Herbicides are used to control weed populations on 215 million acres of cropland in the USA. If herbicides were unavailable, U.S. crop production would decline by 300,000,000,000 lbs of food.


---

**Introduction to Herbicides**

---

**Total Pesticide Use in ND**

(Acres applied)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td>41.1</td>
<td>36.8</td>
<td>30.1</td>
<td>33.6</td>
<td>28.8</td>
<td>27.8</td>
<td>24.8</td>
<td>16.9</td>
</tr>
<tr>
<td>Insecticides</td>
<td>4.5</td>
<td>1.0</td>
<td>0.3</td>
<td>1.5</td>
<td>1.2</td>
<td>2.2</td>
<td>2.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Fungicides</td>
<td>7.3</td>
<td>3.1</td>
<td>0.8</td>
<td>1.5</td>
<td>0.9</td>
<td>0.6</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Desiccants</td>
<td>1.4</td>
<td>0.3</td>
<td>0.01</td>
<td>0.07</td>
<td>0.07</td>
<td>0.02</td>
<td>0.07</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>54.4</td>
<td>41.2</td>
<td>31.2</td>
<td>36.8</td>
<td>30.9</td>
<td>30.5</td>
<td>28.3</td>
<td>17.5</td>
</tr>
</tbody>
</table>

---

**Categorized Pesticide Use in ND**

(Percentage of total pesticide application)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicides</td>
<td>75.6</td>
<td>89.2</td>
<td>96.5</td>
<td>91.6</td>
<td>93.0</td>
<td>90.7</td>
<td>87.4</td>
<td>96.6</td>
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<tr>
<td>Insecticides</td>
<td>8.3</td>
<td>2.6</td>
<td>1.1</td>
<td>4.1</td>
<td>3.8</td>
<td>7.3</td>
<td>10.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Fungicides</td>
<td>13.5</td>
<td>7.6</td>
<td>2.5</td>
<td>4.1</td>
<td>3.0</td>
<td>1.9</td>
<td>1.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Desiccants</td>
<td>2.6</td>
<td>0.6</td>
<td>&lt;0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>

---

**Summary: Pesticide use in ND Tables**

- Overall pesticide use is increasing
  - Applications per acre are increasing
  - 44 million total acres in ND
- Fungicide use continues a steady rise as formulations and products improve
- Insecticide use increased approximately 3 fold from 2004 to 2008
  - but generally trended towards decreased usage

---

**Herbicide Usage in ND**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Fenoxaprop</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>Bromoxynil</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>2,4-D</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Thifensulfuron + tribenuron</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>5*</td>
</tr>
<tr>
<td>Dicamba</td>
<td>14</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Clopyralid</td>
<td>2</td>
<td>7</td>
<td>14</td>
<td>19</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MCPA</td>
<td>10</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

- only primary herbicides included
- * Clopyralid + fluroxypyr tank mix

Important but not obvious here was shift from PRE to POST herbicides
ND Weed Surveys, 1979 & 2000

<table>
<thead>
<tr>
<th>Weed Species</th>
<th>2000 rank</th>
<th>1979 rank</th>
<th>2000 density</th>
<th>1979 density</th>
</tr>
</thead>
<tbody>
<tr>
<td>green foxtail</td>
<td>1</td>
<td>1</td>
<td>14.4/m²</td>
<td>63.2/m²</td>
</tr>
<tr>
<td>wild oat</td>
<td>2</td>
<td>2</td>
<td>4.5</td>
<td>4.1</td>
</tr>
<tr>
<td>yellow foxtail</td>
<td>3</td>
<td>5</td>
<td>7.0</td>
<td>6.4</td>
</tr>
<tr>
<td>kochia</td>
<td>4</td>
<td>9</td>
<td>3.0</td>
<td>1.3</td>
</tr>
<tr>
<td>wild buckwheat</td>
<td>5</td>
<td>3</td>
<td>3.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Canada thistle</td>
<td>6</td>
<td>11</td>
<td>2.5</td>
<td>0.5</td>
</tr>
<tr>
<td>redroot pigweed</td>
<td>7</td>
<td>4</td>
<td>1.8</td>
<td>3.7</td>
</tr>
<tr>
<td>volunteer cereals</td>
<td>8</td>
<td>7</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>common ragweed</td>
<td>9</td>
<td>9</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>field Bindweed</td>
<td>10</td>
<td>10</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>com. lambsquarters</td>
<td>11</td>
<td>7</td>
<td>0.5</td>
<td>1.2</td>
</tr>
<tr>
<td>quackgrass</td>
<td>12</td>
<td>16</td>
<td>0.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Russian thistle</td>
<td>13</td>
<td>8</td>
<td>0.5</td>
<td>1.3</td>
</tr>
<tr>
<td>wild mustard</td>
<td>14</td>
<td>6</td>
<td>0.5</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Summary: ND Weed Survey

- Movers and shakers
  - yellow foxtail – more difficult to kill than green
  - Kochia – ALS resistance
  - Canada thistle – a perennial moving up
- Largest jump
  - Volunteer cereals – more reduced tillage
  - Common ragweed – more row crops
- Largest drop
  - Wild mustard – once was a target weed
- OVERALL, weed frequencies and densities are declining

Important Points from Organic Chemistry

- The chemistry of Carbon containing molecules
- Chemical structures can dictate environmental behavior.
- Compounds are named by the number of C in their structure and their functional groups
- Some functional groups are more prone to degradation and metabolism than others

Classification of Herbicides

Herbicides are Classified Two Ways in WCG

- Site of Action [WCG page 108–109]
  - Classification of how herbicides kill plants or affect growth
  - Widely accepted as the most precise way
  - The big picture and the fine details
- Chemical structure/families
  - Subcategory listing in Weed Control Guide
  - Problem is nearly identical structures present vastly different outcomes

Examples: MOA vs. SOA

- Herbicide:
  - clodinafop-P
- Tradename:
  - Discover NG
- Herbicide Family:
  - Aryloxyphenoxypropionate or “Fops”
- Site of Action:
  - ACC-ase inhibition
- Mode of Action:
  - Lipid Synthesis inhibition
Mode of Action: Plant Growth Regulators (4)

Plant Growth Regulators

- Mimic the natural PGRs (stimulate growth)
  - IAA, 4-Cl-IAA, IBA
- Auxin-type most common (IAA)
  - Auxin from the greek “Auxein” which means “to increase”
  - Fritz Went 1926 first described oat curvature

Plant Hormones

- Six classes of hormones that affect plant growth
  - auxins, cytokinins, gibberellins, ethylene, abscisic acid, and polyamines
  - Most of these six hormones interact with each other making their specific roles cloudy

Plant Growth Regulator History

- PGR discovery lead to the use of chemicals for weed control in modern agriculture
  - Weed Science blossomed because of the PGRs
- Early researchers explored phototropism and linked it to the natural auxin, indol-3-acetic acid (IAA) (Went 1928)

Fritz Went Described Auxins –

- "ohne wuchsstoff kein wachstum"
- Without growth substance, no growth
- Auxins cause cell elongation, and with synthetic herbicides, over-growth

2,4-D History (Roe et al.)

- Pokorny (1941) mentions 2,4-D as a plant hormone
- Early in WWII, in England, discovery of selectivity of NAA auxin compound
- 1944, Mitchell and Marth sprayed 2,4-D on a Maryland lawn and killed all dandelions, sparking the herbicide revolution
- 1945, nearly 200 field experiments were conducted testing the efficacy of 2,4-D
Plant Growth Regulator Herbicides

- Herbicide families:
  - phenoxyacetic acids
  - benzoic acids
  - pyridines
  - pyrimidines
  - quinolines
  - semicarbazone

Four Active Ingredient Chemical Formulations

- Acids
- Salts
- Esters
- Oil-soluble amines

- Remember “acid equivalent (ae)”
  - Additional ai vs ae comment see WCG page 4

Acid Formulation is the Starting Point

- Substitutions are made for the H+ of the carboxyl group (COOH)

- Acid
- Dimethyl amine
- Isooctyl ester

ACIDS

- Rarely used
- Poor water solubility
- Expensive to make
- Physiologically active form within the plant

SALTS

- Any ionic compound that does not contain either OH− or O2−
  - Low volatility
  - Soluble in water
- Few inorganic salt formulations
- Amines – quaternary N

ESTERS

- Short chain (highly volatile), not for sale
- Long chain (less volatility), for sale, expensive
- Soluble in oil, but not in water
- Generally the most effective formulation (extra chains make more oil-soluble)
- Time of day can reduce volatility risks!
- ALWAYS READ THE _ _ _ _ _!
OIL-SOLUBLE AMINES

- Soluble in oil, but not in water
- Non-volatile
- Most expensive

Formulation differences.

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Water-soluble</th>
<th>Oil-soluble</th>
<th>Volatility</th>
<th>$Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>Slight</td>
<td>No</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Salt (amine)</td>
<td>Yes</td>
<td>No</td>
<td>V. Low</td>
<td>Low</td>
</tr>
<tr>
<td>Ester</td>
<td>No</td>
<td>Yes</td>
<td>Med-High</td>
<td>Medium</td>
</tr>
<tr>
<td>Oil-Soluble</td>
<td>No</td>
<td>Yes</td>
<td>Minimal</td>
<td>Highest</td>
</tr>
</tbody>
</table>

* oil-soluble formulations are generally most effective because of improved absorption from their ability to penetrate the leaf cuticle - but rarely used in Ag

Sizes impact ai and cost but ae remains constant

2,4-D formulation molecular weights.

<table>
<thead>
<tr>
<th>Herbicide formulation</th>
<th>Molecular weight g/Mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>222</td>
</tr>
<tr>
<td>Dimethylamine salt</td>
<td>266</td>
</tr>
<tr>
<td>Methyl ester</td>
<td>235</td>
</tr>
<tr>
<td>Isooctyle ester</td>
<td>333</td>
</tr>
<tr>
<td>Oil-soluble amine</td>
<td>378</td>
</tr>
</tbody>
</table>

Biological properties

- Auxins – cause cell elongation
- Very limited to very long soil residual
  - May still be absorbed by plant roots
- Broadleaf action – does not kill grasses
- Translocated in most susceptible weeds
- There appears to be multiple sites of action that disrupt hormone balance, nucleic acid metabolism, and protein synthesis
  - But responses all tied to binding at primary site
  - Initiates cascade of signals

Phenoxyacetic Acids

- The original organic herbicide – WWII (1948)
- Wild mustard the original ND weed targeted
- Trade names
  - ND WCG lists 35+ products with some form of 2,4-D
  - 2007 Herbicide handbook has 29 active ingredient formulations, the vast majority amines and esters
- Cost:
  - Amines: $4.73/lb
  - Esters: $5.79/lb
2,4-D

- Rates (ae)
  - 0.25 - 0.5 lb/acre, annual weed control
  - 1 - 2 lb/acre, perennial weed control
- Time applied
  - POST
  - Translocated

Weed Control Guide

- Rating scale
  - Excellent = E, 90% or better
  - Good = G, 80 to 90%
  - Fair = F, 65 to 80%
  - Poor = P, 40 to 65%
  - No control = N, less than 40%

Weeds controlled – broadleaf

- Wild Mustard – E
- Common lambsquarters – E
- Dandelion – E
- Common ragweed – G – E
- Redroot pigweed – G
- Canada thistle – F
- Wild buckwheat – P
- Kochia – P (contact, need good coverage)
- Grasses – N

Crops labeled

- Grasses
  - Wheat and barley
  - Turf
- Others
  - Oat
  - Corn
  - Soybean
  - Strawberry (some labels)
  - Red potato (very touchy)
  - Sorghum
  - Sorghum – sudan

Application stages

- HRSW, durum, winter wheat, barley
  - *5L to boot, 3L to boot
  - *Winter wheat well tillered to boot
  - *Read the LABEL
- Turf – apply anytime after establishment
- Oat – easily injured
- Corn – 3 to 8 in, if taller use drop nozzles
- Soybean – prior to crop emergence (5–7 d)

Crop Stage
**MCPA**

- Developed around the same time as 2,4-D (MCPA in the UK)
- (4-chloro-2-methylphenoxy)acetic acid
  - Current chemical name
- (2-methyl-4-chlorophenoxyacetic acid)
  - Old-school chemical name explains common name
- Trade names
  - ND WCG lists 20+ products with some form of MCPA
  - 2007 Herbicide handbook has 13 formulations, the vast majority amines, and some esters

**Weeds controlled**

- Wild mustard – E
- Winter annual mustards – G-E
- Common lambsquarters – E
- Dandelion – E
- Canada thistle – P-F
- Common ragweed – G
- Redroot pigweed – P-F
- Wild buckwheat – N
- Kochia – P
- **Generally less effective than 2,4-D**

**Crops labeled**

- Grasses, primarily
  - Wheat and barley
  - Oat
  - Flax
  - NO CORN!
  - Lawn/turf
  - Peas – only some brands
  - Alfalfa – under a companion crop

**Application stage**

- Wheat, Barley, Oat
  - 3 leaf to preboot (similar ranges to 2,4-D)
- Flax
  - 2–8 inches

**MCPA Amine 500**

<table>
<thead>
<tr>
<th>Small grain underseeds with a legume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat &amp; barley</td>
</tr>
<tr>
<td>Use on grasses established with alfalfa (except early maturing varieties)</td>
</tr>
</tbody>
</table>

Established pastures, alfalfa stands, and clover have already grown. Do not apply to newly established alfalfa varieties.
2,4,5-T

- No longer on the market due to concerns about teratogenicity (pulled 1970 (except rice), 1985 all)
  - Teratogen – substances that cause birth defects in humans
  - Contains trace amounts of Dioxin (TCDD)
- 2,4,5-T + 2,4-D
  - “Agent Orange”
  - Defoliant used in Vietnam

Dichlorprop

- aka 2,4-DP
- Trade names: Many
- Time applied: POST
  - Translocated
- Weeds controlled: 2,4-D resistant turf weeds and some brush control, buckwheat spp.
  - Turfweeds – chickweed, clover, knotweed, ground ivy
  - Crops labeled: lawns, right-of-ways
- Enantiomeric product

Mecoprop

- aka MCPP
- Tradename: many
- Used in many lawn mixtures
  - Trimec classis/Trimec plus
  - Very high lawn safety
- Weeds controlled
  - Chickweed spp., clover spp., plantain spp., knotweed spp., common lambsquarters, pigweed spp., and ground ivy

2,4-DB

- Trade names: Butyrac 200
  - dma-salt
  - Cost: $20/lb
  - Rates: 0.25 – 0.5 lb/acre
- Time applied: POST and translocated
- Weeds controlled:
  - Many annual broadleaf weeds
    - Common cocklebur – E
    - Common lambsquarters – E
Crops labeled
- Some 2,4-D susceptible crops
- Peanut,
- Other small seeded legumes
- Soybean
  - PRE or POST Directed (prebloom, avoiding foliar contact)
- CRP
- Alfalfa
  - \textit{Seedling alfalfa only}

Selectivity in broadleaf crops?
- Function of less retention and absorption in legumes compared to others
  - Chemical doesn’t stick to the leaves as well as common cocklebur
- Differential rates of metabolism
  - 2,4-DB is not phytotoxic, per se.
  - It undergoes $\beta$-oxidation in plants to form 2,4-D
  - This reaction is faster in susceptible plants than tolerant plants

Concept: Selectivity
- Selectivity is function of three factors:
  - \textbf{Absorption}
    - Young seedlings often have greater absorption \textit{(growth stage)}
    - Remember small grains
  - \textbf{Translocation}
    - Burcucumber, 2,4-D moves slow (safe); 2,4,5-T moves fast (injury)
  - \textbf{Metabolism}
    - Normally, modification of the molecule eliminates phytoxicity
      - There are exceptions
      - Rate – differential metabolism
  - Much of the time these factors can be codependent

Why is 2,4-DB safe to seedling alfalfa?
- Legumes retain less 2,4-DB spray than susceptible species
- Therefore less 2,4-DB is absorbed by the legume
- In alfalfa, young plants are not as developed as older ones and do not have efficient $\beta$-oxidation systems
  - Poor $\beta$-oxidation, the herbicide stays mainly 2,4-DB
  - Older plants are able to break down the 2,4-DB to 2,4-D, an immediately phytotoxic transformation

$\beta$-oxidation
- Tolerant species
  - Legumes, low levels of $\beta$-oxidation
  - Less metabolism
  - Mostly 2,4-DB
  - Phytotoxicity
- Susceptible species
  - Weeds, high levels of $\beta$-oxidation
  - More metabolism
  - Mostly 2,4-D
  - Tolerance

MCPB
- Trade name: Thistrol
- Cost: $25.00/\text{lb}$
- Rates: 0.5 – 1.5 lb/acre
- Time applied: POST and translocated
- Weeds controlled
  - Canada Thistle, unique and very good activity
- Crops labeled
  - Pea: 4 – 6 inch
  - Mint: less than 6 inch
Family: Benzoic Acids
Mode of action: PGR

Dicamba
- Trade names: Banvel, Clarity, many others, New formulation Engenia
- Costs: range
  - dma salt (Banvel) $14.50/lb
  - dga salt (Clarity) $27.50/lb
  - Bapma salt (Enginia) $/lb
- Rates:
  - 1–2 oz/acre – wheat and oats
  - 1–8 oz/acre – perennial weeds
  - 2–4 oz/acre – corn (8 oz HIGH)
- Time applied: POST and translocated
  - PRE at higher rates (readily leached in soils)

Weed control spectrum
- Weed control spectrum similar to 2,4-D
- More effective than 2,4-D on many weeds...
  - At lower rates
  - More effective on perennial weeds
  - More foliar activity than 2,4-D
- Does not control mustard family well
- Does very well on buckwheat family
- Applied in many combo mixtures
  - dicamba + diflufenzopyr = Distinct

Weeds Controlled
- Buckwheat spp. –
  - Kochia – E
  - Common lambsquarters – G
  - Nightshades – E
  - Common cocklebur – E
  - Marshelder – E
  - Common ragweed – E
  - Canada thistle – F–G
  - Mustard spp. – P
- Redroot pigweed – G
- Biennial wormwood – G–E

Crops labeled
- Grasses:
  - Wheat – 2 – 4 leaf
  - Oat – 2 – 5 leaf (low rate at 5–leaf stage)
  - Corn –
    - Em–8 inches, (high rate, 4–8 oz/acre)
    - 8–36 inches tall (low rate, 4 oz/acre)
    - Injury to brace roots
  - Many turf/lawn mixtures
  - Barley easily injured
- Dicamba resistant soybean ~ 2015
- Pastures

Crop tolerance to dicamba

Grasses:  
- Wheat – 2 – 4 leaf
- Oat – 2 – 5 leaf (low rate at 5–leaf stage)
- Corn –
  - Em–8 inches, (high rate, 4–8 oz/acre)
  - 8–36 inches tall (low rate, 4 oz/acre)
  - Injury to brace roots
- Many turf/lawn mixtures
- Barley easily injured
- Dicamba resistant soybean ~ 2015
- Pastures
Other comments

- Clarity is formulated as a dga salt for reduced volatility
- Engenia is formulated as bapma salt for even more reduced volatility
- Many lawn/turf mixtures
  - Weed & Feed generics
  - spray when lawn is established, not young

Herbicide Family: Pyridinecarboxylic acids
Mode of Action: PGR

Picloram

- Tradename: Tordon
- Cost: $40.00/lb
- Rates: 0.25 – 0.5 lb/A for perennials, label allows 1 – 2 lbs/A, but this rates this high are not practical
- Time applied: POST and translocated

Weeds controlled

- Most annual and perennial broadleaf weeds
- Does a good job on the “tough customers”
  - leafy spurge
  - Canada thistle
  - common milkweed
  - field bindweed
  - Russian knapweed
- Poor on wild mustard
- No control of kochia

Crops labeled

- In general, picloram is considered a rangeland/permanent pasture product. CRP as well
  - Potato, sunflower, and pea are VERY susceptible to residual... up to 4 – 5 years at higher rates

Restricted use pesticide!

- Long soil residual – biggest problem, injury to non-target plants
- Water soluble and easily leached/moved with water
  - Must wait 2 wk after treatment to feed cattle treated grass

Picloram: RUP

- Very persistent in soils
  - microorganisms slowly degrade it
  - application rate influences residual period
- Leaching potential
  - Organic matter (OM) and certain clays adsorb picloram
  - readily leached through sandy soils low in OM
  - Salt formulations are more easily leached than acid formulations

Monaco et al. 2002
Picloram: RUP

- Applied with 2,4-D or MCPA for wild mustard and kochia control
- According to the ND WCG, THE most cost-effective broadcast treatment for leafy spurge control is: Tordon (picloram) + 2,4-D (1 pt/A + 2 pt/A, respectively) for 3 – 5 years.

Clopyralid

- Tradename: Stinger (sugarbeets), Transline (pasture)
- Cost: $160/lb (Stinger), $63/lb (Transline)
- Rate: 1.4 – 4 oz/A
- Time applied: POST and translocated

Weeds controlled

- Excellent on composite family (sunflower family)
- Excellent on nightshade family
- Fair – (Good) on buckwheat
- Canada thistle – E
- common ragweed – G – E
- wild buckwheat – F – G
- redroot pigweed – P
- wild mustard – P

Crops labeled

- Wheat and barley: 4-leaf to jointing
- Sugarbeet: 2 – 8-leaf
- CRP, pasture: weeds actively growing
- Corn: up to 24 inches tall
- Safe to coniferous species (i.e. Christmas trees)

Other comments

- Shorter soil residual
  - 18 months: Potato, dry bean, chick pea
  - 10.5 months: many broadleaf crops
- Causes less injury than picloram on most crops
- Often sold with 2,4-D or MCPA, fluroxypyr
  - Tradenames: Curtail or Curtail M, WideMatch
  - Cost: $24/lb, $93/lb
  - wild mustard (E), redroot pigweed (G), wild buckwheat (G)
  - Not labeled for sugarbeets
Fluroxypyr

- Tradename: Starane (ester)
- Cost: $95/lb
- Rates: 1.5 to 2 oz/A
- Time applied: POST and translocated

Weeds controlled

- Some annual broadleaf weeds
- Kochia (including ALS-res.) – E
- up to 8 in tall
- common ragweed – E
- vol. flax – G
- Russian thistle – P
- wild mustard – p
- common lambsquarters – N

Crops labeled

- Wheat, Barley, Oat: 2-leaf – flag-leaf stage
  - WIDE WINDOW
    - Even onion! (not in ND)
    - SLN’s (Sec 24c) in many other states
- Chemical fallow
- Rights-of-way

Other comments

- Excellent crop safety
- No soil residual
- Sold in many premixes with MCPA, 2,4-D, and bromoxynil
- Many premixes
  - WideMatch (fluroxypyr + clopyralid)
  - Starane NXT (fluroxypyr + bomoxynil)
  - GoldSky (proxysulam+florasulam+fluroxypyr)

Triclopyr

- Tradename: Garlon
- Cost: $30/lb
- Rates: 1 to 8 lb/A
  - Up to 2 lbs on range and pasture (grazed areas)
  - Up to 6 lbs on forestry areas
  - Up to 8 lbs on industrial, non-crop areas
- Time applied: POST and translocated
- Remedy Ultra, $17.5/lb
- Crossbow: triclopyr + 2,4-D (musk thistle control)

Weeds controlled

- Primarily used for woody plant control
  - Saltcedar
- ND Prohibited Noxious Weed
Crops Areas labeled

- Non-crop areas
  - industrial manufacturing and storage sites
  - rights-of-way
  - power lines
  - communication lines
  - pipelines
  - roadsides
  - railroads
  - fence rows
  - forests

Most grasses are tolerant!

Milestone label: Page 1

IMPORTANT ADVISORY TO PREVENT INJURY TO DESIRABLE PLANTS
- It is mandatory to follow the Use Precautions and Restrictions section of this product label.
- Carefully read the section "Plant Resistance or Maximize."
- Manure and urine from animals consuming treated grass or hay may contain enough aminopyralid to cause injury to sensitive broadleaf plants.
- Inform the recipient of hay or manure from animals grazing pasture or feeding on hay from areas treated with aminopyralid of the use precautions and restrictions.
- Contact with a Dow AgroSciences representative if you do not understand the "Use Precautions and Restrictions." Call [1-800-303-1199] Customer Information Group.

Weeds controlled

- Rangeland
  - Russian knapweed
  - musk thistle
  - spotted knapweed
  - yellow starthistle
  - Canada thistle

What’s missing from this list?

Crops labeled

- Mainly used in non-crop situations
  - Pasture
  - Range
  - CRP
  - Trees (see label for species) only as a directed spray
- Also labeled for use in riparian areas (up to the waters edge) where clopyralid and picloram are not recommended
- No grazing/haying restrictions
  - But allow 3 days for animals to graze untreated areas before transferring animals to areas with sensitive broadleaf crops

Other comments

- Soil residual varies with environmental conditions, application rate, condition and growth stage of target weeds, density and vigor of competitors
- 35 day ½ life

Tradename: Milestone
Cost: $200/lb
Rate: 0.75–1.75 oz/A
Time applied: POST and translocated

Aminopyralid – 2004

Tradename: Milestone
Cost: $200/lb
Rate: 0.75–1.75 oz/A
Time applied: POST and translocated

Soil residual varies with environmental conditions, application rate, condition and growth stage of target weeds, density and vigor of competitors

35 day ½ life
Herbicide Family: Pyrimidine
MODE OF ACTION: Plant Growth Regulator

TRADENAMES:
- Viewpoint, Perspective, Streamline
- All pre-mixes + ALS Inhibitors

COST: $298, 223, 243/lb
RATE: 1.2 to 4 oz/A
TIME APPLIED: PRE or POST and translocated
NEW HERBICIDE: Officially registered with the EPA in 2010

Weeds controlled:
- Similar spectrum to Aminopyralid
  - Knapweeds
  - Thistles
  - Partial control of yellow and Dalmation toadflax
  - Good activity on leafy spurge
  - No yellow starthistle

Applied to non-crop areas

Other comments

Quinclorac

TRADENAMES:
- Paramount, Drive

COST: $5/oz
RATE: 4–6 oz/A
TIME APPLIED: PRE or POST and Translocated

AUXIN-LIKE ACTIVITY IN BROADLEAF PLANTS
- Similar to 2,4-D and dicamba

ACTIVITY IN SUSCEPTIBLE GRASSES, QUINCLORAC INHIBITS
the growth of roots and shoots and also lead to
chlorosis and necrosis of expanding leaves
- Barnyardgrass control in rice
- IN GRASSES – the mode of action is different (unknown)

Weeds Controlled

BROADLEAF
- Field bindweed: G–E
  - Fallow, postharvest, and preplant in spring prior to seeding
    wheat or durum
  - USE MSO
- Leafy spurge: G–E (prior to frost, actively growing)
- Prickly lettuce: E (PRE)
- F–P control of most other broadleaf weeds
  - This is good because it doesn’t injure most native forbs

GRASSES (PRE OR POST)
- Barnyardgrass: G–E
- Green foxtail: E
- Yellow foxtail: G
Crops labeled

- Fallow
- Post-harvest or preplant prior to seeding wheat
- Pasture
- Rangeland
- Rice

Other comments

- Soil persistence
  - Read label for rotational restrictions
  - May injure susceptible grasses 10 months after application
  - May injure susceptible broadleaf crops 24 months after application
  - Mobility in soil is soil type, and organic matter dependent

- ND WCG pages 112–113

Herbicide Family: Semicarbazones

MODE OF ACTION: Plant Growth Regulator

Diflufenzopyr

- Weeds controlled: broadleaf weeds (G–E)
- Crops labeled: Corn

  - MOA: Auxin transport inhibitor (PGR)
  - Blocks auxin transport

- Always marketed with another auxin–type herbicide
  - Most commonly with Dicamba
  - Tradename: Distinct, Status