RE DISCOVER PHENOXIES

A guide to phenoxy herbicides

Nufarm
Grow a better tomorrow
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PHENOXY HERBICIDES
70 YEARS OF SUCCESS
**Introduction**

Nufarm believes that within the current agricultural climate in the UK, phenoxyes have an important role to play. With growing resistance to other herbicide groups, along with phenoxyes unique mode of action, you could say phenoxyes are more relevant than ever. This guide was written in the mind that whilst we at Nufarm know how useful phenoxyes can be, due to their longevity in the market place some of their key benefits may have been forgotten over time.

We encourage a new generation of agronomists and growers to learn more about phenoxyes, as well as invite those already established in the industry to rediscover how to best utilise phenoxy herbicides.

- Phenoxyes is a general term to describe a group of herbicides that mimic the effect of natural plant hormones called auxins.
- First developed in USA & UK in 1940’s - First used commercially in 1946.
- Remain amongst the world’s most widely used herbicides.
- Nufarm is a global leader in manufacture, supply and marketing of phenoxy herbicides. With manufacturing plants in the UK, Australia and Austria.
- Nufarm manufacture from raw material so we can guarantee the quality of finished product.
- Phenoxy herbicides play a special role in managing resistance because they have the lowest risk of fostering the development of resistance.
- The phenoxy herbicides are often mixed with resistance prone broad leaf weed herbicides or used in rotations to delay resistance.
- Postponement of resistance by the phenoxy herbicides lengthens the time before resistant prone herbicides becomes truly non-renewable.

**Nufarm, Built on Phenoxyes**

Nufarm is a global manufacturer and supplier of crop protection chemicals. We synthesise and manufacture a wide range of chemicals including MCPA, 2-4 D, CMPP-P, 2,4-DB, MCPB, 2-4 Dichlorprop-P.

An Australian company, we have grown from humble beginnings over 50 years ago at our Laverton site in Melbourne to be the eighth largest crop protection company in the world. Nufarm has prided itself on its production of phenoxyes over the years and operates the largest flexible phenoxy production site in the world, right here in the UK.

Our site at Wyke (near Bradford), which was established in 1877 as a Picric Acid manufacturer, now produces Phenoxy herbicides, Glyphosate, intermediates and inhibitors.
Mode of Action

Phenoxy herbicides mimic the plant growth regulator indol-3-acetic acid (IAA), or auxin in plants, thus it is necessary to review the function of auxin to properly understand their mechanism of action. Auxin is a plant growth regulator that controls cell enlargement, division and plant development through the plant life cycle. While much remains to be explored about the workings of IAA, it is known that IAA binds to auxin binding proteins (ABPs) located in the following:

- the cell membrane.
- the endoplasmic reticulum (an internal cellular membrane system).
- the cell nucleus.
- the cytoplasm.

The control of growth that IAA exerts is multifunctional. Alterations induced by IAA cause rapid changes in cell elongation, and both rapid and slow changes in gene expression. Auxins influence other growth regulators including cytokinins, abscisic acid and ethylene (a gas that functions as a plant growth regulator). The concentration of IAA in plant cells regulates cell growth. However, plant tissues differ in their sensitivity. Depending on tissue type and IAA concentration, IAA may either inhibit or stimulate a response.

IAA concentrations are highly regulated in plants by synthesis, degradation and both reversible and non-reversible conjugation. Synthesis increases the IAA content, while degradation decreases it. Conjugation, which is the linking of IAA to another molecule, frequently an amino acid, inactivates IAA. However, if conjugation is reversible, it may act as a slow release mechanism for maintaining relatively constant IAA levels.
Mode of Action

These herbicides are capable of moving from leaves (sources of sugar production) with sugars to sites of metabolic activity (sites of sugar utilization) such as underground meristems (root tips), shoot meristems (shoot tips), storage organs and other live tissues. Since movement to sites is essential for continued plant growth, these herbicides have the potential to kill simple perennial and creeping perennial weeds with only one or two foliar applications. Symptoms are evident on new growth first. Pigment loss (yellow or white), stoppage of growth, and distorted new growth are typical symptoms. Most injury appears only after several days or weeks. Herbicides in this group are usually non-charged at low pHs found in the cell walls and negatively charged at higher pHs encountered in the cytoplasm of leaf sieve cells of the phloem (the ionization inside the cytoplasm of the phloem accounts for trapping and movement of these herbicides).

- Phenoxies are acids, normally formulated as salts, sometimes as esters.
- Well tolerated by cereal crops within specific GS limitations.
- Foliar activity, absorbed into leaf within 4 - 6 hours.
- Concentrates in the actively growing regions of a plant (meristematic tissue).
- Over stimulate plant cells causing abnormal plant growth and death.
- Interferes with plant metabolism, protein synthesis, cell division and transportation of nutrients within the plant.
- However, the plant has no mechanism to control the concentrations of these ‘impersonators’.
- Translocated within plant to growing points in stems and roots.
- MOA Classification: Group O (Synthetic auxins).
- Phenoxies may be used solo but are more often used in mixtures with other phenoxies, dicamba or other selective herbicides such as SU products.
- Almost all plants can be affected.
- Phenoxys do affect most monocots, but only at specific growth stages.
- Selectivity most likely due to:
  - Restricted translocation
  - Morphological / structural differences
  - Ability to metabolise toxin
How Do Auxins Work?

When sunlight is overhead the IAA molecules (auxins) produced by the meristem are distributed evenly in the shoot.

Once the sunlight shines on the shoot at an angle, the IAA molecules move to the far side and induce elongation of cells on that side.

Cell elongation results in the bending of the shoot towards the light.


Phenoxy Symptoms

Observations in the field include:

- Epinastic growth eg. twisting & bending (1-3 days)
- Leaf cupping and curling (1-3 days)
- Thickening and elongation of leaves (7 days)
- Chlorosis at the growing point (7-10 days)
- Finally, wilting and death (21+ days)
Some products such as 2,4-D can be formulated as either an Amine or Ester formulation. Esters tend to have better uptake into plants especially in cooler conditions while Amines generally have a much lower risk of volatilisation and therefore less risk to nearby sensitive crops.

**Ester Formulations**
- Esters are not very water soluble but dissolve readily in organic solvents (EC).
- Ester can be applied in relatively hardwater.
- Ester formulations tend to resist washing from leaves following rain.
- Work better under challenging conditions.
- Little to no root absorption.
- May be more volatile than other Phenoxies and higher odour level.
- Quickest uptake through leaves, trichomes and glands, plus stomata uptake of vapour.
- Higher activity per g ai of 2,4-D - controls harder to kill weeds.

**Amine Formulations**
- Formulated as solutions which makes them more water soluble.
- More prone to water quality effects (high pH and salts).
- Water solubility increases susceptibility of being washed from leaves by rain.
- Less compatible than Esters with many other product eg. foliar fertilisers and trace elements.
- Non-volatile & less odour than esters.
- Intermediate uptake through leaves - must be actively transpiring.
- Some root uptake possible.
- Intermediate activity per g ai of 2,4-D, not as high as Ester but greater than salts in stressed conditions.

**Comparison Summary**

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<thead>
<tr>
<th></th>
<th>Esters</th>
<th>Amine</th>
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<tbody>
<tr>
<td>Root Uptake</td>
<td>Low</td>
<td>Low - Moderate</td>
</tr>
<tr>
<td>Shoot Uptake</td>
<td>High</td>
<td>Moderate - High</td>
</tr>
<tr>
<td>Volatility</td>
<td>Low</td>
<td>Non-volatile</td>
</tr>
<tr>
<td>Activity per gram active ingredient</td>
<td>Highest</td>
<td>High under good growing conditions. Moderate under stressed conditions.</td>
</tr>
<tr>
<td>Speed of Uptake</td>
<td>Quickest</td>
<td>Moderate</td>
</tr>
<tr>
<td>Compatibility</td>
<td>High</td>
<td>Moderate</td>
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</table>

**Chemistry Matrix**

<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>“Acetics” MCA (Acetic acid + Chlorine)</th>
<th>“Propionics” L-Chloro-propionic Acid</th>
<th>“Butyrics” L-Chloro-propionic Acid Gamma-Butyrolactone (GBL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-Cresol</td>
<td>MCPA</td>
<td>CMPP-P/Mecoprop-p</td>
<td>MCPB</td>
</tr>
<tr>
<td>Phenol</td>
<td>2,4-D</td>
<td>2,4-DP-P/Dichloroprop-p</td>
<td>2,4-DB</td>
</tr>
</tbody>
</table>
Phenoxies

Group 4 Herbicides

The mode of action in herbicides is the way an active ingredient controls the plant. It describes the physiological process that is interrupted in the plant which ultimately affects the plants growth and development. In other cases, the mode of action may be a general description of the injury symptoms seen on susceptible plants.

There are 7 different mechanisms listed below and Herbicide Resistance Action Committee (HRAC) use groups from A-Z to class different types of modes without these mechanisms.

1) ACCase inhibitors  2) ALS inhibitors  3) EPSPS inhibitors  4) Synthetic auxins
5) Photosystem II inhibitors  6) Photosystem I inhibitors  7) HPPD inhibitors

Phenoxy herbicides are in Group 4 “Synthetic auxin” category and are in HRAC group O.

Knowing mechanisms and groups of herbicide is important in order to manage resistance. Herbicide resistance is the inherent ability of a weed to survive a herbicide rate that would normally control it. This is not the same phenomena as poor herbicide performance. If herbicide resistance develops, other herbicides or different control methods will have to be used to control a weed. These options may be more expensive or less effective. Once developed, herbicide resistance will persist for many years.
MCPA (2-methyl-4-chlorophenoxyacetic acid)

Brand straights: Agritox, Easel
Brand co-formulations: CloverMax, PastureMaster, Mircam Plus, TurfMaster

With its roots extending back to investigation of auxins in 1936, MCPA was first synthesised in 1945 and has been used as a powerful selective herbicide ever since. Nufarm manufactures MCPA from its state of the art production facilities in Wyke Bradford.

- Formulated as a salt or an ester, MCPA offers a good broad-leaved spectrum in cereals and grassland.
- Rate response depends on species and size but generally you need 500-750g active in mixtures in cereals minimum.
- Use in cereals is increasing to control SU resistant weeds such as Poppy.
- Easel is approved up to the later time of GS39 in Winter Wheat.
- Boosts Thistle, Fat hen and Hempnettle control in cereals.
- Controls Thistles and Buttercups in grassland.

MCPA Weed Control

<table>
<thead>
<tr>
<th>Less Susceptible</th>
<th>More Susceptible</th>
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</thead>
<tbody>
<tr>
<td>Chickweed</td>
<td>Dandelions</td>
</tr>
<tr>
<td>Soft Rush</td>
<td>Ragwort</td>
</tr>
<tr>
<td>Docks</td>
<td>Nettles</td>
</tr>
<tr>
<td>Thistles</td>
<td>Buttercup</td>
</tr>
</tbody>
</table>

Brand straights: Agritox, Easel
Brand co-formulations: CloverMax, PastureMaster, Mircam Plus, TurfMaster
2,4-D (2,4-Dichlorophenoxyacetic acid)

Brand straights: Depitox
Brand co-formulations: Kyleo, Thrust, PastureMaster

Like MCRA, 2,4-D was developed in the 1940’s and has been a vital component of British Crop protection since. It is now one of the most widely used herbicides in the world. It has proven to be systemic which is ideal for perennial weed control.

- One of the most widely used herbicides in the world.
- Developed during World War II at Rothamsted Experimental Station with the aim to increase crop yields for a nation at war.
- 2,4-D typically applied as an amine salt, but more potent ester versions exist.
- 2,4-D has a similar weed spectrum to MCPA. Cereals less tolerant than to MCPA.
- Early tillering in winter cereals can result in severe ear damage. No later than before first node otherwise ear damage. Better control of docks in grassland than MCPA.

2,4-D is Systemic

2,4-D has systemic activity this means the herbicide will move both up and down the plant and into the roots giving a faster speed of kill than that of a contact product. This is especially important when it comes to controlling perennial weeds such as docks or ragwort.

- Radio labelled 2,4-D is sprayed on oilseed rape at 4 leaf stage.
- 48 hours after treatment, the amount of radiolabelled 2,4-D is observed in the plants through radioactivity in liquid scintillation.
- The 2,4-D has migrated from leaves to roots.

2,4-D Weed Control

![Weed Control Diagram]
Mecoprop-P (methylchlorophenoxypropionic acid)

**Brand straights:** Duplosan KV, Compitox Plus  
**Brand co-formulations:** Mircam Plus, High Load Mircam, Duplosan Super, TurfMaster

Discovered by Boots Agrochemicals in 1953, registered in 1957. This initial formulation consisted of two chemical isomers in equal proportion, only one of which is the active herbicide.

- New technologies in the 1980s allowed for the creation of products with higher concentrations of the optically active isomer.
- Boosts Cleaver and Fat hen control, which are not well controlled by many SUs. Also strong on Chickweed, and killing leguminous volunteers but generally boosts the weed control of anything it is mixed with.
- Works in cooler weather than the other phenoxyis.
- Rate response. Activity falls off quickly below 1.0 l/ha.

### Mecoprop-P Weed Control

<table>
<thead>
<tr>
<th>Least Susceptible</th>
<th>More Susceptible</th>
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<tbody>
<tr>
<td>Soft Rush</td>
<td>Chickweed</td>
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<td>Dandelions</td>
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<td>Ragwort</td>
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<td>Nettles</td>
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<td>Thistles</td>
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<tr>
<td>Buttercup</td>
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<tr>
<td>Cleaver</td>
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</table>
2,4-DB (4-(2,4-dichlorophenoxy)butyric acid)

**Brand straights:** CloverMaster  
**Brand co-formulations:** CloverMax

Clover safe weed control in established grassland and new sown leys. An ideal mixing partner with Squire Ultra.

- Butyric phenoxyes are about half as active as Acetics.
- 2,4-DB is the key active in CloverMaster, and one of the key actives within Clovermax.
- 2,4-DB is safe to Clover when applied before 4th trifoliate leaf stage because young Clover can’t convert 2,4-DB to 2,4-D.
- If applied when Clover (or Lucerne) is more mature, it will damage, or kill the crop.
- Clovermax and CloverMaster can be applied to cereal crops (wheat, barley or oats) under-sown with Red or White Clover.
- Other legume crops, such as Peas and Beans are not tolerant to 2,4-DB as they have the ability to convert it to 2,4-D, which causes the damage.

2,4-DB Weed Control

**Less Susceptible**

1. Black Bindweed
2. Redshank
3. Speedwell species

**More Susceptible**

1. Field Penny Cress
2. Shepherds Purse
3. Fat Hen
4. Charlock
5. More Susceptible
6. Less Susceptible
MCPB (4-(4-chloro-o-tolyloxy)butyric acid)

Brands: Tropotox

Discovered at Wye College, London University in 1955 by Professor Louis Wain. It is converted within the plant by susceptible weeds into MCPA. As a butyric phenoxy it is generally about half as active, but has some unique selective properties.

- Some legume crops, notably peas and clover lack the conversion mechanism and therefore are tolerant, however others are not e.g. lucerne, beans.
- Weed spectrum similar to MCPA but less than half as active.
- Tropotox is approved for use in Combining and Vining Peas.

MCPB Weed Control

Less Susceptible  More Susceptible

- Chickweed
- Ragwort
- Docks
- Fat Hen
- Orache
- Thistles
- Nettles
- Buttercup
Dichlorprop-p (2,4-dichlorophenoxy propionic acid)

Brand co-formulations: Duplosan Super

Discovered by Boots Agrochemicals in 1945. It was initially a mix of two isomers, now single isomer Dichlorprop-p. Dichlorprop-p is not available for use as a straight active.

- Improved control of polygonum weeds such as Black bindweed & Redshank over CMPP.
- Ideal product for spring barley.
- More temperature dependant than CMPP-P.

Dichlorprop-p Weed Control

Less Susceptible

- Soft Rush
- Ragwort
- Cleaver
- Nettles
- Dandelions

More Susceptible

- Black Bindweed
- Redshank
- Buttercup
- Thistles
Dicamba

**Brand co-formulations:** High Load Mircam, TurfMaster, Mircam Plus, Thrust

As with Dichlorprop-p, Dicamba is not available for use as a straight active in cereals and grassland. This compound was discovered in 1965 by Veliscol. Dicamba is not a phenoxy and is more closely related to clopyralid but it acts in a similar way to phenoxyes. Effective at a far lower dose than phenoxyes.

- Adds control of most of the Polygonums including Redshank and Knotgrass and improves control of Docks. Will boost Chickweed and control of most Mayweed species and also gives good control of Fumitory in mixtures. Kills clover.
- Safe in cereals up to about 100g/ha ai but can be used at higher doses up to about 300g/ha in grassland.
- An effective mixing partner for phenoxy actives.

**Dicamba Weed Control**

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**Less Susceptible**

- Groundsel
- Mayweed
- Chickweed

**More Susceptible**

- Knotgrass
- Black Bindweed

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Brand co-formulations: High Load Mircam, TurfMaster, Mircam Plus, Thrust
### Spring Cereal Product Spectrum

<table>
<thead>
<tr>
<th></th>
<th>CMPP-P</th>
<th>CMPP-P + Dicamba</th>
<th>MCPA</th>
<th>MCPA + CMPP-P + Dicamba</th>
<th>Bromoxynil</th>
<th>Tribenuron -methyl</th>
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<td>Cleavers</td>
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<td>Chickweed</td>
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<td>Fat hen</td>
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<td>Small Nettle</td>
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<td>Fumitory</td>
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<td>Docks</td>
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<td>Knotgrass</td>
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<td>Redshank</td>
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<tr>
<td>Groundsel</td>
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### Winter Cereal Product Spectrum

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<th>MCPA + CMPP-P + Dicamba</th>
<th>Fluroxypyr</th>
<th>MCPA</th>
<th>Florasulam</th>
<th>Bromoxynil</th>
<th>Tribenuron -methyl</th>
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Susceptible, Moderately Susceptible, Moderately Resistant, Resistant
Getting the Best Results

Best Use:

- Weed must be growing. Avoid cold frosty conditions.
- Phenoxies take about 4-6 hours rain free to get into the plant.
- Check the species is actually susceptible.
- Get the timing right – ideally young plants.
- Make sure the crop is not under stress due to poor nutrition, drought or disease otherwise weed control will be reduced and there is the possibility of damage to the crop.

Application Guidelines – Know your waxes!

Dicot weeds will more often than not be either hairy eg thistle or waxy eg Voi OSR. Knowing what the target is will help to make decisions on spray quality, rate and whether an adjuvant is required.

Most dicot weeds have amorphous (layer) wax however there are some exceptions, fat hen for example has a crystalline wax (hairy in appearance under the microscope and more commonly found in grasses.

Crystalline waxes tend to be harder to penetrate as the spray droplet will sit on top of the ‘hairy’ waxes.

Understand your Weed Target

Waxy and hairy. Difficult to penetrate leaves

- Very small target. Finer spray. Big droplets may bounce off or miss the target

Small fine shoot system big root system = hard to control.

Dock - Big root system but also many leaves = Spray when enough foliage but not too much as unlikely to get a lethal concentration.

Small root, big leaves and susceptible species = Easy to kill.
Application Timing Guidelines

Cereal crops are sensitive to phenoxy herbicide application at several growth stages throughout the season. The sensitive timings usually coincide with periods of high growth or reproductive activity.

Cereal Growth Stages

- The BBCH cereal growth Stage key does not run chronologically from GS00 to GS99, for example when the crop reaches 3 fully unfolded leaves (GS13) it begins to tiller (GS20), before it has completed 4, 5, 6 fully unfolded leaves (GS14, GS15, GS16).
- It is easier to assess main stem and number of tillers than it is the number of leaves (due to leaf senescence) during tillering. The plant growth stage is determined by main stem and number of tillers per plant e.g. GS22 is main stem plus 2 tillers up to GS29 main stem plus 9 or more tillers.
- Later autumn sown or spring sown crops will very rarely reach GS29 (main stem & 9 tillers or more) before the main stem starts to elongate at GS30.
- After stem elongation (GS30) the growth stage describes the stage of the main stem only, it is not an average of all the tillers.

<table>
<thead>
<tr>
<th>GS 00 - 09</th>
<th>GS 10 - 19</th>
<th>GS 20 – 29</th>
<th>GS 30 - 39</th>
<th>GS 40 - 49</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development</td>
<td>Germination</td>
<td>Seedling growth</td>
<td>Tillering</td>
<td>Stem elongation</td>
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<tr>
<td>GS 50 - 59</td>
<td>GS 60 - 69</td>
<td>GS 70 – 79</td>
<td>GS 80 - 89</td>
<td>GS 90 - 99</td>
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<tr>
<td>Development</td>
<td>Ear emergence</td>
<td>Flowering</td>
<td>Milk Development (grain fill period)</td>
<td>Dough Development (grain fill period)</td>
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</tbody>
</table>
**Safe Timing**

- Critical period is the ‘double ridge’
  - Shoot apex changes from leaf production to spikelet formation.
- Safety period occurs 1 leaf after the ‘double ridge’ stage.
- Timing can be determined by leaf number in spring cereals.
- Spikelet initiation occurs later in winter varieties
  - Plant has more leaves by the time it has occurred.
  - Safe stage is when the crop reaches Leaf sheath erect GS30.
  - Can only be determined exactly by dissection.
- GS30 - The tip of the developing ear is 1 cm or more from the base of the stem where the lowest leaves attach to the shoot apex.
- GS31 - The first node can be seen 1 cm or more above the base of the shoot (with clear internode space below it) and the internode above it is less than 2 cm.
- Spikelet initiation is delayed in dry seasons.
- Ear distortion doesn’t always translate through to a yield reduction.
- Can sometimes be mistaken for frost damage.

**Incorrect Timing in Cereals Risks Damage**

- Symptoms of phenoxy damage include:
  - Ear deformities
  - Rachis (stem of the ear) thinning
  - Missing spikelets
  - Increased shattering at harvest
- This doesn’t always translate through to a yield reduction.
- Can sometimes be mistaken for frost damage.

**Cereal Application Timing with Phenoxies**

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Cereal crops</th>
<th>1 leaf</th>
<th>5 leaf</th>
<th>Leaf sheath erect</th>
<th>First node</th>
<th>Second node</th>
<th>Third node</th>
<th>Before flag leaf extending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easel</td>
<td>MCPA</td>
<td>Winter wheat</td>
<td>01</td>
<td>15</td>
<td>30</td>
<td>31</td>
<td>32</td>
<td>33</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter barley</td>
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<tr>
<td></td>
<td></td>
<td>Spring cereals</td>
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<tr>
<td>Depitox</td>
<td>2,4-D</td>
<td>Winter cereals</td>
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<td>Spring cereals</td>
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<tr>
<td>Duplosan KV</td>
<td>MCPP-P</td>
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<td>Spring cereals</td>
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</tr>
</tbody>
</table>

- Recommended timing
Water Stewardship

Herbicide Application Requires Careful Management to Protect our Water Sources

In areas where a range of agricultural enterprises co-exist, conflicts can arise, particularly with the use of pesticides. A major problem that can occur is damage to susceptible crops caused by “off-target” herbicide drift. All herbicides are capable of drift if applied in the wrong manner or conditions, regardless of the active ingredient or the formulation type.

Herbicide users have a moral and legal responsibility to prevent herbicides from drifting and contaminating or damaging neighbouring crops or environmently sensitive areas. Off-target crops may be up to 10,000 times more sensitive than the crop being sprayed. Even small quantities of drifting herbicide can cause severe damage to highly sensitive plants.

Over 50% of phenoxy which gets into water is point source.

Water and Phenoxies

The challenge
- They are all very soluble.
- They don’t get locked up much in the soil.
- Easy for them to leach into field drains and ground water.

The good
- The half life varies but is relatively short i.e. less than a month.
- If there is a reasonably thick crop canopy it can be intercepted.
- They can be taken out by water companies if plant was put in place prior to the water framework directive.
- Measures to remove oestrogen in the future will actually remove phenoxies too.
Reducing Off-Target Herbicide Drift

Factors that Affect the Risk of Off-Target Drift

How to Minimise Spray Drift

- Herbicides can drift as droplets (spray), as vapours or as particles. Spray drift is the most common form of off-target effect. Vapour and particle drift are different to spray drift.
- **Vapour Drift** - arises directly from the spray or evaporation of herbicide from sprayed surfaces. Changing to a less volatile or non-volatile formulation reduces this risk.
- **Physical Drift** - occurs when water and other herbicide carriers evaporate quickly from the droplet leaving tiny particles of concentrated herbicide. This can occur with many types of pesticides. Minute particles float in the air stream and are poorly collected on catching surfaces. They may be carried for miles in thermal up-draft before being deposited.
- **Spray Drift (Droplet)** - is the easiest to control because under good spraying conditions, droplets are carried down by air turbulence and gravity, to collect on plant surfaces. Under nil wind conditions and very windy conditions droplets, especially fine droplets, can be carried off-target. This can occur regardless of the herbicide used. Spray drift is the major offender for off-target effects.

The drift hazard, or off-target potential of a herbicide in a particular situation depends on the following factors:

- Proximity of susceptible crops to the particular herbicide being applied and their growth stage.
- The method of application and equipment used - air, ground, mister and their specific configurations can affect off-target drift.
- Size of the area treated and the amount of active herbicide applied.
- Efficiency of the capture surface, bare soil versus crop.
- Volatility of the formulation applied; ester-based formulations are recognised as the most volatile phenoxy formulations - changing to a non-volatile amine or salt formulation reduces risk.

- Before applying any herbicide, always check for susceptible crops in the area.
- Do not use unless wind speed is more than 3 kilometres per hour and less than 15 kilometres per hour as measured at the application site.
- Restrict sprayer forward speed and limit boom height to that recommended for nozzles.
- Notify neighbours of your spraying intentions.
- Always monitor meteorological conditions carefully and understand their effect on “drift hazard”.
- Supervise all spraying even when a contractor is employed.

- Record weather conditions, wind direction, herbicide and water rates, and operating details for each field.
- Spray when temperatures are less than 28°C to reduce vapour drift risks.
- Maintain a down-wind buffer.
- Minimise spray release height (50cm above the target).
- Use 3* rated Drift reduction nozzles and minimize spray pressures.
- If in doubt – do not spray.
PROTECT YOUR WATER

Use Plant Protection Products safely.

Ensure only certificated spray operators and equipment apply the products.

Observe all product buffer zones.

Clean and wash down your sprayer at the end of the day, well away from water bodies or open drains.

Do not fill or wash down sprayer in yard unless measures to collect washings for safe disposal in place.

Do not use on waterlogged fields, if tyre marks are visible the field is too wet.

Do not exceed the maximum application rate.

Do not use if rainfall is expected. Apply on a calm day when weather conditions are good.