Control of perennial weeds based on weed biology and environmental considerations

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Implications

Timing, type and duration of tillage operations and cropping practices are of importance for reducing the regeneration of perennial weeds and also for minimizing the environmental impacts of such operations. In the present work and with reference to previous publications we find that it is possible to combine control of perennial weeds with reduced environmental impact and without reduction in yield.

Background and objectives

Control measures of perennial weeds in organic farming systems most often include mouldboard ploughing and the main factor determining minimum ploughing depth is control of perennial weeds (Kouwenhoven et al. 2002). In order to allow early sowing, autumn ploughing is often preferred. However, soil erosion risk and N-leaching losses increase with the number of tillage operations in autumn (Askegård et al. 2011) and the depth of mouldboard ploughing is directly related to CO_2 loss from the soil and increased use of fuel (Reicosky and Archer 2007) and erosion is larger with deep than with shallow tillage (Lundekvam et al. 2003).

For optimization we need insight into weed biology and growth pattern, and response to mechanical and cultural measures. Is it then possible to combine weed control with reduced environmental costs?

Measures to reduce environmental impact:

Timing and erosion……

Tillage System	Time of sowing	Relative erosion risk
Ploughing autumn	Spring	0.80 -1.00
Harrowing autumn	Spring	0.50-0.65
Ploughing spring	Spring	0.33-0.40

Fig 1. Lundekvam, 2003

Timing and effect on weed and yield…….

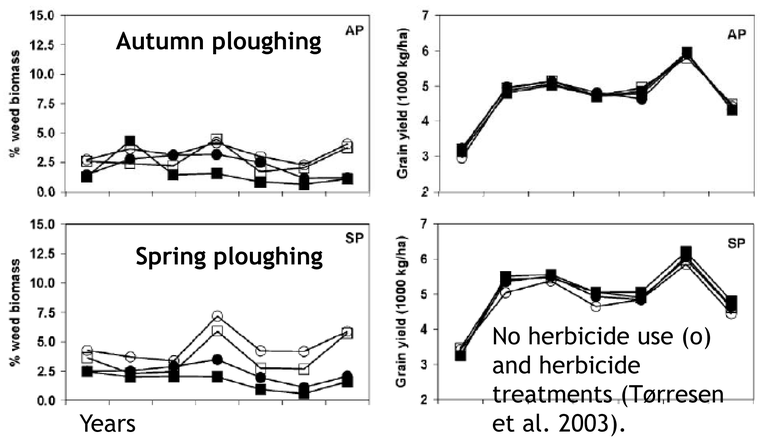

Fig. 2

Tillage depth, yield and weed……

Weed species	Year	Biomass (g DM m^{-2})	
		Depth, spring ploughing	
		15 cm	25 cm
C. arvense	2004	40.3	23.7
	2005	60.3a	22.3b
E. repens	2004	33.7a	20.5b
	2005	44.2a	20.6b

letters indicate row-wise significant differences

Year	2003		2004		2005		2006	
Depth, spring ploughing	15 cm	25 cm	15 cm	25 cm	15 cm	25 cm	15 cm	25 cm
Cereal yield, Mg DM ha^{-1}	3.87	3.87	4.49	4.77	3.58	3.85	3.35	3.75
	P>0,2		P=0.133		P=0.049		P=0.069	

Fig. 3 After Bakke et al. 2009 and Brandsæter et. al. 2011

Keen and Russel, Rothamsted 1937 found: 'no justification for (tillage) operations beyond the minimum needed to get a seedbed and to check weeds until the crop is well established. Work in excess of this minimum, far from increasing the crop, appreciably diminishes it'. (J.Roy.agric. Soc.Eng. 98: 53)

Weed biological traits:

Weed species and seasonal growth pattern……

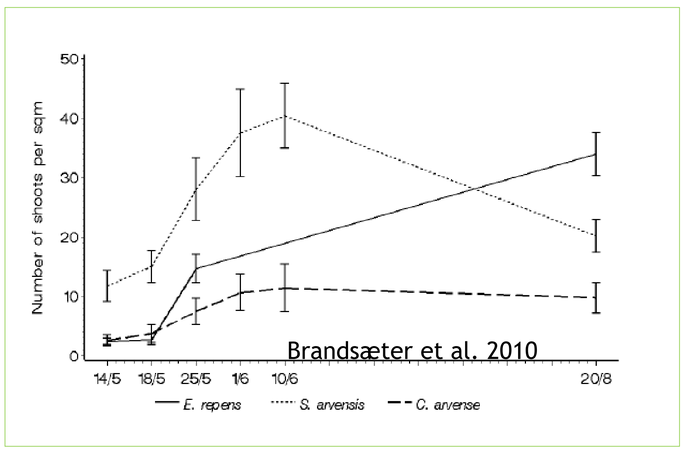

Fig. 4

Regeneration of undisturbed roots and root fragments of C. arvense..

Table 1. Roots undisturbed below the digging depth in 2005-A and 2005-B. Roots undisturbed below the digging depth in 2006 / 2011 and root fragments replaced with the soil into the hole or removed .

Experimental treatments			
2005-A / 2005-B Digging depth	Root fragments removed (-) or replaced (+)	2006 / 2011 Digging depth	Root fragments removed (-) or replaced (+)
0 cm		0 cm	
10 cm	-	15 cm	+
20 cm	-	15 cm	-
30 cm	-	30 cm	+
40 cm	-	30 cm	-

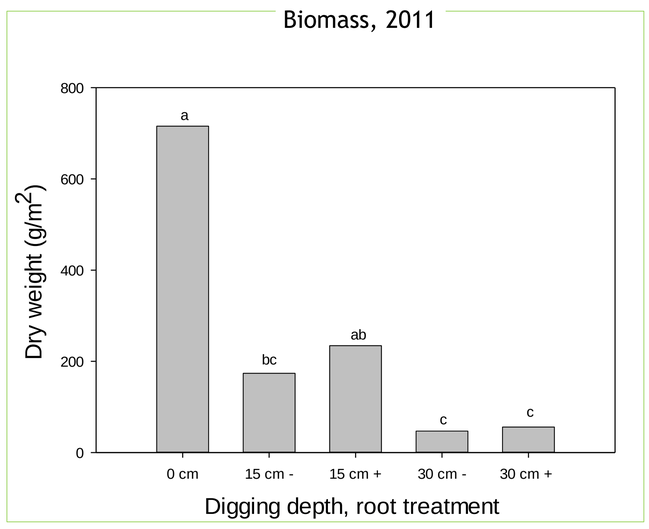

Fig. 5 Thomsen et al. 2013

Control measures:

Weed control and green manure cover crop….

Green manure cover crop to avoid regeneration of root fragments of *C. arvense* following spring tillage

Length of root fragment in spring, cm	Burial depth, cm	Cover crop	Total weight of new roots in autumn, g
10	5	-	3,06 a
5	5	-	1,99 a
10	15	-	1,89 ab
5	15	-	0,28 bc
10	5	+	0,12 c
5	5	+	0,03 c
10	15	+	0 c
5	15	+	0 c

Fig. 6

Spring fallow, intensity, weed control and yield….

Weed / cereal biomass (g DW m^{-2})	Spring fallow					Shallow ploughing
	Control	2 x harrow	3 x harrow	2 x harrow + plough-ing.	3 x harrow + Plough-ing.	Control + shallow ploughing autumn
Elymus repens	17.9 a	2.6 bc	6.6 ab	4.0 bc	1.4 c	4.8 abc
Sonchus spp.	98.3 a	27.3 abc	20.3 bc	8.9 bc	17.6 bc	41.6 ab
Stachys palustris	4.8 ab	7.8 ab	13.9 a	2.1 ab	1.1 ab	0.2 b
Cirsium arvense	6.1 a	8.5 a	10.3 a	4.7 a	3.5 a	3.1 a
All perennials	127.4a	46.0 bc	51.2 b	19.6 cd	23.6 d	49.6 bc
Cereal yield	436 b	615 ab	458 b	674 a	504 ab	556 ab

Letters indicate row-wise significant differences

Fig. 7 Thomsen et al in Thomsen 2012

Key results and discussion

In order to reduce the risk of erosion, autumn tillage operations should preferably be avoided and replaced by spring ploughing (Fig. 1). Ploughing in spring compared to autumn may result in higher variation in weed biomass production but does not have much effect on yield (Fig. 2). Deep ploughing in spring compared to shallow ploughing as a single measure is found to give a better control of perennial weeds (Fig. 3) but less effect on yield (Fig. 3). The different weed species show differences in growth and timing of weed management has to be planed in relation to this (Fig. 4). Root fragments of *C. arvense* present in the upper 5-30 cm of the soil following tillage operations are found to have limited influence on the total shoot biomass produced, compared to biomass produced from the undisturbed root system, and the undisturbed roots in depth below 40 cm possess a high capacity for regeneration in the field (Table 1, Fig. 5). Root fragments of *C. arvense* present in the upper 5-15 cm of the soil, following spring ploughing, may however be hampered by a highly competitive green manure cover-crop established in the same spring (Fig. 6). It is nevertheless important to select competitive species and undersowing of *Trifolium pratense* in oats has been found not to compete well enough with established perennial weed plants (Brandsæter et al. 2012). In cases where spring fallow is used due to heavy infestation of perennial weeds, we do not see any increased effect of autumn ploughing on weed control or yield. Furthermore we do not see any effect of increasing the number of harrowing's from two to three (Fig. 7).

Conclusion

Spring ploughing should thus as far as possible be performed. In the studies referred to here large variation in weed biomass may occur but with low effect on yield. Due to these effects combined with the studies on weed biology we find implications for a positive effect of variation in time and space of tillage intensity (Peigné et al.2007) and for a combination of methods for weed control and without reduction in yield. Control of perennial weeds based on weed biology and environmental considerations are possible and operations should be adjusted to this.

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