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BEEKEEPING 101 FOR CRANBERRY GROWERS

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Why would it benefit a cranberry grower to know the basics about bees and beekeeping? If growers understand what the honey bees are doing in those boxes and why, it will be much easier to ensure that the cranberries receive adequate pollination. Beekeeping is an art and a science that has been practiced by man as long as history has been recorded. Most people keep bees to harvest honey from them. But bees provide an enormous service as pollinators. Currently the value of honey bee pollination to US agriculture is over 14 billion.

Beekeeping has lots of lingo. A *colony* of bees lives in a *hive*. The hive usually refers to the equipment and the colony to the bees. As many cranberry growers know, the presence of lots of hive boxes doesn't always mean there are lots of bees in the colonies. Hive boxes have standard and very specific dimensions that mimic the natural architectural instincts of the bees. As a colony grows, the beekeeper adds new boxes on top to allow the colony to expand. Bees naturally build parallel, vertical hanging combs made of beeswax that they secrete from glands on their abdomens. However, beekeepers provide colonies with wooden frames and *foundation* of beeswax or plastic to encourage the bees to draw out wax comb within the frames, so that the beekeeper can easily remove the frames to inspect the colony. Each box can hold 10 frames, although most beekeepers keep 9 frames per box, which makes it easier to remove frames without damaging bees. Bee colonies are kept in *apiaries*; generally a commercial beekeeper will maintain 32-40 colonies per apiary, whereas a hobby beekeeper may maintain an apiary of 1-2 colonies in their backyard. Many commercial beekeepers keep their colonies on pallets, 4 colonies per pallet, to facilitate transporting colonies to different locations for pollination or honey production. The pallets are lifted with a bobcat onto a truck, which can usually carry about 400 colonies in one load.

Colonies generally start out in one box, or one *deep hive body* containing the *queen* and about 10-20,000 *workers*, or sterile female bees. The queen is the only reproductive female in the colony and can lay up to 15000 eggs per day for the duration of her lifetime of 1-3 years. As the colony population grows, the beekeeper will add a second deep box to allow the queen to expand her *brood chamber*. The beekeeper must provide room for the bees to expand in advance of when the bees will need it. If a colony outgrows its hive, it will *swarm*. The queen and about half of the bees will leave the hive and land in a tree for a day or two while they search for a new nest site. When they find one, which could be a hollow tree, the walls of a house, or discarded beekeeping equipment, they will build new comb and continue growing. The bees that remain in the colony rear a new queen bee from the female larvae of the old queen that left with the swarm. They feed some chosen larvae *royal jelly* and due to the nutritional change in quality and quantity of food, these larvae develop into queens rather than a sterile workers. The first queen to emerge from her cell kills the other rival queens while they are still in their cells. When this new queen is a week old, she flies from the hive to take her one and only mating flight. She will fly up to a mile in search of male bees, or *drones*. A strong colony will rear about 100 drones for every 10,000 workers. These males do not sting, do not collect pollen and nectar, and do not secrete wax. Their sole purpose is to propagate their genes. When mature, they leave the colony every afternoon, and fly to a *drone congregation area* where they meet up with other drones from other colonies located within a 1-2 mile radius. When a virgin queen flies into one of these congregation areas, she will mate with up to 20 different drones, which ensures she will outcross and avoid mating with her own sons. She stores sperm from all the males in a structure called a *spermatheca* and will fertilize her eggs with these sperm for the remainder of her lifetime. If an egg is fertilized, it will develop into a diploid female, either queen or worker depending on how it is fed as a larva. If an egg is not fertilized, it will develop into a haploid male. *Diploid* means having 2 sets of chromosomes, one inherited from the father, one from the mother. *Haploid* means having only 1 set of chromosomes, and in the case of drones, they come only from the mother. In essence, drones are flying queen gametes. They have no fathers, but do have grandfathers. If you can figure that out, you're ahead of many beekeepers!

The most important information for growers concerns the diet of bees. A bee's diet requires 3 things: Pollen, nectar, and water. Nothing more. Pollen is their sole source of protein, nectar is their sole source of carbohydrate, and water is water (they need a continuous source of it). As a bee visits a flower, the sticky pollen collects on her fuzzy, hairy body. She grooms the pollen from her body with her legs, and packs it into a ball on her hind legs. Her hind legs have special features (collectively called a *pollen basket*) that allow her to carry large balls of pollen back to the colony. She will find an empty cell in the brood chamber to unload the pollen, and will return to the same kind of flower over and over to collect more pollen, ensuring pollination. To attract bees to flowers, flowers have developed a reward system: they produce sweet, rich nectar for the bees. The nectar is produced in nectaries, usually located at the base of the reproductive structures of the flower, so that to reach the nectar the bee has to brush against the anthers and pollen. She will sip up the nectar with her tongue, and carry the undigested nectar back to the colony in her *crop*. Bees can forage up to 5-8 miles to collect nectar and pollen, but if sufficient flowers are available, they prefer to forage within a mile or two of the colony.

In the colony, she will regurgitate the nectar to a hive bee (a bee not yet old enough to forage), and the hive bee will store the nectar in a vacant cell. During this nectar transfer and strorage, enzymes produced by the bees break down the sugars into more simple sugars, and the bees evaporate excess water from the nectar by fanning their wings. When the nectar contains around 18% moisture, we call it honey. When the cells are filled with honey, the bees cap the cells with a wax capping. When beekeepers notice that the bees are sealing honey cells with brand new white wax, they give the colony more hive boxes. These boxes are called *supers*, which are different than the deep brood chambers because they are used exclusively to store honey. Most colonies used for pollination come with 2 deep brood chambers and may have several honey supers on top.

Bees store huge amounts of honey to ensure their survival during the winter months. bees are the only bees that survive the winter as a colony; in other bee species such as bumble bees, only the queens survive the winter by hibernating in the ground. Honey bee colonies remain in their nest boxes, and will consume 50-100 lbs of honey over the winter, from October to April. So when beekeepers harvests honey, they must leave sufficient stores for the bees to survive the winter. When temperatures drop below 55°F, the bees cluster together and using the energy from honey consumption, shiver their flight muscles to produce heat. They will not fly from the nest unless ambient temperatures are at least 40°F, and even then they only fly out to defecate, and return immediately. Inside the cluster, they can maintain the temperature between 70-94°F, and so are essentially "warm blooded" as a colony. Even when temperatures drop to –30°F outside, the temperature in the middle of the cluster will be around 80°F. The queen stops laying eggs around October, but will resume egg laying, slowly, as early as late January. When there is a little brood in the nest, the bees must maintain the temperature around the brood at 94°F, or it will not survive.

These are some of the basics of bees and beekeeping. If you are interested in learning more about beekeeping, you might consider taking out Beekeeping in Northern Climates short course; a 3 day class offered every March at the University of Minnesota, St. Paul Campus. Look under Short Courses at www.entomology.umn.edu

POLLINATION CONTRACTS AND EVALUATING HONEY BEE COLONY STRENGTH

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When cranberry growers rent honey bee colonies for pollination, it is important that the grower and the beekeeper have a clear understanding of each other's expectations. The information here is to be used a guide to help growers understand what beekeepers expect and need. The word "guide" is key here: growers will need to tailor these recommendations for their particular circumstances and for those of the beekeeper.

Most growers will want to rent from 1-3 colonies of honey bees per acre of cranberries. The more honey bees the better, although over 3 colonies per acre is not necessary. Without honey bees, growers will still get a crop of cranberries, but having lots of bees available will definitely increase yield, fruit size and quality.

The grower should establish a working relationship with a reliable beekeeper. How do you know if a beekeeper is reliable? If a beekeeper is willing to negotiate and sign a pollination contract, it is a good first indication that the person is trustworthy. A sample pollination contract can be found on the next page. Basically, the grower and beekeeper need to agree on how many colonies will be rented, and what the rental fee will be. They need to agree on when the bees will be brought into the cranberry plantations, where they will be located, and when they will be removed. And they need to agree on pesticide use, and who is responsible for vandalism and stinging incidents.

Here is an example of how rental fees are determined for almond pollination in California. Many almond growers determine the fee by the strength of the colonies upon arrival. An independent person (not the grower or the beekeeper) sets up the pollination contract, and inspects 10% of the beekeeper's colonies to evaluate colony strength. In most cases, the grower pays for the services of this independent contractor. Colonies must be of minimum strength, which for almonds is 6-8 frames of bees (this minimum will be higher for cranberries, see below). The grower will pay the beekeeper $6.50 to $7.00 per frame of bees, with a cap at 10 frames of bees. Sometimes the grower will pay a flat fee of $55 or $60 per hive, but will require that the colonies have a minimum of 8 frames of bees. If they have less, the weak colonies must be removed or replaced. If they have more (on average), the grower may increase the pay.

In some cases, the grower pays the beekeeper half of a pre-determined rental fee on arrival of the bees. The grower and beekeeper then each pay half of the cost to bring an independent person in to evaluate colony strength. If the colonies are all of a minimum strength, the beekeeper gets his money back, and the grower pays the remainder of the set fee. In California, beekeepers have learned which growers do not give their money back, and these growers now have a hard time finding reliable beekeepers for pollination.

Almonds bloom in February, at a time when bee colonies are not as strong as later in the season. Research has shown that a colony with 6-10 frames of bees is sufficient for almond pollination, and stronger colonies do not increase efficiency.

Cranberries bloom in mid to late June. This is the time of year when honey bee colonies are very strong and have sufficient bees of foraging age to collect honey. It is also the time of year when clover and other flowers are in bloom, which are much more attractive to bees than cranberries, and produce much more honey. To move their bees into cranberries for pollination, the beekeeper must be paid enough to compensate the beekeepers for the loss of honey production. Otherwise, the grower will likely end up with hive boxes containing colonies that too weak to provide adequate pollination. In May and June, beekeepers can split their strong colonies, keeping the strongest units for honey production and renting the weakest one for pollination. If growers want strong colonies for pollination, they must be willing to pay for them. How much? The price should be negotiated with the beekeeper, and may vary depending on honey prices. Most experienced beekeepers know how much honey they produce during the 3 week period when they would bring in bees for pollination, and also know how much their bees will produce from the cranberries, so can give the grower an honest estimate of the difference. Another thing to consider is where the cranberry property is located. If the property is surrounded by open fields, the bees will tend to forage on both the cranberries and on surrounding clover and wildflowers in the area. Pollination efficiency may go down, so more colonies may be needed per acre (2-3 per acre), but the beekeeper will not lose too much of a honey crop, so the negotiated price may be less. If the property is surrounded by woods, the bees will tend to forage more on the cranberries, fewer colonies may be needed (1-2 per acre), but the rental fee may be higher because the beekeeper will lose more honey.

How strong should a colony be? A colony should contain *a minimum* of 9-10 frames of bees, and a maximum of 15-16, although a colony with 9-10 frames of bees is sufficient. To be more specific, one deep hive box (brood chamber) contains 9-10 frames. Most colonies are kept in 2 deep hive bodies, with honey supers (less deep boxes) on top. A good frame of bees is *covered* with bees, both sides, top to bottom. If there are 10 frames of bees, there should be 6-8 frames of brood of all ages (eggs, larvae, and pupae). If there are 16 frames of bees, there will be 10-13 frames of brood. There should be a laying queen, noted by the presence of eggs in the combs. Lots of brood in the colony, especially larvae which require constant feeding, stimulates bees to collect pollen – this is an important thing for a grower to know.

Another important point is that the colonies should have empty supers where they can store honey. If the supers are full when they arrive, the bees will have no place to store honey and may swarm. Empty supers stimulate the bees to collect honey – another important fact for growers.

In sum, strong colonies with good, laying queens and room to store honey will be the best pollinators of cranberries. After 2-3 weeks in the cranberry fields, the beekeeper will want to move the bees to a different location where they can build back up and produce more honey.

Main points:

1. Growers and Beekeepers should have signed pollination contracts. Handshakes and gentlemen agreements don't ensure payment or responsibility.
2. The bee colonies should have a minimum of 9-10 frames of bees. They should have a minimum of 6 frames of brood and should all have laying queens. They should also have at least 1 empty honey super on arrival.
3. At least 10% of the colonies should be inspected, preferably by an independent person, for strength (frames of bees).
4. The rental fee should consider the minimum and maximum the grower will pay per frame of bees or per colony, the current price of honey, and how much honey crop the beekeeper

would lose by putting *strong* colonies in the cranberries. (Note: a beekeeper will not lose any honey crop from weak colonies because weak colonies neither pollinate nor make honey!)

5. The contract should stipulate when the bees should be brought into the cranberry fields, and when they should be removed. It is best to have the bees brought in during very early bloom to ensure they first flowers they find are the cranberries in front of their 'noses', which will help ensure they keep on foraging on the cranberries.
6. The contract should also stipulate that the grower will NOT use toxic insecticides on the cranberries or surrounding edges during the rental period, except with the understanding and consent of the beekeeper.
7. The grower should assume liability for vandalism while the bees are on his property, and for stinging incidents. Foraging bees rarely sting unprovoked, but the colonies can stage a good defense if need be.

Questions? Feel free to contact me:
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Pollination Agreement

Date____________________________ For Season ____________________

The Beekeeper

Name____

Address____

Phone Number ____

The Grower

Name ____

Address____

Phone Number ____

No. of colonies ordered ____

Rental Fee for Grade A colonies ____________________________________

Rental Fee for Grade B colonies ____________________________________

Compensation for Additional Movement

Of bees or other Extras ____

Total Rental Fee ____

Name of Crop ____

Location of Crop ____

Distribution Pattern of Colonies shall be ____________________________

The Grower Agrees:

1. To give _______ days notice to bring colonies into crop
2. To give _______ days notice to take colonies out of the crop
3. To pay one-half the agree total fee when the bees are delivered
4. To pay in full within ______ days after the delivery date
5. To pay one percent a month interest on amount unpaid after the due date.
6. To use no toxic pesticides in the crop during the rental period, except with the understanding and consent of the beekeeper, and to warn the beekeeper if neighbors use toxic sprays
7. To provide an uncontaminated water supply
8. To assume liability for livestock damage or vandalism
9. To assume public liability of stinging while the bees are located in the crop.

The Beekeeper Agrees:

1. To open and demonstrate the strength of colonies randomly as selected by the grower.
2. To leave the bees in the crop for a period necessary for effective pollination, estimated to be approximately _____ days with a maximum period of ______ days, after which time the bees will be removed or a new contract negotiated.
3. To ensure that colonies are properly located and will remain in good condition while pollinating the crop.

Signed **Date** ______________________

____________________________________ ____________________________

Grower **Beekeeper**

PHOSPHORUS RESEARCH: WHAT WE'VE LEARNED SO FAR

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Phosphorus (P) is one of 13 mineral elements required for plants to grow, develop, and reproduce. It is involved in energy capture, transport, and utilization as well as in membranes, proteins, and genetic materials. Phosphorus is also potentially an environmental contaminant. It is often the limiting factor for algae growth and the growth of aquatic weeds. Balancing the agricultural requirement for phosphorus while protecting aquatic environments is the challenge for cranberry growers. This article will outline some reports from the literature, Wisconsin yield trials, and water sampling results.

The landmark research dealing with the phosphate needs of cranberry vines was done in Massachusetts by DeMoranville and Davenport (1997). They examined forms, rates, and timing for application of phosphorus containing fertilizers on cranberry yields. They conducted trials for three years at six properties before reporting the results. While their research was conducted in Massachusetts, I believe that the results apply equally well to Wisconsin conditions.

Forms. They looked at phosphorus in three different forms plus combinations including triple super phosphate (TSP), phosphoric acid, rock phosphate, inorganic 10-20-10, fish fertilizer, chicken manure, bone meal, 14-14-14, and Osmocote slow release fertilizer. TSP breaks down quickly into phosphate ions as does phosphoric acid. Rock phosphate is relatively insoluble and breaks down to phosphate slowly. The rate of release is likely related to soil pH and moisture. 10-20-10 and 14-14-14 contain phosphate as monoammonium phosphate and/or TSP and is readily soluble. Results of this research are shown in Tables 1 and 2.

Comparing the inorganic sources in Table 1, there were no differences among the products or combinations for yield. All had higher yields than the control. Tissue P was also similar among the products (data not shown). Subtle differences were noted between the inorganic, organic, and slow release products. However, all were better than no P. Rock phosphate and rock phosphate plus phosphoric acid were better than chicken manure or fish fertilizer. All other treatments were roughly equal in terms of yield or tissue P.

Rates. Phosphate as TSP was applied at four different rates: 0, 46, 92, or 137 pounds of P_2O_5 per acre. The fertilizer was applied in equally split amounts at roughneck, bloom, fruit set, and bud set. Yield was determined by harvesting rings with 2 x 2 meter plots. Plots receiving fertilizer had higher yields than unfertilized plots (Table 3). However, yield did not increase as fertilizer application increased above 46 lbs P_2O_5/a. This strongly suggests that 46 lbs P_2O_5/a is the optimal rate for P fertilization for cranberries. As P applications increased tissue P also increased, but yield did not increase along with P applications.

Timing. Plots received different rates of fertilizer at different timings. When the effect of fertilizer rate was factored out there was no effect of the timing of application on yield (data not shown).

Wisconsin Yield Trials

Over the past three years we have conducted a similar trial in Wisconsin. We wanted to pinpoint with more accuracy the optimal rate of P application for cranberries under Wisconsin conditions. We primarily used TSP, but we have also evaluated an inorganic slow release product. Rates of N and K were identical for all treatments. We have found no differences in yield as either fruit number or weight per 6" ring at either of two properties so far (Table 4). We did find some differences in tissue P at Marsh 1. However, note again that increasing tissue P with increasing fertilization did not lead to higher yields.

Water Sampling

Over the past three seasons we have monitored the phosphorus concentration in water in inlet and outlet water at two cranberry marshes in central Wisconsin. Marsh 1 is an older property with peat based beds. The inlet samples were taken in the reservoir while the outlet samples were taken in a major drainage ditch that exits the property. Marsh 2 is a newer property with sand based upland beds. The inlet samples were taken in a stream that supplies water to the property while the outlet samples were taken in a drainage pond or ditch. Samples were collected using autosamplers at each location. Water samples were pulled every 12 hours and then pooled across a week. Data are shown by week. Results are shown in Figures 1-3.

On only one sampling date across the three years did P in any sample exceed 1 ppm. This was also associated with having drawn algae into our sample bottles. We did find some P in outlet water for Marsh 1 on many dates, particularly later in the season during 2002 and 2003. Marsh 1 generally showed inlet and outlet water with less than 0.2 ppm P.

These data show that some P is leaving some properties in drainage water. While the concentrations are very low, when this is multiplied by a substantial amount of water moving through a property the total amount of P may be environmentally significant.

Conclusions

The data presented here strongly suggests that growers can reduce the amount of P fertilizer they apply while still maintaining high yields. There is no general relationship between tissue P and yield when fertilizer application exceeds 46 lbs P_2O_5/a and tissue P is above 0.1%. We urge growers to think carefully about the amount of P fertilizer they apply and to make every effort to reduce introducing phosphate into the environment.

Table 1. Comparison of soluble, insoluble and foliar P forms applied to field grown cranberries. Data collected after three successive years of treatments. All materials were applied each year at the rate of 40 lbs P_2O_5/a. Mean separation within columns by Tukey's HSD test.

Product	Yield (bbl/a)
Triple super phosphate	175 a
Phosphoric acid (foliar)	163 a
Phosphate rock	176 a
Rock + foliar	175 a
Rock + TSP	182 a
Control	124 b

Table 2. Comparison of inorganic, slow release, and organic forms of P applied to field grown cranberries. Data collected after three successive years of treatment. Mean separation within columns by Tukey's HSD test.

Product	Yield (bbl/a)	Shoot P (%)
Inorganic 10-20-10	173 ab	0.098
Fish (2-4-2 liquid)	137 bc	0.083
Phosphate rock	193 a	0.078
Osmocote	173 ab	0.071
Inorganic 14-14-14	163 ab	0.084
Chicken manure (3-4-3)	146 bc	0.085
Bone meal (4-12-0)	160 abc	0.081
Rock phosphate + foliar	190 a	0.078
Osmocote + foliar	162 ab	0.083
Control	124 c	--

Table 3. Comparison of four rates of phosphorus applied to field grown cranberries. Data collected after three successive years of treatment. Mean separation within columns by Tukey's HSD test.

Rate (lbs P_2O_5/a)	Yield (bbl/a)	Shoot P (%)
0	136 b	0.123 c
46	170 a	0.136 b
92	156 a	0.148 a
137	164 a	0.152 a

Table 4. Comparison of rates of triple super phosphate and polyon on two cranberry marshes in Wisconsin. Data were collected after 3 years of treatments. Mean separation within columns by Duncan's MRT following a significant F-test.

Treatment	Marsh 1			Marsh 2		
# P_2O_5/a	Fruit no.	Weight (g)	Tissue P (%)	Fruit no.	Weight (g)	Tissue P (%)
Control 0	144	218	0.140 a	53	74	0.125
5 TSP	146	230	0.146 ab	48	63	0.130
10 TSP	173	269	0.153 abc	60	84	0.134
15 TSP	144	222	0.159 bc	47	68	0.157
20 TSP	181	269	0.158 bc	47	63	0.142
30 TSP	139	217	0.156 bc	40	57	0.143
10 Polyon	158	239	0.155 bc	38	52	0.135
15 Polyon	152	239	0.160 bc	48	69	0.128
20 Polyon	134	207	0.163 cd	35	50	0.147
30 Polyon	146	228	0.175 d	36	46	0.158

Figure 1. Results of water sampling above and below two Wisconsin cranberry marshes during 2001. Samples were taken every 12 hours using an autosampler and were subsequently pooled across weeks.

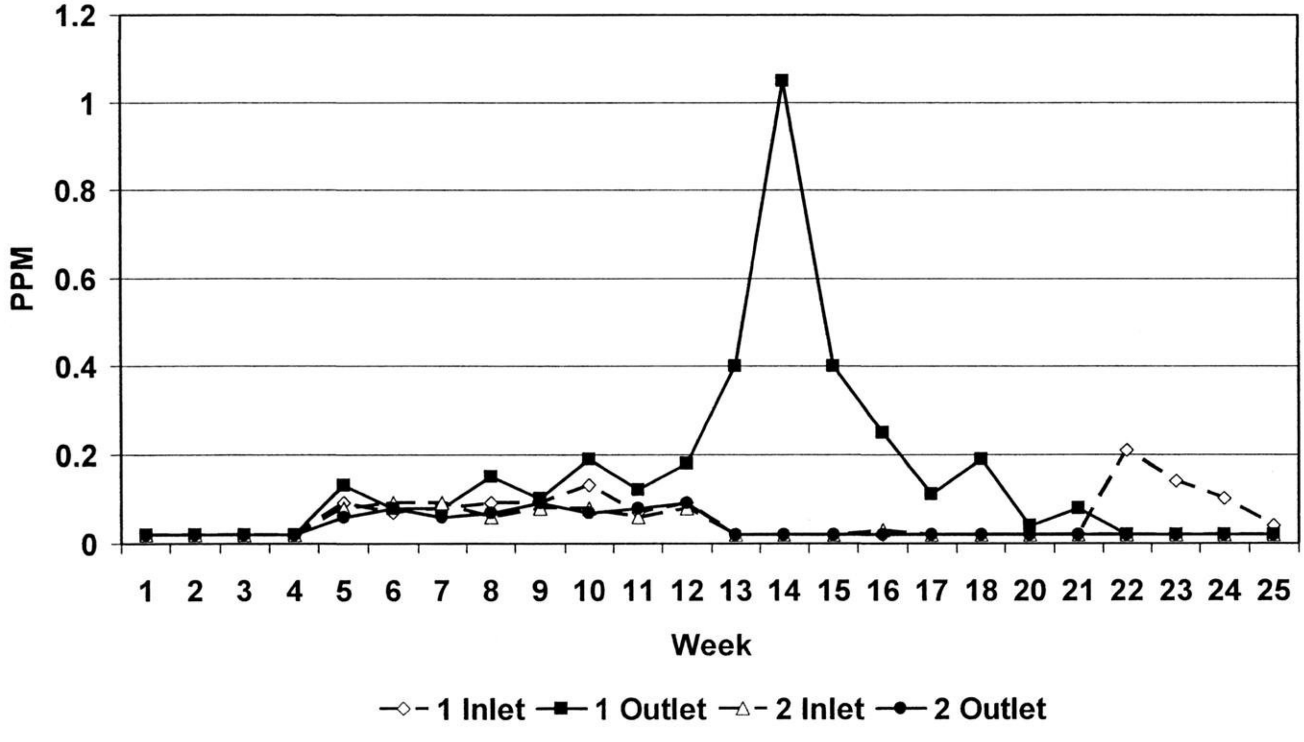


Figure 2. Results of water sampling above and below two Wisconsin cranberry marshes during 2002. Samples were taken every 12 hours using an autosampler and were subsequently pooled across weeks.

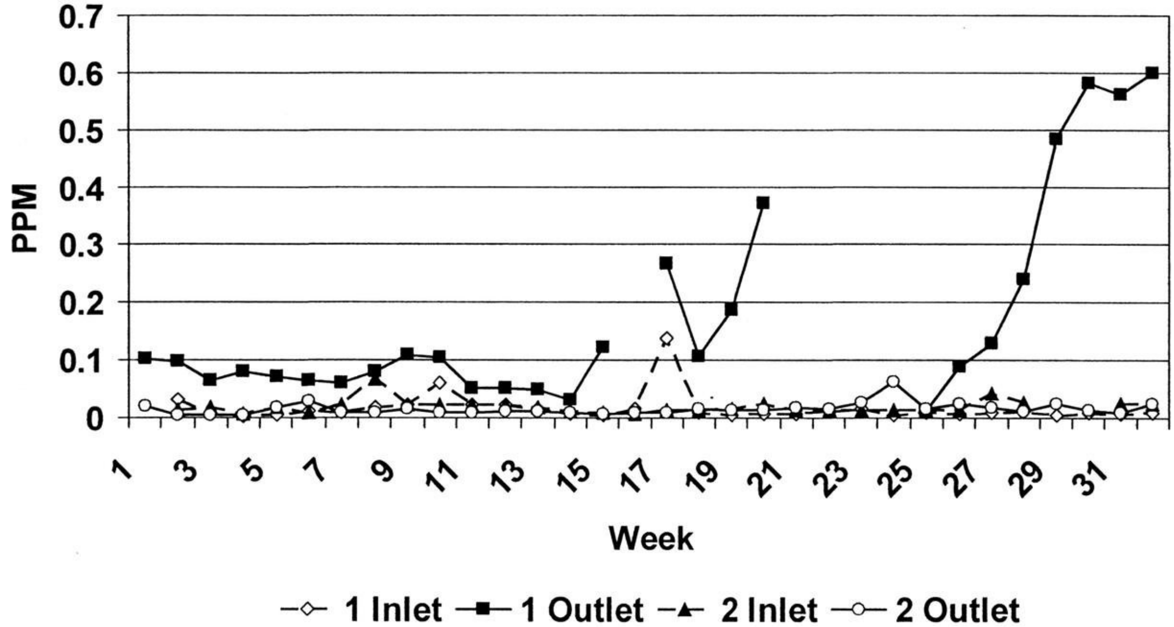
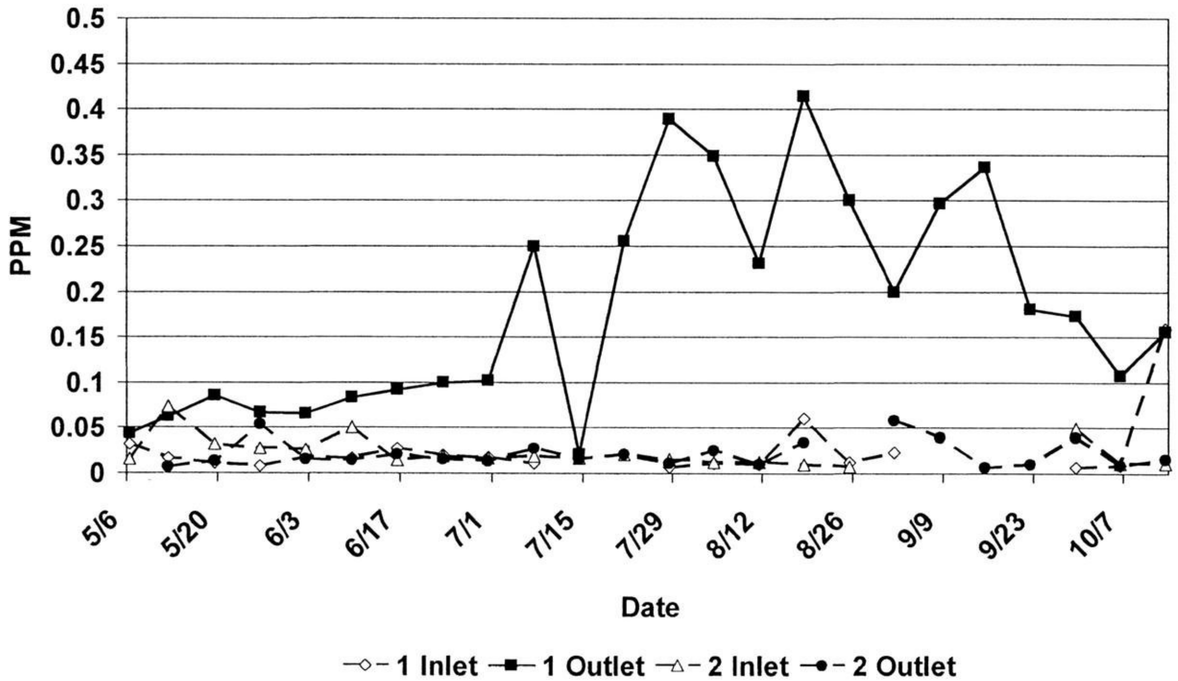


Figure 2. Results of water sampling above and below two Wisconsin cranberry marshes during 2002. Samples were taken every 12 hours using an autosampler and were subsequently pooled across weeks.



CRANBERRY FRUIT ROT: CURRENT STATUS AND MANAGEMENT

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Cranberry fruit rot can be divided into four categories: (i) field rot, which is caused by fungi in the field up to the time of harvest; (ii) storage rot, which is caused by fungi while berries are being stored; (iii) scald, which is caused by exposure to sunlight, either direct or reflected off sand; and (iv) sterile breakdown, in which fruit decay in the apparent absence of fungi. Sterile breakdown is more common in storage, although it can occur in the field before harvest. For example, deterioration of fruit following scald injury can occur in the absence of pathogens. The focus of this article will be on field rot. Field rot is not a concern for most growers in Wisconsin, although in any given year, economically significant losses occur on some marshes.

In 1999 and 2000, several 'Stevens' beds in Cranmoor (just west of Wisconsin Rapids) were surveyed for field rot. Field rot incidence ranged from 2% to 8% by berry count; the incidence by berry weight was somewhat lower, since rotten berries often weigh less than healthy berries. Newer upland plantings did not differ from older traditional planting in fruit rot incidence. The major fruit rot pathogen identified in that survey was *Physalospora vaccinii* (blotch rot). However, in miscellaneous sampling conducted in 1998 through 2003, we found that where fruit rot incidence was high (about 15% to 40% of berries rotted), fungi in the genus *Colletotrichum* were the problem. Therefore, *Colletotrichum*, although not as common as *Physalospora*, is more likely to cause significant losses.

Cultural practices. Several cultural practices should be considered in areas where fruit rot is a problem. Reflooding beds in the spring to remove "trash" probably reduces fruit rot inoculum, since many of the fruit rot fungi overwinter and produce spores on dead leaves. Fungi generally proliferate if vines remain wet for several hours at a time. A dense canopy of vines, such as from too much nitrogen, will remain wet for long periods of time. Irrigating in the evening will result in longer periods of wetness than morning irrigation and may lead to fungal fruit rot. Finally, fruit rot is often less severe in seasons following sanding, possibly because the sand buries the leaf litter that harbors pathogens.

Fungicides. Five broad-spectrum fungicides are currently available to combat fruit rot. These are described and their relative strengths and weaknesses are pointed out.

- **Bravo** (chlorothalonil). This is the most effective fruit rot fungicide, but it can be phytotoxic, especially if applied during early bloom. Forms of phytotoxicity reported in research trials and by growers include reduced fruit set that sometimes (but not always) translates into reduced yield; burned flowers; and red flecks and burns on berries.
- **Abound** (azoxystrobin). Abound was registered on cranberry in 2003. It has been deemed "reduced-risk" because of its low toxicity and lack of carcinogenicity to mammals. It is also easy on birds and bees. However, it is toxic to fish, so be sure to read and follow the instructions on the product label to prevent fish kill.
- **Ferbam** is the active ingredient in a few different products (e.g., Carbamate, Ferbame, Ferbam). It is used in New Jersey, especially during bloom because it's not phytotoxic.

- **Mancozeb** is the active ingredient in Dithane, Penncozeb, and a few other formulations. In research trials, mancozeb has proven only moderately effective against field rot, and it reduces fruit color if applied during bloom or to fruit.
- **Copper** comes in many forms (e.g., copper hydroxide, copper oxychloride, copper sulfate) marketed under numerous names. Copper fungicides are marginally effective against fruit rot at best. In the eastern U.S. where field rot incidence commonly exceeds 50%, coppers generally do better than not spraying at all, but they fall far short of the other fungicides. In Wisconsin, copper has never been different from the untreated check in research trials.

A major limitation in developing a spray program to manage fruit rot is that we don't know which species of fungi are releasing spores at what time. Spray programs are not fine-tuned for controlling specific pathogens (e.g., no specific program to control *Colletotrichum*). Therefore, we assume pathogens are present and apply broad-spectrum fungicides when plants are most susceptible to infection, Over the past several years, research by Peter Oudemans at Rutgers University and Frank Caruso at University of Massachusetts has demonstrated that the most critical time to spray is *bloom through early fruit set stages.* They found that delaying the first Bravo spray until after bloom was much less effective. For example, applying Bravo during late bloom (once at 50% out of bloom and a second time 10 days later at 80% out of bloom) resulted in 8% field rot at harvest, whereas applying Bravo at 10 and 20 days after bloom resulted in 42% field rot at harvest, only slightly better than the 60% rot in the untreated check.

Where does the new fungicide Abound fit into a fruit rot spray program? Abound has not been as consistently effective against rot as Bravo in field trials, but it is not phytotoxic. Therefore, it may have role during early to full bloom. Abound is effective against the cottonball pathogen, so if both field rot and cottonball are problem, then Abound would be a good choice during bloom. Abound has a very specific mode of action, however, so fungicide resistance is a great concern. Abound should not be used in more than two consecutive sprays. The label allows up to six sprays per season, but a maximum of four should be enough for control of cottonball and field rot in Wisconsin.

Considerations for 2004. If field rot was less than 10% in 2003, you're at about "par" for Wisconsin. You should probably just take your chances in 2004, because fungicides are not likely to pay for themselves at that level of rot. However, if rot was greater than 15%, and especially if pathogens were identified in the rotten fruit, then fungicides are probably justified in 2004. Bravo has the proven track record *if sprays are started during full to late bloom.* Abound has been as good as Bravo in some but not all trials, but Abound is safe during bloom.

Possible field rot spray programs. Several possible spray programs to manage fruit rot, and relevant comments, are listed in the table below. In the eastern U.S., many growers spray Bravo two or three times per season and reduce rot from about 50-100% to 5-10%. In Massachusetts growers apply chemicals in very dilute form (hundreds of gallons of water per acre) through the irrigation system and do not experience phytotoxicity from Bravo. In New Jersey mancozeb or ferbam is often used during early bloom to avoid potential phytotoxicity. In Wisconsin, two sprays (full bloom and early fruit set) are probably adequate, since we almost never see 50% field rot. The efficacy of a single spray of Bravo has not been studied, but the best timing would probably be at early fruit set—fruit are susceptible at this time and the risk of phytotoxicity is less than during bloom. Abound would almost certainly be better than nothing, but Abound has not been as consistently effective as Bravo in trials.

Program	10-20% bloom	50-60% bloom	Early fruit set	Comments
1	Bravo	Bravo	Bravo	At high or low rate, likely to be effective, but risk of phytotox.
2	Abound	Abound	Bravo	If Abound used at high rate, should be effective; phytotox. risk less than #1
3		Bravo	Bravo	Phytotox. risk
4		Abound	Bravo	Phytotox risk less than #3
5		Abound	Abound	Little or no phytotox risk, but possibly less effective than #3 or 4

What about hail and fruit rot? To my knowledge, the benefits of fungicides applied to hail-damaged fruit has not been demonstrated in the field. In 1995 Teryl Roper at University of Wisconsin tested the effect of fungicides applied to fruit mechanically injured with a cow magnet. In this experiment there were three groups of fruit with various degrees of injury: (i) bruised, but skin intact; (ii) skin broken; and (iii) undamaged fruit. Half the fruit in each group were inoculated with fungi by dipping them into cranberry ditch water, while the other half were not inoculated. Then fruit were sprayed with Bravo, Penncozeb, or nothing. Some fruit were held at room temperature while another group was stored in a refrigerator. The main findings were: (i) bruised fruit rotted more quickly than healthy fruit, but broken fruit rotted the fastest of all; (ii) fungicides applied to bruised or broken fruit did not reduce rot; and (iii) fruit rotted faster at room temperature than in the cold.

Growers themselves are in the best position to do a real-life field study to test the effect of fungicides after hail; they know where the hail hit and can get out there within a day to apply treatments. It's critical, however, to leave at least a few areas unsprayed for later comparison to sprayed areas. This can be done either by turning off nozzles or covering plants with a tarp, and then marking with flags which areas are which.

HOW LONG DO INSECTICIDE RESIDUES PERSIST?

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A question that I frequently get asked is "How long do insecticides last after spraying?" Usually this question relates to the insecticidal effectiveness of the spray. But with some growers experiencing abnormally high acephate residues in 2003, the question is equally relevant to residues at the time harvest in relation to federally-allowable limits. The question is not an easy one to answer, as a diversity of factors impact insecticide persistence. Further, in many cases, there has been little research on specific pesticides against specific pests on specific crops. Once the Environmental Protection Agency (EPA) determines what the allowable residues will be on a crop at harvest, chemical companies must then do field trials to determine how long residues last after application. But much of this information is held by the companies and never published in accessible locations. Further, for pests of minor crops such as cranberry, there has been relatively little research done on the effective life of pesticides after spraying, or the factors that lengthen or shorten the period of effectiveness.

Insecticides begin to break down as soon as they are mixed in the spray tank. Indeed, many products start to break down while still in the original container, and most products have an acknowledged shelf life. Once mixed and applied, factors that influence rate of breakdown include

- the chemistry of the insecticide,
- chemical and physical properties of spray additives,
- chemistry (pH, hardness) of the spray water,
- a multitude of environmental factors (temperature, humidity, rainfall),
- factors relating to the plant (surface chemistry, waxiness, etc.).

All of these factors can influence (1) the insecticidal effectiveness of a product , (2) its fate and persistence in the environment, and (3) the amount of residues left in or on the berries at harvest.

Defining some terms. The following terms relate to pesticide residues.

Residue. Any quantity of the originally applied pesticide chemical. This can refer to residues in or on the plant, or in the environment, such as soil residues.

Residual effectiveness. The period of time the the applied material remains as an effective insecticide.

Half-life. The amount of time it takes for ½ of the original material to be broken down or removed. For each additional half-life period, 50% of the remainder will be lost.

Breakdown product. Insecticides disappear in a variety of ways. They may be washed off and end up in the soil or water. They may evaporate. Or they may decompose. Decomposition can be caused by light (photodecomposition), chemical reactions, or other factors. When the molecules break down, smaller molecules of various types remain; these are called breakdown products. These in turn can further decompose into yet additional breakdown products. Breakdown products may be either more or less toxic (e.g. to mammals) than the original insecticide. For example, a breakdown product of acephate is methamidophos, which is itself manufactured and sold as an insecticide. Methamidophos is about 50 times more toxic to mammals (by oral exposure) than is acephate.

Tolerance. This is the level of a pesticide that is allowable in a commodity that is in a position to be purchased and used by a consumer. Tolerances are established by EPA. Based on rates of decomposition, the tolerances dictate the amount of product that can be used on the crop (rate of application; number of sprays) and the Preharvest Interval (days between last application and harvest).

Insecticide residues: a historical review. Until recently, in the historical development of insecticides, most could be grouped into six major categories based upon either their derivation or their chemistry. Each group has somewhat different residue characteristics. I have gleaned the following information from a variety of sources; in some cases the information is a bit ambiguous.

- Inorganic (elemental) insecticides are those that are based on the elements, such as sulfur, lead, and arsenate. As elements, they can not be further broken down and therefore have a long persistence. However, they can be combined with other chemicals; such molecules may have different toxicity characteristics from the elements themselves.
- Botanical insecticides are those that are derived directly from plants, such as pyrethrum and rotenone. These have a relatively short persistence on plants and in water and soil. Pyrethrins, the insecticidal molecules in pyrethrum, are rapidly decomposed by water, light, and mildly acidic or alkaline pH. Rotenone has a half-life of only 1-3 days, and in the heat of summer is nearly totally lost within 2-3 days.
- Organochlorine insecticides include such materials as DDT, chlordane, and aldrin, which have long since been discontinued because of their very high persistence in soil and water. The half-life of DDT is 2-15 years; for chlordane 4 years.
- The organophosphate (OP) and carbamate insecticide groups are nerve toxins. Though chemically different, they have similar properties. Most of our older cranberry insecticides are organophosphates, including phosmet, acephate, chlorpyrifos, and azinphosmethyl. The insecticide of choice in cranberry many years ago was parathion, an OP that is no longer available. Carbaryl is a carbamate. The following are examples of these two groups. Parathion is relatively short-lived; the half-life on foliage is 1 day to 2 weeks; breakdown is slower in soil. Chlorpyrifos has a soil half-life of 11-140 days; persistence increases in more acidic soils; "residues" (unspecified levels) occur on plant surfaces for 10-14 days after application. Carbaryl has a soil half-life of 7-28 days; plant surface residues (unspecified levels) usually last less than 14 days.
- Microbial insecticides are those which include living microorganisms such as bacteria, fungi, or viruses. These microbes are usually very susceptible to ultraviolet light and die quite rapidly when exposed to sunlight; persistence is longer if protected in the soil. *Bacillus thuringiensis* (Bt) is the most commonly used microbial insecticide in cranberry. In one study it was found to have a soil half-life of 4 months, but this included reproduction in the dead cadavers of its host insects. The half-life on foliage exposed to sunlight is about 4 hours.

Reside impacts: insecticidal effectiveness. The following table contains data of cranberry insecticides derived from a variety of sources. The fact that some of the data are conflicting reflects on the complexity of variables that affect persistence of residues. Also, note that the data are presented in different ways, such as "half-life" vs. "residual" vs. "effectiveness." Also note that none of the data are derived from cranberry; the limited data available are largely from major crops such as cotton and soybean; results on cranberry might be quite different.

Product	**Residual on Foliage**
acephate (Orthene™)	1-15 day half-life.
azinphosmethyl (Guthion™)	3-5 day half-life. 2 weeks of effectiveness.
Bt	4 hour half-life.
carbaryl (Sevin™)	Less than 14 day residual.
chlorpyrifos (Lorsban™)	10-14 day residual.
diazinon	2-14 day half-life.
phosmet (Imidan™)	No data located.
spinosad (SpinTor™)	No data located.
tebufenozide (Confirm™)	No data located.

A closer look at the above information for azinphosmethyl is quite revealing. It has a relatively short half-life on foliage (3-5 days) but it has 2 weeks of effectiveness. This indicates that the recommended rates are sufficiently high to allow for longer residual effectiveness.

The following factors generally **decrease** the residual effectiveness of an insecticide (but note that the amount of decrease can vary with product and other factors):

- lower application rates,
- high pH (greater alkalinity) of spray water,
- high pH of overhead irrigation water,
- amount of irrigation or rainfall,
- amount of sunlight,
- high temperatures, low humidity, wind.

Residue impacts: fate in the environment. Generally, pesticide contamination of the environment is viewed unfavorably and we do everything that we can to avoid such problems. In fact, it is impossible to totally avoid insecticide residues on non-target plants, in the soil, or in water. The following factors tend to **increase** environmental persistence:

- more product used: more applications and/or higher rates,
- neutral to acidic spray water and irrigation water,
- how soluble the material is in water,
- how much adhesion it has to soil particles and organic matter,
- amount and intensity of irrigation and rainfall,
- favorable soil and water chemistry,
- lack of microorganisms that decompose pesticide molecules,
- low soil temperature and moisture.

Residue impacts: residues in the crop. By law, pesticide residues on the consumable crop can not exceed federal tolerances. To avoid illegal residues, the insecticide label includes directions on the allowable rates of use, the possible frequency of application, the number of applications, the total amount that can be applied during one cropping cycle, and the minimum time that must be observed between the last application and harvest. Many of the same factors that often increase environmental persistence also impact insecticide decomposition in or on the fruit. Some of these factors include

- more product used: more applications and/or higher rates,
- closeness to harvest,
- adsorption to the fruit surface (a property of the material and adjuvants),
- amount of weathering and irrigation,
- low temperatures and/or high humidity.

Some summary thoughts. Very little data on residues exist in accessible literature; most is proprietary information of the chemical companies. Information that is available is mostly from major crops; I could find nothing specific to cranberry. Even less information is available on the newer chemicals becoming registered, from newer insecticide classes. However, many of the newer products are more selective, with fewer non-target effects; many have a very low level of toxicity to humans. Therefore, these products may have very acceptable periods of residual effectiveness with fewer concerns of having unacceptable residues in the crop.

Web sources for pesticide information. The following websites contain useful pesticide information:

- Extension Toxicology Network: http://ace.orst.edu/info/extoxnet
- CDMS Ag Chem Information Services: http://www.cdms.net/manuf/manuf.asp
- US EPA: http://www.epa.gov/ebtpages/pesticides/html

STINGER 3A FOR COMPOSITE AND LEGUME WEED CONTROL IN CRANBERRIES

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Stinger 3A is a new herbicide available to control certain broadleaf weeds in cranberries. The label is a 24(c) Special Local Need label, and is available in most cranberry producing states. Obtain a copy of the label from your local county agricultural agent or farm supply dealer. Attached to the label is a Waiver of liability. Fill out, sign, and mail the Waiver of Liability Certificate according to the directions. Read and follow all Specific Use Restrictions on the label.

Stinger 3A controls Composite and Legume weeds in cranberries. Composite weeds include annuals such as ragweed, fireweed (American burn weed), and beggars ticks (pitchforks), and perennials such as asters species, goldenrod species, and Canada thistle. Legume weeds include annuals such as vetch species, and perennials such as wild bean and clover species. Stinger 3A should be applied as a single or split application by a ground driven boom sprayer calibrated to deliver between 20 and 50 gallons per acre. Application should be made as target weeds emerge, or soon afterward, before perennials exceed two to four inches tall, and before annuals exceed two inches tall or develop more than four to six true leaves. The cotyledons, or halves of the seed, do not count. Stinger will have little or no affect on most weeds that are not in the Composite or Legume plant families.

Apply Stinger 3A at the rate of 2.66 to 8.0 fluid ounces of product per acre (0.0625 to 0.188 lb ai/acre) when a single application is planned. When more than one application is sprayed, do not exceed 1 pint of Stinger per acre (0.375 lb ai /acre) per year. Do not apply within 50 days of harvest.

Stinger 3A is a growth regulator type herbicide. Typical injury symptoms in sensitive plants includes twisting, curling, stretching, feathering, cupping and other abnormal leaf growth, swelling of the growing point and no new growth, and finally plant death. Seedlings die more quickly than larger established weeds. Cranberries affected by Stinger 3A will look more silver in color from a distance. The leaves of the new growth will be oriented vertically rather than horizontally around the stem so the underside of the leaves, which is more silver in color, is visible rather than the top of the leaves.

Cranberries are more sensitive to Stinger before bloom. Use ONLY the lower rate of 2.66 fluid ounces per acre of Stinger 3A when applications are made in the early spring before growth begins, during the period of rapid shoot growth in late May and June, and before bloom. Use the higher rate of 5.33 fluid ounces per acre of Stinger 3A for most weed problems when applications are made in the summer after bloom. Apply the highest labeled rate of 8.0 fluid ounces per acre to control heavy aster, goldenrod, or Canada thistle infestations. Applications in late July and August must be made with attention to the projected harvest date to maintain the 50 day pre-harvest interval (PHI).

Stinger is a residual herbicide. The Stinger rate per acre cannot be controlled when applying spot treatments "sprayed to wet". This type of application may result in moderate or severe crop injury, therefore **spot treatments "sprayed to wet" are NOT recommended**.

THE PHYTOTOXICITY AND EFFICACY OF SEVERAL EXPERIMENTAL HERBICIDES IN CRANBERRIES

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The cranberry weed control program at Rutgers has been active since the mid 1990's. Weeds, particularly perennials, are difficult to control in cranberry bogs. Efforts have focused on identifying and developing new herbicides for use in cranberries that do not injure the crop, control troublesome weeds, and are environmentally and toxicologically safe. To accomplish this goal, cooperation with IR-4, the herbicide manufacturers, and state and federal agencies to obtain registration for herbicides is essential. Effective herbicides must be integrated into the current cranberry practices to improve weed control, prevent crop phytotoxicity, and maintain or improve yield and quality. Herbicides registered on other crops and experimental herbicides are first screened for phytotoxicity to cranberries. Three herbicides with potential crop safety in cranberries have been identified, and are being evaluated for the control specific weeds that are troublesome in cranberries. Research continues with these herbicides on the potential for crop phytotoxicity and impact on yield and quality in the cranberry production system.

DPX 6025 has been identified as safe for use in cranberries is under evaluation for the control of cranberry weeds. Good control of sedges *Cyperus* species, and a variety of annual broadleaf weeds have been controlled by late spring applications of DPX 6025. Screening to identify additional herbicides with the potential to control weeds in cranberries will continue.

BAS 514, has been identified as another herbicide safe for use in cranberries, and has controlled yellow loosestrife *Lysimachia terrestris*. Date developed to date indicates that the optimum time to apply quinclorac for the control of yellow loosestrife is during late bloom or immediately after bloom. Yellow loosestrife bloom occurs in or near early July in New Jersey cranberry bogs and the optimum treatment time is the month of July. In addition, quinclorac has demonstrated potential for controlling additional weeds in cranberries when applied preemergence, including fireweed and sedges. Additional research and concurrence of the manufacturer is needed on the time of application, rate, and other weeds controlled by quinclorac in cranberries, and to integrate the optimum time of application for yellow loosestrife control with applications to control other susceptible weeds.

Za 1296 is the most recent herbicide that has been identified to have excellent safety when applied to cranberries. Research indicates ZA 1296 controlled sedges and rushes, Juncus species, and redroot, *Lachnanthes tinctoria,* in cranberries. The manufacturer has interest in supporting an IR-4 project on mesotrione in cranberries, and has confirmed that environmental data on file at the EPA will support a label for up to 0.25 lb ai/A per application, and two applications per year and up to 0.5 lb ai/A per year with fourteen days between applications. Additional research is needed on the time of application, rate, and other weeds controlled.