PERENNIAL WEEDS

A growing problem

10-12 November 2008

Wageningen
The Netherlands

PERENNIAL WEEDS

A growing problem

Programme and Abstracts

10-12 November 2008

Wageningen University
Wageningen
The Netherlands

An
EWRS – NJF WORKSHOP

Rationale

Perennial weed species are identified as an upcoming and increasing problem in European agriculture. This is, however, not yet reflected in the current weed research agenda. Work is going on, but often the activities are modest and very scattered. To be better able to appreciate what has been established, what is going on and what still needs to be done, the European Weed Research Society (EWRS), in collaboration with the Nordic Association of Agricultural Scientists (NJF) and Wageningen University, has taken the initiative of organizing a 3-day workshop on this topic.

Main objectives of the meeting are:

- To identify and detail the perennial weed problem
- To update our current understanding of the biology and ecology of perennial weeds
- To make an inventory of current control options and management strategies
- To inform one another on ongoing research projects
- To discuss future research needs and prospects for collaboration

Venue

WICC
Wageningen International Conference Centre
(Hof van Wageningen)
Lawickse Allee 9
6701 AN Wageningen
Tel. 31(0) 317 490 133

Organizing committee

Lammert Bastiaans
Ilse A. Rasmussen
Jukka Salonen
Rommie van der Weide

Proceedings of the EWRS-NJF Workshop on '*Perennial Weeds – A Growing Problem*', Wageningen University, Wageningen 10-12 November, 2008.

Programme

Monday 10 November 2008

Arrival of participants at WICC

12:30-13:15 Lunch
13:15-13:40 Welcome and introduction of participants

Session 1 – Identification of the perennial weed problem
Chair: Ilse A. Rasmussen

13:40-14:05 Jukka Salonen – *Key perennial weeds in arable crops in the Nordic countries.*
14:05-14:20 Dace Piliksere – *Perennial weeds in Latvia*
14:20-14:30 Baerbel Gerowitt – *Perennial weeds in Germany*
14:30-14:40 Rommie van der Weide – *Status of perennial weeds in The Netherlands*
14:40-14:50 Lynn Tatnell – *Perennial weeds in the UK*
14:50-15:20 Dace Piliksere – *Diversity of perennial weeds as affected by crop rotation.*

15:20-15:40 Discussion I – ranking the weeds and identifying their main drivers

15:40-16:10 Coffee break

Session 2 – Current control and management
Chair: Rommie van der Weide

16:10-16:40 Anne Merete Rask – *Non-chemical weed control on hard surfaces – an investigation of long term effects of thermal weed control methods.*
16:40-17:10 Bo Melander – *Exposure and destruction of* Elymus repens *rhizomes and* Rumex crispus *rootstocks.*
17:10-17:40 Marleen Riemens – *Management and control of perennial weeds.*
17:40-18:10 Lars-Olav Brandsaeter – *Effects of undersown red clover, autumn mechanical treatments and ploughing time on some creeping perennial weeds in cereals.*

18:10-18:40 Discussion II – destruction or starvation

19:00-20:30 Dinner

Tuesday 11 November 2008 [1)]

Session 3: The life-cycle of perennial weeds
Chair: Jukka Salonen

9:00-9:30 Theo Verwijst – *Pre-emergence variation in willow cuttings: Size variation and allelometry of shoots during early development.*

9:30-10:00 Anneli Lundkvist – *The effects of pre-emergence variation in roots of* Sonchus arvensis *L. and* Cirsium arvense *(L.) Scop. on their population dynamics.*

10:00-10:30 Lammert Bastiaans – *Modelling population dynamics of perennial weed species – what is making the difference?*

10.30-11:00 Coffee break

11:00-11:30 Baerbel Gerowitt – *Spread and survival of* Cirsium arvense *by seeds and root fragments*

11:30-12:30 Discussion III – where to target perennial weed species

12.30-13:30 Lunch

13:30-14:30 Guided Wageningen City tour

Session 4: Biology and ecology of perennial weeds
Chair: Lammert Bastiaans

14:30-15:00 Lynn Tatnell – *Glasshouse and pot experiments on common couch (*Elytirgia repens*) and creeping thistle (*Cirsium arvense*) biology*.

15:00-15:20 Lars Andersson – *Dormancy in reproductive vegetative buds of perennial species dominating the agricultural weed flora in Scandinavia.*

15:20-15:45 Josefine Liew – *continuation of the previous presentation*

15:45-16:15 Coffee break

16:15-16:45 Libère Nkurunzia – *Induced adventitious bud sprouting and carbohydrate reserves remobilization in Canada thistle (*Cirsium arvense *(L.) Scop.).*

16:45-17:15 Jukka Salonen – *Activities of the NJF working groups on Perennial Weeds – Comparison of seasonal sprouting readiness of three perennial weeds*

17:15-18:15 Discussion IV – identifying important research priorities

19:00-21:00 Dinner

[1)] *A Board meeting of the NJF Working Group on Perennial Weeds is scheduled from 8:00-9:00 in the morning.*

Wednesday 12 November 2008

Session 5: Experimental aspects
Chair: Rommie van der Weide

9:00-9:30 Ilse A. Rasmussen - *Research project on* Cirsium arvense *and* Tussilago farfara – *examples of how to design experiments and take samples.*

9:30-10:00 Theo Verwijst – *Size and weight relations in* Cirsium arvense (L.) Scop.: *The use of allometric relations to assess above-ground growth and allocation patterns.*

10:00-10:30 Discussion V – experimentation with perennial weeds

10:30-11:00 Coffee break

Session 6: Future research initiatives
Chair: To be announced

11:00-11:20 Overview of current research projects

11:20-12:20 Discussion VI – new research projects and future collaboration

12:20-12:30 Closing and Coming Events
Lammert Bastiaans and Jukka Salonen

12:30-13:30 Lunch

Depart of participants

Content

Abstracts

Key perennial weeds in arable crops in the Nordic countries

Jukka Salonen*, Lars Andersson, Christian Andreasen & Kirsten Semb Torresen

MTT Agrifood Research Finland, FIN-31600 Jokioinen, Finland.
e-mail: jukka.salonen@mtt.fi

Our review on the most common perennial weeds in the Nordic countries draws on 1) a Nordic/Baltic joint desk-top study done in 1997-99, 2) information from national weed surveys and 3) expert opinions from Denmark, Finland, Norway and Sweden.

Cereals are the predominant crops in the Nordic countries, where temperature represents a major constraint on types of cultivated crops and weed species associated with prevailing cropping systems. The relative importance of grassland increases towards the north in Norway, Sweden and Finland. Similarly, the dominance of spring-sown annual crops increases from south (DK) to north.

The weed species of greatest economic importance in the region is *Elymus repens* (syn. *Agropyron repens*, *Elytrigia repens*). Its relative importance has increased, as demonstrated e.g. in the national weed surveys of FI from the 1960s until today. *E. repens* is a problem weed also in NO and SE despite common use of glyphosate. In DK, however, the occurrence of *E. repens* has declined in the main crops since the 1960s, probably because of regular use of selective graminicides and the non-selective glyphosate, but it is still considered to be a noxious weed. In the countries north of DK the short period when glyphosate can be applied and the less favourable climatic conditions after harvest weaken the control effect.

Other troublesome perennial grasses are volunteers such as *Lolium perenne*, *Poa trivialis* and *Poa pratensis*. These species can pose serious problems in grass seed production (DK) by contaminating seed lots. In direct drilling, *Phleum pratense* also occurs as a volunteer weed (FI).

The most common broad-leaved perennials are *Cirsium arvense* and *Sonchus arvensis*. They thrive particularly well in organic cropping systems, but also in conventional cereal production because the early application time of the commonly used sulphonylureas is not optimal for their control. Moreover, the use of more effective phenoxy acid herbicides has been restricted (DK) because of the risk of leaching. The increasing area sown to winter crops results in less time between harvest and sowing, which in turn means less thorough soil cultivation. This favours perennial, vegetatively propagated species such as *Artemisia vulgaris*, which thrives also in fields with reduced or no-tillage.

The area of grassland has decreased and become restricted to particular regions in each country. The characteristic grassland weeds (e.g. *Achillea millefolium, Ranunculus repens, Taraxacum* spp.) have become less dominant in crop rotations. However, farms with livestock encounter problems with some perennial species like *Juncus* spp. (NO) and *Rumex* spp., which have increased substantially during recent decades (in SE).

The composition of the weed flora is slowly but continuously shifting, reflecting adaptation to climate changes as well as to alterations in cropping systems and cropping practices. Perennial weed species are likely to maintain their key status both in terms of their economic importance and their challenging control.

References

Andreasen, C. & Stryhn, H. 2008. Increasing weed flora on Danish arable fields and its importance for biodiversity. *Weed Research* **48**, 1-9.

Andreasen, C., Stryhn, H. & Streibig, J.C. 1996. Decline of the flora on Danish arable fields. *Journal of Applied Ecology* **33**, 619-626.

Håkansson, S. (1995). Weeds in Agricultural Crops. 1. Life-forms and occurrence under Swedish conditions. *Swedish J. Agric. Res.*, 25, pp. 143-154.
Hyvönen, T., Ketoja, E. & Salonen, J. 2003. Changes in the abundance of weeds in spring cereal fields in Finland. *Weed Research* **43**, 348-356.
Salonen, J., Bromand, B. & Jørgensen, L.N. 2001a. Crop production conditions in the northern European region with a special reference to crop production. *DIAS report* No. 59. 125 p.
Salonen, J., Hyvönen, T. & Jalli, H. 2001b. Weeds in spring cereal fields in Finland – a third survey. *Agricultural and Food Science in Finland* **10**, 347-364.
Tørresen, K.S., Skuterud, R., Tandsæther, H.J. & Hagemo, M.B. 2003. Long-term experiments with reduced tillage in spring cereals. I. Effect on weed flora, weed seedbank and grain yield. *Crop Protection* **22**, 185-200

***Table 1**. Ranking of some perennial weed species in the Nordic/Baltic region according to Salonen et al. (2001a). Species marked with 1 cause minor problems, but they have to be controlled sporadically. Species marked with 2 cause problems in most years and have to be controlled regularly. 0 indicates weeds of no economic importance or not found in the country. Based on expert opinions from each country and related to the situation at the end of the 1990s.*

	COUNTRY							
Weed species	**EE**	**LT**	**LV**	**DK**	**FI**	**NO**	**SE**	**PL**
Achillea spp.	1	2	1	0	1	1	0	1
Alopecurus geniculatus	1	0	0	2	1	1	0	1
Anthriscus sylvestris	2	1	0	0	1	1	1	0
Artemisia vulgaris	2	2	1	2	1	1	1	1
Cirsium spp.	2	2	2	2	2	1	2	1-2
Cerastium arvense		2	1	1	0	1		1
Elytrigia repens=Agropyron repens	2	2	2	2	2	2	2	1-2
Equisetum arvense	2	2	1	2	1	1	1	1-2
Mentha arvensis	2	2	1	1	0	1		1
Plantago major		2	1	0	1	1		1
Ranunculus spp.	2	1	1	0	1	2	2	1
Rumex spp.	2	2	1	2	1	2	1	1
Sonchus arvensis	2	2	2	2	2	2	2	2
Stachys palustris	1	2	1	0	1	1	1	1
Taraxacum spp.	2	2	1	1	1	2	2	1-2
Tussilago farfara	2	1	1	1	1	1	1	1-2
Urtica spp.		2	1	1	0	1	1	1-2

Status of perennial weeds in the Netherlands

Rommie van der Weide*, Piet Bleeker, Marleen Riemens & Lammert Bastiaans

PPO, Wageningen University and Research centre, Edelhertweg 1, 8219 PH Lelystad, The Netherlands. e-mail: rommie.vanderweide@wur.nl

The number of perennial weeds is increasing significantly in the Netherlands. This is especially noticeable in maize, cereals, sugarbeet, onion, carrot, almost all vegetable crops, summerflowers and trees in both organic as well as conventional agricultural systems. The most problematic species are *Sonchus oleraceus*, *Cirsium arvense*, *Rorippa sylvestris, Cyperus esculentus*, *Mentha arvensis*, *Elymus repens*, *Persicaria amphibia*, *Convolvulus sepium, Inula britannica, Petasites hybridus* and *Equisetum arvense.* Especially organic growers consider perennial weeds as problematic and sometimes choose to fallow and regularly cultivate. Growers of trees and plant material are not allowed to distribute their plants when the soil is infested with perennials. In case of a *Cyperus* infestation there is a regulation which prohibits the cultivation of root crops and orders the control of *Cyperus* for several years. Another regulation aims at prevention of seed spread of *Cirsium* and *Sonchus*.

The increase in spread of the perennials is a result of:

- the reduced availability of herbicides (e.g. 2,4 D and MCPA are restricted in use, dichlobenil will disappear),
- the reduced maximum allowed dosages (e.g. dose restrictions of 2,4 D and MCPA),
- changes in crop rotations (e.g. more green manure crops in autumn, less fallow with grass in organic farming),
- regulatory changes regarding mineral accounting system (e.g. killing of grassland only allowed in spring, green fallow compulsory after maize),
- warmer winters and wetter summers (climate change) during recent years.

Diversity of perennial weeds as affected by crop rotation

Dace Piliksere

State Priekuli Plant Breeding Institute, 1A Zinatnes Street, Priekuli, Cesis District, LV-4126, Latvia
e-mail: dacepil@e-no.lv

Traditional soil tillage is very energy-intensive and expensive. Therefore, different possibilities to minimize the primary soil tillage in crop rotations are studied in Europe and also in Latvia. However, it was observed that minimization of primary soil tillage encourages spreading of perennial weed species (Ausmane & Melngalvis, 2007).

Investigations on weed infestations in arable fields were carried out at State Priekuli Plant Breeding Institute in Latvia (57˚19΄ N, 25˚20΄ E). Weed species (both annual and perennial; at species or family level) and weed abundance (plants per m^{-2}) were determined in three 6-field crops rotations during the period from 2006-2008. Crop rotations were:

1) spring cereals – spring cereals/clover – clover – winter cereals – potato – oilseed radish or rape (organic crop rotation);
2) barley – clover/grass – barley – rye – barley – potato;
3) barley – clover/grass – clover/grass – rye – barley – potato.

The latter two crop rotations were established under five different fertilization systems: unfertilized, animal manure (20 t ha^{-1}), NPK (66, 90, 135), animal manure + NPK (66, 90, 135), NPK (132, 180, 270). No herbicides were used throughout the experiment.

The aim of this research was to study the diversity of perennial weeds in differently managed arable fields. This information should serve as the knowledge base for making recommendations regarding control of these long-living weeds in the upland regions of NE Europe.

The results showed higher diversity of perennial weeds in the organically managed crop rotation. In this rotation, 16 different perennial weed taxa were observed, while only 9 perennial weed taxa were identified in conventionally managed rotations. Characteristic perennial weeds in the conventionally managed system were: *Sonchus* spp., *Cirsium* spp., *Plantago* spp., *Taraxacum* spp., *Equisetum arvense*, *Elytrigia repens*, *Potentilla anserina*, *Stachys palustris* and *Mentha arvensis*. Only the latter two from these weed taxa were not registered in the organic crop rotation. However, other perennial weeds were present, particularly: *Trifolium* spp., *Cerastium* spp., *Festuca* spp., *Rumex* spp., *Epilobium* spp., *Achillea millefolium*, *Artemisia vulgaris*, *Ranunculus repens* and *Tussilago farfara*. Not all weed species were wild plants. Some of them were relicts of cultivated plants from previous years.

Results of this investigation enabled us to identify and detail the perennial weed problem. It builds the base for further data analysis and conclusions. There are many factors that should be taken into consideration to solve the problem of perennial weed infestation: environmental (soil properties, weather conditions, weed seed bank), economic (soil tillage practice, costs) and social factors (human resources and knowledge). Due to the many factors that are involved it is to be expected that only an integrated approach will lead up to a sustainable desirable result.

Reference

Ausmane M., Melngalvis I. (2007) Minimalization of primary soil tillage in crop rotation III. The changes in weediness of sowings. *Proceedings of the Latvia University of Agriculture* 18 (313); 1-8

Non-chemical weed control on hard surfaces – an investigation of long term effects of thermal weed control methods.

Anne Merete Rask* & Christian Andreasen

Danish Centre for Forest, Landscape and Planning Department of Agricultural Sciences, University of Copenhagen. e-mail: anr@life.ku.dk

A literature review carried out by Rask and Kristoffersen (2007) revealed that there is a substantial need to optimise the dose and increase the knowledge of treatment intensity of non-chemical weed control methods (Rask & Kristoffersen, 2007). Especially, there is a need to investigate how repeated treatments during a growing season influence the optimal dose. Research on traffic islands in 2004 by Kristoffersen *et al.* (2007) shows that established grass weeds could be kept down with 8 flame treatments per year with a dose of about 1000 kWh ha^{-1}. These experiments were carried out with a fixed dose and fixed number of treatments on hard surfaces. In 2005-2006 the number of treatments was determined by the weed coverage, whereas the dose was still fixed at 1000 kWh ha^{-1}. The results showed that with 5-7 treatments a year the weed cover could be kept below 2%.

The present experiments are being carried out from September 2007 to August 2010 as part of a PhD study. The aim is to investigate long term effects of thermal weed control methods (mainly flame weeding) on perennial weeds, and optimise non-chemical weed control on hard surfaces (dose, treatment frequency, influence of species composition).

One experiment carried out in 2008 and 2009 is a semi-controlled dose-response study with varying doses and treatment intervals during two entire growing seasons. The aim is to estimate doses and treatment frequency necessary to control established grass weeds on long term basis. The preliminary results from 2008 will be presented at the Perennial Weed Workshop. A trial with *Lolium perenne* was prepared in autumn 2007 and treatments are carried out at regular intervals from May-October 2008. The experiment will be repeated in 2009. The treatments are carried out with a HOAF thermHIT® 75M gas burner with a working width of 75 cm. The field is divided into 37 treatment areas per block, 3 blocks in total. The doses vary from 20 to 180 kg gas ha^{-1}.Treatment intervals vary from every second week to two treatments per year. Weed coverage is assessed by digital image analysis of marked plots (three per treated area).

References

Kristoffersen P, Rask AM & S U Larsen (2008) Non-chemical weed control on traffic islands: A comparison of the efficacy of five weed control methods. *Weed Research* 48, 124-130

Kristoffersen *et al.* (2007) http://www.cleanregion.dk/Kristoffersen%20oct.07.pdf.

Rask AM & P Kristoffersen (2007) A review of non-chemical weed control on hard surfaces. *Weed Research* 47 (5), 370-380.

Exposure and destruction of *Elymus repens* rhizomes and *Rumex crispus* rootstocks

Bo Melander*, Michael Nørremark & Erik Fløjgaard

*Aarhus University, Faculty of Agricultural Sciences, Department of Integrated Pest Management, Denmark. e-mail: Bo.Melander@agrsci.dk

The traditional strategy of repeated stubble cultivation to control *Elymus repens* evolved from the basic studies in the 1960's on *E. repens* rhizome growth in response to mechanical disintegration, uprooting, desiccation and subsequent burial. However, the efficacy depends strongly on weather. In organic farming, intensive and prolonged post-harvest tillage is often avoided because of the preference to keep the soil plant-covered to maintain otherwise leachable nutrients in the upper soil layer. Alternatively, a competitive catch crop could be sown immediately after a few initial stubble cultivations. This strategy was investigated in the recently finished Danish project *Management of perennial weed species in organic farming* (DARCOF II). However, the effect was small and the strategy would only be relevant at low infestation level.

To meet the need for plant cover during the post-harvest period, we suggest an innovative approach: effective uprooting, exposing and destroying of the rhizomes within a short time span using new machinery developed for this purpose. Melander (*unpubl. data*) found that only half of the rhizome biomass in the soil was exposed on the soil surface, using 1-2 passes on a sandy soil with the currently most promising implements. But in previous investigations, much better rhizome exposure was obtained, and with new tool designs an even more effective uprooting seems achievable, considering the predominant placement of the rhizomes in the top 5-15 cm soil layer according to the studies of Håkansson in the 60's. Exposing the rhizomes will not necessarily kill them in the humid autumn climate of Scandinavia, and a strategy aimed at exhausting the rhizomes by repeated cultivation, stimulating rhizome buds to sprout repeatedly, is costly and with erratic effect. Mechanic removal of rhizomes from the field (up to 8 tons per ha) seems not feasible. However, physical destruction quickly after exposure appears possible, and research should look at the practical use and efficiency of different methods of rhizome destruction, e.g. hot water, flaming, steaming, mechanical crushing and high voltage.

Rumex crispus control is most effective when rootstocks are manually uprooted and removed from the field. However, there is a need to rationalise uprooting and removal of rootstocks and therefore the technology developed for *E. repens* should also include capabilities to control *R. crispus* rootstocks.

The work on effective uprooting, exposing and destroying of *E. repens* rhizomes and *R. crispus* rootstocks are dealt with in the newly started Danish research project entitled: *Effective control of perennial weeds and intra-row weeds in organic farming – novel technology and new management strategies* (http://www.weeds.elr.dk/uk/). In this presentation, we will present the first results with destructing *E. repens* rhizomes and discuss our initiatives with designing and investigating new technologies for the exposure of vegetative propagules.

Management and control of perennial weeds

Marleen Riemens*, Piet Bleeker, Roel Groeneveld, Rommie van der Weide, David van der Schans

Plant Research International, Droevendaalsesteeg 1, 6708 PB Wageningen.
e-mail: marleen.riemens@wur.nl

One of the largest problems in organic agriculture is perennial weed control. It is almost impossible to completely eradicate these weeds and very difficult to control them. Our research focuses on the exploration and development of a systems approach based weed control. The approach comprises the development and adjustment of a large number of crop growth procedures, such as the inclusion of green manures and timing of tillage to decrease the perennials' possibilities to thrive.
The research started with an analysis of the biology of the most troublesome species at present, and those species that are expected to become increasingly more difficult to control in future. The weakest spots in the life cycle of the species are used to develop an optimal control system.
One of the species under investigation is *Sonchus arvensis*. This species uses reserves from its rhizomes for its initial growth. Assimilates, produced by the aboveground plant parts will replenish these reserves after the 5-7 leaf stage is reached. Prior to this stage, the reserves are not replenished. Belowground cutting of the main root in this stage will wear the rhizomes of the plant out and help improve control of the plant.
Several field experiments (2003-2008) were performed to investigate the optimum cutting depth in relation to weather and soil type. Furthermore, the efficacy of this root cutting method was compared with the effects of coverage (plastic), hoeing at different frequencies, application of the Kvik up with and without removal of plant rests, hot water treatments, growing green manure crops, and the incorporation of grass in the soil with and without plastic coverage. The effects of some of the treatments were also analysed for other species such as *Elymus repens, Rorippa sylvestris, Persicaria amphibia*, and *Sonchus oleraceus*.
Several methods were effective in reducing perennial weed populations. The most effective method depended on the species, the soil type and, to some extent, weather conditions.

Effects of undersown red clover, autumn mechanical treatments and ploughing time on some creeping perennial weed species in cereals

LO Brandsæter[1,2] & H Fykse[2]

[1]Norwegian Institute for Agricultural and Environmental Research; [2]Norwegian University of Life Sciences, Høgskoleveien 7, 1432 Ås, Norway. e.mail: lars.olav.brandsaeter@bioforsk.no

In stockless organic cereal systems undersowing a legume shortly after sowing of cereals is a commonly used practice. Nitrogen supply as well as retarded growth of annual weeds is mentioned as benefits of such use of legumes in cropping systems. There is, however, limited knowledge on the influence of undersown cover crops on the growth of perennial weeds. This issue was addressed in a field experiment (#1) at Ås in South-eastern Norway. Furthermore, a second series of field experiments (#2) aimed at investigating the influence of (i) time of ploughing and (ii) that of black fallow. To obtain a field (#1) with uniform distribution of the perennial weed species, root fragments of *Cirsium arvense* (L.) Scop. and *Sonchus arvensis* L. and rhizomes of *Elymus repens* (L.) Mould., were transplanted by hand in the spring of 2002. The experiment, designed as a split-plot with 3 replicates, was initiated in 2003 and continued until the autumn of 2006. Oat undersown with red clover versus oat alone composed each year the two main plot treatments, except in 2006, in which the whole field was seeded to oat without red clover. Each main plot was divided into four sub-plots based on mechanical treatment in autumn: 1) untreated control; 2) mowing; 3) rotary tilling and 4) shallow ploughing plus harrowing. The autumn treatments were only carried out in 2004 and 2005. The number of weeds was counted at different dates throughout the growing season, and the weed biomass was assessed just before harvest. Preliminary results showed that red clover undersown in oat, compared to oat alone, had limited and in most cases insignificant effects on biomass and number of shoots of all investigated species. No significant interaction between red clover and mechanical treatments in autumn was found. Shallow ploughing suppressed *E. repens* most, followed by rotary tilling, mowing and untreated, in that order. On *S. arvensis*, mowing showed the best control, and rotary tilling the poorest. On *C. arvense*, significant differences between treatments were detected only in 2005, when rotary tilling and shallow ploughing reduced the weed biomass significantly compared to the untreated control.

In the second experiment series (#2) *C. arvense, S. arvensis* and *E. repens* were subjected to the following treatments: 1) black fallow (soil cultivation) + ploughing in autumn 2) ploughing in autumn 3) spring ploughing, and 4) black fallow + ploughing in spring. Preliminary results from the first experimental year have shown very clear interactions between treatment and weed species: Time of ploughing did not influence the growth of *E. repens* significantly. On the other hand, fallow in autumn suppressed this species more efficiently than fallow in spring. In general, *C. arvense* and *S. arvensis* showed the opposite behaviour regarding both time of ploughing and effect of fallow. Spring ploughing, as well as spring fallow, suppressed these species more than treatments in autumn. However, not all comparisons were significantly different.

Although the results need more attention as well as new experiments before detailed recommendations can be given, the studies indicate clearly that the effect of different treatments including time of ploughing and soil cultivation periods depends on weed species.

Pre-emergence variation in willow cuttings: Size variation and allometry of shoots during early development

Anneli Lundkvist*, Nils-Erik Nordh & Theo Verwijst

[*]Department of Crop Production Ecology, Swedish University of Agricultural Sciences (SLU), P.O. Box 7043, SE-750 07 Uppsala, Sweden. e-mail: Anneli.Lundkvist@vpe.slu.se

One of the major problems in the establishment of a willow crop consists of the variation in plant size which enlarges over time and leads to mortality, thereby leading to production losses during consecutive harvests. Early variation in willow plant size gives rise to a size hierarchy, which is preserved below-ground over harvest. While size hierarchy variation development in willow has been studied and its negative effects have been shown in commercial production, no studies have been undertaken hitherto to quantify the contribution of pre-emergence variation in the cuttings, used to establish willow stands.

In the present study, we assess the effects of variation in cutting size, weight and origin (position along long shoot) on the consecutive shoot population, in terms of sprouting ability, numbers and size. Using five different clones, cutting lengths of 12, 18 and 24 cm and cuttings sampled from long shoots from basal to apical positions, we perform a continuous sensus of emergence and shoot size during ca. seven weeks. At harvest, allometric relations are established between shoot diameter, height, dry weight and leaf area, to study if pre-emergence variation in cuttings leads to differences in early allocation patterns in emerging shoots.

The effects of pre-emergence variation in roots of *Sonchus arvensis* L. and *Cirsium arvense* (L.) Scop. on their population dynamics

Anneli Lundkvist & Theo Verwijst

Department of Crop Production Ecology, Swedish University of Agricultural Sciences (SLU), P.O. Box 7043, SE-750 07 Uppsala, Sweden. e-mail: Anneli.Lundkvist@vpe.slu.se

The objective of this study is to 1) quantify the impact of pre-emergence variation in *Cirsium arvense* (L.) Scop. and *Sonchus arvensis* L. roots on the population dynamics of the respective species., and 2) to test the effects of experimental treatments on the development of size- and weight hierarchies in the respective populations. The treatments are selective above-ground biomass removal, and below ground root fragmentation in the weed populations based on size, weight and origin (basal or apical) of the cuttings.

To develop practical tillage- and hoeing regimes to fragment roots of perennial weeds in such a way that resulting root populations are less viable than before fragmentation it is of paramount importance to be able to predict the consecutive growth and dynamics of root-fragmented populations. We start with planting a number of experimental root populations of *C. arvense* and *S. arvensis*, after having measured root length, root weight and their position along the roots. Individual roots will be tagged and a continuous census of the above ground growth will be performed during the growing season, before measuring the resulting roots populations during winter.

Our preliminary results show that shoot number and size are positively correlated to absolute root size. However, one meter of root length generates more but smaller shoots when fragmented in smaller parts. Both *C. arvense* and *S. arvensis* are able to produce a second generation of shoots by bud burst on sylleptic roots (i.e. from buds on roots which originated during the actual growing season). Bimodal size/weight frequency distributions primarily are due to differences in emergence time, not due to dominance/suppression of shoots by competition.

Modelling population dynamics of perennial weed species – what is making the difference?

Lammert Bastiaans

Crop and Weed Ecology Group, Centre for Crop Systems Analysis, Wageningen University, PO Box 430, 6700 AK Wageningen, The Netherlands. e-mail: lammert.bastiaans@wur.nl

Modelling is a commonly used tool for studying the long-term dynamics of weed populations in agriculture. Often the structure of the model represents the life history of a weed species. A number of life cycle stages is discerned and transition rates between consecutive stages are defined. These rates are either kept constant, or related to environmental circumstances like abiotic factors (e.g. temperature, availability of essential resources like light, water and nutrients), biotic factors (e.g. the presence of a crop or other weed species) and management (e.g. weed control). The required level of detail of a model is largely dependent on the purpose for which the model is constructed. Essentially, this level of detail is reflected in the number of life cycle stages included in the model, in the formulation of transition rates and in whether or not spatial aspects and genetics are explicitly accounted for.

For annual weed species numerous examples of population models do exist, and the life cycle stages that are commonly present in those models are a seed bank, established weed seedlings, reproductive plants and newly produced seeds (e.g. review of Holst *et al*., 2007). Though for perennial weed species these stages are often also very important, an extension needs to be made to include the asexual means of survival and multiplication. In this contribution the challenge of turning a simple demographic model of an annual weed into a model for a perennial weed species will be discussed. Options, difficulties and knowledge gaps will be identified.

Reference

Holst, N., Rasmussen, I.A. & Bastiaans, L., 2007. Field weed population dynamics: a review of model approaches and applications. *Weed Research* 47: 1-14

Spread and survival of *Cirsium arvense* by seeds and root fragments

Bärbel Gerowitt

University of Rostock, Faculty for Agricultural and Environmental Sciences, Institute for Land Use, Crop Health. e-mail: baerbel.gerowitt@uni-rostock.de

The species *Cirsium arvense* is characterised by a complex population strategy based on the ability to spread and survive by seeds and root fragments. Results of field surveys, field experiments and pot experiments were combined to show the importance of both survival strategies in arable systems. Investigations into the genetic diversity by molecular methods enabled us to differentiate between the two strategies in field populations.

Root fragments have the potential to sprout under various conditions. However, they are very susceptible to dryness. Field surveys indicated the minor importance of spread by root sprouts on a field level. Buried roots fragments did not survive longer than a year. Seedlings were found in arable crops, but their survival was limited.

Cirsium arvense obviously occurs in patches. Even in patches spread by seeds happens, since genetic diversity of patches was shown to be much higher than expected. Patches seems to “grow” via two ways: vegetative clonal growth and establishment of new clones.

Glasshouse and pot experiments on common couch (*Elytrigia repens*) and creeping thistle (*Cirsium arvense*) biology

Lynn Tatnell & Karen Jones

ADAS Boxworth, Boxworth, Cambridge, CB23 4NN, UK. e-mail: Lynn.tatnell@adas.co.uk

Controlling perennial weeds in organic and low-input farming systems is extremely challenging and poor management often results in complete crop loss due to the competitive and persistent nature of these weeds. Most situations require a management plan for a mixed population of both annual and perennial weeds; therefore spread via rhizomes is an additional factor.

A set of pot experiments have been established at ADAS Boxworth to investigate the suppression of common couch (*Elytrigia repens*) from a range of plant species commonly used as green manures in the fertility building phase of organic systems. These include vetch (*Vicia sativa*), red clover (*Trifolium repens*), phacelia (*Phacelia tanacetifolia*), mustard (*Sinapis alba*) and buckwheat (*Fagopyrum esculentum*). Initially pots were planted using common couch seed, at two different sowing densities of weed and all other plants. Weed and plant emergence and growth were monitored every 3-4 days by measuring leaf lengths. All pots were harvested by hand when the flowering head of the couch was just emerging and weight per pot of weed and other plant material was recorded. There was slow and poor emergence of the couch from seed. The experiment was also repeated using couch rhizomes, planted on two different sowing dates with the same green manure species as listed above and following similar methodology. Initial results are indicating that buckwheat and to a lesser extent phacelia are providing greatest suppression of the emergence of couch.

A second experiment to investigate how long rhizomes of couch or creeping thistle need to remain on the soil surface before they become fully desiccated has been established. Certain cultivations commonly used in organic farming drag pieces of rhizome to the soil surface and then they are left to desiccate for a period of time. They are either then ploughed or disced back into the land. However there is a risk that if the period of desiccation is too short the rhizomes will still be viable and will re-grow in the following crop. A range of rhizome lengths, time periods and burial depths are being investigated.

Experiments with weeds can be notoriously difficult as their germination in experimental conditions can be so varied. Difficulties have been experienced in germinating the seed of common couch and creeping thistle (*Cirsium arvense*) for glasshouse pot experiments, which is currently limiting the progress of our work.

Dormancy in reproductive vegetative buds of perennial species dominating the agricultural weed flora in Scandinavia

Andersson, L.*, Bostrom, U., Hakman, I. , Liew, J., Karlsson, L. & Milberg, P.

Department of Crop Production Ecology, Swedish University of Agricultural Sciences, Box 7043, SE-750 07 Uppsala, Sweden. e-mail: Lars.Andersson@vpe.slu.se

Many perennial weeds propagate vegetatively from belowground buds, which increasingly sprout when the roots or rhizomes are fragmentised. Soil tillage, repeated with a few weeks interval, is a primary method to control these weeds in organic agriculture. Soil tillage is also one of the most energy demanding measures used. In the light of global heating and climate change, there is an increasing need of low input agricultural systems, aiming at maintained soil fertility, integrated pest management and less use of energy. Thus, it is crucial that energy consumptive management, such as soil tillage is conducted when it has the largest impact on the target weeds, especially since in some perennials, sprouting capacity from vegetative buds seems to vary according to season.

In this project, funded by The Swedish Research Council Formas, we study dormancy, a suspension of normal growth from meristems, in *Elytrigia repens*, *Equisetum arvense*, *Tussilago farfara*, *Cirsium arvense*, and *Sonchus arvensis*. In a semi-field experiment, which will be repeated for two years, the seasonal pattern of dormancy is followed by monthly investigations of shoot emergence from detached plants placed at controlled temperature and light conditions. We also investigate the effects of temperature, photoperiod and exogenous application of phytohormones on dormancy. The developmental changes in bud structure are studied by microscopy, and molecular markers of dormancy/active growth are used to study the gene expression pattern in dormant and non-dormant buds.

Induced adventitious bud sprouting and carbohydrate reserves remobilization in Canada thistle [*Cirsium arvense* (L.) Scop.]

Libère Nkurunziza & Jens C. Streibig

University of Copenhagen, Faculty of Life Sciences, Department of Agricultural Sciences Højbakkegard Allé 13, 2630 Taastrup, Denmark. e-mail:lnku@life.ku.dk

While the dormancy of underground parts of perennial weeds can be an important factor for their reproduction and survival strategy, knowledge of underlying mechanisms involved in sprouting are scarce. In two independent experiments, we tested four potential stimuli for roots of Canada thistle [*Cirsium arvense* (L.) Scop.]. We treated root fragments for either 7 or 10 days with the following treatments: chilling (4^{o}C), warm water (13^{o}C), ethylene gas and gibberellic acid (GA_3) and we had an untreated control. Subsequently all fragments were incubated in a dark growth chamber (13^{o}C). The sprouting rate (%) and shoots/fragments ratio were recorded after a period of 3, 7 and 11 days of incubation.

In the first experiment, the sprouting rate was significantly higher with ethylene treatment than with chilling or GA_3, while warm water and the control were intermediate. Ethylene and GA_3 treatment both resulted in significantly higher shoot/fragments ratio than chilling, ethylene also than the untreated control. There was a strong and positive effect of incubation period length on the sprouting rate, however, no differences owed to treatment exposure (7 or 10 days) neither for the sprouting rate nor for the shoots/fragments ratio. In the second experiment, a high interaction between treatments and incubation period was found ($P<0.01$).

Because of these differing results, we could not conclude on which treatment induced the sprouting most. We need more experiments and probably to include various doses of ethylene and GA_3 and different incubation temperatures. Other response than sprouting rate (%) and shoots/fragments ratio, such as carbohydrate remobilization during the sprouting process will perhaps reveal the source sink dynamics characterizing *C. arvense.*

Activities of the NJF working group on Perennial Weeds – Comparison of seasonal sprouting readiness of three perennial weeds

Jukka Salonen*, Lars Olav Brandsæter, Bo Melander & Håkan Fogelfors

MTT Agrifood Research Finland, FIN-31600 Jokioinen, Finland.
e-mail: jukka.salonen@mtt.fi

The NJF working group on Perennial Weeds was launched in 2001 to facilitate communication and collaboration among the research scientists working with perennial weeds. The working group belongs to the Section of Plant Protection of the NJF (Nordic Association of Agricultural Scientists, www.njf.nu). The authors of this short communication are national representatives of the working group.

The working group has arranged annual meetings since 2001, hosted in a circulating manner in each Nordic country (DK, FI, NO, SE). In 2003, we were responsible for a session on perennial weeds at the NJF Congress in Finland and presented our work at the EWRS Symposium in Italy in 2005, as well as at the seminar for advisory persons in Norway in 2007. Typically, some 10-15 scientists have attended the annual meetings and relevant information, such as new journal articles, have been delivered to the members on the email list.

Already at the first meeting in Uppsala, Sweden in 2001 we initiated work on a protocol for a joint experiment. Our effort was supervised by Professor emeritus Sigurd Håkansson from Uppsala. The joint experiment aimed to study the differences in dormancy behaviour among *Elymus repens, Cirsium arvense* and *Sonchus arvensis*.

The rationale behind our collaborative study was that mechanical control of regenerative structures is a feasible option for controlling many perennial weeds. In fact, post-harvest stubble treatment has been a common practice in the Nordic countries, particularly to control *E. repens*. Such a management strategy aims at depleting the food reserves of underground plant structures (roots and rhizomes). The main hypothesis was, however, that the three weed species selected for our study do not behave in a similar way in terms of sprouting after being mechanically disturbed and fragmented in the latter half of growing season.

The bud dormancy/growth readiness in roots and rhizomes was tested in growth chambers by following the sprouting of underground fragments for four weeks after being cut from test plants collected and grown outdoors in each country. The material for the chamber phase was obtained by cutting 5 cm regenerative fragments at two-week intervals from early July until late October. In this way we gathered information about seasonal variation in the bud activity of roots and rhizomes.

Significant variation in sprouting ability was demonstrated both during the growing season and among the plant species. The development of dormancy was strongest in the roots of *S. arvensis* and weakest in the rhizomes of *E. repens*. In practice this means that weakening of regenerative structures in autumn is likely to be the most successful strategy for managing *E. repens*, but not so efficient for managing *S. arvensis*.

The article of the co-operative study (by Brandsæter *et al*.) is under editorial process with the journal Weed Research. We thank the NJF Board for providing us with financial support to partially cover the costs of annual meetings.

Research project on *Cirsium arvense* and *Tussilago farfara* – examples of how to design experiments and take samples

Ilse A. Rasmussen

Department of Integrated Pest Management, Faculty of Agricultural Sciences, University of Aarhus, Research Centre Flakkebjerg, DK-4200 Slagelse, DK. e-mail: ilsea.rasmussen@agrsci.dk

The project WEEDS (Effective control of perennial weeds and intra-row weeds in organic cropping through novel technology and new management strategies) under ICROFS (International Centre for Research in Organic Food Systems, previously DARCOF) includes a work package on *Cirsium arvense* and *Tussilago farfara*, two perennial weeds which are problematic in organic farming. Control is often attempted by stubble tillage, but this increases risk of nutrient leaching (Rasmussen *et al*., 2005). For *C. arvense*, results from a crop rotation experiment indicated that growing catch crops in autumn decreased biomass of the weed the following year as much – or as little – as did stubble tillage. For *T. farfara*, there is little research to base the choice of management options on.

In this project we seek to gain a better understanding of the source/sink allocation pattern to optimize tillage and cutting regimes. In order to do so, we carry out experiments with root/rhizome fragments in glass-house. The results will be supplemented by semi-field experiments, where root/rhizome fragments were planted and left to grow for two years to obtain a dense and homogenous stand of the weeds with root/rhizome systems similar to those found in natural stands.

In addition, we carry out experiments in natural stands of the weeds in organically managed fields with comparison of different catch crops with and without stubble cultivation and timing and intensity of stubble cultivation and ploughing. The weeds are not uniformly distributed. In order to even out possible differences between the level of weeds before the treatments are carried out, our blocks in the fields are chosen in order to minimize variation within the block by mapping the occurrence of the weed in the field after harvest the previous year. For *C. arvense*, 5 blocks with each 8 plots of 5 x 10 m^2 were determined after mapping in autumn 2006: block 1, no *C. arvense* plants, block 2, only one to four solitary plants, block 3, more than 4 solitary plants or a small colony, block 4, less than 25 % of the area covered by colonies and block 5, more than 25% of the area covered by colonies. In 2007, when the field was grown with spring barley, the density of *C. arvense* in the different parts of each plot was visually assessed in four categories: no weeds (0), solitary plants or thin colony (1), denser colony (2) and very dense colony (3). A map of each plot was hand-drawn according to these categories. The area of each plot allocated to each category was determined, and a destructive biomass sample was taken in each category.

For block 1 and 2, there was no difference between the means of total area with *C. arvense* and area with very dense colonies, but both traits increased from these to block 5. The total biomass of *C. arvense* in each plot was estimated by multiplying the biomass in each category by the area covered by each category. The tendency was the same as for the area with dense colonies, and the means of blocks 1 and 2 were significantly different from the means of blocks 3, 4 and 5. The means of the plots assigned to the different treatments were not significantly different.

References

Rasmussen, I.A., Askegaard, M. & Olesen, J.E. (2005): Long-term organic crop rotation experiments for cereal production – perennial weed control and nitrogen leaching. Proceedings of the First Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR): Researching sustainable systems. 21-23 September 2005, 227-230.

Size- and weight relations in *Cirsium arvense* (L.) Scop.: The use of allometric relations to assess above-ground growth and allocation patterns

Anneli Lundkvist & Theo Verwijst

Department of Crop Production Ecology, Swedish University of Agricultural Sciences (SLU), P.O. Box 7043, SE-750 07 Uppsala, Sweden. e-mail: Anneli.Lundkvist@vpe.slu.se

In agronomic experimentation, growth studies in general go along with time-sequential harvests. In forestry, traditional growth studies are sustained by non-destructive biomass estimations, based on allometric relations between weight and easily measured variables, such as diameter and height. This approach is time and cost-effective and allows for non-destructive estimates in running experiments.

We assess the performance of allometric methods, originally developed in forestry, to estimate relations in *Cirsium arvense* (L.) Scop., with the aims to: 1) test if accurate non-destructive biomass estimations can be performed in *C. arvense*, 2) find adequate predictors for above-ground biomass, leaf area and SLA and 3) describe changes in such parameters through time in single equations.

Our preliminary results show that 1) the growth of *C. arvense* can be captured accurately my means of time-sequential allometric methods, 2) Courses of LAI and SLA developments over time and along vertical gradients can be captured, and 3) that the methodology has applications in the evaluation of commercial practices.

List of Participants

Denmark

Bo Melander
University of Aarhus
Faculty of Agricultural Sciences
Dept. of Integrated Pest Management
Forsøgsvej 1
DK-4200 Slagelse, Denmark
Bo.Melander@agrsci.dk

Ilse A. Rasmussen
University of Aarhus
Faculty of Agricultural Sciences
Dept. of Integrated Pest Management
Forsøgsvej 2
DK-4200 Slagelse, Denmark
IlseA.Rasmussen@agrsci.dk

Christian Andreasen
University of Copenhagen
Faculty of Life Sciences
Dept. of Agricultural Sciences,
Crop Science
Hoejbakkegaard Allé 13
DK-2630 Taastrup, Denmark
can@life.ku.dk

Anne Merete Rask
University of Copenhagen
Faculty of Life Sciences
Dept. of Agricultural Sciences,
Crop Science
Hoejbakkegaard Allé 13
DK-2630 Taastrup, Denmark
anr@life.ku.dk

Libère Nkurunziza
University of Copenhagen
Faculty of Life Sciences
Dept. of Agricultural Sciences,
Crop Science
Hoejbakkegaard Allé 13
DK-2630 Taastrup, Denmark
lnku@life.ku.dk

Finland

Jukka Salonen
MTT Agrifood Research Finland
Plant Protection
FIN-31600 Jokioinen, Finland
jukka.salonen@mtt.fi

Germany

Bärbel Gerowitt
University of Rostock
Faculty of Agricultural and
Environmental Sciences
Institute for Land Use, Crop health
Satower Str. 48
18051 Rostock, Germany
baerbel.gerowitt@uni-rostock.de

Latvia

Dace Piliksere
State Priekuli Plant Breeding Institute,
Latvia
Zinatnes st. 1a, Priekuli,
Cesis district LV-4126, Latvia
dacepil@e-no.lv

The Netherlands

Aad van Ast
Wageningen University
Crop and Weed Ecology
P.O. Box 430
6700 AK Wageningen, The Netherlands
Aad.vanAst@wur.nl

Lammert Bastiaans
Wageningen University
Crop and Weed Ecology
P.O. Box 430
6700 AK Wageningen, The Netherlands
Lammert.Bastiaans@wur.nl

Piet Bleeker
PPO
Edelhertweg 1
8219 PH Lelystad, Nederland
Pieter.Bleeker@wur.nl

Henriette Drenth
Wageningen University
Crop and Weed Ecology
P.O. Box 430
6700 AK Wageningen, The Netherlands
Henriette.drenth@wur.nl

Erwin Mol
Plantenziektekundige Dienst
Afdeling Strategie & Ontwikkeling
Postbus 9102
6706 EA Wageningen, The Netherlands
e.s.n.mol@minlnv.nl

Marleen Riemens
Plant Research International
Agrosystems Research
P.O. Box 16
6700 AA Wageningen, The Netherlands
Marleen.riemens@wur.nl

Rommie van der Weide
PPO
Edelhertweg 1
8219PH Lelystad, The Netherlands
Rommie.vanderweide@wur.nl

Marieke Zeeland
PPO
Edelhertweg 1
8219PH Lelystad, The Netherlands
Marieke.vanZeeland@wur.nl

Norway

Lars Olav Brandsæter
Norwegian Institute for Agricultural and Environmental Research (BIOFORSK)
Plant health and Plant protection Division & Norwegian University of Life Sciences (UMB)
Høgskolevn. 7
N-1432 Ås, Norway
lars.olav.brandsaeter@bioforsk.no

Sweden

Lars Andersson
Swedish Univ. of Agricultural Sciences
Dept. of Crop Production Ecology
P.O. Box 7043
S-750 07 Uppsala, Sweden
Lars.Andersson@vpe.slu.se

Josefine Liew
Swedish Univ. of Agricultural Sciences
Dept. of Crop Production Ecology
P.O. Box 7043
S-750 07 Uppsala, Sweden
josefine.liew@vpe.slu.se

Anneli Lundkvist
Swedish University of Agricultural Sciences
Dept. of Crop Production Ecology
P.O. Box 7043
SE-750 07 Uppsala, Sweden
Anneli.Lundkvist@vpe.slu.se

Theo Verwijst
Swedish University of Agricultural Sciences
Dept. of Crop Production Ecology
P.O. Box 7043
SE-750 07 Uppsala, Sweden
Theo.Verwijst@vpe.slu.se

United Kingdom

Paul Hatcher
The University of Reading
School of Biological Sciences
Reading, United Kingdom
p.e.hatcher@reading.ac.uk

Karen Jones
ADAS Boxworth
Battlegate Road, Boxworth
Cambridge, CB23 4NN,
United Kingdom
Karen.Jones@adas.co.uk

Lynn Tatnell
ADAS Boxworth
Battlegate Road, Boxworth
Cambridge, CB23 4NN
United Kingdom
Lynn.Tatnell@adas.co.uk

Louise Brinkworth
Dow AgroSciences
Latchmore Court, Brand Street, Hitchin
Herts. UK SG5 1NH
United Kingdom
LBrinkworth@dow.com

Perennial weed species index

Species	Common name (UK)	*Page number*
Frequency > 5		
Cirsium arvense	- creeping thistle	*3,5,6,10,12,14,15,16,17,18,19,20*
Elymus (Elytrigia, Agropyron) repens	- couch grass	*3,5,6,8,9,10,15,16,18*
Sonchus spp.		*3,5,6,9,10,12,16,18*
Sonchus arvensis	- field sowthistle	
Sonchus oleraceus	- smooth sowthistle	
Frequency = 4		
Equisetum arvense	- field horsetail	*3,5,6,16*
Tussilago farfara	- colt's-foot	*3,6,16,19*
Frequency = 3		
Rumex spp.		*3,6,8*
- *Rumex crispus*	- curly dock	
Frequency = 2		
Achillea millefolium	- milfoil	*3,6*
Artemisia vulgaris	- common mugwort	*3,6*
Lolium perenne	- perennial ryegrass	*3,7*
Mentha arvensis	- corn mint	*3,5*
Persicaria amphibia	- amphibious bistort	*5,9*
Plantago spp.		*3,6*
- *Plantago major*	- greater plantain	
Ranunculus spp.		*3,6*
- *Ranunculus repens*	- creeping buttercup	
Rorippa sylvestris	- creeping yellowcress	*5,9*
Taraxacum spp.	- dandelion	*3,6*
Frequency = 1		
Cerastium arvense	- field mouse-ear	*3*
Convolvulus sepium	- hedge bindweed	*5*
Epilobium spp.	- willowherb	*6*
Festuca spp.	- fescue	*6*
Inula britannica	- british yellowhead	*5*
Juncus spp.	- rush	
Poa spp.		*3*
- *Poa pratensis*	- smooth-stalked meadowgrass	
- *Poa trivialis*	- rough(-stalked) meadowgrass	
Petasites hybridus	- butterfly dock	*5*
Phleum pratense	- timothy	*3*
Potentilla anserina	- silverweed	*6*
Stachys palustris	- marsh woundwort	*6*
Trifolium spp.	- clover	*6*