Crop Protection 32 (2012) 104–110

Contents lists available at SciVerse ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Effects of repeated clover undersowing in spring cereals and stubble treatments in autumn on *Elymus repens*, *Sonchus arvensis* and *Cirsium arvense*

L.O. Brandsæter [a,*], M. Goul Thomsen [b,c,d], K. Wærnhus [a], H. Fykse [d]

[a] Norwegian Institute for Agricultural and Environmental Research, Plant Health and Plant Protection Division, Aas, Norway
[b] Hedmark University College, Faculty of Education and Science, Hamar, Norway
[c] Norwegian Institute for Agricultural and Environmental Research, Arable Crops Division, Kapp, Norway
[d] Norwegian University of Life Sciences, Department of Plant and Environmental Sciences, Aas, Norway

ARTICLE INFO

Article history:
Received 10 June 2011
Received in revised form
19 September 2011
Accepted 22 September 2011

Keywords:
Perennial weeds
Weed control
Cover crop
Stubble cultivation
Red clover
Cereals

ABSTRACT

Cover crops are included in cropping systems in order to achieve various ecological benefits. In stockless organic cereal systems in Scandinavia, nitrogen is commonly supplied by undersowing a legume shortly after sowing. Retarding the growth of annual weeds is considered an additional benefit of using cover crops. However, studies on the influence of undersown cover crops on the growth of perennial weeds are lacking. In this paper we present data from a four- year field experiment on the growth of *Cirsium arvense* (L.) Scop., *Sonchus arvensis* L. and *Elymus repens* (L.) Gould., in cereals with and without undersown red clover (*Trifolium pratense* L.), combined with contrasting stubble treatments after harvest. Clover did not significantly reduce the growth of any of the weed species. Regression analyses showed, however, that the growth of *C. arvense* and *S. arvensis* increased with increasing clover biomass at low densities of clover, whereas at higher densities it decreased with increasing biomass of clover. Amongst the stubble treatments, shallow ploughing followed by harrowing gave the best control of all weed species. The effect was most pronounced on *E. repens*, and least on *S. arvensis*, for which neither the number nor the weed biomass were significantly different from the untreated control. Rotary tilling gave a similar effect, but again less pronounced on *S. arvensis*. Mowing suppressed *E. repens* to some degree, tended to suppress *S. arvensis* (n.s.) but had no effect on *C. arvense*. The growth and survival of seed-propagated plants of the same species were studied in a one-year field experiment and in a greenhouse experiment, the latter only including the species *S. arvensis* and *C. arvense*. The use of a cover crop reduced the number of leaves per plant in *S. arvensis* both in the field and in the greenhouse. The same effect was found for *C. arvense*, but only in the greenhouse experiment. In the latter, above-ground biomass of the cover crop explained 67% of the variation in total biomass of *S. arvensis* and 47% of that for *C. arvense*. From a practical point of view, the study has shown that undersown red clover has only marginal effects on perennial weeds, in contrast to various stubble treatments which influence strongly on weed growth. In general, soil tillage suppresses perennial weeds best, but mowing may be a more environmentally friendly alternative for some weed species, such as. *E. repens*.

1. Introduction

Sufficient nutrient supply and adequate weed control, especially of perennial species, are thought to be key factors for achieving stable yield levels in organic crop rotations dominated by cereals. Most of the cereal production in Norway is located in areas with limited access to livestock manure. In organic farming systems this implies that nutrient supply is a serious challenge. Possible nutrient sources in such farming systems, especially of nitrogen (N), are legume cover crops, either (i) undersown in the cereals or (ii) as green manure grown in rotation with the cereal crops. Cover crops may also have other beneficial effects, such as reducing soil erosion, improving soil quality and minimizing nutrient or pesticide losses caused by leaching and surface runoff (Sustainable Agriculture Network, 1998; Teasdale et al., 2007). Retarded growth of annual weeds is also reported in some studies as an additional benefit of using cover crops (e.g. Breland, 1996). Less is known, however, about the influence of undersown cover crops on the growth of perennial weeds. Most studies on cover crops in cereals have focussed on nutrient supply and effects on yield (e.g. Breland, 1996;

* Corresponding author.
E-mail address: lars.olav.brandsaeter@bioforsk.no (L.O. Brandsæter).

0261-2194/$ – see front matter
doi:10.1016/j.cropro.2011.09.022

Bergkvist et al., 2011). Although Breland (1996) and Hartl (1989) included assessments of weeds in their studies, very few investigations have concentrated on the development of the weeds as the main subject. Use of undersown cover crops in cereals may render mechanical weed control impossible if the cereal and the cover crop are sown at the same time. Another jeopardizing aspect is that cover vegetation growing in autumn will prevent stubble cultivation aimed at controlling couch grass (Rasmussen et al., 2006), which is a very commonly used non-chemical treatment against this weed.

Seedling establishment of *Cirsium arvense* (L) Scop. is common in arable fields (Hettwer and Gerowitt, 2004). Competition from and sufficient nutrient supply to the main crop has been shown to be important in order to reduce infestation by this weed, either from seedlings or from roots (Dau and Gerowitt, 2004). However, it is a challenge to find how to combine these factors in a practical manner in organic farming.

The present paper addresses the following three main questions: (i) In infested areas, does the use of repeated undersown clover suppress the development of *C. arvense*, *Sonchus arvensis* L. and *Elymus repens* (L) Gould.? (ii) In fields where perennial weeds are not yet established, will the use of undersown clover in cereals prevent or delay the invasion or establishment of these weed species? (iii) Will competition from the cover crop during the growing season, combined with mowing after the cereal harvest, reduce weed growth?

2. Material and methods

2.1. Location

The study was located at the Norwegian University of Life Sciences, Ås (59°40N, 10°46E, 90 masl) and included vegetative as well as seed propagated weed plants.

2.2. Vegetative propagated plants

The trial started in spring 2002 and continued until autumn 2006 in a field with sandy loam soil. Prior to the experiment, the field had been farmed conventionally for a number of years, mainly with cereal crops. The experimental treatments included spring oats with and without undersowing of red clover in spring combined with four different mechanical treatments in autumn in a factorial split-plot randomised block design with three replicates. The cover crop was allocated to large plots (9 m × 20 m) and mechanical treatments to sub-plots (9 m × 5 m).

In order to obtain uniform distribution of the perennial weed species in the plots, root fragments of *C. arvense* and *S. arvensis* and rhizome pieces of *E. repens*, were transplanted by hand in the spring 2002. The reproductive material of each species was collected from fields in the surrounding area on 12th April and intermixed with soil placed in separate plastic containers, which were kept in a cool-storage chamber at 2–3 °C until transplanting.

Before planting of the weed species the plots were fertilized with 40 kg N ha^{-1} given as cattle slurry and seeded with spring oats (*Avena sativa* L.) *cv.* Kinnan (100 kg ha^{-1}), with twice the normal row spacing used in Norway (25 cm). On 8th May, root pieces/rhizomes, 10 cm in length, of the three weed species were planted in three rows between the cereal rows. Seven fragments were planted at ca 5 cm depth in each row. The weed species were concentrated in separate, marked squares, 1 m × 0.75 m in size, randomly distributed within the sub-plots (Fig. 1).

Naturally-occurring specimens of the planted species in the area surrounding the squares with planted weeds were removed carefully by repeated single plant applications of 1000 g ha^{-1} glyphosate (N-(phosphonomethyl)glycine, 360 g l^{-1}) in 250 L of water during the summer.

To secure establishment of the weeds, the experimental treatments were delayed until 2003. During the trial period (2003–2006) the field area was ploughed with a reversible plough (Kverneland Moulboard plough, Norway) in late October or early November to a depth of 23–25 cm. In spring, the field was levelled with an under- and over leveller and harrowed with an S-tine cultivator. The large plots which were to be seeded with (i) cereals only, and (ii) cereals and the red clover cover crop, were supplied with 80 and 40 kg N ha^{-1} respectively in a compound fertilizer. The extra nitrogen on plots without cover crop was applied to compensate for the subsequent fertilization effect of the undersown clover (Henriksen, 2005).

Spring oats (*A. sativa* L.) cv. Biri, 200 kg ha^{-1}, were sown in late April (2002, 2003, 2005) or early May (2004, 2006) depending on the weather conditions, at 3–4 cm depth and with 12.5 cm row spacing. Immediately afterwards, the red clover (*Trifolium pratense* L.) cv. Nordi, 7–9 kg ha^{-1}, was sown.

In the autumn of 2004 and 2005, the four sub-plots were subjected to one of the following treatments: 1) untreated control; 2) mowing; 3) rotary tillage or 4) shallow ploughing plus harrowing. These were carried out 10–14 days after the cereal harvest, during the last week of August or first week of September. As the studied species did not reach the compensation point, which may be defined as that time where the sink-source dynamic of carbohydrate reserves shifts from the underground organs as the source and above ground organs as the sink, to the opposite (Håkansson, 2003), following the first operations, these treatments were performed only once each year.

The stubble treatments 2–4 were carried out by tractor-drawn equipment, (i) mowing (by Kverneland FH180 Chopper, Norway) at a stubble height as low as possible (2–5 cm), (ii) rotary tillage (by Ferraboli Rotavator, Italy), driven slowly (3–4 km h^{-1}), and (iii) shallow ploughing (by Kverneland Moulboard plough, Norway) at 10–12 cm depth, followed by two passes of an S-tine harrow.

The area of assessment in 2003–2005 was 1.5 m × 1.5 m and in 2006 1 m × 1 m with the original weed-transplanted plot in the middle. At harvest time in August, the number of stems of each weed species was counted. Then the stems were cut 5 cm above the soil surface and dried at 70 °C for 72 h before the dry weight was determined. Annual weed species were harvested as well and pooled for each plot. Additionally, in the spring and early summer of 2004, i.e. before the first mechanical autumn treatments were carried out, the number of shoots of each weed species was recorded several times within short intervals (see Fig. 2) to study their rate of emergence in well-established populations.

Cereal and clover plants were cut, separated and dried in the same way as the weeds. The total biomass of clover and, after threshing, the grain weight, expressed at 15% moisture content, of the cereal were determined. The remaining vegetation in the field was removed by a combine harvester.

2.3. Seed propagated plants

Seedlings of *E. repens*, *C. arvense* and *S. arvensis* were grown in the field, the two latter species also in pots in a greenhouse experiment. Seeds of the three species were collected in September 2003, dried at room temperature for 2 weeks and stored in a cooling chamber at 2–4 °C in darkness until start of the current experiment. For plant propagation the seeds were sown in plastic trays (20 cm × 50 cm, 5 cm deep) filled with limed peat enriched with nutrients [L.O.G. 'Gartnerjord', Mixture 840 g kg^{-1} sphagnum peat, 100 g kg^{-1} fine sand, 60 g kg^{-1} clay, 5.5 kg dolomite lime m^{-3}, 1.2 kg fertilizer (NPK 15-4-12), 0.2 kg. F.T.E. no. 36 (micronutrients),