

A World without Roundup (Glyphosate)

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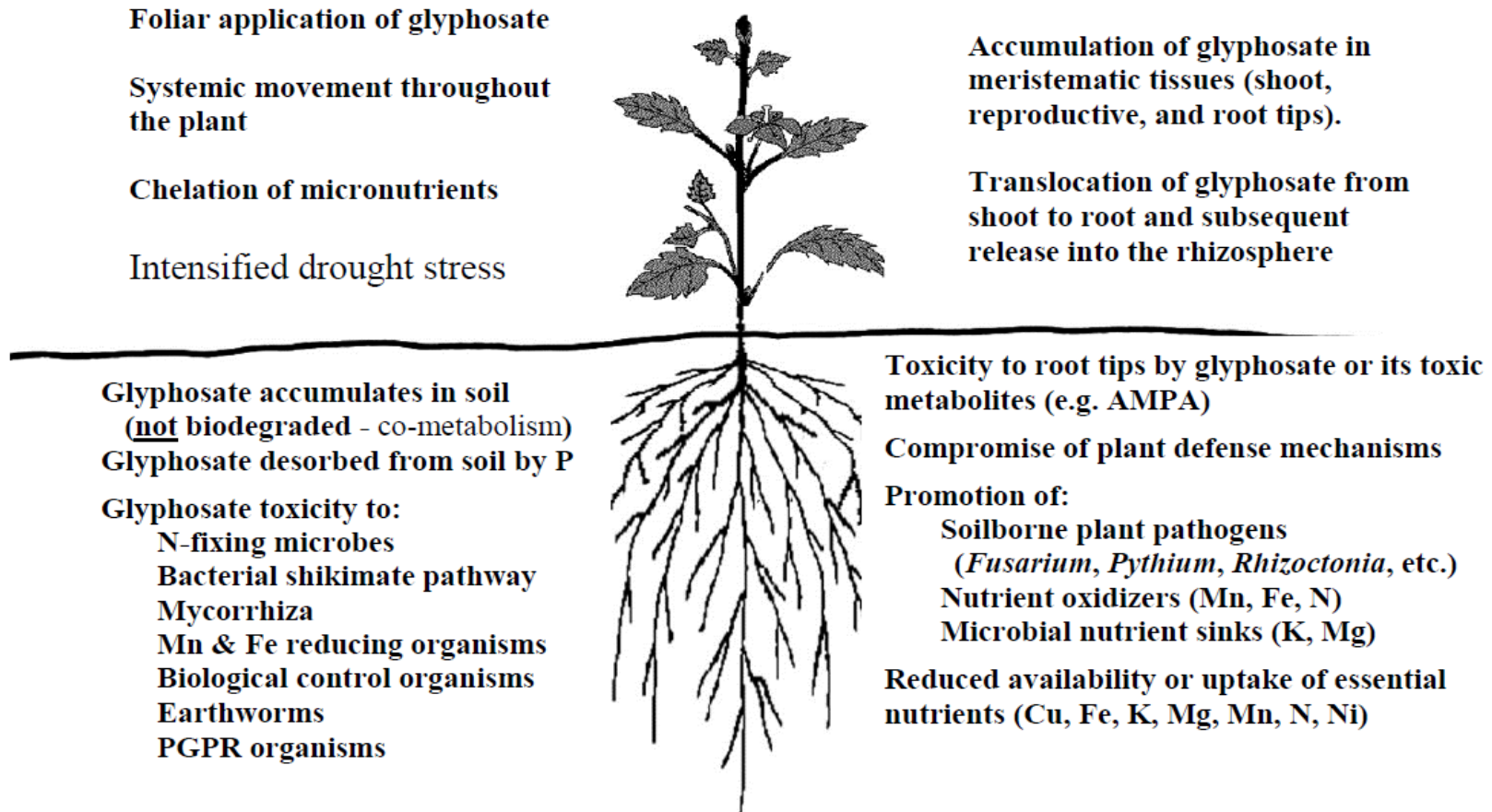
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Glyphosate Impacts



Schematic of glyphosate interactions in soil

Major Plant Issues with Glyphosate

- Chelates Nutrients (Iron, Manganese, Zinc, Copper, Calcium, Magnesium, Nickel). All Plant available nutrients with a 2+ valence.
- Reduces uptake up Nitrogen and Potassium.
- Even in GMO crops with Roundup ready gene, it accumulates glyphosate in the meristematic tissue (roots, leaf tips, reproductive tissue).
- Translocation of glyphosate from shoot to root and releases in the rhizosphere.
- Toxicity to root tips and its metabolites (AMPA).
- Reduces plant defense mechanisms. (Ties up Zinc)

Major Disease Issues with Glyphosate

- Increases Disease organisms (Fusarium, Pythium, Rhizoctonia, Sclerotinia, Sudden Death Syndrome, Soybean Cyst Nematode, Charcoal Stem Rot etc.
- Changes the soil microbial community. Promotes soil oxidizers rather than soil reducers. Soil reducers make nutrients plant available.
- After Roundup (Glyphosate) is applied, it can take 6 weeks for soil to return to normal microbial levels needed for optimum nutrient uptake.
- Enhances drought and temperature stress. Also enhances cold stress.
- Less nutrients available (Iron, Manganese, Zinc, Copper, Calcium, Magnesium, Nickel, Cobalt. Also, Potassium and Nitrogen).

Changes to Soil Microbes

- Harmful effects to Nitrogen fixing microbes (Rhizobium) but also free-living nitrogen microbes that produce 20-100# of free N in soil.
- Harmful to Pseudomonas Bacteria involved in Rhizophagy responsible for 40-60% of plant nitrogen.
- Reduces AMF (arbuscular mycorrhizae fungi).
- Harmful to earthworms
- Harmful to PGPR organisms (plant growth promoting rhizobacteria) that produce hormones and soluble nutrients for plant growth.

Effects the Shikimate Pathway in Microbes

Shikimate Pathway: A seven-step metabolic pathway used in bacteria, fungi, algae, some protozoa, archaea, and plants. Involved in the biosynthesis (making) of amino acids (tryptophan, phenylalanine, and tyrosine and folates.

Folates: Vitamin B9 needed to make DNA.

Good NEWS: Does not affect mammals.

However: It potentially changes and affects the microbes in the human gut: Ex: Gluten Free Illness. Skyrocketed about 20-30 years ago with the increased use of Glyphosate.

Human Diseases Enhanced by Glyphosate

Glyphosate does not have a primary effect on human disease, it has a secondary effect. Not a direct cause, just enhances the disease.

Human diseases: Gluten Free, Autism, Chron's Disease, Lupus, chronic fatigue syndrome, diabetes, Alzheimer's, Parkinson, infant mortality, depression, dementia, liver, kidney, cancer?? May even substitute in our genes (DNA).

May not be the glyphosate that causes the most damage in humans. May be the other chemicals and additives (stickers, surfactants, etc.) that cause the most harm. Not well studied.

Roundup or glyphosate drift may travel 4 miles. With 280 million pounds used in the USA, almost all food (even organic) holds some trace amount of glyphosate.

How Glyphosate Degrades

Roundup is like an eight-legged octopus. Each leg has multiple suction cups (metabolites). You can cut the head off an octopus and separate the legs. You can even chop up the legs, but until the suction cups (metabolites) are destroyed, it still has an effect on the soil microbes and metabolic pathways.



How Glyphosate Degrades

- Both Calcium and Phosphorus help in the degradation of glyphosate. Binds tightly to clay & SOM in the soil. Also binds to soil metal oxides.
- The problem is that yes it starts to degrade in 30-60 days, but the metabolites of the degradation can last for a long time in the soil. For up to 748 days in one study with 59% still remaining.

Soybean Mystery Disease (s)



Soybean Mystery Disease (s)

Main Points

- 1) Symptoms noticeable by August 1st**
- 2) Starts at bottom, Yellow halos, yellow leaves, Manganese deficiency (dark green veins), loss of leaves and pods.**
- 3) By August 10th, top of soybean plant thins out, loss of leaves and pods.**
- 4) Always see upright trifoliate leaf. Looks like soybean is giving you the middle finger!**

Soybean Mystery Disease (s)



Soybean Mystery Disease (s)

Main Points

- 1) Looks like Charcoal Stem root, Soybean Cyst Nematode (SCN), Sudden Death Syndrome (SDS), Septoria stem rot.**
- 2) Symptoms are worse during dry conditions (drought).**
- 3) Yield loss can be 10-50 bushels.**
- 4) Seems to be worse on Conventional soybeans.**

Soybean Mystery Disease (s)



Soybean Mystery Disease (s)

Main Points

- 1) Starts about August 1st. Worse in dry years. Leaves at bottom show symptoms MN deficiency, Septoria then leaves fall off and lose pods**
- 2) About August 10th, tops thin out like Charlie Brown Xmas tree, lose leaves and pods.**
- 3) Noticeable symptom: Small leaves (Ca deficiency), upright leaf (middle finger) on top trifoliate leaf.**

Issues with Glyphosate

- 1) Glyphosate chelates major nutrients:
Fe²⁺, Mg²⁺, Mn²⁺, Ca²⁺, Zn²⁺, Cu²⁺,
Ni²⁺, Co²⁺**
- 2) Glyphosate enhances drought symptoms.**
- 3) Glyphosate makes these diseases worse:
Charcoal Stem rot, SDS, SCN, Septoria,
Fusarium, Phytophthora, Rhizoctonia,
Pythium, Sclerotinia.**
- 3) Glyphosate changes microbial
composition, increases oxidizers, decreases
reducing bacteria for six weeks. Reducing
bacteria make plant available nutrients.**

Resistant Weed Species

December 2022, 515 “unique weed resistance species” resistant to at least one herbicide (in 267 species), only ten cases in 1974.

100 species are resistant to two herbicide modes of action

More than 50 species are resistant to three modes of action.

Weeds have evolved resistance to 21 of the 31 known herbicide modes of action, 165 different herbicides.

Glyphosate-resistant weed species = 56.

Glyphosate resistance weeds: water hemp, marestail, palmer amaranth, horse weed, Italian rye grass, giant and common ragweed, Johnson grass, etc.



Fighting Weed Resistance

- The movement of farm equipment (combines, feed equipment) appears to be a major way resistant weed seed is spread.
- Cleaning tillage and harvest equipment when moving between fields may reduce the movement of weed seeds and slow the spread of resistant populations.
- Rotate chemical modes of action
- Weed management practices like reducing crops resistant to other herbicide modes of action such as glufosinate, HPPD inhibitors, and synthetic auxins (2,4-D and dicamba) offer additional tools to manage glyphosate-resistant weeds.

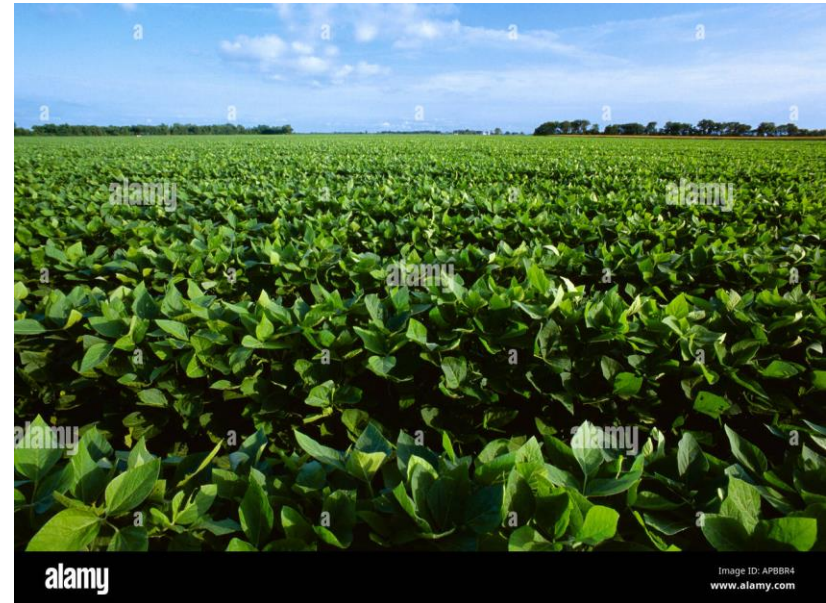
Natural Alternatives to Glyphosate

Fight weeds Biologically!

Cultural: Row spacing, fast canopy, kill weeds early.

Crop Rotation: Early planting for fast crop growth, fast canopy to block the sun.

Shorter crop maturity, fast harvest, plant cover crops to reduce weeds and weed growth. Allelopathic cover Crops: radish, cereal rye, wheat, oats, sorghum, Buckwheat, sunflower



Natural Alternatives to Roundup (Glyphosate)

Physical barriers: mulches, plastic or mechanical weed barriers, etc.

Mechanical ways: cultivators, electric weed zappers, drones or small robots that either spray, zap, or physically remove weeds.

Crimper Crop Rollers to terminate cover crops.



Cover Crops Reduce Weed Populations Naturally!

Cover crops: cereal rye, barley, wheat, sorghum, oats.

Brassicas (radish, rape, kale)

Buckwheat, sunflower, and even alfalfa and red clover contain natural chemicals that reduce weed growth.

Allelopathic or negative effect on weed growth.

Some suppress weed germination; others suppress weed growth.

Cover crops compete with weeds for sunlight, water, nutrients to reduce weed growth and weed seed.



Chemical Alternatives to Roundup (Glyphosate)

Burndown Chemicals:

Sharpen (saflufenacil) on soybeans

Burns down small growing broadleaf weeds: marestail, pigweed, and horseweed.

Fast acting but is not as good on grassy weeds.

Glyphosate is really good on most grass weeds, so often two (glyphosate + Sharpen) were combined.



Chemical Alternatives to Roundup (Glyphosate)

Burn down chemicals:

2-4D Ester on soybeans

Burndown to control broadleaves, especially marestail.

2-4D may drift and cause damage to other crops.

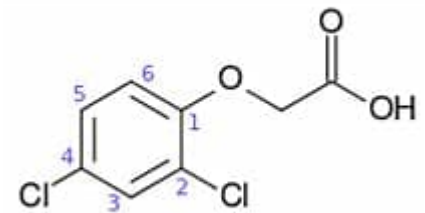
Toxic to fish and aquatic invertebrates.

Pre-Plant

Wait Period: 7-14 days to plant.

Rainfall often shortens the waiting time.

Always follow the label.



Chemical Alternatives to Roundup (Glyphosate)

Burndown Chemicals:

Atrazine: restricted use corn herbicide

Atrazine used as a burndown to kill small broadleaves plus some grasses.

Residual soil activity (long lasting) but has some environmental concerns regarding groundwater contamination.

Princep: Another burndown triazine herbicide. Good on popcorn. Beneficial to AMF fungi. 2X more \$\$\$.



Chemical Alternatives to Roundup (Glyphosate)

Burn down chemicals:

Gramoxone (paraquat): nasty restricted use chemical, highly effective at killing almost all vegetation. It's a desiccant (absorbs moisture) and hard on plants, equipment, and people. Avoid contact.

Burns all top growth immediately but does not hurt the roots.

Good on Palmer Amaranth and barnyard grass

Zero residual activity

Best applied in warm sunny conditions. It can be used as a quick burndown before planting most crops

Chemical Alternatives to Roundup (Glyphosate)

Burn down chemicals:

Zidua (Pyroxsulfone) for corn and soybeans.

Long lasting residual control.

Controls Palmer amaranth and water hemp effectively.

Needs soil incorporation adequate rainfall (.5 inches) or soil moisture to kill emerging weeds.

Problem: Expensive (at least \$8-\$16 per acre)

Timing is critical.

Prices vary.



Chemical Alternatives to Roundup (Glyphosate)

Burn down chemicals:

**Anthem Maxx/Flex (Pyroxsulfone + Fluthiacet-methyl)
For corn and soybeans.**

Minimum of 10-40gallons of water for dense vegetation.

Used to control resistant glyphosate ALS resistant weeds.

Good on Palmer amaranth, water hemp, and many other weeds as long as the weeds are small.

May cause some crop injury if used at high rates.

Chemical Alternatives to Roundup (Glyphosate)

Burn down chemicals:

Avoid Liberty (glufosinate) as burndown. Controls wide variety of weeds post emergence but requires good growing conditions (warm, sunny days and fast good growing conditions to work effectively).

Surtain (Saflufenacil + Pyroxasulfone) on corn

Long residual activity but is not considered a burndown. It is applied 3 weeks before planting and is good on water hemp and grasses.

More \$\$\$.

Chemical Alternatives to Roundup (Glyphosate)

Other chemicals to control grasses:

Metribuzin: Sencor, Valent, Glory, Matador, Boundary, Tricor, Lexone, etc. are group 5 herbicides.

Inhibits photosynthetic activity for corn and some soybeans varieties. Crop injury may occur with Metribuzin sometimes.

Dual Magnum (Metolachlor) pre-plant or post.

Select (clethodim) post to control annual grasses in corn and soybeans. Select Max is designed for use with glyphosate only, use regular Select if not using glyphosate.

Chemical Alternatives to Roundup (Glyphosate)

Chemicals to control grasses:

**Sharpen does not control grasses but Select does:
Sharpen + Select possible use as burndown in spring.**

Corn: 3 oz Sharpen (residual effect) + Select

**Soybeans: 1.5 oz (14-day restriction, small residual) + Select
for early small weeds. Select poor on large grass weeds.
Grass cover crops have to be killed early.**

**Minimum of 15 gallons water needed for Sharpen. Need 1
pint of MSO/A plus AMS 8.5-17#/Acre.**

Other Alternatives to Roundup (Glyphosate)

**Commercial Grade Vinegar: 20% Acetic Acid
(regular vinegar is 5%). Melts leaf waxy layer.
Variable results.**

**Citron: Enhances Glyphosate so you can lower the
rate. AMS lowers pH=0.5, Citron lowers pH by 2-3
units (pH = 2 to 4)**

**Ionic Water: No surface tension, H⁺ , OH⁻
Not on herbicide label. Use 1/10 as much
glyphosate for same kill rate. **Not on label!!!****

Alternatives to Glyphosate

European Alternative: Slasher or Scythe (common name) or Pelargonic Acid (comes from thistles) or nonanoic acid. Weed killer and blossom thinner. From planting time till harvest. No residual, contact herbicide. Not harmful to humans at low rates but is a skin and eye irritant. Breaks down fast. No or little environmental concerns.

Also used to thin apple and pear blossoms.

Companies: Enforcer, Mycogen, West Agro

Slasher (Pelargonic Acid)

1) Expensive in small quantities

2) Cheaper but still \$\$ if purchased in larger quantities. Half-life is 1.6 days. Clear liquid, rancid odor! Insoluble in water, soluble in organic solvents. Typically need 10 lbs/Acre as burndown

Size	Price/kg (lbs)	Price for 10 pound/Acre	Also need organic solvent
1 kg (2.2#)	\$198 (\$90/lb)	\$900/Acre	Varies
5kg (11 #)	\$48 (\$21.82/lb)	\$218.20/Acre	Varies
10 kg (22#)	\$28 (\$12.72/lb)	\$127.20/Acre	Varies
50kg (110#)	\$22 (\$10/lb)	\$100/Acre	Varies
190 kg (418#)	\$16 (\$7.27/lb)	\$72.70/Acre	Varies

Scythe (Pelargonic Acid)

- 1) Scythe cost \$200 for 2.5 gallons or \$80 per gallon.**
- 2) One gallon holds 128 fluid ounces (oz).**
- 3) Rate: Need a minimum of 13 oz per 10 gallons of water @\$\$.625/oz or \$8.125 per 10 gallons.**
- 4) Rates vary per acre for size of weeds.**
- 5) At 30 gallons/Acre = \$24.375/acre.**
- 6) Larger weeds or cover crops require more herbicide. Best to kill cover crops early if using Scythe as a burndown.**

Future Alternatives to Roundup (Glyphosate)

**HarpeBio: Organic herbicide being developed
Has three (3) modes of action.**

Developed in North Carolina.

**Do not know cost,
etc. Is being researched.**

**Working on GMO varieties to
insert gene into corn, wheat,
soybeans, etc. to make
resistant to Harpe**



Future Alternatives to Glyphosate

HarpeBio Mode of Action: Organic herbicide

Has three (3) modes of action.

Weakens a weed's capacity to hold or absorb water

Causes weeds to quickly wilt.

- Impacts the weed's photosynthesis and energy creation**
- This sets off the release and cascade of reactive oxygen species, ions and free radicals, which degrade cell membranes, compromising the weed plant or seed, resulting in death.**

Not harmful to humans!

HARPE Herbicide

Active ingredients in Harpe BioHerbicide have all been determined by EPA to be minimum risk pesticides and pose little to no risk to human health or the environment. Natural Harpe BioHerbicide formulations are exempted from further EPA review.

Derived from plant extracts including Mentha (mint). Found in mouthwash, toothpaste, gum, as well as for medicinal purposes. One of the key compounds is even used to target varroa mites that impact bee and pollinator health.

HarpeBio application rate and cost

Minimal Target Release is 2026! Expect 2027 or later for agricultural release.

Daniel Pepitone: Daniel@harpebio.com

Bill Buskner, CEO & Director; Dr. Chad Brommer, Kip E. Tom; Dr. Robb Fraley; Rick Kjellberg; Adam Connolly; Stephen Powles; Adrian Percy, Wesley Everman located at Raleigh, North Carolina

Harpebio.com ADM is a major investor

HARPE Bio: Need about 20-29.2 fluid oz HarpeBio per 40 gallons of water per acre.

Cost: ????

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