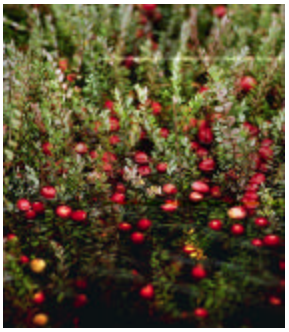
Crop Profile for Cranberries in New Jersey

General Production Information



- Cranberries are a high-value crop assessed at almost $275 million nationally; nearly 5.50 million barrels of fruit were produced on 35,700 acres in 1997 in the United States (70).
- In 1997, Wisconsin was the leading cranberry producer, followed closely by Massachusetts. New Jersey ranked third at 10 percent of the total national output (1).
- Cranberry was the third top agricultural commodity for New Jersey in 1997; cranberry sales accounted for 4.5% of New Jersey's total farm receipts (69). In 1997, New Jersey harvested 582,000 barrels of fruit at a value of nearly 33 million dollars. The 1997 crop showed a 20% increase over 1996 (70).

Production Regions

Cranberries are grown commercially in the Pine Barrens of New Jersey on approximately 3,900 acres. Production is centered around the towns of Chatsworth and Pemberton in Burlington County. Thirty-five of New Jersey's 47 cranberry farms were located in Burlington County in 1997 (71). The majority of the remaining farms were located in the nearby counties of Atlantic and Ocean (1, 71, 50).

Cultural Practices

The cranberry is a woody evergreen perennial that grows vegetatively by horizontal stems called 'runners', and reproductively by vertical shoots from the leaf axils of the runners called 'uprights'. The white cranberry flowers produced on uprights give rise to clusters of the cranberry fruit. Although the cranberry is self-pollinating, the introduction of bees to a bog increases the yield (5). Cranberry vines have been traded across state borders since the nineteenth century. This practice continues today. However, as cranberry cultivation becomes more intensive, the threat of new and destructive pests and pathogens may soon require an additional certification process (52).

Important cultural practices for maintaining good productivity of established beds include: pruning (or 'mowing'); sanding; fertilization; and water management. Cranberry beds can be pruned after harvest to stimulate the production of vigorous uprights that will produce more fruit; this is reportedly not a typical practice by New Jersey growers (54). Pruning also prevents runners from becoming matted and thus reducing crop productivity (62). Mowed beds may produce no yield the year following mowing. The cuttings resulting from mowing are baled and can be used to establish new beds (5). Six- to eight-inch lengths of vine cuttings are scattered uniformly over the sand, and are then disked to a depth of 3 to 4 inches. Cranberries are grown over naturally acidic peat bogs in beds that have been drained, cleared, leveled, and covered with sand before the crop is planted with selected vines (15). Approximately 5 years are required for a newly established bed to reach full commercial production (52). Commercial cranberry bogs are harvested from 100 to 130 days following bloom (82).

Sanding is a practice where a thin layer of sand is spread over the cranberry beds in order to stimulate new root and vine growth, improve aeration, and promote surface water drainage. New Jersey growers typically sand 1 to 1.5 inches every 3 to 4 years (54). The sand layer provides a better rooting zone for cranberries than the natural peat itself, and helps reduce weed seed germination (62). This practice may suppress some insects and pathogens (52). Sanding can be used to level out low spots to make dry harvesting easier and to accelerate decomposition of the trash layer to make more nutrients available (12, 14, 18, 52). Additionally, sanding helps maintain uniform water levels throughout the bed (5).

Fertilizers are applied as necessary for optimum growth and to prevent deficiencies. Ammonium or urea nitrogen, and other major and minor elements are applied in granular or liquid formulations (62). In New Jersey, most fertilizers and pesticides are applied by air as granules rather than as liquids using sprinkler systems (52, 54). The exception is pronamide (Kerb 50 WP), used to control dodder (43). The optimum pH range for growth of cranberry is approximately 4.0 to 4.8 pH units; monitoring is necessary as an excessively high pH may induce nutrient deficiencies in the crop (29).

Large quantities of water are needed in cranberry production. Surface waters, such as lakes, streams, and ponds, are used as a constant water supply for irrigation, frost protection, heat protection, and, in some states, application of fertilizers and pesticides through permanent solid-set sprinkler systems. In the northeast, cranberry beds are typically flooded with water in December to protect the vines from winter injury due to low temperatures. Most growers leave this

winter flood in place until spring. However, some growers, especially in Massachusetts, will remove the winter flood when air temperatures rise during the winter months and will then re-flood when temperatures begin to drop. This practice of water removal and re-flooding is believed to reduce the chances of creating conditions of oxygen deficiency (52).

New Jersey cranberry growers using sprinklers for frost protection remove flood from the beds in late March or early April. This early flood removal extends the growing season by a month or more and thereby increases crop yield. It also helps to further avoid spring oxygen deficiency for cranberries. However, earlier-drawn bogs are more difficult to pollinate, and may require installation of additional honeybee hives. New Jersey cranberry growers lacking sprinklers for frost protection hold flood until early May. May flood drainage brings rapid lush growth in the bogs. Pest problems, particularly insect, vary depending upon the time of flood drawing (*see 'Insect Controls' below*) (23).

Cranberries are harvested in two ways, depending on the region and intended crop use. Dry harvest utilizes a picking machine that combs the berries off the vines, and may also prune the runners that come in touch with its multiple knives (37, 62). Dry-picked berries are typically sold for the fresh market. Water harvest is generally used for berries intended for processing (mainly juice) (5).

New Jersey harvests more than 95% of its cranberry crop by water harvesting. A small percentage of the crop is dry-harvested for fresh market sale (52). The harvest season in New Jersey for cranberries is typically late September through October (54). Beds are flooded just prior to harvesting. A water-reel, commonly called a 'beater', knocks the berries off the vines and the buoyant berries rise to the water surface. The floating berries are moved with booms to one corner of the flooded bed and are then loaded onto trucks by conveyor belts or pumps (37).

Although water harvesting is more efficient than dry harvesting, water harvesting can reduce the keeping quality or shelf life of the fruit. The immersion in water and bruising of the fruit by the water reel can promote dispersion of spores and infection by fungi that cause black rot (66). In addition, bruising will promote development of latent fungal infections into active fruit rotting infections. Due to the high fungal rot pressure in New Jersey, all water-harvested fruit is used in processing for juice or other products (52). Water-harvested berries can be frozen until required by processing plants, or dried prior to packaging for fresh-market sale (24).

Insect Pests of Cranberry

Insect pests of cranberry in New Jersey versus other parts of the nation vary considerably in terms of relative importance (54). The top five insect pests for New Jersey cranberry are listed directly below, and are followed by insect pests of lesser import relative to New Jersey cranberry.

Spotted fireworm [*Choristoneura parallela* (Robinson)] is considered the most important insect pest of cranberry in New Jersey (54). It is currently not reported as a cranberry pest nationally; bogs that are regularly flooded do not manifest infestation (2).

First-generation larvae overwinter on bog floors. In spring (late April, early June), these larvae typically feed between uprights they have webbed together. Fireworm larvae characteristically injure the foliage such that it turns brown, as if burned (2). In New Jersey, first generation adult moths emerge the first week of June, followed by second-generation adult emergence in early August (54). Their larvae emerge in mid-August, causing further damage to cranberry crops by the feeding and scoring of cranberry fruit.

Sparganothis fruitworm [*Sparganothis sulfureana* (Clemens)] is a primary cranberry pest of the East Coast, including New Jersey, overwintering as an early instar caterpillar (54, 2). The larvae of the first generation are indirect pests, feeding on new foliage and flowers, often webbing one or more terminals together, similar to that of fireworms (37). Second generation larvae feed on foliage but also cause direct damage by boring into the fruit and consuming three to five berries during development (4). This fruitworm typically ejects the frass, leaving the berry clean inside. This pest is more of a problem in areas where there are routine sprays of broad-spectrum organophosphate pesticides (54).

Cranberry blossomworm [*Epiglaea apiata* (Grote)] is estimated to be the third most important insect pest of cranberry in New Jersey (54). Although a common pest in Massachusetts' bogs, numbers are typically small (2). The larvae of these cutworms initially impact cranberry crops by feeding on leaves and boring into buds. Fruit production is further decreased as maturing larvae nip off cranberry blossoms.

The impact of cranberry blossomworm on crop production in Massachusetts relates to the time of flood removal (2). Early flood removal in April results in initial cranberry blossomworm larvae development in mid-May when

buds and blossoms are an abundant food source for developing larvae. If flood is held later, cranberry blossomworm larvae are not present until late May/ early June, and do not impact cranberry crop production as greatly.

Blackheaded fireworm [*Rhopobota naevana* (Hübner)] is a sporadic pest in New Jersey and the East Coast in general (54). It is a primary pest of the cranberry in Wisconsin, and on the West Coast. It overwinters on cranberry leaves as eggs that hatch in early spring. Control can sometimes be affected by spring flooding of beds (80). Larvae feed primarily on terminal foliage, webbing the terminals together, frequently destroying buds and skeletonizing leaves, giving the vines a characteristic burnt appearance. If larvae hatch before cranberry buds begin growing, they will starve to death without the need for chemical controls (80).

In New Jersey, second-generation larvae hatch in early June (during bloom and early berry set) and feed on foliage, flowers, and fruit (54). The first generation larvae are indirect pests as foliar feeders. First-generation moth flight peaks in New Jersey around the second week of June. The second-generation larvae feed on blossoms and fruit and are generally the most damaging.

Gypsy moth (*Lymantria dispar*) is another serious insect pest of cranberry in New Jersey (54). Gypsy moth populations in Massachusetts' bogs are highly variable from year to year. Overwintering eggs are often killed extensively in northern New England as temperatures drop below 25• (2).

Infestation of bogs by gypsy moth occurs through overwintering of eggs on the bog floor, wind drift of newly-hatched larvae, dropping of larvae from overhanging trees, and crawling of later stage larvae onto bogs from surrounding uplands (2). Their larvae are early-season foliage feeders, attacking terminal buds first and leaving outer scales. This makes early detection, and control, difficult. Further, bogs often do not yield well until the second year after infestation has occurred.

A brief description of other cranberry insect pests that are of lesser import for New Jersey growers, as well as those pests that occur elsewhere in the nation follows.

Cranberry fruitworm [*Acrobasis vaccinii* (Riley)] *i*s considered nationally the most economically important insect pest of the cranberry, causing direct damage to maturing berries (37). It is the most serious and widespread pest of Massachusetts' cranberry (2). In New Jersey, the cranberry fruitworm is a major pest of blueberries, but not cranberries (54). There is a single generation per year. This pest overwinters as larvae encased in a hibernaculum. Adults emerge in mid-June to late July and deposit eggs singly at the blossom end of berries.

The character of injury by the cranberry fruitworm is very different compared to other fruitworms. Larvae feed only on developing berries, consuming seeds and pulp before moving to an adjacent fruit (25, 46). Three to six berries are normally eaten by each larva (25). Infested fruits become frass-filled, redden prematurely, and later dry and shrivel on the vine (2).

Cranberry tipworm [*Dasineura oxycoccana* (Johnson)] is considered an important pest of cranberry on the East Coast and Wisconsin**.** But, it is not considered a major pest of New Jersey cranberry bogs (54).

Eggs are laid at the tip of growing uprights. The larvae feed on the leaves for about 10 days (25). Developing terminals fed upon by larvae develop cupped leaves and the apical meristem is killed (36). The long-term effect of feeding injury on cranberry production is uncertain but the extent of the damage is relative to the length of the growing season. In areas where damage occurs early in the season, plants have time to recover. Alternately, in areas where tipworm damage is later in the season, crop losses are much higher (54).

Cranberry girdler [*Chrysoteuchia topiaria* (Zeller)] is an important but sometimes sporadic pest nationally. This is an occasional pest in New Jersey bogs (54). Larvae live in leaf litter on the bog floor. Accordingly, bogs that are sanded regularly (i.e., every 3 to 4 years) typically do not have a problem with this pest. These pests feed on the bark and wood of the cranberry vines from late July to until after harvest. Girdled vines die and lose their leaves, resulting in thin or dead spots in the bed; but damage to the vines is often not apparent until the following spring (57, 59).

Other cranberry pests of lesser concern in New Jersey include: the **spotted cutworm** [*Xestia* sp. (Franclemont)]**, false armyworm** [*Xylena nupera* (Lintner)]**, cranberry flea beetle,** and the **cranberry rootworm** [*Rhabdopterus picipes* (Oliver)] (54).

The **brown and green spanworms** [*Ematurga amitaria* (Guenee) and *Itame sulphurea* (Packard)] are sporadic cranberry pests of New Jersey, and are considered a very minor concern (54). Larvae hatch just before and

during blossom; they feed on foliage, buds, and blossoms (25). The brown spanworm is more damaging than the green spanworm and causes serious losses when numerous (25). Several other species of spanworm cause similar damage to cranberry.

The **black vine weevil** [*Otiorhnychus sulcatus* (F.)] is a cranberry pest in other areas of the nation. It is the most destructive insect pest in Washington State and Oregon (62). However, root weevils are not currently considered a problem in either New Jersey or Wisconsin, and are a sporadic pest in Massachusetts (54).

Insect Control

Cranberry growers have utilized **integrated pest management** (IPM) practices since 1986. As part of IPM implementation, pest management procedures were developed to improve the timing of pest controls. Cranberry beds are now monitored to determine presence and numbers of pests; over 75% of the cranberry acreage in New Jersey is currently scouted (54). In New Jersey, there is heavy reliance on insect monitoring and using economic thresholds to determine the appropriateness and timing of chemical controls. There is good grower acceptance of IPM within the cranberry industry.

Good **sanitation** in and around the beds helps reduce some pest problems. Mowing and removing vegetation around the perimeter of beds destroys weeds that may serve as alternate hosts for insect pests.

Sanding can also reduce infestations of cranberry girdler, green spanworm, and cranberry tipworm (12, 40, 59). Sanding also enhances the effectiveness of insecticides by restricting larval girdler activity to a location where there will be no interference by insecticide binding to organic matter on the bed surface (33).

Utilization of **flooding** at various times throughout the growing season is a traditional method of pest control that can delay the emergence of certain insects (12). However, it is reported that this pest control method is not typically practiced because of logistics problems (54). Cranberry pests controlled by flooding include Sparganothis fruitworm, cranberry fruitworm, cutworms, false armyworm, green spanworm, fireworms, cranberry scale, and mites. These terrestrial species are not well adapted for survival when submerged in water for long periods. In New Jersey, the timing of winter flood removal directly affects pest populations. Fireworm and cranberry fruitworm populations are reduced when winter flood is held until early May. However, tipworm infestation is encouraged by the lush growth that follows May flood drawing. Recent data suggests that tipworm populations are reduced when with an earlier winter flood removal in late March or early April (23). New Jersey growers are now drawing water at least 2 to 3 weeks earlier than in the past. It is postulated that this has contributed to an increase in pest populations (54).

The use of **pesticides** in the different cranberry growing regions is dictated by the pest complex and intensity of pest pressure, the time of year and weather conditions, specific management objectives, and the properties of the pesticides. In New Jersey, more than 80 percent of the cranberry acreage is treated with pesticides using fixed-wing airplane, while the remainder is treated using ground equipment (54). Alternately, most pesticides are applied elsewhere in the United States using groundspray units; some are also applied aerially or through chemigation systems. .

The top seven insecticides applied to New Jersey cranberry in 1997 were determined according to grower records of total pounds active ingredient applied (50).

Chlorpyrifos (Lorsban 4E) is registered to control fireworms, cranberry fruitworm, brown spanworm, Sparganothis fruitworm, cutworms, and cranberry weevil. Insecticide should be applied when insects become a problem at 1.5 to 3.0 lb a.i./A by either by ground, air, or by chemigation. In New Jersey, the majority of sprays are aerially applied (48, 54). Two applications per year and are allowed with a 60-day pre-harvest interval. Seventy-five percent of all cranberry acres are treated with chlorpyrifos.

Chlorpyrifos ranked **first (51.56%)** of insecticides used on cranberry in New Jersey for 1997; 3,196.126 lbs. a.i. were applied (50).

Azinphos-methyl 50WP is registered to control fireworms, Sparganothis fruitworm, and cranberry fruitworm. The 2S and 35WP formulations are also registered for use against cranberry tipworm. Insecticide should be applied at 0.5 to 1.0 lb a.i./A by aerial application when insects become a problem, with a maximum of three applications per year and a 21-day interval before harvest. Azinphos-methyl is applied to 43% of the national cranberry acres. Azinphos-methyl ranked **second (24.90%)** of insecticides used on cranberry in New Jersey for 1997; 1,543.429 lbs. a.i. were applied (50).

Carbaryl (Sevin, carbaryl) is a broad-spectrum insecticide registered to control fireworms, cranberry fruitworm, cutworms, elm spanworm, and leafhoppers. Several liquid formulations are available for use at 1.5 to 3.0 lb a.i./A

by ground application as needed every 7 to 10 days. There is a one-day interval required before harvest. Six percent of the all cranberry acres are treated with carbaryl. Carbaryl ranked **third (12.78%)** of insecticides used on cranberry in New Jersey for 1997; 792.106 lbs. a.i. were applied (50).

The use of carbaryl on cranberry in 1997 was uncharacteristically high due to infestation by cranberry tipworm (54). It is anticipated that carbaryl use can be replaced by imidacloprid in the future (see below), available for use on cranberry in New Jersey under a Section 18 Emergency Exemption since July 1999.

Diazinon 50W, AG500, AG600, and 4EC are organophosphate insecticides registered to control blackheaded fireworm and cranberry fruitworm. Applications against these insects also control other pests such as spanworms and other fireworms. Insecticide should be applied at 2 (fireworm) or 3 (fruitworm) lb a.i./A by ground equipment when insects appear, and repeated as needed, with a 7-day interval before harvest.

Diazinon 14G was previously registered on a Section 24(C) label only for control of larvae of the cranberry girdler, applied at 3 lb a.i./A. Novartis (Geigy) Diazinon 14G is no longer labeled for use in cranberries; however, UAP's Diazinon G14 is currently labeled (under a 24(C) Special Local Need registration) for girdler control in New Jersey (54). In Wisconsin, this granular formulation cannot be applied by air, or within 10 feet of ditches, and is limited to one application per year. Two applications of the granular formulation are permitted in other states, with a 7-day interval before harvest in all areas.

Diazinon is applied to 64% of the national acreage. Diazinon ranked **fourth (8.89%)** of insecticides used on cranberry in New Jersey for 1997; 550.920 lbs. a.i. were applied (50).

Acephate 75S is registered for control of fireworms, blossomworm, false armyworm, gypsy moth, spanworms, and Sparganothis fruitworm. Two 1 lb a.i./A ground, aerial, or chemigation applications are permitted each season with a 75-day interval before harvest. It should not be applied from the start of bloom until all berries are set. Acephate is applied to 20% of the national cranberry acres. Acephate ranked **fifth (1.68%)** of insecticides used on cranberry in New Jersey for 1997; 104.115 lbs. a.i. were applied (50).

Pyrethrins are contact botanical insecticides derived from the flowers of *Chrysanthemum cinerariaefolium*. Synergists are necessary to produce rapid knockdown and good kill at an economic level. The most useful combination is 1:2:3.3 parts pyrethrins, the synergists piperonyl butoxide**,** and N-octyl bicycloheptene dicarboximide (Pyrenone Crop Spray). This insecticide is registered for control of numerous insects at 1 - 3 lb a.i./A with no harvest restriction. It is often combined in tank mixes with other insecticides for faster and better control where insect resistance may be a problem, and as an exciter to flush out insects. Pyrethrins are used on 40% of the national cranberry acres. Pyrethrins ranked **sixth (0.18%)** of insecticides used on cranberry in New Jersey for 1997; 11.022 lbs. a.i. were applied (50).

Bacillus thuringiensis* var. *kurstaki (Btk, Dipel ES, MVP, MVPII, Cutlass, Crymax, Agree, Mattch) and ***Bacillus thruringiensis* var. *aizawai*** (Bta, Xentari) are microbial insecticides used for control of most lepidopteron larvae with high gut pH. Dipel ES is registered for control of spanworms, gypsy moth, blossomworm, and false armyworm at 1 quart/A with no harvest restriction. Dipel was the first brand to be registered for use on cranberry. Other brands are now registered. Nine percent of all of the cranberry acres are treated with Btk. *Bacillus thuringiensis* var. *kurstaki* ranked a distant **seventh** of insecticides used on cranberry in New Jersey for 1997; 0.258 lbs. a.i. were applied (50). Bt's are most effective against early instar larvae (54).

Other insecticides for use on cranberry include:

Tebufenozide (Confirm 2F) is an insecticide that will manage caterpillar pests such as blackheaded fireworm and Sparganothis fruitworm**.** Tebufenozide received a Section 18 Emergency Exemption for use in New Jersey on blackheaded fireworm in March of 1998; it was withdrawn in May of 1999 (76). However, tebufenozide received pesticide tolerances for various crops, including cranberry, effective in April of 1999 (78). Thus, New Jersey cranberry growers did not report use of tebufenozide for 1997 (50). Preliminary reports indicate that approximately 1,000 acres of cranberry were sprayed with tebufenozide in 1999. Tebufenozide is being used in place of organophosphates used extensively during bloom; typical use is now approximately about 250 to 350 lb a.i. per year (54). This product is a reduced-risk insecticide (74).

Imidacloprid (Admire 2F) received a Section 18 Emergency Exemption for use in New Jersey on cranberry for control of cranberry rootworms from July 21, 1999 through June 1, 2001 (76). Thus, this insecticide was not used on cranberry in 1997 when growers reported pesticide use. It is anticipated that this insecticide will likely be available in 2000 under a Section 3 label (54).

Cryolite is bait for control of the adult black vine weevil **on the west coast.** It consists of 12 lb a.i./A of the naturally occurring mineral sodium alumino-fluoride in a dry apple presscake. The bait is broadcast over the bed with a rotary spreader. Because this is a relatively new product, usage information was not available at the time of this report.

Nematodes that kill insects are commercially available for use in cranberry beds for control of black vine weevil, and are being tested for control of cranberry girdler and other soil-inhabiting pests. Insect parasitic nematodes are well adapted to the environment of the cranberry root zone; i.e., its high soil moisture, lack of direct sunlight, and temperature. Commercially available nematode species recommended for target cranberry pests include: *Steinernema carpocapsae* and *Heterohabditis bacteriophora*, and *H. marelatus* for girdler; *H. bacteriophora* and *H. marelatus* for blackvine weevils and strawberry rootweevils; and *H. bacteriophora* for cranberry rootworm (55). Nematodes *Steinernema carpocapsae* and *S. glaseri* are formulated for application at 1 to 3 billion per acre. One or two applications are usually sufficient. Nematodes may be applied through chemigation, boom sprayers, and/ or air spray. The majority of nematode applications to cranberry occur through chemigation. Three percent of the national cranberry acreage receives nematode treatments.

No-Mate BHF is a mating disruption pheromone used to control the blackheaded fireworm; it was nationally registered for use in 1998. Currently, its use is not widespread commercially but the technology has great IPM potential. 3M Canada was the recent registrant of two other mating disruption products; sprayable pheromones for control of blackheaded fireworm (BHF) and Sparganothis fruitworm (54), respectively registered as biopesticides as the Z and E enatiomers of tetradecenyl acetate. The Sparganothis fruitworm mating disruptor was used commercially in Maine, Wisconsin, and New Jersey in 1999.

Insecticides are important, especially to prevent damage from direct fruit pests. The most widely employed insecticides registered for use on cranberry in the United States are chlorpyrifos, diazinon, and azinphos-methyl. In New Jersey, insecticide use on cranberry crops is typically low. Approximately 9% of the pesticides sprayed on cranberry in New Jersey in 1997 were insecticides. The top three insectides applied that year were chlorpyrifos (3,196.126 lbs a.i.); azinphos-methyl (1,543.429 ibs a.i.); and carbaryl (792.106 lbs a.i.) (50). The use of carbaryl on cranberry in New Jersey was uncharacteristically high in 1997; the third most highest-applied insecticide would more typically be diazinon or acephate, applied during pre-bloom period (54).

Parathion was the most extensively used insecticide in all cranberry production areas prior to its cancellation. Growers abandoned the use of this product prior to its cancellation in anticipation of its loss of registration. Nationally, the decrease in parathion use did not result in a dramatic increase in use of other insecticides, it has been suggested that this was due to the implementation of IPM programs. In New Jersey, the decrease in parathion use was met with an increase in the use of azinphos and chlorpyrifos (54). If the four nationally-major insecticides chlorpyrifos, diazinon, azinphos-methyl, and acephate were no longer available, growers would have to rely on other insecticides that may only provide fair-to-adequate control, or attempt to use less effective and/or more expensive specific cultural or biological alternatives for certain pests. However, there are no alternatives for most direct pests, such as the cranberry fruitworm and second-generation blackheaded fireworm.

In most places, yields would be reduced since the remaining insecticides are not as effective, and cultural or biological alternatives do not provide as good or as fast control as chemical. Between 30 to 35 percent of the East Coast crop could potentially be lost to direct pests within one year without these four key pesticides (54). Yield reductions of 15 to 50 percent are estimated for elsewhere in the United States. In subsequent years, it is speculated that pest pressure would most likely increase and losses more severe, enough to drive many growers out of business.

However, lesser yield reductions are estimated for New Jersey than the rest of the East Coast (54). New Jersey does not have as many pests as Massachusetts. New Jersey cranberry growers use the least amount of insecticide (per acre per season) in the country as a result of a solid IPM program. New Jersey cranberry crops average two applications per year, while Massachusetts' crops average four to five, and Wisconsin crops average two to three. If all of the organophosphate pesticides were no longer available to New Jersey cranberry growers, there would be no effective controls for cranberry fruitworm and cranberry weevil. The newer reduced risk pesticides are not as effective against these particular pests.

Diseases of Cranberry

Fruit rot, all caused by fungi, is the most important disease problem in cranberry production in New Jersey (64). Fungal diseases tend to be the most serious in regions with long growing seasons and relatively high summer temperatures, such as are encountered in New Jersey (5).

Numerous species of fruit-rotting fungi cause cranberries to rot, either before harvest (collectively called field rots), or after harvest (collectively called storage rots) (53). Some fruit-rotting fungi may also cause leaf spots or blossom blight. Although fruit rot fungi are widely distributed wherever cranberries are grown, the degree of infection is greatly affected by weather conditions. Most of the fungi cause field rot symptoms only under high summer temperatures and moisture, like those in New Jersey (53). Generally, fungal infections occur early in berry development and remain latent until the fruit begins to mature (53). In New Jersey, disease pressure is high and field rots are commonly encountered where proper fungicide controls are not used (53). It is estimated that fruit rot, left uncontrolled, could eliminate more than 80% of New Jersey and Massachusetts cranberry production in a three-year period (60).

The most common diseases of cranberry in New Jersey are:

Phytophthora root rot (Cranberry Root Rot) affects plants in poorly drained low-lying areas where water accumulates (8, 11, 32). Phytophthora root and runner rot affects plants in poorly drained areas where water accumulates. The virulent pathogen *Phytophthora cinnamomi* as well as a weaker pathogen *P. megasperma* plague New Jersey cranberry vines (51). Acute symptoms of the disease are dead patches varying from a few square meters to several hectares (60). Root systems are poorly developed and severely affected plants eventually die (41)**.** New vines planted in areas where symptomatic vines were removed usually also die unless drainage is improved 11, 52).

Fairy ring (Psilocybe agrariella), believed to be caused by the fungus *Psilocybe agrariella-vaccinii*, is frequently observed in mature cranberry beds in New Jersey and Massachusetts (56). Mushrooms of this fungus were reported in the 1930's and 1940's; however, they have not been reported since that time. Early infections appear as small areas of dead vines. These can be easily mistaken for insect (i.e., grub or rootworm) injury, *Phytophthora* infection, or herbicide damage. In the case of fairy ring, the dead areas expand at a rate of 1-1½ feet per year. As this area expands, the vines in the center begin to recover resulting in a ring of dead vines. In advanced cases, rings will actually merge and form more complex patterns. Direct applications with the fungicide carbamate are the only control of this disease.

Upright and runner dieback, caused by *Phomopsis vaccinii* [perfect stage *Diaporthe vaccinii* (6), or *Synchronoblastia crypta* Uecker et Caruso (68)], occurs widely in New Jersey (67). The disease develops during summer when vines are stressed by hot weather, drought, or too much moisture (41). Infection occurs at bud break but symptoms do not appear until plants are stressed. Infected uprights, that appear scattered among healthy vines, take on a yellowish cast and eventually turn orange, bronze, or brown (6). The fungus *Phomopsis vaccinii* also causes twig blight in blueberry (48).

Diseases of cranberry in other parts of the United States include:

Twig blight, caused by *Lophodermium* spp., occurs on the West Coast (22), and rarely in Wisconsin (26). Uprights are infected primarily in July and early August, and die the following spring, as the infected leaves turn from dark red to bleached tan.

Cotton ball is a fruit-rotting fungus caused by *Monilinia oxycocc*i. Infected fruit are filled with cotton-like fungal masses and are unfit for fresh or processing markets. Although it is the most important field rot in Wisconsin, it has been reported in other regions generally at insignificant levels. Cotton ball disease has not been a significant problem in New Jersey (52).

Disease Control

Good sanitation in and around the beds will help reduce some pest problems. Mowing and removing vegetation around the perimeter of the bed promotes air movement to reduce fungal problems (62). Beds are sometimes re-flooded after harvest to remove plant debris that can harbor fungal fruiting bodies.

Utilization of flooding at various times throughout the growing season is a traditional method of pest control that can decrease the inoculum potential of the fruit rot fungi (12). Losses to fruit rots in both the field and in storage can be very high (52). Fungicides used for fruit rot control also generally control foliar diseases. Most of the fungicides available for use on cranberry are protectants that are effective only on the plant surface, although a few have limited systemic activity.

The top seven fungicides applied to New Jersey cranberry in 1997 were determined according to grower records of total pounds active ingredient applied (50).

Chlorothalonil 720F, 500 is a broad spectrum fungicide registered for fruit rots, *Lophodermium* leaf/ twig blight, and upright dieback at 3 to 5.25 lb a.i./A. Applications should be made at early bloom or after petal fall and repeated at 10 to 14 day intervals for fruit rot control. In Wisconsin there is a Section 24(c) registration for application at bud break for control of upright dieback. Chlorothalonil cannot be applied more than 3 times per season, or within 50 days of harvest. It may be applied through sprinkler irrigation equipment, but not to flooded beds, and irrigation water must not be released from beds for at least 3 days following application. In Wisconsin, chlorothalonil is used mainly for control of upright dieback. Chlorothalonil ranked **first (38.53%)** of fungicides used on cranberry in New Jersey for 1997; 22,419.615 lbs. a.i. were applied (50).

Ferbam 76WDG is a protective fungicide nationally registered for control of fruit rots and fairy ring. For fruit rots, applications of 1.5 lb a.i./A should be made early in the bloom period and repeated at 14-day intervals, with a maximum of five applications per year. It cannot be applied later than 28 days after mid-bloom. Apply 0.07 lb a.i./ft2 immediately in June or July (52) for fairy ring, treating an area 3 feet beyond the advancing line of dead vines and 2 feet within this line. Forty percent of the national cranberry acres are treated with ferbam. Ferbam ranked **second (31.06%)** of fungicides used on cranberry in New Jersey for 1997; 18,075.080 lbs. a.i. were applied (50).

Mancozeb 80WP, 75DF, 4F is a broad spectrum EBDC (ethylene bisdithiocarbamate) protectant fungicide registered to control fruit rots on cranberry. The fungicide may be applied by ground, air or through irrigation equipment at 2.4 to 4.8 lb a.i./A, starting at mid bloom and repeating at 7 to 10 day intervals, with a maximum of 14.2 lb a.i./A per season. There is a 30-day interval before harvest. Twenty-five percent of the cranberry crop in the United States is treated with mancozeb. Mancozeb ranked **third (27.93%)** of fungicides used on cranberry in New Jersey for 1997; 16,251.169 lbs. a.i. were applied (50).

Copper compounds are registered for control of fruit rots and upright dieback disease, with no harvest restrictions. The various forms include Bordeaux mixture, inorganic salts (carbonates, chloride, hydroxide, oxalate, oxides, phosphate, silicate, sulphates, and zinc chromate complex), and organic compounds such as acetate, naphthenate, oleate, quinolinolate, and resinate. Bordeaux 8: 8: 100 should be applied at 24 lb/A. Applications of copper ammonium carbonate and copper hydroxide at 3 to 3 .25 lb/A are recommended at petal fall and then at 7 to 10 day intervals. Continued use of copper sprays may cause some plant injury. Copper is applied to 29% of the national cranberry crop. Copper ranked **fourth (1.12%)** of fungicides used on cranberry in New Jersey for 1997; 648.836 lbs. a.i. were applied (50).

Metalaxyl 2E, and 5G, Gold, are registered for control of soil-borne diseases caused by *Phytophthora* spp. A maximum of three applications are to be applied at 1 to 1.75 lb a.i./A, with the first application in the fall after harvest, the second in the spring, and the third 45 days before harvest. No more than 5.25 lb a.i./A may be applied in a single season. Metalaxyl ranked **fifth (0.21%)** of fungicides used on cranberry in New Jersey for 1997; 120.505 lbs. a.i. were applied. The registration of metalaxyl was effectively cancelled on May 31, 1996, with sale allowed until December 31, 1998 or until supplies are exhausted. There will be no loss of uses, as metalaxyl will be replaced with its R-enantiomer, mefenoxam (50, 73).

Mefenoxam is considered a reduced-risk pesticide by EPA (74). Mefenoxam ranked **sixth (1.16%)** of fungicides used on cranberry in New Jersey for 1997; 675.486 lbs. a.i. were applied (50).

Maneb ranked **last** (less than 1%) of fungicides used on cranberry in New Jersey for 1997; 40.163 lbs. a.i. were applied (50).

Fungicides used on cranberry in other parts of the United States include the following:

Triforine 1.6 EC is a locally systemic fungicide that has a Section 24(c) registration for control of cottonball in Wisconsin. It is not approved for use in New Jersey. Fungicide is to be applied by ground or air equipment at 0.3 lb a.i./A, with no more than 4 applications per season, and a 60-day interval to harvest. Applications should be made at budbreak and 7 to 10 days later to protect young uprights, and at early bloom and 7 to 10 days later to protect the blossoms and prevent fruit rot. Five percent of the cranberry acres in Wisconsin were treated with triforine in 1997. However, production of triforine has ceased and stocks are depleted (52).

Sulfur is available in various forms, including finely ground elemental sulfur for dusting, colloidal, flowable, micronized wettable, and wettable sulfurs. Sulfur may be used in tank mixes with other fungicides to control fruit rots and other early-season fungi. Sulfur-based fungicides are typically not a preferred option for cranberry

disease control as they can cause blackening of the leaves and rapid defoliation (63). Although application rates vary by location, less than one percent of the cranberry acres in the United States are treated with sulfur. In Wisconsin, sulfur is only used to manipulate pH and not as a fungicide.

Propiconazole is a broad-spectrum systemic fungicide used under a Section 18 in Wisconsin during 1996 - 98 to control cottonball in cranberries after infection. The first application may be made by either ground or air at leaf bud break, and the second application 7 to14 days later. The third application is made at early bloom and the fourth, 7 to 14 days later during full bloom. Propiconazole may not be applied through irrigation equipment or within 45 days of harvest. In Wisconsin 17% of the cranberry acreage is treated with propiconizole.

In New Jersey, the top three fungicides applied in 1997 were chlorothalonil (22,419.615 lbs a.i.), ferbam (18,075.080 lbs a.i.), and mancozeb (16,251.169 lbs a.i.) (50). Fungicides account for nearly 84% of the pesticides applied on cranberry in New Jersey. The most widely employed registered fungicides used on cranberry in the United States are chlorothalonil and mancozeb.

If chlorothalonil were not available, mancozeb, ferbam, and copper compounds would be used as alternatives. If the two most nationally important fungicides, chlorothalonil and mancozeb, were not available, overall cranberry yield for the United States would be reduced by 20 percent, with losses of up to 100 percent occurring in individual beds. A greater quantity of less-effective fungicides would probably be applied to compensate for this loss of efficacy (56, 52).

Weeds of Cranberry

Many native and introduced plant species are considered weeds when they invade managed cranberry marshes. Most of the weeds affecting cranberry production are adapted to a wet, marshy environment and grow directly in the beds. Others tend to be found mainly in the ditches or edges of beds.

Weeds reduce yield and quality through competition with cranberry vines for light, air, water, and nutrients needed for growth, color, and fruit development (27). Competition reduces berry size and yield, and affects the coloring of the berries (20). Weeds also compete with a cranberry crop for pollination. June-flowering weeds and cranberry compete directly for pollinators. Indirectly, weed canopies reduce affective pollination by concealing cranberry blossoms from pollinators such as bees (43). Heavy stands of weeds slow harvest operations, and some weeds directly damage fruit skin during harvest (16). One weed (dodder) is directly parasitic on the cranberry plant.

Annual grasses are usually important only in new plantings or where cranberry vines are sparse. Some common species nationally include barnyard grass, *Echinochloa crusgalli* L.; witch grass, *Panicum capillare* L.; and fall panicum, *Panicum dichotomiflorum* Michx.

Perennial grasses often occur in patches, with new infestations often arising from roots, rhizomes, or stolons from the sand used for sanding operations. Rice cutgrass or sickle grass, *Leersia oryzoides* (L.) Swartz, is a wiry perennial that commonly invades thin stands in low spots and ditches. The rough leaves can cut the surface of berries at harvest, which increases the occurrence of storage rots (13). Other perennial grass species include bluejoint grass, *Calamagrostis canadensis* Michx. and rattlesnake mannagrass, *Glyceria canadensis* Michx.

Annual broadleaves occur throughout beds or along ditch banks and edges. Several species of beggarticks or sticktights, *Bidens* spp., are common in cranberry beds. Ragweeds, *Ambrosia* spp., are tall upland plants found only on dry areas in beds. Swamp dodder, *Cuscuta gronovii* Willd. ex R. & S., is a leafless, rootless plant that is parasitic on cranberries and weeds, directly reducing the vigor of the crop plants. It germinates in late spring, twining slender orange stems around the host to derive its nutrients from that plant. Tearthumb smartweed or arrow-leaved tearthumb, *Polygonum sagittatum* L., has sharp recurved spines on the stems and is common in beds such as cranberry where there are thin vines. In New Jersey, vetch (*Vicia sativa*) is a trailing vine-like annual that forms sprawling mats or may even envelop other plants (43, 49). *Erechtites hieraricifolia* (L.) Raf; commonly known as burnweed or fireweed, is another annual weed of concern in New Jersey bogs. It reproduces by seeds from numerous heads on 1- to 9-foot high stems (43, 49).

Perennial broadleaves include aggressive plants that grow for many years from the same root system. Asters, *Aster* spp., prefer relatively dry conditions. Common and silverleaf cinquefoil, *Potentilla canadensis* L. and *P. anserina* L., are invasive native plants that spread by slender runners (38). Creeping buttercup, *Ranunculus repens* L., is a trailing, creeping herb that often roots at stem nodes and reproduces by seeds and runners (38). Ditch stonecrop, *Penthorum sedoides* L., invades sparse vines and new plantings, especially in wet areas, and spreads by underground runners. Goldenrods, Solidago spp., are tall plants common on ditch banks and in beds (43). Joe Pye weed, *Eupatorium* spp., is a 2- to 5- foot high herb common on ditch banks and wild marshes. Sheep sorrel, *Rumex acetosella* L., is a native of Eurasia that spreads by extensive shallow rhizomes and also reproduces by seed (38). Yellow loosestrife, *Lysimachia*

terrestris (L.) B.S.P., is common in wild marshes and invades cranberry beds as bulbils dispersed by water. It grows at the waters' edge and spreads by stolons. The latex sap of this weed causes dermatitis in some people.

Sedges, rushes, horsetails, and ferns are common perennial weeds in cranberry. Numerous species of sedges or nutsedges in invade cranberries; these include many genera with various common names (e.g., bulrushes, stargrass, tussocks) (43). Rushes (*Juncus* spp.) are commonly found in wet soils around water. Horsetails, *Equisetum* spp., are perennial plants that grow in ditches or poorly drained spots in the field, and interfere with mechanical harvest. Many species of ferns occur in beds, on dikes, and along roadsides.

Woody plants encompass numerous species. Patches of blackberry, brambles, or dewberry (*Rubus* spp.) are typically found on sand beds where a poor job of scalping was done before planting. They are very persistent plants that compete with cranberries for light and interfere with harvest. Dewberry and brambles grow prostrate among the cranberry vines and are therefore hard to wipe with herbicides for control. Truly woody species are frequently native flora. Leather leaf, *Chamaedaphne calyculata* (L.) Moench, is a common small native woody evergreen shrub in peat bogs that often occurs in old cranberry beds. Poison ivy, *Rhus radicans* L., is common on dikes and ditch banks, and in cranberry beds. Several species of woody *Spiraea* with various common names are native shrubs in wild bogs that frequently invade cultivated beds. Red maple (*Acer rubrum*), alder (*Alnus* spp.), and willow (*Salix* spp.) trees invade beds as windblown seed.

In New Jersey, the roundleaf greenbriar, *Smilax rotuntifolia* L., is a persistent prickly-stemmed woody plant that forms impenetrable thickets or climbs other vegetation. It is especially difficult to remove it by its deeply situated tubers (43, 49). Similarly, wild bean (*Apios americana* Medic.) is a serious threat to cranberry crops as it can reproduce vegetatively by underground tubers that can spread rapidly throughout a cranberry bog despite removal of above-ground stems; physical removal of the tubers of these weeds is impossible without damage to the interspersed cranberry vines (43, 79).

Weed Control

Commercial herbicides are used for most weed control in cranberries today. Hand weeding is selectively used on newly established beds, but is usually not economically feasible for widespread use. Utilization of flooding at various times throughout the growing season is a traditional method of pest control that can cause a general reduction of annual weeds (12).

In New Jersey, certain weeds have been designated with a 'zero tolerance' threshold; these weeds should not be allowed to become established f in all crops, including cranberry. Zero tolerance weeds are: mugwort, Jerusalem artichoke, nutsedge, quackgrass, milkweed, hemp dogbane, horsenettle, and Canada Thistle (30).

The top five herbicides applied to New Jersey cranberry in 1997 were determined according to grower records of total pounds active ingredient applied (50).

Napropamide 10G and 50WP is registered for control of a few annual broadleaf and grass weeds. It does not control established weeds, as it is a germination inhibitor (42). In New Jersey, 3 lb a.i./A should be used on new weed-free plantings in the spring after setting vines, and 6 lb a.i./A on established plantings in either spring or fall to control purple beggarticks and rice cutgrass. At least ¼ inch of rain or sprinkler irrigation within 3 to 4 days after application is recommended for weed control (62, 42). Napropamide is used to treat 32% of the national cranberry acres. Napropamide ranked **first (72.13%)** of herbicides used on cranberry in New Jersey for 1997; 3,582.310 lbs. a.i. were applied (50).

Glyphosate is a 'reduced-risk' non-selective herbicide without residual action, registered for control of many annual and perennial grasses and broadleaf weeds by wiper application only (74). A 20 percent solution (a dilution of the commercial product to equal 0.8 lb a.i./gal) should be applied by wick or other wiper applicator after fruit set and no later than 30 days before harvest, wiping herbicide on the weeds that grow taller than the cranberry plants. Treated plants slowly turn yellow, but may not die until several weeks after application. Repeat or spot treatment may be necessary where weeds were initially dense or to eliminate weeds that were missed. Glyphosate usage cannot be determined on an acreage basis since it is only used as a spot treatment. Glyphosate ranked **second (27.11%)** of herbicides used on cranberry in New Jersey for 1997; 1,346,593 lbs. a.i. were applied (50).

Sethoxydim (Poast) is a post-emergence herbicide registered for the control of annual and perennial grasses in nonbearing cranberries. It should be applied to actively growing weeds at a rate of 0.3 to 0.5 lb a.i./A. A crop oil concentrate or spray adjuvant must be used along with sethoxydim to allow for thorough wetting. There is a one-year pre-harvest interval for nonbearing cranberries. No national use data is available as this herbicide was registered for use in cranberries after the assessment was completed. Sethoxydim ranked **third (0.45%)** of herbicides used on cranberry in New Jersey for 1997; 22.401 lbs. a.i. were applied (50). Sethdoxydim received

pesticide tolerances for various crops, including cranberry, effective in June of 1999; this replaces the previous time-limited tolerance for sethoxydim for the commodity (77).

Dichlobenil (Casoron, Norosac) is a benzonitrile herbicide registered for selective control of numerous perennial and annual, broadleaved and grassy weeds, including rushes and sedges. Herbicide use is limited to a single application per year at 4 to 6 lb a.i./A. Alternately, annual application of dichlobenil to cranberry in New Jersey is recommended at 2 to 4 lb. a.i./A by Cooperative Extension (43). It can be applied in the spring while perennial weeds are still dormant and before annual weeds have started to germinate, or after harvest in the fall. Spring applications should not be made if the bed was treated the previous fall. Fall application is recommended nationally for control of certain weeds, such as wiregrass sedge. Fall application of dichlobenil is discouraged in the 2000 New Jersey Small Fruit Weed Control Guidelines (42).

Dichlobenil may be used in combination with 2,4-D or simazine for better control of some perennial weeds (62). Temporary reddening of cranberry plants may occur with late spring application or on sandy beds. Uneven applications or a gradual buildup in the soil after annual applications may cause vine injury (20). Diclobenil is used on 48% of the cranberry acres in the United States. Dichlobenil ranked **fourth (0.22%)** of herbicides used on cranberry in New Jersey for 1997; 10.900 lbs. a.i. were applied (50).

Clethodim (Select) is a selective post-emergence herbicide used to control annual and perennial grasses. It will not control sedges or broadleaf weeds. Chlethodim may only be applied to non-bearing cranberries that will not bear fruit for at least one year. Herbicide application rate will depend on the life habit of the weed as well as species. Apply clethodim at a rate of 0.095-0.251 lb a.i./A; crop oil concentrate is added per label directions. Since this herbicide was registered for use on cranberries after the cranberry assessment was complete there is no information available on the percentage of national cranberry acres treated with clethodim. Clethodim ranked **fifth (0.09%)** of herbicides used on cranberry in New Jersey for 1997; 4.519 lbs. a.i. were applied (50).

Brief details of other herbicides registered for use on cranberry in New Jersey that were not reported in growers' 1997 pesticide application records follow.

Clopyralid is a selective, post-emergence, broadleaf herbicide. that is applied by New Jersey growers at 0.0625 lb a.i./A per application before bloom, and at a higher rate of 0.125 lb a.i./A per application during late bloom or after bloom (42). Clopyralid application on cranberry is not to exceed 0.375 lb a.i./A annually. The pre-harvest interval is 60 days.
Cranberry growers did not report use of clopyralid in 1997 when the most recent New Jersey Department of Environmental Protection pesticide use survey was conducted (42, 50). Clopyralid was not specified for use on cranberries in New Jersey in the Cooperative Extension Pesticide Use Recommendations either in 1999 or 2000 (42). But, this herbicide later received emergency exemptions for use in New Jersey specifically on wild bean from July 24th to December 31st of 1998, from March 30th through December 1st of 1999, and again from April 28th through December 1st of 2000 (76, 39). Clopyralid also has a Section 18 Emergency Exemption for use in cranberries in Massachusetts, Oregon, Washington, and Wisconsin (75). National usage data is not available for clopyralid at this time.

Propyzamide (commonly known as pronamide) is an herbicide active ingredient that has received Section 18 Emergency Exemptions for use in New Jersey on cranberry for the removal of dodder

New Jersey cranberry growers did not report use of propyzamide in 1997 when the most recent New Jersey Department of Environmental Protection pesticide use survey was conducted (42, 50). However, EPA issued emergency exemptions for New Jersey for March 18th through December 15th of 1999, and again for March 17th through December 15th of 2000 (76, 39). A principal Cooperative Extension weed specialist for New Jersey notes that the 1999 Section 18 for pronamide for dodder control specified spray or sprinkler application of 1-2 lbs. of Kerb WP (0.5 - 1.0lb a.i./A) in the spring before dodder germination; the corresponding pre-harvest interval for pronamide was 90 days (43).

2,4-D (Weedar-64) is available as a dimethlyamine salt for weed control in cranberries in New Jersey through a Special Local Need 24(c) label. There was no reported use of this herbicide by New Jersey cranberry growers in 1997 (42, 50).

Norflurazon (Evital 5G) is a soil-applied, pre-emergence treatment for the control of certain annual and perennial grasses, sedges, and broadleaf weeds in cranberries. Herbicide is to be applied as a single ground or aerial application at 4 to 8 lb a.i./A in the early spring after removal of winter flood and before weed growth resumes, or in the fall after harvest at least two weeks before winter flood. Application rates vary depending on the weed species present, soil type, cranberry variety, and the condition of the bed. Norflurazon is limited to one application

per year, not to exceed 4 lb a.i./A in a newly planted bed or 8 lb a.i./A for established beds. However, the higher rate can be damaging to cranberry vines. Eight percent of the national cranberry acres are treated with norflurazon. Although it is a recommended option for the control of grasses, rushes, and sedges in cranberry in New Jersey, norflurazon was not used in 1997 by New Jersey cranberry growers (42, 50).

Soil fumigants **metam-sodium (Vapam)** and **Dazomet** are recommended for use in New Jersey for bog renovation only. There was no reported use of either of these fumigants by New Jersey cranberry growers in 1997 (42, 50).

Herbicides used on cranberry in other parts of the United States include the following:

Ferrous sulphate, or iron sulfate [FeSO4 CH2O], is a selective herbicide for control of mosses and broadleaf weeds. Ferrous sulphate is used on less than one percent of the nation's cranberry acres; it was not used on cranberry in New Jersey in 1997 (42, 50). Granules are applied by hand around the weeds. It should be applied from April through July at a rate of 5,600 to 8,000 lb/A with no harvest restriction. It should not be applied to new beds or mature vines sanded within 18 months. Ferrous sulphate is used on less than one percent of cranberry acres nationally.

Fluazifop-P-butyl (Fusilade DX) is a post-emergence grass herbicide used elsewhere in the United States; however, it was not used on cranberry in New Jersey in 1997 (**,** 42, 50). The herbicide is applied at a rate of 0.25 to 0.375 lb a.i./A and must be applied with a crop oil or nonionic wetting agent. There is a one-year pre-harvest interval. Actual national usage data is not available on this pesticide; it was registered for use on cranberries after the cranberry assessment was completed.

Pelargonic acid is an herbicidal soap. It is not recommended or used in New Jersey in cranberry (42, 50). It has limited use elsewhere in the United States as a non-selective, post-emergence herbicide in cranberries. Pelargonic acid is applied as a 3 to 10% solution (v/v) directed spray to young annual broadleaf or grass weeds, or as a top-kill for perennial weeds. There is currently no national usage data available for this herbicide in cranberries.

Simazine is a pre-emergence herbicide registered for control of most annual grasses and broadleaf weeds. Several formulations are available for use at 2 lb a.i./A to be applied before grass and broadleaf weed emergence and cranberry growth begins in the spring. Simazine is not recommended or used in New Jersey (42, 50).

The top two herbicides applied in cranberry production in New Jersey in 1997 were napropamide (3,582.310 lbs a.i.) and glyphosate (1,346,593 lbs a.i.); they respectively represent 72% and 27% of the total herbicide applied (50). It is reported that New Jersey cranberry growers have not yet recovered from the cancellation of several herbicides, such as chloprophan (Furloc) previously used on dodder (42). Devastating results on cranberry production in New Jersey are predicted if currently registered herbicides napromide (Devrinol), glyphosate (Roundup), dichlobenil (Casoron), or sethoxydim Poast) were no longer available. Further, failure to register clopyralid (Stinger) and pronamide (Kerb), currently used under Section 18 is characterized a serious blow to cranberry weed control (42).

The nationally top-ranking herbicides used in cranberry production are diclobenil, napropamide, and glyphosate. If these were not were not available, growers would have to resort to less effective, more costly means of weed control. This would include hand pulling and mowing, and use of greater quantities of less effective herbicides. Yields would decline significantly, but the major impact on yield would not be seen for several years. Without some selected herbicides or any herbicide, up to half of the growers would eventually go out of business because it would no longer be profitable to farm when their beds become overwhelmed by weeds in 5 to 10 years (K. Patten, personal communication, 1993).

Other Cranberry Pest Control Strategies

Pesticide tolerances for cranberry at risk of being lost during the tolerance reassessment process include: acephate, azinphos-methyl, carbaryl, carbofuran, chlorothalonil, chlorpyrifos, diazinon, dicloropropene, mancozeb, maneb, metam, and parathion-methyl (72).

The Interregional Research Project #4 (IR-4) program carries out research and petitions EPA to obtain tolerances or exemptions for specific uses of pest controls needed for minor crops, such as cranberry (31). Its goals include assisting in obtaining registration of reduced-risk pesticides, as well as facilitating reduced-risk patterns for existing tolerances (72). Once a project is selected for research, IR-4 estimates that the process averages approximately four to five years to complete. IR-4 projects for insecticides, fungicides, and herbicides are ongoing. Less toxic alternatives to chlorpyrifos for

the control the cranberry weevil are being evaluated. Post-emergence graminicides and effective dodder herbicides are also being investigated. In addition, several other new, unnamed compounds have shown considerable promise against cranberry weeds in preliminary studies (19).

In addition to pesticides, the cranberry industry is evaluating and researching many other pest management approaches including biological and cultural controls. Reduced-risk compounds are being tested for the control of all pests. The private sector, led by the Cranberry Institute, is investing heavily in the discovery, testing, and registration of alternatives to organophosphates, carbamates, and B2 carcinogens. Biological or cultural alternatives being investigated include: indigenous nematodes; *Trichogramma* parasitic wasps; mating disruption pheromones for blackheaded fireworm, Sparganothis fruitworm and cranberry girdler; mycoinsecticides (*Metarhizium*) to control black vine weevil and cranberry girdler; and water-management options (e.g., post-harvest flooding, later winter flooding) to control numerous pests.

Further, the Cranberry Institute has formed a Pesticide Environmental Stewardship Program (PESP) partnership with the EPA. Selected stewardship goals that have arisen as a result of this partnership include:

- Protecting and enhancing natural resources while managing viable cranberry operations. Industry organizations will continue to fund research and implement results that will protect surface and ground water, protect and encourage natural enemies of crop pests, and enhance wildlife utilization of the unique habitats provided by cranberry farms.
- Strengthen IPM - the current, widely-practiced IPM programs will be strengthened by the implementation and use of newly developed pheromones, survey techniques, and control measures as they become available.
- Continue grower education meetings with handler, university, and association organizations to address the latest research findings and innovative control techniques that will lead to strengthening IPM programs.
- Industry organizations will continue to provide significant support and funding for research on alternative practices that will strengthen IPM and protect natural resources.
- Pursue and obtain reduced risk registrations with the EPA's commitment to assist.

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