Crop Profile for Cranberries in Wisconsin

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General Production Information

- Cranberries are a high-value crop with a value of almost $162 million.
- Nearly 2.3 million barrels of fruit were produced on 13,700 acres in 1997
- In 1997, Wisconsin was the leading cranberry producer, followed closely by Massachusetts.

Production Regions

In Wisconsin, there are 15,000 acres located in several counties in west central and northern part of the state.

Cultural Practices

Cranberries are grown in beds that have been drained, cleared, leveled and covered with sand to level the bed before the crop is planted to selected vines (12). The sand layer, over a natural peat bog, provides a better rooting zone for cranberries than the peat itself, and helps reduce weed seed germination (42). Six- to eight-inch lengths of vine cuttings are scattered uniformly over the sand and are then disked to a depth of 3-4 inches. Several years are required to reach full production.

Important cultural practices for maintaining good productivity of established beds include pruning, sanding, fertilization, and water management. Beds are pruned after harvest to stimulate the production of uprights and to prevent the runners from becoming matted and reducing productivity (42). A thin layer of sand spread over the bed stimulates new root and vine growth, improves aeration and drainage of surface water thereby reducing disease development, and levels out low spots to make dry harvesting easier. Ammonium or urea nitrogen fertilizers, in granular or liquid formulations, and other major and minor elements, are applied as necessary for optimum growth and to prevent deficiencies (42).

Surface waters, such as lakes, streams, and ponds, are used for 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 that provide complete coverage of the vines. Large quantities of water are used to flood beds for harvest and to protect the vines from desiccation and drastic temperature fluctuations during dormancy in the winter in northern temperate regions (12).

Cranberries are harvested in two ways, depending on the area and intended crop use. Dry-picked berries are often sold for the fresh market. Dry harvest utilizes a picking machine that combs the berries off the vines, and may also prune the runners that come in touch with multiple knives (29,42).

Water harvest is generally used for berries intended for processing. Wisconsin harvests 100% of its cranberry crop by this method. 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 floating booms to one corner of the flooded bed and loaded onto trucks by conveyor belts or pumps (29). Although water harvesting is much more economical than mechanical dry picking machines, water harvesting affects the keeping quality of the berries. Lengthy water immersion increases physiological breakdown, especially of fruit bruised from water-reel picking, and promotes the dispersion of spores and infection by fungi that cause black rot in storage (45). With proper handling and storage, however, the quality of water-harvested berries can be maintained through the traditional Thanksgiving and Christmas fresh fruit marketing season (45).

Insect Pests

Cranberry fruitworm [*Acrobasis vaccinii* Riley] is the most economically important insect pest of cranberry, causing direct damage to maturing berries (29). Adults emerge from overwintering pupae in mid-June to early August and deposit eggs singly at the blossom end of berries. Larvae feed only on developing berries, consuming seeds and pulp before moving to an adjacent fruit (20,34). Three to six berries are normally eaten by each larva (20). Infested fruits redden prematurely and later dry and shrivel on the vine.

Blackheaded fireworm [*Rhopobota naevana* (Hübner)] is a primary pest in Wisconsin. It overwinters on cranberry leaves as eggs that hatch in early spring. Larvae feed primarily on terminal foliage, webbing the terminals together, frequently destroying buds, and skeletonizing leaves, giving the vines a burnt appearance. Second generation larvae hatch in midsummer (during bloom and early berry set) and feed on foliage, flowers, and fruit (18). The first generation is an indirect pest as foliar feeders, but during the second generation it may be a direct pest if berries are fed upon. The second generation is generally most damaging (38).

Sparganothis fruitworm [*Sparganothis sulfureana* (Clemens)] is a primary pest in Wisconsin. 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 the fireworms (29). Second generation larvae feed on foliage but also cause direct damage, boring into the fruit and consuming three to five berries during

development (2).

Cranberry tipworm [*Dasineura oxycoccana* (Johnson)] is important in Wisconsin beds. Eggs are laid at the tip of growing uprights. The larvae feed on the leaves for about 10 days (20). Developing terminals fed upon by larvae develop cupped leaves and the apical meristem is killed(28). 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.

Cranberry girdler [*Chrysoteuchia topiaria* (Zeller)] is an important but sometimes sporadic pest. Larvae live in leaf litter on the bog floor and feed on the bark and wood of the cranberry vines from late July to after harvest. Girdled vines die and lose their leaves, resulting in thin or dead spots in the bed, but damage is often not apparent until the following spring (37,39).

Spanworms [*Ematurga amitaria* (Guenee) and *Itame sulphurea* (Packard)] are sporadic pests. Larvae hatch just before and during blossom and feed on foliage, buds, and blossoms (20). The brown spanworm is more damaging than the green spanworm and causes serious losses when numerous (20). Several other species of spanworm attack cranberry, causing similar damage.

Insecticides

Most pesticides are applied by ground spray units with some applied through chemigation systems, or by helicopter or fixed wing airplane.

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.

Integrated pest management (IPM) practices have been utilized by cranberry growers in Wisconsin since 1986. As part of the development of an IPM program, pest management procedures were developed to improve the timing of pest controls. Monitoring thresholds were initiated to help growers determine whether pest control is actually necessary to prevent economic damage from occurring. Currently, over 80% of the cranberry acreage in Wisconsin is scouted. There is good grower acceptance of IPM within the cranberry industry.

Parathion was the most extensively used insecticide in all areas prior to its cancellation. Growers abandoned the use of this product prior to its cancellation in anticipation of its loss of registration. Of the insecticides currently registered for use on cranberry, chlorpyrifos, diazinon, and azinphos-methyl are the most widely employed insecticides.

Although pesticide use fluctuates each year depending on pest pressure, insecticide use in Wisconsin is

relatively high because of high insect pest pressure. The decrease in parathion use did not result in a dramatic increase in use of other insecticides, perhaps because of the implementation of IPM programs.

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 application is 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 cranberry acres.

Azinphos-methyl 50WP, are 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 cranberry acres.

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 7-10 days. There is a one day interval before harvest. Six percent of the cranberry acres are treated with carbaryl.

Chlorpyrifos 4E is registered to control fireworms, cranberry fruitworm, brown spanworm, Sparganothis fruitworm, cutworms, and cranberry weevil. Insecticide should be applied at 1.5 lb a.i./A by either ground or aerial application, or chemigation, when insects become a problem, with a maximum of two applications per year and a 60 day interval before harvest. Seventy-five percent of all cranberry acres are treated with chlorpyrifos.

Diazinon 50W, AG500, AG600, and 4EC are registered to control blackheaded fireworm and cranberry fruitworm. Applications against these insects also control other pests such as spanworms. 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 is registered on a Section 24 (c) label only for control of larvae of the cranberry girdler, applied at 3 lb a.i./A. 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 acreage.

Tebufenozide (Confirm 2F) is an insecticide that will blackheaded fireworm and Sparganothis fruitworm. A Section 3 label is expected sometime in 1999. This product is a reduced-risk insecticide.

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 cranberry acres.

Cryolite is a 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.

Bacillus thuringiensis* var. *kurstaki (Btk, Dipel ES, MVP, MVPII, Cutlass, Crymzx, Agree, Mattch) and ***Bacillus thruringiensis var. aizawai*** (Bta, Xentari) is a microbial insecticide for control of most Lepidoptera larvae with high gut pH. Dipel ES is registered for control of spanworms, gypsy moth, blossom worm, and false armyworm at 1 quart/A with no harvest restriction. Dipel was the first brand to be registered on cranberry. Other brands are now registered. Nine percent of the cranberry acres are treated with Btk.

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. *Steinernema carpocapsae* and *S. glaseri* are formulated for application at 1 to 3 billion per acre. One or two applications are usually sufficient. Three percent of the cranberry acreage receives nematode treatments.

No-Mate BHF is a mating disruption pheromone for the blackheaded fireworm that became registered for use in 1998. Currently, its use is not widespread commercially but the technology has great IPM potential.

Diseases

Fruit rots, all caused by fungi, are the most important disease problem in cranberry production (43). 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 (44).

Fruit rotting fungi (numerous species) cause cranberries to rot, either before harvest (collectively called field rots) or after harvest (storage rots), and some may also cause leaf spots or blossom blights. Although the 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 rot in the field only under relatively high summer temperatures and moisture. Generally, fungal infections remain latent and develop later as storage rots(23). In Wisconsin, disease pressure is usually low and field rots other than cottonball are rarely encountered (1,26).

Upright and runner dieback, caused by *Phomopsis vaccinii* (perfect stage *Diaporthe vaccinii*) (3) or

Synchronoblastia crypta Uecker et Caruso (46)), occurs widely in Wisconsin(3). The disease develops during summer when vines are stressed by hot weather, drought, or too much moisture (32). 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 (3). The fungus also causes twig blight in blueberry (36).

Phytophthora root rot affects plants in poorly drained low areas where water accumulates (5,8,24). Wisconsin is plagued by the weak pathogens *P. cryptogea* and *P. megasperma*. Root systems are poorly developed and severely affected plants die (32). New vines planted in areas where symptomatic vines were removed usually also die unless a fungicide is used or drainage is improved (8).

Twig blight, caused by *Lophodermium* spp., occurs rarely in Wisconsin (21). 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, caused by *Monilinia oxycocci* is the most important field rot in Wisconsin. It has been reported in other regions but generally at insignificant levels. Infected fruit are filled with cotton-like fungal masses and are unfit for fresh or processing markets.

Fungicides

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.

Chlorothalonil 720F, 500 is a broad spectrum fungicide registered for fruit rots, *Lophodermium* leaf/ twig blight, and upright dieback at 3 to 5¼ 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.

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 3-3 1/4 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 cranberry crop.

Ferbam 76WDG is a protective fungicide registered for control of fruit rots and fairy ring. For fruit rots,

applications of 1½ 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 after harvest 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 cranberry acres are treated with ferbam.

Mancozeb 80WP, 75DF, 4F is a broad spectrum EBDC 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/season. There is a 30 day interval before harvest. Twenty-five percent of the cranberry crop is treated with mancozeb.

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. may be applied in a single season.

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 7-14 days later. The third application is made at early bloom and the fourth, 7-14 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.

Sulfur in various forms, including finely ground elemental sulfur for dusting, colloidal, flowable, micronized wettable, and wettable sulfurs, may be used in tank mixes with other fungicides to control fruit rots and other early season fungi, but is not recommended in most places. Application rates vary by location. Sulfur is exempt from tolerance. Less than one percent of the cranberry acres are treated with sulfur. In Wisconsin, sulfur is only used to manipulate pH and not as a fungicide.

Triforine 1.6 EC is a locally systemic fungicide that has a Section 24(c) registration for control of cottonball in Wisconsin. 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 nearly depleted.

Weeds

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 (22). Competition reduces berry size and yield and affects the coloring of the berries (17). Heavy stands of weeds slow harvest operations, and some weeds directly damage fruit skin during harvest (13). One weed (dodder) is directly parasitic on the cranberry plant.

Annual grasses are usually important only in new plantings or where vines are sparse. Some common species 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 that contaminate 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 storage rots (10). Other perennial grass species include bluejoint grass, *Calamagrostis canadensis* (Michx.) and rattlesnake mannagrass, *Glyceria canadensis* Michx.

Annual broadleaves occur throughout beds or along ditchbanks 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 with thin vines.

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 (30). Creeping buttercup, *Ranunculus repens* L., is a trailing, creeping herb that often roots at the stem nodes and reproduces by seeds and runners (30). Ditch stonecrop, *Penthorum sedoides* L., invades sparse vines and new plantings, especially in wet areas, and spreads by underground runners. Goldenrod, *Solidago* spp., are tall plants common on ditchbanks and in sand beds. Joe Pye weed, *Eupatorium* spp., is a 2 to 5 foot high herb common on ditchbanks and wild marshes. Sheep sorrel, *Rumex acetosella* L., is a native of Eurasia that spreads by extensive shallow rhizomes and also reproduces by seed (30). 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 causes dermatitis in some people.

Sedges, Rushes, Horsetails and Ferns are common perennial weeds in cranberry. Numerous species of

sedges or nutsedges in many genera and with various common names (e.g., bulrushes, stargrass, tussocks) invade cranberries. 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. Blackberry, brambles, or dewberry, *Rubus* spp. occur in patches, mainly on sand beds where a poor job of scalping was done before planting. They are very persistent plants that compete for light and interfere with harvest. Dewberry and brambles grow prostrate among the cranberry vines and are therefore hard to wipe 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 ditchbanks, 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.

Herbicides

Hand weeding is used on newly established beds in Wisconsin, but is usually not economically feasible. Commercial herbicides are used for most weed control in cranberries today. Those registered for use include the following.

Clethodim is a selective postemergence herbicide used to control annual and perennial grasses. It will not control sedges or broadleaf weeds. Chlethodim may only be applied to nonbearing cranberries that will not bear fruit for at least one year. Herbicide 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 along with a crop oil concentrate. Since this herbicide was registered for use on cranberries after the cranberry assessment was complete there is no information available on the percentage of cranberry acres treated with clethodim.

Clopyralid is a selective, postemergence, broadleaf herbicide that has a Section 18 for use in cranberries in Massachusetts, Oregon, Washington and Wisconsin. It is applied by either spot spray or wiper application at a rate of 0.09375 to 0.25 lb a.i./A. Actual use data is not available for clopyralid at this time.

Dichlobenil 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. 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 for control of certain weeds, such as wiregrass sedge in Wisconsin. Dichlobenil may be used in combination with 2,4-D or simazine for better control of some perennial weeds (41). 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 (17). Diclobenil is used on 48% of the cranberry acres.

Ferrous sulphate, or iron sulfate [$FeSO_4$ CH_2O], is a selective herbicide for control of mosses and broadleaf weeds. 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 the cranberry acres.

Fluazifop-P-butyl (Fusilade DX) is a postemergence grass herbicide. 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 preharvest interval. Actual usage data is not available on this pesticide since it was registered for use on cranberries after the cranberry assessment was completed.

Glyphosate is a non-selective herbicide without residual action, registered for control of many annual and perennial grasses and broadleaf weeds by wiper application only. 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.

Napropamide 10G and 50WP is registered for control of a few annual broadleaf and grass weeds. It does not control established weeds. In Wisconsin, 3 lb a.i./A should be used on new 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 days after application is essential for weed control (41). Napropamide is used to treat 32% of the cranberry acres.

Norflurazon 5G is a soil-applied, preemergence 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 cranberry acres are treated with norflurazon.

Pelargonic acid is an herbicidal soap. It has limited use as a nonselective, postemergence herbicide in cranberries. Pelargonic acid is applied as a 3-10% solution (v/v) directed spray to young annual broadleaf or grass weeds, or as a top-kill for perennial weeds. There is currently no use data available for

this herbicide in cranberries.

Simazine is a preemergence 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 used in Wisconsin.

Alternative Pest Management Strategies

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, cause a general reduction of annual weeds, and delay the emergence of certain insects (9). Insect control is best for terrestrial species such as Sparganothis fruitworm, cranberry fruitworm, cutworms, false armyworm, green spanworm, fireworms, cranberry scale, and mites that are not well adapted for survival when submerged for long periods.

Sanding, a practice where a thin layer of sand is spread over vines, may suppress some insects and plant pathogens, and helps accelerate decomposition of the trash layer making more nutrients available (9,11,15).

Sanding can also reduce infestations of cranberry girdler, green spanworm, and cranberry tipworm (9,31,39). 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 (25)

Good sanitation in and around the beds will help reduce some pest problems. Mowing and removing vegetation around the perimeter of the bed destroys weeds that may serve as alternate hosts for pest insects. It will also help minimize weed incursion and promotes air movement to reduce fungal problems (42). Beds are sometimes re-flooded after harvest to remove plant debris that can harbor fungal fruiting bodies.

Pheromonal disruption of mating of blackheaded fireworm and Sparganothis fruitworm is currently not available for use but may prove to be a promising method of management in the near future.

The Cranberry Institute has formed a PESP partnership with the EPA. Some of the EPA stewardship goals that have arisen as a result of this partnership include:

1. 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.

2. Strengthen IPM - the current, widely practices IPM programs will be strengthened by the implementation and use of newly developed pheromones, survey techniques, and control measures as they become available.

3. 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.

4. Industry organizations will continue to provide significant support and funding for research on alternative practices that will strengthen IPM and protect natural resources.

5. Pursue and obtain reduced risk registrations with the EPA's commitment to assist.

Critical Pest Control Issues

Cranberry vines are traded across state borders with no certification process and are essentially unregulated. This practice is almost certainly responsible for introducing new pests, and new strains of pests, into regions where they previously did not exist.

Synthetic chemical pesticides are an important component of pest control strategies for the various pest of cranberry, however, other management methods are routinely used in cranberry production. The cranberry industry continues to develop and adopt new means of pest suppression, both chemical and non-chemical, for incorporation into existing pest management strategies.

Insecticides are extremely important, especially to prevent damage from direct fruit pests in Wisconsin where there is moderate insect pressure.

If the four 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 significantly reduced since the remaining insecticides are not as effective and cultural or biological alternatives do not provide as good or as fast control as the chemicals. At least half of the crop could be lost to direct pests alone the first year in East Coast beds, with yield reductions of 15 to 50 percent estimated elsewhere. In subsequent years, pest pressure would be higher and losses more severe, enough to drive many growers out of business.

If the major herbicides diclobenil, napropamide, and glyphosate were not available, growers would have to resort to hand pulling and mowing, and use more herbicides that are less efficacious to attempt to control most weeds. These methods would not be as effective as the major herbicides and in most cases would be much more expensive. 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).

Losses to fruit rots in both the field and in storage can be very high. Foliar diseases are also generally controlled by fungicides used for fruit rot control.

If chlorothalonil were not available, mancozeb, ferbam and copper compounds would be used as alternatives. If the two most important fungicides, chlorothalonil and mancozeb, were not available, overall yield reductions of 20 percent would be common, 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.

In Wisconsin, where cottonball is a significant problem, triforine is used extensively. Lack of this fungicide would result in devastating losses to cottonball.

Outlook for New Registrations

The IR-4 program is very supportive of cranberry projects. There are many ongoing IR-4 projects for insecticides, fungicides and herbicides. Less toxic alternatives for the use of chlorpyrifos to control the cranberry weevil are being evaluated. Postemergence 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 (16).

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 commodity, led by the Cranberry Institute, is investing heavily in the discovery, testing and registration of organophosphate, carbamate, and B2 carcinogen alternatives. 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 flood, later winter floods) to control numerous pests.

Sethoxydim is a postemergence 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 preharvest interval for nonbearing cranberries. No use data is available as this herbicide was registered for use in cranberries after the assessment was completed.

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