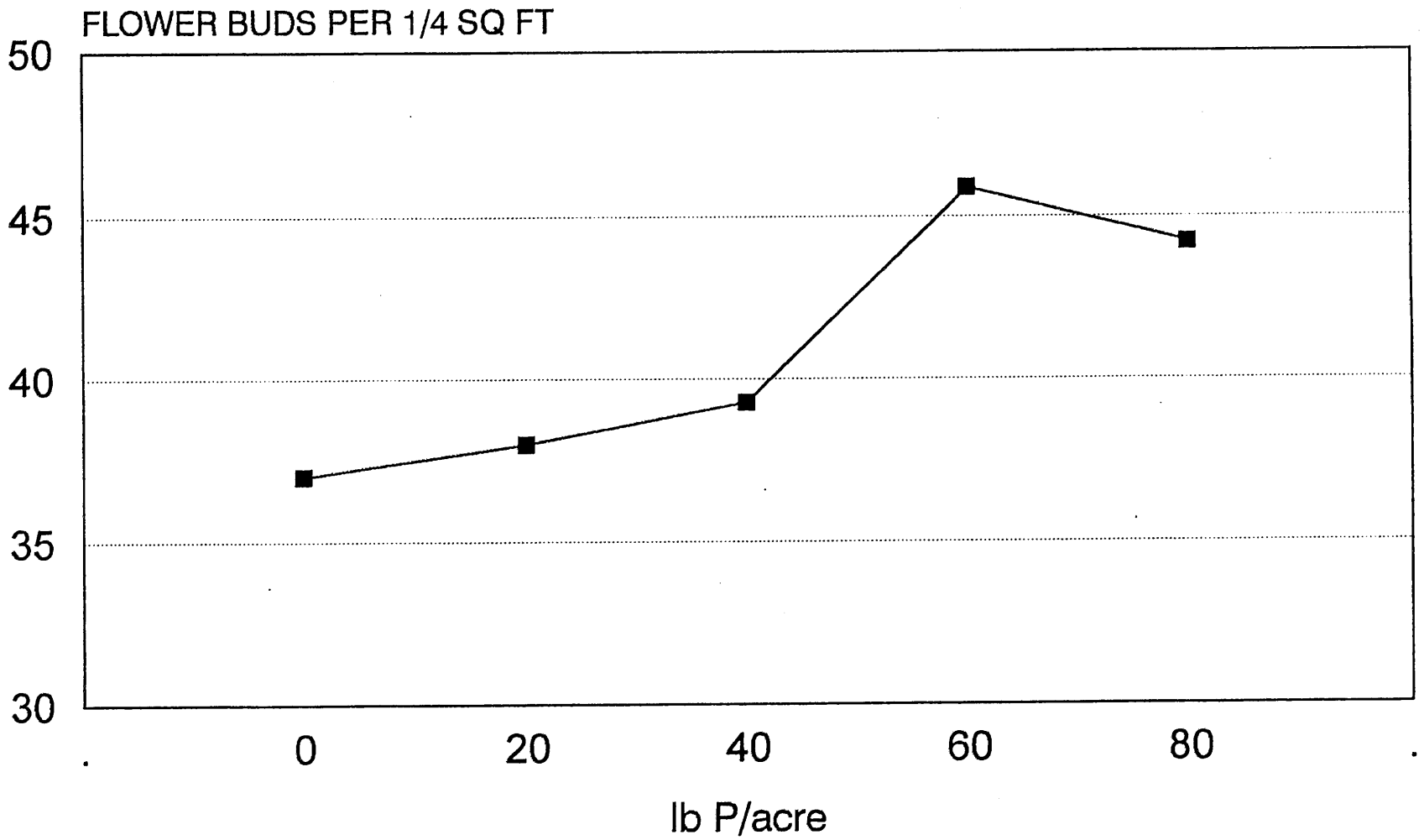
FLOWER BUD FORMATION
HIGH P FIELDS



1993, NS

Figure 23

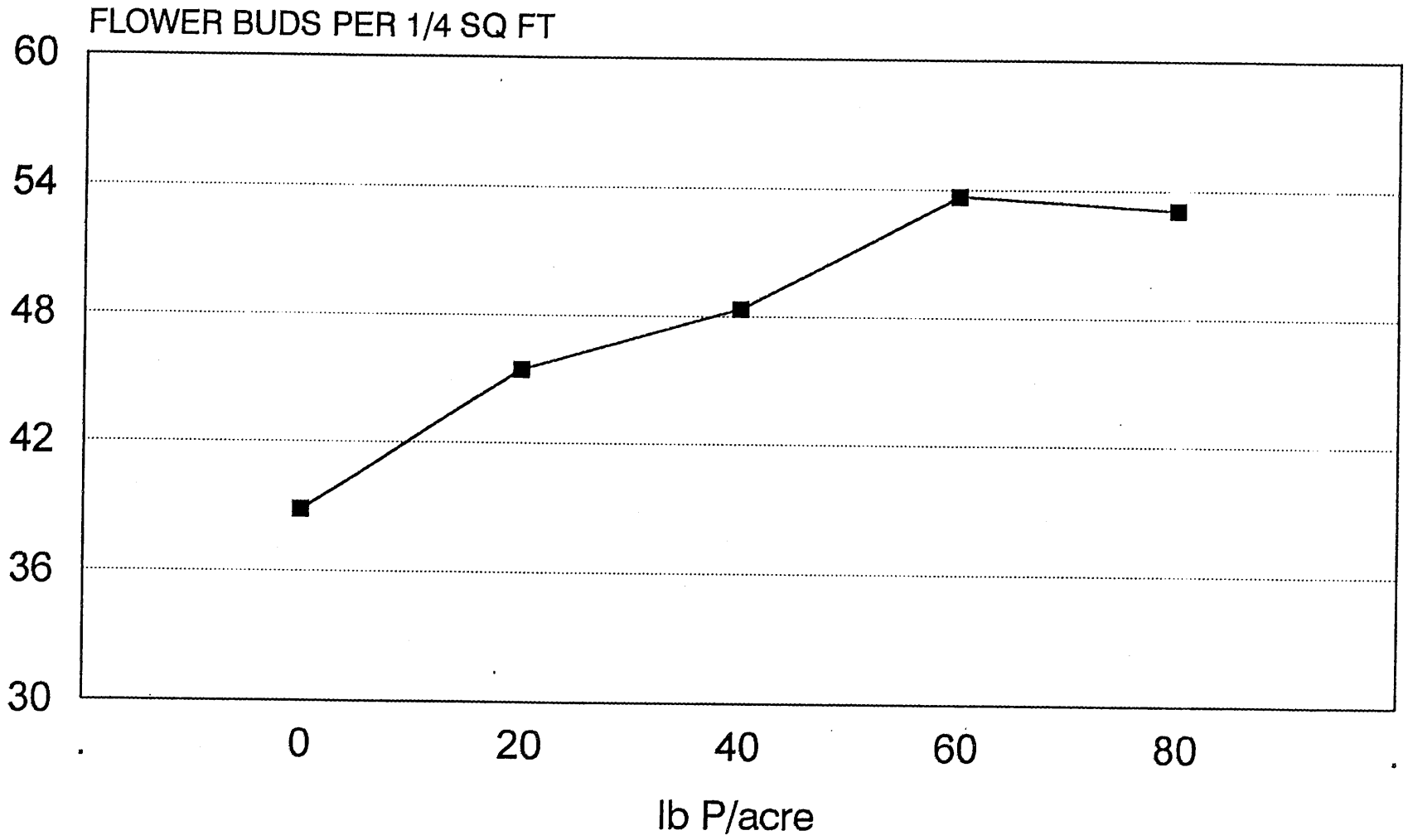
FLOWER BUD FORMATION
LOW P FIELDS



1993, 1%

Figure 24

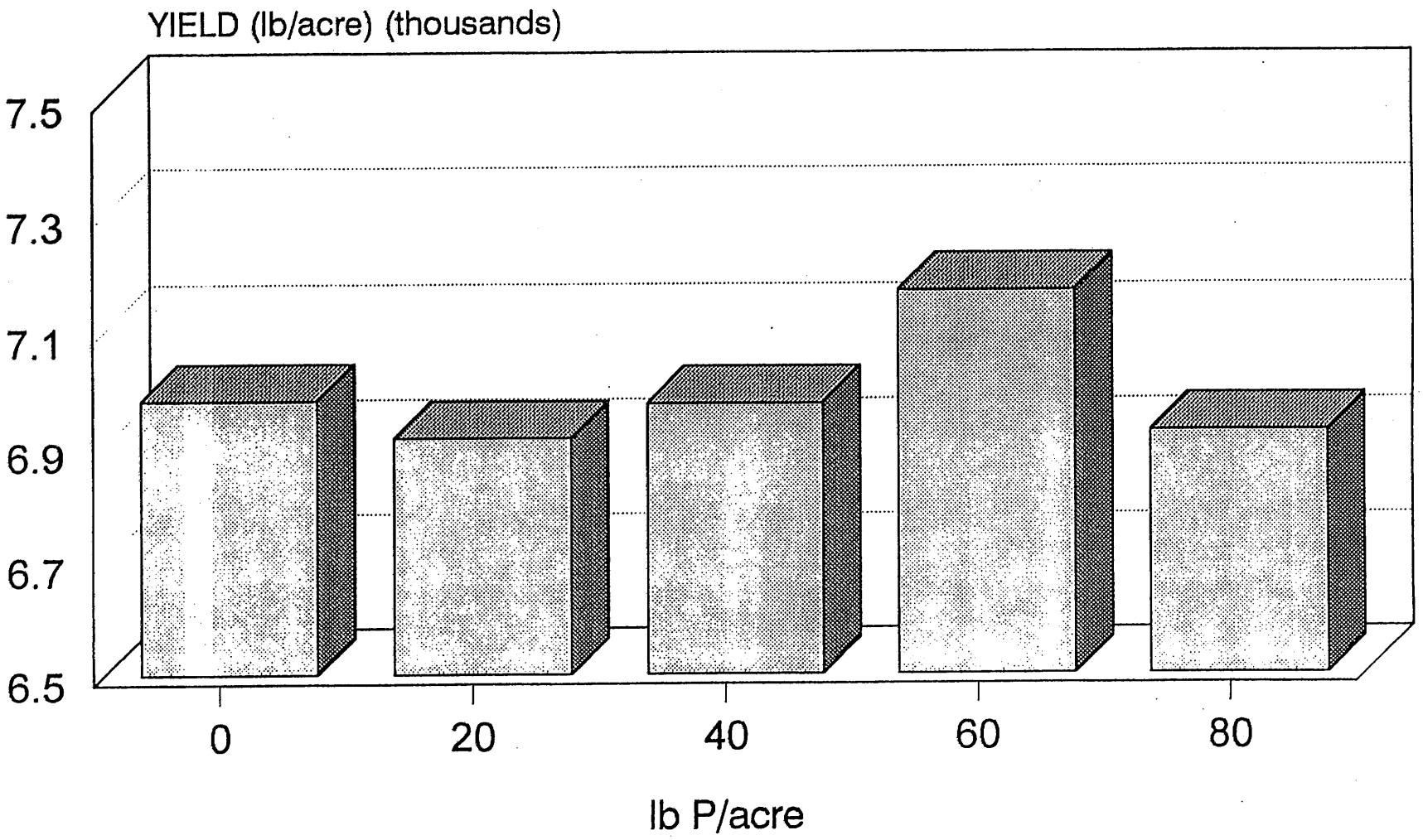
FLOWER BUD FORMATION
AN INDIVIDUAL LOW P FIELD



1993

Figure 25

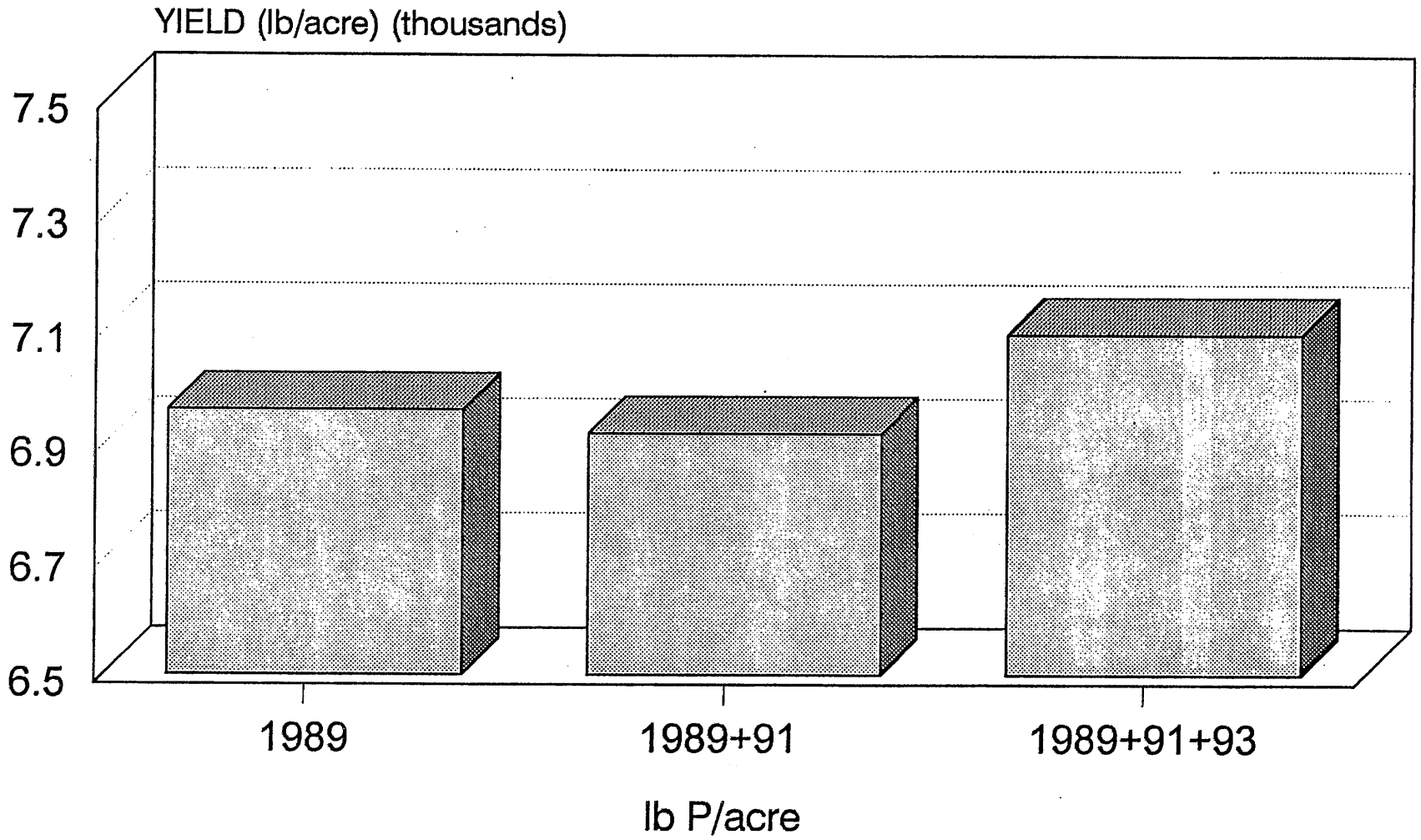
BLUEBERRY YIELD
ALL FIELDS



1994, NS

Figure 26

BLUEBERRY YIELD
ALL FIELDS



1993, NS

INVESTIGATORS: John M. Smagula, Professor of Horticulture
Scott Dunham, Crop Technician
Cooperators: Delmont Emerson, Blueberry Hill Farm Manager
Alfred Bushway, Professor of Food Science

2. TITLE: Multiple Cropping of Wild Stands

METHODS: An experiment to determine the effect of additional management inputs on second year cropping was established at Blueberry Hill Farm in 1990. This six year study assessed the effect of fertility, weed control and water management on improving a second consecutive crop in a three year cycle, compared to a low or no input three year cycle. A two year cropping cycle and a low input three year cropping cycle served as controls and as a basis for comparison.

A split block randomized complete block design with five blocks was used but one block was accidentally mowed and had to be abandoned. Irrigation was split across treatment plots, which allowed a comparison of all two and three year cycles with or without irrigation. Intensive management of 3-yr cycle plots involved yearly weed control and fertilizer application. Fertilization was with N alone (urea, 50 lbN/acre) or NPK (10-10-10, supplying 50 lbN/acre) Leaf tissue analysis, soil analysis, growth characteristic measurements, and berry yield were used to evaluate the effect of treatments.

RESULTS:

IRRIGATION

Irrigation supplemented rainfall to insure 0.5 inches of water every 3 days. Figure one illustrates the effect of irrigating on total amount of water the plots received May through August 1994.

LEAF TISSUE ANALYSIS

The 2-yr cycle plots and the 3-yr cycle plots were in the cropping cycle in 1994. Treatments supplying nitrogen the cropping year raised leaf nitrogen concentrations above the crop year standard (Fig. 2) Leaf phosphorus concentration was raised above the crop year standard on the treatment that supplied phosphorus the crop year (Fig. 3). The treatment supplying potassium the cropping year raised leaf potassium concentration but all treatments were above the crop year standard (Fig. 4). Leaf magnesium concentrations were higher in the 2-year cycle plots compared to all 3-year cycle plots but all plots had concentrations above the crop year standard (Fig. 5). Fertilizing the crop year with urea or NPK resulted in lower leaf calcium concentrations that were at or below the crop year standard (Fig. 6).

SOIL ANALYSIS

Soil samples taken to a depth of three inches from all treatment plots in July 1993 were analyzed for pH, organic matter content and nutrient concentrations. Soil pH was not affected

by any treatments. Soil phosphorus concentrations were significantly higher in the 3-yr cycle plots which received NPK compared to the other treatment plots (Fig. 7). This was expected as this was the only plot to receive phosphorus. Soil potassium concentrations were also highest in the treatments plots which received potassium, the 3-yr cycle NPK plots (Fig 8). Soil organic matter was determined by loss of carbon on ignition (%LOI) and the 3-yr cycle plots receiving urea were significantly lower in soil organic matter (Fig 9). We have no explanation for this.

YIELD

In 1994 all treatment plots were in a cropping cycle; however, the 2-yr cycle was a first crop and the 3-yr cycles were second crops. A 60 ft strip in each plot was harvested with a 15 inches wide metal blueberry rake. There was no effect of irrigation on yield (Fig 10). There was, however, a significant difference among treatments; the 2 yr cycle produced a better crop than all the 3 yr cycles in 1994 (Fig 11).

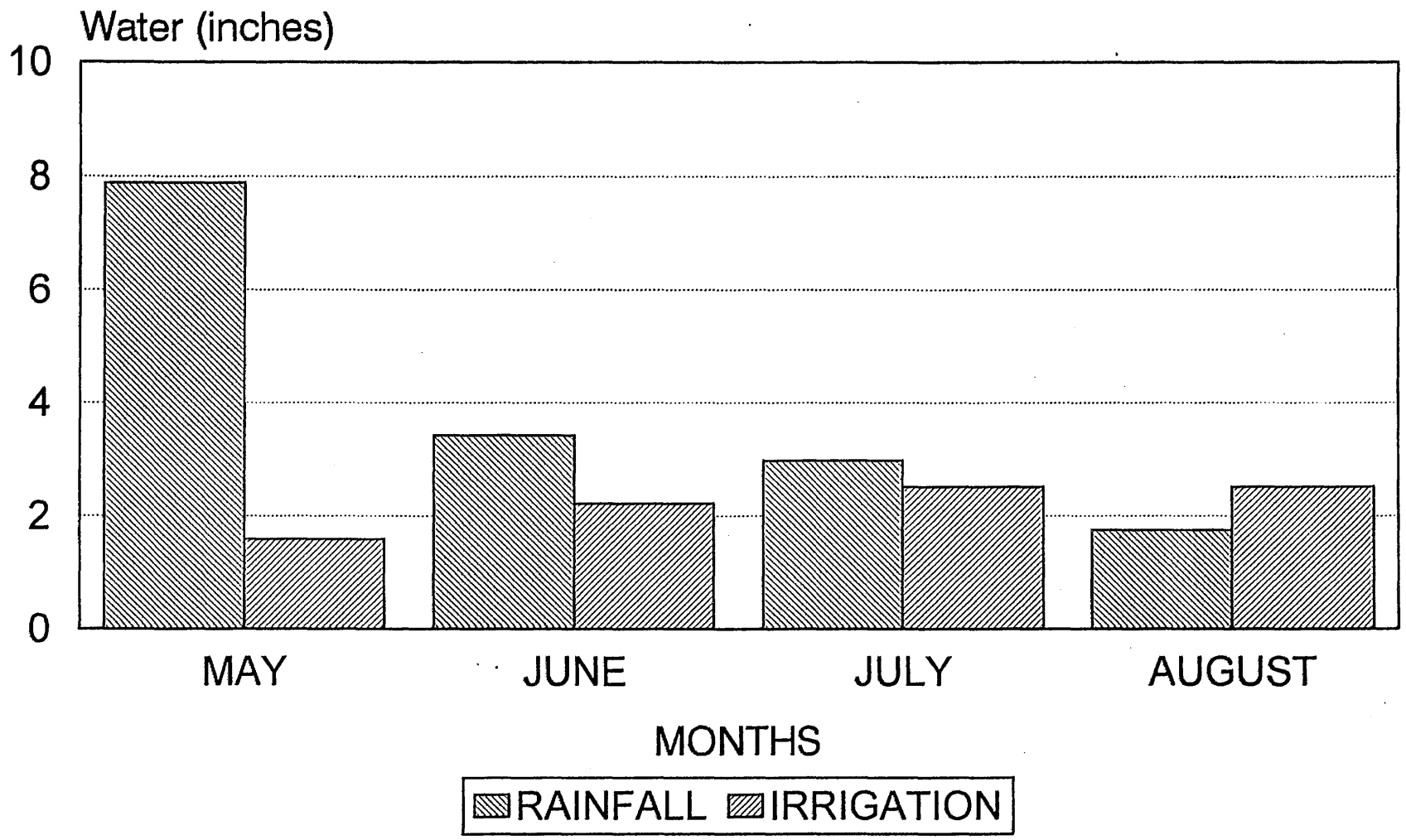
CONCLUSIONS: No conclusions can be made until further analysis of the data such as cumulative yield is completed and economic factors are considered.

RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1

RAINFALL AND IRRIGATION COMPARSION

FOR MAY, JUNE, JULY, AND AUGUST

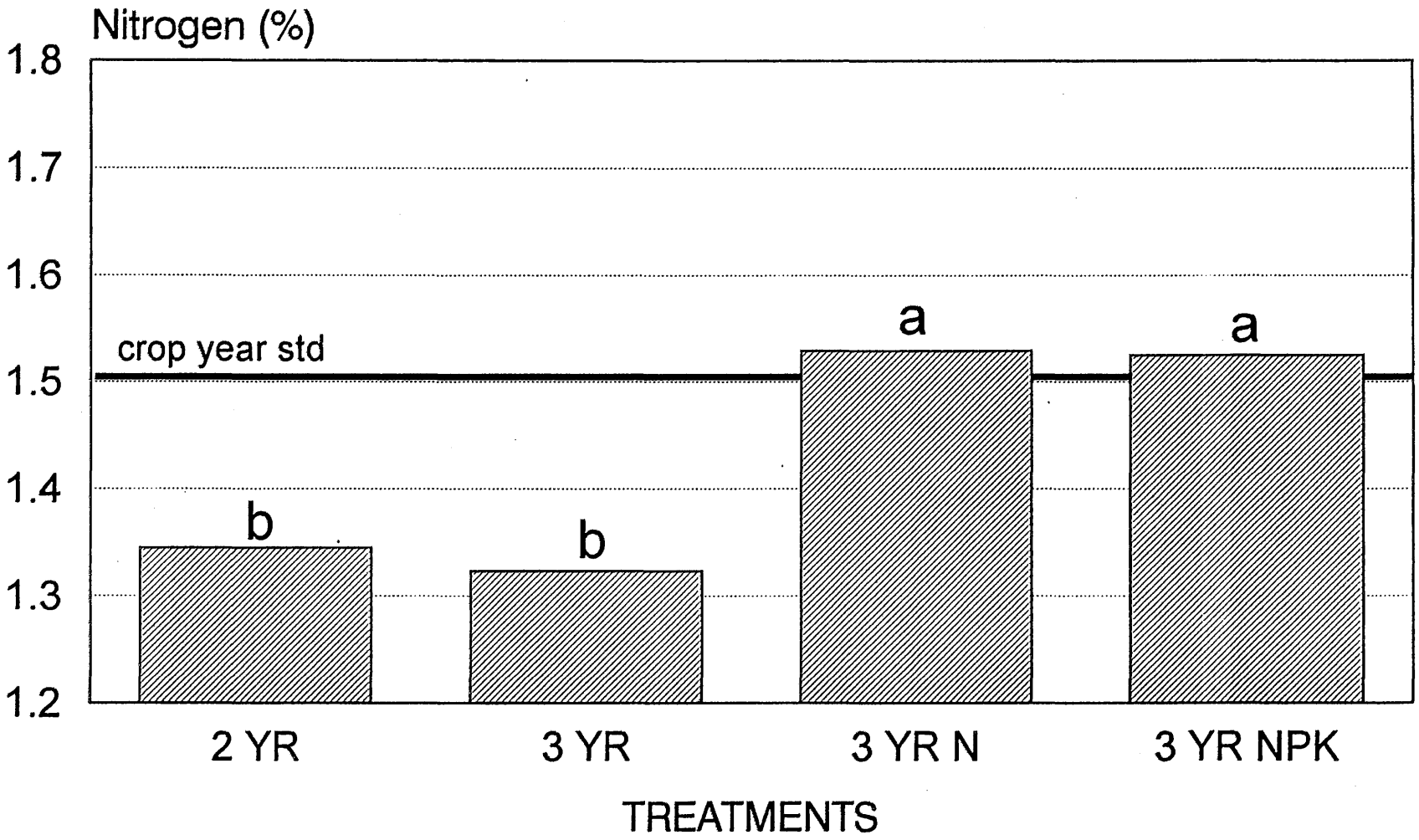


1994

Figure 2

1994 MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON LEAF NITROGEN

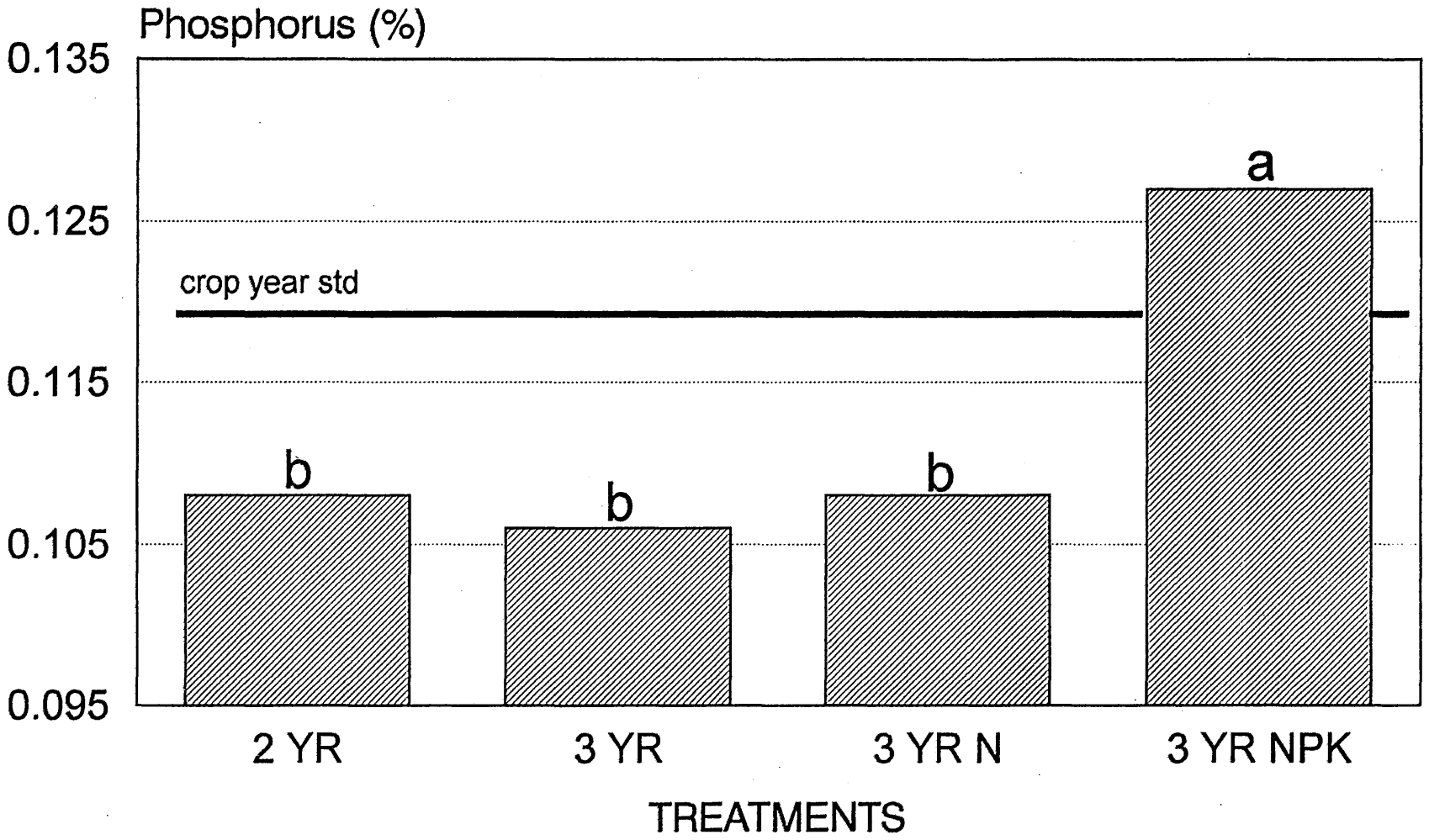


SIGN .01

Figure 3

1994 MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON LEAF PHOSPHORUS

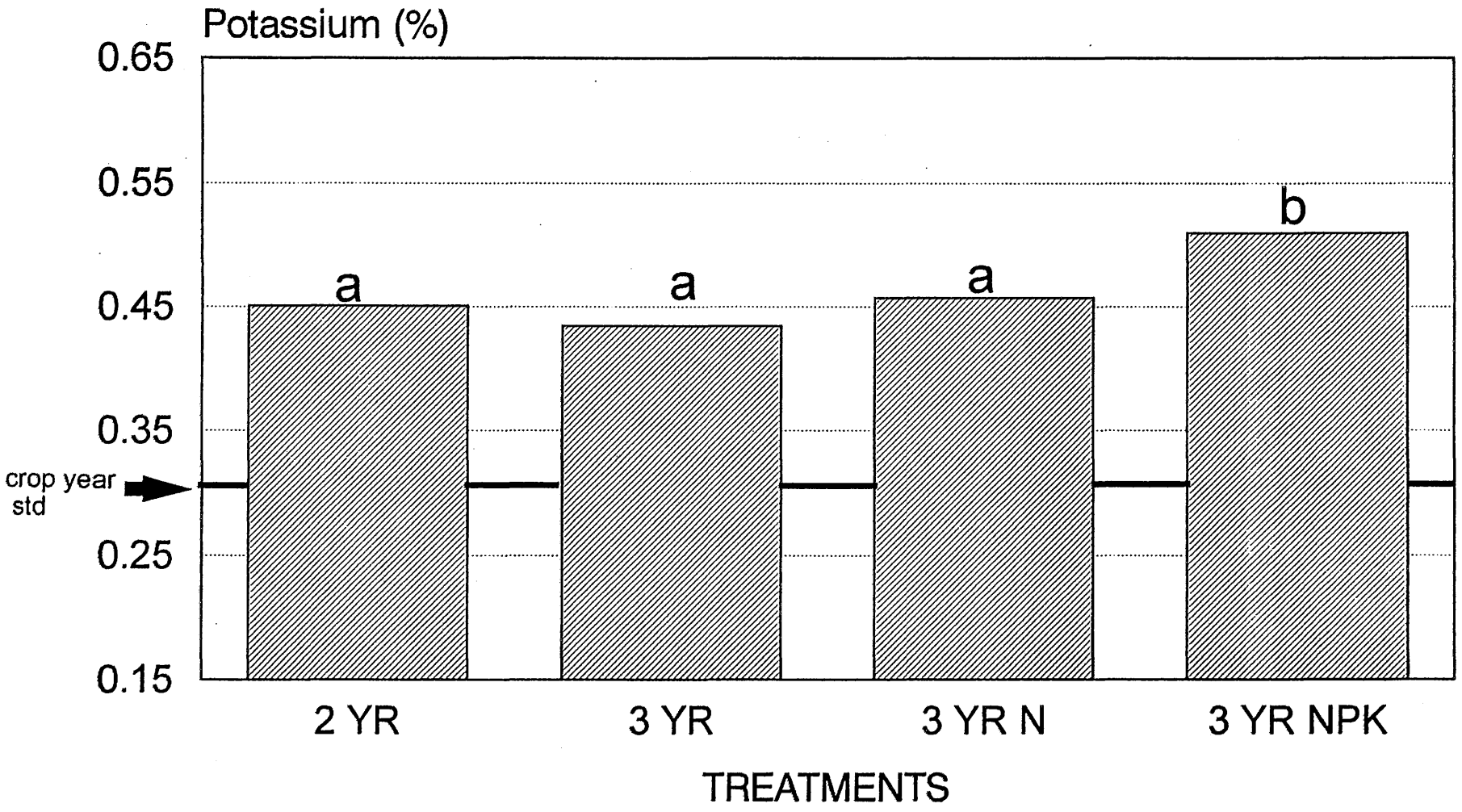


SIGN .05

Figure 4

1994 MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON LEAF POTASSIUM

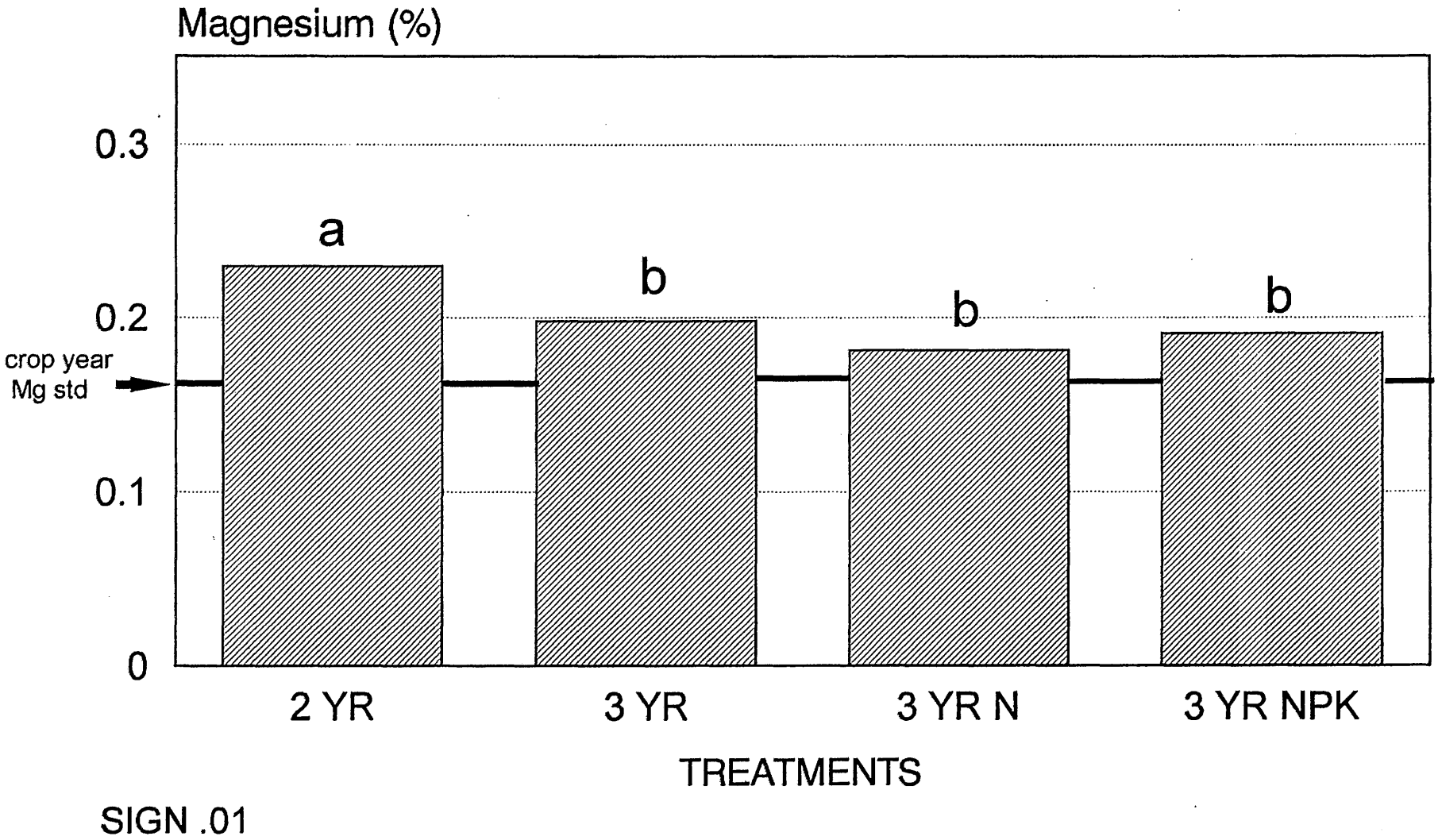


SIGN .05

Figure 5

1994 MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON LEAF MAGNESIUM

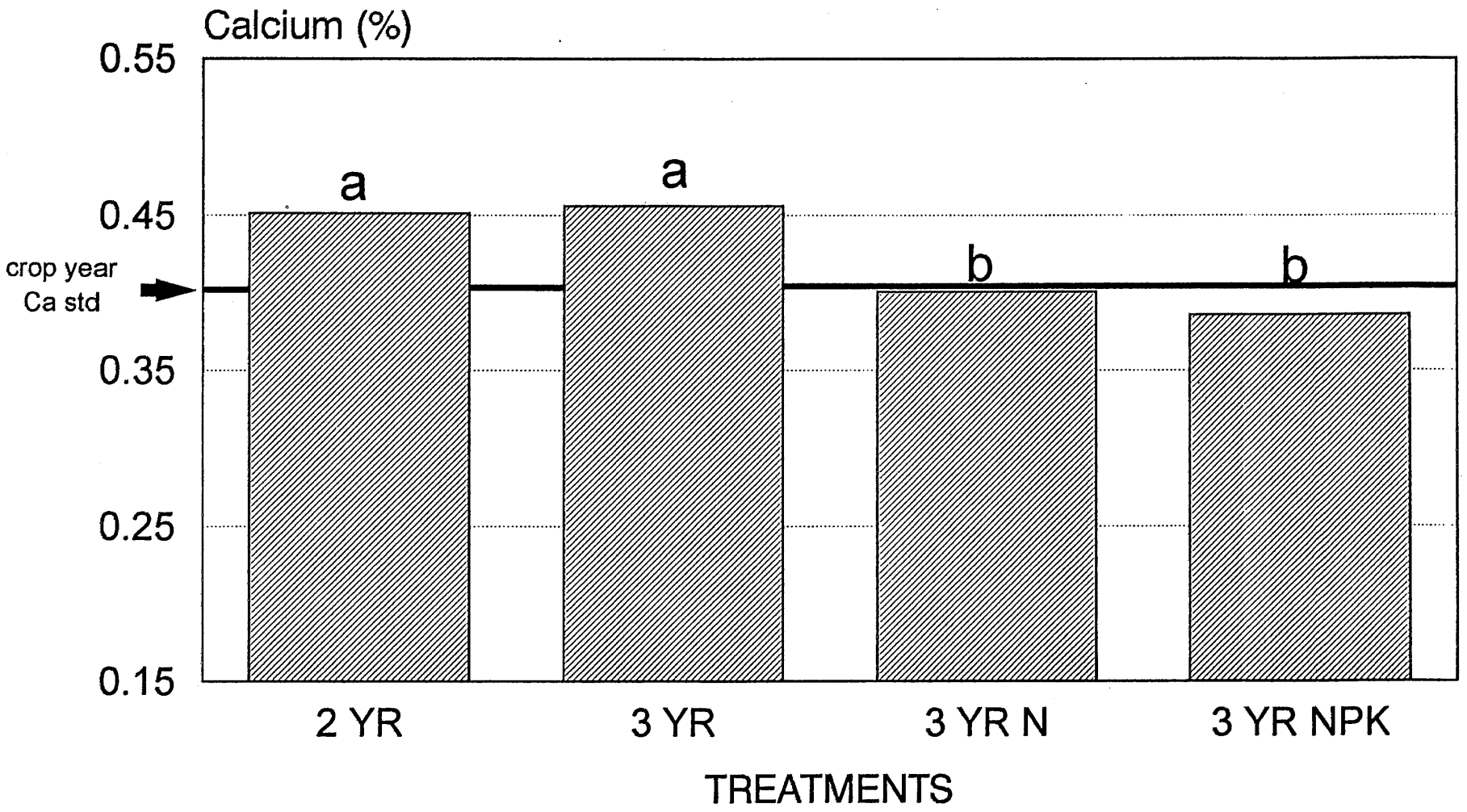


SIGN .01

Figure 6

1994 MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON LEAF CALCIUM

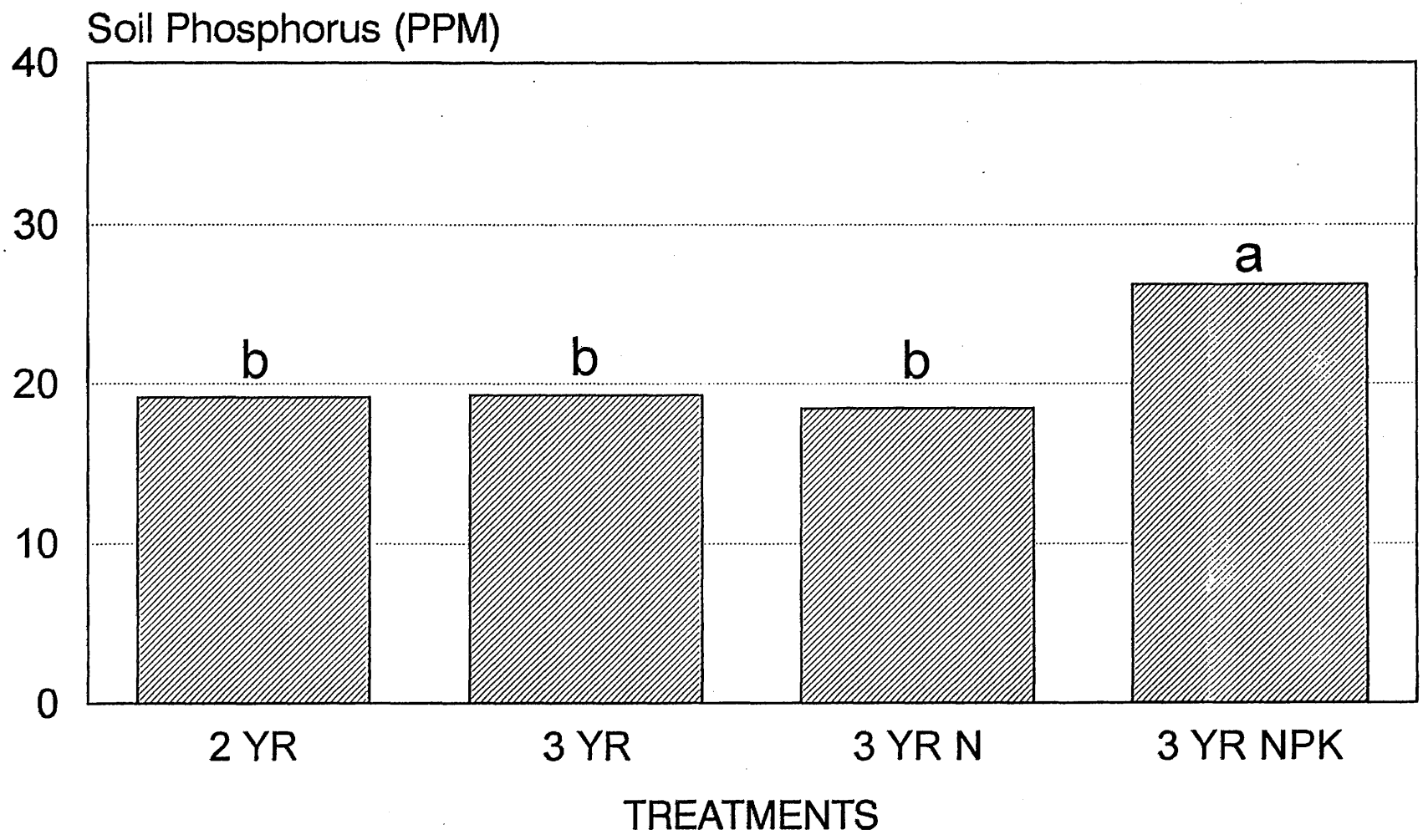


SIGN .05

Figure 7

MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON SOIL PHOSPHORUS



1994, SIGN .05

Figure 8

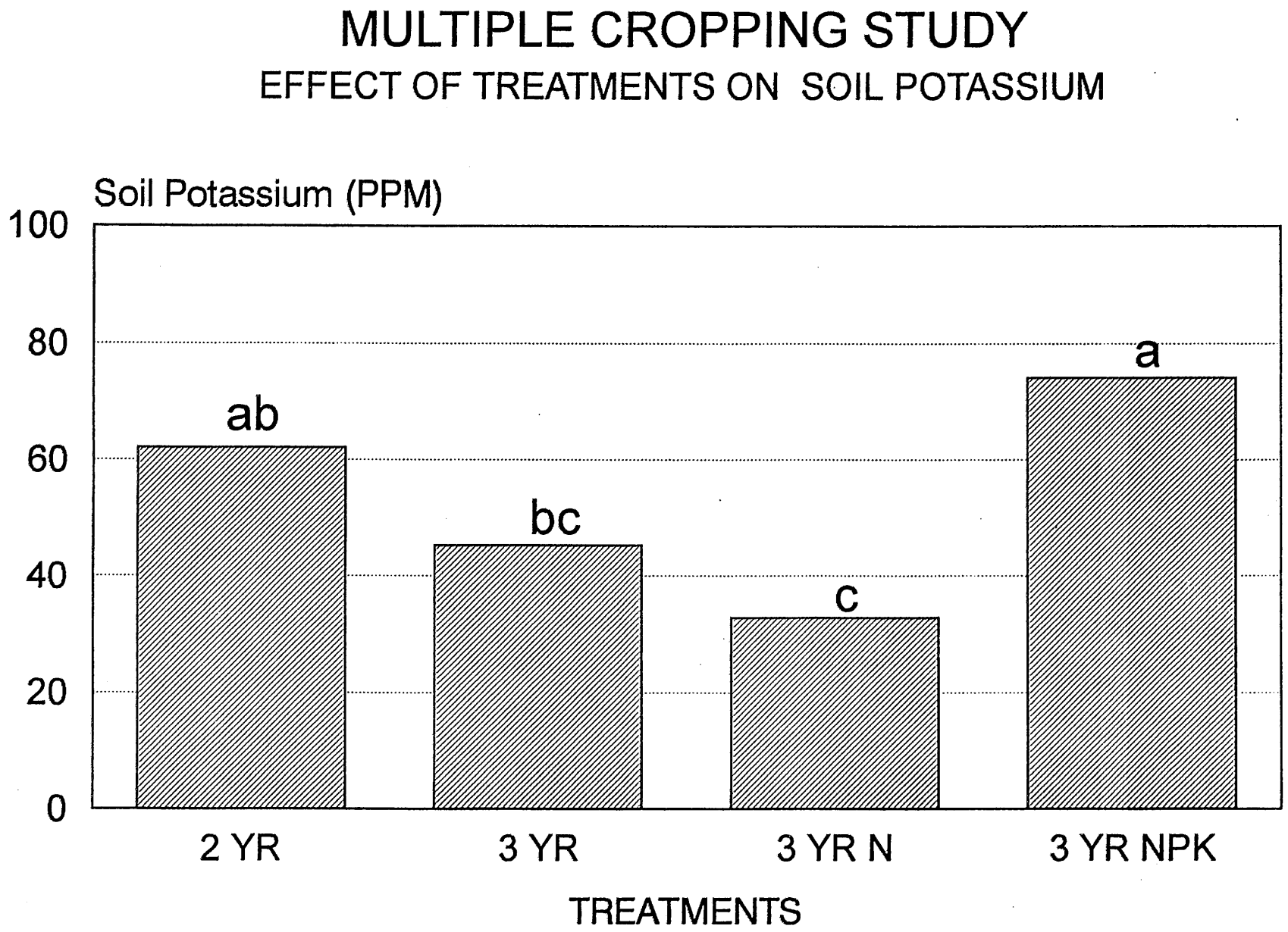
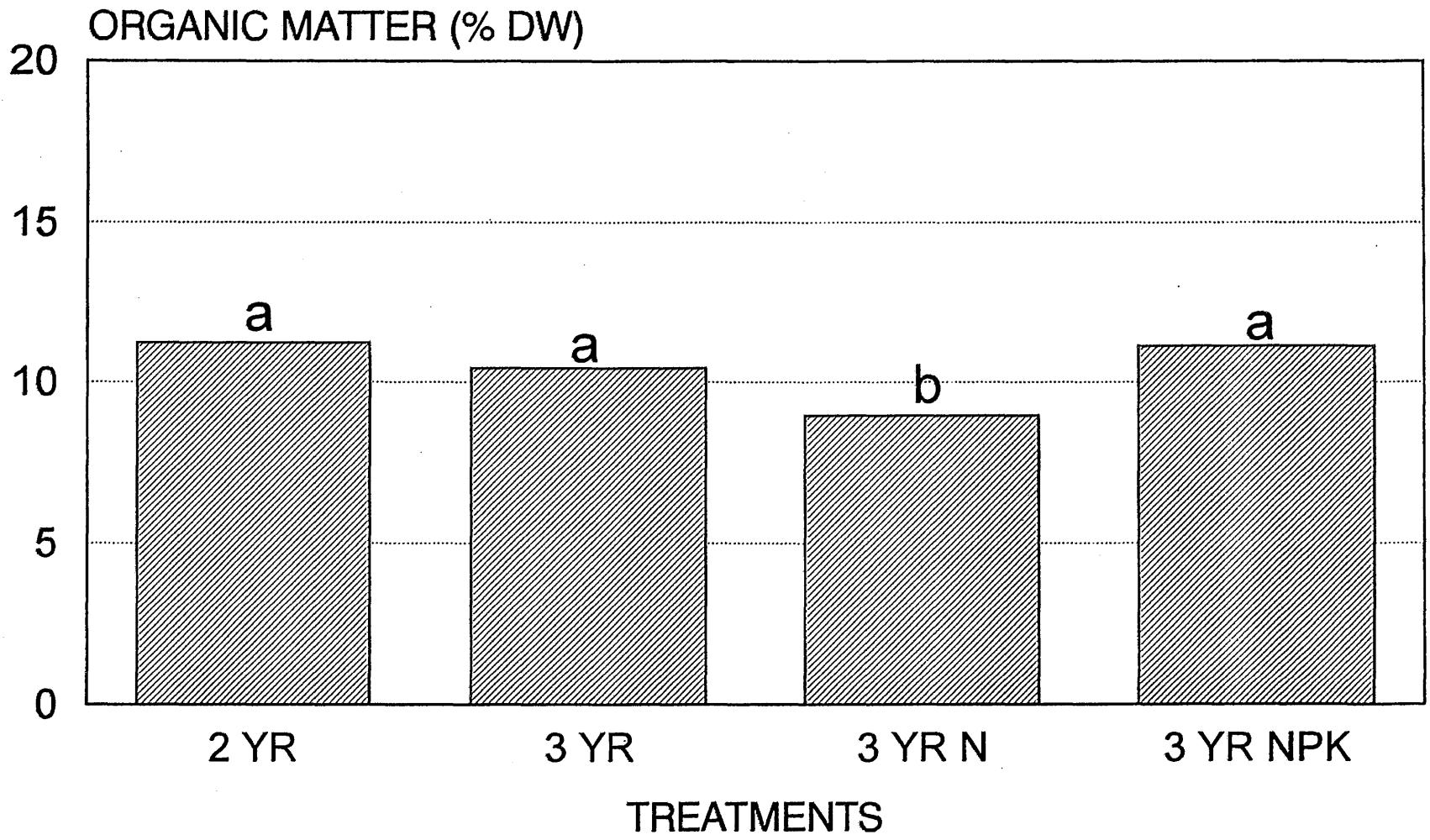

MULTIPLE CROPPING STUDY
EFFECT OF TREATMENTS ON SOIL POTASSIUM
Soil Potassium (PPM)
100
80
60
40
20
0
ab
bc
c
a
2 YR
3 YR
3 YR N
3 YR NPK
TREATMENTS
1994, SIGN .05

Figure 9

MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON SOIL ORGANIC MATTER

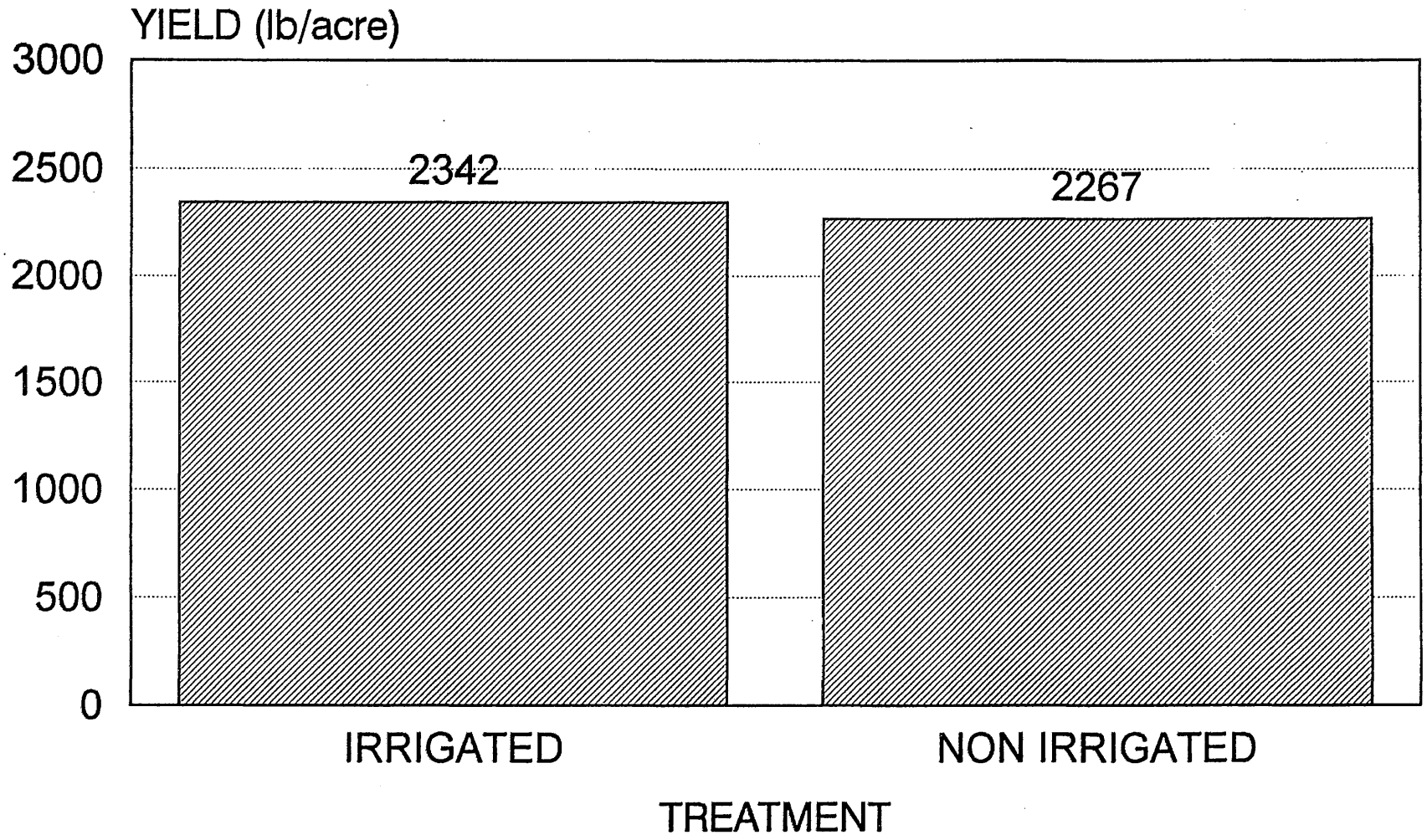


1994, SIGN .05

Figure 10

MULTIPLE CROPPING STUDY

EFFECT OF IRRIGATION ON YIELD

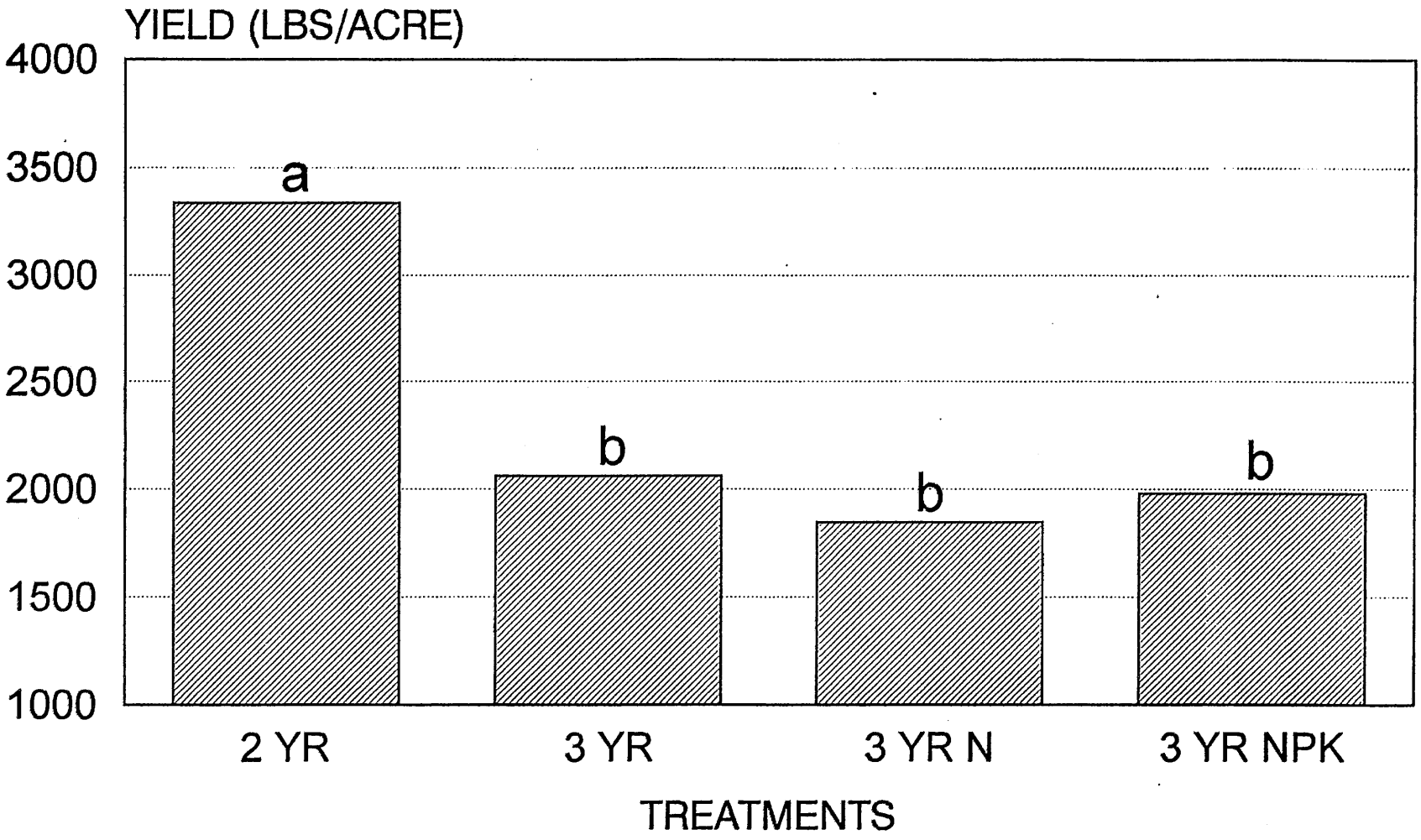


1994, no significant difference

Figure 11

MULTIPLE CROPPING STUDY

EFFECT OF TREATMENT ON YIELD



1994, SIGN .05

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

3. TITLE: Effect of Soil pH on Nutrient Uptake

METHODS: An experiment to determine the effect of soil pH adjustment on nutrient uptake, plant growth, and yield was established at two locations this in 1994. Eight clones were selected at a field in Lamoine that had shown a history of low soil pH and 8 clones were also chosen at a field in East Machias with a history of high soil pH. Within each clone two 4 ft x 8 ft plots were established. One of these plots will be a control while the other plot will have the pH adjusted in the spring of 1995 with lime or sulphur. Nutrients will be monitored by leaf tissue analysis and soil analysis. Yield data will also be recorded.

RESULTS: Yield of the two 4 ft x 8 ft plots within each clone was taken August 1994 before the treatments were assigned. The yield data shows that some of the adjacent 4 x 8 ft plots within a clone were very similar while others showed differences (Figs. 1&2). Covariance analysis can be used to adjust the yields of differing treatments plots within a clone to better show the true effects of treatments.

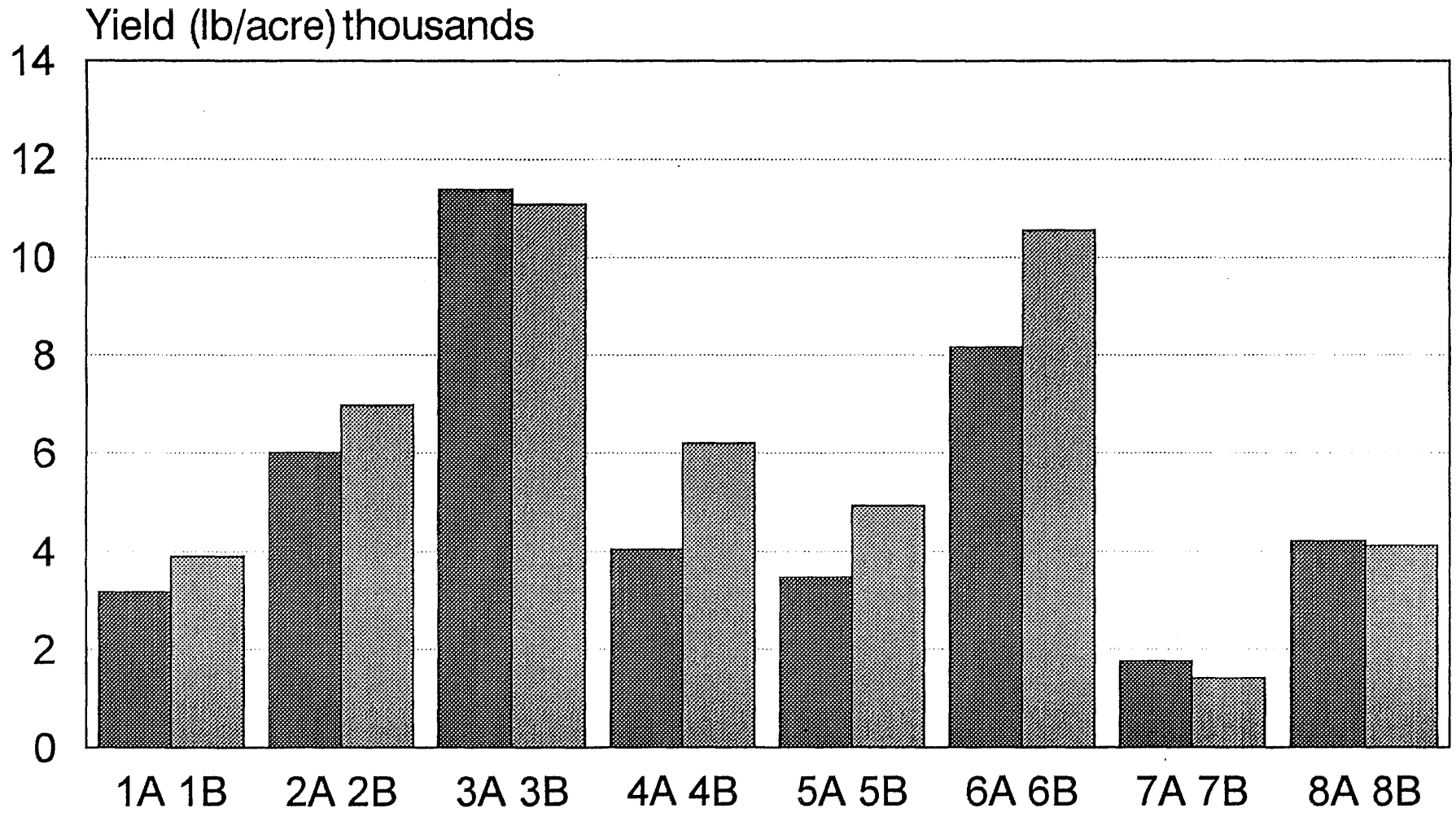
CONCLUSIONS: No conclusions can be made at this time.

RECOMMENDATIONS: No recommendations can made at this time.

Figure 1

SOIL pH STUDY

PRE-TREATMENT YIELD - LOW pH FIELD

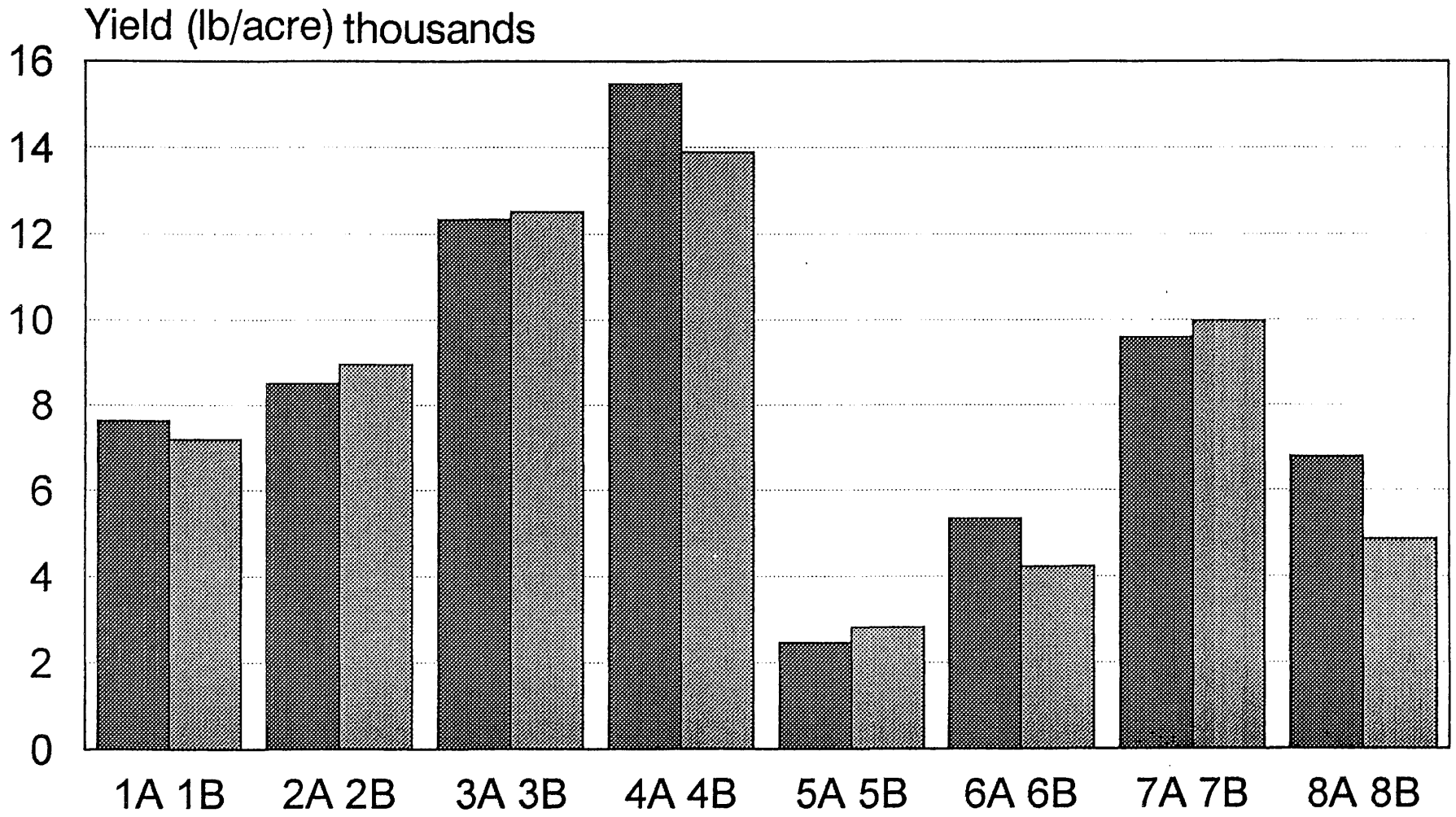


1a and 1b are treatment plots in clone 1.

Figure 2

SOIL pH STUDY

PRE-TREATMENT YIELD - HIGH pH FIELD



1a and 1b are treatment plots in clone1.

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

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

STUDY I - 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*) 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 plugs were taken from each of these strips, placed in 5 inch standard plastic pots, transported to the university cold storage facility and stored at 37°F for 1,000 hours to satisfy the flower bud dormancy requirement. In

March, the potted sod plugs 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 plugs 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 the number of pollen grains transferred (15). 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 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 for the two remaining clones, stems with only three flower buds were chosen in these clones. 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. Data currently being collected on these samples include: fruit number, fruit set (number of fruit/total number of blossoms), fruit diameter, fruit weight, and fruit color.

SEED COUNT

Successful pollination leads to fertilization of the egg cell in the ovary of the flower and the development of seeds. 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 will be extracted from fruit that developed at the third bud. Preliminary studies indicated that seed number and size distribution is similar among fruits from all buds. For practical reasons ten randomly selected stems from each treatment plot will be evaluated. Extraction will be on an individual berry basis so correlations can be made between berry weight and diameter and seed number and seed size.

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. 5). 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). We have no explanation for a negative response rather than a lack of response (no increase but no decrease). Perhaps a clearer picture of how the treatments would have influenced yields without winter injury will be seen by looking at the weight of fruit produced per stem, since only stems without winter injury were tagged.

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 6).

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, including boron and calcium. Boron concentrations were raised in fruit samples from treatment plots receiving foliar boron and calcium application (Fig. 7), but fruit calcium concentrations were unaffected by treatments supplying calcium.

Titratable 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 titratable acidity. There was no effect of any treatment on fruit acidity (titratable acidity)

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 was not affected by treatments.

Sugar/Acid Ratio

The sugar/acid ratio was measured by dividing soluble solids by titratable 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.

pH

A pH meter was used to determine the pH of blended blueberry samples. Fruit pH was not meaningfully effected by treatments.

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 flower buds) were analyzed for boron concentrations. The source of boron had no effect on stem/bud tissue boron concentrations (Fig. 8).

The leaf boron concentrations before treatment and the stem boron concentrations after treatment for each clone is illustrated in figure 9.

Experiment 2 - boron plus calcium sources

Stems samples from treatment plots receiving two sources of a combination of boron and calcium had comparable concentrations of boron and calcium (Fig. 10). The variation among clones of leaf boron concentrations before treatment and the concentrations in stem tissue after treatment is presented in figure 11.

BLOSSOM/FRUIT CHARACTERISTICS:

Twenty stems in each treatment plot were tagged in April 1994. To eliminate differences due to number of flower buds per stem, stems with four flower buds were tagged in five clones and stems with two flower 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. This data has not been compiled or analyzed yet.

YIELD:

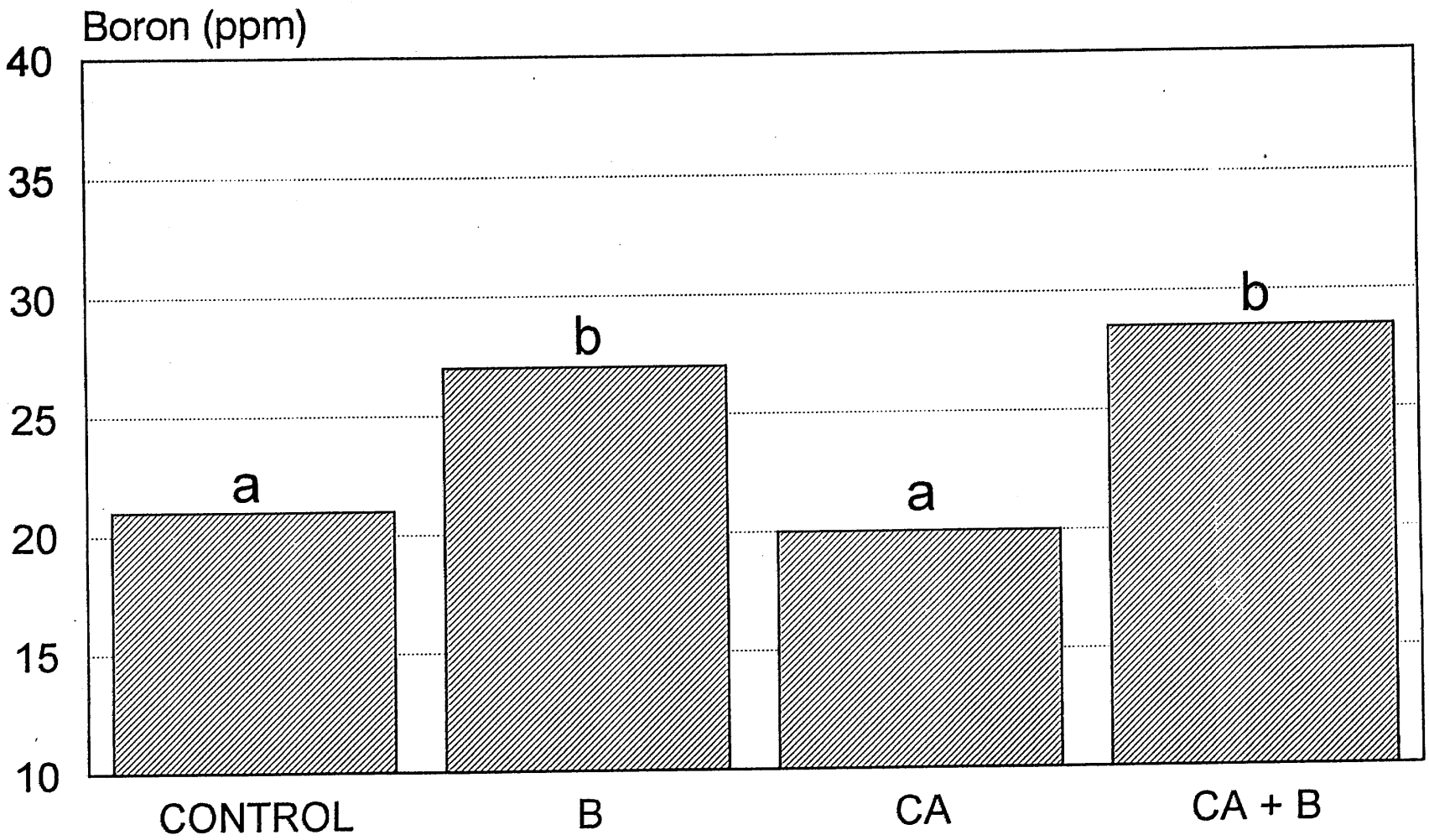
Yield of treatment plots is illustrated in figure 12. There was no significant differences among sources of boron or sources of boron plus calcium on yield. It appears that the treatments providing only boron had higher average yields for the six clones in this study, however, due to the experimental design used (paired plots) the plots receiving boron can not be statistically compared to the plots receiving boron plus calcium. Yield will also be assessed on the basis of fruit weight per stem when this data becomes available.

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

RECOMMENDATIONS: No recommendations can be made at this time.

Figure 1

1994 BORON STUDY
STEM TIP BORON CONCENTRATION

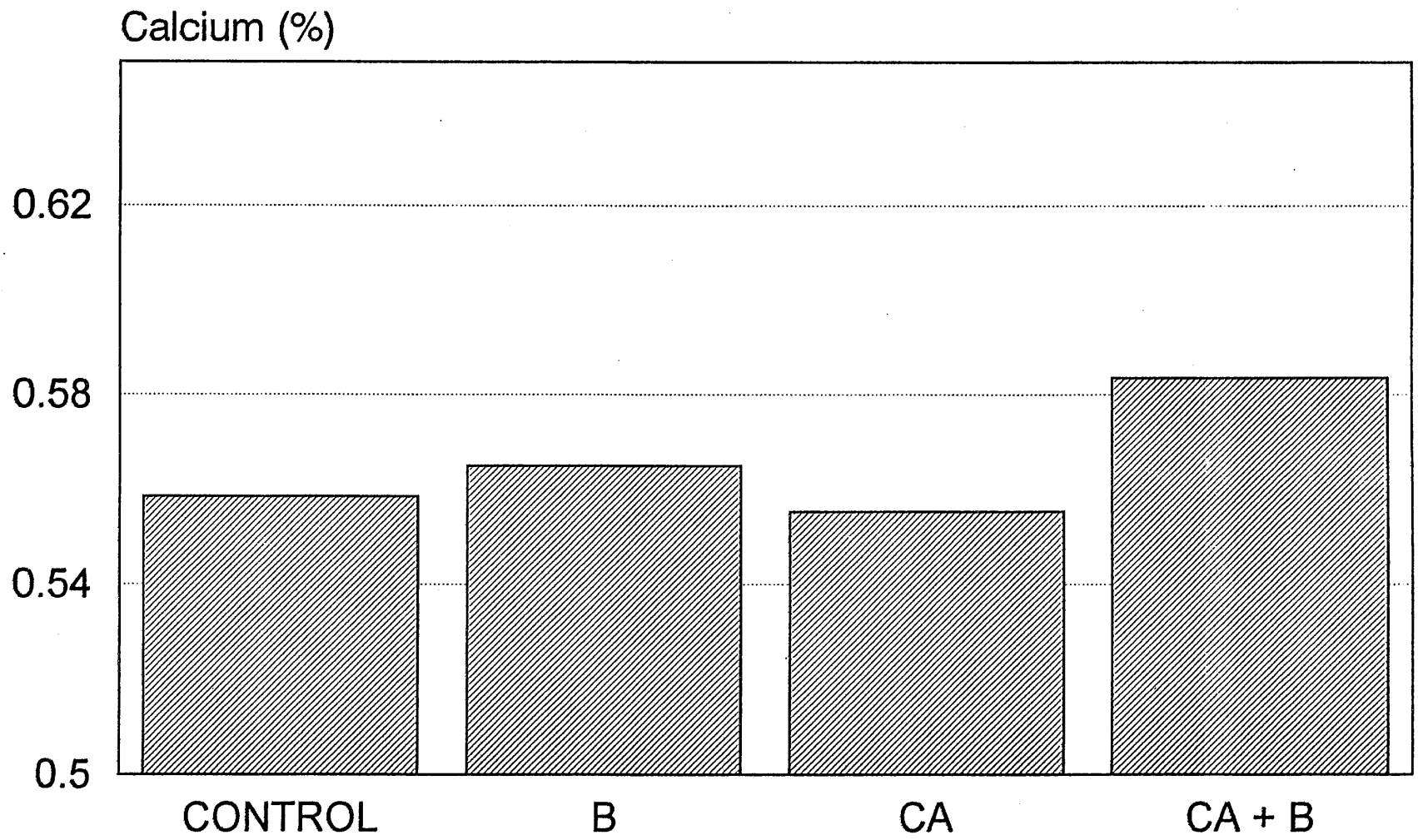


SIGN .01

Figure 2

1994 BORON STUDY

STEM TIP CALCIUM CONCENTRATION

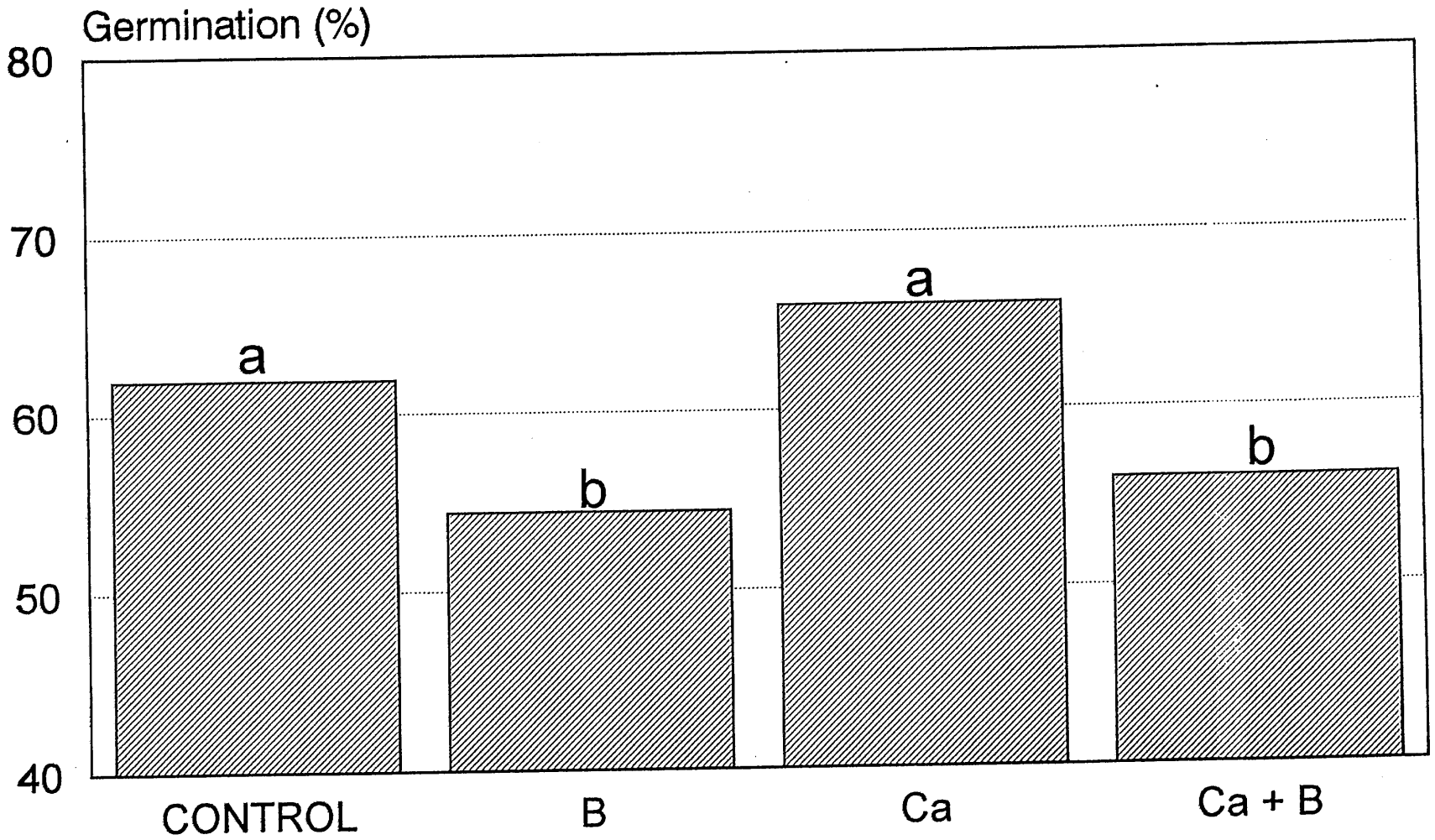


NS, treatments not significantly different at 5% level.

Figure 3

1994 BORON STUDY

POLLEN GERMINATION in vitro*

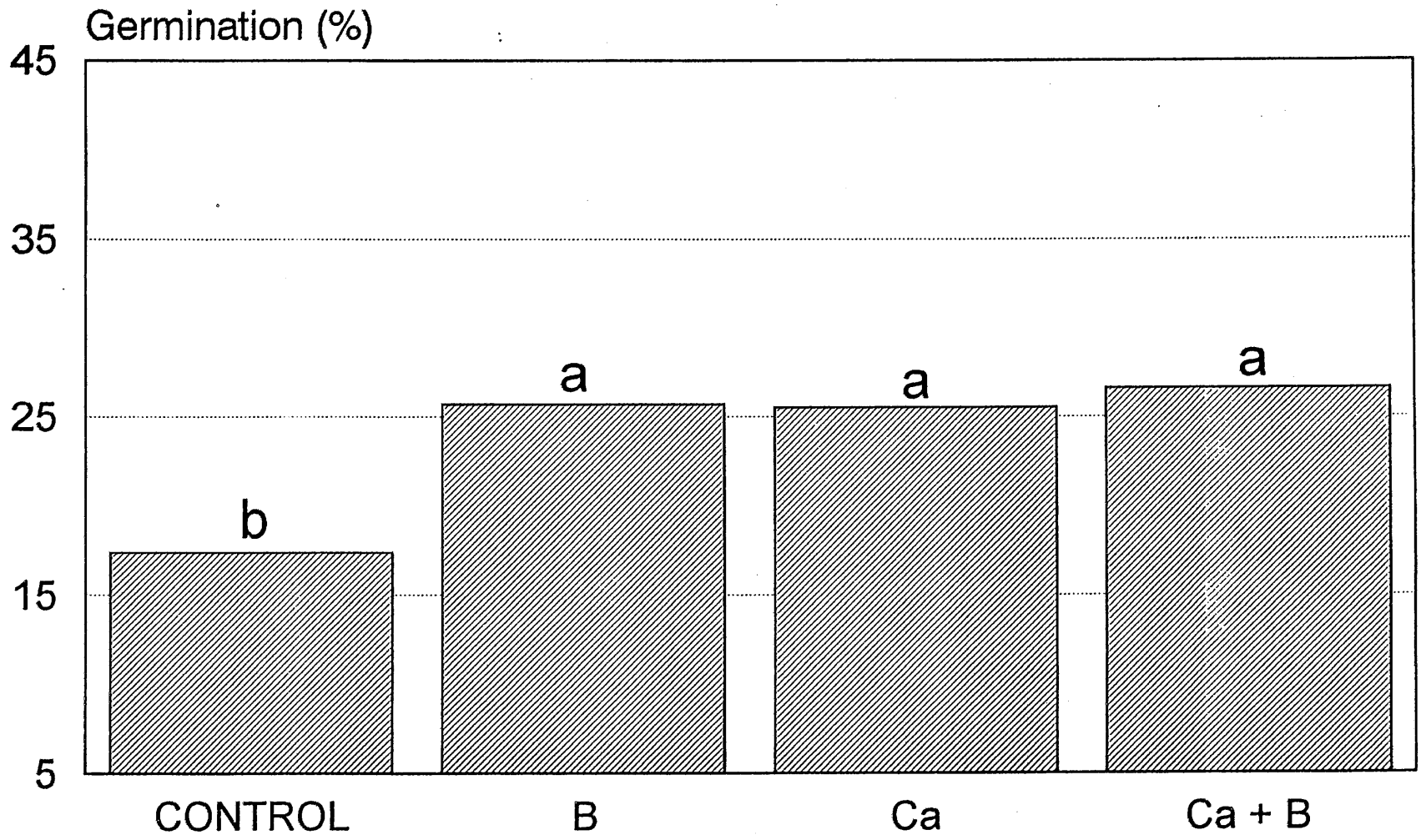


* Pollen germinated on agar
SIGN 1%

Figure 4

1994 BORON STUDY

POLLEN GERMINATION in vivo*



* pollen germinated on flower stigma,
SIGN 5%

Figure 5

1994 BORON STUDY
YIELD

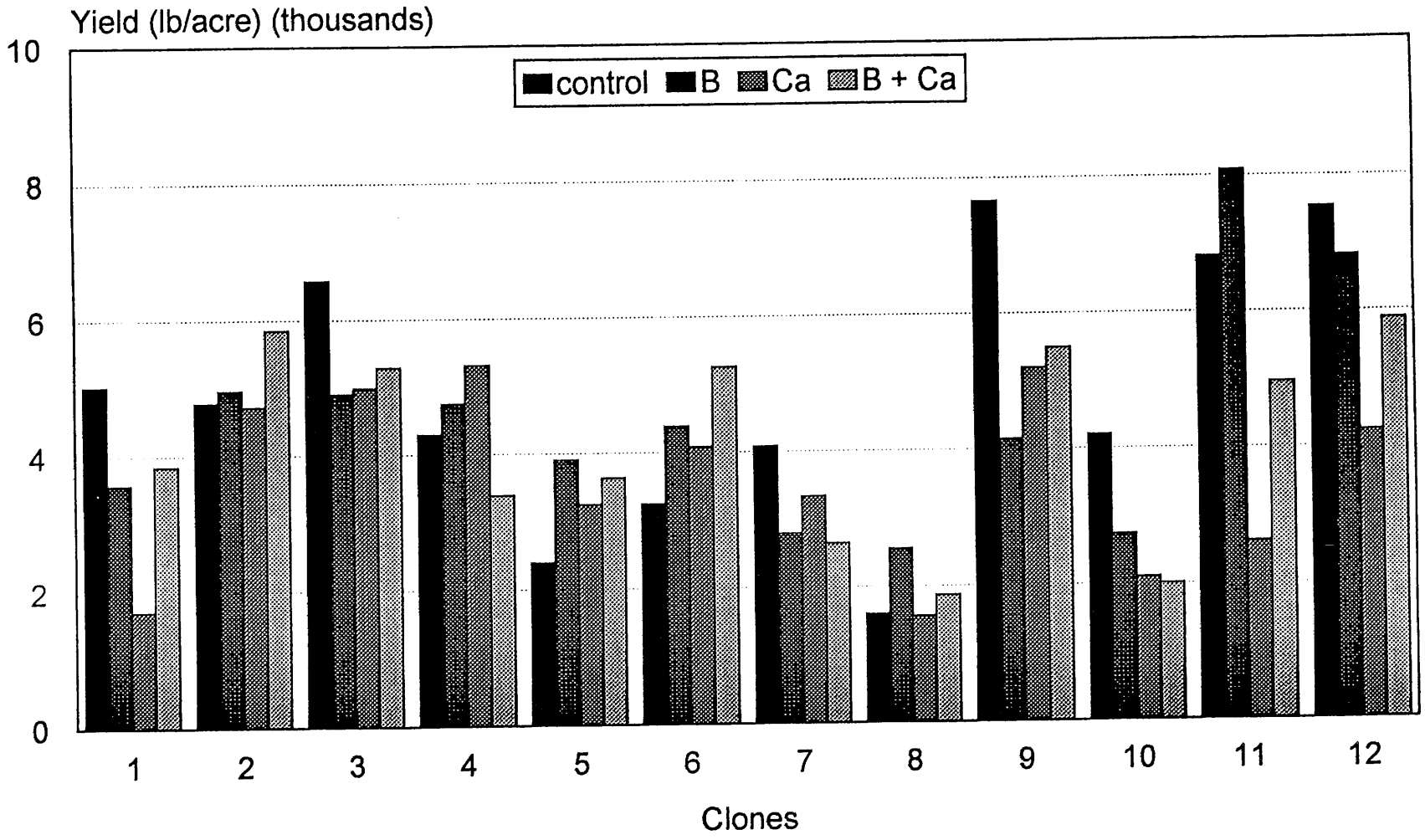
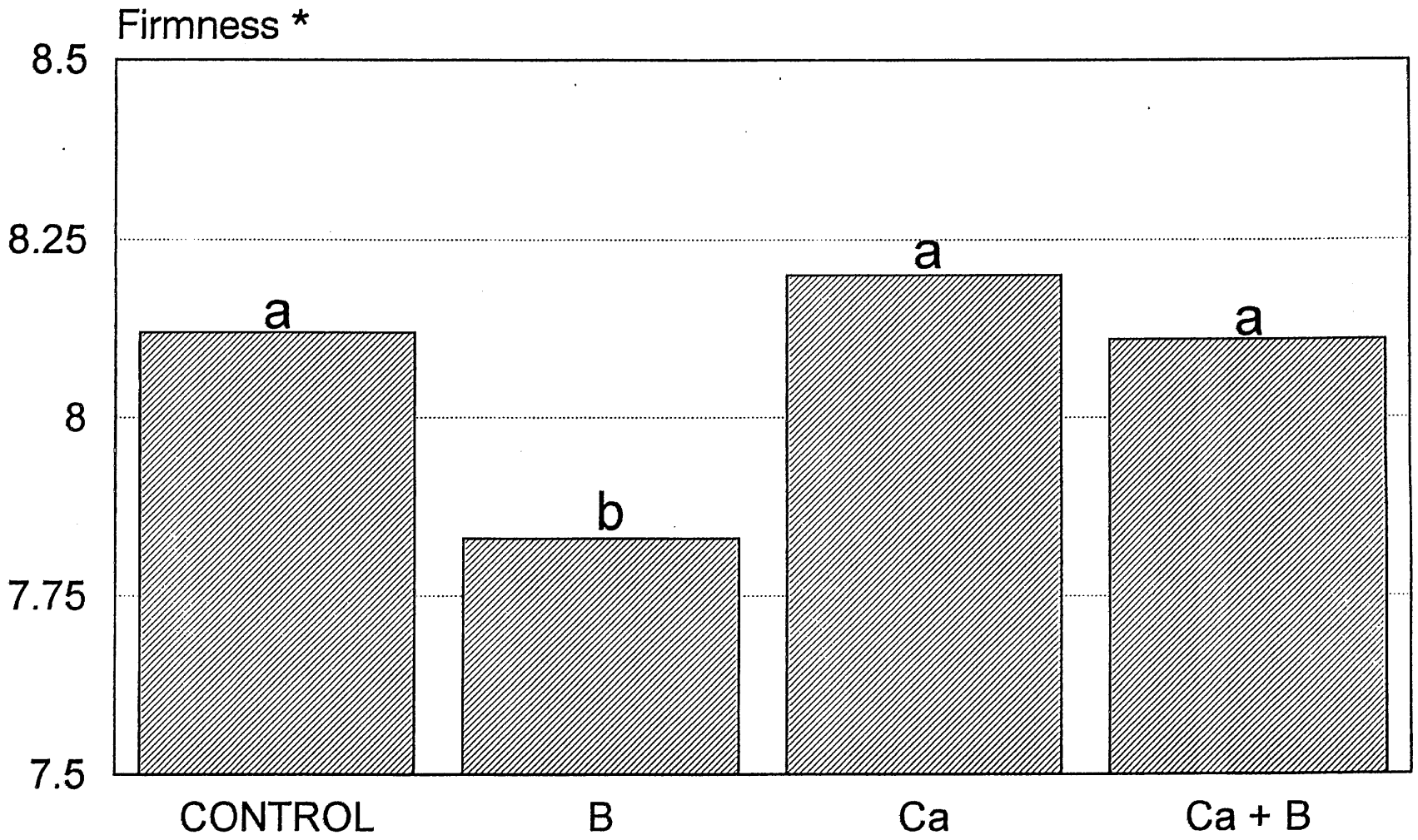


Figure 6

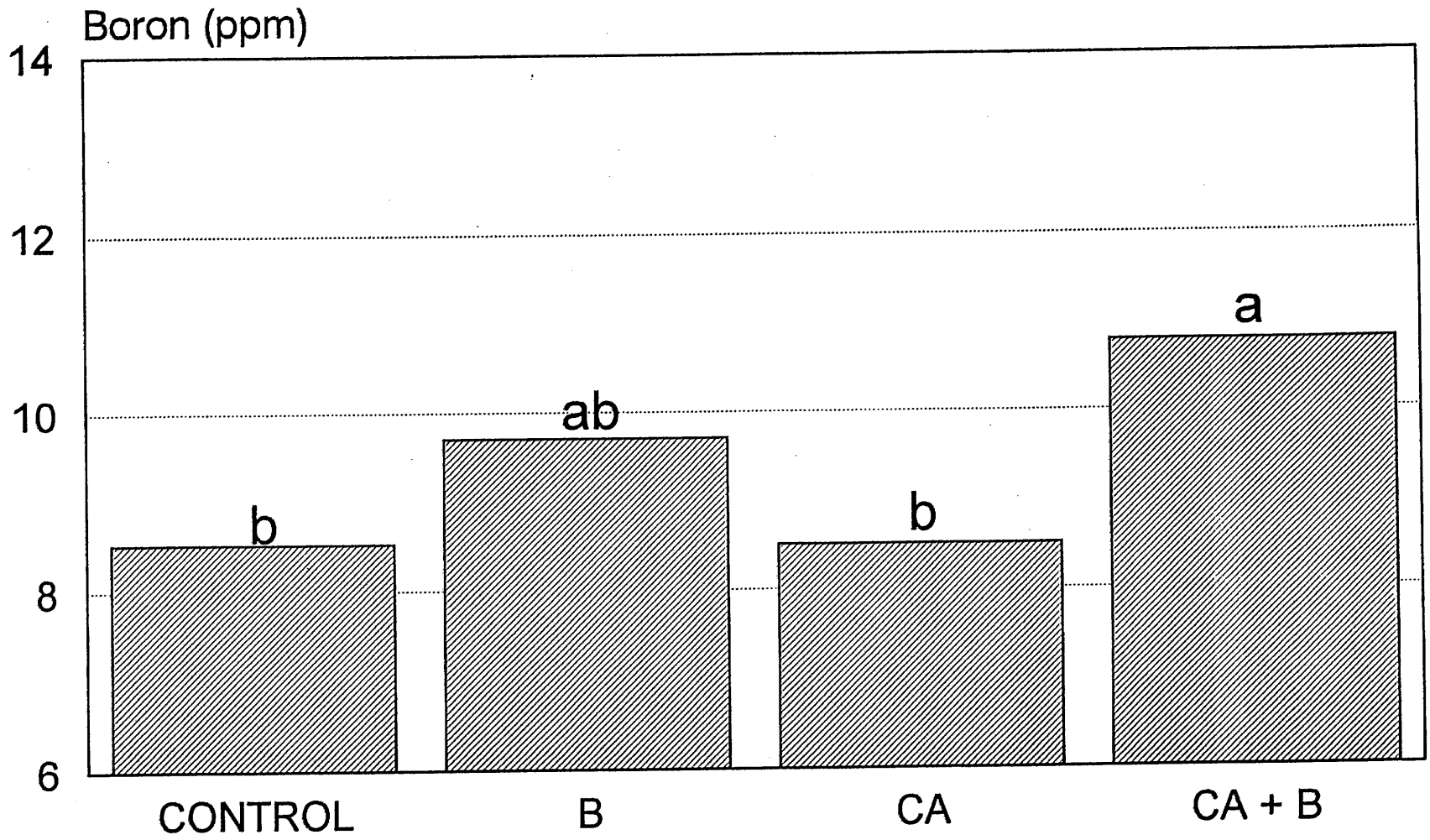
1994 BORON STUDY
BLUEBERRY FIRMNESS



* grams force /grams berries,
SIGN 10%

Figure 7

1994 BORON STUDY
FRUIT BORON CONCENTRATION

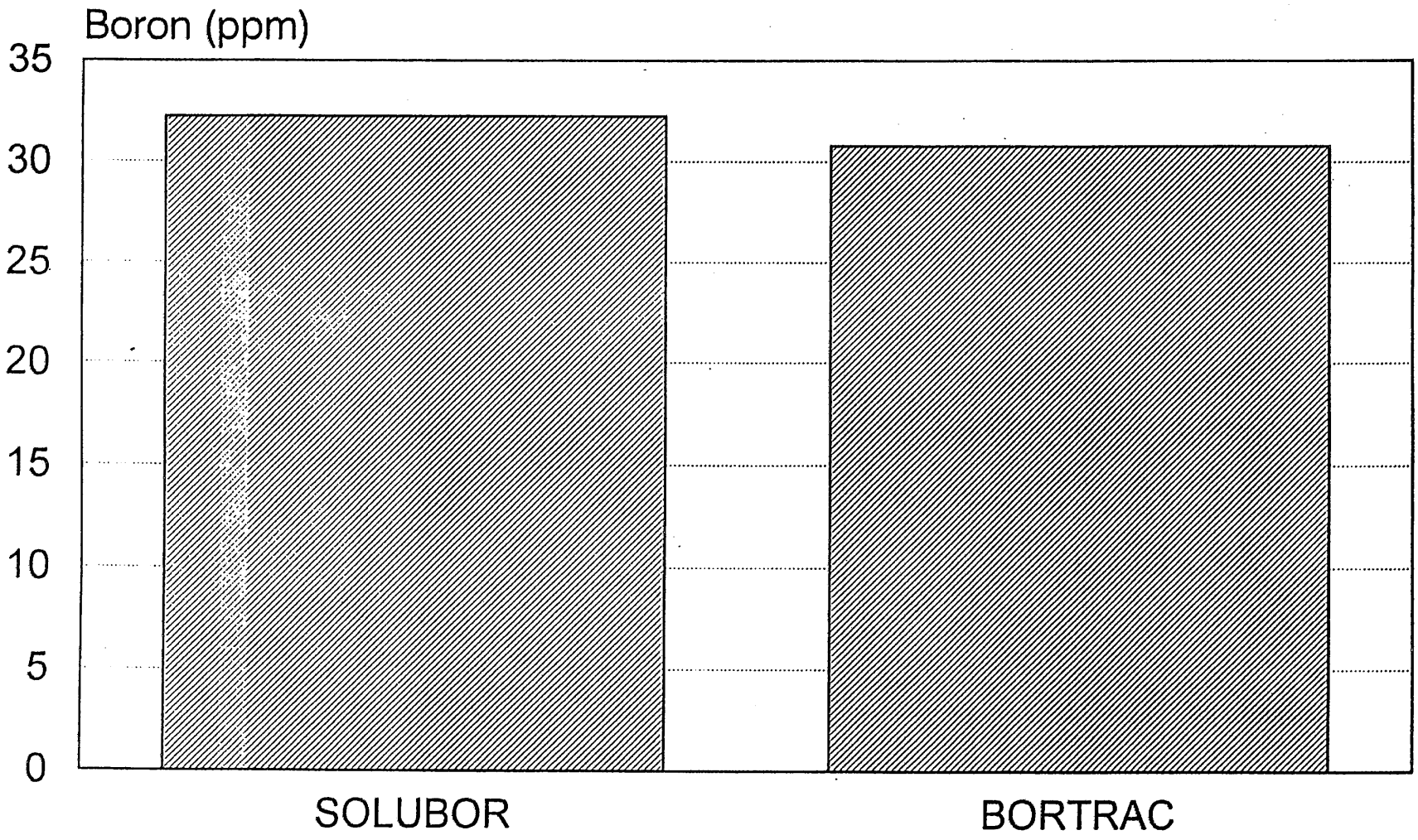


SIGN .01

Figure 8

1994 BORON SOURCE STUDY

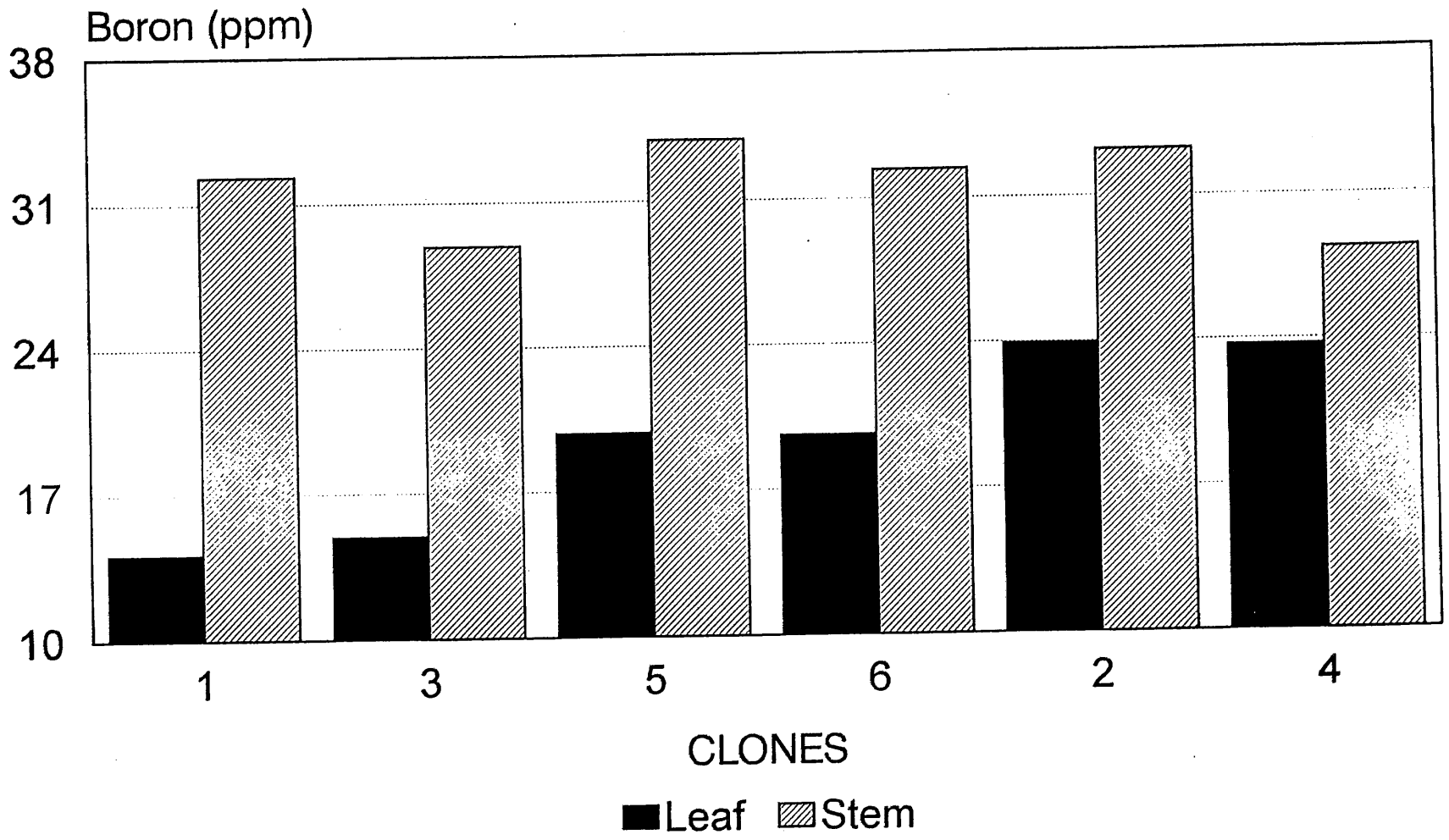
STEM TIP BORON CONCENTRATION



NS

Figure 9

1994 BORON SOURCE STUDY
LEAF AND STEM BORON CONCENTRATIONS

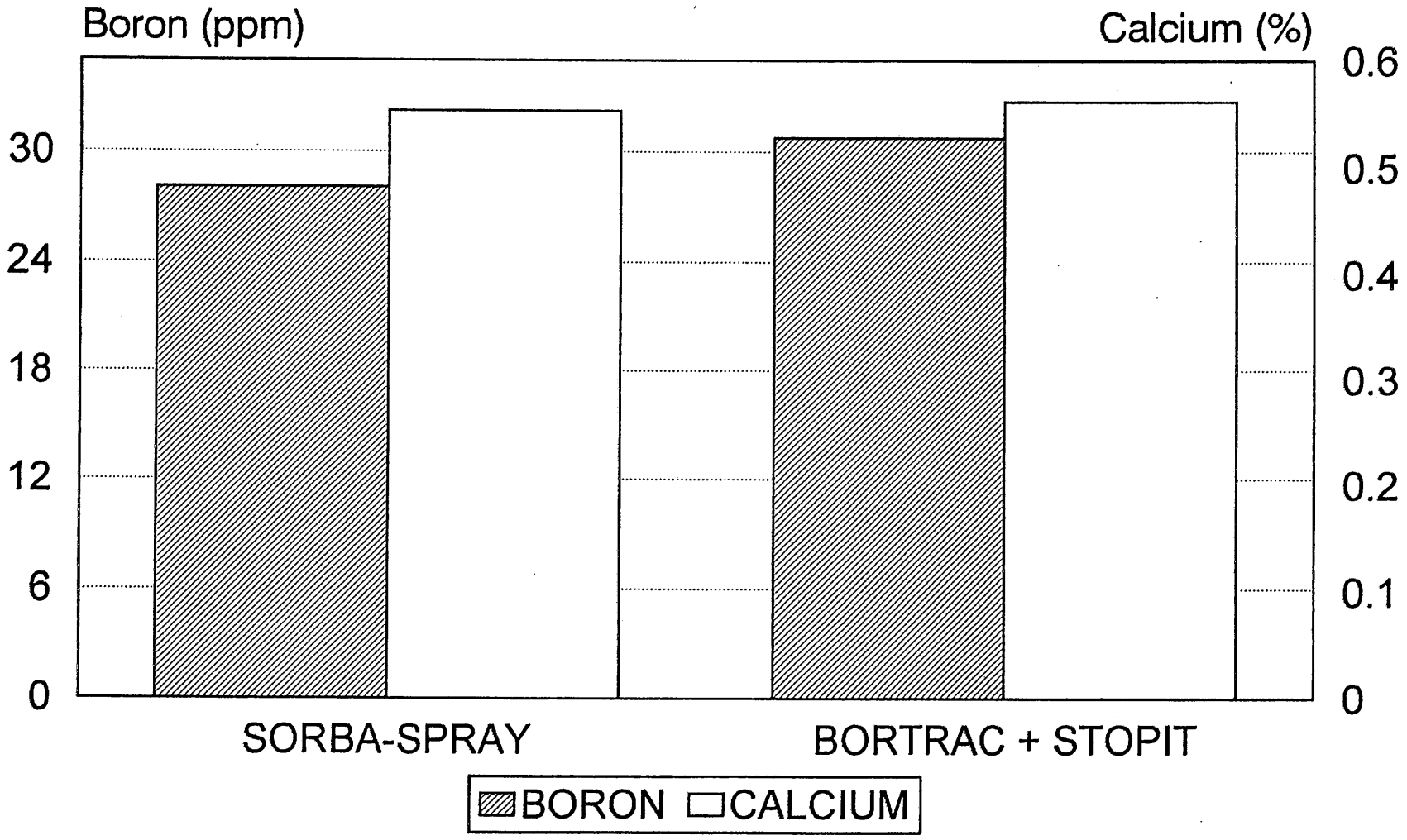


Leaf tissue sampled July 1993, stem tissue November 1993

Figure 10

1994 BORON/CALCIUM SOURCE STUDY

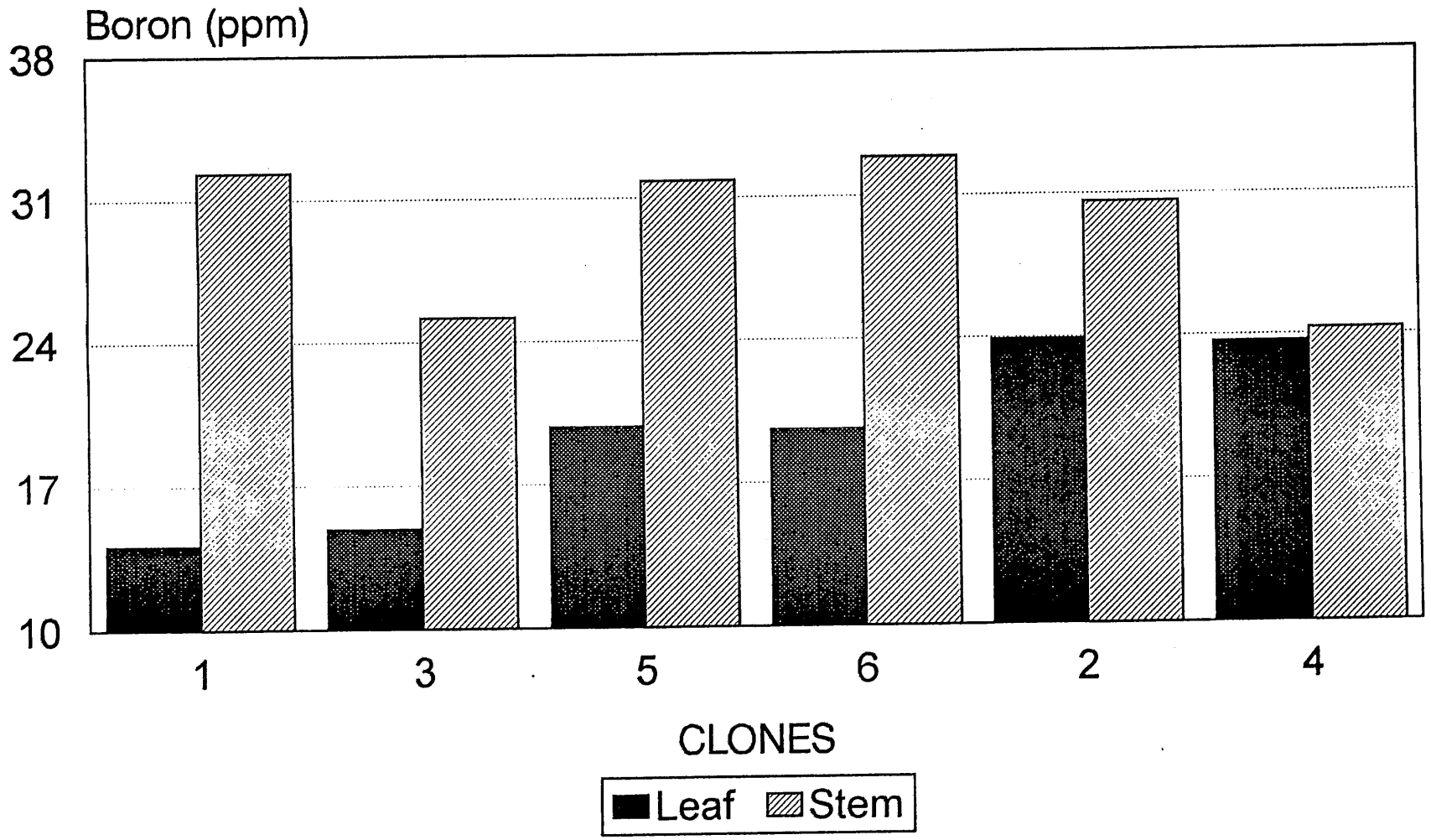
STEM TIP BORON AND CALCIUM



NS

Figure 11

1994 BORON/CALCIUM SOURCE STUDY
LEAF AND STEM BORON CONCENTRATIONS

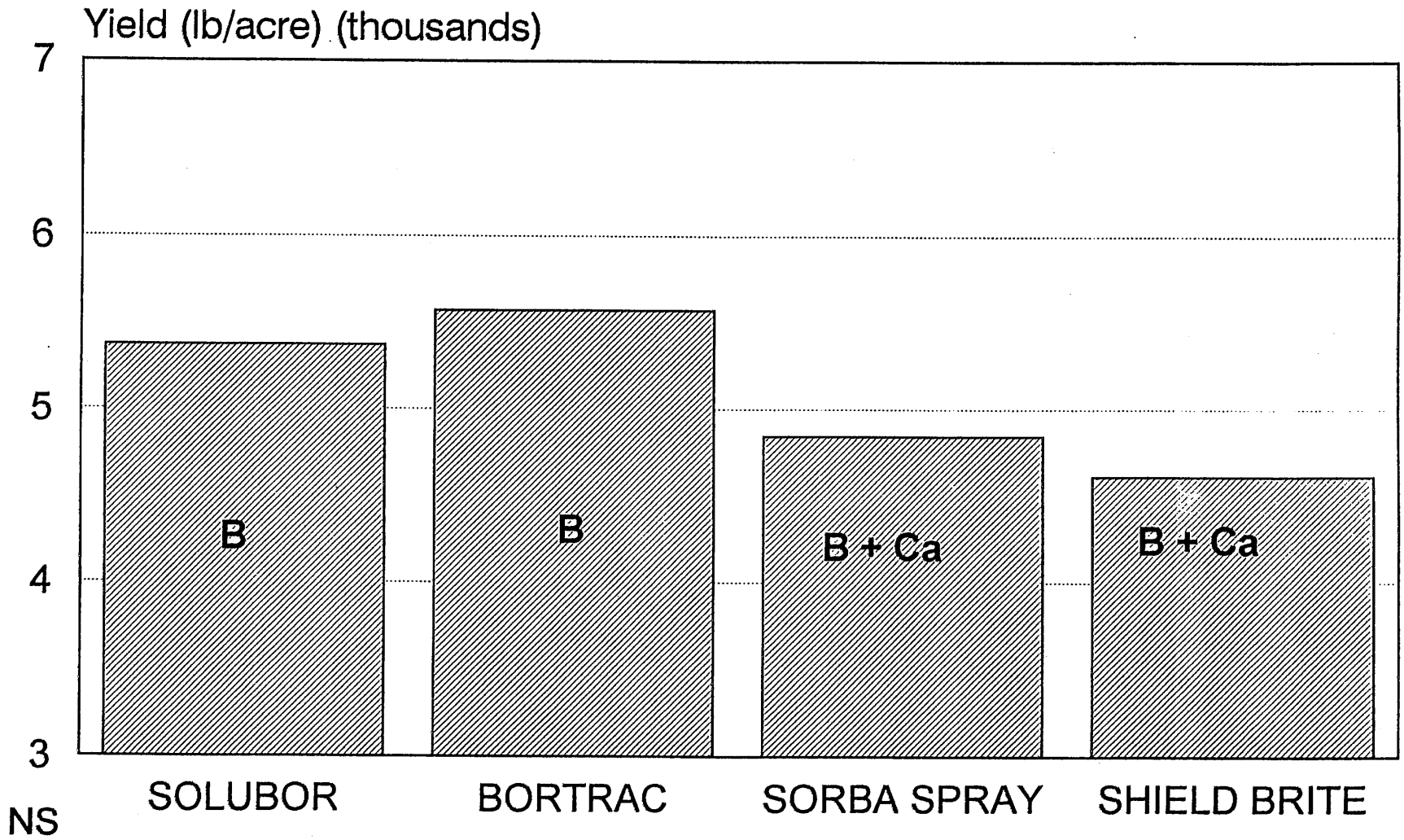


Leaf tissue sampled July 1993, stem tissue November 1993

Figure 12

1994 BORON SOURCE STUDY

YIELD



F. WEED CONTROL AND PRUNING

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

1. TITLE: Effect of Time of Fall Pruning on Growth and Productivity of Blueberries and Evaluation of Infrared Burner to Prune Blueberries.

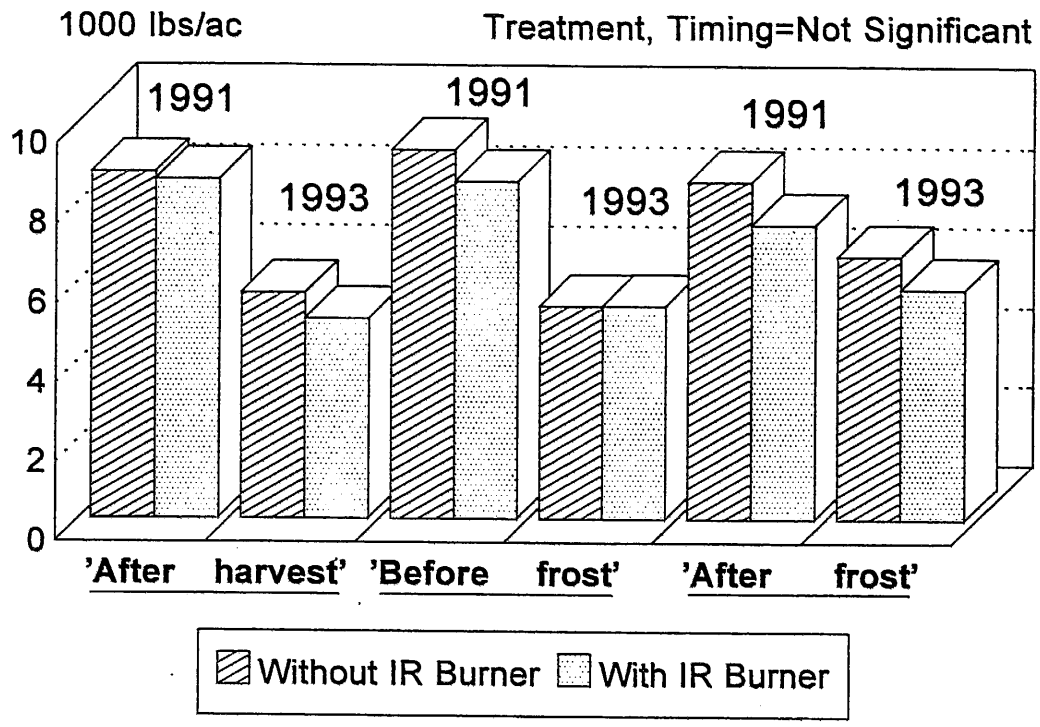
METHODS: A plot at Blueberry Hill Farm was established and harvested on August 26, 1991 to provide pretreatment yield data. Pruning times were; immediately after harvest, on August 27, 1991; before frost, on September 12, 1991; and after frost, on October 23, 1991. In addition, one half of each plot was treated with the infrared burner to evaluate it's effect on blueberry growth and yield. The split-split block experiment has 3 dates of pruning by 2 pruning treatments and 6 replications for a total of 36 plots. Plot size is 6 x 40 feet with two, 1 ft^2 subplots per plot. Stem samples were cut in October 1992 and the first harvest after treatment was taken in August 1993. The plots were pruned again as in 1991; on August 27 after harvest; on September 13, before frost; and on October 14, after frost. Stems were cut in October 1994 and plots will be harvested in August 1995. The cycle will be repeated with final treatments in the fall of 1996 and harvest in August 1997.

RESULTS: The over all harvest was lower in 1993 than in 1991 because of drier growing conditions (Figure 1). No significant differences in stem data attributed to pruning date or treatment with the infrared burner was observed (Table 1).

CONCLUSION: Pruning needs to be repeated over several cycles before any conclusions may be made.

RECOMMENDATIONS: Continue with experiment through harvest in 1997.

Figure 1. Effect of Pruning Time on Yield



prunyld

Table 1. Stem Data from 1992 and 1994

Pruning Date	Stems/ft²		Buds/stem		Laterals/stem		Stem Length (cm)	
	1992	**1994**	**1992**	**1994**	**1992**	**1994**	**1992**	**1994**
After Harvest	78	86	4.5	3.6	1.3	1.3	9.6	8.9
Before Frost	85	91	4.0	3.9	0.4	1.0	9.4	9.3
After Frost	85	97	3.6	3.6	0.3	1.0	10.3	9.9

No significant differences observed

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INVESTIGATORS: David E. Yarborough, Assistant Professor of Horticulture
Michele C. Marra, Associate Professor of Agricultural Resource Economics

COOPERATOR: Kevin J. Sibley, Sibley Engineering

2. TITLE: A Reinvestigation of the Economics of Mechanical Harvesting

METHODS: This trial is to update an initial economic assessment of mechanical harvesters made in 1988. Improvements in the Bragg harvester and the introduction of a new Nimco harvester warranted a reevaluation of new technologies. Four technologies were evaluated: the Bragg harvester, a modified Bragg Harvester, the Nimco prototype, and hand-harvesting at two locations: one a land leveled field (T-19) with plant height 8 to 12 inches and the other with out land leveling (Deblois) with plant height 6 to 8 inches. The Experimental design was a randomized complete block with eight replications. A 150 foot strip was harvested by each technology, with strips directly adjacent to each other to minimize field variability. Time to harvest and berry weights were measured. Kevin Sibley provided an engineering assessment of the machines. Dr. Al Bushway, in the Department of Food Science and Human Nutrition made a quality analysis in a separate report. Machines were assessed as they were working in the field, no attempt was made to optimize performance, since trials have been done on the Bragg harvesters by Kevin Sibley and these data are available for comparison.

RESULTS: Performance results will be summarized in this report, a final economic assessment will be provide by Michele Marra at a later date. Observations on the Bragg harvester indicated it had worn rollers and its forward speed was too fast. Although the skill of the operator was judged to be excellent, the machine recovered only 69% of the berries relative to hand harvest in T-19 and 59% in Deblois (Figure 1).

Each site had a different modified Bragg harvester. In T-19 the headspeed to groundspeed ratio was too fast, reducing the machine efficiency. On the Deblois site the modified Bragg harvester had worn cams, the automatic mode of the electronic head-speed control system was malfunctioning, and the operator skill was poor resulting in excessive air time in which the picking head was of the ground. The modified Bragg harvester was able to obtain 61% of the hand harvested yields at both locations (Figure 1).

The Nimco harvester had a new picking action which appeared to be superior to anything tried in wild blueberries before. The canoe shaped teeth provided excellent stripping action without grabbing plants, as happens with the reel style harvesters and hand rakes. This action eliminated crushing and the picked berries appeared to have superior quality versus the Bragg or hand harvested berries. The picking head used a system of sensors in front of the head which allowed the head to lift over hummocks and small obstructions which kept the picking head from digging into the ground. The Nimco out performed the rakers by picking 107% of the hand harvest yield on the land leveled fields in T-19, but only picked 92% of the hand harvest in Deblois where the field was not land leveled. The Nimco harvester was mounted on a walk behind tractor and the speed and maneuverability were poor.

The effective field capacity of the Bragg harvesters was determined to be 0.29 a/hr (2.9

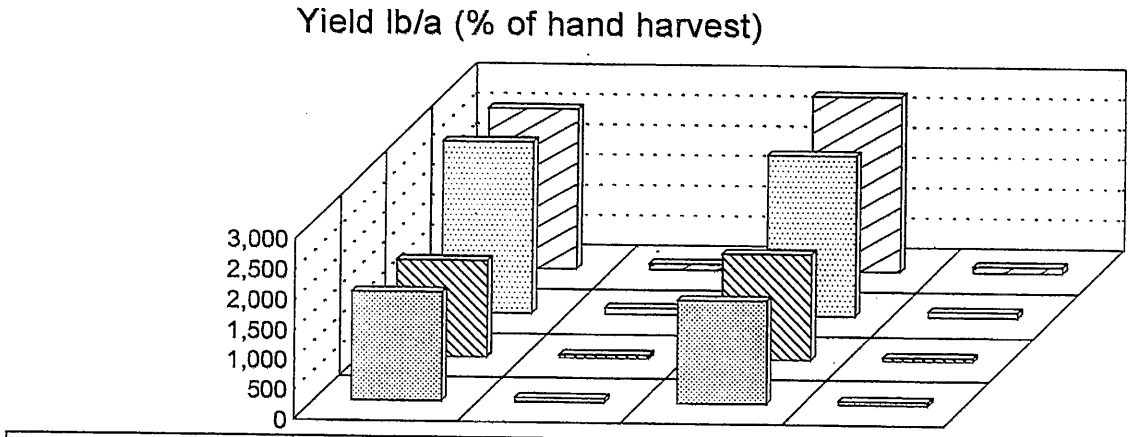
a/ 10 hr day) which is consistent with the 5.6 a/10 hr day for the 2 headed Bragg machine measured in 1988. A hand raker is expected to harvest 0.338 a/ 6 hr day which means a Bragg harvester can do the work of 8 field rakers assuming they could work 6 hours.

CONCLUSION: Poor maintenance, adjustment and skill of the operator contributed to poor recovery by both the Bragg and modified Bragg harvesters relative to hand harvest. Kevin Sibley showed that 92% recover could be obtained by a properly adjusted and operated Bragg harvester.

The Nimco harvester has great potential, but only if it is properly mounted to allow it to cover the fields at a speed similar to the Bragg harvesters. The land leveled field allowed for greater recovery for the Bragg and Nimco harvester indicating that smoother fields allow for greater berry recovery.

RECOMMENDATIONS: Combine performance, berry quality and economic assessment to provide growers with an assessment tool for determining which technology is best for individual grower needs.

Figure 1. Comparison of Harvest Technologies



Hand Harvest	2,654	100	2,898	100
Nimco	2,841	107	2,654	92
Modified Bragg	1,609	61	1,755	61
Bragg	1,821	69	1,724	59
	T-19		Deblois	

Harvest technology

Bragg Modified Bragg Nimco Hand Harvest

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

3. TITLE: Thresholds by Mechanical and Chemical Controls in Wild Blueberries.

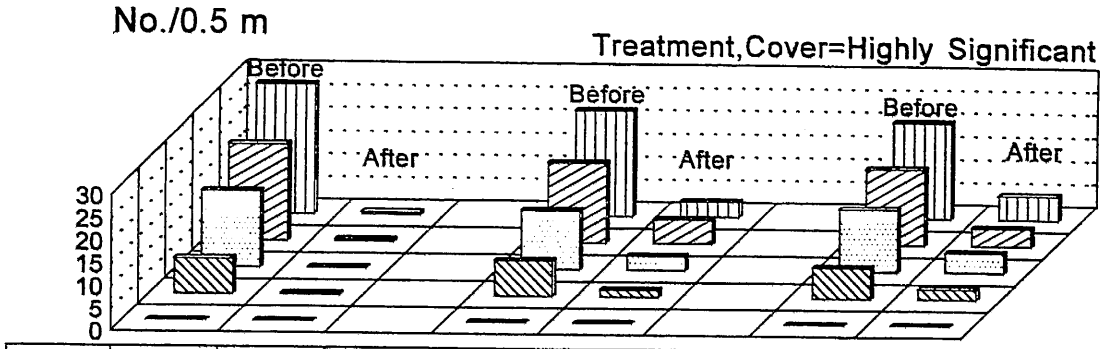
METHODS: Three hundred, 1 m^2 (10.76 ft^2) plots were established in June in 1991 and 1993 at Blueberry Hill Farm Experiment Station in Jonesboro, ME and in 1992 in a commercial blueberry field in Centerville, ME with either 0%, 25%, 50%, 75% or 100% dogbane or bracken fern weed cover. The experimental design was completely randomized with two species, three treatments (mow, wipe and untreated), at five weed densities replicated ten times. One half of each plot had weed cover and one half was kept weed free in order to compare the effect of weed density on yield. Plots were treated with either 10% v/v Roundup® in a hand held weed-wiper, mowed with a string trimmer or left untreated in July. The year after treatment, weed counts and weed cover determinations were made in June and the plots were harvested in August. All stem count data and blueberry yields were averaged over the three years of the study. Deviation in blueberry yield was determined by subtracting the yield from the treated areas from the untreated area.

RESULTS: Bracken fern numbers decreased substantially the year after treatment in the untreated plots with numbers comparable to the mowed plots (Figure 1). The wiper treatment resulted in a substantial reduction in bracken fern. A slight reduction in the dogbane density occurred in the year after treatment but mowing and wiping produced a significant reduction in dogbane numbers the year after treatment (Figure 2). Increasing cover of bracken fern or dogbane in the untreated areas resulted in a substantial reduction in blueberry yield (Figures 3 and 4). Blueberry yields were less than the weed free treatments for all bracken fern and dogbane densities of 25% to 100% (Figures 3 and 4). Both treatments were effective in increasing yields for the bracken fern with mowed plots having greater yields than wiping for the 50% and 75% weed densities (Figure 5). For the dogbane the mow treatment was more effective than the wipe, with the wiper treatments equivalent to or less than the untreated (Figure 6).

CONCLUSION: Although wiping was more effective than mowing in reducing weed numbers, mowing resulted in greater yields than wiping with Roundup® for the control of bracken fern and dogbane. Yield reduction may have occurred from weed competition early in the season when they were shading the blueberry plants, but non selective postemergence treatments require a height differential to make treatment possible. The additional reduction in yields associated with the wiper treatment may have been due to injury to blueberry plants from dripping or wiping the blueberry plants with Roundup®. Even with careful application some injury will occur.

RECOMMENDATIONS: Mowing was effective in controlling both species but wiping was not effective in reducing dogbane compared to no treatment. Use existing figures to calculate economic thresholds.

Figure 1. Comparison of Bracken Fern Number Before and After Treatment

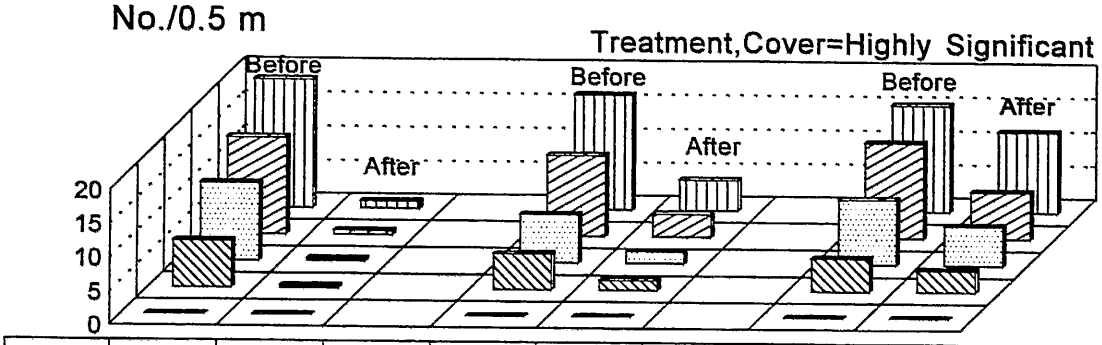


100%	28.3	0.6		23	3.4		21	5.4
75%	21.1	0.4		17.6	5.4		16.8	4
50%	16.8	0.2		13.1	3.2		13.9	4.4
25%	7.8	0.3		7.9	1.6		6.8	2.3
0%	0	0		0	0		0	0

Wipe Mow Untreated

Initial Weed Cover
0% 25% 50% 75% 100%

Figure 2. Comparison of Dogbane Number Before and After Treatment

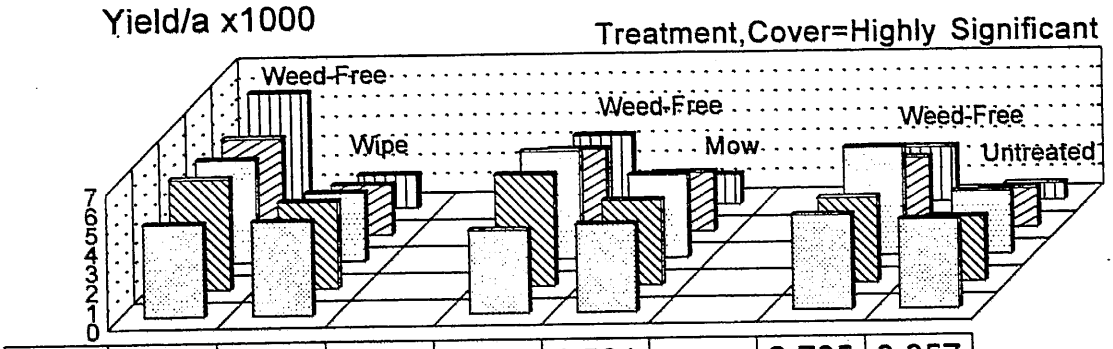


100%	19	1.1		17	4.6		15.8	12
75%	14.4	0.6		12.1	3.4		14.2	7
50%	11.6	0.4		7.2	1.8		9.7	5.8
25%	6.9	0.4		5.3	1.5		4.9	3.2
0%	0	0		0	0		0	0

Wipe Mow Untreated

Initial Weed Cover
0% 25% 50% 75% 100%

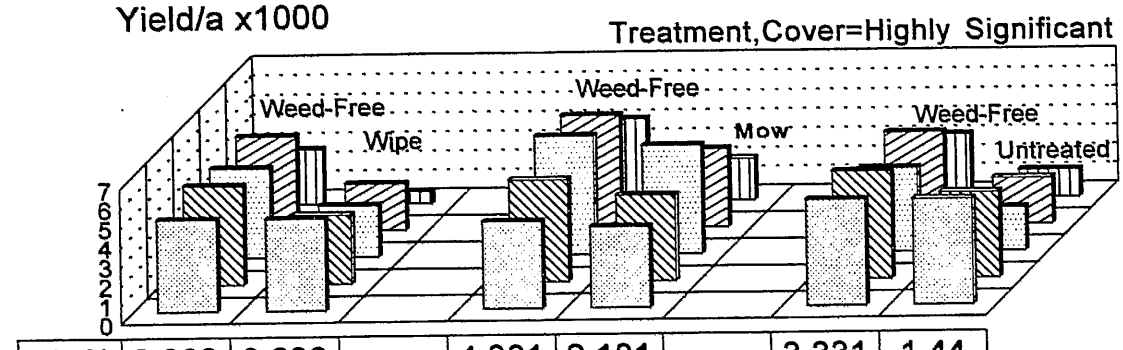
Figure 3. Comparison of Yield on Treated vs Weed-Free Area with Bracken Fern



100%	5.935	1.703		3.586	1.501		2.785	0.857
75%	5.022	2.569		4.278	3.016		3.633	1.987
50%	5.332	3.568		5.573	4.304		5.584	3.252
25%	5.737	4.521		5.775	4.405		4.398	3.371
0%	4.823	4.905		4.327	4.582		4.913	4.639
	Wipe			Mow			Untreated	

Initial Weed Cover
0% 25% 50% 75% 100%

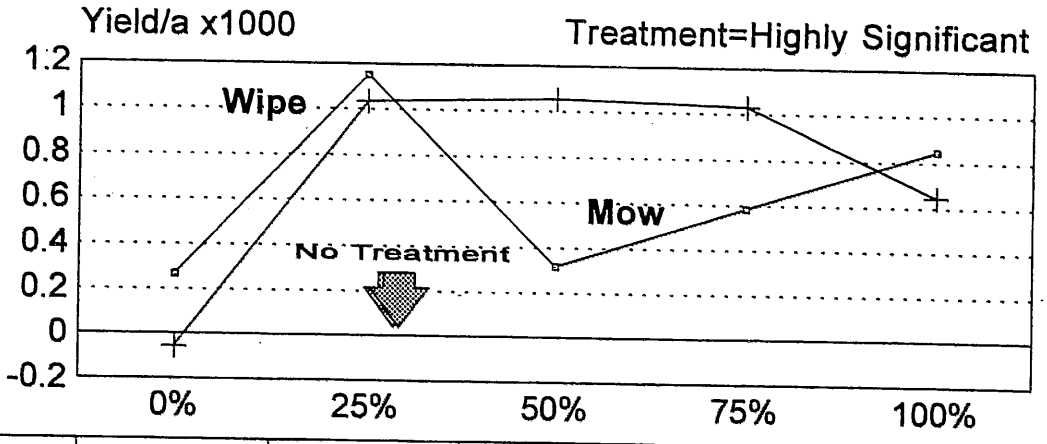
Figure 4. Comparison of Yield on Treated vs Weed-Free Area with Dogbane



100%	2.882	0.636		4.301	2.181		3.331	1.44
75%	4.948	2.442		5.88	4.095		4.844	2.412
50%	4.68	2.705		6.204	5.66		4.376	2.272
25%	5.154	3.612		5.318	4.475		5.606	4.463
0%	4.802	4.786		4.546	4.223		5.524	5.515
	Wipe			Mow			Untreated	

Initial Weed Cover
0% 25% 50% 75% 100%

Figure 5. Effect of Treatment on Yield Deviation by Bracken Fern Cover

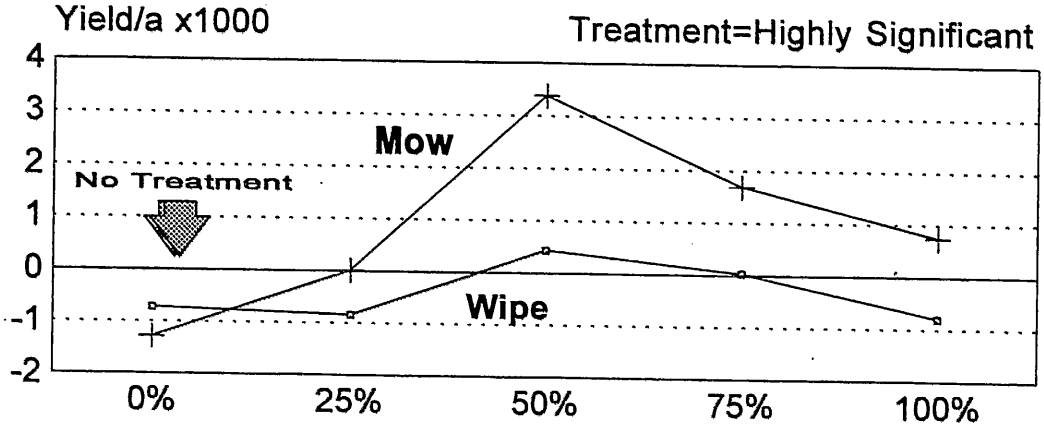


Wipe	0.266	1.15	0.316	0.582	0.846
Mow	-0.057	1.034	1.052	1.029	0.644

Initial Weed Cover

Treatment
Wipe Mow

Figure 6. Effect of Treatment on Yield Deviation by Dogbane Cover



Wipe	-0.729	-0.851	0.433	0.03	-0.804
Mow	-1.292	0.012	3.383	1.683	0.741

Initial Weed Cover

Treatment
Wipe Mow

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

COOPERATOR: Delmont Emerson, Blueberry Hill Farm Manager

4. TITLE: Evaluation of Pressurized Rope Wick Master Wiper for Treating Weeds Growing Above Lowbush Blueberries.

METHODS: A split-block experiment was set out on a commercial field in Centerville in both 1992 and 1993 to evaluate the efficacy of the modified weed wiper for the control of dogbane and bracken fern. The first experiment was established on 7-15-92 and had 5 treatments: wiped once, wiped twice, wiped with a hand held sideswipe, mowed with a motorized string trimmer and an untreated control. All wiper treatments were with 10% v/v Roundup®. Plot size was 12 x 85 feet. Each treatment had 10, 1 ft^2 count plots. Weeds were counted before treatment, and one month later. Injury to blueberries due to treatments were also evaluated. Weeds were recounted in June 1993.

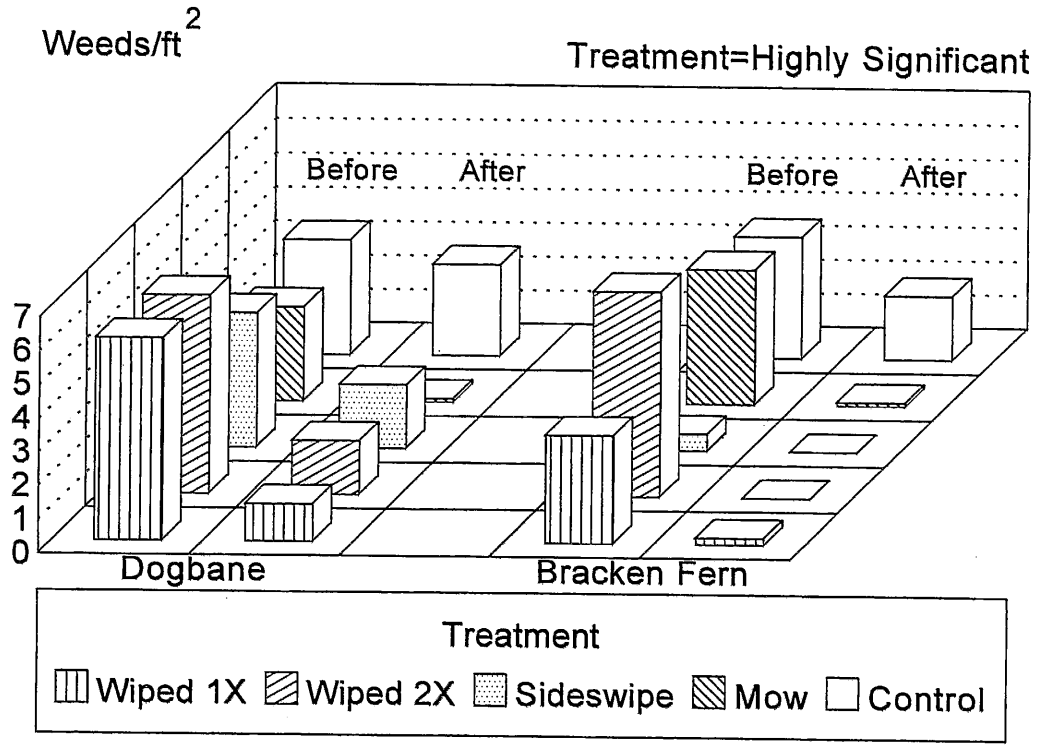
In the winter of 1992, the wiper was modified by replacing the tandem wheels with skids. This enabled the wiper to better follow the terrain of an uneven blueberry field. Another trial was conducted to assess this modification on an adjacent field by evaluating the wipers' effectiveness on hardwoods as well as bracken fern and dogbane. An experiment with the same size and design was established and treated on 7-26-93 with a 20% v/v RoundUp®. Weeds were counted before treatment, and one month later. Carryover effects and counts were made again in June 1994.

RESULTS: In 1992, two passes and mowing were the most effective treatments for controlling bracken fern (Figure 1). In 1993 two passes was the most effective treatment (Figure 2). Dogbane was best controlled by mowing in 1992 (Figure 1) and by the modified wiper treatments in 1993 (Figure 2). There were no significant differences in hardwood numbers by treatment in 1993 study (Figure 3). No phytotoxicity was observed in either year with the modified wiper applications.

CONCLUSION: Compared to the hand held sideswipe applications, the modified wiper effectively applied the herbicide to the weeds without dripping, thus eliminating damage to the blueberries. Mowing was also an effective treatment for dogbane and bracken fern.

RECOMMENDATIONS: Construction plans for the modified wiper are available to growers as is the finished product (current cost is $1800). Mowing with a string trimmer remains an effective alternative to chemical controls.

Figure 1. Effect of Treatment on Dogbane and Bracken Fern One Year After Treatment-1992



wipe92

Figure 2. Effect of Treatment on Dogbane and Bracken Fern One Year After Treatment-1993

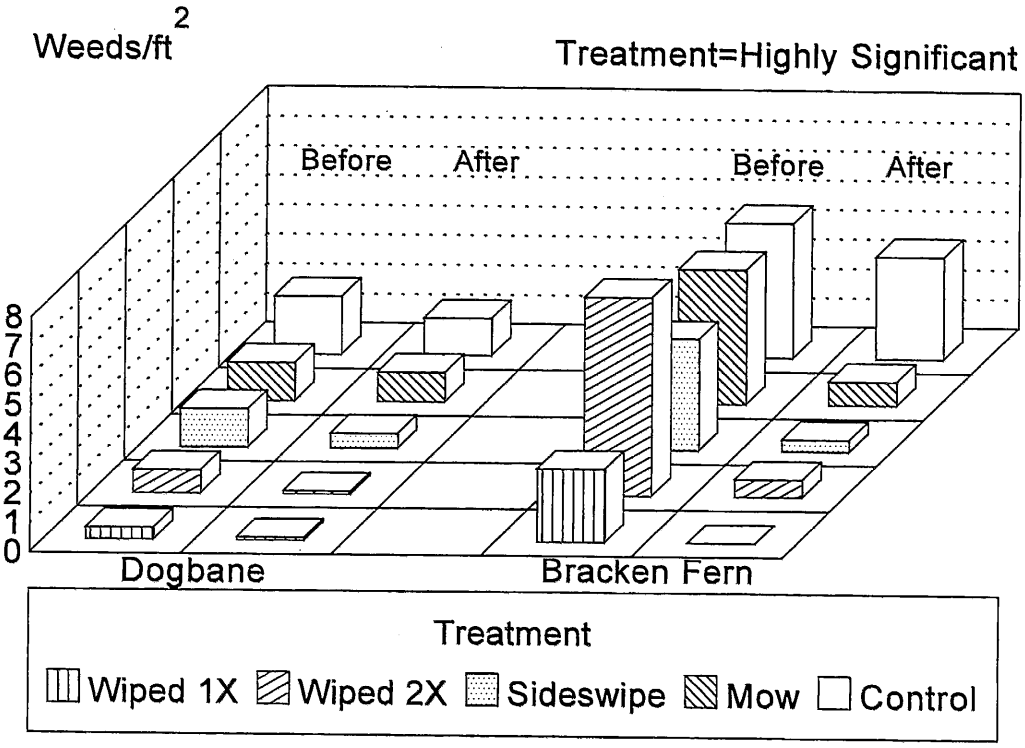


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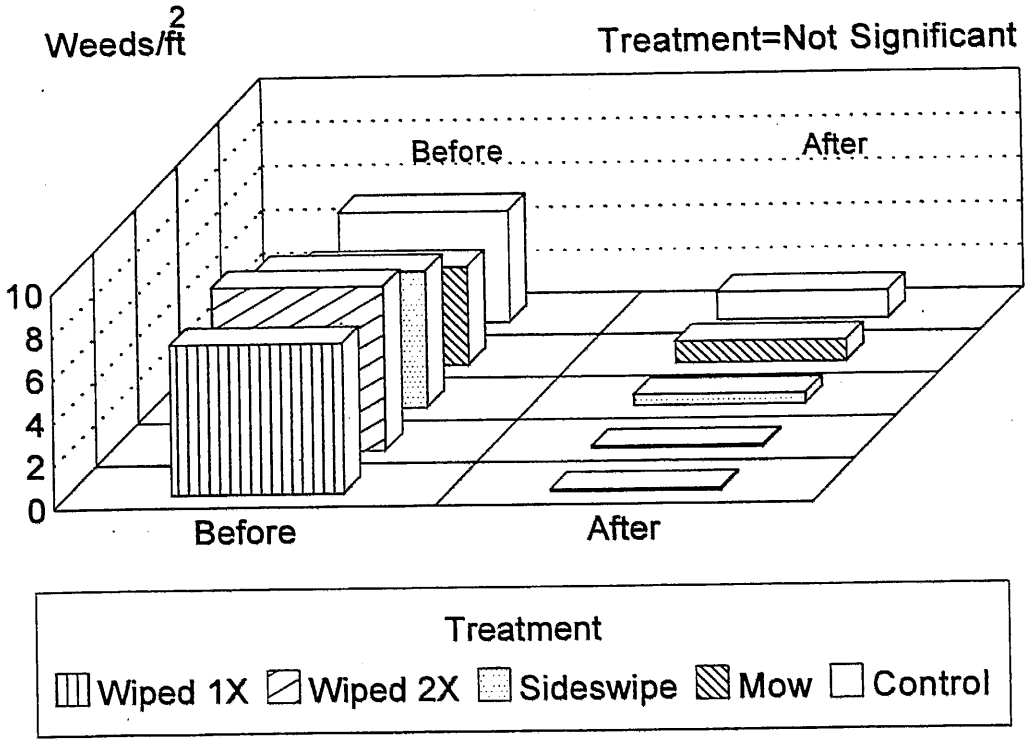
Figure 3. Effect of Treatment on Hardwoods One Year After Treatment-1993



hwipe93

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

5. TITLE: Evaluation of Infrared Burner for Selective Weed Control.

METHODS: A preliminary experiment conducted at Blueberry Hill Farm, Jonesboro in the summer of 1991 indicated that the infrared burner was effective in suppressing bunchberry plants growing among blueberry clones. In May 1993, a split-block experiment was established at Blueberry Hill Farm to determine if the infrared burner had any selectivity in suppressing bunchberry growing within the blueberry clones. Plot size was 3 by 30 feet with a 3 by 30 foot alleyways. There were 4 treatment dates, with 2, 1 ft^2 count plots per plot and 6 repetitions for a total of 24 plots. Treatments were; untreated; treated on May 20, just as bunchberry were emerging but before blueberry emerged; on May 28, with bunchberry fully emerged; and blueberry just emerging, and on June 11, with both fully emerged. Phytotoxicity was evaluated in July and stems were cut in October 1993. Counts of bunchberry were conducted in June 29, 1994 and plots harvested on August 23, 1994.

RESULTS: All bunchberry recovered to higher levels than before treatment in the second year except for the 6-11-93 treatment date (Figure 1). Although the best suppression of bunchberry was obtained on the last treatment date this also resulted in a significant yield loss (Figure 2).

CONCLUSION: The IR burner treatment resulted in more bunchberry in the crop year on all treatment dates and a reduction in yield on the last treatment date. The IR burner did not exhibit any selectivity. Suppression of bunchberry is best obtained by treating bunchberry growing among the blueberry clones, not within the clones.

RECOMMENDATIONS: Previous trials indicate bunchberry may be suppressed with repeated applications to bunchberry growing among blueberry clones. The IR burner is a non-chemical option for growers but the cost effectiveness still needs to be evaluated and compared to commercial methods.

Figure 1. Effect of Infra Red Burner on Bunchberry Numbers

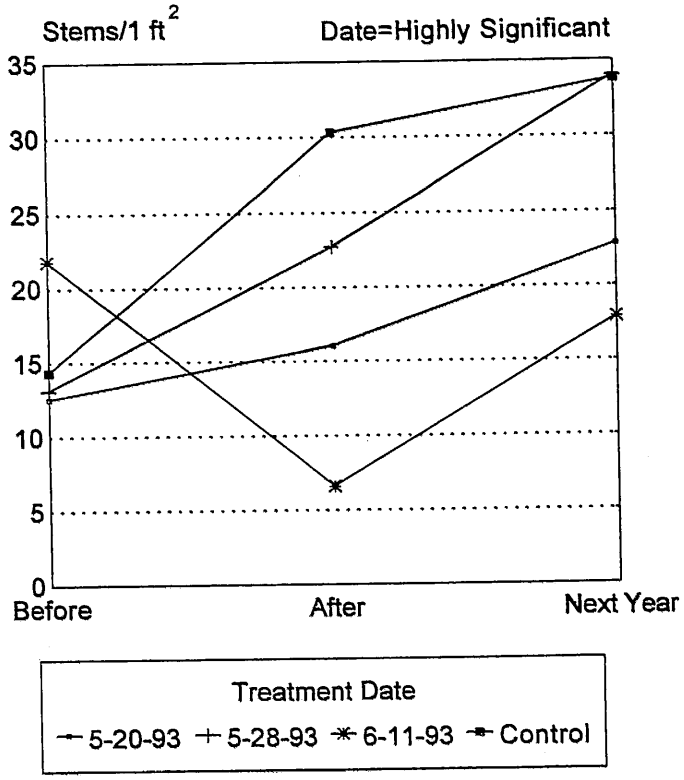


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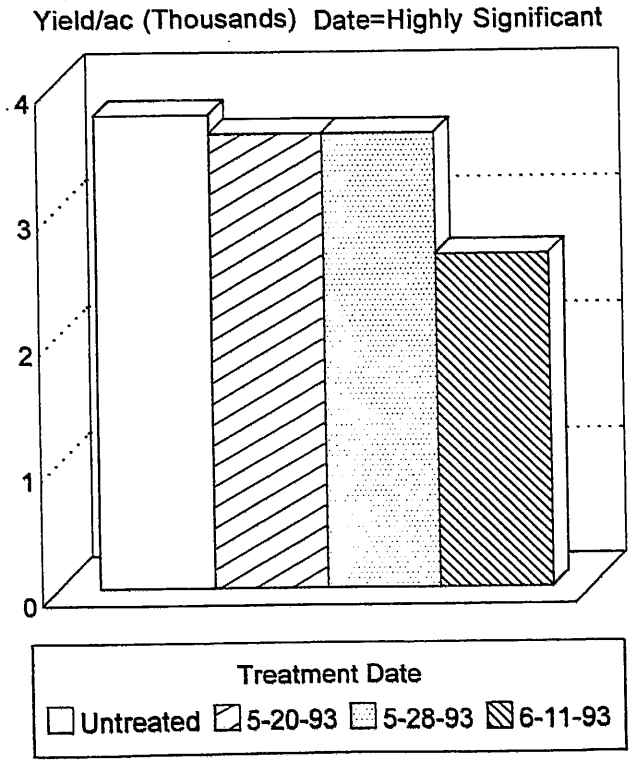
Figure 2. Effect of Infra Red Burner on Yield



lr93yld

TABLE OF CONTENTS
1994 Blueberry Tax Reports

A. Entomology

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

1. TITLE: Control of blueberry pest insects.

METHODS:

Laboratory screenings: Insecticides were screened in the laboratory against spanworm larvae and adults, sawfly larvae, strawberry rootworm adults, grasshopper nymphs, and lygaeid nymphs. Evaluation of control was based on percent mortality of the insects at intervals after treatment. Any reduction in feeding activity in comparison with untreated controls was also noted.

Field trials: The effectiveness of various insecticides was determined in field trials against spanworm larvae, sawfly larvae, flea beetle larvae, red-striped fireworm, and thrips. Control of thrips was evaluated by counting the number of sprouting blueberry stems with and without thrips' curls. In the control test on red-striped fireworm, populations were monitored by counting the number of infested stems in square foot samples. Spanworm, sawfly, and flea beetle populations were measured by taking pre- and post-treatment sweep-net samples. Evaluation of the effectiveness of insecticides against blueberry maggot was based on sampling ripening berries in selected areas and processing for maggots.

IR-4 residue sampling: Treatments were applied and residue samples collected to aid in the reregistration of Imidan 70WP.

RESULTS AND CONCLUSIONS:

Secondary pest insects: Spanworm adults were controlled effectively in a laboratory screening trial using malathion and carbaryl (Sevin). The registered materials phosmet (Imidan) and methoxychlor (Marlate) worked well in the laboratory against strawberry rootworm adults. The most effective materials for control of lygaeid nymphs were diazinon and the unregistered pyrethroid tau-fluvalinate (Mavrik); Imidan gave good control, but knockdown was slower. Mavrik also performed well against spanworm and sawfly. Cryolite, an unregistered inorganic aluminofluoride, controlled sawfly larvae; however, it was less effective for spanworm larvae. Pyrethrum + piperonyl butoxide (Pyrenone), a tolerance-exempt natural pyrethrum, also reduced sawfly populations; spanworm were not controlled by Pyrenone. A test of Mavrik and Cryolite on flea beetle larvae appeared to show control; however, statistical analysis indicated no significant differences because of too much variation in count numbers. Results were obtained for the first time for red-striped fireworm. Diazinon, Imidan, Sevin, and azinphosmethyl (Guthion) controlled the larvae of this insect when applied when sampling indicated 1 infested blueberry stem/4 sq ft. Because of the long period of egg hatch, repeat applications may be warranted.

Blueberry maggot control: For blueberry maggot, comparison of berry samples collected from

treated and untreated areas showed that three applications of malathion (16 oz) gave very good control; three applications of Pyrenone (12 oz) were generally ineffective against a vigorous adult population. However, a high rate of Pyrenone did give fair to good control of a moderate population. Mavrik was not as effective as malathion or Imidan. This might have been expected since Mavrik is a pyrethroid material with a shorter residual.

Status of IR-4 projects: IR-4 has stated that currently there seem to be currently no further obstacles to the registration of Mavrik. Analysis of residue samples is proceeding. With the submission of additional samples by other interested states, positive progress is now being made toward the registration of dimethoate (Cygon) in the U.S. Sodium aluminofluoride (Cryolite) is now a high priority for IR-4; field trials may be conducted in 1995. Additional residue samples may be required for Imidan because of new NAFTA regulations.

RECOMMENDATIONS:

Recommendations for control of blueberry pest insects during the long bloom period remain essentially unchanged from 1994. Marlate, or the Bt insecticides Dipel, Javelin, and Biobit may be used to control blueberry spanworm larvae. Imidan is recommended for use in pruned fields only and when bees are not actively foraging. Sawfly and flea beetle larvae, as well as flea beetle adults, can be controlled by Marlate during bloom and by Imidan at postbloom. A high rate of Pyrenone may also be effective against low to moderate populations of flea beetle and sawfly larvae. However, repeat applications may be needed. Sevin 4XLR Plus may be used to control flea beetle adults.

Two applications of diazinon or malathion in the pruned year as plants are sprouting is effective in controlling thrips. Populations of thrips in crop-year fields should be noted and marked for treatment in the spring after pruning.

Burning as a pruning technique may reduce populations of insects that spend part of their life cycle in the litter. It may also be used to eliminate small infestations of thrips after plant emergence.

Although some data were obtained for control of red-striped fireworm in 1994, these results must be verified before any recommendation can be made.

For blueberry maggot, insecticides may be applied when monitoring indicates populations of flies exceed threshold levels. One or two applications of Guthion or Imidan, or three applications malathion, may be applied; two applications of Sevin 4XLR Plus are also recommended. A high rate of Pyrenone may also prove somewhat effective, particularly against low to moderate populations; repeat applications should be made as determined by monitoring with yellow sticky traps.

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

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

METHODS:
Studies were continued to determine the biology and to define an economic injury level for the red-striped fireworm. Larval feeding and movement on blueberry stems were monitored by counting the number of stems with webbed-together leaves in square-foot samples and the number of leaves webbed together per infested stem. The presence or absence of larvae on stems was also monitored. Feeding damage to fruit buds and the number of fruit buds on paired infested and noninfested stems were observed.

Fact Sheets: Two blueberry insect fact sheets, "Red-striped Fireworm and Blueberry Sawfly", were developed in cooperation with the University of Maine Cooperative Extension. These guides illustrate life history and economic damage and will aid growers in the identification of these pest insects.

RESULTS AND CONCLUSIONS:
Red-striped fireworm: The average number of blueberry stems with webbed-together leaves per sq ft increased steadily throughout the season from 1.3 in mid-July to 10.0 on September 1st. However, the number of old stems apparently no longer infested increased as the season progressed. This may be indicative of some movement of maturing larvae to new stems or of movement of larvae into the litter. Sampling also showed that at least some fireworm larvae move about on individual stems webbing together additional leaves as they feed. Examination of infested stems showed that from 17 to 55% of previously infested stems had at least one additional webbed-together leaf on any given sample date; in general, fewer new leaves were webbed late in the season.

For the first time in our studies, analyses showed a significant reduction in number of fruit buds on infested stems when compared to noninfested stems (4.5 vs. 3.6). It is unclear what other factors may have contributed to this finding; results of similar studies from two previous year showed no differences.

Action thresholds of secondary pest insects: A general lack of suitable populations in 1994 hindered the completion of studies to refine economic injury levels and action thresholds for flea beetle and sawfly in crop and vegetative-year fields.

RECOMMENDATIONS:
Secondary pest insects: Although tentative action thresholds have been developed for flea beetle and sawfly in crop year fields (30-50 per 10 sweeps), data should still be accumulated and analyzed to confirm these results and to define action thresholds for vegetative fields. Similar information should be developed for less abundant pest species such as blueberry looper, blueberry leaf beetle, casebearer, and lygaeids. Also, development of additional biological information such as migration habits, host associations, environmental preferences, and natural

enemies must be completed for major secondary pest species such as blueberry spanworm, flea beetle, and sawfly.
Finally, mating and oviposition sites must still be verified to complete the life history of red-striped fireworm.

Fact Sheets: Existing fact sheets on blueberry spanworm, blueberry flea beetle, thrips, and leaf beetle need to be updated and revised. Funding for these projects should be a priority. After information has been collected it is essential it be made available to growers as soon as possible.

B. Fertilization

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

Cooperator: Delmont Emerson

1. TITLE: NITROGEN-PHOSPHORUS STUDY

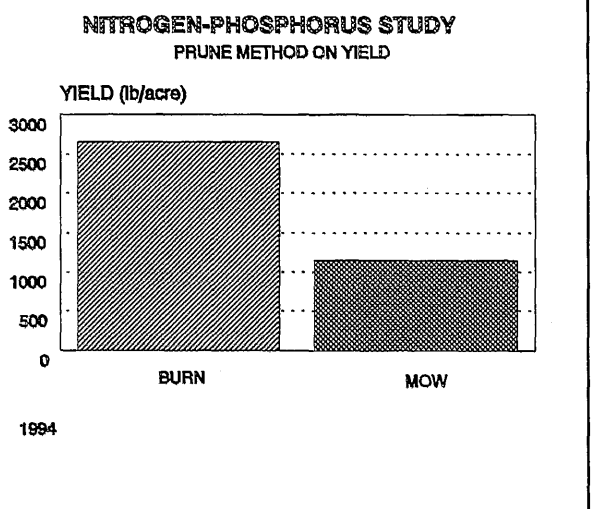
METHODS: DAP was applied at 0, 90, 120, 150 or 180 pounds of phosphorus per acre in 1991 but not in 1993. Pruning by either burning (oil fire) or by mowing was continued another cycle. Fifty foot long treatment plots were split: one side was pruned by burning and the other by mowing. Please refer to the 1988, 1989, 1990 and 1991 project proposal outlines for more details.

RESULTS:

BLUEBERRY YIELD

The main effect of pruning method significantly effected yield (Fig 1). Burned plots yielded more berries than mowed plots.

Figure 1



CONCLUSIONS: There was no interaction between fertilizer treatment and pruning method. In other words, you don't need higher rates of fertilizer if you are mowing instead of burning. DAP has effectively raised the level of nitrogen and phosphorus in lowbush blueberry leaf tissue. When leaf tissue phosphorus concentration is near 0.096%, application of DAP at rates which supply 80-90 lbs P/acre or higher were necessary to raise leaf tissue phosphorus to levels above the current standard of 0.125%. The standard should be raised to 0.130% because plots in this study and others have benefited from DAP fertilizer when leaf tissue analysis revealed phosphorus leaf tissue concentrations of 0.125% were present.

Burned plots have yielded greater than mowed plots for 3 consecutive prune cycles in this study. Pruning by fire may therefore produce higher yields in similar fields.

RECOMMENDATIONS: Apply DAP to correct phosphorus deficiency, increase leaf nitrogen concentration and increase yield. Data provided in this study suggests that rates of DAP that provide 80 lb P/acre are economically justifiable in a field that has leaf tissue levels near 0.96%. Pruning by fire resulted in higher yields compared to mowing over several cycles.

C. Weed Control

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

1. TITLE: Evaluation of Pronone 10G® for Control of Weeds in Lowbush Blueberries.

METHODS: A 6 acre, split-block experiment was established on Cherryfield Foods land in Cherryfield, ME on June 8, 1993 to evaluate the efficacy of an air assist application of Pronone 10G® for control of weeds at 10 lb/a product (1 lb ai/a) and 20 lb/a product (2 lb ai/a). Velpar L® at 1 lb ai/a served as the control. Twenty, 1 yd^2 cover plots per treatment were evaluated one month after application for blueberry and weed cover and for any phytotoxicity. Yields were not taken and project was terminated in Fall of 1993 after irrigation lines were established in plot.

RESULTS: Preliminary results, published in the 1994 Progress Report, indicated slightly higher injury rate from 2 lbs ai/a of Pronone 10G® versus 1 lb ai/a or 1 lb ai/a liquid Velpar®.

CONCLUSION: Pronone 10G® is expected to provide equivalent weed control to liquid Velpar® with the added benefit of later application dates.

RECOMMENDATIONS: Evaluate leachability of Pronone 10G® versus liquid Velpar® to determine if there is an advantage with the granular product.

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

2. TITLE: Evaluation of Tribenuron Methyl for Bunchberry Control

METHODS: A 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 emergence; June 9, after bunchberry but before blueberry emergence; on June 24, after both emerged or left untreated. Plot size is 6 X 45 ft with 2 ft alleys, 6 blocks and 4 treatment dates for a total of 24 plots. Each plot has 2, 1 ft^2 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 will be reevaluated in June and plots will be harvested in August of 1995.

Two other trials were also 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, and an adjacent untreated one acre plot served as a control. Each plot had 15, 1 yd^2 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, 1ft^2 plots per treatment on October 20, 1994 and phytotoxicity and carryover effects will be evaluated in June of 1995. The plots will not be 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, have 15, 1 yd^2 count/cover plots for a total of 45 plots.

RESULTS: In the Jonesboro timing study phytotoxicity was first noticed with the June 9th treatment date where stem length observed to be stunted and leaf colour was red so a high phytotoxicity rating was given (Figure 1). Data from stems cut in October. 1994 showed no significant differences in stem length, stem number or bud number. In the Jonesboro acre treated plot blueberry cover on the treated plot increased compared to the untreated plot but results were not statistically significant (Figure 2). Bunchberry cover was significantly reduced two months after treatment (Figure 3).

CONCLUSION: The phytotoxicity observed in the timing trial is typical for tribenuron methyl applications, but the plants recover without affecting yields. A 0.56 oz/a application of tribenuron methyl resulted in 70% reduction in bunchberry two months after application.

RECOMMENDATIONS: Continue with carryover counts and harvest in 1995.

Figure 1. Effect of Tribenuron Methyl Application Date on Blueberry Phytotoxicity-1994

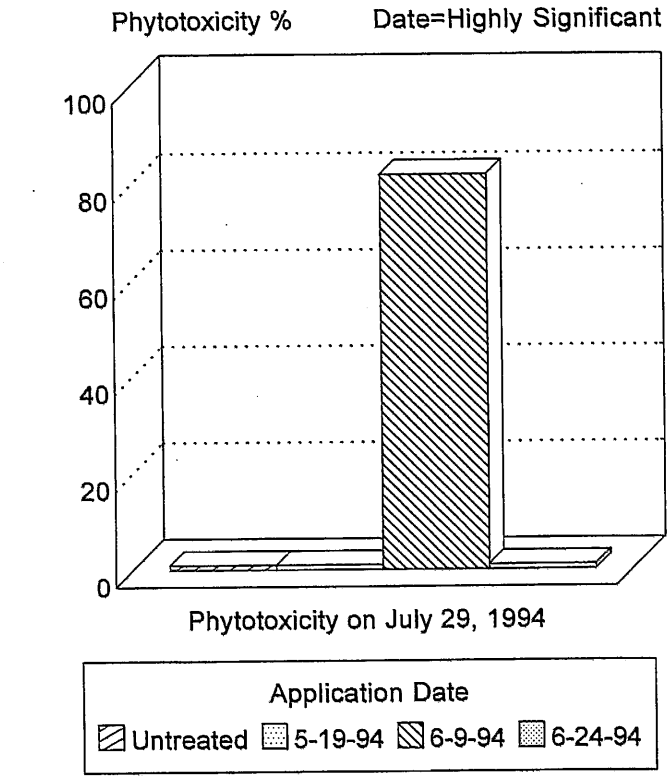


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Figure 2. Effect of Commercial Application of Tribenuron Methyl on Blueberry Cover-BBHF

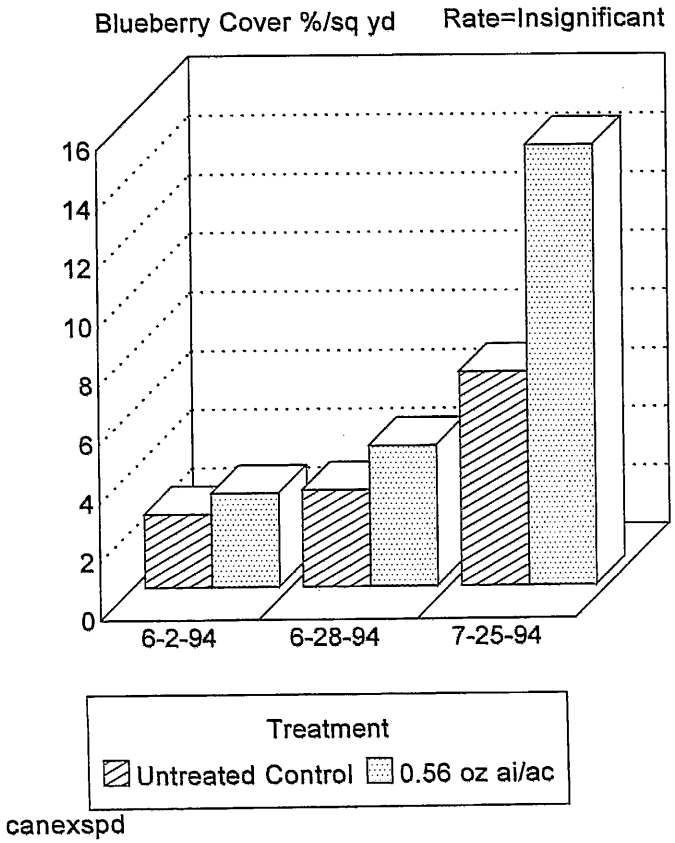

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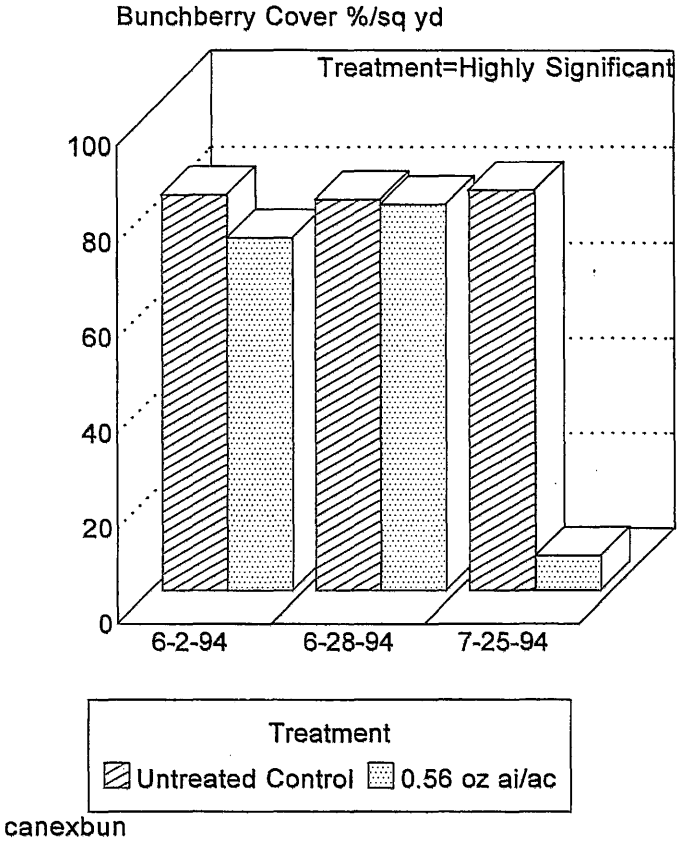
Figure 3. Effect of Commercial Application of Tribenuron Methyl on Bunchberry Cover-BBHF



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

3. TITLE: Evaluation of pendimethalin for Control of Annual Grasses in Lowbush Blueberries.

METHODS: Three, split-block experiments were established, one in Appleton, ME and two at Blueberry Hill Farm, in early May, 1994 to evaluate the efficacy of pendimethalin, a preemergence herbicide, for control of annual grasses and broadleaf weeds. Rates of application were 2.4 and 4.8 qt/a product and an untreated control. The 36 X 20 ft. Appleton site had 10, 1 ft^2 cover plots per treatment. The Blueberry Hill Farm site had 10, 1 yd^2 cover plots per treatment over 3 acres. Weed cover was observed in late May and again in early July, two months after treatment. Another site at Blueberry Hill Farm was treated on 5-11-94 with 1.2, 2.4, 4.8 qt/a product or left untreated. Plot size was 6 X 30 ft with 10, 1 ft^2 cover plots per treatment. Cover was taken on 7-5-94.

RESULTS: Pendimethalin failed to control any weed species at either Blueberry Hill Farm or Appleton at any to the rates applied.

CONCLUSION: Pendimethalin is not effective for controlling weeds in wild blueberries.

RECOMMENDATIONS: Discontinue evaluating pendimethalin.

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

4. TITLE: Evaluation of Time of Application of Clopyralid for Control of Vetch, and Effect on Flowering of Wild Blueberries.

METHODS: Fifteen blocks were set out in a split-block experiment in Addison and were treated on August 16, 1993 with clopyralid at 0.25 lbs ai/a, pulled by hand, or not treated. Phytotoxicity ratings on both vetch and blueberry were taken in late August 1993 and blueberry stems were cut on October 4, 1993. In May, 1994 bloom was assessed for any fusing of the petals, a problem observed on previous Canadian trials with earlier application dates. Cover and phytotoxicity ratings were taken in late July and plots were harvested in August of 1994.

Another experiment was initiated on a commercial field in Whiting in August, 1994. In late August, 10 vetch plants were treated with 0.25 lbs ai/a, 10 were hand pulled and 10 were untreated controls. Vetch cover and phytotoxicity will be taken in June and plots harvested in August, 1995

RESULTS: Observation of the flowers during bloom and activity of bees indicated no effect of treatment on the blueberry flower. Vetch cover one year after treatment was significantly lower in the clopyralid treated plots versus hand pulling and untreated controls (Figure 1). Yields were not significantly different (Figure 2).

CONCLUSION: A later application, early to mid August versus June or July, resulted in no significant effect on blueberry flowers or subsequent yields but provided good suppression of vetch.

RECOMMENDATIONS: Continue to evaluate Whiting trial and establish another experiment on a larger scale in Addison to further evaluate timing and rate recommendations.

Figure 1. Effect of Treatment on Vetch Cover

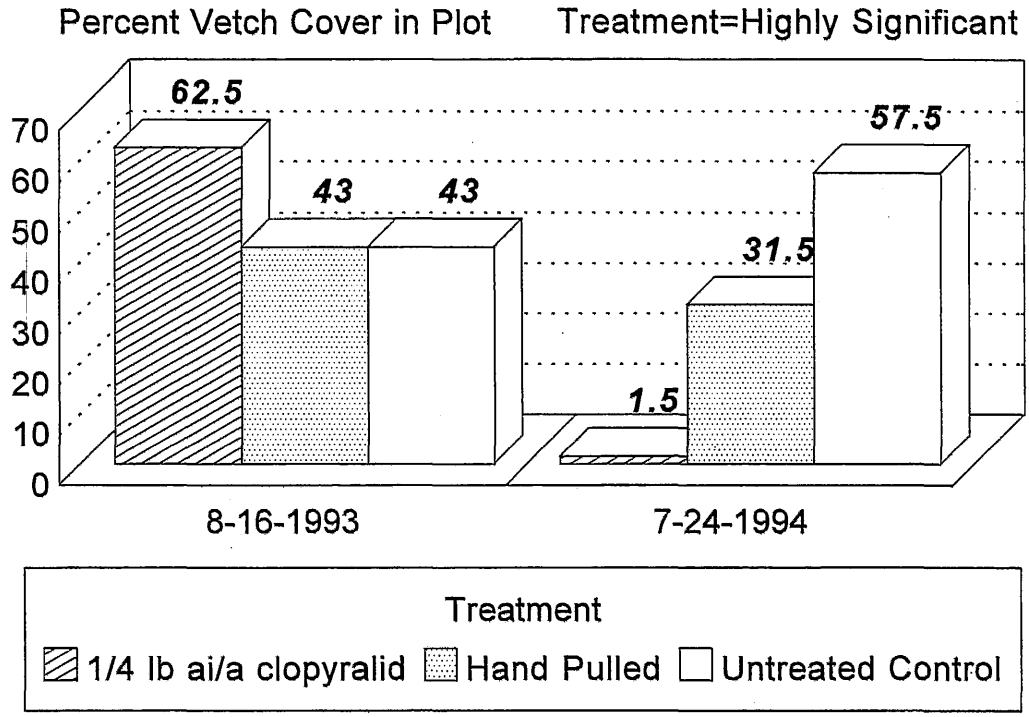

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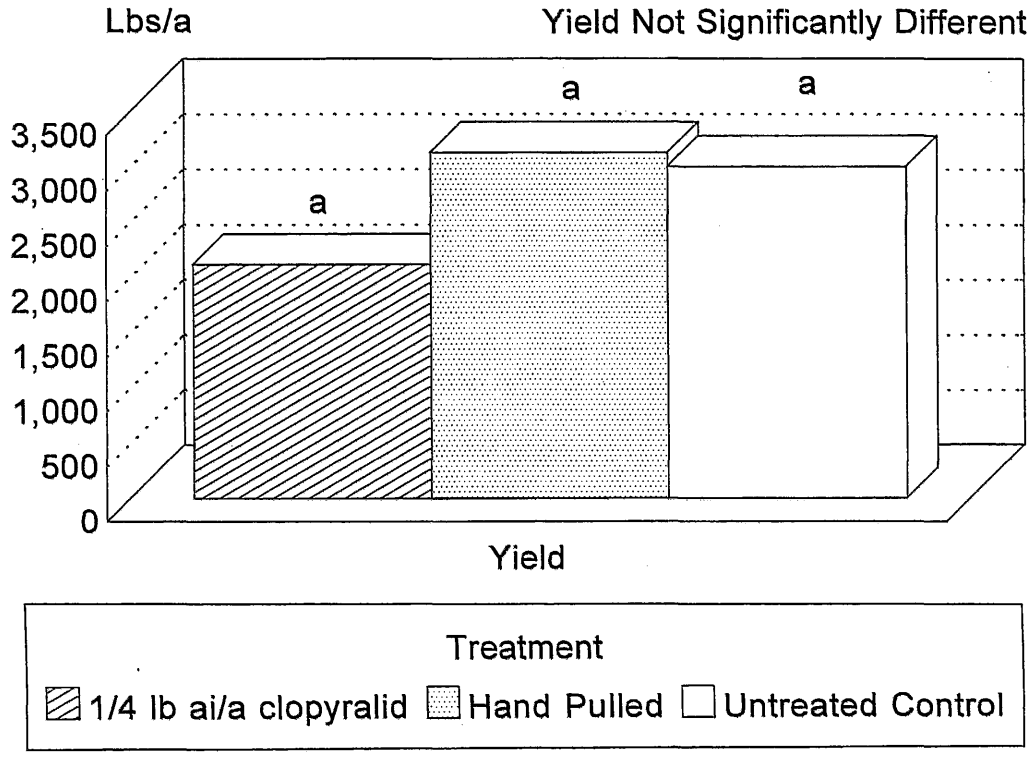
Figure 2. Effect of Treatment on Blueberry Yield



PRINCIPLE INVESTIGATOR: David E. Yarborough, Cooperative Extension blueberry specialist

COOPERATORS: John Jemison, Cooperative Extension water quality specialist

5. TITLE: Hexazinone ground water survey

METHODS: Fifteen wells adjacent to blueberry fields in four counties were sampled in 1994 at 0, 1, 2, 3 and 4 months after hexazinone application. Seven 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 six ponds or streams associated with the well sites, the number associated with the surface sample corresponds to that of the well (Table 1). Soil organic matter, pH and texture was determined for all of the sites. Residue analysis of the well 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 0.05 parts per billion (ppb), and a quantification limit of 0.5 ppb.

RESULTS: The wells tested in 1994 varied from no detects up to a high level of 25 ppb on site 9 (Table 1). Site 9 is a former blueberry field being brought back into production and has poor blueberry cover and stand density. Site 11 is a test well which had over 10 ppb. No drilled wells had a level above 5 ppb. On most wells it appeared that the trend was for hexazinone levels to vary over the summer with a trend of no change or decreasing levels. An exception was site 23, in which hexazinone increased over the summer. The levels of hexazinone in the surface water did not correspond to the wells, but other fields in the area could have been contributing to the levels found.

In the two test wells with the highest levels there is a considerable variation in levels since 1992 (Figure 1). Since there was no hexazinone applied to site 9 since 1992, and this site is isolated, I assume these fluxuations are because of dilution or concentration from rainfall. On site 11 a spring 1994 application resulted in an increase in hexazinone level, but not until August.

In Aurora, two drilled wells, one test well and a pond were sampled in 1994 (Figure 2). The pond shows an initial level followed by a sharp decline. It appears that a field up slope of the pond contributed the hexazinone, but levels in the school well did not rise. The field adjacent to the school was not treated but a much larger field was treated 500 feet from this well. No increase was seen in either the test well or home well even though the hexazinone application was applied on the same field with these wells. A slight increase was noted for the last sampling date for the test and school well but not for the home well.

CONCLUSION: Hexazinone is a very soluble herbicide, and if used on sandy loam soils it has a high potential to leach into groundwater. Hexazinone levels appear to slowly decrease over time with fluxuations associated with water levels. Hexazinone applications may or may not not result in increases in hexazinone levels in the ground water in the same year. Wells will be

resampled in 1995 to determine if levels increase from the previous year's application.

RECOMMENDATIONS: Continue to sample wells to obtain longer term information and expand information on site history, well depth, distance from field. Continue to vary management practices to determine how they influence hexazinone movement in blueberry soils. Continue to emphasize best management practices to growers in educational programs and increase awareness of solubility of hexazinone and potential for well water contamination.

1994 Hexazinone Test Result Summary
University of Maine Well Water Survey
Hexazinone in parts per billion

Site #	May	June	July	August	September
WELLS					
1 drill	3.7	3.3	0	0	0
4 drill	0.9	1.0	1.2	0.6	0
5 test	2.5	1.8	2.1	1.4	1.7
6 test	2.6	4.5	5.0	4.3	5.4
7 test	7.3	2.1	2.9	0.5	2.8
8 test	0.5	0.2	0.4	0.5	0
*9 test	25.4	19.6	24.9	23.1	23.9
10 dug	0.3	0.3	0.2	0.3	0.4
11 test	8.9	7.6	4.3	10.5	11.2
12 test	1.3	2.2	4.5	4.3	5.7
*13 drill	2.4	2.1	2.1	2.1	2.7
21 drill	0.1	0.3	0.2	0.1	0
23 drill	2.2	4.4	2.6	4.8	4.9
24 dug	1.2	0.8	0.5	0.4	0.3
25 drill	0.6	0.5	0.6	0.6	0.6
SURFACE					
4 stream	1.8	1.2	1.7	0.9	1.0
7 pond	0.5	0.4	0.2	0.2	0
13 pond	1.6	0.6	0	0	0
12 stream	-	4.3	4.7	3.9	5.6
24 stream	-	2.6	0.1	2.1	0.2
9 stream	0.1	0.5	0.6	2.1	2.0

*Not treated in 1994

Figure 1. Hexazinone in test wells
1989-1994

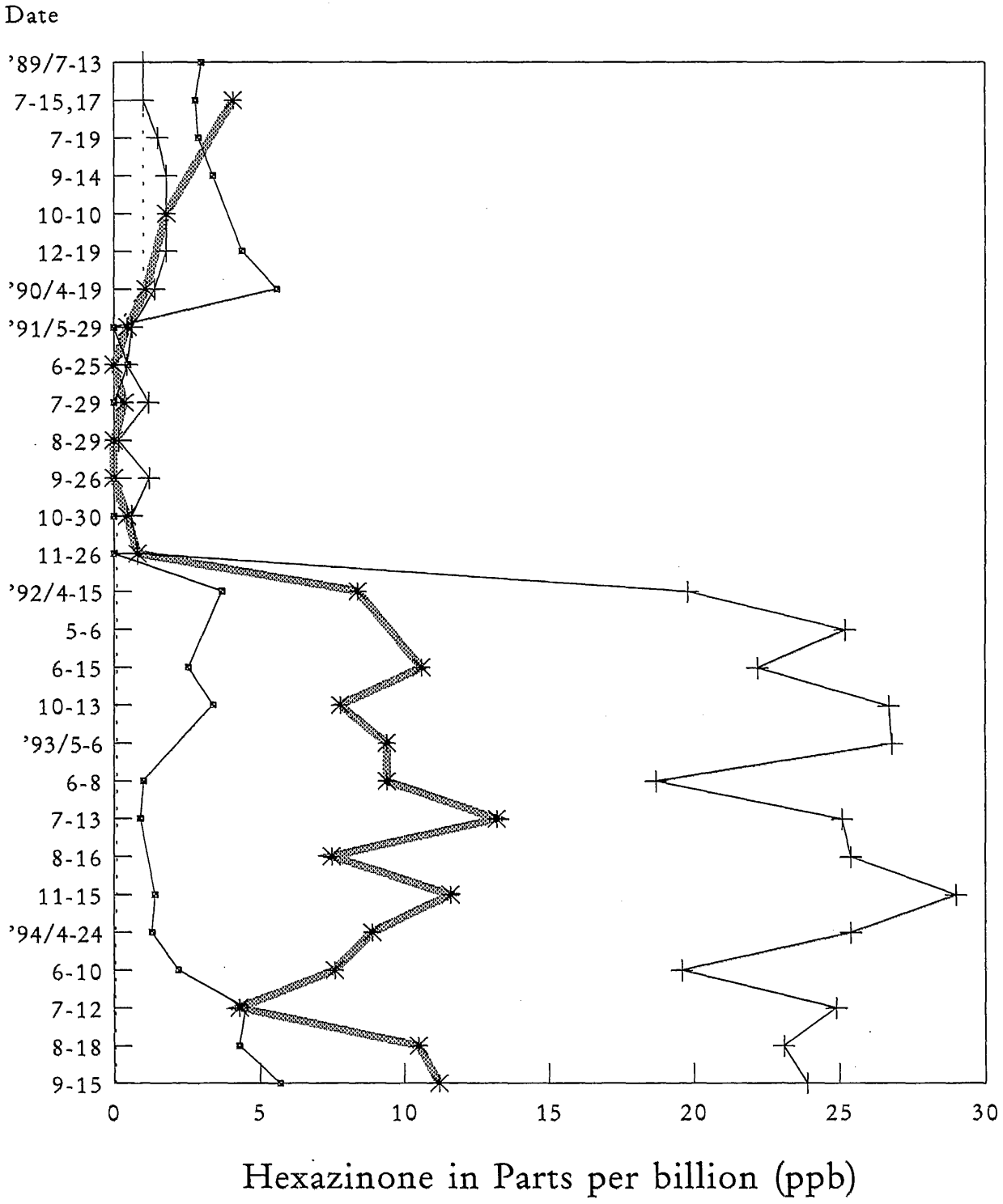
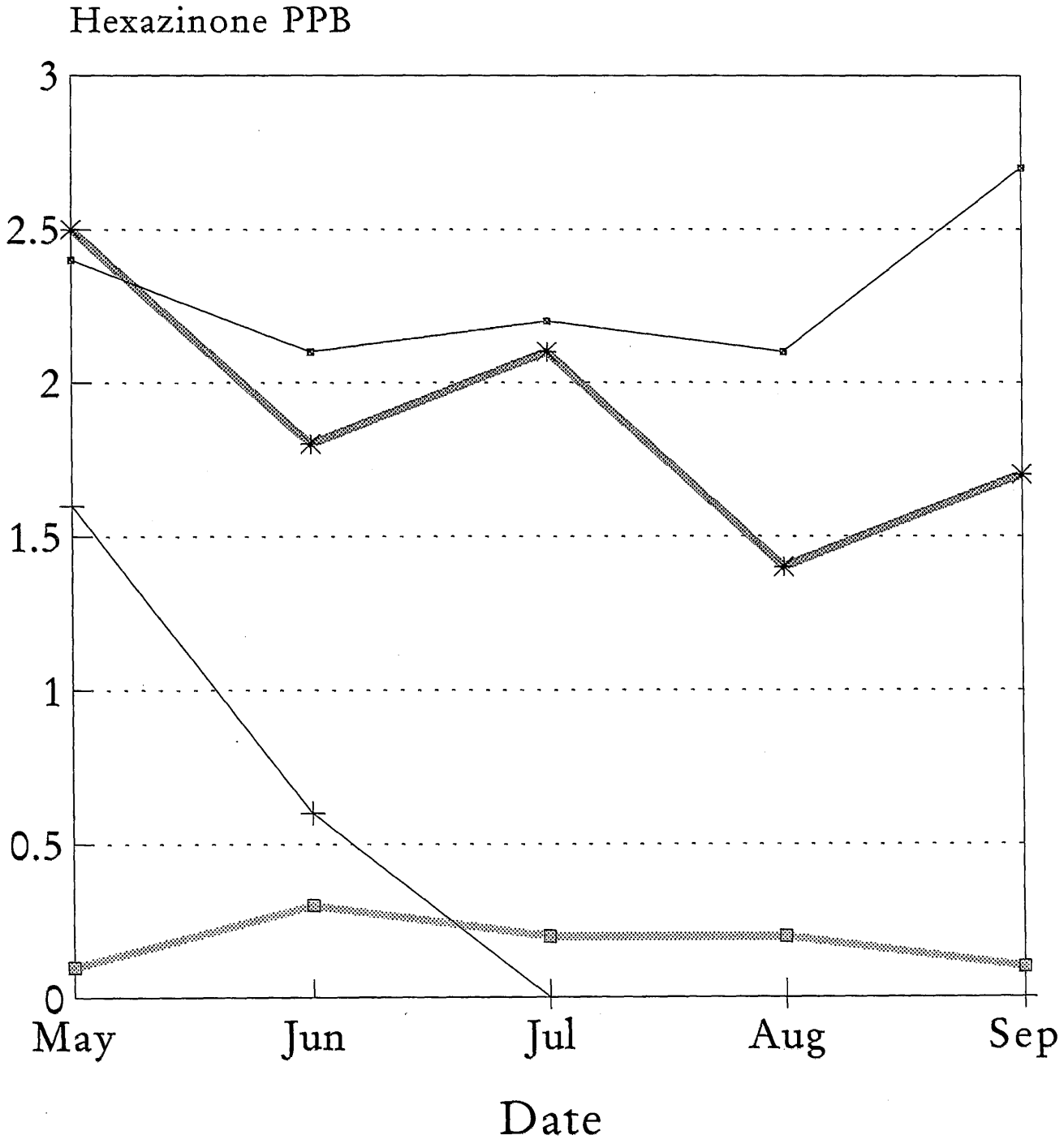


Figure 2. Hexazinone water survey
Aurora test results



Velpar applied 5-23-94 adjacent to test/home wells

PRINCIPLE INVESTIGATOR: David E. Yarborough

6. 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 lowbush 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:

Presented "Effect of Express on Bunchberry in Wild Blueberry Fields" at the Northeastern Weed Science Society Meetings in Baltimore, MD on January 5, 1994.

Discussed "Velpar Well Water Results" on January 19, 1994 with school board and parents at AirLine Community School in Aurora.

Presented "Methods for increasing the Density of Plant Stands in Wild Blueberry Fields" and "Methods for Producing and Harvesting High Quality Blueberries" at the New Brunswick Horticultural Congress. in Moncton, NB on February 12, 1994.

Discussed "Velpar well water survey" on February 16, 1994 with growers at the University of Maine at Machias.

Met with Blueberry Advisory Committee on February 18, 1994 to determine funding needs for 1995. Projects funded for Extension to expand a project to monitor wells for Velpar residue. Information obtained from this project will help establish best management practices for the use of this herbicide.

Gave guest lecture on "Blueberry Management" in Orono for PSE101 on February 24, 1994.

Gave a presentation with small group discussions on "Blueberry Production in North America" to 125 students at the Massabesic Junior High School in Waterboro on March 22, 1994.

1994 Spring Blueberry Meetings held in Ellsworth, March 29, in Union March 30, in South Paris, March 31, and in Machias, Apr. 2. 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 'Effect of Express on bunchberry in wild blueberry fields' and 'Hexazinone ground water survey' at Lowbush Blueberry Research and Extension Workers Conference at Charlottetown, PEI on April 6, 1994.

Discussed ICM program with WQIP growers in Warren on April 19, 1994.

Conducted Cranberry educational program for cranberry growers by sponsoring experts to discuss cranberry management at grower sites. Sessions held in Columbia/Cherryfield on bog construction and erosion control on May 13, in Harrington/Cherryfield on Varieties on May 28, in Columbia on Integrated Pest Management and insect identification on June 11, in Harrington on nutrition and fertilization on June 18, in Jonesboro on diseases on June 29, in Dennisville on frost control , drouth and irrigation on July 14, in Ellsworth on plant growth on July 23 and in Harrington on weed management and mapping on July 26.

Demonstrated Integrated Crop Management field techniques on equipment calibration, determining Velpar rate, and blight identification and control at field days on April 30 and May 7 in Jonesboro, Appleton and Franklin.

Demonstrated Integrated Crop Management field scouting techniques on insect ID and sweeping at field days on May 14 and 21 in Rockport, Blue Hill and Jonesboro.

Demonstrated Integrated Crop Management field scouting techniques on weed management and sampling for plant nutrition at field days on June 22, 23 and 25 in Hope, Orland and Jonesboro.

Discussed non-chemical, cultural alternatives for insect, disease and weed control at Blueberry Hill Farm, Jonesboro on May 21 and June 25.

Chaired session on Blueberry, Cranberry and Peat for Sunrise County Economic Development Council at the University of Maine in Machias on June 14, 1994.

Presented 'Control of bunchberry in wild blueberry fields' at 7th North American Blueberry Research Extension Workers conference in Beltsville, MD on July 7, 1994.

Testified to Pesticide board on Velpar in groundwater on July 8 in Ellsworth.

Discussed Integrated Crop Management at Hancock County Extension Association Annual Meeting in Ellsworth.

Trained growers in blueberry management for pesticide applicators exam on July 13, in Ellsworth.

Presented 'Weed thresholds by mechanical and chemical controls in wild blueberries' at 91st meeting of the American Society of Horticultural Science, in Corvallis, OR on August 10.

Talked to Welsey Club on Blueberry Culture at Blueberry Hill farm in Jonesboro, on August 13.

Held Annual summer field day and crop guesstimate at Blueberry Hill Farm in Jonesboro on July 20.

Released Video on 'Factors Affecting Wild Blueberry Fruit Quality', distributed to Extension offices and to Blueberry Industry members, offered for sale to blueberry growers, over 60 copies in circulation.

Participated in Maine Farm Days in Norridgewalk on August 23 and 24. Explained Maine wild blueberry production to hundreds of attendants.

Explained Maine wild blueberry production to hundreds of attendants of the Big E Agricultural Fair in Springfield, Mass. on September 24-25.

On October 3-6 participated in the regional IR-4 meetings to set minor use priorities in San Juan, P.R.

On October 20-21 met with DuPont management in Wilmington, DE to explain results of well testing program and to discuss Velpar label changes.

On October 29, facilitated first meeting of the Maine Organic Blueberry Growers, determined needs for future sessions to develop programs.

Participated in monthly meetings of the DownEast RC&D Cranberry Committee. Reviewed 1994 Cranberry Educational Program and did needs assessment for 1995 program.

On November 7 and 8, participated in meetings of the Maine Blueberry Advisory Committee. Reported on 1994 Educational program and determined needs for 1995 proposed programs.

On November 14, participated in meetings of the Maine Blueberry Commission. Reported on 1994 Educational program and determined needs for 1995 proposed programs.

On November 29, established uniform criteria for WQIP programs with state and county NRCS and FSA personnel.

On December 10, sponsored second meeting of the Maine Organic Blueberry Growers, to discuss marketing issues and set agenda for future meetings.

Developed new Blueberry Enterprise Budget with Michele Marra and Adam Carmichael, University of Maine Agricultural Resource Economics. Computer version will be shared with Blueberry growers at Agricultural Trade show and at County Extension offices.

I continue to respond to calls and letters on blueberry related matters through my office. Requests range from basic to technical. I responded to over 1200 inquiries in the last year.

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

I update fact sheets as needed and add new ones as pertinent topics occur.

I have contributed 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 1994.

I am coordinator for the CSRS special research grant 'Lowbush blueberry production and processing technologies' which is granted by the USDA; $208,666 was awarded for 1995. I coordinate proposals and reports from the researchers involved.

I am a member of the Cranberry research advisory committee which assists the progress of cranberry development in Maine.

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

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

PRINCIPLE INVESTIGATOR: David E. Yarborough

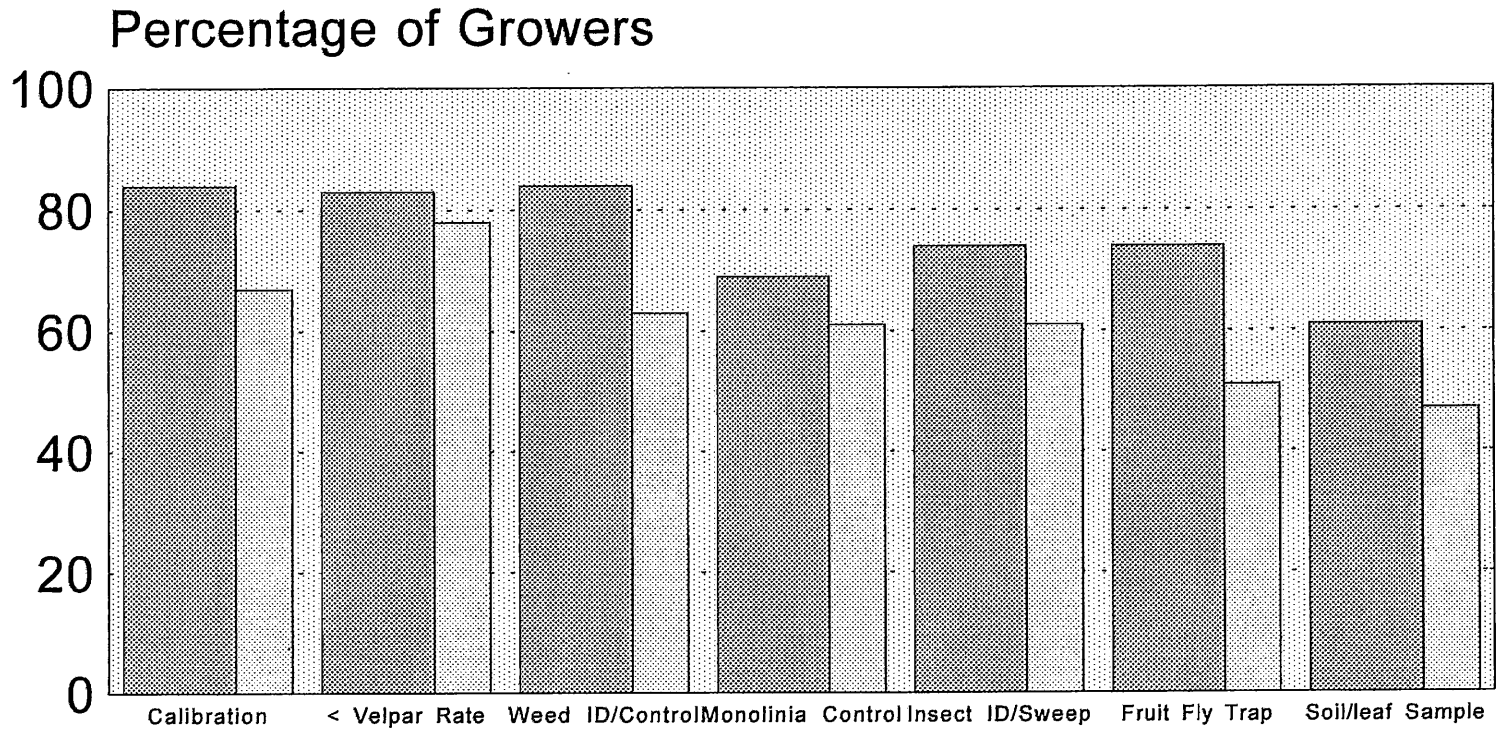
7. TITLE: Blueberry ICM program for Hancock County

COOPERATORS: Marjorie Hundhammer, Hancock County Cooperative Extension
Roland Dupuis, Hancock County SCS
Sue Hill, Hancock County ASCS

RESULTS: Provided field training sessions for 17 growers on 961 acres; this is substantially up from 1993 program of five growers on 50 acres.

CONCLUSION: The ASCS IPM cost share program increased the number of growers in the program in 1994. More interest is being shown in the program and it is expected that participation will increase without advisory committee funding.

1994 Skills Survey Results
Wild Blueberry ICM Educational Program



	Calibration	< Velpar Rate	Weed ID/Control	Monolinia Control	Insect ID/Sweep	Fruit Fly Trap	Soil/leaf Sample
Learned	84	83	84	69	74	74	61
Changed	67	78	63	61	61	51	47

Integrated Crop Management Skills

126 growers in 4 counties on 9296 acres (50% return)
53% do pesticide applications and 45% have pesticide license