Crop Protection Online

Preventive and curative measures against herbicide resistant weed species

Latest version: April 2017

What is herbicide resistance?

In Denmark, there are increasing problems with weed populations less sensitive to certain herbicides. In the field, herbicide resistance is detected when the efficacy of a herbicide is significantly lower than expected.

Two different types of resistance occurs in Denmark:

Target site resistance
Resistant plants prevents herbicide active substance by blocking a specific biochemical process in the plant. The effect is 'on / off', which means that resistant plants will be completely unaffected by the dose that previously gave satisfactory effect

Metabolic resistance
Resistant plants convert (metabolize) the active substance to a greater or lesser degree. This characteristic often occurs gradually over several years, so this type of resistance can be difficult to detect.

To which herbicides are resistance developed against?

In Denmark, there are many herbicides with similar modes of action in plants. This means that resistance to one herbicide in the group automatically leads to resistance to other herbicides with the same mode of action. This is called 'cross-resistance'.

Presently, considerable resistance to three groups of herbicide-active substances is detected; SU-products containing active substances from the sulfonylurea group, ALS-products containing triazolopyrimidins and the so-called fop/dim-products (the active agent names end in '-fop' or '-dim').

SU- and ALS-products

Examples of SU-products include the following herbicides (active substances in brackets):

- Ally (metsulfuron methyl)
- Atlantis WG (mesosulfuron-methyl + iodosulfuron-methyl-Na)
- Broadway (florsulam + pyroxsulam)
- Express (tribenuron methyl)
- Harmony Plus (imazethapyr)
- Hussar OD (iodosulfuron-methyl-Na)
- MaisTer (foramsulfuron + iodosulfuron)
- Monitor (sulfosulfuron)

• Primus (florasulam)
• Hussar (iodosulfuron)

SU-products acts by blocking the synthesis of branched amino acids in plants by blocking (inhibiting) enzyme acetolactat synthase (ALS). Because ALS is controlled by one gene in plants, just one 'unfortunate', natural mutation can start a resistant population.

Triazolopyrimidins also acts by blocking (inhibiting) enzyme acetolactat synthase (ALS) and cross-resistance is observed between the two groups.

Examples of ALS-products include the following herbicides (active substances in brackets):

- Broadway (florasulam + pyroxsulam)
- Primus (florasulam)

ALS-inhibiting herbicides are classified as HRAC: Class B

Fop/dim-products

Examples of fop/dim-products include the following herbicides (active substances in brackets):

• Agil 100 EC (propaquizafop)
• Focus Ultra (cycloxydim)
• Fusilade Max (fluazifop-P)
• Primera Super (fenoxaprop-P)
• Topik (clodinafop)

Fop/dim-products block the synthesis of fatty acids in plants, by inhibiting the enzyme acetyl CoA carboxylase (ACCase). Because ACCase is controlled by one gene in plants just one 'unfortunate', natural mutation can start a resistant population.

ACCase-inhibiting herbicides are classified as HRAC: Class A

Metabolic resistance
The level of metabolic resistance varies and it is not possible to set a precise level. It has been decided to operate with a general level of 40% of the efficacy to susceptible species in Crop Protection Online when considering products containing only fop/dim- og ALS-products. This is intended as an indication of the required changes in choice of product, when metabolic resistance is discovered in a field. As metabolic resistance develops a range of products will no longer be able to provide the needed efficacy (reach the target efficacy). Hence, these solutions will no longer be the optimal choice to control the metabolic resistant biotypes. The products can still be found in a solution with mixed products if other species occur in the field, which are still susceptible.

Which weed species may be resistant?

In Denmark, SEGES monitors the development of resistance in cooperation with the AU.

This is done by farmers submitting viable seeds from plants suspected of herbicide resistance to AU. The seeds are then tested for resistance for a fee. Contact: Solveig K. Mathiassen sma@agro.au.dk. Guide to order a test for resistance is found here.

A monitoring project was conducted between 2013 and 2016 by Aarhus University and the report can be downloaded as a pdf (in Danish). Not all resistant species were registered in the monitoring project and the report must be considered a supplement to the complete list of resistant species in Denmark.

Resistant plants regarded as 'resistant biotypes' of a particular weed. There are significant populations of resistant biotypes against SU, ALS and fop/dim and some which are resistant to both modes of actions, simultaneously.

Weed species	Resistance mechanism	First registered observation	Number of locations with confirmed resistance
Perennial ryegrass	Fop/dim-res (ACCase) ALS-res Metabolic resistance	2015	3
Blackgrass	Fop/dim-res (ACCase) ALS-res Metabolic resistance	2001	83
Chickweed	SU-res ALS-res	1991	27*
Hemp-nettle	SU-res (ALS)	?	1
Shephards purse	SU-res (ALS)	2011	1
Ital. ryegrass	Fop/dim-res (ACCase) ALS-res Metabolic resistance	2009	28
Poppy	SU-res ALS-res	2003	10
Scentless chamomile	SU-res ALS-res	2010	19
Corn marigold	SU-res (ALS)	2010	2
Silky bent grass	ALS-res Metabolic resistance	2010	6

The list is continously being updated along with new registered observations. *chickweed is no longer being registered as it is commonly found all over Denmark.

In Crop Protection Online the biotypes is named after the following principle:

- [Species name] SU-res
- [Species name] ALS-res
- [Species name] fop/dim-res
- [Species name] metabolic

PVO containing the following resistant biotypes of weeds:

• Common chickweed SU-res
• Common chickweed ALS-res
• Mayweed, scentless SU-res
• Mayweed, scentless ALS-res
• Poppy, corn SU-res
• Poppy, corn ALS-res
• Blackgrass SU-res
• Blackgrass fop/dim-res
• Blackgrass metabolic
• Ryegrass, Ital., SU-res
• Ryegrass, Ital., fop/dim-res
• Ryegrass, Ital., metabolic
• Ryegrass, perennial, SU-res
• Ryegrass, perennial, fop/dim-res
• Ryegrass, perennial, metabolic
• Silky bent grass, SU-res
• Silky bent grass, fop/dim-res
• Silky bent grass, metabolic

New resistant weed biotypes are added when they become agronomically relevant.

Strategy for control

Prevention of development of resistant biotypes

Resistant biotypes occur from time to time by natural mutations affecting the genes, which are involved in the biochemical mechanism causing the herbicide action.

If the resistant biotypes are affected by herbicides with a single mode of action repeatedly season after season, it is highly likely that a resistant population will develop.

There are not many exact test results from Denmark or abroad, which shows you how often you can repeat application with the same mode of action on the same area and maintain security against resistance development.

A relatively conservative (safe) approach is to systematically change herbicide group between each growing season. Especially for the herbicide groups, for which significant problems with resistance has already been detected. Other means are a diverse crop rotation, avoid dense weed stands and incorporate mechanical weeding.

SEGES has produced information on prevention of resistance, which can be found here. For more information on IPM from SEGES (www.dansk-ipm.dk)

Control of resistant biotypes

All types of resistance is serious, because resistant plants and their descendants will never regain normal sensitivity. Therefore, resistant populations must be controlled efficiently.

This can be done by demanding 95 - 97% efficacy from herbicides with other modes of

action and / or other control methods in several seasons in succession until no viable seeds or other living plants of the resistant biotypes is detected.

Crop protection Online demands resistant biotypes controlled with the following effects in different density classes:

- ½ - 1 pl./m2: 95%
- 2 to 10 pl./m2: 95%
- 11 to 40 pl./m2: 95%
- 41-150 pl./m2: 96%
- > 150 pl./m2: 97%

According to the literature, weed seeds in the ground dies with a speed that best indicated by a half-life. This means that even after many years of effective control a few seeds in the ground can be viable. These seeds can quickly regenerate a population in a field. Lifetime depends on species, and therefore it is recommended that effective control of resistant biotypes is continued in the following number of years:

Common chickweed	6-8 years
Mayweed, scentless	6-8 years
Poppy	8-10 years
Blackgrass	4-6 years
Ryegrass, Ital. + perennial	4-6 years
Silky bent grass	4-6 years

In Crop Protection Online the efficacies for the resistant biotypes of herbicides with the mode of action that the species are resistant to are extremely low. For metabolic biotypes a general level of 40% compared to susceptible biotypes has been decided upon. This forces PVOs Problem solver to select herbicides with other mechanisms of action that is expected to have the same effect on both resistant and non-resistant biotypes.