“Crop diversification and weeds” (PRODIVA project 2015-2018)

Weed management with cover crops in the Nordic-Baltic region

– a snapshot from the references

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2017

Luke
NATURAL RESOURCES INSTITUTE FINLAND

CORE organic II

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Cover crops have gained popularity in cereal cropping, where they improve soil fertility and quality. The potential for using cover crops in weed management is an interesting but little addressed option in organic arable crop production. Some comments on feasible measures for cereal production are extracted in this round-up from the references and information relevant to the Nordic-Baltic region.

The rationale for using undersown cover crops in weed management is that they provide strong weed suppression without severely compromising weed species diversity and crop yields. Competition for light, nutrients and water represents a key issue in choosing appropriate cover crop species and their mixtures. Fast establishment and rapid early growth of cover crops are desired characteristics for successful weed suppression. Poorly developed cover crops can even result in extensive proliferation of rhizomatous perennial weeds if mechanical weed control is not included. Failures with leguminous cover crops in particular are risky because even poorly growing legumes increase the soil nitrogen content, which favors weed growth.

Fig. 1. *Cirsium arvense* and *Sonchus arvensis* are two common aggressive perennial weed species of cereal fields. Photo: Jukka Salonen.

Wide selection of plant species

Undersown cover crops in cereal fields are typically either intended to protect the soil structure or to catch soluble nutrients after harvest. Leguminous species and some grass species are most commonly used in field experiments and in production (Table 1).

Table 1. Potential cover/catch crops species for the Nordic-Baltic region.

Plant species	Latin name	Reference example
Cover crop, suitable for undersowing		
Perennial ryegrass	*Lolium perenne* L.	Løes *et al.* (2011), Ringselle (2015)
Italian ryegrass	*Lolium multiflorum* Lam.	Kvist (1992), Känkänen & Eriksson (2007)
Westerwold ryegrass	*L. multiflorum* subsp. *westerwoldicum*	Aronsson (2012)
Meadow fescue	*Festuca pratensis* Huds.	Känkänen & Eriksson (2007)
Red fescue	*Festuca rubra* L.	Olsen (1995), Bergkvist (2010)
Tall fescue	*Festuca arundinacea* Schreb.	
Timothy	*Phleum pratense* L.	Känkänen & Eriksson (2007)
Red clover	*Trifolium pratense* L.	Känkänen & Eriksson (2007), Ringselle (2015)
White clover	*Trifolium repens* L.	Känkänen & Eriksson (2007)
Alsike clover	*Trifolium hybridum* L.	den Hollander *et al*. (2007)
Berseem clover	*Trifolium alexandrinum* L	Kauppila (1992)
Crimson clover	*Trifolium incarnatum* L.	Kauppila (1992)
Persian clover	*Trifolium resupinatum* var. Majus L.	den Hollander *et al*. (2007)
Subterranean clover	*Trifolium subterraneum* L.	Kauppila & Kiltilä (1992)
Black medic	*Medicago lupulina* L.	Känkänen & Eriksson (2007)
White sweet clover	*Melilotus alba* Med.	Moyer *et al*. (2007)
Birdsfoot	*Ornithopus sativus* L.	Doltra & Olesen (2013)
Birdsfoot trefoil	*Lotus corniculatus* L.	Doltra & Olesen (2013)
Chicory	*Cichorium intybus* L.	Bergkvist *et al*. (1994),
Common/Hairy vetch	*Vicia sativa/villosa*	Bamford & Entz (2017)
Catch crop, sown after the main crop		
White mustard	*Sinapis alba* L.	Olsen (1995)
Radish, various spp.	*Raphanus sativus* L.	Olsen (1995)
Phacelia	*Phacelia tanacetifolia* Benth.	Olsen (1995)

The strategy of using cover crops for weed control should rest on both short-term and long-term appraisal. In northern conditions, the most effective and reliable method is to establish the cover crop stands early in the spring when the main crop is sown, or at the very latest in connection with weed harrowing. The optimal sowing time depends particularly on cover crop species and soil type.

Clover species with small seeds (*Trifolium pratense*, *T. repens*) are more sensitive to dry conditions than those with larger seeds (*T. resupinatum*, *T. subterranum*). In general, a sowing technique that incorporates seeds at a depth of 1-2 cm is recommended for all cover crop species to secure even emergence, particularly in the dry conditions of early spring.

Figs. 2. Typical sowing times for cover crops in spring cereals: at the same time as cereals (left/Jukka Salonen) or in connection with weed harrowing (right/Kari Koppelmäki).

There are marked differences in the characteristics of cover crops (Table 2). Clover species (*Trifolium* spp.) alone or in mixtures with grass species such as Italian ryegrass (*Lolium multiflorum*) thrive in the Nordic-Baltic region. Other plant species, including oilseed radish (*Raphanus sativus*) and white mustard (*Sinapis alba*), are commonly used as catch crops after harvest in countries where the growing season continues until late autumn. The main purpose is to prevent nutrient leaching but a dense catch crop stand also suppress weeds.

Table 2. Characteristics of cover crops. Information is compiled from Känkänen & Eriksson (2007), Känkänen (2011) and Aronsson *et al*. (2012).

Plant species	Emergence	Autumn growth	Biomass production	Competition against crop	Competition against weeds	Nitrogen uptake from soil
Legumes						
Trifolium pratense	**	**	**	**	**	*
Trifolium repens	*	**	**	*	*	*
T. resupinatum	**	*	***	***	-	*
Medicago lupulina	-	**	*	*	*	*
Grass species						
Lolium multiflorum	**	***	***	***	***	***
Lolium perenne	**	**	**	*	**	**
Phleum pratense	**	**	**	*	*	**
Festuca rubra	***	*	**	*	**	**
Other species (as catch crops after harvest)						
Raphanus sativus* var. *oleiformis	**	***	*** in warm autumn	-	**	*** in warm autumn
Sinapis alba	**	***	*** in warm autumn	-	**	*** in warm autumn

*Scores: *** = good/high, ** = moderate, * = poor/low, - = no information found*

Effect of cover crops on weeds

The occurrence of weeds has often had a minor role in the assessments of cover crops from field experiments in northern conditions. Moreover, only some results from long-term experiments are available. However, some references give an idea about the potential of cover crops in weed management (Table 3).

Table 3. Effect of cover crops on weeds and crops. Findings from the Nordic countries.

Location	Cover/Catch crop	Effect on weeds	Effect on crop	Reference
Apelsvoll, Norway Kise, Norway	Perennial ryegrass, red clover, white clover. Mixtures of clover and ryegrass.	Ryegrass and mixtures reduced weed biomass. Increased weed seed bank after clovers.	Subsequent effect on cereal yield next year: clovers +30%, mixtures +28% and ryegrass -4%.	Løes *et al*. (2011) Sjursen *et al*. (2011)
Apelsvoll, Norway	Red clover and white clover	Increased weed density, biomass and weed seed bank after four-year rotation with clovers.	Higher yields in white clover plots: organic wheat +16% and oat +12% (two year average).	Stenerud *et al*. (2015)
Jyndevad, Foulum,Flakkebjerg, Denmark (Long-term field experiment with organic rotation 1997-2008)	Multispecies mixture with perennial ryegrass and leguminous species Perennial ryegrass. Mixture of perennial ryegrass, clover and chicory.	Annual weed species were replaced by perennial weeds. Higher weed infestation after cover crops compared with stubble-treated plots without cover crops. Cover crops reduced weed density.	Higher spring barley yield with perennial ryegrass in rotation. Higher winter wheat yield with clovers in rotation.	Olesen *et al*. (2007), Rasmussen *et al*. (2006), Olesen *et al*. (2008), Doltra & Olesen (2013) Rasmussen *et al*. (2014)
Lilla- Böslid, Sweden	Perennial ryegrass and red clover.	No clear effect on *Elymus repens*.	No effect on barley yield.	Aronsson *et al*. (2015)
Uppsala region, Sweden	Perennial ryegrass, red clover and their mixture.	35-40% reduction of *Elymus repens* tillers with ryegrass and clover/ryegrass mixture. 20-30% higher root biomass of *Elymus repens* one year after red clover.	5% higher crop yield with cover crop mixture. 4% higher yield with red clover.	Ringselle *et al*. (2015)
Säby, Sweden	Red fescue.	27% reduction of *Elymus repens* tillers and 40% reduction of rhizome biomass.	No yield effect on winter wheat yield	Bergkvist *et al*. (2010)

Cover crops respond to the growing conditions

The response to available nitrogen in soil differs among cover crop species. The relative growth of clover species loses to grass species (incl. cereal crops) with increasing nitrogen fertilization. Mixtures of leguminous and grass species are recommended to optimize and secure the biomass production in variable growing conditions.

Spring cereals are highly competitive crops, particularly when sown with equipment that also places fertilizer. Furthermore, some cover crops are relatively aggressive in crop stands: *Melilotus alba*, *Medicago lupulina* and tall-growing clovers like *Trifolium resupinatum*, *T. incarnatum*, *T. alexandrium* easily grow above the cereal crop, hamper the harvest and reduce the yield (Fig. 3). Also grass species, e.g. *Lolium multiflorum*, can grow strongly and reduce the crop yield.

Figs. 3. Be careful with aggressive cover crops. *Trifolium resupinatum* and *T. incarnatum* (left) easily out-compete spring barley. *Melilotus alba* (right) was used as cover crop in winter wheat in 2016 but remained as volunteer weed in spring wheat, particularly in the plots with reduced tillage. Photos: Jukka Salonen, field experiments in Jokioinen, Finland.

The choice of cover crop species and the field management practices affect the growth of cover crops and weeds. Some cultivars of Italian ryegrass may proceed to the generative stage and produce seeds. This is unwanted in organically cropped fields in the long run. Likewise, reduced tillage promotes cover crops to appear as volunteer weeds in the crop stand (Fig. 4).

Fig. 4. A timothy cover crop has remained as a volunteer weed after reduced tillage. Photo: Jukka Salonen

Farmers are encouraged to trial new options that might be most suited to the local conditions (e.g. crop rotation, crops, soil type, weather, risk level). Sowing cover crops in winter wheat stands in early spring conferred a competitive advantage on the crop rather than the cover crops in field trials in Jokioinen Finland.

Fig. 5. Cover crops can be sown in winter cereal stands early in the spring to give the crop a head start. Photo: Jukka Salonen.

Economic factors naturally influence the use of cover crops. Seed cost and additional labor should be taken into account. On the other hand, for instance in Finland, cover crops are numbered among the subsidized cropping measures in agri-environmental support schemes of the EU. The strategy of using cover crops for weed management should have long-term scope, targeting the most harmful species, including the perennials *Cirsium arvense*, *Elymus repens* and *Sonchus arvensis.* The most efficient control strategy against perennial weeds is to leave undersown cover crops (e.g. clover-grass mixtures) for an additional growing season and include repeated mowing in cropping operations.

Fig. 6. Weed management with cover crops could prevent problems caused by perennial weeds such as *Elymus repens*. Photo: Jukka Salonen

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PRODIVA project "Crop diversification and weeds" (2015-2018)

Combinations of crop and cover crops, as well as crop sequencing, conform integrated management principles for weed control. The PRODIVA project (ERA-Net Core Organic Plus Action) aims at identifying weed community associations with the most common crop types in organic production systems. We have summarized here information from the literature on exploiting cover crops for weed management in cereals.
This compendium is one of the project deliverables extracted and modified from the original report in Finnish language (Luke Report 65/2016 by Koppelmäki et al. available at http://urn.fi/URN:ISBN:978-952-326-324-6)

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The PRODIVA project (2015-2018) web site:

http://coreorganicplus.org/research-projects/prodiva)