**MODE OF ACTION:**
**Cell Membrane Disruptors**

**SITE OF ACTION:**
A. PHOTOSYSTEM I (PS$_1$) INHIBITORS
   GROUP 22
B. PROTOPORPHYRINOGEN OXIDASE (PPO) INHIBITORS
   GROUP 14

**Herbicide injury symptoms - PS$_1$**
- Limp water-soaked appearance, followed by necrosis

**Herbicide injury symptoms - PPO**
- Plants may turn yellow, then turn brown and die

**Herbicide Groups classified as CMDs**
- PS$_1$
  - Bipyridylum
  - Paraquat, Diquat
- PPOs
  - Diphenylether
    - Acifluorfen, lactofen, fomesafen, oxyfluorfen
  - N-phenylthalimide
    - flumiclorac, flumioxazin
  - Oxadiazole
    - oxadiazon
  - Tiazofurinone
    - Carfentrazone, sulfentrazone

**Biological properties of action**
- CMDs are photodynamic
  - they act independently of photosynthesis, but require light for activity
  - PS$_1$
    - PS energy is diverted from normal pathway and leads to production of toxic species and cell membrane destruction
  - PPOs
    - inhibit PPO causing an accumulation of Proto, damaging membranes, causing “leaks” (water soaked appearance)
**Site of action:** PS₁  
**Herbicide family:** bipyridilium
- Herbicide: paraquat  
- Trade name: Gramoxone Inteon, Cyclone Star  
- Cost: $17/lb  
- Rates: 0.25-0.67 lb/A  
- Time applied: POST, contact  
  - action is very fast, a few hours to 2 days

![Paraquat molecule]

**Weeds controlled**
- Non-selective, most annual grass and broadleaf weeds
- Some resistance has occurred worldwide when paraquat is used repeatedly for 8 or 9 years
- burns off the tops of perennials
  - like mowing, weeds just come back
- Similar to glyphosate, but not translocated

**Crops labeled**
- Preplant or prior to crop emergence:
  - Many agronomic crops
  - Many horticultural crops
  - Corn: directed application
    - drop nozzles only in the lower 3 inches of the corn crop
- Desiccant: Product used to kill the above ground growth.
  - promotes dehydration of plant tissue
  - may lower moisture level of seeds to facilitate harvest
- Crops desiccated
  - corn, soybean, drybean, field pea, lentil
  - sunflower (oil-type only)
  - Chemical fallow

**Other comments**
- Restricted use pesticide
  - ORAL TOXICITY
  - Not translocated in the plant (contact)
  - requires a non-ionic surfactant
    - aids in more thorough coverage
    - higher water volume recommended for coverage
  - Immediately inactivated by contact with soil
    - no soil activity
    - very safe preemergence

**Ways to avert people from drinking paraquat**
- Stench
- Induces vomiting (emetic)
- Purgative
- Acid induced gel alginate (turns into gel)
- These Precautions Have Effectively Made Paraquat TEN TIMES SAFER – according to estimates
Site of action: PS₁
Herbicide Family: bipyridylium
- Herbicide: diquat
- Trade name: Reglone, Reward
- Cost: $52.50/lb
- Rates: 0.25-0.5 lb/A
- Time applied: POST, contact

Weeds controlled
- Primarily used as a desiccant
  - dry many crops to facilitate seed harvest, ornamentals included
  - canola
  - potato vine killing
    - can be used for storage potatoes
  - directed underneath several horticultural and tree crops
  - aquatic environments (restrictions apply)
- Non-cropland, non-selective weed control
  - not restricted use
    - Still some risk (i.e. Warning, even Caution)
- www.cdms.net (2010)

Search Results for reglone

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer</th>
<th>Category</th>
<th>Labels MSDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desiccant</td>
<td>Syngenta Crop Protection, Inc.</td>
<td>Agriculture/Crop Protection</td>
<td><img src="https://www.cdms.net/images/diagram.png" alt="" /></td>
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Other...
- Observer characteristics similar to paraquat
  - contact, no soil activity, etc
  - Fast acting, requires NIS
    - Rapid action caused by diquat due to diversion of energy from PS, producing peroxide radicals, which result in rapid cell collapse and onset of phytotoxic symptoms
- Now used in some home and garden mixtures with glyphosate in a consumer targeted product
  - Very small amount of product
  - Claim: “makes the glyphosate work faster”
  - Fact: Visual injury does happen faster, but...

From Wehtje et al.
- Experiment: Applied 14C-glyphosate with and without diquat to compare absorption and translocation
  - Glyphosate applied alone: ~60% recovered on the treated leaf, 40% translocated
  - Glyphosate with diquat: ~80% recovered on the treated leaf, and only 6.1% translocated
  - Diquat antagonized the glyphosate! The claim is misleading.
    - The rapid tissue death from the diquat prevented glyphosate entry into the vascular tissues for translocation
  - To overcome antagonism, higher glyphosate rates must be used
  - These rates are excessive though for the actual need if the consumer would be patient.
**Site of Action: PPO inhibitor**

**Mode of action: Cell membrane disruptor**

- Herbicide group: Diphenylether
- Herbicide: acifluorfen
- Trade name: Ultra Blazer
- Cost: $35/lb
- Rates: 0.25-0.5 lb/A
- Time applied: POST, contact

**Weeds controlled**

- many broadleaf weeds
  - nightshades, G-E
  - common lambsquarters, G
  - wild mustard, E
  - redroot pigweed, E
  - annual smartweeds, E
  - common ragweed, F-G
  - Russian thistle, G
  - Canada thistle, N
  - foxtails, P-F

**Crops labeled**

- soybean
- peanut
- rice
- strawberry

**Other comments**

- No soil residual
- Daytime temperatures should exceed 70 F, but not exceed 85 F
  - If too hot, crop injury
- Adjuvant needed (NIS, PO/COC, AMS, UAN)
  - Temp + RH =155 is benchmark for crop injury concern
  - Adjuvant selection
  - Adjuvant rate
- Mixed with bentazon for broadspectrum control
  - bentazon + acifluorfen = Storm

**Site of action: PPO Inhibitor**

**Mode of action: Cell Membrane Disruptor**

- Herbicide family: Diphenylether
- Herbicide: lactofen
- Trade name: Cobra, Phoenix
- Cost: $80/lb, $90/lb
- Rates: 1.5-3.2 oz/A
- Time applied: POST, contact

**Weeds controlled**

- Many broadleaf weeds
  - common cocklebur, G
  - wild mustard, E
  - redroot pigweed, E
  - nightshades, G
  - common ragweed, G-E
  - annual smartweeds, G
  - foxtails, P-F
### Crops labeled
- Soybean, peanut, kenaf
- Directed in pine seedling, cotton

### Other comments
- Soil residual activity minimal
- Application to soybean at the first bloom has resulted in some white mold (sclerotinia) suppression
- Cobra requires adjuvant, Phoenix has built-in
- Herbicide "burns" soybean, outgrow in 3 wk

### Weeds controlled
- G-E control of most broadleaf weeds listed in the WCG except
  - Wild buckwheat, P
  - Horseweed, N-P
  - Common lambsquarters, P-F
  - Hairy nightshade, F-G
  - Biennial wormwood, P
  - Canada thistle, N

### Site of action: PPO Inhibitor
- Mode of Action: CMD

### Other comments
- Rate varies with geography, due to soil residual
- Include an adjuvant (NIS or MSO)
- Can be mixed with some EC herbicides but the emulsifier may increase crop injury
- Also sold in a premix with glyphosate
  - fomesafen + glyphosate = Flexstar GT

### Site of action: PPO Inhibitor
- Mode of Action: CMD

### Weeds controlled
- Broadleaf weeds
  - G-E on most WCG broadleaf weeds except...
    - Mustards, F
    - Annual smartweed, F
    - Canada thistle, N
    - WCG grasses, P
      - Except Wild Oat, F-G
Crops Labeled

- Key horticultural crop herbicide
  - many trees
  - vegetables, broccoli, cabbage, cauliflower, onion
  - Fruit, nut, and vine crops
- Micro-rate research for weed control in onion
  - Oxyfluorfen (GoalTender):
    - 1 oz ai/A (three sequential applications)
    - Common lambsquarters, F-G
    - Redroot pigweed, E
    - Highest yielding treatment
      - controlled common purslane, E

GoalTender

Other comments

- Surface applied before transplanting of some cover crops (some soil activity)
- Usually can apply over-the-top of conifers but not over-the-top on deciduous trees
- Deciduous trees applied to soil surface after tree leaves have fully expanded

Site of action: PPO Inhibitor

- Herbicide family: N-phenylthalimide
- Herbicide: flumioxazin
- Cost: $260/lb
- Rate: 0.1 to 0.3 oz ai/A
- Trade name: Resource
- Weeds controlled: broadleaf weeds
  - Limited information in ND
  - Limited activity on weeds tested
- Crops labeled
  - corn and soybean

Site of action: PPO Inhibitor

- Mode of Action: CMD

- Herbicide family: N-phenylthalamide
- Herbicide: flumilacar
- Cost: $260/lb
- Rate: 0.1 to 0.3 oz ai/A
- Trade name: Resource
- Weeds controlled: broadleaf weeds
  - Limited information in ND
  - Limited activity on weeds tested
- Crops labeled
  - corn and soybean

Flumioxazin Uses

- Weeds controlled: small-seeded broadleaf
- Crops applied
  - Valor – cotton, bean, corn, potato
  - Chateau – grape, mint, fruit and nut crops
  - Payload – vegetation management, right-of-way
- Available in premixes
  - Fierce – flumioxazin+pyroxasulfone
  - Enlite – flumioxazin+thifensulfuron+chlorimuron
- Available in copack
  - Gangster – flumioxazin+chloransulam
**Site of action**: PPO Inhibitor  
**Mode of Action**: CMD

- Herbicide family: Oxadiazole  
- Herbicide: oxadiazon  
- Trade name: Ronstar  
- Weeds controlled: Annual grass and broadleaf weeds

**Herbicide**: oxadiazon

**Trade name**: Ronstar

**Weeds controlled**: Annual grass and broadleaf weeds

**Herbicide**

**Crops labeled**: turf

- For use in dormant, established turf  
- apply 2-3 wk prior to green-up  
- if rain not expected within 4 hours, water in using irrigator

**Crops labeled**: ornamentals

**Herbicide Family**: Triazolinone  
**Herbicide**: carfentrazone  
**Trade name**: Aim  
**Cost**: $500/lb  
**Rates**: 0.125 - 0.25 oz/A  
**Time applied**: POST, contact

**Site of action**: PPO Inhibitor  
**Mode of Action**: CMD

**Herbicide Family**: Triazolinone  
**Herbicide**: carfentrazone  
**Trade name**: Aim  
**Cost**: $500/lb  
**Rates**: 0.125 - 0.25 oz/A  
**Time applied**: POST, contact

**Weeds controlled**

- Broadleaf weeds (need to be small)  
  - kochia, F-E  
  - common lambsquarters, F-E  
  - nightshades, G  
  - redroot pigweed, G-E  
  - common waterhemp, F-E  
  - wild mustard, P  
  - Canada thistle, N  
  - field bindweed, F  
  - common waterhemp, pigweed family, annual  

**Crops labeled**

- Small grains – up to jointing stage  
  - Premix with 2,4-D called Rage D-tech  
- Soybean – V3 to V10 (not typically used in ND)  
- Corn – up to 12 inches tall  
- Turf – actively growing  
  - Quicksilver  
- Many other directed application labels (avoiding contact with foliage)  
- Can be used PRE to kill existing weeds in more than 200 crops
**Other comments**

- Suitable in many tank-mixes with both grass and broadleaf herbicides
- Requires NIS at 0.25% v/v
- May cause some cosmetic injury (speckling and spotting) soon after treatment to crop plants, but will soon outgrow
- Injury may be increased if applied during high humidity and higher moisture
- Data shows carfentrazone may be safened by ALS inhibiting herbicides

**Site of action:** PPO Inhibitor

**Mode of Action:** CMD

- Herbicide family: Triazolinone
- Herbicide: sulfentrazone
- Trade name: Spartan, Blanket, generics
- Authority: Speedzone
- Cost: $162/lb
- Rates: 1.5-3 oz/A
- Time applied: PRE, PPI, POST (usually not in ND)

**Weeds controlled**

- Many annual small-seeded broadleaf weeds G-E
  - PRE, PPI
    - Goosefoots, E
    - Pigweeds, F-G
    - Nightshades, F-E
    - Mustards, G-E
    - Smartweeds, E
      - Including wild buckwheat, F-G
    - Biennial wormwood, F-G
    - Horseweed, F-G
    - Grass: downy brome, F-G
  - POST
    - Used for grass suppression or control in sod production
    - Yellow nutsedge
    - Purple nutsedge
    - Other sedges

**Crops labeled**

- Soybean
- Dry bean
- Chickpea, field pea
- Sunflower
- Potato
- Flax
- Turf grass for sod production
  - Well established root systems
  - Three month harvest restriction

**Other comments**

- Tank-mixed with PPI/PRE herbicides registered in soybean
- Consistent weed control requires 1/2-3/4 inch of rainfall prior to weed emergence – PRE
  - PPI has become less and less due to cropping systems
- Residual concerns
  - Crop rotation restrictions, especially greater than 1 yr for mustard crops, sugarbeet, and several horticultural crops

**Site of action:** PPO Inhibitor

**Mode of Action:** CMD

- Herbicide family: pyrimidinedione
- Herbicide: saflufenacil
- Trade name: Sharpen (Verdict: saflu + dimethenamid-P)
- Cost: $201.75/lb
- Rates: 0.35-1.1 oz/A
- Time applied: PRE (residual) and POST (burndown)
- Weeds controlled: Most ND WCG broadleaf weeds, G-E
- Crops labeled: PRE: small grains, corn, field pea, chickpea, soybean, sunflower (desiccant)
Homework

- Develop a diagnostic model/tree to separate herbicide site of action by symptomology
- Include all sites from Growth Regulator through next week's Pigment inhibition modes of action
- Work in groups is encouraged, turn in one form per group
- Scematics/diagrams encouraged
- Due April ?, worth 15 pts