

Laboratory

Herbicide Symptomology and Surfactant Technology

Note: This lab will be used to review herbicide symptomology and surfactant technology and will be used in conjunction with the *Herbicide Symptomology Experiment* conducted in the greenhouse.

I. Herbicide Symptomology

A. Phenoxys: 2,4-D (Weedar 64[®], Weedone LV4[®], MCPA, 2,4-DB (Butoxone[®], Butyrac[®])

- (1) Used primarily in grass crops such as corn, small grains, sorghum, rice, sugarcane, pasture, and turf
- (2) Mimics auxin, a growth hormone
- (3) Controls most broadleaf weeds
- (4) 2,4-D was the first herbicide synthesized (Pokorney, 1940's)
- (5) Primarily post applied, but some soil activity occurs
- (6) Grasses can be injured if applied at reproductive stages:
 - (a) Tiller and boot stages in small grains
 - (b) Tassel to dough stage in corn and sorghum
 - (c) After green ring (panicle initiation) stage in rice
 - (d) Do not apply phenoxies within 4-6 weeks prior to planting sugarcane stalks
- (7) Epinastic injury may be seen within hours after application, but die back may take more than 14 days
- (8) Apoplastic and symplastic translocation
- (9) Phenoxys are acid herbicides. They will dissociate to form a negatively charged ion in soils (proton donor) – it will not adsorb to soil colloids readily.

Phenoxy Symptoms: What did you observe?

B. Amino Acid Derivatives: glyphosate (Roundup Ultra[®], Rodeo[®], Touchdown[®], and others)

- (1) Symplastic translocation
- (2) Non-selective. Inhibits EPSP synthase causing a disruption in the shikimic acid pathway (phenylalanine, tryptohan, tyrosine). Also inhibits δ -amino-levulinic acid pathway, which is necessary for porphyrin ring synthesis (chlorophyll, cytochromes, peroxidases, etc.).
- (3) Very little soil activity. Rapidly reacts with soil. Microbes will degrade glyphosate within 60 days.
- (4) Very safe and effective, but somewhat slow acting

Amino Acid Derivative Symptoms: What did you observe?

C. Bipyridyliums: paraquat (Gramoxone Extra[®], Boa[®]), diquat (Weedtrine[®], Diquat[®])

- (1) Acts as an electron *diverter* at photosystem I. Excess electrons causes lipid peroxidation.
- (2) A contact herbicide. Very minimal translocation may occur, but herbicide molecules stop at the wall of the xylem.
- (3) Exist in cationic form. Lacks soil activity.
- (4) Very non-selective. High mammalian toxicity, except when diluted in water bodies for aquatic weed control.
- (5) Quickness of membrane disruption is dependent on *rate of photosynthesis*, not light levels.
- (6) Will only cause ‘top kill’ of perennial plants. Used as a burndown treatment.

Bipyridilium Symptoms: What did you observe?

D. Triazines: atrazine (Aatrex[®], Atrazine[®]), cyanazine (Bladex[®]), metribuzin (Sencor[®])

- (1) Used for selective preemergence and postemergence control of selected seedling grasses and (most commonly) broadleaf weeds.
- (2) Selectivity is based on differential rates of detoxification of the herbicide between plant species.
- (3) Primarily moves in the apoplast. Root absorption is usually most effective. Will remain in the leaves if foliar applied.
- (4) *Inhibits* electron transport at photosystem II. Binds to the protein at the Q_b binding site on the D1 thylakoid protein.
- (5) Triazines are basic herbicides. They readily accept protons in low pH soils to become positively charged.

Triazine Symptoms: What did you observe?

E. Sulfonylureas: chlorimuron-ethyl (Classic[®]), nicosulfuron (Accent[®]), halosulfuron (Permit[®], Sempra[®], Manage[®])

- (1) Inhibits the enzyme acetolactate synthase (ALS), also called acetohydroxyacid synthase (AHAS). These enzymes are involved in the first step in the synthesis of the essential amino acids valine, leucine, and isoleucine.
- (2) Apoplastic and symplastic translocation. Absorbed by roots and shoots.
- (3) Selectivity based on differential rates of detoxification between labeled crops and susceptible weeds.
- (4) Used at very low rates.
- (5) Controls broadleaf weeds and some grasses and sedges. Absorbed by roots and foliage.

Sulfonylurea Symptoms: What did you observe?

F. Diphenyl ethers: fomesafen (Reflex[®], Flexstar[®]), acifluorfen (Blazer[®]), lactofen (Cobra[®]), oxyfluorfen (Goal[®])

- (1) Used for selective broadleaf weed control.
- (2) Inhibits protoporphyrinogen oxidase (PPOase).
- (3) *Light dependent*, fast-acting, contact, photobleaching herbicides.
- (4) Very little translocation once it enters the leaf or root.
- (5) Tolerance is based on differential metabolism between tolerant crops and susceptible weeds.
- (6) Strongly adsorbed to soil colloids. Very little leaching occurs.
- (7) Low mammalian toxicity

Diphenyl-ether Symptoms: What did you observe?

G. Imidazolinones: imazaquin (Image[®], Scepter[®]), imazethapyr (Pursuit[®]), imazapyr (Arsenal[®])

- (1) Controls grass and broadleaf weeds in certain crops and warm season turfgrasses
- (2) Inhibits ALS and AHAS, similar to the sulfonylureas.
- (3) Absorbed by roots and foliage.

Imidazolinone Symptoms: What did you observe?

H. Aryloxyphenoxy-propionates and Cyclohexanediones: fluazifop (Fusilade DX[®]), quizalofop (Assure II[®]), sethoxydim (Poast[®], Poast Plus[®])

- (1) Selective postemergence control of annual and perennial grasses in broadleaf crops
- (2) Inhibits lipid biosynthesis in grasses. Acts on the acetyl-CoA enzyme (ACCase) in the stroma of plastids.
- (3) Translocated rapidly in the symplast, where it concentrates in the meristematic regions.
- (4) Broadleaves are unaffected since they are able to produce a graminicide tolerant ACCase. A few grasses can do this as well.
- (5) Wheat is an exception. It is tolerant because it can rapidly detoxify the herbicide.

Aryloxyphenoxy and Cyclohexanedione Symptoms: What did you observe?

I. Acid Amides: metolachlor (Dual II[®]), alachlor (Lasso[®]), dimethenamid (Frontier[®]), propanil (Stam[®])

- (1) A very diverse herbicide family; metolachlor, alachlor, and dimethenamid are soil applied and propanil foliar applied.
- (2) Primary mode of action is not known for the soil applied herbicides.
- (3) Lipid biosynthesis and synthesis of proteins, gibberillins, lignin, and anthocyanin. Inhibits electron transport at photosystem II.
- (4) The soil applied herbicides control grasses and small seeded broadleaves in grass and broadleaf crops.
- (5) Propanil controls selected annual grasses and broadleaf weeds in rice and has no preemergence activity.

Propanil Symptoms: What did you observe?

J. Dinitroanilines: trifluralin (Treflan[®], Tri-4[®], Trilin[®], etc.), prodiamine (Barricade[®]), pendimethalin (Prowl[®], Pentagon[®])

- (1) Control grasses and small seeded broadleaf weeds preemergence in grass and broadleaf crops.
- (2) Inhibit mitosis (cell division) of roots and shoots in meristems.
- (3) Herbicides are not translocated following root or shoot absorption.
- (4) Herbicide placement that avoids contact with roots of desired plants is the primary factor in plant selectivity.
- (5) Herbicides in this family are volatile and subject to photodecomposition, requiring that some be incorporated.

Dinitroaniline Symptoms: What did you observe?

K. Thiocarbamates/Carbamothioates: EPTC (Eptam[®], Eradicane[®]), thiobencarb (Bolero[®]), vernolate (Vernam[®]), metham (Vapam[®])

- (1) Control grasses and broadleaf weeds, and purple and yellow nutsedge preemergence in grass and broadleaf crops.
- (2) Inhibit lipid formation by interfering with biosynthesis of surface lipids (waxes, cutin, and suberin)
- (3) Herbicides are rapidly absorbed by roots and shoots and translocated upward in apoplast. Limited translocation from postemergence application.
- (4) Herbicide placement and rapid metabolism by tolerant plants account for differences in selectivity.
- (5) Herbicides are highly volatile and readily lost from surface of moist soils. Some herbicides require incorporation.

Carbamothioate Symptoms: What did you observe?

L. Bentazon: bentazon (Basagran[®])

- (1) Postemergence control of broadleaf weeds and yellow nutsedge in certain grass and broadleaf crops
- (2) Inhibits photosynthesis by blocking electron transport at PSII.
- (3) Almost entirely translocated in the apoplast.
- (4) Selectivity based on detoxification rates of plants.
- (5) Much less effective on purple nutsedge than yellow nutsedge.

Bentazon Symptoms: What did you observe?**M. Bleaching Herbicides:** clomazone (Command[®]), norflurazon (Zorial[®])

- (1) Both herbicides are primarily used preemergence, but some post activity does occur.
- (2) Both are apoplastically translocated. Therefore, the symptoms will appear in the leaves when absorbed by the roots.
- (3) The herbicides differ in their water solubility. Clomazone rapidly diffuses out of the veins into the interveinal spaces of the leaf (*interveinal* chlorosis). Norflurazon tends to remain in the veins, causing *intraveinal* chlorosis (within the veins). This is usually only evident when the herbicides are applied as preemergence. Foliar applications may show only a general whitening of the leaf.
- (4) The bleaching herbicides inhibit carotenoid or carotenoid/chlorophyll synthesis in the leaf. Carotenoids protect chlorophyll from photodegradation. The result is a bright-white, bleaching effect on the leaves rather than a yellowing caused by inhibitors of PSII.
- (5) The specific mechanism responsible for selectivity of these herbicides is not known.

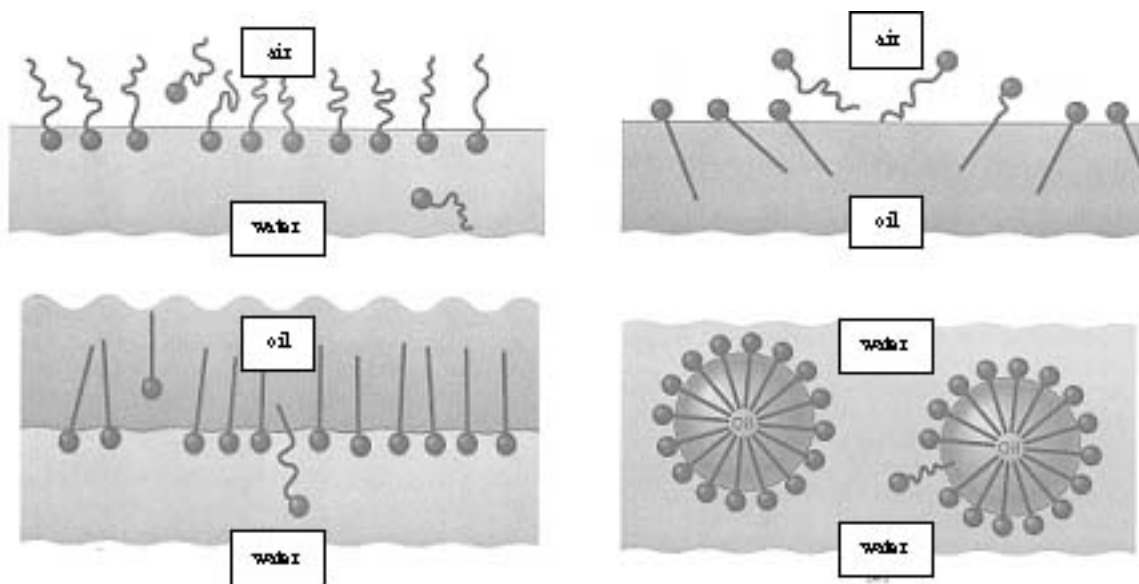
Clomazone and Norflurazon Symptoms: What did you observe?

II. Surfactant Technology

Adjuvant: any substance used with a herbicide that enhances the performance or handling of a herbicide. They are based on their use rather than their class of chemistry.

(1) Surfactants: materials that favor or improve the emulsifying, dispersing, spreading, wetting, or other surface modifying properties of liquids.

- (a) Emulsifiers: Promote the suspension of one liquid in another. Usually used for dispersing oil in water. Act by orienting themselves between the oil and the water interfaces and linking the two. This prevents the oil from combining to form larger droplets that would otherwise separate from the water carrier.
- (b) Wetting Agents: Reduces surface tension that would normally repel one another. Adding a wetting agent to an aqueous spray solution allows the spray droplet to spread and make better contact with the waxy, lipophilic cuticle.



- (a) *Figure 1. The surfactant action of soaps. The circular 'heads' are hydrophilic while the 'tails' are lipophilic. This allows oil and water to be compatible at their interface. (a) The heads are soluble in water. (b) In oils, the reverse is true. The tails will dissolve readily in the oil suspension. (c) At an oil/water interface, the heads orient themselves in the aqueous solution while the tails orient themselves in the oil solution. (d) Adding oil droplets into a soap solution causes the soap molecules to surround the oil droplet. The hydrophilic heads aid in the emulsion of the oil in the hydrophilic solution.*

- (c) Stickers: Adjuvants that cause the herbicide to adhere or "stick" to the plant surfaces. They reduce spray runoff and wash-off by rain. Many commercial products combine stickers with wetting agents, often called 'spreader-stickers'.

(2) Antifoaming Agents: Reduces foaming in a sprayer system so that pumps and nozzles can function properly.

(3) Compatibility Agents: Used to aid in the suspension of herbicides when they are combined in tank mixes with other pesticides or fertilizers that may normally cause problems with compatibility.

(4) Crop Oils: Non-phytotoxic oils that also contain surfactants to aid in their mixing in water. These materials are added to herbicide solutions to enhance their effectiveness in penetrating the cuticle layer of foliage.

(5) Drift Control Agents: Reduces the fine particles or droplets in spray solution that may result in increased drift.