

## Lecture

### Auxin Type Plant Growth Regulators (Hormonal)

#### 1. General Information

As a group, herbicides with this mode of action are used on more land area worldwide than any other group. The herbicide 2,4-D provided stimulus for the agricultural chemical industry.

Auxins are a class of naturally produced plant hormones. These compounds regulate many processes in the plant, including cell growth and differentiation. One of the most studied of these hormones is indole acetic acid or IAA. Auxins are present at low concentrations in the growing point in the plant, and endogenous mechanisms control the concentration within the physiological range.

Synthetic auxins (herbicides) mimic IAA and the relatively high concentration compared with "natural" auxins causes a rapid growth response. It is often said that plants exposed to herbicides with this mode of action "grow themselves to death".

One of the first commercially available herbicides with this mode of action was 2,4-D, a synthetic auxin. Herbicides in this group are primarily used to control broadleaf weeds and have limited activity on grasses. Grasses grown for seed, however, are sensitive to 2,4-D at germination and small seedling stages; tolerant in early tillering stage; susceptible at jointing, heading, and flowering; and tolerant at soft dough. Even though 2,4-D is applied postemergence it can have significant preemergence activity on both grasses and broadleaves.

The herbicide 2,4,5-T (Agent Orange) was used extensively during the Vietnam War. Comment on dioxin contamination problem. Various formulations of 2,4-D are available.

#### 2. Mode of Action

Though these herbicides have been around longer than most, their precise mode of action is still in question. The difficulties in studying these herbicides arise from the many different functions auxins have on the plant leading to the possibility that several modes of action exist. See Figure 13.1; page 2.

Plant responses observed with auxin type plant growth regulator herbicides include:

- increased RNA polymerase activity
- increased RNA and protein synthesis
- cell wall loosening and cell enlargement
- uncontrolled cell division and growth
- increased ethylene production
- vascular tissue plugging

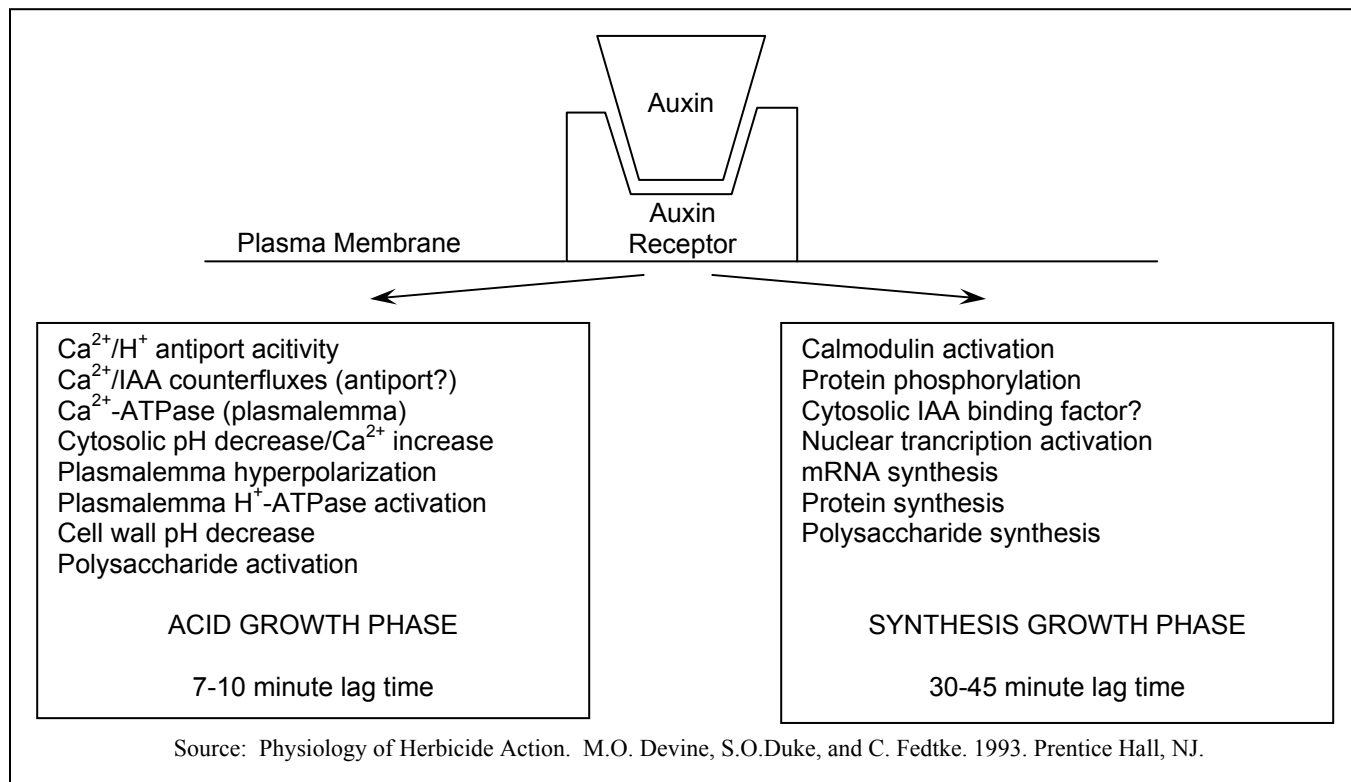


Figure 13.1 Effects of auxin type growth regulators in the plant

### 3. Site of Action

The site of action is presumed to be an unidentified auxin receptor on the external side of the plasma membrane. The receptor may induce Ca<sup>2+</sup> signals that trigger the herbicidal effects or the receptor may actively transport the auxin into the cell.

### 4. Symptoms

#### grasses at the wrong timing

abnormal seedhead emergence, blanked seedheads, abnormal brace root development (fused roots)

#### broadleaf weeds

epinasty – downward twisting and curvature of stems

stem swelling and elongation

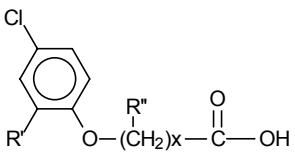
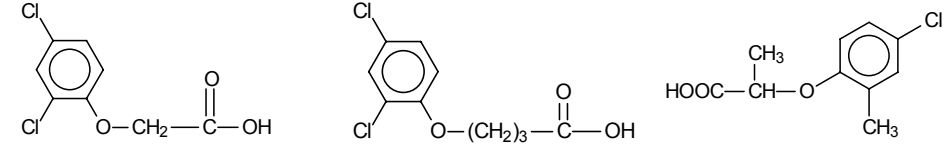
cracks and splits in bark of woody plants

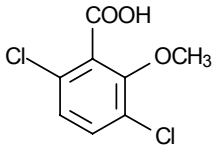
leaf strapping, cupping, and curling

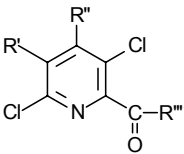
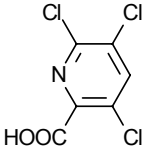
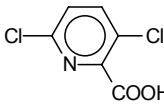
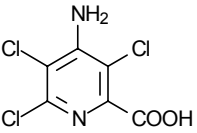
chlorosis in growing points, wilting, and necrosis

initial symptoms observed within hours after application; three to four weeks may be required before plant death occurs

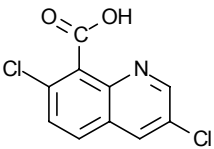
## 5. Herbicide Families

Phenoxys	
Base Structure	 <p>phenyl ring with an attached O to the #1 C (phenoxy) an aliphatic acid is attached to the O</p>
Examples	 <p>2,4-D (Weedar 64, HiDep, etc.)      2,4-DB (Butyrac 200)      mecoprop/MCPP</p>
Others	<p>dichlorprop      MCPB 2,4-DP      MCPA</p>
Metabolism	<p><u>plant</u>: hydroxylation, decarboxylation, conjugation (2,4-D, MCPP); beta-oxidation (2,4-DB) <u>soil</u>: microbial half-life – 2,4-D 10 d; 2,4-DB 5-10 d; MCPP 21 d ; dissociates to a (-) charged ion in soil and not attracted to soil colloids</p>
Absorption & Translocation	<p>absorbed by the foliage and transported by symplast (including phloem) and accumulates in growing points of shoots/roots absorbed by roots and transported in apoplast transpiration stream</p>
Selectivity	<p>selective – differential metabolism between species</p>
Herbicide Use	<p>broadleaf weed control <u>2,4-D</u> - POST in turf, wheat, barley, oats, rye, sorghum, sweet corn, rice, sugarcane, pastures, aquatic situations (formulation dependent); preplant in soybeans and cotton (formulation dependent) <u>2,4-DB</u> - POST or PD in soybeans, peanuts, forage legumes <u>MCPP</u> - POST established turf and cereal crops</p> <p>volatility dependent on formulation; off-target drift problems; use prohibited in cotton growing parishes</p>

Benzoic Acids		
Example	 <p>dicamba (Banvel, Clarity, Distinct)</p>	benzene ring with an acid group (COOH) attached to the #1 C (hence a benzoic acid)
Metabolism	<p><u>plant</u>: hydroxylation, demethylation, conjugation  <u>soil</u>: microbial  half-life – 4.4 d ; dissociates to a (-) charged ion in soil and not attracted to soil colloids; quite mobile in soil</p>	
Absorption & Translocation	readily penetrates leaves, roots, stems but not as rapidly as 2,4-D transported by symplast (including phloem) and apoplast (including xylem); slower in grasses than broadleaves	
Selectivity	selective – differential metabolism between species	
Herbicide Use	<p>broadleaf weed control  preplant in corn; preharvest in sorghum; POST in small grains, pasture, rangeland, asparagus, turf  weakly adsorbed to soil, mobile in soil but degraded rapidly</p> <p>a premix WeedMaster (dicamba + 2,4-D / 1:2.87) can be purchased  off-target drift problems; more biologically active than 2,4-D on soybeans but less active on cotton</p>	

Pyridinecarboxylic Acids			
Base Structure		contains a pyridine ring (6 member ring with one N) with a carboxylic acid group (COOH) attached; this family is sometimes referred to as the picolinic acids or the pyridines	
Examples	 <p>triclopyr (Garlon, Grandstand)</p>	 <p>clopyralid (Reclaim, Stinger)</p>	 <p>picloram (Tordon)</p>

Others	fluroxypyr (sold in Europe as Starane; being looked at in sugarcane in LA)
Metabolism	<u>plant</u> : hydroxylation, conjugation <u>soil</u> : microbial half-life – triclopyr 30 d; clopyralid 40 d; picloram 90 d (much longer than the phenoxys and benzoics); quite mobile in soil
Absorption & Translocation	readily penetrates foliage, also absorbed by roots; rapidly transported by symplast (including phloem) to growing points; root absorbed triclopyr appears to be translocated in xylem to shoots
Selectivity	selective – differential metabolism between species
Herbicide Use	controls annual and perennial broadleaf weeds <u>triclopyr</u> – POST in non cropland areas, utility, pipeline right-of-ways, roadsides, railroads, industrial sites, certain forestry sites, rangeland, permanent pastures, turf, rice, injected into stem cuts of large trees, freshly cut stumps, mixed with oil for bark application to young trees <u>clopyralid</u> – <u>Stinger</u> POST in sugarbeets, Christmas trees, field corn, pastures, rangeland; <u>Reclaim</u> POST for mesquite control; <u>Lontrel</u> POST for Canada thistle control in rapeseed in Canada <u>picloram</u> – POST (same as triclopyr) but highly leachable in some situations premixes include Grazon P+D (picloram + 2,4-D); Crossbow (triclopyr + 2,4-D); Curtail (clopyralid + 2,4-D)

Quinoline Carboxylic Acids	
Example	<div style="display: flex; align-items: center; justify-content: center;">  <div style="margin-left: 10px;"> <p>contains a quinoline structure (two joined 6-member rings with one ring containing a N; a carboxylic acid (COOH) group is attached to the 6 member C ring; notice the common name of the herbicide quinclorac (quinoline)</p> </div> </div> <p style="text-align: center;">quinclorac (Facet)</p>
Metabolism	<u>plant</u> : slowly metabolized by susceptible plants <u>soil</u> : microbial half-life – soil residues may injure susceptible crops planted one year after application
Absorption & Translocation	readily absorbed by emerging grass coleoptiles and by roots when soil applied translocation in both phloem and xylem
Selectivity	selective – differential metabolism between species

Herbicide Use	<p>Pre, delayed PRE, and POST in rice</p> <p>controls certain annual grasses and has activity on certain annual and perennial broadleaves</p> <p>this herbicide is different from others with this same mode of action since it is applied PRE and POST and controls grasses and broadleaves</p> <p>serious drift problems on tomatoes a few years ago; barnyardgrass resistance</p>
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## 6. General Comments

In 1941, Pokorney described the synthesis of 2,4-D and research began during World War II. The potency of 2,4-D as a hormone was discovered one year later. Drs. E. J. Krause, P.C. Marth, and J.W. Mitchell were among the first to consider the compound for herbicidal use.

After its introduction as the first selective herbicide to be synthesized and sold, 2,4-D revolutionized weed control in crops and started a surge in pesticide research. Other similar herbicides followed having the same mode of action, but with somewhat different species selectivity.

## 7. References

Ahrens, W. Herbicide Handbook, seventh edition. 1994. Weed Science Society of America, Champaign, IL.

Devine, M.D., S.O. Duke, and C. Fedtke. Physiology of Herbicide Action. 1993. Prentice Hall, NJ.

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