3. Dubois, M., D. A. Gilles, J. K. Hamilton, P. A. Reners, and F. Smith. 1956. Colormetic method of determining sugars and related substances. *Anal. Chem.* 28:350-356.
4. Hughes, J. C., R. M. Folks, and A. Grant. 1975. Texture of cooked potatoes: Relationship between the compression strength of cooked potato disks and release of pectic substances. *J. Sci. Food Agric.* 26:731-738.
5. Hoover, M. W. 1955. Influence of maturity and storage treatments upon the ascorbic acid content of seeds of southern peas. *Food Res.* 20:469-473.
6. James, W. O. and J. M. Cragg. 1943. The ascorbic acid system as an agent in barley respiration. *New Pathologist* 42:28-44.
7. Jenkins, W. F. 1954. Postharvest changes in refrigerated and nonrefrigerated southern peas. *Proc. Amer. Soc. Hort. Sci.* 64:327-330.
8. Knapp, F. W. and G. D. Kuhn. 1962. The effects of storage conditions on sugar content of fresh blackeye peas. *Proc. Florida Hort. Soc.* 75:311-317.
9. Kuhn, G. D. 1961. A study of the microbiological activity and other deterioration in cold storage of fresh southern peas. *Proc. Florida Hort. Soc.* 74:259-262.
10. Park, J. W., J. L. Collins, I. W. McCarty, and M. R. Johnston. 1971. Chemical changes and amylase activity of freshly shelled southern peas, *Vigna sinensis*. *J. Amer. Soc. Hort. Sci.* 96:419-421.
11. Pointing, J. D. and M. A. Joslyn. 1948. Ascorbic acid oxidation and browning in apple tissue extracts. *Arch. Biochem.* 19:47-63.
12. Sistrunk, W. A. 1965. Effects of storage time and temperature of fresh beans on chemical composition of the canned product. *Proc. Amer. Soc. Hort. Sci.* 88:380-386.
13. ———. 1965. Influence of postharvest storage of snap beans on chemical and physical changes during canning. *Food Res.* 30:240-247.
14. Smittle, D. A. and G. A. Bradley. 1966. The effects of irrigation, planting and harvest dates on yield and quality of peas. *Proc. Amer. Soc. Hort. Sci.* 86:441-446.
15. ——— and S. J. Kays. 1976. Quality deterioration of southern peas in commercial operations. *HortScience* 11:151-153.
16. Williamson, R. E. and D. A. Smittle. 1978. Quality loss of bulk-handled shelled southern peas during field loading and transport. *Amer. Soc. Agr. Eng. Tech. Paper* 78 – 1027.

*J. Amer. Soc. Hort. Sci.* 104(6):786–789. 1979.

# Barrenberry Control in Lowbush Blueberry Fields through Selective Application of 2,4-D and Glyphosate[1]

**David E. Yarborough and Amr A. Ismail**[2]
*Department of Plant and Soil Sciences, University of Maine, Orono, ME 04469*

*Additional index words.* herbicide, 2,4-dichlorophenoxyacetic acid, N-phosphonomethylglycine, chokeberry, chokepear, *Aronia melanocarpa, Vaccinium angustifolium*

*Abstract.* **Effects of selective contact application of 2,4-dichlorophenoxyacetic acid (2,4-D) or N-phosphonomethylglycine (glyphosate) on a mixed stand of blueberry (*Vaccinium angustifolium* Ait.) and barrenberry (*Aronia melanocarpa* (Michx.) Ell.) were studied using a selective herbicide applicator. The greater height of barrenberry in its second year of growth provided the selectivity. Herbicide application on the burn year reduced both blueberry and barrenberry plant stands. Selective application of glyphosate or 2,4-D reduced the number of barrenberry plants without seriously affecting blueberry plant stem length or fruit bud number when applied to crop year plants after harvest. Higher rates of herbicides resulted in a greater reduction in barrenberry plant stand. Glyphosate or 2,4-D provided adequate control of regrowth of black barrenberry plants in lowbush blueberry fields.**

Lowbush blueberries in Maine are commercially harvested from about 20,000 ha of native stands. Because of the origin and cultural practices employed on these fields most plant species abundant in the native flora are also present. Black barrenberry plants (syn. chokeberry, chokepear) like lowbush blueberry, are low growing with an extensive rhizome system and edible fruit. In recent years they have become widespread in most of Maine's blueberry fields and the problem is increasing in the Maritime Provinces.

Since barrenberry plants are usually interspersed throughout blueberry stands, it is difficult to harvest blueberries without including some barrenberry fruit. Separation of mixed berries is complicated due to their similarity in size, shape and specific gravity. U. S. D. A. standards for frozen berries specify that no more than 10 foreign edible berries in 454 g of blueberries are allowed for class A, 16 for class B and 20 for class C (16).

A properly timed application of (2-chloroethyl)phosphonic acid (ethephon) to mixed blueberry-barrenberry stands will induce abortion of barrenberry fruit (5, 15) without deleterious effects on the yield (5) or quality (4) of the blueberry. Since this method does not limit the presence or spread of the barrenberry and is costly, it has not been widely adopted by growers.

Research efforts to identify a selective herbicide that will control barrenberry without harming lowbush blueberry stand have not been successful (13). A nonselective spray application of 2,4-D has been shown to control 99.5% of the barrenberry but also to eliminate 94.5% of the blueberry stand (14). A selective method of application that places the herbicide on barrenberry plants and not on the blueberry plants is a prerequisite for safe use of 2,4-D for reducing barrenberry in lowbush blueberry fields. Recent development of a modified selective herbicide applicator at the University of Maine (1) that utilizes differences in height between barrenberry and blueberry fields justifies further evaluation of the use of nonselective herbicides for barrenberry control in blueberry fields.

Glyphosate is a nonselective broad spectrum post-emergence herbicide (2, 6, 11). It is effective in controlling perennial rhizomatous plant species (7, 9, 17). When applied selectively, glyphosate has been shown to be safe for use in orchards (3, 8) and vineyards (10).

[1]Received for publication July 13, 1978. Partially supported by funds from the Hatch Act and Maine Blueberry Industry Board.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.
[2]Assistant Technologist and Maine Blueberry Professor of Horticulture.

The objective of this study was to determine the effects of selective application of 2,4-D and glyphosate to black barrenberry in commercial lowbush blueberry fields.

## Materials and Methods

In order to identify a growth stage where optimum selectivity of herbicide application is achieved to control barrenberry with minimum or no injury to blueberry plants, treatments were applied to plants at different stages of development as related to the pruning (burning) cycle. Two concurrent experiments were conducted in adjacent commercial fields; one in newburn (first growing season following pruning) and the other in the first crop year stage (second growing season after pruning). Both fields were located on the "barrens" in Eastern Maine and had a considerable infestation of black barrenberry.

Herbicides were applied to barrenberry stems taller than blueberry plants using a prototype selective herbicide applicator (1) (Fig. 1). The device consists of 2 offset mounted tractor drawn drums, each 61 cm in length and 23 cm in diam. Drums are covered with an absorbent material saturated with herbicide and rotated at 42 rpm counterclockwise to the direction of travel. Skid height was adjusted to miss most of the blueberry plants. The herbicide applicator was then driven at about 0.62 kilometer/hr over the test areas.

Two herbicides, glyphosate at rates of 0, 1.2, 2.4 and 4.8 g/liter active ingredient (a.i.) or the low volatile iso-octyl ester of 2,4-D at 0, 2.4, 4.8 and 9.6 g/liter a.i. with 0.1% X-77 surfactant were applied to 1.2 × 30.5 m plots. Experimental design was a randomized complete block with 4 replications in the newburn treatments and 6 replications in the crop year location. Data were statistically analyzed by analysis of variance, individual degrees of freedom were obtained by regression analysis, and significance was determined with an F test. Due to the greater herbicidal action and higher cost of glyphosate we compared half the concentration of glyphosate to 2,4-D.

In the newburn field, plants were pruned by fire in early spring, 1976 and herbicide treatments were applied to new growth on 1 or 2 dates: July 29 or August 25, 1976.

In the first crop year location, barrenberry and blueberry plants were in their second year of growth, following a burn in the spring of 1975 and were yielding fruit. In this study herbicides were applied on August 25, 1976 after the commercial harvest of the field.

In the fall of 1976, after leaf abscission, experimental areas were covered with straw and pruned by fire in the spring of 1977. The effects of treatment on blueberry and barrenberry

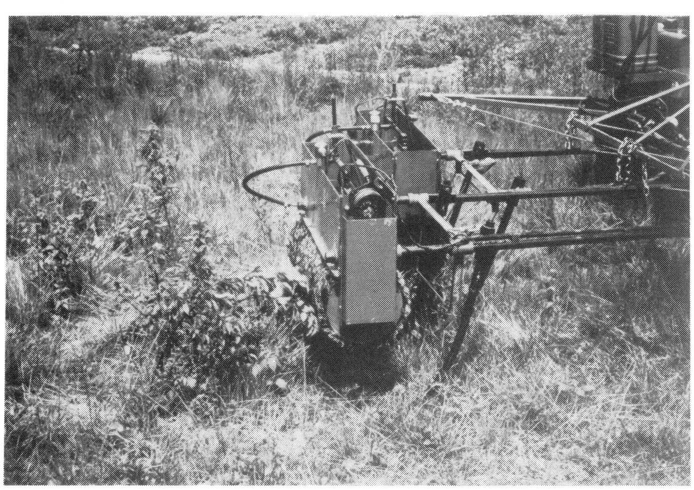

Fig. 1. Prototype of selective herbicide applicator developed at the University of Maine Blueberry Experimental Station in Jonesboro.

Table 1. Influence of 2,4-D or glyphosate applied in the newburn year on changes in blueberry and barrenberry plant stands, (1977).[z]

| Date (1976) | Change in plant stand (%) Glyphosate | 2,4-D |
|---|---|---|
| | *Blueberry* | |
| July 29 | −20.1 | −11.7 |
| August 25 | −24.3 | −25.6 |
| Mean | −22.2 | −18.6 |
| | *Barrenberry* | |
| July 29 | −14.9 | −30.2 |
| August 25 | −41.7 | −27.1 |
| Mean | −28.8 | −28.6 |

| Source of variance | Degree of freedom | F ratio | Significance[y] |
|---|---|---|---|
| *Blueberry* | | | |
| glyphosate × 2,4-D | 1 | 0.500 | ns |
| glyphosate × date | 1 | 0.263 | ns |
| 2,4-D × date | 1 | 2.817 | ns |
| *Barrenberry* | | | |
| glyphosate × 2,4-D | 1 | 0.002 | ns |
| glyphosate × date | 1 | 7.281 | * |
| 2,4-D × date | 1 | 0.945 | ns |

[z]Treated burn year, summer 1976; pruned by fire, spring 1977; evaluated, fall 1977.

[y]* = 5% level, ns = nonsignificant.

Table 2. Influence of rate of 2,4-D or glyphosate applied in newburn year on changes in blueberry and barrenberry plant stands, (1977).[z]

| Rate (g/liter) | Change in plant stand (%) Glyphosate | Rate (g/liter) | 2,4-D |
|---|---|---|---|
| | | *Blueberry* | |
| 0.0 | 0.1 | 0.0 | 7.1 |
| 1.2 | −35.0 | 2.4 | −26.6 |
| 2.4 | −21.3 | 4.8 | −20.5 |
| 4.8 | −32.6 | 9.6 | −34.6 |
| | | *Barrenberry* | |
| 0.0 | −2.7 | 0.0 | −0.3 |
| 1.2 | −10.8 | 2.4 | −24.4 |
| 2.4 | −53.8 | 4.8 | −47.2 |
| 4.8 | −45.9 | 9.6 | −42.8 |

| Source of variance | Degree of freedom | F ratio | Significance[y] |
|---|---|---|---|
| *Blueberry* | | | |
| glyphosate × rate | | | |
| Linear | 1 | 6.173 | * |
| quadratic | 1 | 2.478 | ns |
| cubic | 1 | 6.079 | * |
| 2,4-D × rate | | | |
| Linear | 1 | 12.693 | ** |
| quadratic | 1 | 2.760 | ns |
| cubic | 1 | 3.742 | ns |
| *Barrenberry* | | | |
| glyphosate × rate | | | |
| Linear | 1 | 11.169 | ** |
| quadratic | 1 | 2.969 | ns |
| cubic | 1 | 3.246 | ns |
| 2,4-D × rate | | | |
| Linear | 1 | 8.105 | ** |
| quadratic | 1 | 3.999 | ns |
| cubic | 1 | 0.000 | ns |

[z]Treated burn year, summer 1976; pruned by fire, spring 1977; evaluated fall 1977.

[y]* = 5% level, ** = 1% level, ns = nonsignificant.

Table 3. Effect of 2,4-D or glyphosate applied after harvest on changes in blueberry and barrenberry plant stand, stem length and number of fruit buds per blueberry stem, (1977).[z]

| | Change in plant stand (%) | | Stem length (cm) | | Fruit buds/stem |
|---|---|---|---|---|---|
| Herbicide | Blueberry | Barrenberry | Blueberry | Barrenberry | Blueberry |
| Glyphosate | 24.6 | −9.2 | 9.7 | 13.2 | 1.2 |
| 2,4-D | 38.8 | −16.7 | 10.2 | 15.0 | 1.2 |
| F ratio | 2.000 | 0.617 | 2.390 | 2.928 | 0.029 |
| Significance[y] | ns | ns | ns | ns | ns |

[z]Treated in crop year after harvest 1976; pruned by fire, spring 1977; evaluated, fall 1977.

[y]ns = nonsignificant.

plant stands, vigor and potential blueberry productivity were determined in the fall of 1977 by counting the number of stems from each species present in 4 permanent 0.1 $m^2$ randomly selected quadrats per plot. Percentage change in plant stand was calculated. Barrenberry and blueberry stems were cut to ground level, their length measured and the number of fruit buds per blueberry stem were counted to evaluate vigor and productivity.

## Results

*New burn study.* Glyphosate and 2,4-D applied in the new-burn growth cycle reduced both the barrenberry and blueberry plant stands. Glyphosate application on the second date resulted in a greater reduction in barrenberry plant stand (Table 1). Differences due to herbicides used or date of application were not significant for blueberry stand. While the number of stems on untreated plots increased slightly, increasing herbicide concentration resulted in a significant decline in blueberry and barrenberry plant stand (Table 2).

*First crop year study.* Glyphosate and 2,4-D applied after harvest had the same effect on barrenberry plant stand, stem length and number of blueberry fruit buds per stem (Table 3). An increase in blueberry and a decrease in barrenberry stand were noted with the herbicide application (Table 3).

Table 4. Effect of rate of application of 2,4-D or glyphosate applied after harvest on changes in blueberry and barrenberry plant stands, (1977).[z]

| Rate (g/liter) | Change in plant stand (%) Glyphosate | Rate (g/liter) | 2,4-D |
|---|---|---|---|
| | | *Blueberry* | |
| 0.0 | 56.5 | 0.0 | 43.1 |
| 1.2 | 14.4 | 2.4 | 54.7 |
| 2.4 | 17.3 | 4.8 | 20.4 |
| 4.8 | 10.2 | 9.6 | 37.0 |
| | | *Barrenberry* | |
| 0.0 | 46.0 | 0.0 | 34.4 |
| 1.2 | −8.1 | 2.4 | −17.2 |
| 2.4 | −26.7 | 4.8 | −34.3 |
| 4.8 | −48.0 | 9.6 | −49.6 |

| Source of variance | Degree of freedom | F ratio | Significance[y] |
|---|---|---|---|
| *Blueberry* | | | |
| glyphosate × rate | | | |
| Linear | 1 | 3.858 | ns |
| quadratic | 1 | 2.038 | ns |
| cubic | 1 | 0.988 | ns |
| 2,4-D × rate | | | |
| Linear | 1 | 0.450 | ns |
| quadratic | 1 | 0.352 | ns |
| cubic | 1 | 2.248 | ns |
| *Barrenberry* | | | |
| glyphosate × rate | | | |
| Linear | 1 | 22.395 | ** |
| quadratic | 1 | 3.357 | ns |
| cubic | 1 | 0.407 | ns |
| 2,4-D × rate | | | |
| Linear | 1 | 17.600 | ** |
| quadratic | 1 | 4.027 | ns |
| cubic | 1 | 0.357 | ns |

[z]Treated in crop year after harvest, 1976; pruned by fire, spring, 1977; evaluated, fall 1977.

[y]** = 1% level, ns = nonsignificant.

Table 5. Effect of rate of application of 2,4-D or glyphosate applied after harvest on blueberry and barrenberry stem length, (1977).[z]

| Rate (g/liter) | Stem length (cm) Glyphosate | Rate (g/liter) | 2,4-D |
|---|---|---|---|
| | | *Blueberry* | |
| 0.0 | 10.3 | 0.0 | 10.6 |
| 1.2 | 9.8 | 2.4 | 10.0 |
| 2.4 | 9.8 | 4.8 | 10.6 |
| 4.8 | 8.9 | 9.6 | 9.7 |
| | | *Barrenberry* | |
| 0.0 | 17.4 | 0.0 | 17.8 |
| 1.2 | 15.7 | 2.4 | 14.5 |
| 2.4 | 11.0 | 4.8 | 13.8 |
| 4.8 | 8.6 | 9.6 | 14.0 |

| Source of variance | Degree of freedom | F ratio | Significance[y] |
|---|---|---|---|
| *Blueberry* | | | |
| glyphosate × rate | | | |
| Linear | 1 | 67.728 | ** |
| quadratic | 1 | 34.239 | ** |
| cubic | 1 | 11.407 | ** |
| 2,4-D × rate | | | |
| Linear | 1 | 0.937 | ns |
| quadratic | 1 | 0.129 | ns |
| cubic | 1 | 1.318 | ns |
| *Barrenberry* | | | |
| glyphosate × rate | | | |
| Linear | 1 | 26.042 | ** |
| quadratic | 1 | 0.692 | ns |
| cubic | 1 | 1.290 | ns |
| 2,4-D × rate | | | |
| Linear | 1 | 3.201 | * |
| quadratic | 1 | 2.557 | ns |
| cubic | 1 | 0.195 | ns |

[z]Treated in crop year after harvest, 1976; pruned by fire, spring, 1977; evaluated, fall 1977.

[y]* = 5% level, ** = 1% level, ns = nonsignificant.

Table 6. Effect of rate of application of 2,4-D or glyphosate applied after harvest on number of fruit buds per blueberry stem, (1977).[z]

| Rate (g/liter) | Blueberry fruit buds/stem Glyphosate | Rate (g/liter) | 2,4-D |
|---|---|---|---|
| 0.0 | 0.93 | 0.0 | 0.94 |
| 1.2 | 1.15 | 2.4 | 1.17 |
| 2.4 | 1.38 | 4.8 | 1.46 |
| 4.8 | 1.38 | 9.6 | 1.19 |

| Source of variance | Degree of freedom | F ratio | Significance[y] |
|---|---|---|---|
| glyphosate x rate | | | |
| Linear | 1 | 4.045 | ns |
| quadratic | 1 | 1.239 | ns |
| cubic | 1 | 0.084 | ns |
| 2,4-D x rate | | | |
| Linear | 1 | 1.185 | ns |
| quadratic | 1 | 3.654 | ns |
| cubic | 1 | 0.370 | ns |

[z]Treated in crop year after harvest, 1976; pruned by fire, spring 1977; evaluated, fall 1977.

[y]ns = nonsignificant.

Glyphosate and 2,4-D at all tested rates had no significant adverse effects on blueberry plant stand. When applied in the crop year after harvesting an increase in blueberry plant stand was noted regardless of herbicide applications to adjacent barrenberry plants (Table 4). An increase of 46% in control barrenberry plants was contrasted to significant decline ranging from 8.1 to 48.0% in treated plots.

Increasing glyphosate rate resulted in a significant decline in blueberry and barrenberry stem length (Table 5). The average glyphosate treated blueberry stem was reduced by 1.4 cm when compared to the control while the glyphosate treated barrenberry stem decreased by 8.8 cm. Barrenberry stem length decreased with increasing 2,4-D concentration but blueberry length did not decline significantly (Table 5). Neither glyphosate nor 2,4-D lowered the potential productivity of the blueberry stems as indicated by the number of fruit buds per stem (Table 6).

## Discussion

In this study glyphosate or 2,4-D applied to mixed blueberry-barrenberry stands in the newburn growth cycle provided a significant reduction in barrenberry plants but also caused a considerable decrease in the number of emerging blueberry stems 1 year after treatment and pruning. This reduction is indicative of a lack of selectivity in herbicide application. During the first growing season after pruning, differences in height between barrenberry and blueberry plants were minor. Placement of 2,4-D or glyphosate on either plant species caused a significant reduction in its population. Since yield in lowbush blueberry fields is strongly correlated to plant population (12) and adequate selectivity was not obtained, herbicide application in the burn year is not advised.

Application of glyphosate and 2,4-D in the crop year after harvest was more successful in achieving selectivity as indicated by the reduction in barrenberry plants and the increase in blueberry stand. In the first crop year, which is 2 growing seasons following pruning, a greater height difference existed between blueberry and barrenberry plants. This allowed for better selective herbicide placement. An 8 to 50% reduction in barrenberry stand due to herbicide application in contrast to a 46% increase without herbicide treatment indicates that the method provides a safe and practical means of reducing barrenberry plants in commercial lowbush blueberry fields. This control was achieved with minor adverse affects to blueberry vigor, and no affect to potential productivity. The extent of control (8 to 50%) using selective herbicide application was not as great as that reported by Trevett and Durgin (14) who obtained 99.5% control after spraying a mixed blueberry-barrenberry stand with 2,4-D. However, the practice described in this report is preferable for field application as it has fewer adverse affects on blueberry plants in contrast to broadcast spraying that caused 95.5% reduction in blueberry plant population (14).

It is concluded that black barrenberry plants can be effectively reduced in native lowbush blueberry fields through selective applications of glyphosate or the low volatile iso-octyl ester of 2,4-D after harvest. The method utilizes the differential in height between these two species that was achieved by the second year of growth.



### Literature Cited


1. Anon. 1976. Ninety-second annual report 1976. *Univ. Maine Agr. Expt. Sta.* p. 33-34.
2. Baird, D. D., R. P. Upchurch, W. B. Homsley, and J. E. Franz. 1971. Introduction of a new broad spectrum postemergence herbicide class with utility for herbaceous perennial weed control. *Proc. North Cent. Weed Control Conf.* 26:64-68.
3. ———, N. J. Shaulis, and C. G. Waywell. 1974. Glyphosate for herbaceous perennial weed control in Northeastern apple orchards and vineyards. *Proc. Northeastern Weed Sci. Soc.* 28:205-209.
4. Ismail, A. A. 1973. Effects of preharvest application of ethephon on physical and chemical characteristics of the lowbush blueberry fruit. *Can. J. Plant Sci.* 53:553-557.
5. ———. 1974. Selective thinning of black barrenberry fruit in lowbush blueberries with ethephon. *HortScience* 9:346-347.
6. Jaworski, E. G. 1972. Mode of action of N-phosphonomethylglycine: inhibition of aeromatic acid biosynthesis. *J. Agr. Food Chem.* 20:1195-1198.
7. Parochetti, J. V., H. P. Wilson, and G. W. Burt. 1975. Activity of glyphosate on johnsongrass. *Weed Sci.* 23:395-400.
8. Putnam, A. R. 1976. Fate of glyphosate in deciduous fruit trees. *Weed Sci.* 24:425-430.
9. Rioux, R., J. D. Bandeen, and G. W. Anderson. 1974. Effects of growth stage on translocation of glyphosate in quackgrass. *Can. J. Plant Sci.* 54:397-401.
10. Rogers, R. A., T. J. Zabadal, D. E. Crowe, and T. D. Jordan. 1978. The relation of the phytotoxicity of glyphosate to its injury-free use in vineyards. Part II. Injury-free use in New York Vineyards. *Proc. Northeastern Weed Sci. Soc.* 32:254-259.
11. Sprankle, P., W. F. Meggitt, and D. Penner. 1975. Absorption, action, and translocation of glyphosate, *Weed Sci.* 23:235-240.
12. Trevett, M. F. 1962. Nutrition and growth of the lowbush blueberry. *Maine Agr. Expt. Sta. Bul.* 605.
13. ———and R. E. Durgin. 1971. Chokepear in lowbush blueberries. *Res. Life Sci.*, (Maine Agr. Expt. Sta.) 19(1):11-15.
14. ——— and ———. 1973. Leaf dessicants and the selective eradication of barrenberry (*Pyrus floribunda* and *Pyrus melanocarpa*) in lowbush blueberry fields. *Res. Life Sci.* (Maine Agr. Expt. Sta.) 20(9):1-6.
15. ——— and ———. 1973. Progress report on the selective abortion of black barrenberry fruit in lowbush blueberry fields with ethephon (2-chloroethyl)phosphonic acid. *Res. Life Sci.*, (Maine Agr. Expt. Sta.) 20(11):1-8.
16. U. S. D. A. 1955. United States Standards for grades of frozen blueberries. May 7, 1955. Washington, D. C.
17. Zandstra, B. H., C. K. H. Teo, and R. K. Nishimoto. 1974. Response of purple nutsedge to repeated applications of glyphosate. *Weed Sci.* 22:230-232.