# Herbicides for Aquatic Invasive Species Management

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# CEH is the UK's centre of excellence for research in the land and freshwater environmental sciences

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# History of CEH

The Centre for Ecology & Hydrology (CEH) was formed in April 2000 from a merger of four long-established research institutes:

- **Institute of Terrestrial Ecology**
- **Institute of Freshwater Ecology**
- **Institute of Hydrology**
- **Institute of Virology & Environmental Microbiology**


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# Resources

## 325 scientists & 125 support staff spread across the UK

Photos - CEH


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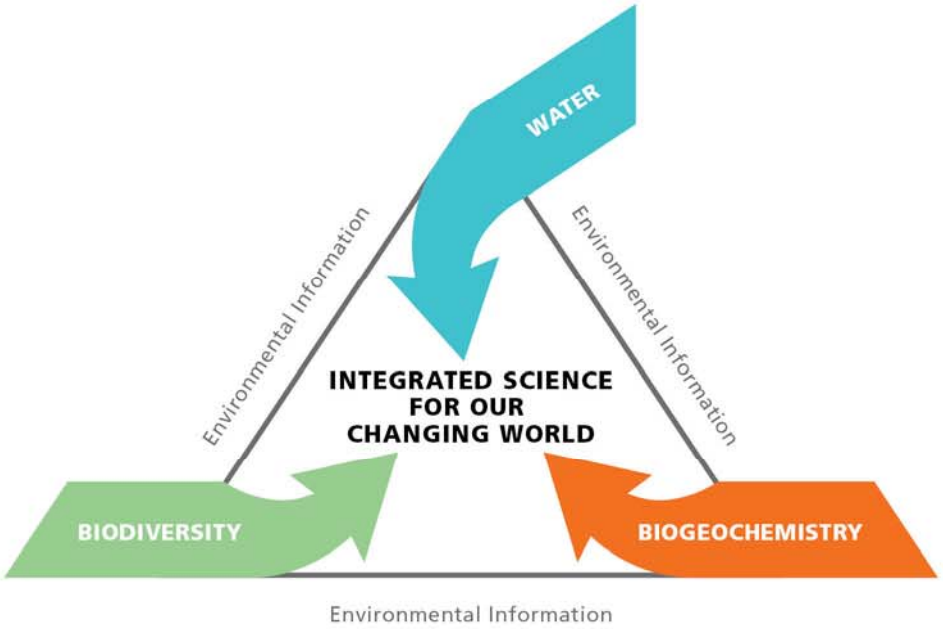
# CEH integration of scientific disciplines

**Science Programmes:**

- **Water**
- **Biogeochemistry**
- **Biodiversity**

All linked through an **Environmental Information Data Centre**




**Scientific disciplines are integrated to develop practicable solutions for environmental sustainability**

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# In Defence of Aquatic Herbicides

- Mechanical control always spreads aquatic invasive species
- Up to $10^6$ invertebrates per $m^3$m lost during mechanical removal
- Sediment disturbance increases eutrophication and creates open habitat niches that are usually colonised by the invasive species you are trying control
- Access and disposal are usually difficult

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# Why use herbicides at all?

- Selective
- Non-toxic
- Less disruptive to the environment
- Easier access than machinery
- Cheaper
- Longer lasting
- More effective
- Produce few fragments
- Short lived in the environment

# Why shouldn't I use herbicides in water

- Toxic
  - **NO**
- Persistent
  - **NO**
- Non-selective
  - **NO**
- I don't like the idea
  - = I don't understand how they work, or I don't understand the benefits of herbicides, or I just think pesticides are poisons

# Relative toxicities

| | Test Conditions | Chlorine $LC_{50}$ ppm | NaCl $LC_{50}$ ppm | Roundup pro Biactive $LC_{50}$ ppm |
|---|---|---|---|---|
| *Daphnia magna* | 48 h Flow-through | 0.032 | 1,853 | 676 |
| *Chironomus* spp. | 96 h Flow through | 0.018 | 4,026 | >989 |
| Oncorhynchus mykiss. | 96 h Flow through | 0.062 | 1,595 | >989 |

Roundup Pro Biactive is about 58,000 times less toxic than Chlorine and about 2.7 times more toxic than salt to *Daphnia magna*

The caffeic acid content of Lettuce is carcinogenic

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# Non-Toxic

- New formulations, less ecological impact
  - Roundup Pro Biactive® some 1000 times less toxic than original Roundup®
  - Half life of ~ 7 days in water
  - Diquat - half life of less than 3 hours in muddy water
    - Laboratory tests not always suitable for extrapolation to field studies
- New Actives not (yet) approved in Europe
  - Flumioxazin: less than 15 minutes half life
  - Imazamox: no non-target toxicity

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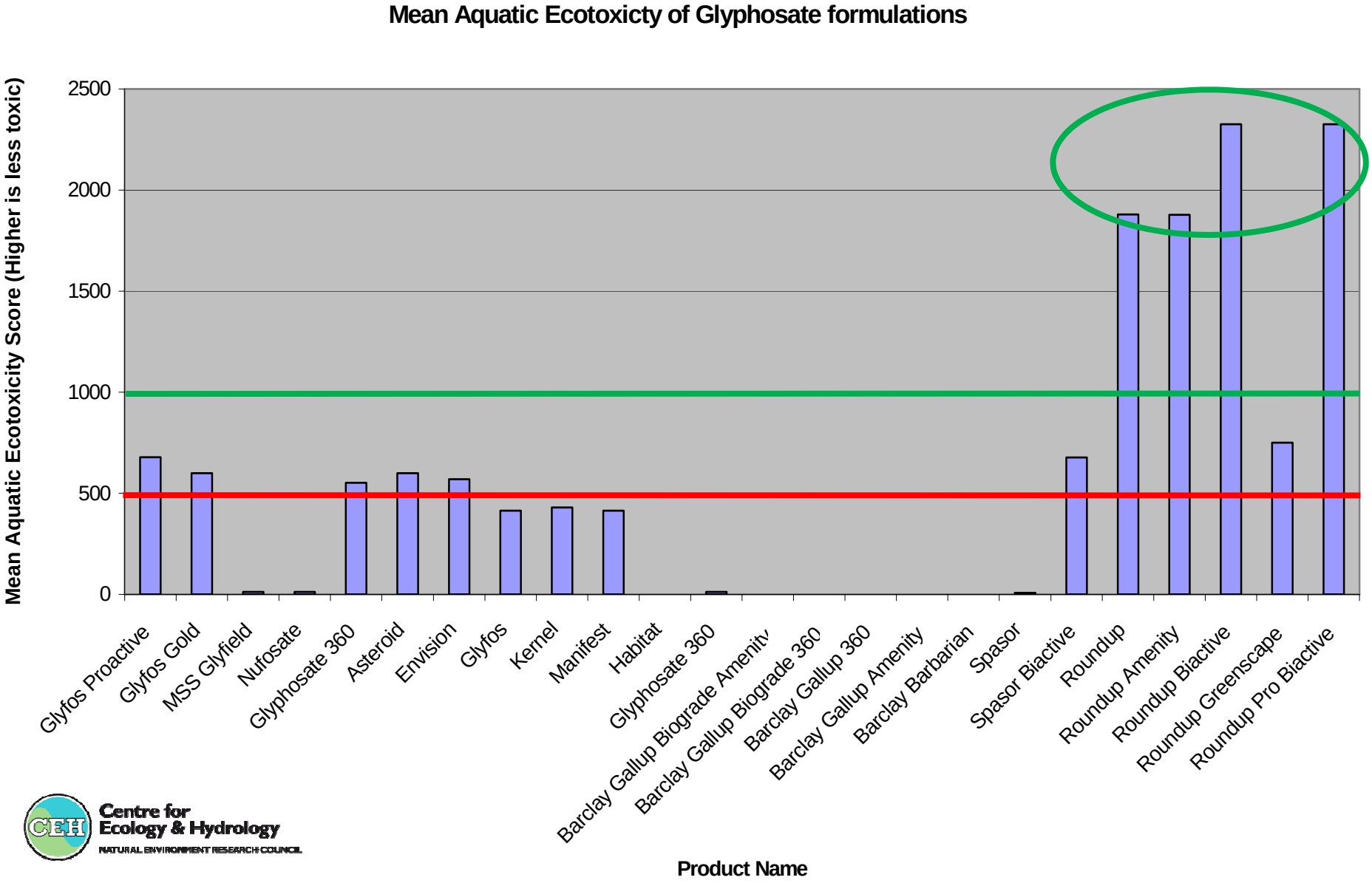
# Formulation Differences

| | Roundup Biactive<br>Roundup Pro Biactive | Roundup Ultra ST, | Roundup Max | Sting ECO | Roundup Gold | Roundup and own branded ETA formulations |
|---|---|---|---|---|---|---|
| Surfactant | Biactivators<br>Non-ionic Humectant + Quaternary Ammonium salt | Alkyl Phosphate Ester<br>(APE) | Alkoxylated cationic surfactant | Coco-amine (Alkoxylated fatty amine) | Transorb technology | Ethoxylated Tallow amine (ETA) |
| **Toxicity**<br>Acute Oral LD50,rat,mg/kg<br><br>Classification | >5000<br><br>Not classified | >2000<br><br>Not classified | >5000<br><br>Not classified | >5000<br><br>Not classified | >5000<br><br>Not classified | >5000<br><br>Not classified |
| Irritancy | **Non irritant** | Non irritant | **Risk of serious damage to eyes** | Non irritant | Non irritant | **Irritating to eyes and skin** |
| Aquatic $LC_{50}$ Trout (96h), Static mg/L | **>989**<br><br>**( Flowthrough)**<br>**Not classified** | >8.2<br><br>**Harmful to fish or other aquatic life** | 20<br><br>**Harmful to fish or other aquatic life** | 2.1<br><br>**Harmful to fish or other aquatic life** | 12-21<br><br>**Harmful to fish or other aquatic life** | **8.2**<br><br>**( Flowthrough)**<br>**Harmful to aquatic organisms** |
| Aquatic use on label | **YES** | NO | NO | NO | NO | SOME |

# Formulation differences.....

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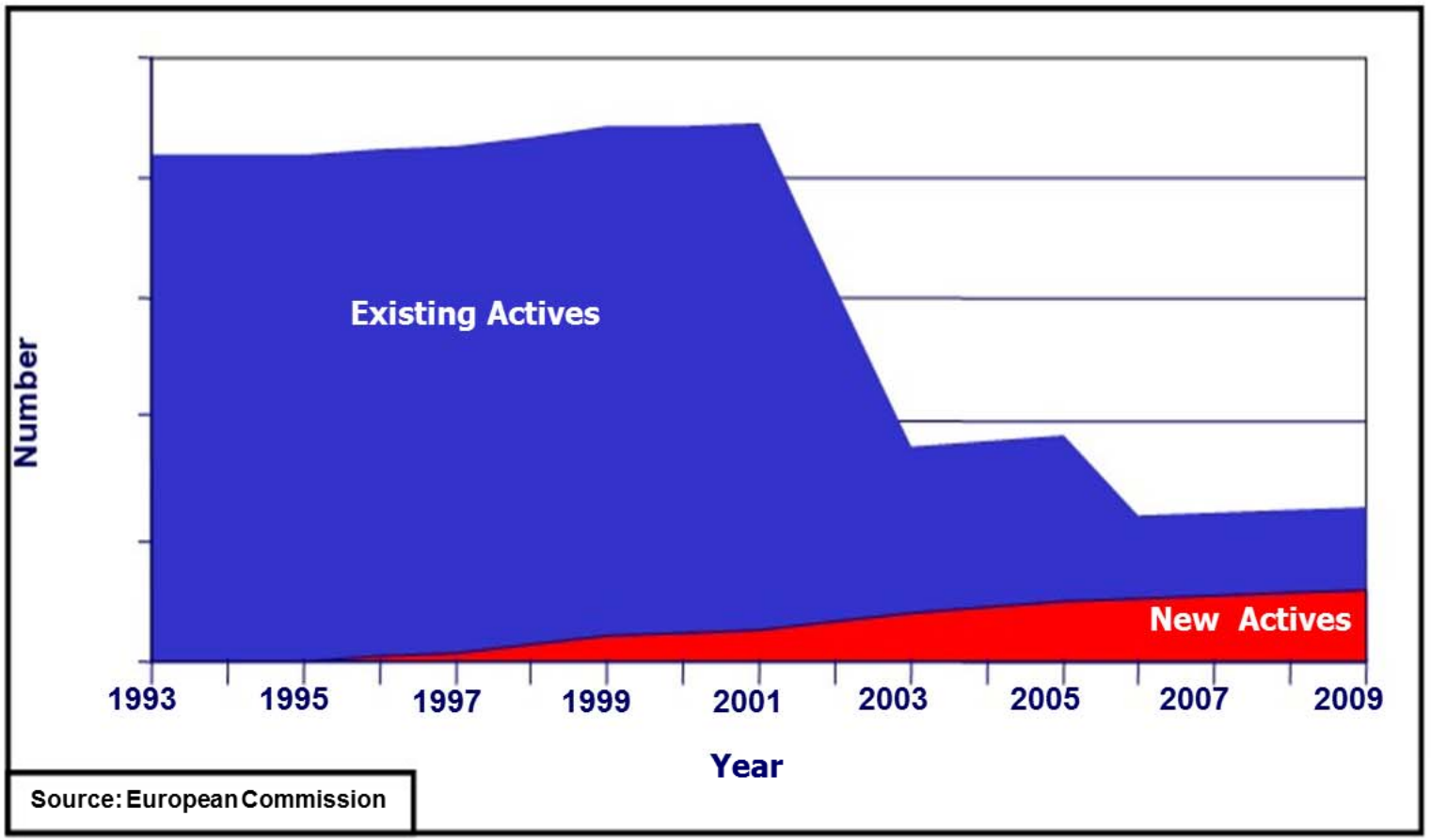
# Selective

- Spot treatment
  - Localised application with limited non-target damage
- Herbicide chemistry
  - Broad leaved selectivity
- Dose dependence
  - Species specific dose rates
- Adjuvants
  - Make what we have work better
  - Increased cost effectiveness = better economics

# Why do we just seem to lose aquatic herbicides?

- Regulation
- Progress
- Commercial (Market size)
- Aquatic weeds are all not a big an issue

# Regulation - EU PPPD 91/414/EU

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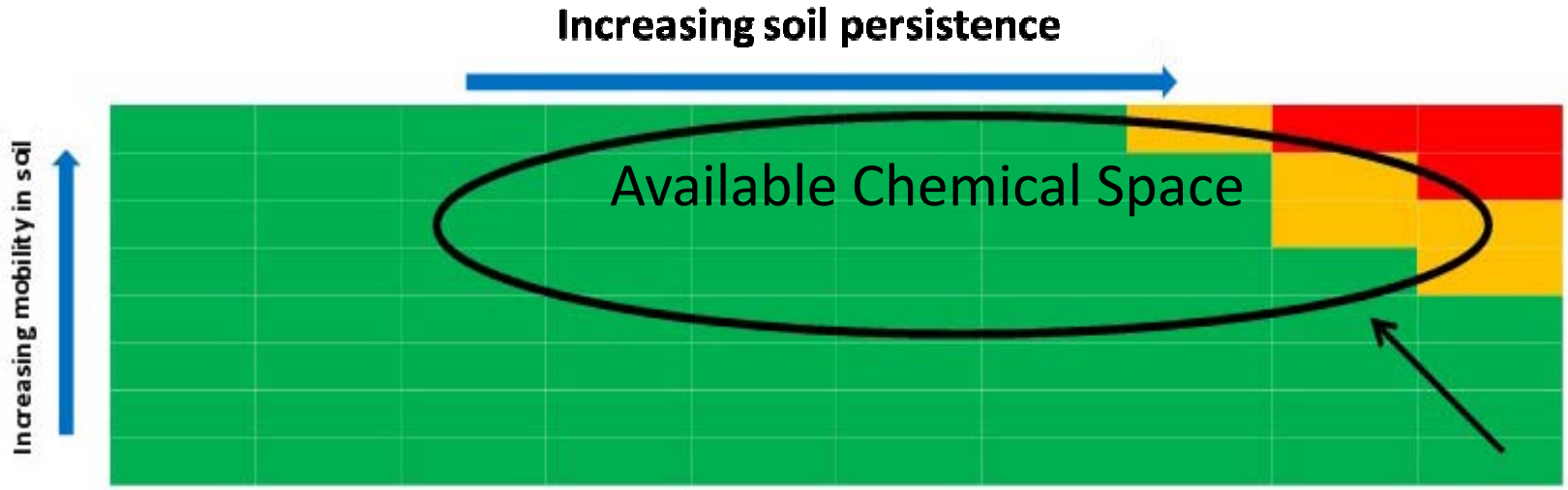
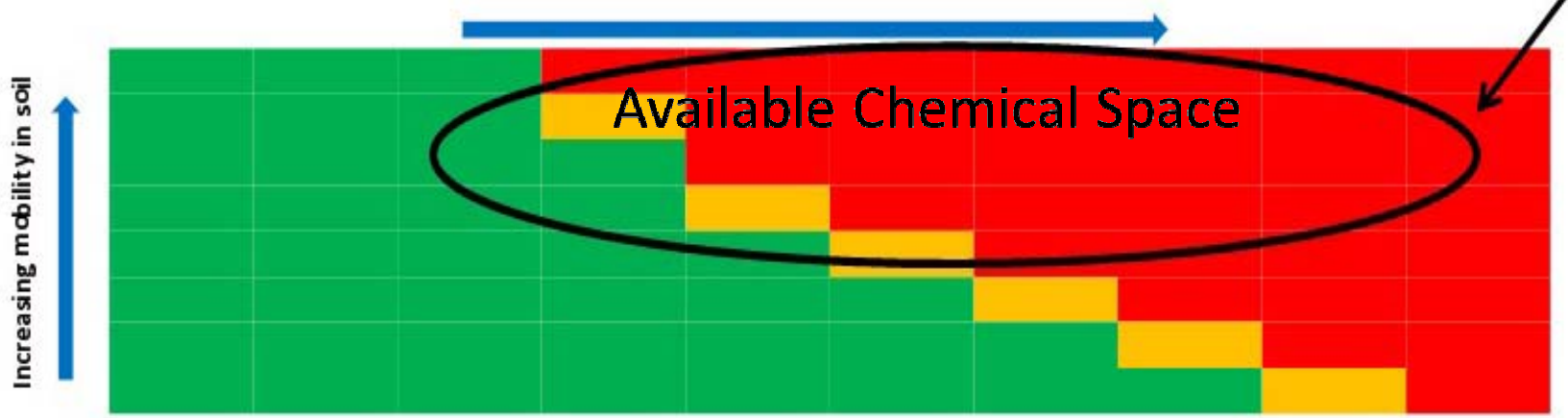
# Water Regulations and Innovation: Regional Comparison

**US EPA - risk cup style assessment including drinking water and dietary intake (worst case)**




**EU27 - 0.1ppb groundwater cut-off (worst case)**

Optimum Biological Performance*

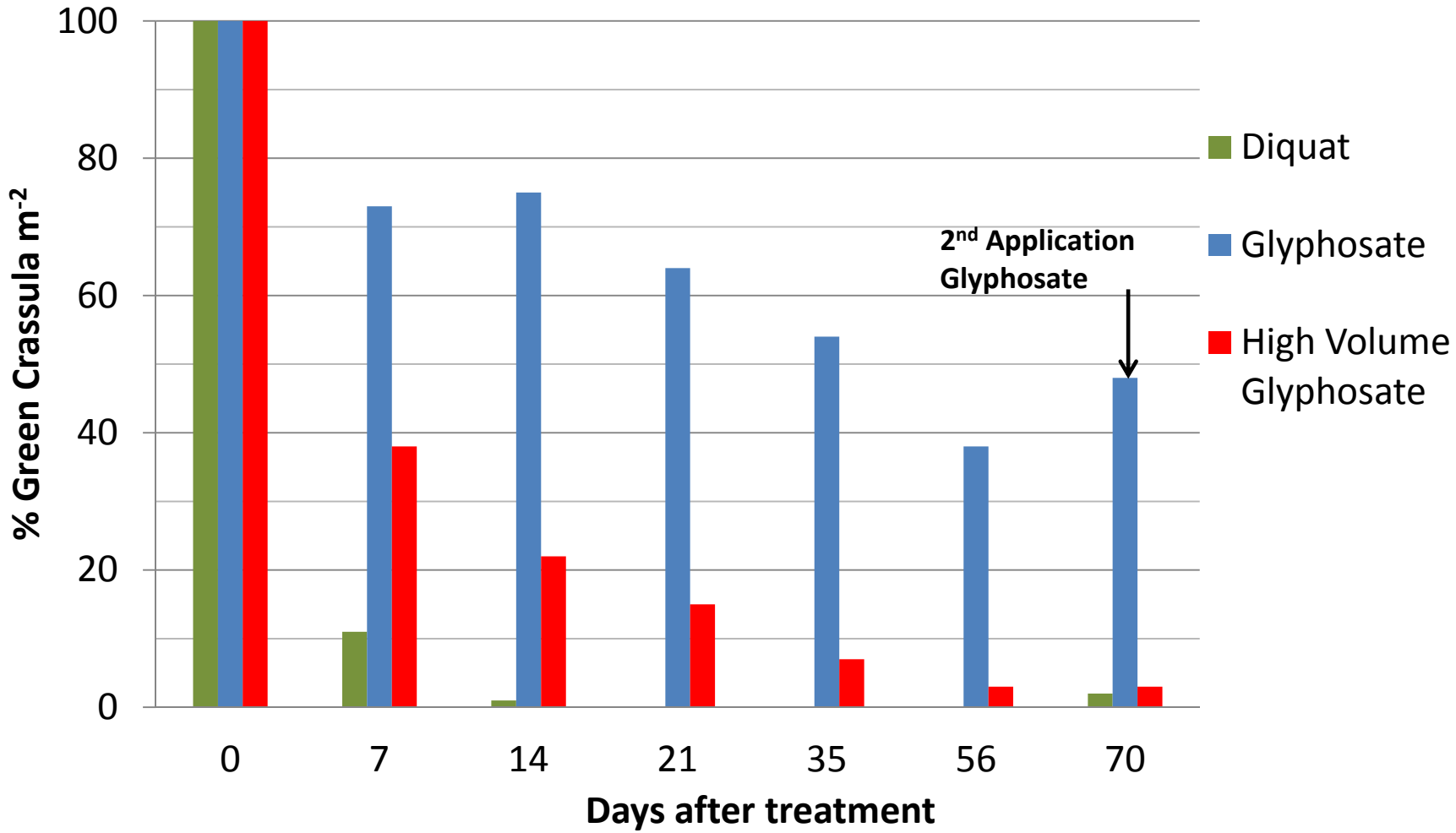



* Efficacy (lower application rates), systemicity (perennial weed control) and better safety (lower phytotoxicity)

# Useful aquatic herbicides

- Glyphosate (Roundup Pro Biactive)
  - **Still approved**
- Diquat - banned
  - Midstream - gel
    - Use in flowing water
    - Selective control of submerged patches
    - Delivery onto the weed mass
  - Reglone - liquid
    - The best herbicide for *Crassula helmsii* and *Hydrocotyle ranunculoides, and perhaps Myriophyllum aquaticum*

# Comparison of Diquat and Glyphosate efficacy on *C. helmsii*

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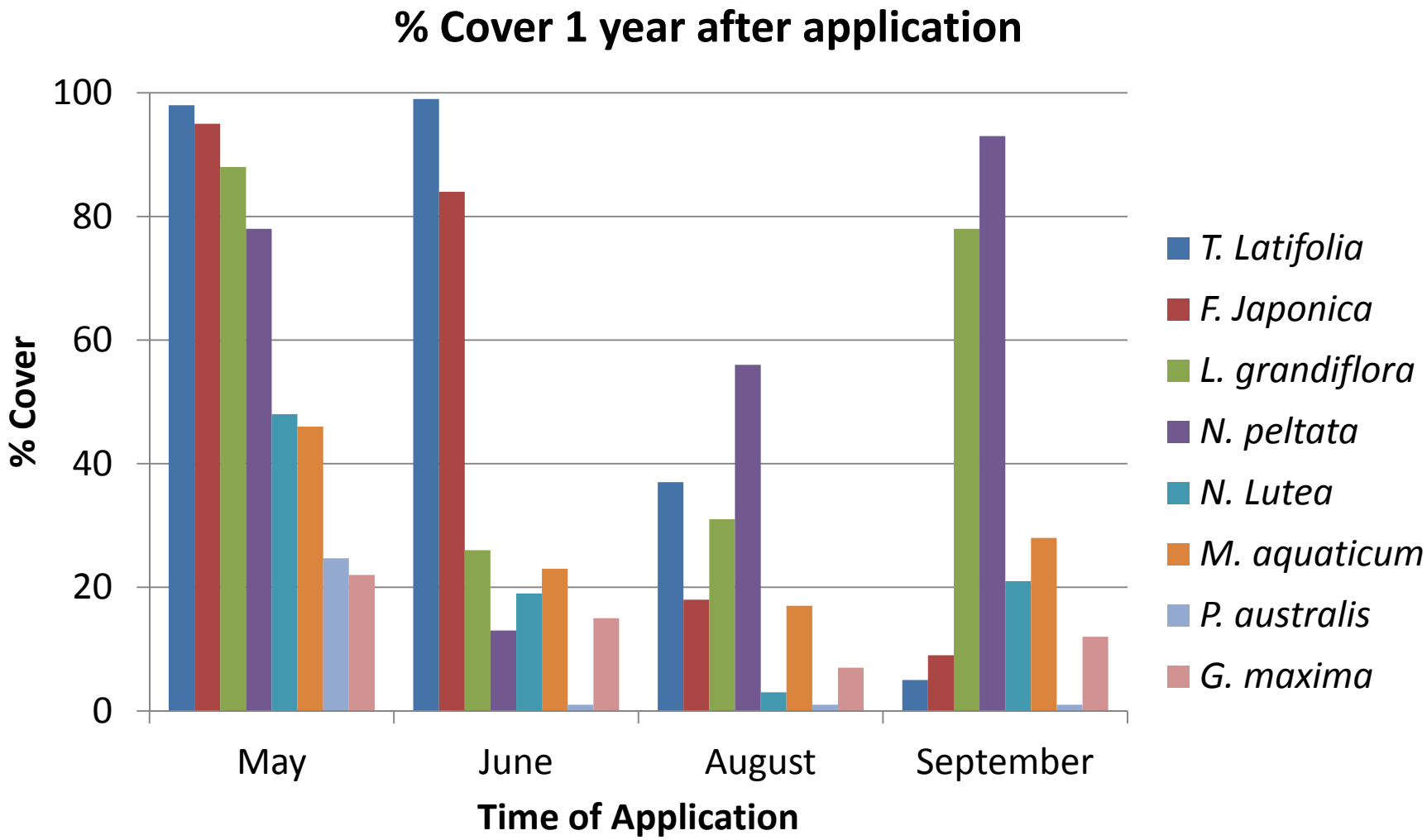
# Lack of Active Ingredients

- New active ingredient development
  - ~ 10 years
- Make existing active ingredients work better
  - Biology
  - Timing
  - Adjuvants
  - Dose rates
  - Mixtures
  - Repeat application intervals
  - Integrated management plans

# Mixtures and adjuvant effects on control of *Ludwigia grandiflora*

| Treatment | Dry weight at Time 0 (kg $m^{-2}$) | Dry weight at + 21 Days (kg $m^{-2}$) | Dry weight at + 56 days (kg $m^{-2}$) |
|---|---|---|---|
| Glyphosate | 2.10 ± 0.22 | 1.15 ± 0.32 | 0.45 ± 0.07 |
| Glyphosate + 2,4-D Amine | 2.05 ± 0.08 | 0.86 ± 0.11 | 0.63 ± 0.09 |
| Glyphosate + TopFilm | 2.21 ± 0.13 | 0.63 ± 0.28 | 0.06 ± 0.03 |
| Control – no treatment | 2.06 ± 0.19 | 2.35 ± 0.27 | 2.15 ± 0.33 |

# Effects of timing on aquatic weed control

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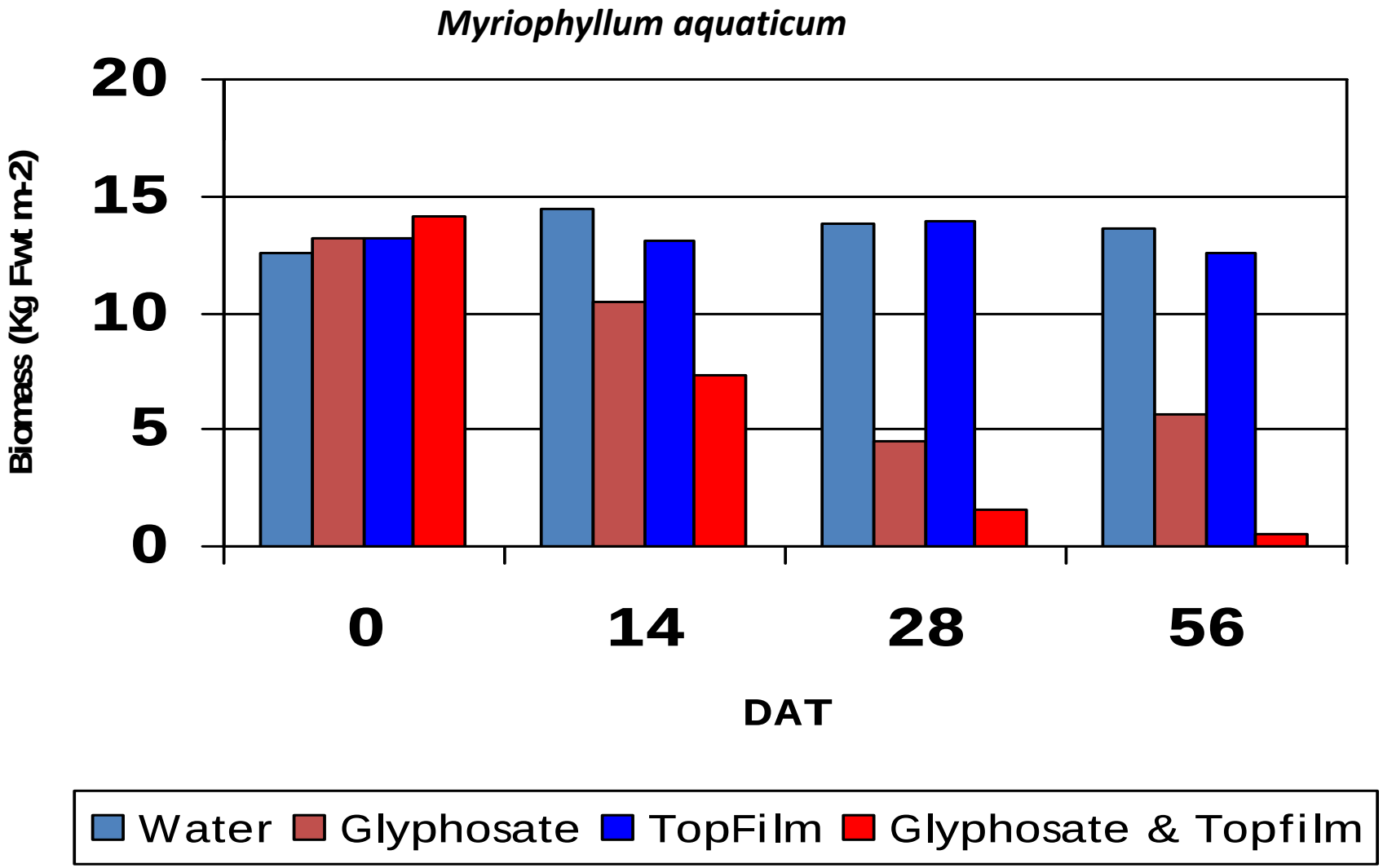
# Adjuvants

- **TopFilm®**
  - Soya microcrystalline sponge formulation
  - Sticks herbicide to leaves
  - 3 weeks rain fastness
  - 0.6% spray volume
  - €34 per hectare
- **Codacide Oil**
  - Oilseed
  - 12.5% spray volume
  - €66 per hectare
- **Ecoflex**
  - Oilseed
  - 70% spray volume
  - € 168 per hectare

# Benefits of TopFilm® for herbicide efficacy

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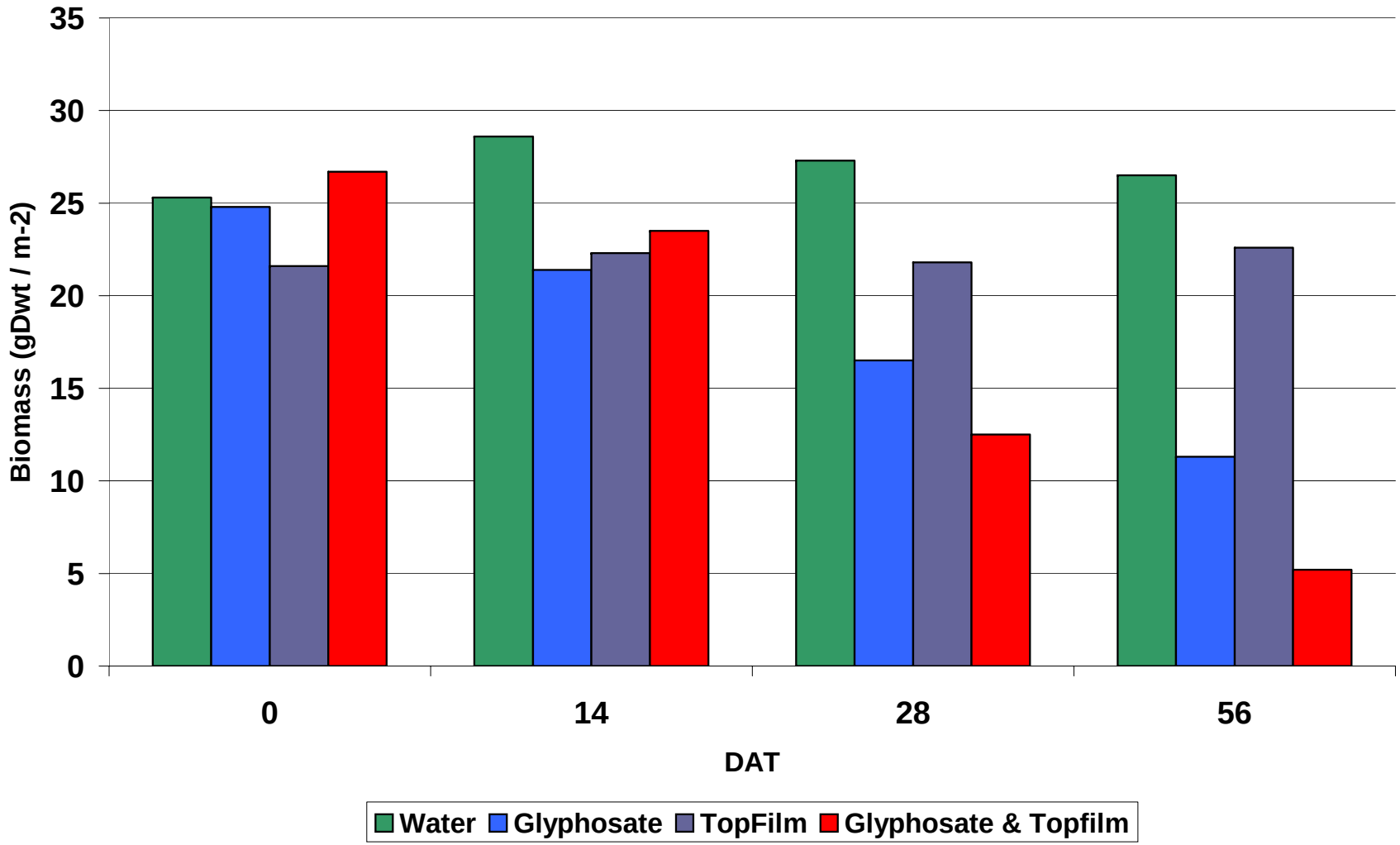
# *Ludwigia grandiflora*

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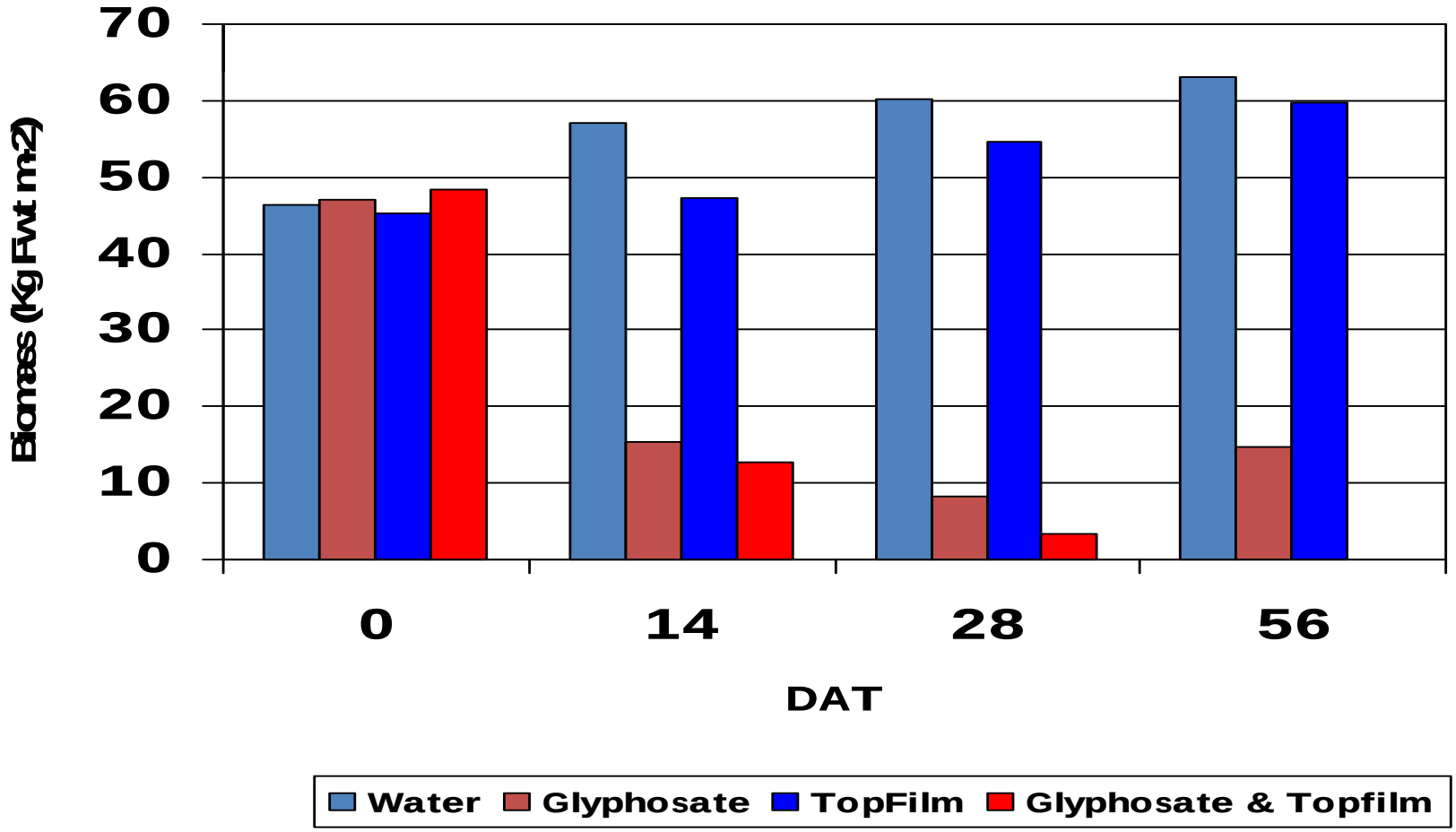
# *Hydrocotyle ranunculoides*

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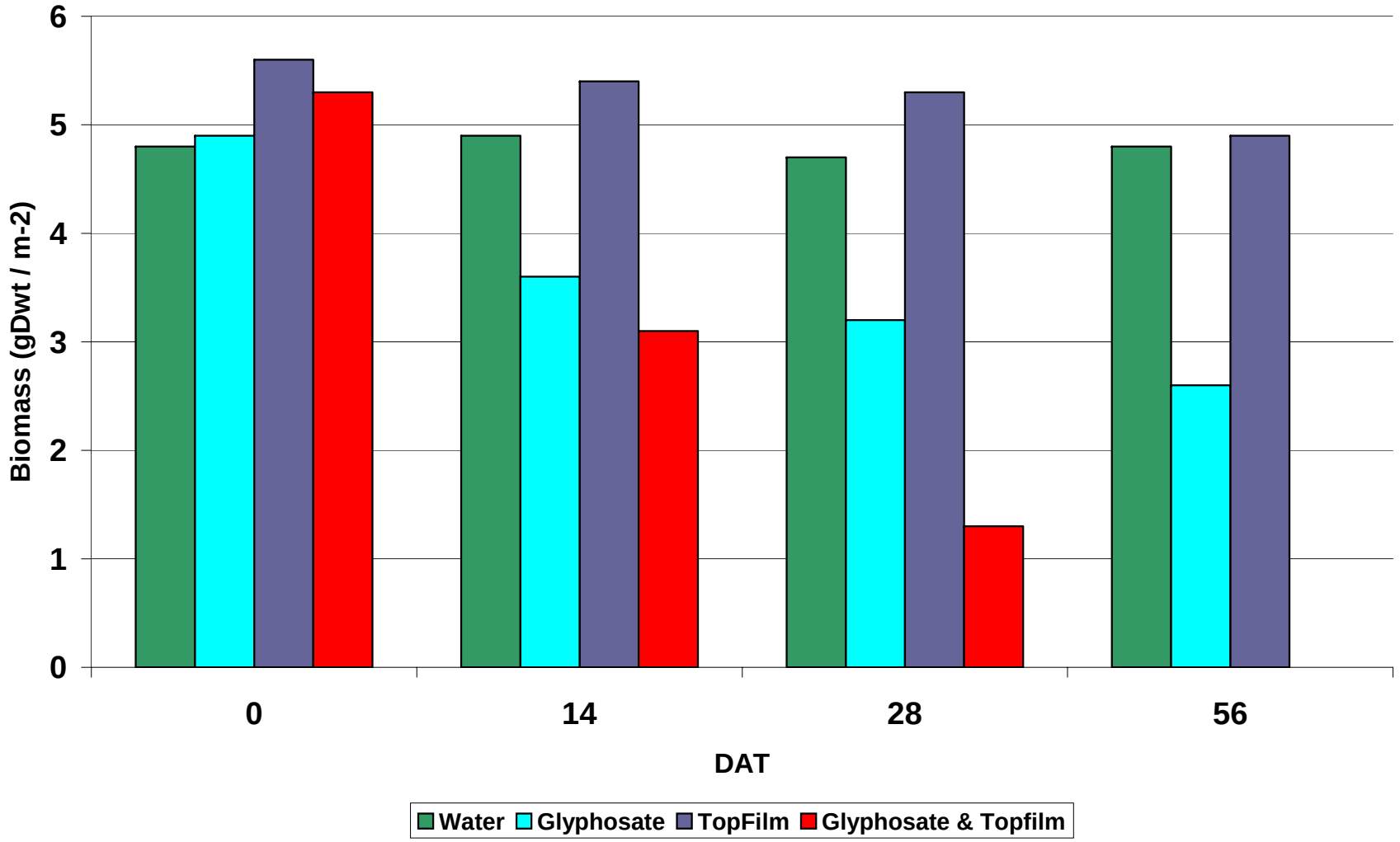
# *Nymphoides peltata*

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# Potential new herbicides for Europe

| Generic Name | Primary use/ Potential use & Herbicide Family |
|---|---|
| Triclopyr | Broadleaf weed control, floating plant control<br>*Auxin mimic* |
| Imazapyr | Floating/emergent plants only, torpedograss control.<br>More cost effective than glyphosate<br>*Acetolactate Synthase Inhibitor (ALS) – inhibits protein synthesis* |
| Carfentrazone | Water lettuce, full range of activity unknown<br>*Protoporphyrinogen Oxidase (Protox) Inhibitor – rapid cell membrane disruption* |
| Penoxulam | Hydrilla control, whole lake treatments, selectivity.<br>Timing and rates not well understood?<br>*Acetolactate Synthase Inhibitor (ALS) – inhibits protein synthesis* |
| Imazamox | Hydrilla control, whole lake treatments, selectivity.<br>Timing and rates not well understood.<br>*Acetolactate Synthase Inhibitor (ALS) – inhibits protein synthesis* |
| Flumioxazin | Contact herbicide for hydrilla control, selectivity and timing,<br>Rates not well understood.<br>*Acetolactate Synthase Inhibitor (ALS) – inhibits protein synthesis* |
| Bispyribac - Sodium | Hydrilla control, whole lake treatments, selectivity.<br>Timing and rates not well understood.<br>*Acetolactate Synthase Inhibitor (ALS) – inhibits protein synthesis* |

# Defend what we have got left

- Glyphosate
  - Questions about aquatic use
  - EQS from 2014
    - Make sure that level is correct
- Diquat
  - No hope of reinstatement
  - Badly handled and fell foul of assessment process
  - Learn the lessons
  - Help the chemical companies

# Alternative methods

- Dyes
  - Macrophytes in static water
- Ultrasound
  - Algae
- Electromagnetism
  - Algae
- Education
  - Everything

# Hydrocotyle *ranunculoides* – Best Practice

- April
  - remove by hand, mechanically and spray remainder
- May
  - Remove by hand, spray remainder
- June
  - Spray remainder
- July
  - Mechanical removal from now on if no treatment before, followed by herbicide treatment
- September – January
  - Mechanical control, hand picking, herbicide, every 2 – 3 weeks

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# *Ludwigia grandiflora* – Best Practice

- Spray with 2,4-D amine or Glyphosate with TopFilm as often as is required
- Retreat seedlings or growth from fragments
- Dig up and bury on site

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# Mixed Communities Work Better

**Manage expectations:**

1. You will not get rid of invasive aquatic species at every site in a short time

2. Aim to minimise the risks and spread until control measures become economically acceptable

3. Get everyone involved

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