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Prepared by Martha M. Sylvia and Katherine M. Ghantous

Pesticide resistance is **an inheritable** (genetic) characteristic of a pest that makes it less sensitive to a pesticide and can occur in **all** types of pests (weeds, insects, fungi, etc.). Repeated use of the same pesticide (or pesticides with the same mode of action) over time kills pests that are susceptible to the pesticide and leaves behind individuals that are less sensitive. These then reproduce and pass on the genes that let them survive pesticide exposure to their offspring. The goal in resistance management is to not repeatedly use compounds that fall within the same group. Resistance management may include alternating products with different modes of action or limiting the total number of applications per season.

International groups have been founded for a cooperative approach to resistance management. They have assigned group numbers to pesticides to help growers make decisions on how to rotate pesticides. They are based on mode of action – how and where the chemicals in the pesticide work on the target.

In an effort to manage resistance with our pesticides, most labels now come with a “group” number assigned to them. The group number is specific for each type of pesticide (i.e. Group 1 insecticides have no relation to Group 1 herbicides). The following 3 pages show the groupings for our cranberry pesticides. Some active ingredients are available under several different product names, and different active ingredients have the same mode of action. When rotating pesticides for resistance management, use the **group number** as your guide and NOT the product name or active ingredient.

The group number is located on the first page of the label, and is usually displayed similarly to this example:

GROUP **5** INSECTICIDE

Insecticide Resistance Action Committee (IRAC) (<http://www.iraconline.org/>)

The Insecticide Resistance Action Committee (IRAC) has been formed to assemble the information for insecticides. For cranberry, organophosphates and neonicotinoids have the most compounds within their group. We are reliant on several compounds in these groupings. As long as growers remember to alternate between groupings and not repeat same mode-of-action compounds over and over, we should be able to keep newer compounds viable for decades. See Cranberry Insecticides by grouping on the next page.

Fungicide Resistance Action Committee (FRAC) (<http://www.frac.info/home>)

The group that advises for fungicide resistance is the Fungicide Resistance Action Committee (FRAC). Their goal is to prolong the effectiveness of fungicides that are likely to encounter resistance problems. For cranberry, Ridomil and Abound are fungicides that are at high risk for resistance development, while Indar and Proline are at medium risk. They should not be used repeatedly and should be carefully alternated with other fungicides from other groupings. See Cranberry Fungicides by grouping on page 6.

Herbicide Resistance Action Committee (HRAC) (<http://www.hracglobal.com/pages/Home.aspx>)

The Herbicide Resistance Action Committee and The Weed Science Society of America (WSSA) have both developed similar classification systems of herbicides. WSSA uses numbers instead of letters to designate the categories. A key step in resistance management is to minimize the continuous use of herbicides with the same mode of action through rotations and combinations of products. One of the purposes of these classification systems is to make it easier for farmers and farm advisors to understand which herbicides share the same mode of action without having to actually know the biochemical basis.

In cranberry, our biggest concern for developing resistance is our reliance on Callisto. Be sure to rotate other compounds into your herbicide schedule. Do not treat the same bog with Callisto year after year. See Cranberry Herbicides by grouping on page 7.

Insecticide Resistance Action Committee (IRAC) Grouping for cranberry insecticides

| IRAC GROUP | TRADE NAME | ACTIVE INGREDIENT | MODE OF ACTION | CHEMICAL FAMILY |
|------------|-------------------------------------|-------------------------------|--|---------------------------------|
| 1 | Diazinon | diazinon | Acetylcholine esterase inhibitor | Organophosphates and carbamates |
| | Imidan | phosmet | | |
| | Lorsban | chlorpyrifos | | |
| | Orthene | acephate | | |
| | Sevin | carbaryl | | |
| 3 | Pyganic | pyrethrin | Sodium channel modulators | Pyrethrins |
| 4, 4A | Actara | thiamethoxam | Nicotinic Acetylcholine receptor agonists | Neonicotinoids |
| | Admire | imidacloprid | | |
| | Assail | acetamiprid | | |
| | Belay | clothianidin | | |
| | Scorpion | dinotefuran | | |
| 5 | Delegate | spinetoram | Nicotinic Acetylcholine receptor allosteric activators | Spinosyns |
| | Entrust | spinosad | | |
| 11 | Dipel Xentari Biobit | <i>Bacillus thuringiensis</i> | Microbial disruptors of insect midgut membranes | <i>Bacillus thuringiensis</i> |
| 15 | Rimon | novaluron | Inhibitors of chitin biosynthesis | Benzoylureas |
| 18 | Confirm | tebufenozide | Ecdysone agonists / molting disruptors | Diacylhydrazines |
| | Intrepid | methoxyfenozide | | |
| 21 | Nexter | pyridaben | Mitochondrial complex / electron transport inhibitor | Meti acaracides |
| 22 | Avaunt | indoxacarb | Voltage-dependent sodium channel blockers | Oxadiazines |
| 23 | Oberon | spiromesifen | Inhibitors of acetyl CoA carboxylase | Tetramic acid derivatives |
| 28 | Altacor | chlorantraniliprole | Ryanodine receptor modulators | Diamides |

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Fungicide Resistance Action Committee (FRAC) Grouping for cranberry fungicides

| FRAC GROUP | TRADE NAME | COMMON NAME | MODE OF ACTION | GROUP NAME | CHEMICAL GROUP | Resistance Development Risk |
|-----------------|-----------------------------|----------------------|---|---|--------------------------------|-----------------------------|
| 4 | Metastar | mefenoxam | A1: RNA polymerase I | PA – fungicides (PhenylAmides) | acylalanines | High Risk |
| | Ridomil | metalaxyl | | | | |
| | Ultra Flourish | | | | | |
| 11 | Abound | azoxystrobin | C3: cytochrome bc1 at Qo site | QoI-fungicides | methoxy-acrylates | High Risk |
| | Aftershock | fluoxastrobin | | Strobilurins | dihydro-dioxazines | |
| | Evito | | | | | |
| 3 | Indar | fenbuconazole | G1: c14-demethylase in sterol biosynthesis | DMI-fungicides (DeMethylation Inhibitors) | triazoles | Medium Risk |
| | Proline | prothioconazole | | | | |
| 19 | OSO | Polyoxin D zinc salt | H4: chitin synthase | polyoxins | peptidyl pyrimidine nucleoside | Medium Risk |
| | Ph-D | | | | | |
| 33 | Aliette | fosetyl-Al | Unknown | phosphonates | ethyl phosphonates | Low Risk |
| | Legion | aluminum-tris | | | | |
| | Fosphite | | | | | |
| | Fungi-Phite | | | | | |
| | K-Phite | | | | | |
| Phostrol | phosphorous acids and salts | | | | | |
| ProPhyt | | | | | | |
| Rampart | | | | | | |
| M1 | Champ | copper (salts) | M1: Multi-site contact activity | inorganic | inorganic | Low Risk |
| | Kocide | | | | | |
| M3 | Ferbam | ferbam | M3: Multi-site contact activity | dithiocarbamates | dithiocarbamates | Low Risk |
| | Manzate | | | EBDC's | | |
| | Dithane | mancozebs | | (Ethylene bis dithio carbamate) | | |
| | Penncozeb | | | | | |
| M5 | Bravo | chlorothalonil | M5: Multi-site contact activity | chloronitriles | chloronitriles | Low Risk |
| | Chloronil | | | | | |
| | Echo | | | | | |
| | Equus | | | | | |
| | Initiate | | | | | |

Herbicide Resistance Action Committee (HRAC) Grouping for cranberry herbicides
Group numbering from Weed Science Society of America (WSSA) at right

| HRAC GROUP | TRADE NAME | ACTIVE INGREDIENT | MODE OF ACTION | CHEMICAL FAMILY | WSSA GROUP |
|------------|------------------------|-------------------|--|----------------------------------|------------|
| A | Fusilade | fluazifop-P-butyl | Inhibition of acetyl CoA carboxylase (ACCase) | Aryloxyphenoxy-propionate 'FOPs' | 1 |
| | Select | clethodim | | Cyclohexanedione | |
| | Poast | sethoxydim | | 'DIMs' | |
| F1 | Evital | norflurazon | Bleaching: Inhibition of carotenoid biosynthesis at the phytoene desaturase step (PDS) | Pyridazinone | 12 |
| F2 | Callisto | mesotrione | Bleaching: Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD) | Triketone | 27 |
| G | Roundup | glyphosate | Inhibition of EPSP synthase | Glycine | 9 |
| K3 | Devrinol | napropramide | Inhibition of VLCFAs (Inhibition of cell division) | Acetamide | 15 |
| L | Casoron | dichlobenil | Inhibition of cell wall (cellulose) synthesis | Nitrile | 20 |
| | Quinstar | quinclorac | | Quinoline carboxylic acid | 26 |
| O | Quinstar | quinclorac | Action like indole acetic acid (synthetic auxins) | Quinoline carboxylic acid | 4 |
| | 2,4-D Weedar 64 | 2,4-D | | Phenoxy-carboxylic acid | |
| | Stinger | clopyralid | | Pyridine carboxylic acid | |