HERBICIDE CARRYOVER

Y1. Herbicide persistence into the next growing season restricts rotational crops. The following information explains herbicide degradation for chemistries known to carryover.

General Rules For Herbicide Breakdown

1. Many herbicides are broken down in soil by microbial decomposition. In addition, SUs and triazines are broken down by chemical reactions like acid hydrolysis.
2. Herbicide molecules must be free from binding to soil particles or organic matter for soil microorganisms to degrade.
3. Most herbicide molecules are more tightly adsorbed to soil particles in dry soils than moist soils.
4. Chemical degradation of herbicides in soil is affected by soil pH. Acid hydrolysis nearly ceases at soil pH above 6.8.

Effect of pH on Herbicide Activity and Persistence

Negative charges (-) on soil particles and organic matter adsorb positive-charged (+) compounds or substances. Soil pH influences adsorption and availability of the following herbicides by determining the electrical charge of the herbicide molecules: Imidazolinones, SUs, Triazines, and Triazolopyrimidines (TPS).

Molecules become (-) charged when a proton is removed or become (+) charged when a proton is added. Most herbicides become (+) charged in acid (H+) pH conditions. Positively charged herbicide molecules are adsorbed to the (-) charges on soil particles soil particles.

Y2. Breakdown of Imidazolinone (Imi), TPS Herbicides, and some HPPD herbicides (Callisto).

In general, breakdown occurs by soil microbes and **breakdown occurs more rapidly and herbicide activity increases as soil pH increases.** Rate of breakdown decreases in dry conditions. Imi and TPS herbicides are:

1. Broken down by microbes - not broken down by hydrolysis.
2. Not degraded in anaerobic (waterlogged soil) conditions.
3. Not volatile nor photodegraded by sunlight.
4. Not leached beyond 12 inches.
5. Weakly bound to soil but strongly bound to OM.
6. Adsorbed more strongly as soil dries and through time.

For Imi herbicides applied in dry conditions, herbicide molecules adsorb to OM. The next spring, winter moisture can displace herbicide molecules from soil and OM allowing the molecules to become free for plant uptake and microbial breakdown. For sensitive crops like sugarbeet, the adsorption and desorption process may occur over several years causing crop injury from herbicide residues that become available after moisture events.

7. Negatively (-) charged, not adsorbed, and free for plant uptake and microbial degradation at soil pH >6.5 for Imi herbicides and pH >7 for TPS herbicides.
8. Strongly bound to OM at pH <6.5 for Imi herbicides and pH <7 for TPS herbicides. For Imi herbicides: Amount adsorbed changes little from 6.5 to 8. At soil pH <6.5, pH reduction as small as 0.2 pH units can **DOUBLE** the amount adsorbed.

Vvariation in pH can exist in the same field. In low pH, residues of Imi herbicides can injure sensitive plants for many years.

In summary, activity and degradation of Imi and TPS herbicides increase as soil pH increases. Herbicide adsorption increases as OM matter increases and as soil pH decreases. All factors increasing microbial activity also increase herbicide degradation (warm, moist soils). Degradation increases in soils with pH above 6.5 (Imi) or 7 (TPS) because herbicide molecules are not adsorbed and are free in soil solution for plant uptake and microbial breakdown.

Y3. Breakdown of SU Herbicides (with exceptions):

In general, most SU herbicides are broken down by acid hydrolysis and can leave a residue in soil for more than one year. The chemical reaction ceases at soil pH above 6.8.

Exceptions: Express*, Harmony*, Option, and UpBeet are rapidly broken down by soil mirobes. Pemit and Resolve*/Matrix* are broken down faster by hydrolysis as pH moves above and below pH of 7.0. Herbicide breakdown is slowest in neutral soil pH of 7.0.

Most SU herbicides are:

1. Not leached, nor volatile, nor broken down by photodegradation.
2. Affected by pH. Water solubility increases as pH increases.
3. Broken down primarily by acid hydrolysis. Microbial degradation is very slow.
4. Non-microbial hydrolysis for most residual SU herbicides ceases at soil pH above 6.8.
5. SU herbicides are undissociated (neutral charge) at pH less than 7.0 and are adsorbed to soil and OM. As soil pH increases above 7.0 molecules are (-) charged, are in a free form, do not bind with (-) charged soil particles, and are are available for plant uptake. **Even at low pH ranges, SU herbicides are so biologically active at low concentrations that plant response may still occur.**

SU herbicides carryover more in high pH soils (above 6.8) because acid hydrolysis ceases above that level. Hydrolysis is minimally affected by soil moisture, organic matter, soil texture, soil microbes, and soil compaction or aeration. Hydrolysis is affected by soil temperature and soil pH. As temperature increases and pH decreases below 6.8, hydrolysis increases.

Y4. Breakdown of Triazine Herbicides

Triazines are degraded by hydrolysis similar to SU herbicides. Therefore, the same factors affecting SU breakdown also affect breakdown of triazine herbicides - See Y3. Some slight differences are noted below. Triazine herbicides are:

1. More active in high pH soils.
2. Broken down by photodegradation only when herbicide remains on soil surface for extended periods.

Triazine molecules are (+) charged at soil pH < 7.5. Positive charged triazine molecules bind to (-) charges on soil and OM making them unavailable for plant uptake and microbial breakdown. This is why pH sensitive herbicides like atrazine and Sencor* can be used with less risk of crop injury in low pH soils. However, as pH fluctuates across the field, herbicide availability may be radically altered ranging from complete crop safety and erratic weed control at low pH to crop injury and adequate weed control at high pH.

At high soil pH, the opposite reaction occurs. At soil pH > 7.5, triazine herbicide molecules donate protons (H^+) resulting in ($H + OH = H_2O$) so the molecules have a net neutral charge, which do not bind to soil particles and OM, and are free for plant uptake and microbial decomposition.

Y5. Persistence of phytotoxic levels of a herbicide for more than 1 year can be a problem with some herbicides. Herbicide residues are most likely to occur following years with low rainfall because chemical and microbial activity needed to degrade herbicides are limited in dry soil. Crop damage from herbicide residues can be minimized by applying the lowest herbicide rate required for good weed control, by using band rather than broadcast applications, and by moldboard plowing before planting the next crop. Moldboard plowing reduces phytotoxicity of some herbicides by diluting the herbicide residue in a large volume of soil. Moldboard plowing is effective in reducing the residual effects of atrazine, Nortron, Prowl, Sencor*, Sonalan, and Treflan*.

*Or generic equivalent.

Y6. Herbicide residues often can be detected by bioassay. Representative soil samples of the whole field are obtained by sampling many places to the depth of the tillage layer. A soil sample free of herbicide residues can serve as the untreated check. The samples should be dried and the clods broken so that the largest particles are no larger than a wheat kernel. Prepare two or more samples of untreated check soil and the test soil in pots or other containers with holes in the bottom for water drainage.

The crop to be grown in the field should be used as one bioassay species. Alfalfa and canola also should be planted as an additional bioassay species because of their relative sensitivity to many residual herbicides. Plant seeds of large-seeded crops like corn or soybean at 1 seed per 1 to 2 square inches, or seeds of small-seeded crops like cereals or flax at about 1 seed/sq inch. Water as needed but do not over-water. Thin plant stands when seedlings are 2 to 3 inches tall to allow sufficient space for adequate growth. Position containers in direct sunlight and maintain temperature at 70 to 75 F. Observe the plants 2 to 3 weeks after emergence. Record visible and physical measurements such as plant height and leaf length for abnormalities.

Symptoms of some herbicides like atrazine* and Sencor* do not develop until 2 to 3 weeks after emergence. Observe roots of plants grown in root inhibiting herbicides, such as dinitroanilines. Window bioassay does not provide accurate information for ALS herbicide carryover.

Field Bioassay Instructions: Plant several strips of desired crops across the field perpendicular to the direction the suspect herbicide was applied. Strips should be spaced to represent different field conditions (texture, pH, and drainage). If no visible signs of injury, stand reduction, or yield reduction occur, then the field can be seeded with the desired crop the next growing season. Do not plant if injury occurs and the bioassay must be repeated the next growing season to determine the safety of the crop to existing residues.

Y7. Atrazine at rates over 0.38 lb ai/A generally has residue the year following application to corn in North Dakota. If soil moisture is deficient, atrazine may cause injury to susceptible crops the following year. Corn and millet are tolerant to atrazine while other crops vary in susceptibility. The approximate ranking of crops from most to least tolerant is corn, sorghum, millet, flax, soybean, barley, wheat, oat, sunflower, canola/mustard, alfalfa, and sugarbeet.

Y8. Balance Flexx (isoxaflutole) may have a residue the following year. Breakdown is primarily by microbial activity. Risk of Balance carryover increases as precipitation occurring during the growing season decreases. Balance becomes more active as soil texture becomes more coarse and organic matter decreases. Rotation restrictions are found on pages 108-110.

Y9. Banvel* (dicamba) at rates greater than 1.5 pt/A may remain as a residue in soil. Most grass and broadleaf crops can be planted 4 months or more after application at 1.5 pt/A. Allow 45 days/pt/A of Banvel*, excluding days when ground is frozen to rotate to any crop. NDSU research indicates Banvel* at 1 qt/A applied in late September caused visible injury to wheat and barley planted the following spring, but effect on yield was minimal. Banvel* at 1 pt/A applied the previous fall prevented seed production in sunflower. The approximate ranking of crops from most to least tolerant is corn, barley, wheat, oat, potato, buckwheat, soybean, dry edible bean, sunflower, flax, and sugarbeet. Rotational crop restrictions for Banvel* are found on pages 108-110.

*Or generic equivalent.

Y10. Flexstar/Reflex (fomesafen) at 0.75 to 1 pt/A may have a residue the year following application to soybean, dry bean, or potato. Most crops can be planted the next growing season except canola, crambe, flax, potato, safflower, sugarbeet, and sunflower. Fomesafen is weakly adsorbed by OM but mobility and amount available for plant uptake increases as soil pH increases above 6.5. Degradation is through soil microbes and under anaerobic conditions. Conditions that inhibit microbial activity also reduce fomesafen breakdown. Cold or dry conditions after application reduce rate of breakdown. Northern production areas, like ND, have a shorter growing season and the soil temperature is colder for longer periods of time, which limits breakdown. Late applications in beans decreases the amount of time that breakdown can occur.

Ways to reduce risk of fomesafen carryover include lower application rates, banded herbicide applications, and tillage to dilute herbicide residues. The approximate ranking of non-labeled crops from most to least tolerant is cereals, potato, oil-seed rape/canola, field corn, sunflower, sugarbeet, sorghum, and alfalfa. Rotational crop restrictions for Flexstar/Reflex are found on pages 108-110.

Y11. Nortron* (ethofumesate) often has a residue the year following use on sugarbeet. The approximate ranking of crops from most to least tolerant is sunflower, dry beans, soybean, corn, barley, and wheat. Moldboard plowing usually will eliminate crop injury. Nortron should be applied in a band to reduce cost and reduce potential crop injury from residues the following year.

Y12. Sencor* (metribuzin) may not have residue the following year at 0.25 lb ai/A, but rates over 0.5 lb ai/A may damage susceptible crops the next year. Rotational crop restrictions for Sencor* are found on pages 108-110. The approximate ranking of crops from most to least tolerant is potato, soybean, dry edible bean, corn, barley, wheat, oat, sunflower, flax, and sugarbeet.

Y13. Sonalan (ethalfluralin), **Prowl/Prowl H_20** (pendimethalin), and **Treflan*** (trifluralin) are similar herbicides called dinitroanilines. Under dry soil conditions these herbicides can persist in soil for more than 1 year. Sonalan has less soil residue than Treflan* and Prowl. Land treated with Sonalan in the spring may be planted to any crop the next year except sugarbeet. Sunflower, soybean, potato, and dry edible bean are quite tolerant of dinitroaniline herbicides. Rotational crop restrictions for Prowl, Sonalan, and Treflan* are found on pages 108-110. The approximate ranking of other crops from most to least tolerant is soybean, flax, alfalfa, barley, wheat, corn, oat, and sugarbeet.

Y14. Spartan (sulfentrazone) residue may remain in soil the following season. Most grass and broadleaf crops can be planted the following year except canola, crambe, lentil, and sugarbeet. Spartan is degraded by soil microbes, is not affected by sunlight, and is not volatile. Spartan applied PRE does not degrade on the soil surface. Precipitation activates the herbicide by moving it into the soil. Spartan solubility increases as soil pH increases above 6.5, as soil texture changes from fine to coarse, and as OM decreases. As Spartan solubility increases availability for plant uptake increases, weed control increases, and risk of crop injury increases. The approximate ranking of crops from most to least tolerant is soybean, flax, chickpea, mint, sunflower, potato, field pea, dry edible beans, safflower, crambe, canola, lentil, and sugarbeet. Rotational crop restrictions for Spartan are found on pages 108-110.

*Or generic equivalent.

Y15. Crop Rotation Restrictions for North Dakota

Herbicide	Alf-alfa	Bar-ley	Can-ola	Corn	Cra-mbe	CRP grss	Dry bean	Field pea	Flax	Oat	Edibl Leg.[1]	Pot-ato	Saff lowr	Soy-bean	Sgr-beet	Sun-flwr	HRS/ Drm
	---------- (months after application) ----------																
Herbicides that allow most crops to be planted the year following application: 2,4-D, 2,4-DB*, Affinity*, Aim, Avenge, Axial XL, Basagran*, Betamix*, Buctril*, Cadet, Cobra, Discover, diquat*, Dual*, Ignite, Eptam*, Express*, FirstStep, GoldSky, Harmony*, Harness*, IntRRo*, linuron*, MCPA, Option, Orion, Outlook*, paraquat*, POST grass herbicides, PowerFlex, Resource, Rezult, Ro-Neet, Roundup*, Sequence, Sharpen, Starane/Flex, Status, Supremacy, Surpass*, Thistrol, Ultra Blazer, UpBeet, Verdict (v), Vida, Warrant.																	
DO NOT USE IN ND = Beacon, Exceed, NorthStar, Scepter, Spirit, Steel.																	
Accent*****(<0.68 oz DF/A)	10j	8	18	0	18	18	10j	10j	18	8	10	18j	18	0.5	18a	10j	8
Ally* (c)	34d	10	34d	34e	34d	6	34e	34d	34e	10	34d	34d	34e	34d	34d	34e	1/10
Ally Extra* (0.2 oz) (e)	22	10	22	22	22	6	22	22	22	10	22	22	22	22	22b	22	1/10
Amber	4b	18c	B	22b	B	B	B	B	B	18c	B	B	B	36b	B	24b	0
Assert	15	NCS	12/15f	NCS	12/15	4	NCS	15	15	15	15	15	NCS	NCS	20	NCS	NCS
atrazine* (0.38 lb ai)	NCS	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	12	NCSb	NCS	NCS
atrazine* (0.38-0.5 lb ai)	2CS	NCS	2CS	0	2CS	2CS	2CS	2CS	NCS	2CS	2CS	NCS	2CS	12	2CSb	2CS	2CS
atrazine* (0.5-1 lb ai)	2CS	2CS	2CS	0	2CS	2CS	2CS	2CS	2CS	2CS	2CS	2CS	2CS	12	2CSb	2CS	2CS
Authority Assist	12	9.5	40b	10	40b	12	4	4	26	18	4/12[1]	26	18	0	40b	18	4
Authority First/Sonic	12	12	24	10	30b	30b	12	12	30b	12	12	18	30b	0	30b	30b	4
Authority MTZ	12	4	24	10	18	12	12	18	18	18	18	12	18	0	36	12	4
Axial TBC	9	0.5	9	4	12	12	9	9	9	0.5	9	9	9	9	9	9	0.5
Balance Flexx (j)	10	6	18	0	18	18	18	18	18	6	18	6	6	6	18	10	6
Banvel* (<1.5 pt) (h)	4	4h	4	0h	4h	4	4	4	4	4h	4	4	4	4	4	4	0h
Beyond	9	18t	18	8.5	18	9	0	9	18	9	9	18t	18	0	18t	9	3
Boundary	4.5	8	12	8	12	12	12	8	12	12	12	0	12	0	18	12	8
BroadAxe	12	4	24	10	24	12	0	0	10	12	0/12[1]	12	10	0	24b	0	4
Capreno (i)	18	10	18	0	18	18	18	18	18	18	18	18	18	10	18	18	4
Callisto	10	4	NCS	0	18	18	18	18	10	4	18	10	18	10	18	10	4
Callisto Xtra	NCS	NCS	NCS	0	18	18	18	18	NCS	18	18	NCS	18	NCS	18	NCS	NCS
ClearMax	9	18t	18	8.5	18	9	0	9	18	9	9	18t	18	0	18t	9	3
Curtail* / M*	10.5m	1	5	1	5	1	10.5m	18	5	1	18	18	10.5m	10.5m	5	10.5m	1
Everest 2.0	NCS	9	9	NCS	NCS	NCS	9	11	9	18	24	9	9	9	9	9	0/4
Extreme	4	9.5	40b	8.5	40b	4	4	4	26	18	4	26	18	0	40b	18	4
Far-Go	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	18	NCS	NCS	NCS	NCS	NCS	NCS	0
Fierce	18	18	18	0.25	18	18	18	18	18	18	18	18	18	0	18	18	1
FirstRate	9	30b	30b	9	B	9	9	9	30b	9	9	18	B	0	30b	30b	3
Flexstar / GT 3.5	18	4	18	10	18	18	0	10	18	4	18	18	18	0	18	18	4
Gangster	12	B	B	9	B	9	9	9	9	9	9	18	B	0	30b	30b	3
Glean*	B	16	B	B	B	4	B	B	B	10	B	B	B	B	B	B	0
GoldSky	9	0.25	9	9	9	B	9	9	9	0.25	9	9	9	4	9	9	0.25
Halex GT	10	4	10	0	18	18	18	18	10	4	18	10	18	10	18	10	4
Harness*	9	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	4
Hornet	10.5m	4	26b	0	B	12	10.5m	10.5m	26b	4	10.5m	18	B	10.5m	26b	18	4
Huskie	9	0.25	9	9	9	B	9	9	9	0.25	9/18[1]	9	9	4	9	9	0.25
Huskie Complete	10	9	10	9	B	B	10	10	10	10	18	18	B	10	10	10	0.25
Ignite 280	6	2.33	0	0	2.33	2.33	6	6	6	2.33	6	2.33	6	0	0	6	2.33
Impact	9	3	9	0	18	18	18n	9	9	3	18	9	18	9	18	9	3
Laudis	10	4	10	0	18	18	10g	10	18	4	18	10	18	8	10g	18	4
Lightning	9.5	9.5	40b	8.5	40b	40	9.5	9.5	40b	18	9.5	26	18	9.5	40b	18b	4
Lumax (<3 pt/A)	18	4.5	18	0	18	18	18	18	18	NCS	18	18	18	NCS	18	18	NCS
Matrix*	12	9/18p	18	0	18	18	10	18	18	9	18	0	18	4	18	10	9
Maverick	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	0

Herbicide	Alf-alfa	Bar-ley	Can-ola	Corn	Cra-mbe	CRP grss	Dry bean	Field pea	Flax	Oat	Edibl Leg.[1]	Pot-ato	Saff lowr	Soy-bean	Sgr-beet	Sun-flwr	HRS/ Durm
	---------- (months after application) ----------																
Milestone (b)	36b	B	24b	12b	B	B	B	B	B	B	B	B	B	B	B	B	B
Nortron	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0	12	12
Olympus	B	B	B	22k	B	B	B	12k	B	24	22k	B	B	B	B	B	0
Osprey	10	1	10	12	10	10	3	3	10	10	10/3	10	10	3	10	1	0.25
Paramount	24b	10	10	10	10	10	24b	24b	24b	10	24b	24b	24b	10	24b	10	0
Permit / Sandea	9	2	15	1	B	2	9	9	B	2	9	9	B	9	36	18	2
Plateau	36	24	48b	36	36	0	36	36	36	24	36	48b	36	18	48b	36	12
PowerFlex	9	9	9	9	9	9	9	9	9	9	9	9	9	5	9	9	1
PrePare	NCS	9	9	NCS	NCS	NCS	9	11	9	18	24	9	9	9	9	9	0/4
Prequel	10j	9	18	0	18	18	18j	18	18	9	18	6	18	10	18j	18	9
Prowl EC / H2O	NCS	NCS	NCS	0s	NCS	NCS	0	0	NCS	NCS	0	0	NCS	0	2CS	0	NCS
Pulsar	9	0.67	9	0	12	12	9	9	9	0.67	9	9	9	9	9	9	0.67
Pursuit	4	9.5	40b	8.5	40b	4	4	4	26	18	4	26	18	0	40b	18	4
Python	4	4	26b	0	26b	12	4	4	26b	4	4	12	26b	0	26b	18	4
Raptor / Beyond	9	18t	18	8.5	18	9	0	9	18	9	9	18t	18	0	18t	9	3
Raze	NCS	9	9	NCS	NCS	NCS	9	11	9	18	24	9	9	9	9	9	0/4
Reflex	18	4	18	10	18	18	0	10	18	4	18	18	18	0	18	18	4
Require Q	10j	9	10j	0	18	18	10	18	18	9	18	0	18	10	10j	10	9
Resolve*(<1.1 oz DF/A)	10j	9	10j	0	18	18	10	18	18	9	18	0	18	10	10j	10	9
Resolve Q	18j	9	18j	0	18	18	10	10	10	9	18	0	18	10	18j	10	9
Rimfire Max	10	10	10	10	12	12	10	10	10	10	10	12	10	10	10	10	0
Sencor* (u)	4	8u	12	4	12	4	12	8	12	12	8	4	12	4	18	12	8u
Sharpen (1 fl oz) (v)	4	0	4	0	4	4	4	0	4	0	0/1	4	4	0-1	4	4	0
Sharpen (2 fl oz) (v)	5	0	5	0	5	5	5	1	5	0	0/2	5	5	1-2	5	5	0
Sharpen (3 fl oz) (v)	6	0	6	0	6	6	6	3	6	0	2/3	6	6	2-3	6	6	0
Sonalan	NCS	NCS	0	NCS	0	13w	0	0	NCS	NCS	0	NCS	NCS	0	2CS	0	NCS
Spartan	12	4	24	10	24	12	0	0	10	12	0/12[1]	12	10	0	36	0	4
Spartan Charge	12	4	24	10	24	12	0	0	10	12	0/12[1]	12	10	0	24b	0	4
Starane Flex	9	0	9	3	9	0	9	9	9	0	9	9	9	9	9	9	0
Status (h)	4	4	4	0.25	4	4	4	4	4	4	4	4	4	4	4	4	1
Steadfast (<0.76 oz/A)	10j	8	18	0	18	18	10j	10j	18	8	10j	18j	18	0.5	18a	10j	8
Stinger*	10.5	0	0	0	0	0	10.5m	18	0	0	18	18	10.5m	10.5m	0	10.5m	0
SureStart / TripleFlex	18	NCS	26b	0	26b	26b	12/18	NCS	26b	NCS	NCS	18	26b	NCS	26b	18	4
Surpass*	9	NCS	NCS	0	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	NCS	4
Tordon (1.5 oz)	2CS	NCS	2CS	2CSx	2CS	1	2CS	2CS	NCS	NCS	2CS	2CS	2CS	2CS	2CS	2CS	NCS
Treflan* (y)	0	NCS	0	NCS	0	18/21	0	0	0	18	0	0	0	0	2CS	0	NCS
Valor / Chateau	See page 6																
WideMatch*	10.5	0	4	0	4	0	10.5	10.5z	4	0	18	18	10.5	10.5	0	10.5	0
Wolverine	9	0.25	9	9	9	B	9	9	9	0.25	9/18[1]	9	9	4	9	9	0.25

*Or generic equivalent.
[1] Edible legumes = chickpea (garbanzo bean) / lentil.
NCS = Next cropping season after herbicide application.
2CS = Second cropping season after herbicide application.
MAA = months after application.

Field Bioassay Instructions - Refer to label or paragraph Y6 in the narrative section.

a Soil pH <7.5 = 11 MAA for sunflower. Soil pH >7.5 = 18 MAA for sunflower. Soil pH <6.5 = 10 MAA for sugarbeet and all crops not listed. Soil pH >6.5 = 18 MAA for sugarbeet, potato, and all crops not listed + cumulative precipitation in 18 MAA period > 28 inches.

B or b = Bioassay. Do not plant until field bioassay indicates it is safe. Crop rotation after atrazine* is rate and soil pH dependant.

Python, Hornet, and SureStart = 26 month rotation + successful field bioassay.
FirstRate = 30 month rotation + successful field bioassay. Lightning and Pursuit = 40 month rotation + successful field bioassay.

c Do not use on soil with pH greater than 7.9. Barley and oat can be planted 6 months after application west of highway 83.

d Requires soil pH of 7.9 or less and a 34 month minimum rotation interval and 28 inches of cumulative precipitation.

e Requires soil pH of 7.9 or less, 22 months and 22 inches of precipitation west of Hwy 1 or 34 months and 34 inches of precipitation east of Hwy 1. These restrictions apply to Ally Extra* at rates greater than 0.2 oz DF/A.

f Clearfield (imidazolinone resistant) canola varieties may be planted the season after application.
Conventional canola varieties may be planted the following season after application at 1 pt/A in ND counties of Cavalier, Pembina, Ramsey, Rolette, Towner, and Walsh and MN counties of Kittson, Marshall, Pennington, Red Lake, and Roseau.

g Cumulative precipitation between application and planting of dry beans and sugarbeet is 20 inches. 10 MAA rotation interval applies to all dry bean types except red kidney and cranberry (18 MAA). Thorough tillage must precede planting of sugarbeet.

h Any rotational crop may be planted 120 days following application of Banvel* at 1.5 pt/A or less, excluding days when ground is frozen. For all crops and rates greater than 1.5 pt/A allow 45 days per 1 pt/A of Banvel* used excluding days when ground is frozen.

i Crops with a 10 month rotation restriction require 15 inches of cumulative precipitation after application. Crops with an 18 month rotation restriction require 30 inches of cumulative precipitation after application. Soil at 7.5 pH or above require crop rotation to be delayed from 10 months to 18 months and from 18 months to 24 months.

j Requires 15 inches of cumulative precipitation during the growing season following application. An 18 month restriction applies to Accent*, Resolve*, Prequel, and Steadfast applied above rates indicated or if drought follows application. Refer to label for crop rotation restrictions if rates greater than those indicated are used.

k Requires 24 inches of accumulated precipitation.

m Do not plant dry bean, dry pea, soybean or sunflower for 18 months on soil with less than 2% OM and rainfall less than 15 inches during the 12 MAA OR may be planted 12 MAA if risk of injury is acceptable. Perform a field bioassay prior to planting for areas that receive less than 15 inches of rainfall and have less than 2% OM. Do not plant lentil, potato or any other broadleaf crop grown for seed for 18 months unless risk of injury is acceptable.

n Dry bean can be planted after 9 months at Impact rates of 0.5 fl oz/A or less.

p Barley can be planted 9 months after application in Cass, Grand Forks, Pembina, Towner, Traill, and Walsh counties of ND.
In all other counties of ND allow an 18 month rotation restriction before planting barley.

s Corn can be planted only if Prowl*/H20 are applied PRE. DO NOT APPLY PPI.

t Rotation to barley is: 9 months east of Hwy 83 and 18 months west of Hwy 83.
Rotation to potato is: 9 months: soil pH >6.2 and rainfall is >18 inches/year or 18 months: soil pH <6.2 and rainfall is <18 inches/year
Rotation to sugarbeet: 18 months: soil pH >6.2 or 26 months if soil pH is less than 6.2.

u Must add 2 months if soil pH is 7.5 or above. Wheat and barley can be planted 4 MAA following lentil or soybean.

v Do not include time when soil is frozen. Sunflower and safflower are the most sensitive crops.
For Verdict: Fall seeded cereals can be planted 4 months after application. All crops can be planted the spring following application.

w CRP grasses may be planted 13 MAA under the following conditions:
1. By label this is deemed as a non-standard rotation.
2. Dow assumes no liability for injury.
3. Fall is recommended as the best time to plant CRP grasses.
4. A field bioassay is recommended prior to planting CRP grasses.

x Do not plant corn or sorghum until soil samples analyzed for Tordon residue indicates no detectable levels present.
Restriction is based on non-legal herbicide residue that may be found in corn and sorghum and not on crop safety.

y Oats, sorghum, and annual or perennial grass crops may be planted at least 12 MAA in areas that received 20 inches or more of precipitation during the growing season. CRP grasses may be planted 18 MAA if Treflan* is spring-applied or 21 MAA if fall-applied.

z For rotation to field pea in 10.5 months, precipitation must be greater than 7 inches during the 10.5 months following application and greater than 5.5 inches of precipitation from June 1 to August 31 following application. Otherwise allow 18 months.

*Or generic equivalent.

Y16. Laboratories That Analyze For Pesticide Residues in soil, water, and plant samples.

The following list shows laboratories that can analyze for pesticide residues:

A & L Great Lakes Lab
3505 Conestoga Drive, Fort Wayne, IN 46808
219-483-4759, http://www.algreatlakes.com

AgSource Harris Laboratories
300 Speedway Circle, Lincoln, NE 68502
402-476-0300, http://www.agsource.com

Agvise Laboratories
PO Box 510, 604 Hwy 15, Northwood, ND 58267
701-587-6010, www.agviselabs.com
902 13th St N, Benson, MN 56215, 320-843-4109

APT Labs Inc.
1050 Spring St., Reading, PA 19610
610 375-3888, www.aptlabsinc.com

Centralia Animal Disease Laboratory
9732 Shattuc Road, Centralia, IL 62801-5858
618-532-6701
http://agr.state.il.us/animalHW/labs/centralialab.html

Columbia Food Laboratories, Inc.
36740 E. Historic Columbia River Hwy, PO Box 353
Corbett, OR 97019
503-695-2287, www.columbiafoodlab.com/
info@columbiafoodlab.com
Can test for herbicide residue in plant tissue.

Hazelton Environmental Services
525 Science Drive, Madison, WI 53711
608-232-3300

Midwest Laboratories
13611 B Street, Omaha, NE 68144
402-334-7770, www.midwestlabs.com

Minnesota Valley Testing Laboratories, Inc.
Iowa, Minnesota, North Dakota
800-782-3557, www.mvtl.com

Montana State Analytical Laboratory
McCall Hall, PO Box 173620
Montana State University, Bozeman, MT 59717
406 994-3383, Heidi Hickes
Developed the most sensitive test available for Oust.

South Dakota Agriculture Laboratories, Brookings Biospace
Dr. Regina Wixon, regina.wixon@sdaglabs.com
1006 32nd Ave #103 / #105, Brookings, SD 57006-4728
605-692-7325, www.sdaglabs.com

Y17. Susceptibility of certain crops from most to least tolerant:

Chlorimuron: sugarbeet > canola > alfalfa > sunflower > sorghum > corn > oat > wheat > soybean.

Clomazone:
oat = wheat= alfalfa > sunflower = sorghum = corn > soybean.

Dinitroaniline: annual rye > oat > sorghum > corn > wheat > alfalfa > soybean.

Imazethapyr: sugarbeet > canola > sorghum > sunflower > oat > wheat > corn > alfalfa > soybean.

Atrazine: sugarbeet > alfalfa > canola/mustard > sunflower > oat > wheat > barley > soybean > flax > millet > sorghum > corn.

General Guidelines for Laboratory Analysis: Safe Level*

Herbicide	ppb	ppm	Crop
Classic	1-2	0.001-0.002	Corn
(chlorimuron)	2-5	0.002-0.005	Wheat
Command	15-100	0.015-0.100	Wheat/Alfalfa
(clomazone)	50-200	0.050-0.200	Corn
Dinitroaniline	50-100	0.050-0.100	Sugarbeet
	100-200	0.100-0.200	Corn
	200-300	0.200-0.300	Wheat
Pursuit	<1	<0.001	Sugarbeet
(imazethapyr)	4-15	0.004-0.015	Sorghum
	10-30	<0.010-0.030	Corn
Atrazine	<5	<0.005	Sugarbeet
	40-100	0.040-0.100	Alfalfa
	60-150	0.060-0.150	Oat
	75-180	0.075-0.180	Wheat
	150-250	0.150-0.250	Soybean

Atrazine Residue Levels		"Safe" to plant
3 inch sample (No-till)	6 inch sample (Moldboard plow)	
<0.17 ppm	<0.08 ppm	Oat, Alfalfa
0.17 to 0.35 ppm	0.08 to 0.17 ppm	Soybean
>0.35 ppm	>0.17 ppm	Corn

"Safe" values for herbicide residues differ by soil type and pH because of differences in availability in soil. Low-range values are for coarse textured soils with low levels of organic matter, higher values are for fine textured soils with high organic matter.
1 ppm = 1,000 ppb.

Publications on Herbicide Injury Symptoms:

W-1141 Herbicide and Nonherbicide Injury Symptoms on Spring Wheat and Barley, NDSU Extension Service.

A-1085 Herbicide Mode of Action and Sugarbeet Injury Symptoms NDSU Extension Service

PNW-498 Herbicide Drift and Carryover Injury in Potatoes
Ag Publications, U of ID, 208 885-7982, ckink@uidaho.edu

CD-ROM:
Herbicide Mode of Action and Crop Injury Symptoms (U of MN)
To order go to: http://shop.extension.umn.edu/
In the "Search " window type: 06893
Cost is $20.00 per CD-ROM

Web sites:
Herbicide Mode of Action Symptoms (U of WI):
http://ipcm.wisc.edu/pubs/PestMngmt_ref.htm

Herbicide Injury Diagnostic Key:
http://ipcm.wisc.edu/uw_weeds/herbinjkey/

Dicamba Injury to Soybean (U of WI):
http://ipcm.wisc.edu/pubs/PestMngmt_ref.htm

Recognizing Residue and Drift Injury in Canola -
Alberta Res. Council:
www.canola-council.org.PDF/toolbook.pdf#zoom=100