2,4-D and Glyphosate Tolerant Corn, Soybean, and Cotton

From 2015 ENLIST Product List www.enlist.com/~/media/enlist/enlist-ahead/.../productuseguidemenlist.ashx

EPA reverses course, no Enlist Duo technology for 2016

Producers lose new tool to combat herbicide-resistant weeds
Nov 25, 2015 David Bennett | Delta Farm Press

- EPA revokes approval for Enlist Duo.
- Producers left with whiplash after EPA decision.
Monsanto launches its Roundup Ready 2 Xtend™ soybeans in US and Canada

Monsanto Company recently announced its commercial launch plans for its Roundup Ready 2 Xtend™ soybeans after it received import approval in China. This technology has been highly anticipated by farmers and is now available in the United States and Canada in time for the 2016 season.

Although Roundup Ready 2 Xtend soybeans are tolerant to both glyphosate and dicamba herbicides, the use of dicamba herbicide over the top of Roundup Ready 2 Xtend soybeans remains in late stage of Environmental Protection Agency (EPA) review and is not currently approved by the EPA. Once approved, the Roundup Ready® Xtend Crop System – including Bollgard II® XtendFlex® cotton – will offer growers a vital tool for managing tough-to-control and glyphosate-resistant weeds.
Auxin Production Systems and Emerging Technologies

From DuPont Pioneer (2011);

TPSA February 11, 2016
Total Acreage of Agricultural Crops Treated with Herbicides

Shift in greater reliance of pre- and post application SGRs (2,4-D and dicamba) for major crops!
Specialty Crop Registry

The Specialty Crop Competitiveness Act of 2004 and the Food, Conservation, and Energy Act of 2008 have defined "specialty crops" as "fruits and vegetables, tree nuts, dried horticultural products, nurseries (including floriculture), and horticultural crops."
New Soybean Traits Delayed by Brian Hefty  Ag PhD, August 2015

“One last thing I want you to think about with these new traits is what you can spray elsewhere. For example, let’s say you have dicamba soybeans and cotton. That means that if you spray dicamba in your ditches, pastures, and farmyards, there will no longer be a worry of damaging your crops from drift or spray tank contamination. The Enlist trait should mean the crops will be tolerant to most 2,4-D products, etc. Burndown applications with big rates of 2,4-D or dicamba will also be a possibility going forward. We are really excited about all the opportunities these traits mean for weed control on the farm. We just hope they come to market soon.”

There will likely be a need for greater grower-grower communication/cooperation

Use of Synthetic Growth Regulator Herbicides; A Continuing Off-Target Concern with Wine Grape Vineyards and Other Specialty Crops

Vince Hebert
WSU-Food and Environmental Quality Lab

Gail Amos, Washington State Department of Agriculture, Yakima WA

TPSA February 11, 2016
## Agricultural Synthetic Growth Regulators (SGRs)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Trade Names</th>
<th>Common Use Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D</td>
<td>2,4-D, LV-4, LV6, Salvo, Savage, Weedone and other names</td>
<td>Corn, sorghum, cereals, fallow, noncropland, pasture, rangeland, lawn and turf</td>
</tr>
<tr>
<td>2,4-DB</td>
<td>Butyroil, Butoxone, Butyryl</td>
<td>Soybean and alfalfa</td>
</tr>
<tr>
<td>MCPA</td>
<td>MCPA Amine, MCPA Ester, Rhomene and other names</td>
<td>Cereals, lawn and turf</td>
</tr>
<tr>
<td>MCPB</td>
<td>Thistrol</td>
<td>Controls Canada thistle</td>
</tr>
<tr>
<td>Mecoprop</td>
<td>MCPP</td>
<td>Lawn and turf</td>
</tr>
<tr>
<td>dicamba</td>
<td>Banvel, Clarity, Distinct and Vanquish</td>
<td>Lawn and turf</td>
</tr>
<tr>
<td>clopyralid</td>
<td>Stinger, Reclalm and Transline</td>
<td>Corn, pasture, rangeland and noncropland</td>
</tr>
<tr>
<td>fluroxypyr</td>
<td>Starane and Vista</td>
<td>Cereals and noncropland</td>
</tr>
<tr>
<td>picloram</td>
<td>Tordon</td>
<td>Pasture, rangeland and noncropland</td>
</tr>
<tr>
<td>triclopyr</td>
<td>Garlon and Remedy</td>
<td>Pasture, rangeland and noncropland</td>
</tr>
<tr>
<td>quinclorac</td>
<td>Paramount</td>
<td>Sorghum and fallow</td>
</tr>
<tr>
<td>amino pyralide</td>
<td>Milestone, Milestone VM</td>
<td>Range, pasture, industrial</td>
</tr>
</tbody>
</table>

https://agriculture.ks.gov/divisions-programs/pesticide-fertilizer/sensitive-crops-driftwatch
Legend

Field

Crop Type

Alfalfa Hay
Alfalfa Seed
Alfalfa/Grass Hay
Alkali Bee Bed
Apple
Apricot
Asparagus
Barley
Bean Seed
Bean, Dry
Bean, Green
Berry, Unknown
Blueberry
Bluegrass Seed
Buckwheat
CRP/Conservation
Camelina
Caneberry
Canola
Cantaloupe
Carrot
Carrot Seed
Cereal Grain, Unknown
Cherry
Chestnut
Chickpea
Christmas Tree
Cilantro Seed
Corn Seed
Corn, Field
Corn, Sweet
Corn, Unknown
Cucumber
Currant
Dill
Driving Range
Fallow
Flax Seed
Golf Course
Grape, Juice
Grape, Unknown
Grape, Wine
Grass Hay
Green Manure
Hay/Silage, Unknown
Herb, Medicinal
Hops
Market Crops
Mint
Misc. Grass Seed
Nectarine/Peach
Nursery, Caneberry
Nursery, Greenhouse
Nursery, Lavender
Nursery, Orchard/Vineyard
Nursery, Ornamental
Oat
Onion
Orchard, Unknown
Pasture
Pea Seed
Pea, Dry
Pea, Green
Pea/Vetch
Peanut
Pear
Pepper
Plum
Poplar, Hybrid
Potato
Pumpkin
Radish Seed
Research Station
Rosemary
Rye
Ryegrass Seed
Safflower Seed
Sod Farm
Sorghum
Soybean
Spinach
Squash
Strawberry
Sudangrass
Sugar Beet
Sugar Beet Seed
Sunflower Seed
Timothy
Triticale
Unknown
Walnut
Watermelon
Wheat
Wheat Fallow
Wildlife Feed
Yarrow Seed
Yellow Mustard

Washington State Wheat Production

PRESS RELEASE
NATIONAL AGRICULTURAL STATISTICS SERVICE
United States Department of Agriculture • Washington, DC 20250
Washington Field Office • Olympia, WA 98507
Ag Statistics Hotline: 1-800-727-9540 • www.nass.usda.gov/

Posted online August 10, 2012
Contact: David Knopf (360) 709-2400
nass-wa@nass.usda.gov

Washington’s 2012 Winter Wheat Yield Third Highest on Record
One-third of the Acreage Has Been Harvested

Olympia – The August 1 forecast for the 2012 winter wheat crop in Washington is 71.0 bushels per acre, 2 bushels above the July 1 forecast and 4 bushels below last year’s record high yield. With 1.67 million acres for harvest, production is expected to reach 119 million bushels, 9 percent below last year’s crop. Estimates in the Crop

- Stable and traditionally important industry
- Ranks high in Washington agriculture
- Use of good cultural practices and selective broadleaf synthetic growth regulators are essential tools for high yields
Use of SGRs; A Continuing Off-Target Concern with Wine and Juice Grape Vineyards and Other Specialty Crops

Pacific Northwest Wheat Herbicide Use

- ~34% of Total Herbicide Use on Wheat
  - Ibs Winter
  - Ibs Spring

- ~23% of Total Herbicide Use on Wheat

Data from USDA NASS Chemical Usage Database (2009 & 2012)

Pounds of Herbicide Used on Winter & Spring Wheat

Oregon

Washington
The Post War introduction of 2,4-D and other SGRs revolutionized US and Canadian cereal grain production

Before the introduction of SGRs, selective broadleaf weed control was performed using inorganic salts/acids and formulated phenol products
Besides being selective, it was inexpensive to manufacture.

2,4-Dichlorophenoxyacetic acid (2,4-D)

Selected Chemical and Physical Properties

2,4-Dichlorophenoxyacetic acid (2,4-D)

Water solubility: 682 mg/L (pH 7) *(Highly water soluble)*

pKa: 2.64 – 3.31 *(Ionized at environmental pH)*

Vapor pressure: $2.4 \times 10^{-5}$ mm Hg @ 25°C *(Moderately low)*

*(estimated from water solubility and Henry’s Law)*


*Follow the water ....... You will be likely to find 2,4-D after an application event*
Use of SGRs; A Continuing Off-Target Concern with Wine and Juice Grape Vineyards and Other Specialty Crops

Mode of Action

2,4-D

mimics
indole-3-acetic acid

Upper stem bending

Petioles twisting

Parallel venation in new leaves that are severely stunted
2,4-D Formulation Chemistry (old to new)

High Volatility (HV) 2,4-D esters

- VP greater than $10^{-5}$ mm Hg (20°C)
- methyl, ethyl, isopropyl, **butyl**, isobutyl, and n-pentyl forms

Low Volatility (LV) 2,4-D esters

- VP $10^{-5}$ to $10^{-6}$ mm Hg (20°C)
- Low volatile 2,4-D includes the isooctyl, **butoxyethyl**, and propylene glycol butyl ether (PGBE) esters.

NV 2,4-D salts

- VP less than $10^{-7}$ mm Hg (20°C)
- Acid and **amine** compounds of 2,4-D

**New kid on the block!** quaternary amine salt
Use of SGRs; A Continuing Off-Target Concern with Wine and Juice Grape Vineyards and Other Specialty Crops

Rate of Partitioning into Air Is Higher for Esters than for the Amine Salts

Volatilization Rate Constant (K) (hr⁻¹)

- Methyl ester
- n-Butyl ester
- n-Octyl ester
- Dimethyl amine
- Methyl amine

TPSA February 11, 2016
Many SGRs in cereal field production are aerially applied. We have come a long way in application technology to reduce physical drift.

Huge advances in:
Formulation chemistry, nozzle technology and boom design, aircraft delivery and GIS navigation.

TPSA February 11, 2016
Physical Drift Definitions:

**EPA** defines spray drift as the physical movement of pesticide droplets or particles through air at the time of pesticide application or soon thereafter, to any site other than that intended for application (often referred to as non-target).

**EPA does not include** in its definition the movement of pesticides to/from the target sites non-or off-target sites caused by erosion, migration, volatility, or wind-blown particles that occurs after application unless specifically addressed on a pesticide product label with respect to drift control requirements.

**IUPAC** (International Union of Pure and Applied Chemistry) defines drift as the “Downwind movement of airborne spray droplets beyond the intended area of application originating from aerial or ground-based spraying operations.”

**IUPAC notes** the phenomenon of secondary or indirect drift from volatilization: “Agrochemicals may also volatilize from plant and soil surfaces for several days after application, and thereby pose a hazard to non-target receptors.”

TPSA February 11, 2016
Field Measured 2,4-D Ester Volatilization

Volatilization rate and cumulative vapor losses of LV 2,4-D iso-octyl ester over a 5-day period post-application on wheat

From: Grover et al., J. Environ. Quality (1985)
Potential for Movement to Air of Ionizable SGRs from Soil Surfaces, Some Earlier Investigations

Follow the water!

TPSA February 11, 2016
Potential for Movement to Air of Ionizable SGRs from Soil Surfaces, Some Earlier Investigations

Conflicting Agrochemical Land Use Practices

- Rapidly growing industry (from 12 to 750 wineries in 30 yrs)
- Crush was over 180,000 tons FY 2012
- 8.6 billion dollar business in 2012
- Second only to California in U.S. wine sales
- Highly susceptible to SGR herbicide chemistry

Photo by Gail Amos WSDA
Growing vines are highly susceptible to injury from ultra-low (ηg/m³) herbicide concentrations transported in the ambient air.

Critical period is from bud-break through full bloom (April through early July).

Not all grape cultivars are injured equally!

Vines can usually outgrow symptoms if not highly exposed.

In severe exposure incidences, carryover can result.
SGR Grape Vine Exposure Symptoms

Photo by Gail Amos. WSDA
Use of SGRs: A Continuing Off-Target Concern with Wine and Juice Grape Vineyards and Other Specialty Crops

SGR Grape Vine Exposure Symptoms
no visible symptoms of phenoxy-like herbicide contact. Margins and lobes are well defined.

possible rugose (bumpy) features on leaf surface. Possible shortening of lobes and sinus.

will have rugose features as well as marginal disfiguration. The leaf is not able to fully open

Diminished or possible lack of sinus. Leaf will be significantly smaller than those with a lesser rating

definite deformation of leaf margins and sinuses. Venation will appear almost parallel.

grossly deformed leaf. Venation will be parallel. The leaf will be severely dwarfed.

Tools to Understand the Problem

- Growing vines are highly susceptible to injury from ultra-low (ng/m³) herbicide concentrations transported in the ambient air.

- Critical period is from bud-break through full bloom (April through early July).

- Not all grape cultivars are injured equally.

- Vines can usually outgrow symptoms if not highly exposed.

- In severe exposure incidences, carryover can result.

- What to do? Vigilance, Observation, and Reporting.

Leaf Injury Indexing & Severity Reporting

http://feql.wsu.edu/eb/index.html

The Food & Environmental Quality Lab Website (feql.wsu.edu) has full instructions for how to participate in the indexing and severity reporting process that will allow you to make a complaint to the WSDA if you expect drift from a point source.
### Current Status of Complaints Made to WSDA

<table>
<thead>
<tr>
<th>County</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<td>1</td>
<td></td>
<td>2</td>
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<td>Chelan</td>
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<td>Douglas</td>
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</tr>
<tr>
<td>Franklin</td>
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<td>1</td>
<td>2</td>
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<td>Grant</td>
<td>2</td>
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<td>1</td>
<td></td>
<td>3</td>
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<td>Skagit</td>
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<td>5</td>
<td>4</td>
<td>1</td>
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</tbody>
</table>

% of all cases for the year

3 3 3 1

Kathi Matherly, WSDA
Chronology of a Long-standing Regional Controversy

Starting in the 1950’s Columbia and Yakima River Valleys, later Walla Walla areas
2,4-D problems first recognized in concord grape vineyards in central eastern Washington in 1950

“I hope the regulations we finally decided upon will suffice in cutting down most of the injury to grapes. These regulations will no doubt, have to be changed somewhat, but I feel that they are a step in the right direction.”

Sincerely yours,

Glenn A. Riber, Plant Pathologist,
State Department of Agriculture,
Division of Horticulture
The neighborly drift concern did not go away.

- 1952 (in California): Civil Aeronautics Administration (FAA) bans use of 2,4-D dust due to widespread damage to cotton and grapes from use on nearby cereal grains.
- 1952-53: At least nine crop-dusting cases reach appellate courts (suggesting many more cases at lower courts).
- Grape injury surveys were initiated from 1953 through 1955 due to chronic-severe symptoms.
  - Injunction requested but denied to stop Horse Heaven Hills 2,4-D aerial applications to wheat.
  - Observation that problem was related to volatile esters.
- 1959 to 1963 symptom severity triggered a systematic survey of 14 vineyards from Walla-Walla to Grandview.
- 1964 HV 2,4-D esters banned in Benton and Yakima Counties.
- 1964-1969 few symptoms were observed.
- 1969-1973 General and severe damage was again observed but throughout all of central Washington…1973 was worst year on record.
Early 1970’s WSU-Civil Engineering Field Sampling Network Investigations

Meteorological conditions favoring off-target 2,4-D grape injury

- low pressure
- cloud cover
- well defined low level wind flow
- advection
- precipitation

Figure 3. Typical synoptic weather pattern for relatively high concentrations of 2,4-D.


TPSA February 11, 2016
COMPARISON OF DAILY APPLICATION OF 2,4-D IN OREGON AND 12 SITE DAILY AVERAGE OF HV 2,4-D IN WASHINGTON

Fox L. and Robinson E. 1976. Atmospheric drift of 2,4-D in the Lower Yakima Valley. Report 76-34.5. APCA National Meeting.
The 1994 WSU Sentinel Plant Monitoring Network

Injury more associated with light precipitation events and not with 2,4-D application records

From Allan Felsot

TPSA February 11, 2016
Regional Herbicide Issues will not Drift-Away

• A sixty year-old controversy!
• Many steps have been taken to manage the problem (BMPs)!
• Regional air movement of potent SGR herbicides remains difficult to control
  – SGR mass transport by volatilization and post-application land surface evaporative processes remains underappreciated......
• Meteorological conditions are critical to assess, especially during the active growing season for many specialty crops
• Continued communication and education among neighbors and stakeholders
Use of SGRs; A Continuing Off-Target Concern with Wine and Juice Grape Vineyards and Other Specialty Crops

Continued communication and education among neighbors and stakeholders

2,4-D- and Dicamba-tolerant Crops — Some Facts to Consider

William G. Johnson
Steven G. Hallett Travis
R. Legleiter Fred
Whitford Purdue Botany
and Plant Pathology

Stephen C. Weller Bruce
P. Bordelon B. Rosie
Lerner Purdue
Horticulture and
Landscape Architecture

TPSA February 11, 2016
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