1992

G92-1081 Factors That Affect Soil-Applied Herbicides

R. S. Moomaw
University of Nebraska - Lincoln

Robert N. Klein
University of Nebraska - Lincoln, robert.klein@unl.edu

Alex Martin
University of Nebraska - Lincoln, amartin2@unl.edu

Fred Roeth
University of Nebraska - Lincoln, fwroeth41@gmail.com

P.J. Shea
University of Nebraska - Lincoln, pshea1@unl.edu

See next page for additional authors

G92-1081-A

NebGuide

Published by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

Factors That Affect Soil-Applied Herbicides

Characteristics of soil-applied herbicides are discussed, including site of uptake by weeds, solubility, adsorption, persistence, leaching potential, photodecomposition, and volatility.

R.S. Moomaw, Extension Weed Scientist
R.N. Klein, Extension Weed Scientist
A.R. Martin, Extension Weed Scientist
F.W. Roeth Extension Weed Scientist
P.J. Shea, Associate Professor of Agronomy
G.A. Wicks, Extension Weed Scientist
R.G. Wilson, Extension Weed Scientist

- Site of Herbicide Uptake
- Herbicide Solubility
- Herbicide Adsorption
- Herbicide Persistence
- Leaching Potential
- Photodecomposition
- Volatility

For best performance, preemergence and preplant herbicides must be placed in the top 0 to 3 inches of soil. Placement is important because the herbicide must enter the germinating weed seedling in order to kill it. Herbicides can be blended into the soil by mechanical incorporation, rainfall, or sprinkler irrigation, depending on the herbicide. Herbicide characteristics that determine their performance are site of uptake by weeds, solubility, adsorption, persistence, leaching potential, photodecomposition, and volatility. An understanding of these factors will result in more effective herbicide use.

Site of Herbicide Uptake

Herbicides kill weeds in several ways. The vapor (gas) of some volatile herbicides is absorbed and then affects germinating weed seed and seedling development. Examples are Eradicane and Sutan+ (*Table I*). Other soil-applied herbicides enter the weed seedling through either the root, shoot, or both. After being taken up, herbicides kill the weed seedling by interfering with photosynthesis, protein synthesis, enzyme systems, cell division, or in other ways. Maximum herbicide performance results when the herbicide is placed by rainfall, irrigation, or mechanical incorporation in the soil zone of weed seed germination and seedling development (*Figure 1*).

For best performance, shoot-absorbed herbicides like Treflan should be concentrated in the top 0 to 3 inches of soil. This is also true for herbicides that affect germinating weed seed. As the weed shoot passes through

the herbicide zone, uptake occurs and the seedling is killed. If the herbicide is mechanically incorporated too deeply or excessive leaching occurs, poor weed control will result. Dilution occurs if the herbicide is distributed in a larger volume of soil.

Atrazine, Bladex, and Sencor/Lexone are root-absorbed herbicides. As the root emerges from the germinating weed seed, herbicide is absorbed and the weed is killed. Control of some deeper germinating large-seeded broadleaf weeds, such as velvetleaf, cocklebur, sunflower, jimsonweed, and morningglory, may be improved if a root-absorbed herbicide like atrazine is mechanically soil incorporated 2 to 3 inches deep. Roots of the deeper germinating weed seed then encounter more herbicide.

Herbicide Solubility

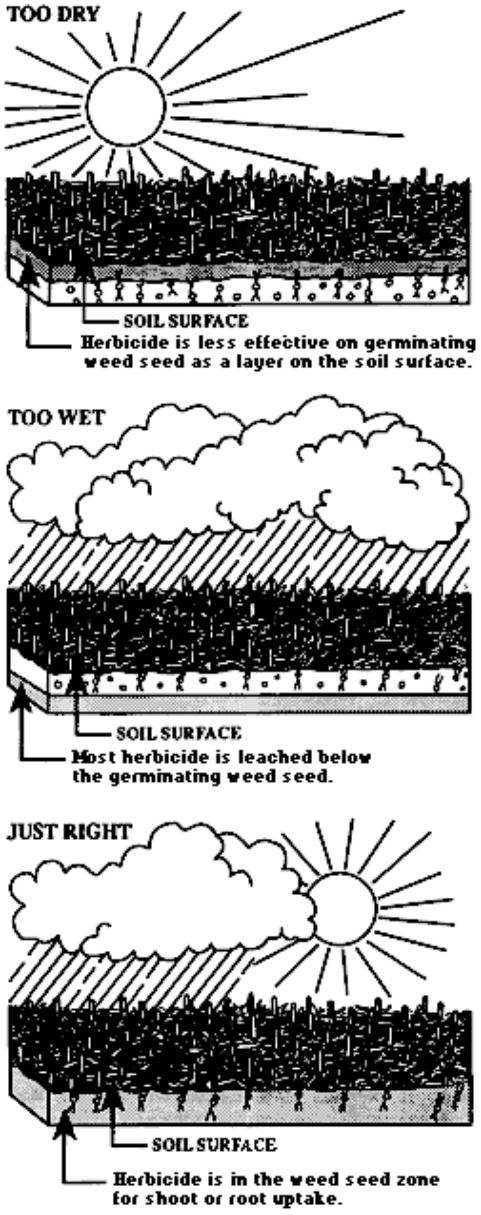

Figure 1. Effectiveness of herbicide based on location in the soil.

Solubility refers to the amount of a herbicide that will dissolve in water (*Table I*). Relatively insoluble herbicides require more rainfall for activation. Rainfall or irrigation is needed within five to seven days of herbicide application for best results.

The amount, duration, intensity, and frequency of rainfall are important relative to herbicide solubility. Slow, gentle rains effectively move most herbicides into the soil. With high intensity rainfall and associated runoff, less soluble herbicides may not be activated. Too little rainfall may not move herbicides far enough into the soil for good performance. Too much rainfall can move certain herbicides deeper into the soil than desirable (*Figure 1*). Soils that are near field capacity require less rainfall for herbicide activation than soils very low in soil water.

When preemergence herbicides are applied to soil with ample moisture, but rainfall does not occur to activate the herbicide, poor weed control may result. This is because soil moisture conditions are ideal for weed seed germination before the herbicide is activated.

Lasso or Dual plus Bladex will generally be more effective with limited rainfall compared to tank mixing Lasso or Dual with atrazine, because of solubility differences between Bladex and atrazine (*Table I*); however, weeds controlled by atrazine and Bladex are not exactly the same. Soil incorporated combinations such as Sutan+ plus atrazine are less dependent on immediate rainfall for activation. In general, soil incorporated herbicides are less affected by variations in weather than are surface applied herbicides.

Highly water soluble herbicides move downward more readily with soil water. However, the percent organic matter, and the type and percentage of clay particles present in a given soil affect movement of herbicides dissolved in soil water.

Herbicide Adsorption

After a herbicide has dissolved in soil water, it may be adsorbed or "tied-up" by soil particles. Factors that are most important for soil adsorption are the clay types, mineral oxides present, the percent organic matter, soil pH, and soil water content. Each soil has its own capacity to adsorb a particular herbicide.

The ratio between the amount of herbicide adsorbed by the soil to the amount in soil solution is termed the sorption index (K_{oc}). A low sorption index means a greater amount of applied herbicide is found in soil solution and less is adsorbed by soil. Herbicides with a low sorption index are more likely to leach in a given soil than those with a larger value (*Table I*).

The sorption index of some herbicides is variable depending upon soil factors such as organic matter and pH. This is illustrated by Classic from the sulfonylurea herbicide family. In low pH (acid) soils, Classic is less soluble and tightly bound to the organic matter. In high pH (alkaline) soil, Classic is much more soluble, less tightly bound to organic matter, and subject to leaching.

Herbicide Persistence

Solubility and the sorption index are important indicators of herbicide mobility and impact weed control effectiveness. Persistence of the herbicide is also important. How long a herbicide remains active in a soil system is expressed by a half-life value. Half-life is a period of time it takes for 50 percent of a herbicide in the soil to degrade (*Table I*). Half-life will vary with soil microbial populations, soil moisture, soil temperature, pH, and farming practices.

Leaching Potential

Protecting groundwater from pesticide contamination is a high priority. Leaching of herbicides and other pesticides can occur as rainfall or irrigation water moves down through soil. Leaching potential of various herbicides (*Table I*) depends on factors just discussed -- solubility, amount and frequency of rainfall, soil adsorption, persistence, and soil texture and structure. How these factors interact to affect leaching potential can be illustrated by atrazine. Atrazine has low solubility and a medium sorption index, which indicates low leaching potential. However, since atrazine has a relatively high half-life, the leaching potential is high (*Table I*). As a result, the atrazine label carries a groundwater advisory statement against using the product on well-drained sand and loamy sand soils where groundwater is close to the soil surface.

Photodecomposition

Photodecomposition, which is the breakdown of a chemical by light, may occur when some herbicides are left on the soil surface for an extended period without rain. Herbicides that are subject to photodecomposition usually volatilize from the soil surface, thus requiring soil incorporation.

Preemergence herbicides remaining on the soil surface for long periods without rain may lose some effectiveness by photodecomposition and volatilization. Shallow incorporation with a rotary hoe or harrow is recommended to prevent photodecomposition and volatilization if rainfall does not occur within five to seven days of herbicide application.

Volatility

Volatility is the tendency of a liquid to undergo a phase change from a liquid to a gas. All herbicides are volatile to some degree, but they differ greatly in this property. Some herbicides must be incorporated because of excessive volatility (*Table II*). Highly volatile herbicides, such as Eptam, Eradicane, Sutan+, and Ro-Neet, are lost rapidly from a moist soil surface with warm temperatures and windy conditions. Sonalan and Treflan comprise another group of volatile herbicides that must be incorporated.

Lower volatilization losses occur from dry, cool soil surfaces. Volatile herbicides should be applied only when the soil is dry enough for good soil mixing. Soil mixing instructions appear on the label of herbicides and vary with the product. For example, label instructions for Eptam, Eradicane and Sutan+ encourage application and incorporation in the same operation to a 2 to 3 inch depth. Incorporation of other herbicides can be delayed, up to 24 hours with Treflan.

Command must be soil incorporated in Iowa and Minnesota and many other eastern states. In Nebraska, Command may be soil incorporated or used in a preemergence surface application. Air temperatures in Nebraska are usually moderate when soybeans are being planted, which minimizes the vaporization potential of Command. Off-site movement of spray drift or vapors of Command can cause foliar whitening or yellowing of plants. The Command label lists several precautions which must be followed when applying it preemergence. These restrict use of Command within 1500 feet of towns and subdivisions, commercial fruit or vegetable production, and commercial greenhouses or nurseries.

Table I. Characteristics of selected herbicides that determine their effectiveness.[a]

Herbicide	*Major site of uptake*	*Water solubility*	*Sorption index*	*Soil half-life*	*Leaching potential[b]*
		(ppm)	(koc)	(days)	
Ally[c]	Root	9500	35	120	High
Atrazine	Root, some shoot	33	100	60	High
Balan	Germinating seed, shoot	<1	9000	40	Low
Banvel	Root	400,000	2	14	High
Bladex	Root, some shoot	170	190	14	Medium
Classic[c]	Root, some shoot	1200	110	40	High
Command	Root, some shoot	1100	300	24	Medium
Dual	Shoot, some root	530	200	90	High
Eradicane	Germinating seed, shoot	344	200	6	Small
Glean[c]	Root	7000	40	160	High
Kerb	Root	15	200	60	High
Lasso	Shoot, some root	240	170	15	Medium
Lorox/Linex	Root, some shoot	75	400	60	Medium
Nortron	Shoot, some root	50	340	30	Medium
Oust[c]	Root	70	78	20	Medium
Princep	Root	6	130	60	High
Prowl	Shoot	<1	5000	90	Low
Pursuit[c]	Root, some shoot	200,000 E	10 E	90	High
Ramrod	Shoot, some root	613	80	6	Low
Ro-Neet	Germinating seed, shoot	95	430	30	Medium

Sencor/Lexone	Root, some shoot	1220	60 E	40	High
Scepter[c]	Root, some shoot	160,000 E	20 E	60	High
Sinbar	Root	710	55	120	High
Sonalan	Shoot	<1	4,000	60	Low
Sutan+	Germinating seed, shoot	44	400	13	Small
Tordon	Foliage	200,000 E	16	90	High
Treflan	Shoot	<1	8000	60	Low

[a]Water solubility, sorption index, soil half-life, and leaching potential values are from the Soil Conservation Service Pesticide Properties Database Technical Guide for Nebraska, Section II-D-5. E = an estimate -- a wide range of values have been reported.

[b]Soil texture and structure will affect leaching potential.

[c]Water solubility and sorption index for these herbicides were measured at pH7.

Table II. Volatility of some soil-applied herbicides.

Herbicide	*Volatility*
Must be mechanically soil incorporated	
Balan	Moderate to high
Eptam	High on wet soil; moderate on dry soil
Eradicane	High on wet soil; moderate on dry soil
Ro-Neet	High on wet soil; low on dry soil
Sonalan	Moderate
Sutan+	High on wet soil; low on dry soil
Treflan	Moderate to high
Do not require mechanical soil incorporation[1]	
Ally	Low
Atrazine	Low to moderate
Banvel	Moderate
Bladex	Low
Classic	Low
Command	Moderate
Dual	Low
Kerb	Low
Lasso	Low
Lorox/Linex	Low
Nortron	Low
Oust	Low
Princep	Low

Prowl	Moderate
Pursuit	Low
Ramrod	Very low
Sencor/Lexone	Low
Scepter	Low
Sinbar	Low
[1]Shallow incorporation is recommended to prevent photodecomposition and volatilization if rainfall does not occur in five to seven days.	

File G1081 under: PESTICIDES, GENERAL
B-13, Herbicides
Issued May 1992; 7,500 printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.