diagnosis & prevention of HERBICIDE INJURY

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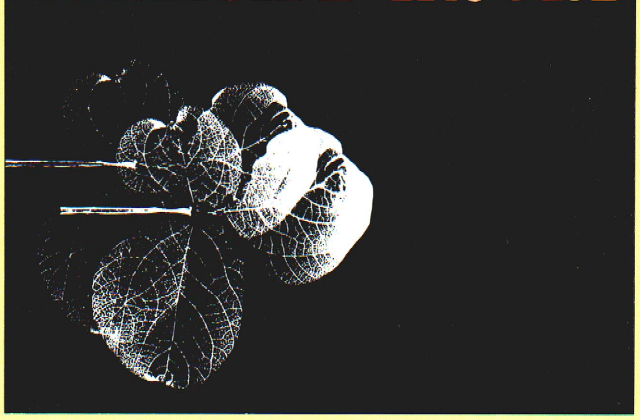

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The color prints were selected on the basis of their importance as models for a group of related herbicides and symptoms. No attempt, implied or intended, was made to single out any symptoms or group of herbicides except as a safeguard in preventing injury and as a diagnostic tool. Trade names are used with the understanding that there is no discrimination by the Cooperative Extension Service. Common names of the herbicides conform to the Herbicide Handbook of the Weed Science Society of America, (see table on inside back cover).

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INTRODUCTION

WEEDS CAUSE MORE CROP LOSSES in the United States than either insects or diseases. Besides competing with crops for light, nutrients and moisture, they may also secrete toxic substances which inhibit crop growth or harbor destructive insects and diseases. If maximum crop yields are to be attained, weeds must be effectively controlled.

Selective weed control is accomplished primarily by herbicides and tillage practices. The bulk of all pesticides now manufactured in the United States are herbicides. In the near future, selective herbicides will probably continue to be the most important weed control tools because of economic and energy considerations.

Although herbicides offer an effective and economical means of control, certain risks are inherent in their use. Crop injury is one of these risks. No crop is completely resistant to herbicide injury, but any crop tolerates certain dosages. Selectivity, or the ability of an herbicide to kill weeds without harming crops, may be partially lost under adverse environmental conditions. Careless application can also result in injury to the grower's crop or that of a neighbor. Injury can range from complete destruction of crops to slight stunting or discoloration which often has no adverse effect on yield.

Several factors can cause injury to crops. Environmental factors such as drought, freezing, lightening, hail and wind are often implicated as the causes. Insects and diseases, nutrient deficiencies or excesses, and more recently, air pollutants may cause injury symptoms that are confused with herbicide damage. In many instances, herbicides have been hastily implicated as the **number one** suspect when, in fact, they were not responsible for the damage. As one observer recently stated, "It's a heck of a lot easier to sue a chemical company than 'Mother Nature'." Lawsuits over chemical injury are costly to everyone in the long term. They have discouraged chemical companies from developing new herbicides that are badly needed for high value specialty crops.

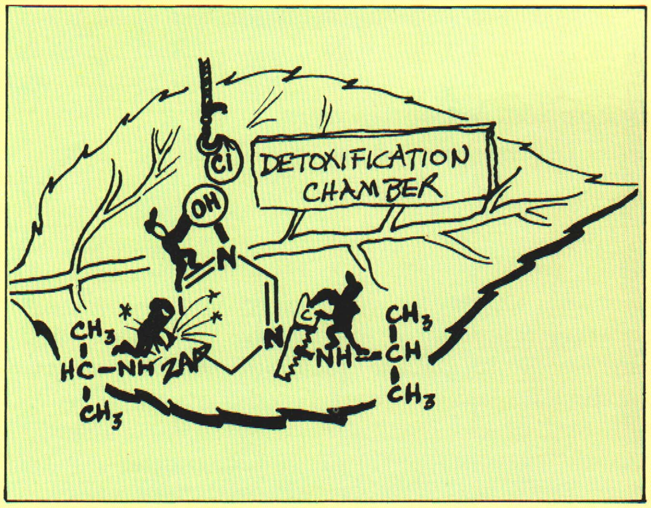
Herbicide injury in a field often displays a distinct pattern. Although herbicide effects on plants vary, related compounds usually cause plants to show a characteristic group of symptoms. Familiarity with these patterns and symptoms and with the history of pesticide use in and around the field can aid in identifying injury causal factors. The purpose of this bulletin is to aid those involved in diagnosis of herbicide injury and to provide information that could decrease the incidence of injury in the future.

How do crops tolerate herbicides?

Mechanisms of selectivity vary among herbicides. The earliest herbicides derived their selectivity from differences in their wetting properties. Sulfuric acid, which was commonly used in onions, was selective because it did not adhere to waxy leaves growing in an upright position. This same principle allows the use of dinoseb (PREMERGE) over the foliage of peas.

Other herbicides such as simazine (PRINCEP) and diuron (KARMEX), which do not move readily in the soil, are selective because they generally remain in the upper soil layer where they are taken up by relatively shallow-rooted weeds and do not readily leach into the root zone of the deeply rooted crops for which they are used.

The third mechanism of selectivity is true physiological tolerance to a particular herbicide. Physiological tolerance involves such things as the plant converting the herbicide to a non-toxic form or failing to translocate the herbicide within the plant. For some herbicides, more than one mechanism may be important. An understanding of the mechanism of selectivity of a particular herbicide can aid in the prevention and/or diagnosis of injury.



HERBICIDE INJURY:

How it occurs and how to prevent it

Read and Heed

Injury occurs in a variety of ways but most often occurs as a result of errors at the time of application. The single most important step the applicator can take to prevent injury is to read and follow the directions on the label. The label contains information on rates, methods of application, cautions on use, chemical selectivity, plant sensitivity and crops for which the material is registered. It is important to remember that following label directions not only helps prevent crop injury, but **failure to do so is illegal.**

Herbicide injury often occurs as the result of using the wrong chemical. If the label is read carefully and understood, misuse should never occur. Labels specifically state under what conditions the chemical can be used. Costly injury cases have occurred when the wrong herbicide was used in the greenhouse where the environment is much different from the outdoors. Using the wrong chemical may not result in injury. Misapplication, however, is an illegal act, and the applicator is subject to both civil and criminal fine, or a food crop may be confiscated. Misuse of herbicides can and has resulted in disastrous consequences.

Injury to crops or fish and wildlife has resulted from improper disposal of excess pesticides. Excess chemicals should never be dumped where they may wash onto cropland or into ditches or streams. Care should also be taken when filling spray tanks to avoid back-siphoning into a well or stream.

Is application equipment working properly?

Faulty application equipment or improper use of equipment can lead to overdosing which causes crop injury. Herbicide applicators are designed to apply chemicals uniformly over a given surface area. Application rates are determined by the speed, pressure, nozzle size and the amount of chemical added to the diluent (usually water). Nozzles designed specifically for herbicide application (flat fan or even-spray) should be used rather than cone-type nozzles used for other pesticides. Improper spacing of nozzles can cause overlapping and result in a banded injury pattern.

Equipment should be calibrated periodically to assure that the desired gallonage is being delivered. When nozzles become worn (particularly by abrasive wettable powders) the flow rate can increase and result in overdosing or uneven application.

Frequent checks on tractor speeds and line pressure during application will insure uniform application rates. Injury occurring on hillsides could result from overdosing if the sprayer were slowed down as it climbs the hill.

Proper agitation in the spray tank is essential if uniform distribution is to be obtained. Failure of the agitation system can cause settling of the spray material, and overdosing may result in the areas that are first sprayed.

Overlapping of spray can result in banded injury patterns caused by overdosing. To prevent this, it is important to mark the areas that have been sprayed and to turn off the sprayer while turning at the end of the row. Failure to shut down the spray system when turning can result in overdosing at the inside of each turn.

Herbicides should not be applied at pressures exceeding 40 PSI. Under high pressure, the carriers for wettable powders may injure plants by abrasion. High pressure is also conducive to drift.

Avoid drift

Drift may cause severe plant injury to crops in a non-target area. Movement of particles or vapor from the area where an herbicide was applied to other areas

is caused primarily by spraying on windy days or using high-spray pressure which generates small droplets. Injury from drift can occur great distances beyond the area where spray mist is visible. Under certain weather conditions (air inversion), small droplets or vaporized chemicals may be lifted and carried several miles with air currents.

Drift potential increases as the distance between the boom and the ground is increased. Therefore, the proper setup of equipment and positioning of booms is very important in reducing spray drift. Closer spacing of spray nozzles or use of wide-angle nozzles will enable the boom to be moved close to the ground and reduce the danger of drift.

There are currently several drift-reducing agents in various stages of development. Spray additives are available which change the physical properties of solutions and eliminate the fine droplets. Application devices have been developed which effectively deliver foams or inverted emulsions (water in oil) that drift less. These developments are increasing the safety of both aerial and ground applications.

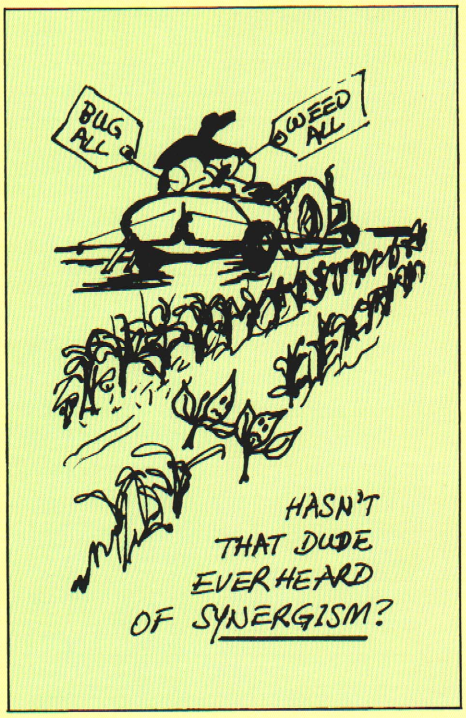
Herbicide injury outside the target area is not always attributable to aerial movement of the material. Heavy rainfall can wash herbicides into low areas of the field or into adjacent non-treated areas. When injury occurs outside the sprayed area, look for patterns of injury on the plants and evidence of soil washing or run-off before the damage is attributed to drift.

Avoid soil residues or plan suitable rotations

Herbicide residues in the soil may damage subsequent plantings or cause the crop to contain residues above permissible levels for consumption. Some herbicides can leave residues in the soil for more than one growing season, particularly under conditions of short growing seasons and cold winters as are experienced in Michigan and other northern states.

When a susceptible crop is rotated into a field that has been previously treated with a herbicide, injury may result if the herbicide has not dissipated. Whenever possible, herbicides and rates of application should be selected to avoid residue carryover. However, in some instances, use of a persistent material may be necessary to eradicate a perennial weed. If carryover is a problem with a particular herbicide, rotations must be planned so that a susceptible crop is not planted in rotation.

Instances occur where a treated crop fails to make a satisfactory stand. One is then faced with trying to establish a second crop in an area already treated with an herbicide. One must either choose another crop for which the herbicide is registered or make sure an adequate interval passes prior to replanting a susceptible crop. Safe intervals are listed on herbicide labels.



Avoid incompatible mixtures

Herbicides are generally only one of several pesticides applied to a crop during a season. They may be tank mixed with other herbicides or pesticides or applied sequentially. Incompatibilities exist between some of the pesticides. They may be immediately obvious in tank mixes where precipitates form, or less obvious where effects are seen only as injury symptoms on the crop.

Interactions which cause crop injury most often take the form of synergism, the process whereby interacting materials exert a greater effect than the sum of the independent effect of each material. The current pesticide law states that pesticide combinations should be used only when prepackaged, labeled for use as tank mixes or when recommended by Agricultural Experiment Stations, State Departments of Agriculture or when they have become a common agricultural practice.

Sometimes the carrier solvent for one pesticide may increase the activity of another. The addition of surfactants or oils may increase herbicide action on both weeds and crops. In some instances, selectivity is decreased, and severe crop injury may occur. Certain herbicides may interact with liquid fertilizers. Problems of this nature are usually discussed on the label.

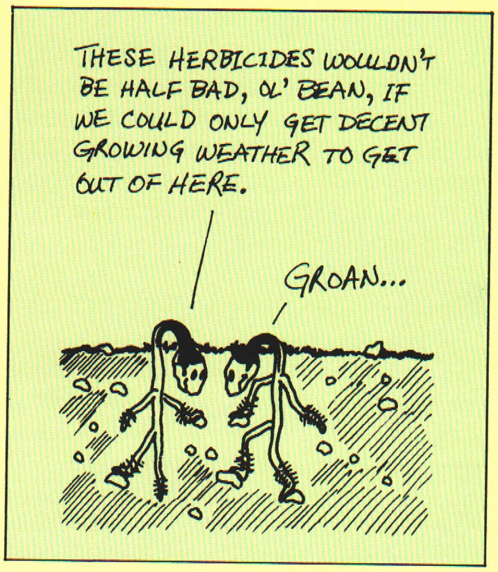
Use proper dosages for soil type

Recommended application rates are printed on all herbicide labels. These rates will vary according to the soil type on which they are applied. Clay soils or soils with a high organic matter content generally require more herbicide to give effective weed control than silt loam or sandy soils that are low in organic matter. Consequently, less herbicide is usually required to induce crop injury on the latter soils. If soils within a field are variable, it may be necessary to use lower rates on the sandy areas. Organic matter is usually highest in the low sections of the field and lowest on knolls. Injury symptoms are often more severe on high spots in the field if moderate overdosing has occurred.

Displacement in the soil may cause injury with herbicides which depend on positioning at the soil surface for selectivity. During periods of heavy rainfall (particularly on sandy soils) these materials may leach into the root zone of the crop and cause injury. At the same time, weed control is usually lost because the herbicide has moved out of the zone where most weed seeds germinate.

Watch the weather

Adverse weather is perhaps the biggest single factor enhancing herbicide injury. All facets of weather affect the performance of herbicides. Injury is more likely to occur when crops are under stress from lack of moisture, too much moisture or other weather conditions which adversely affect plant growth. Even a crop with a high tolerance for a particular herbicide can be injured when cool, wet weather in the early spring limits growth. In general, cool wet conditions during germination and emergence are most conducive to injury from preemergence herbicides.



Crop tolerance to postemergence herbicides is affected by weather conditions both prior to and at the time of application. Humid, cloudy conditions prior to treatment may make crop plants more sensitive, probably because of a decrease in protective wax on the leaves. Hot, humid conditions at the time of treatment are conducive to "leaf scorch" (necrosis) from some postemergence herbicides, and appropriate warnings are included on the labels.

Since weather is one factor which we are unable to control, safety margins are built into herbicide recommendations to minimize injury. Although higher than recommended rates may not injure crops when growing conditions are optimum, the labeled rates have injured the same crop when weather placed the crop under stress.

Watch for susceptible varieties

Some varieties of a crop are inherently more susceptible to herbicide injury than others. The research required to get new chemicals registered involves extensive testing on several of the major varieties. When susceptible varieties are found, warnings about their response are either published on labels or contained in technical information released by the manufacturer or in educational material released by Extension workers. When experimenting with new varieties, it is wise to check their response to the herbicide on a small scale prior to treating large acreages.

Antidotes can be helpful

Antidotes or protectants have been developed which make it possible to grow crops in soils contaminated with herbicide residues or which can actually increase crop tolerance to a herbicide used on that crop. Activated charcoal, for example, can adsorb and detoxify a wide variety of pesticides. It is used successfully to overcome injury from residue carryover in the field, to detoxify harmful residues from improper herbicide application in greenhouses and to increase the tolerance of seeded and transplanted crops to preemergence herbicides. Optimum rates and placement of activated charcoal vary for each herbicide.

Other antidotes are much more specific in their action in that they may only protect one crop from injury by one group of herbicides. For example, there are now commercially available antidotes which increase the tolerance of corn to the thiocarbamate herbicides. This allows the use of these chemicals at higher rates for control of problem weeds like yellow nutsedge without a loss in crop tolerance.

DIAGNOSIS OF HERBICIDE INJURY

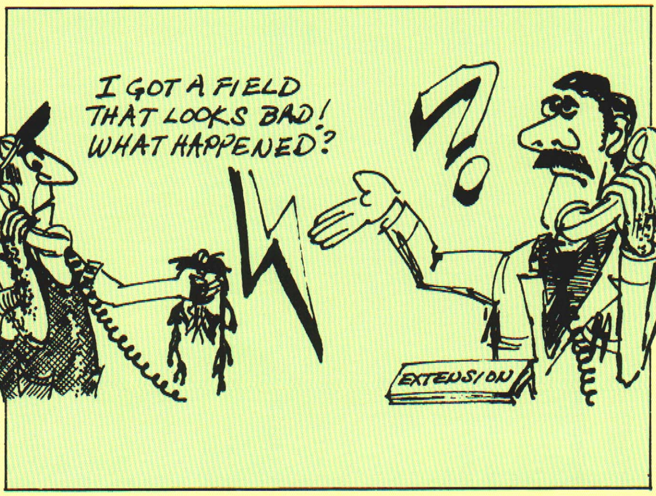
Time is critical

Growers should promptly report to state regulatory personnel any crop damage suspected of being caused by commercial applications. Accurate diagnosis of herbicide injury is often difficult if the investigator looks at dying plants out of context. For this reason, the investigator should actually view the injured field as soon as possible after damage is reported. It is usually impossible to ascertain the cause of damage on a plant sample that has been "yanked" or pulled out of the soil and which, more often than not, arrives in the office in a wilted, dried or rotted condition.

In some instances, residue analysis of plants or soils can help confirm the presence or absence of a suspected chemical. Samples should be taken as soon as possible after symptoms appear and placed in a freezer for storage. If possible, it is helpful to collect a check (non-treated) sample of plants or soil in an adjacent area where injury is not a problem. Whenever possible, document the injury symptoms and/or patterns with good color photographs.

Don't make snap judgements

As in the diagnosis of any ailment, it is important to gather all the evidence and information possible prior to making conclusions. One should spend a major share of the time asking questions, looking for patterns, checking equipment for accuracy of supposed application rates and collecting necessary samples. It may not be possible to make a firm diagnosis based on the initial visit.



What to ask; what to look for

Considering that herbicide injury occurs in a variety of ways such as spraying the wrong chemical, overdosing, calculation errors, drift, excessive soil residue, etc., the investigator should ask many key questions and look for distinct patterns. Some of the more important ones are as follows:

ASK

What herbicide used this year, last year?
How much chemical added per tank?
What other chemical used? When?
How much chemical used on how many acres?
When was sprayer last calibrated? GPA?
Nozzles, speed, and pressure used?
What were dates of planting, spraying, etc.?
What was the timing of the crop?
Had the crop started to emerge?
What were weather conditions before and after application?
What variety of crop?
Are soil tests available?
Was the seed treated?

LOOK FOR

Injury in bands
Injury the width of spray boom
Changes in injury with soil type or organic matter
Injury at ends of fields
Washing downhill
Drift patterns
Non-treated adjacent fields for comparison
Symptoms on susceptible weeds in the field
Obvious symptoms of insects, diseases, wind, hail, etc.
Faulty equipment
Poor agitation
Improper nozzles or spacings

An overdosing pattern can sometimes be readily recognized because it occurs on an area exactly the width of the applicator boom (Figure 1). Injury may also occur in distinct bands, particularly when a sensitive crop is planted after removal of a crop that was banded with a residual herbicide (Figure 2).

Watch out for look-alikes

Disease, nutrient deficiencies, insect damage, adverse weather conditions and other pesticides are some factors which can cause symptoms similar to those produced by herbicides. Therefore, an investigator needs as much information as possible about the history of the area that is showing symptoms before attempting to identify the cause of the injury.

- Symptoms associated with soil-borne diseases can resemble those caused by some of the preemergence herbicides. Both may show similar symptoms when the stems of young plants collapse at the soil line. Timing is very important in diagnosing this type of injury since secondary invaders (microorganisms) can mask the symptoms of the original cause of injury.
- Leaf abnormalities caused by many of the phenoxy compounds are often confused with plant diseases caused by viruses.
- Insects can cause leaf abnormalities by feeding on the foliage or transmitting disease organisms to the plant during the feeding process.
- Leaf abnormalities can also be associated with nutrient deficiency. Interveinal chlorosis caused by the triazine herbicides can often resemble manganese or iron deficiency. If soil test information is available the causal factor of this type of symptom may be easier to identify.
- Post plant applications of fertilizer may burn the foliage and result in symptoms similar to those caused by contact herbicides (Figure 3).
- Certain other pesticides and/or their carrier solvents can induce chlorosis or necrosis (Figure 4).
- Environmental conditions play a major role in modifying plant growth. Low winter temperature resulting in freeze injury as well as high temperature resulting in blast or burn-off can produce symptoms resembling herbicide injury. For example, the necrotic tissue on the upper portion of the plant in Figure 5 could be mistaken for herbicide injury. The necrotic areas were actually caused by freeze injury, and the lower part of the plant was protected from freezing by the snow cover. A close look at the foliage indicated that the only noticeable abnormality was leaf necrosis.
- The necrosis illustrated in Figure 6 is somewhat similar to that induced by freezing; however, other symptoms are present that are distinctly different. This injury was caused by foliar contact with the herbicide 2,4-D. The leaves are curled and twisted and show a varying dose response in different areas of the plant. These are typical symptom patterns that can give important clues to the cause of the injury.

If the majority of evidence implicates a herbicide as the cause of damage, the next step may be to identify the specific chemical that caused the injury. The understanding of general and specific symptoms caused by a herbicide or groups of herbicides is helpful to the person diagnosing a specific case. It is important to remember that some exceptions or irregularities may occur since injury symptoms can be altered by a number of factors such as environment, interactions and specific plant characteristics.

The following photographs portray a number of typical injury symptoms induced by misapplication of herbicides on a variety of plant species.

FIGURE 1 — Overdosing on carrots caused by improper agitation in the spray tank. Virtually all of the herbicide settled to the bottom and was sprayed out in the first pass through the field. A major clue is that the injured area corresponds to exactly one boom width. (Photo courtesy S. K. Ries)

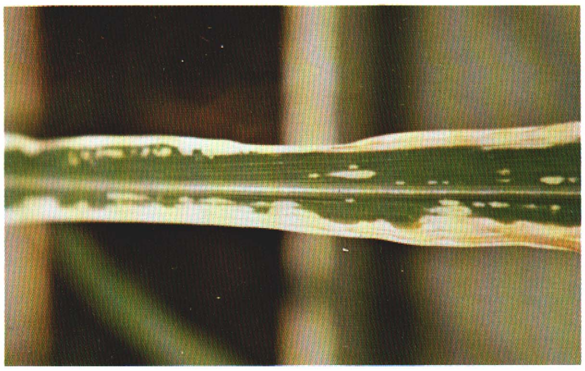


FIGURE 3 — Leaf scorch, or necrosis, on corn leaves caused by foliar contact with anhydrous ammonia, a commonly used nitrogen fertilizer for corn. Symptoms are similar to those caused by contact herbicides.

FIGURE 5 — Necrosis on this young yew plant was caused by a severe winter freeze. The basal area was protected from the cold temperature and severe wind by a snow cover.

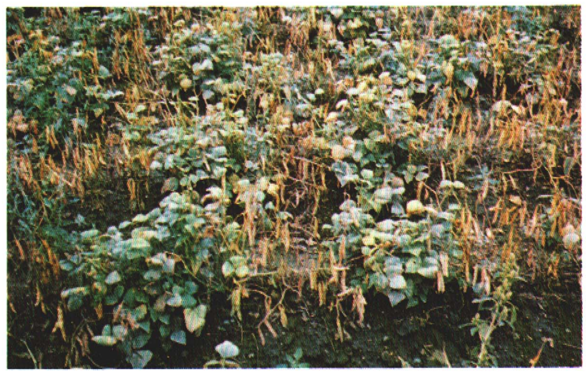


FIGURE 2 — Effect of an herbicide residue on growth and maturity of dry beans. Sugarbeets were planted early in the spring and band sprayed with pyramin and TCA. When the beets failed to make a satisfactory stand, beans were replanted with the rows running in the opposite direction. Note delayed maturity in the treated bands.

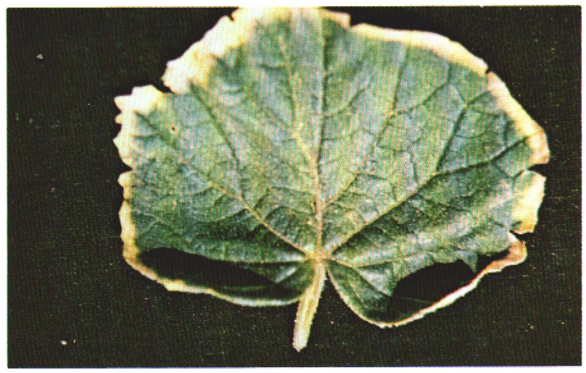
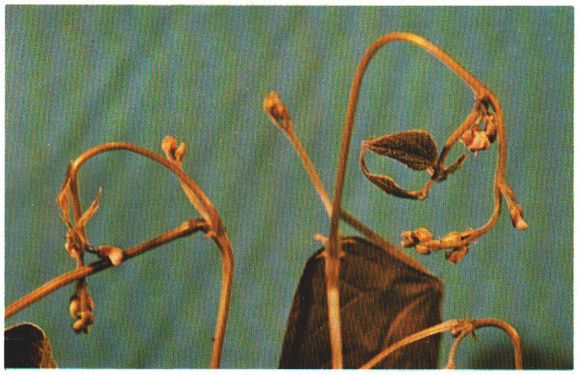


FIGURE 4 — Marginal chlorosis on cucumber leaves was caused by the insecticide, dieldrin, formerly used to control cucumber beetles. This is typical of symptoms that could be induced by a variety of herbicides. (Photo courtesy S. K. Ries)

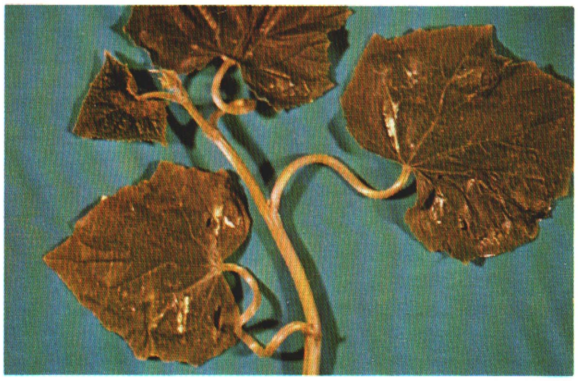
FIGURE 6 — Necrosis on this yew plant was caused by accidentally spraying the plant with 2,4-D used for turf weed control. Leaf areas receiving less contact show the typical curling and twisting which is indicative of 2,4-D injury. (Photo courtesy Harold Davidson)

FEATHERING OF LEAVES — These symptoms are typical of leaf malformations induced by translocated growth regulator herbicides. The symptoms on grapes were induced by contact on a terminal shoot with the herbicide, glyphosate (ROUNDUP). The shoot pictured is a lateral branch which developed behind the shoot that was destroyed. Similar leaf symptoms may be induced by drift of phenoxy herbicides like 2,4-D, Silvex and 2,4,5-T.

FIDDLENECKING — This pronounced symptom occurs in the young growing points of plants. The symptoms on potato were induced by drift with the herbicide, picloram (TORDON). An upward curling of older leaves is also obvious. Dicamba (BANVEL) has caused similar injury symptoms on other plant species.



EPINASTY — This term describes a bending and (usually twisting) that occurs in either the stems or petioles of plants. The bean plants have been exposed to very minute amounts of picloram (TORDON) drift. This plant response often occurs within a few hours after exposure.



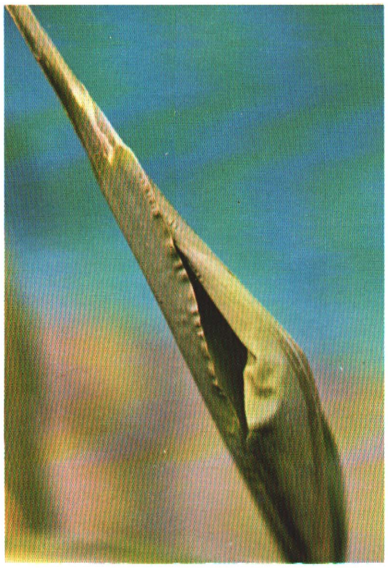
Epinasty can be induced by several herbicides. The symptoms on these cucumber petioles were induced by postemergence spraying with chloramben (AMIBEN), an herbicide in the benzoic acid class. Herbicides of the phenoxy group may also induce epinasty.

CUPPING OF LEAVES — A distinct cupping (usually upward) is typical of herbicides in the benzoic acid group. The cucumber injury depicted is caused by the chemical, dicamba (BANVEL). Loss of the leaf margin and/or an elongation of the leaf as well as cupping may occur on cucumber plants exposed to preemergence overdoses of chloramben methyl ester (VEGIBEN 2E), a closely related herbicide.

Injury symptoms on susceptible weeds may provide a clue to the cause of injury on crops. Common milkweed receiving a spray of dicamba (BANVEL) shows the typical upward leaf cupping that occurs on many crop plants.

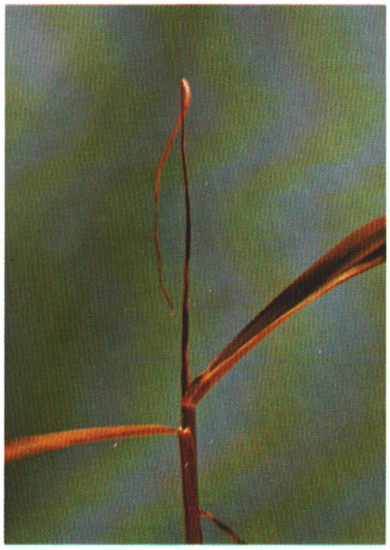
CRINKLING OF LEAVES — In the case of grasses like corn, the leaves fail to emerge from the sheath properly, and the plants remain in a stunted condition with twisted, crinkled leaves. This symptom was induced by an overdose of the herbicide, EPTC (EPTAM). Other thiocarbamates such as butylate (SUTAN) and vernolate (VERNAM) can cause similar symptoms if used improperly.

The crinkling and loss of a smooth margin on soybean leaves was induced by an overdose of the herbicide, alachlor (LASSO). This injury is usually more severe under cool, wet conditions. Injury of the magnitude depicted here is readily outgrown.



Leaf crinkling may also occur with overdoses of alachlor (LASSO) on corn. Leaves can fail to unroll properly and remain attached at the tips, causing a buckling in the center as they elongate.

CHLOROSIS — Chlorosis, or loss of chlorophyll in leaf tissue takes many varied patterns. Chlorosis, which initially occurs in the meristematic regions (growing points) of plants, is typical of the translocated herbicides, amitrole (WEEDAZOL) or amitrole-T (AMITROLE-T, CYTROL). In some plants the chlorotic areas may appear almost white or pinkish in color. Similar symptoms may be observed in broadleaved perennial plants a few days after application of glyphosate (ROUNDUP).



Tissue that initially appears chlorotic may subsequently die. Death of isolated tissues is generally described as **NECROSIS.** The young terminal leaf on this corn plant was killed with an overdose 'of cyanazine (BLADEX). Chlorosis is also visible on the older leaves. Plants which receive applications of herbicides mentioned in the above picture may also sequentially develop symptoms similar to those shown here.

The pattern which chlorosis takes is often useful in determining the nature of the causal agent. Yellowing in the veins of leaves is commonly called **VEINAL CHLOROSIS.** These cherry leaves display symptoms of terbacil (SINBAR) injury after excessive root uptake of the chemical. The symptoms are typical of those caused by the uracil group of herbicides.

Veinal chlorosis can also be induced by other herbicides. This grape leaf shows symptoms of an overdose of diuron (KARMEX) also occurring by root uptake. Several herbicides in the phenylurea group can cause similar symptoms. Injury to fruit crops from these residual herbicides is more apt to occur on younger plants and on sandy soils with a low organic matter content.

INTERVEINAL CHLOROSIS describes a yellowing of tissue between the veins of leaves. It is typical of injury caused by the triazine group of herbicides. The apricot leaves depict injury from atrazine (AATREX) which is considered too mobile in the soil for safe use under deciduous fruit trees.

Interveinal and marginal (around the leaf margin) chlorosis are common symptoms caused by an overdose of the herbicide simazine (PRINCEP) on ornamental plants. These pyracantha plants show typical symptoms. Perennial plants usually grow out of this condition as the herbicide dissipates. When new leaves appear green and healthy as they enlarge, the worst is generally past. (Photo courtesy S. K. Ries)

Chlorosis can also occur as a result of residue carryover in the soil. These melon leaves show symptoms caused by root uptake of simazine (PRINCEP) which has failed to dissipate after removal of a perennial crop. (Photo courtesy S. K. Ries)

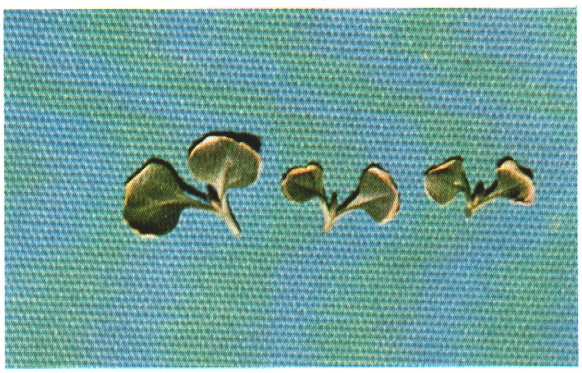
In some instances, chlorosis may be induced by foliar sprays of postemergence herbicides. Sugar beet leaves exposed to high doses of phenmedipham (BETANAL) may show chlorosis as depicted here. The injury is usually more pronounced toward the tip of the leaf.

Another postemergence herbicide, bentazon (BASAGRAN), can cause chlorosis perhaps best described as **MOTTLING.** Some areas of the leaf remain green, whereas others randomly become chlorotic and eventually necrotic. Injury occurs only on leaves that received contact with the spray, and new leaves which enlarge afterward appear normal.

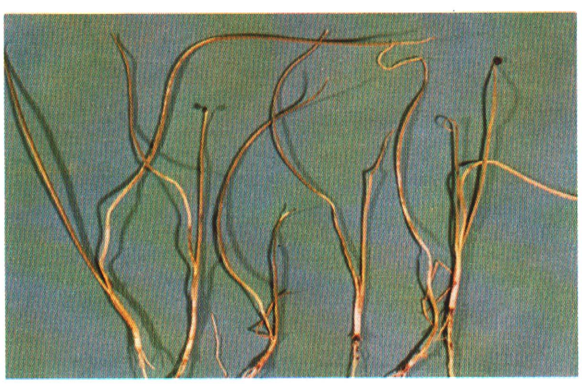
MARGINAL CHLOROSIS can occur in a narrow band almost entirely around the leaf margin. This is sometimes called a **HALO.** The symptoms were induced on these cherry leaves by an overdose of the herbicide, dichlobenil (CASORON) taken up by roots. In more severe cases (right leaf), the tissue becomes necrotic.

MARGINAL NECROSIS often develops first on the older leaves after they have exhibited a chlorotic condition. The potato plant has received an overdose of linuron (LOROX) applied prior to emergence. Problems of this nature are more severe on sandy soils that are low in organic matter.

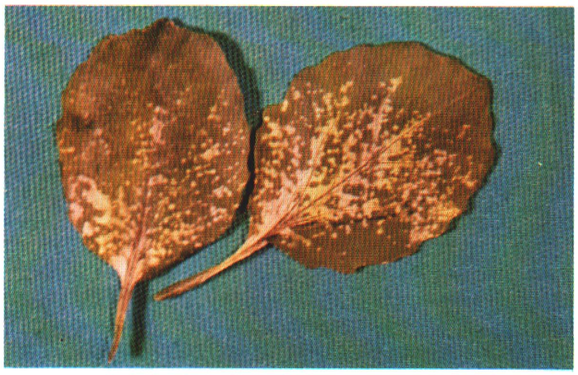
Marginal necrosis can also occur on plants receiving postemergence sprays. Tomato leaves may be injured by applying too much metribuzin (SENCOR, LEXONE) on plants that are too young and on certain of the more susceptible varieties. Environmental conditions also affect the toxicity of postemergence sprays.



Marginal necrosis will often occur on young seedlings that are sprayed with either preemergence or postemergence herbicides. The injury may be caused either by the herbicide itself or its carrier solvent. Most crop plants are at their most susceptible stage to herbicides at this delicate young age. The cabbage plants were injured with an overdose of CDEC (VEGADEX).



The onion plant is quite sensitive to a variety of postemergence herbicides until it has developed 3 to 4 true leaves. The onions shown here with only 1-2 leaves developed were 'burned' with an overdose of the herbicide nitrofen (TOK). Injury occurs as necrotic spots, or necrosis, in sections of the leaf that are several inches in length.



Necrosis can also occur in small spots scattered throughout the leaf. This type of injury is often called **FLECKING.** The cabbage leaves were injured with postemergence sprays of nitrofen (TOK). The emulsifiable concentrate formulation of the herbicide is more toxic than the wettable powder formulation; for this reason, only the latter formulaton is recommended for over-the-crop use.

VEINAL NECROSIS occured on these broccoli plants because the herbicide solution was repelled by wax on the leaves and gathered primarily in the regions over the veins. The herbicide, paraquat (PARAQUAT CL), drifted from an adjacent area onto these plants.

NECROSIS from contact herbicides can range from complete kill of tissue to isolated small spots, depending on the dosage. This injury on grapes occurred from Paraquat (PARAQUAT CL) on trailing canes that were hit by the spray. Some drift occurred and caused necrotic spots on leaves outside the spray pattern.

Tissues other than foliage also display herbicide injury symptoms. These grape canes and fruit clusters show necrosis from contact with paraquat (PARAQUAT CL). After injury occurred in the epidermis of the fruit, microorganisms invaded the fruit, causing rot. Young canes of grape and blueberry and shoots of tree fruits are susceptible to paraquat injury prior to the time bark is formed.

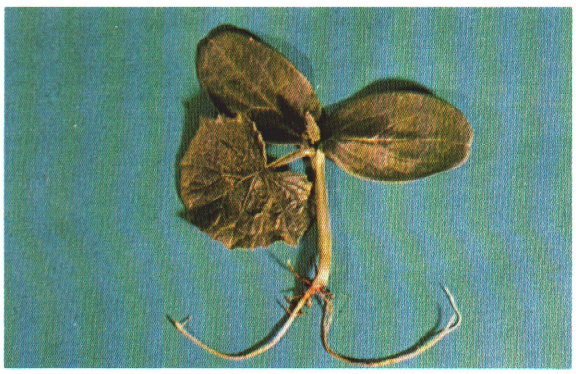
ROOT PRUNING — Examination of plant roots and stems can provide further clues to the cause of injury. Herbicides in the group called dinitroanilines are effective root inhibitors. The soybean plant on the right was exposed to an overdose of trifluralin (TREFLAN). The production of lateral roots is inhibited and those that do develop are thickened and short. These herbicides also cause a swelling in the area of the stem below the cotyledons (hypocotyl). The plants usually appear stunted with dark green leaves. Under dry soil conditions, they will wilt much sooner than those plants with healthy root systems.

Annual grass plants are very susceptible to the dinitroaniline compounds which is why these compounds are not used for crops that are grasses. The corn plant on the right was exposed to low concentrations of trifluralin (TREFLAN). Inhibition of root growth and failure of leaves to unroll properly are typical injury symptoms on grasses.

Inhibition of root growth can also be caused by herbicides in the thiocarbamate group. The bean plant on the right was injured by an overdose of EPTC (EPTAM). **HYPOCOTYL SWELLING** also is a symptom of chemicals in that group. Injury depicted on this page is more apt to occur under cool, wet conditions where crop plants are under stress.

STUNTING is usually an obvious symptom whenever severe root inhibition occurs. It is a typical symptom where overdoses of carbamate, amide and dinitroaniline herbicides occur. The cabbage plant on the right was injured by an overdose of alachlor (LASSO). Seeded cabbage has only marginal tolerance to this herbicide, whereas transplants have excellent tolerance.

STEM CRACKING and root inhibition are symptoms typical of injury with DCPA (DACTHAL). On these oat plants, the cracking is evident through the leaf sheath just above the soil line. On broad leaved crops, such as cucumber, the stems become cracked with callus formation occurring near the soil level. The stems are often brittle and may break off in heavy winds.



NEGATIVE GEOTROPISM — This is a condition where roots lose their orientation and grow upward instead of downward. The condition is induced by the herbicide, naptalam (ALANAP). Foliar symptoms observed with overdosing of this chemical are primarily stunting.

ABNORMAL BRACE ROOTS in corn resulted from postemergence application of dicamba (BANVEL). Corn which is too large when treated with this herbicide may lodge. Oils or surfactants may aggravate the problem.

Table 1. — Herbicides Cited in this Bulletin

Class	*Common Name*	*Trade Names*
Acetanilides	alachlor	LASSO
Benzoic acids	chloramben	AMIBEN, VEGIBEN
	dicamba	BANVEL
Benzonitriles	dichlobenil	CASORON
Bipyridinium salts	paraquat	PARAQUAT CL
Dinitroanilines	trifluralin	TREFLAN
Phenoxyacids	2,4-D	Several
	2,4,5-T	Several
	silvex	KURON, WEEDONE 2,4,5-TP
Phenylethers	nitrofen	TOK
Phenylureas	diuron	KARMEX
	linuron	LOROX
Thiocarbamates	butylate	SUTAN
	CDEC	VEGADEX
	EPTC	EPTAM
	vernolate	VERNAM
Triazines	atrazine	AATREX
	cyanazine	BLADEX
	metribuzin	LEXONE, SENCOR
	simazine	PRINCEP
Triazoles	amitrole	WEEDAZOL
	mamitrole-T	AMITROL-T, CYTROL
Miscellaneous	bentazon	BASAGRAN
	DCPA	DACTHAL
	glyphosate	ROUNDUP
	naptalam	ALANAP
	phenmedipham	BETANAL
	picloram	TORDON

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