Cut fallow to replace black fallow in an organic production system

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1 Introduction

Couch grass (*Elymus repens*) has large impact on yield and management strategies in temperate areas of the world, particularly in the Nordic countries. The control is to a large extent based on use of glyphosate in conventional agriculture and repeated soil cultivations in autumn, i.e. during a period when soil cultivations should be avoided due to the risk of increased nutrient leaching, in organic farming (Askegaard *et al.* 2011). The energy input for the common practice of stubble cultivation exceeds by large the input needed for chemical control in conventional farming (Tzilivakis *et al.* 2005). Therefore it is important to develop methods of couch grass control that are efficient and more environmentally friendly than repeated tillage or use of large quantities of glyphosate. By using subsidiary crops between cash crops and avoiding both glyphosate and tillage, environmental problems like nutrient and pesticide leaching could be avoided and positive cropping system effects could be achieved. However, competition from the subsidiary crop may not be enough to control couch grass.
In earlier investigations under-sown crops have competed well with couch grass during the autumn and the subsequent year and reduced the amount of couch grass substantially compared to treatments without competition, but generally, couch grass biomass have increased compared to the initial situation (Håkansson 1969, Dyke and Barnard 1976, Bergkvist *et al.* 2010). The possibility to improve the effect of competition by mowing has been investigated by e.g. Håkansson (1969) and Brandsaeter *et al.* (2012). According to Håkansson (1969) the method works, but the cutting interval must be very short. Brandsaeter *et al.* (2012) and Ringselle *et al.* (2015) found positive effect of mowing, but it was quite small.
Our aim was to investigate methods to improve the competitive effect of subsidiary crops by management. The hypothesis was that cutting (fragmentation) of the rhizomes by making slits in the soil by a spade (spading) would increase the number of couch grass shoots, thus improve the effect of repeated mowing. A recently developed prototype, "Kverneland Vertical rhizome/root cutter" (tractor propelled), can make similar slits in field scale.

2 Materials and Methods

The hypothesis was tested in three two-factorial field experiments arranged in complete randomized blocks with four replicates. The effect of cutting vertical slits in the soil was tested by comparing treatments with cross-cutting (grid) vertical slits with a control and the effect of mowing was tested by comparing mowed and not mowed plots (Table 1). Experiments were established at Krusenberg, Uppsala, Sweden, in 2012 and 2013, and at Ås, Norway, in 2013, by sowing a pure stand of white clover with 10 kg ha^{-1} in May. The mowed treatments were mowed to 3-5 cm above soil surface when the couch grass had about three new leaves in the experiments at Krusenberg and slightly later in the experiment at Ås. The experiments at Krusenberg were mowed eight and seven times during 2012 and 2013, respectively, and the experiment at Ås was mowed four times. Immediately after the first mowing, 10 cm deep slits was made by a spade in a 20 cm * 20 cm or 10 cm * 10 cm cross cutting pattern according to treatment (Table 1). The number of couch grass shoots was counted in the 80 cm by 80 cm centre in each 1.0 m^2 plot before first mowing and spading, before second mowing at Krusenberg and at final sampling in early October 2012 and late August 2013 at Krusenberg and in late October 2013 at Ås. The couch grass shoot and rhizome biomasses were sampled and dry weight determined at the final sampling. Data were log-transformed to equalize variance and analysed in accordance with the statistical design and with shoot numbers before first cutting as covariate using Model Mixed in SAS.

Table 1. Treatments used in six field experiments investigating the effect of cutting 10 cm deep slits in the soil (Cross Cutting (grid)) with a spade and mowing on couch grass

Treatment	Below ground weed control		Mowing
	Cross Cutting	Distance between slits	
Control	No	-	No
C20	Yes	20 cm	No
C10	Yes	10 cm	No
M	No	-	Yes
MC20	Yes	20 cm	Yes
MC10	Yes	10 cm	Yes

3 Results – Discussion

Cross cutting reduced the amount of rhizomes at Krusenberg (P=0.003), but the effect was different at Ås ($P_{Experiment*Cross\ Cutting}$=0.05) (Figure 1). At Ås, the amount of rhizomes was actually higher after cross cutting with the wide spacing than in the control or with narrow spacing between slits (P<0.05). Mowing reduced the amount of rhizomes at all sites (P<0.001), but the effect was similar with and without Cross cutting, which means that the effects of cross cutting and mowing were additive and that the mechanism was different from the hypothesized. Therefore, the hypothesis that Cross cutting increase the effect of mowing cannot be supported. The reason for the lack of interaction between the two factors could be that the number of shoots before mowing the second time, i.e about two weeks after first mowing and cross cutting, was lower than in the control at Krusenberg (data not presented), which was contrary to the hypothesis that Cross cutting would stimulate shooting and thereby increase the proportion of couch grass biomass cut of at mowing. Thus the control effect of cross cutting found at Krusenberg is probably an effect of damages to the rhizomes caused by the cross cutting procedure. The best effect of the cross cutting was found in the first year at Krusenberg, where cross cutting with 10 cm between the slits reduced the amount of rhizomes in late autumn compared to the control by as much as 60 %, on average (P<0.001). Repeated mowing was even more efficient and reduced the amount of rhizomes by more than 90 % (P<0.001). The combined effect was even greater. Cross cutting tended (P=0.13) to have an effect also at Krusenberg in 2013, but all effects at Krusenberg in 2013 were smaller than 2012. The reason for the smaller effect could be less soil moisture (data not presented) and therefore less growth in 2013 than 2012, but the difference could also be due to the shorter experimental period in 2013. The experimental period was shortened in 2013 compared to 2012, because a shorter fallow period would be beneficial for farmers that want to establish winter wheat after the fallow and because of the big effect of mowing in 2012 that almost wiped out the couch grass and made it difficult to evaluate the effect of cross cutting. We have not been able to interpret the stimulating effect of the cross cutting on couch grass at Ås.

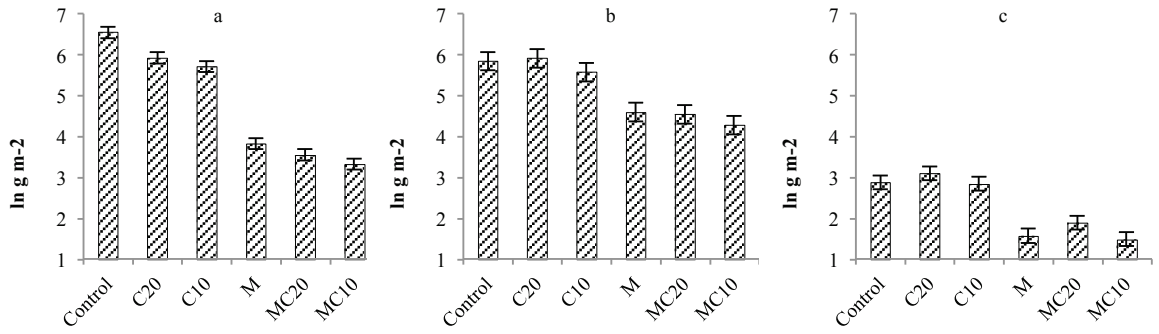

Fig.1. Predicted amount of rhizomes in autumn depending on cross cutting (grid) 10 cm deep vertical slits (C) in the soil with a spade (10 cm by 10 cm = 10; 20 cm by 20 cm = 20) in spring and repeated mowing (M) during summer at a) Krusenberg in 2012, b) Krusenberg in 2013 and c) Ås in 2013.

4 Conclusions

We conclude that Cross cutting to 10 cm could reduce the amount of rhizomes, but that the effect is variable. We also conclude that the cross cutting do not improve the effect of mowing, but that the effects are additive. Cross cutting reduce the amounts of couch grass shoots.

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