Weed regulation and establishment of organic seed crops of *Trifolium pratense* L., *Phleum pratense* L. and *Festuca pratensis* Huds.

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ABSTRACT

Results presented here show the effects of weed regulation on weed occurrence and seed yield in first year seed crops of red clover (*Trifolium pratense* L.), timothy (*Phleum pratense* L.) and meadow fescue (*Festuca pratensis* Huds.). Twelve cm row spacing / high intensity weed harrowing and 36 cm row spacing / inter-row hoeing were compared with a control treatment (12 cm row spacing / no mechanical weed control) in six field experiments in red clover, one in timothy and two in meadow fescue harvested in 2003 and 2004. The experiments also included a treatment in which grass or clover seed and cover crop seed were drilled simultaneously at 24 cm, which enabled row hoeing after crop emergence. As compared with the control treatment, seed yield was higher, but not significantly, in red clover by all weed regulation methods investigated. The content of pure seed was on average higher for all weed regulated treatments. Weed harrowing in the spring of the seed harvest year seed of meadow fescue showed 26% yield increase. In both grasses, the seed yield on plots where cover crop seed and grass seed had been drilled simultaneously at 24 cm row spacing was compareable to the control treatment, but the purity of the seed crop was mostly better. The lowest yield in both grass seed crops was recorded at 36 cm row spacing / row hoeing. The purity analyses emphasised the difficulties to clean timothy from seeds of alsike clover (*Trifolium hybridum* L.), and to clean meadow fescue from seeds of white clover and *T .perforatum*.

Key words: inter-row hoeing, meadow fescue, red clover, simultaneous drilling, timothy, weed harrowing, *Tripleruospermum perforatum*

INTRODUCTION

The production of organic herbage seed has increased significantly in Sweden during the last few years. Seed production was initially restricted due to a poor market (Wallenhammar *et al*. 2005), but by the introduction of partly organic seed mixtures in 2003, where at least 35 % of the components red clover, timothy and meadow fescue are organic seed, the market increased. The acreage increased from 104 hectares in 2000 to 2943 hectares in 2006, which implies that Sweden is by far the largest organic seed producer of timothy, meadow fescue and red clover in the world (Pedersen, 2006). This rapid increase means an increasing demand for the development of cultivation techniques. The experiences of the farmers were documented during 2002 and 2003, and different cultivation techniques as weed regulation, harvesting methods for red clover, and support of plant nutrition were demonstrated at field sites (Ståhl et al, 2004).

Results presented here show the effects of weed regulation on weed occurrence and seed yield in red clover, timothy and meadow fescue. High intensity of weed harrowing was compared with inter-row hoeing in crops established at three different row spacings.

MATERIALS AND METHODS

Nine field experiments were established in 2002 and 2003 and harvested in 2003 and 2004, respectively. The experiments were performed by the Field Experimental Divisions at the Rural Economy and Agricultural Societies, partly as on-farm trials and partly on experimental farms in districts with certified organic seed production.

A randomized block design with four replications was used for each experiment. Weed biomass was determined three weeks after the last cutting. In treatments with 12 cm row distance all weeds were collected in 4 subplots of 0.25 m^{-2}. For row distances >12 cm, weed was collected along a distance of 1 meter and covering half of the width of the row distance in 4 different rows. The weeds were counted, the fresh weight was determined and the three most common species were shown separately. The plots were harvested directly without prior swathing. The total yield of each plot was cleaned by the Rural Economy and Agricultural Society at Borrby, and purity analysis performed at the Seed Testing Station of Central Sweden Ltd, Örebro. The content of pure seed is calculated according to; (weight of cleaned seed lot/ weight of primary seed lot) x 100. The purity analyses were performed following cleaning of a composite sample for each treatment, according to the instructions of the Swedish Board of Agriculture for certified seed. The prevalence of other species was determined in a working- sample of 10 g for timothy and 50 g for meadow fescue and red clover. The highest contamination of other species accepted in certified seed of the investigated species is, on total, 1.5 weight- %, and of one individual species 1.0 weight-%.

High intensity weed harrowing after harvest of the crop and in the spring of the first seed harvest year in crops drilled at 12 cm row spacing was compared to inter-row hoeing on the same dates crops established at 36 cm row spacing. Six field experiments were carried out in red clover, one in timothy, and two in meadow fescue. The experiments in timothy and meadow fescue included a treatment with 12 cm row spacing and weed harrowing only in the spring of the seed harvest year. The experiments also included a control treatment drilled at 12 cm row spacing, and a treatment where grass or clover seed and cover crop seed were mixed and drilled simultaneously at 24 cm row spacing. In all other treatments, the undersown seed crop was established directly after the cover crop. The cereal cover crop was drilled at 90 % of the normal seeding rate when cover crop and seed crop were drilled separately, and 70 % of the normal seed rate when cover crop and seed crop were mixed before drilling. Depending on row spacing, the following seeding rates of red clover (tetraploid) were used; 12 cm: 5 kg ha^{-} 24 cm: 4 kg ha^{-1}, 36 cm: 3 kg ha^{-1}. Of timothy the following seeding rates were used; 12 cm: 8 kg ha^{-1}, 24 cm: 5 kg ha^{-1}, 36 cm: 5 kg ha^{-1}; and of meadow fescue; 12 cm: 12 kg ha^{-1}, 24 cm: 8 kg ha^{-1}, 36 cm: 8 kg ha^{-1}.

Statistical analysis was conducted according to SAS Mixed model.

RESULTS

Red clover

As compared to the control treatment, there was a significant increase in seed yield by all weed regulation methods investigated (Table 1). Drilling at 12 cm combined with weed harrowing gave highest yield. The content of pure seed was, on average, higher for all weed regulating treatments.

There were no significant differences between treatments in the weed biomass, dominated by *T. perforat*um, whereas the number of other seeds in the purity analysis tended to be lower in the row-hoed treatments (data not shown) The content of pure seed was on average higher in all weed-regulated treatments than in the control treatment.

Table 1. Weed regulation in red clover. Yield, content of pure seed and biomass of the weed. [1]Tripleurospermum perforatum in the field . Average of six field experiments in south and central Sweden, 2003 and 2004

Treatment		Pure seed yield kg ha^{-1} (rel)	Content of pure seed %	[1]*Tripleurospermum perforatum* fresh weight g m^{-2}
A.	Row distance 12 cm No mechanical treatment (control)	220 (100)	87.2	367
B.	Row distance 12 cm, weed harrowing after harvest of cover crop and in spring	240 (108)	91.4	128
C.	Row distance 36 cm, row hoeing after harvest of cover crop and in spring	230 (104)	88.0	335
D.	Row distance 24 cm, cover crop and clover seed mixed before drilling, row hoeing after emergence, after harvest of cover crop and in spring	230 (105)	90.1	169
	Prob.	ns	ns	ns

[1] Average of three experiments

Timothy

Weed harrowing in spring had a significant positive influence on seed yield of meadow fescue (Table 3), but not of timothy. The lLowest yield in both species was recorded at 36 cm row spacing. The purity analyses reflects the difficulties in cleaning seeds of alsike clover (*Trifolium hybridum*) from timothy and seeds of white clover (*Trifolium repens*) from meadow fescue. Apart from these species, *T. perforatum* was the dominating weed, especially in the row hoes treatment in meadow fescue (Table 3). However, the purity analyses (Wallenhammar, 2004) show that this species is a minor problem after cleaning.

According to the purity analysis (results not shown here) the seed of meadow fescue passed the requirements for certified seed on one of the experimental sites, whereas the prevalence of *T. perforatum* and white clover exceeds the limits on the other site. The timothy seed did not pass the requirements due to a high prevalence of *T. hybridum*.

Table 2**.** Weed regulation in an organic seed crop of timothy in central Sweden in 2004. Yield, content of pure seed and biomass of weeds

Treatment		Pure seed Yield, kg ha^{-1} (rel.)	Content of pure seed %	*Tripleurospermum perforatum* fresh weight g m^{-2}
A.	Row distance 12 cm No mechanical treatment (control)	314 (100)	76.5	295
B.	Row distance 12 cm, weed harrowing after harvest of cover crop and in spring	289 (92)	75.0	250
C.	Row distance 12 cm, weed harrowing in spring only	324 (103)	80.0	260
D.	Row distance 36 cm, row hoeing after harvest of cover crop and in spring	199 (63)	71.9	260
E.	Row distance 24 cm, cover crop and timothy seed mixed before drilling, row hoeing after emergence, after harvest of cover crop and in spring	297 (95)	80.0	200
	Prob.	ns	ns	ns

Table 3. Yield, content of pure seed, biomass of *Tripleurospermum perforataum* in the field and seeds of *T. perforataum* in purity analysis of meadow fescue. Average of two field experiments in central Sweden 2003-2004

Treatment		Pure seed yield kg ha^{-1} (rel)	Content of pure seed %	*Tripleuro-spermum perforataum* fresh weight g m^{-2}	Number of *T. perforatum* in 50 g
A.	Row distance 12 cm No mechanical treatment (control)	310 (100)	80.36	153	202
B.	Row distance 12 cm, weed harrowing after harvest of cover crop and in spring	370 (117)	83.5	176	104
C.	Row distance 12 cm, weed harrowing in spring only	390 (126)	89.26	134	152
D.	Row distance 36 cm, row hoeing after harvest of cover crop and in spring	280 (89)	84.23	478	300
E.	Row distance 24 cm, seed of cover crop and meadow fescue mixed before drilling, row hoeing after emergence, after harvest of cover crop and in spring	310 (99)	83.96	527	111
	Prob.	0.03	ns	ns	ns
	LSD	60			

DISCUSSION

The purity and germination requirements for certified organic seed are the same as for conventionally produced seed, implying large demands of efficient weed control. Weed control might be improved by different establishment techniques. . Today most farmers drill at 12 cm's (Ståhl *et al*. 2004), and weed problems are obvious.

Our results in red clover show that seed yield may be improved by all treatments investigated (Table 1 Increased yield by increasing row distance to 24 cm in conventional red clover) was reported by Larsson (2002). Weed control was improved by weed harrowing at 12 cm row distance and at 24 cm row distance, whereas the weed biomass at 36 cm row distance was similar to that of the control. In the grass seed crops the lowest yield was recorded when drilling at 36 cm, which is in line with older experiences (Nilsson and Leissner 1950). Weed harrowing early in the spring of the seed harvest year increased yield in meadow fescue by 26 % (table 3), whereas weed harrowing in autumn and spring increased yield by 17 %. Harrowing in autumn might have reduced the crop stand, while the harrowing in spring most probably contributed to increased nitrogen mineralization. In timothy, with a fairly late start of growth in spring, yield decreased 8 % on harrowing both in autumn and spring, whereas the corresponding yield increase on plots harrowed only in spring was 3 %. Simultaneous drilling showed increasing yields only in red clover, but in an earlier experiment this technique was successful also in timothy (Wallenhammar 2004). This technique was also recommended to red clover seed growers during the 1940s (Hertzman *et al.* 1940).

In conclusion, our investigations show that weed harrowing in the spring of the seed harvest year had a positive influence on yield as well as on purity in all of the species investigated. This is a measure to be taken in organic seed crops as growth and nitrogen mineralization will be stimulated. The purity analysis points at the difficulties to clean alsike clover from timothy (Aamlid 1997, Rabaeck- Pedersen 2006), and to clean large amounts of *T. perforatum* from meadow fescue. Row hoeing may be a solution on fields where white clover and alsike clover are expected to become troublesome.

ACKNOWLEDGEMENT

The investigations are part of the project "Cultivation techniques in organic ley seed production" financed by the organic research program, Ekoforsk, at SLU 2002-2004.

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