ISSN 1392-3196 / e-ISSN 2335-8947
Zemdirbyste-Agriculture, vol. 105, No. 2 (2018), p. 133–140
DOI 10.13080/z-a.2018.105.017

Seed yield of tetraploid red clover as influenced by cover crop management

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Abstract

Red clover for seed production is generally sown under cover crops. The warming climate raises a hypothesis that six-row barley cultivars might be replaced by intermediate cultivars of two-row barley as cover crops for establishing red clover seed production stands. The cover crop spring barley (*Hordeum vulgare* L.) cultivar 'Maali' was sown with four different cover crop treatments: 1) seeding rate 333 viable seeds per m², fertilisation rate 60 kg ha^{-1} N; 2) seeding rate 500 viable seeds per m², fertilisation rate 60 kg ha^{-1} N; 3) seeding rate 500 viable seeds per m², fertilisation rate 90 kg ha^{-1} N; 4) seeding rate 333 viable seeds per m², fertilisation rate 90 kg ha^{-1} N. The tetraploid red clover cultivars 'Varte' (early) and 'Ilte' (late) were sown at the rates of 2, 4, 6 and 8 kg ha^{-1} in four replicates using a randomised complete plot design. The height and density of generative tillers of barley, the grain yield and quality, the number of red clover plants per m² were measured in the sowing year. The seed yield and quality of red clover in the first harvest year were determined. Economic calculations were based on the prices valid in 2013–2014. The nitrogen rate and seeding rate had a significant effect on elongation of generative tillers, as well as increasing plant density, grain yield and protein content. Increased seed rate of the cover crop (500 viable seeds m²) and higher fertilization rate (90 kg ha^{-1} N) decreased red clover seed yield to 10 %. Increasing of only the seed rate of a cover crop, resulted in up to 4 % reduction in the red clover yield. The higher nitrogen rate (90 kg ha^{-1} N), when barely was sown at a rate of 500 viable seeds m² and at 300 viable seeds m², resulted in up to 5 % reduction in red clover seed yield. The study showed that it is practical to establish a seed production stand of red clover using a seeding rate of 4–6 kg ha^{-1}.

It can be concluded that two-row barley cultivars are also recommendable cover crops besides the currently used six-row barley cultivars. Economic analysis indicated that it is practical to reduce both the seeding rate of the cover crop and nitrogen rate by one third.

Key words: barley, clover, cover crop, nitrogen and seeding rate, yield.

Introduction

Red clover is the main herbaceous leguminous plant in Estonia, whose seed yield depends on the cultivar type, the weather conditions during the growing season, abundance of pollinators as well as seed crop management. A seed production stand is generally sown under cover crops. The use of cover crop allows seed producers to get income in the sowing year and lessen the pressure of annual weeds on the young clover herbage. Cover crop protects clover seedlings against unfavourable weather conditions during the first half of the summer.

Early six-row barley cultivars are recommended as cover crops in the northern countries as these can be harvested earlier than other spring cereals. Thus the clover stand recovery period between the cover crop harvest and the end of the vegetation period is longer. Disadvantages of the six-row barley cultivars are fine grains and modest lodging resistance. As a result of the global climate warming during the past 30 years, frost free period has lengthened by 17 days in Estonia (Sepp, 2015). In this context, a relevant question has risen whether six-row barley cultivars might be replaced by intermediate cultivars of two-row barley as cover crops for establishing red clover seed production stand.

In order to create better light and soil moisture status for undersown clover, it is recommended to reduce the seeding rate of cover crops by 25–50% (Kotkas, 1969; Jaama, 1986). Similar recommendation has been used in the USA until today (Undersander et al., 1990). At the same time, it is considered necessary to reduce nitrogen rate applied to the cover crop by 25–30%. However, the experience from Norway shows that reduction of the seeding rate of cover crops and nitrogen fertiliser rate is unnecessary (Aamlid, Havstad, 2011 a; b) when modern two-row barley (or even spring wheat) cultivars with improved lodging resistance are cultivated.

Please use the following format when citing the article:
Bender A., Tamm S. 2018. Seed yield of tetraploid red clover as influenced by cover crop management. Zemdirbyste-Agriculture, 105 (2): 133–140 DOI 10.13080/z-a.2018.105.017

Seeding rates between 6–12 kg ha^{-1} have been used for the seed production stands of tetraploid red clover cultivars in Estonia (Kotkas, 1969; Rand, 1992; Bender, 2006). Very wide ranges of seeding rates are reported for red clover in literature but they are generally lower than those recommended here. Most frequent recommendations are between 2.0–4.5 kg ha^{-1} (Pankiw et al., 1977; Bowley et al., 1985; Taylor et al., 1996; Bouet, Sicard, 1998; Huebner, 2016). Nevertheless, in real practices, the seed crops are usually sown at higher rates of 6–13 kg ha^{-1} to ensure establishment of crop stand (Rinker, Rampton, 1985; Taylor et al., 1996; Huebner, 2016). Seeding rates between 8–10 kg ha^{-1} are recommended in Latvia (Jansone, 2008).

Generally, these publications do not specify whether these rates apply to diploid or tetraploid cultivars. A thousand seed weight of diploid red clover cultivars is between 1.4–1.9 g and that of tetraploid cultivars is between 2.5–3.2 g. With the same seeding rate based on weight, considerably less seeds of tetraploid cultivars are sown than with diploid cultivars. Since seed crop management of red clover has not been researched in Estonia during the past decades, field trials were conducted at Estonian Crop Research Institute in 2013 and 2014 to answer the following questions: 1. Can the six-row barley cultivars be replaced by two-row barley as cover crops? 2. What is the effect of seeding rate and nitrogen fertilisation on grain yield and quality of cover crop as well as on the establishment of the undersown red clover stand and seed yield? 3. What is the impact of red clover seeding rate on the formation of red clover stand and seed yield? and 4. What is the effect of seeding rate and nitrogen fertilisation of cover crop and sowing rate of red clover on the monetary value of production in the sowing year and harvest year together?

Materials and methods

The experiment was carried out at the Estonian Crop Research Institute, Jõgeva (58°45′ N, 26°24′ E) in 2013 and 2014. An intermediate two-row barley (*Hordeum vulgare* L.) cultivar 'Maali' was used as a cover crop. The trial constituted four cover crop treatments: 1) seeding rate 333 viable seeds per m², fertilisation rate 60 kg ha^{-1} N; 2) seeding rate 500 viable seeds per m², fertilisation rate 60 kg ha^{-1} N; 3) seeding rate 500 viable seeds per m², fertilisation rate 90 kg ha^{-1} N; 4) seeding rate 333 viable seeds per m², fertilisation rate 90 kg ha^{-1} N. The tetraploid red clover (*Trifolium pratense* L.) cultivars 'Varte' (early) and 'Ilte' (late) at the rates of 2, 4, 6 and 8 kg ha^{-1} were replicated four times using a randomised plot design.

The experiment was done on a *Calcaric Cambic Phaeozem* (*loamic*) (WRB, 2014) with the following soil nutrient contents: 179 mg kg^{-1} P, 162 mg kg^{-1} K, 1392 mg kg^{-1} Ca and 56 mg kg^{-1} Mg. Organic carbon content was 2.0%, soil pH_{KCl} 5.4. P and K fertilisers (19 kg ha^{-1} P and 67 kg ha^{-1} K) were applied manually; nitrogen was applied as ammonium nitrate (NH_4NO_3) according to the experimental design by a fertiliser spreader "Saxonia" (Saxonia GmbH, Germany) prior to sowing. The red clover stands were not fertilized in the following year.

The cover crop (barley) was sown with a seeder "Pöttinger Vitasem 252" (Pöttinger Landtechnik GmbH, Austria) on 30 April. The red clover was undersown using a seeder "Hege 80" (Hege Maschinen GmbH, Germany) on 2 May. The trial area was sprayed against short-lived dicotyledonous weeds with a herbicide MCPA 750 at a rate of 1.0 l ha^{-1}.

The number of generative tillers of the cover crop per 0.5 × 0.5 m area was counted in four replicates and their height was measured during flowering in 16 replicates in the year of establishment. The spring barley was harvested on 30 July. The red clover plants could recover for 90 days before the end of the growing season. Barley was harvested from 7 m^2 plots in six replicates with a combine harvester "Hege 140" (Hege Maschinen GmbH). Grain samples were dried, sorted and weighed; volume weight, 1000 grain weight and crude protein content were determined in the laboratory of the Estonian Crop Research Institute using the standard methods. The number of red clover plants was counted in 0.5 × 0.5 m area in four replicates before the end of vegetation in the year of establishment.

In seed harvest year (2014), the stems of red clover were regularly warped from the plots' edges towards the centre, avoiding the intertwining of plants. The seeds of the early type cultivar 'Varte' were harvested on 20 August and those of the late type cultivar 'Ilte' were harvested on 2 and 3 September, by direct combining by a plot harvester "Hege 125C" (Hege Maschinen GmbH). The seed mass was dried, brushed by a brushing machine "Westrup HA-400" (Westrup A/S, Denmark) and fine-cleaned by a laboratory air-screen cleaner LA-LS (Westrup Kamas Industri AB, Sweden). Germination and 1000 seed weight were determined in the laboratory three months after combine harvesting and cleaning. The trials were located in the vicinity of an apiary (approx. 300 m away) with 8 beehives.

Meteorological conditions of the experimental years. The spring in 2013 arrived later than usual. The air temperature in May, June and July was higher than the long-term average, rainfall was scarce in June, July and August. Emergence of spring barley and red clover was uniform because the seeds were sown as soon as the weather permitted. Tillering was good due to the rainfall in May. Soil moisture deficit and higher than normal air-temperature accelerated the ripening of spring barley, but slowed down the growth and development of undersown clover plants.

The weather conditions in the year of red clover seed harvest (2014) were unpredictable. May was the warmest across the long-term (1922–2014) observations. After the warm May, an unusually cool June followed. Especially cool was the last ten-day period of June when early red clover was already blooming. On four occasions (on 24, 26, 27 and 28 June), frost was registered on the surface of the plant stand. On 17 June, snow pellets were falling and on 23 June hail occurred. The weather improved in July. Average temperature of the month was 2.5° higher and there was 21% more sunshine than the long-term average. Conditions were very favourable

for pollinators. The weather conditions became worse with heavy and frequent rainfall since 23 August. The seeds of early red clover were successfully harvested in favourable weather conditions. The ripening of seeds of late red clover fell into the rainy period and for that reason part of seeds were damaged due to germination in flower heads in the field.

Statistical analysis of data was performed using the software package *Agrobase 20^{TM}*. The least significant differences (LSD) were calculated to evaluate the statistical significance of differences between the measured characteristics.

Results and discussion

Cover crop. The spring barley cultivar 'Maali', sown as a cover crop, did not lodge in any of the treatments. Increasing the seeding rate from 333 seeds to 500 seeds per m² resulted in shorter generative tillers by 2–5 cm (Table 1). In part of the trial, where the early red clover cultivar 'Varte' was undersown, a decrease in the length of generative tillers was statistically significant. The use of higher nitrogen rate (90 kg ha^{-1} N) increased the height of spring barley more (by 7–8 cm) than by reducing seeding rate from 500 to 333 seeds per m^2, which resulted in an increase of plant height by 3–4 cm.

Table 1. Plant height and density of generative tillers in the spring barley cultivar 'Maali'

Cover crop treatment				LSD_{05}
Seeding rate				
333 seeds m^2, 60 kg ha^{-1} N	500 seeds m^2, 60 kg ha^{-1} N	500 seeds m^2, 90 kg ha^{-1} N	333 seeds m^2, 90 kg ha^{-1} N	
Early red clover cultivar 'Varte'				
Plant height from the soil surface to the tip of awns, cm				
72	69	75	79	2
Number of generative tillers per m^2				
592	637	694	621	44
Late red clover cultivar 'Ilte'				
Plant height from the soil surface to the tip of awns, cm				
69	67	72	77	3
Number of generative tillers per m^2				
542	654	700	663	70

The number of generative tillers of spring barley per area unit was affected both by the seeding and nitrogen fertiliser rates. Increasing both rates resulted in a higher density of generative tillers. In general, the difference was statistically significant. Sowing at a rate of 500 seeds per m^2 and fertilizing with 90 kg ha^{-1} N created the hardest growing conditions for the undersown red clover, due to tall and dense cover crop. The height of dense plant stand (approx. 700 tillers per m²) was 72–75 cm.

Barley grain yield ranged between 3586–4760 kg ha^{-1} in the treatments (Table 2). The reduction of seeding rate by one third at the treatment 60 kg ha^{-1} N decreased the yield by 1.8–2.6% and at the treatment 90 kg ha^{-1} N – by 3.0–17.7%. The nitrogen fertiliser rate affected the yield of barley more than the seeding rate. When the fertiliser rate was decreased to 60 kg ha^{-1} N at a barley seeding rate of 500 seeds per m^2, the grain yield was reduced by 14.8–28.1%.

Table 2. Grain yield and quality of spring barley cultivar 'Maali'

Cover crop treatment	Yield		Volume weight	Crude protein content %	1000 grain weight
	kg ha^{-1}	%	g L^{-1}		g
Undersown early red clover cultivar 'Varte'					
Seeding rate 333 seeds per m^2, 60 kg ha^{-1} N	3586	100.0	692	9.0	48.79
Seeding rate 500 seeds per m^2, 60 kg ha^{-1} N	3678	102.6	679	8.7	47.08
Seeding rate 500 seeds per m^2, 90 kg ha^{-1} N	4211	117.4	688	9.7	47.38
Seeding rate 333 seeds per m^2, 90 kg ha^{-1} N	4104	114.4	699	10.1	49.38
Undersown late red clover cultivar 'Ilte'					
Seeding rate 333 seeds per m^2, 60 kg ha^{-1} N	3663	100.0	694	9.4	48.60
Seeding rate 500 seeds per m^2, 60 kg ha^{-1} N	3729	101.8	681	8.9	47.37
Seeding rate 500 seeds per m^2, 90 kg ha^{-1} N	4760	129.9	682	10.3	48.43
Seeding rate 333 seeds per m^2, 90 kg ha^{-1} N	4111	112.2	696	10.3	49.73
LSD_{05}	528		14	0.4	1.57

The reduction of seeding rate by one third to rate 333 seeds per m^2 caused increase (though not significant) of volume weight and 1000 grain weight. Increasing the fertiliser rate from 60 to 90 kg ha^{-1} N caused significant increase in crude protein content. Barley seeding rate also affected crude protein content. Reduction of the seeding rate from 500 to 333 seeds per m² caused significant increase in crude protein content, except for the treatment where fertiliser rate was 90 kg ha^{-1} N and red clover 'Ilte' was undersown.

Effect of red clover seeding rate and cover crop on establishment of red clover. Increasing the seeding

rate of red clover increased the number of plants per area unit counted in the autumn of the sowing year (Table 3). The number of red clover plants increased until the seeding rate 6 kg ha^{-1}. The negative effect of the cover crop on the density of red clover plants was greater in the treatment where spring barley was sown at seeding rate of 500 seeds per m^2 at fertiliser rate of 90 kg ha^{-1} N. Previously it was found (Bender, 2006) that in the case of optimal growth conditions for the cover crop it is necessary to increase the seeding rate of undersown red clover to obtain required density. The same can be concluded from our results.

Table 3. Densities of red clover stands sown under spring barley cultivar 'Maali' in the autumn of the seeding year

Clover seeding rate kg ha^{-1}	Cover crop treatment, seeding rate: 333 seeds per m^2, 60 kg ha^{-1} N	500 seeds per m^2, 60 kg ha^{-1} N	500 seeds per m^2, 90 kg ha^{-1} N	333 seeds per m^2, 90 kg ha^{-1} N	LSD_{05}
Early red clover cultivar 'Varte', plants m^{-2}					
2	23	30	14	19	10
4	35	56	27	37	18
6	53	50	48	52	20
8	59	66	58	61	20
LSD_{05}	19	15	20	23	
Late red clover cultivar 'Ilte', plants m^{-2}					
2	27	28	19	25	8
4	40	47	26	48	9
6	61	69	56	57	20
8	72	77	64	78	29
LSD_{05}	12	12	23	24	

Red clover seeding rates of 6 and 8 kg ha^{-1} both resulted in more or less the same density of red clover stand at all cover crop treatments. Nitrogen rate affected the red clover stand more than seeding rate of barley. Presumably, to obtain a high red clover seed yield, at least 17 plants per square meter are needed (Clifford, Anderson, 1980). On the basis of our data from the autumn of the sowing year, only one treatment did not achieve this level: the seeding rate of undersown red clover was 2 kg ha^{-1} and that of cover crop was 500 seeds per m^2, fertilized with 90 kg ha^{-1} N (commonly used in barley production).

Seed yield of red clover. Seed yield of early red clover cultivar 'Varte' varied between 349–413 kg ha^{-1} (Table 4). All seeding rates of red clover produced higher seed yields when the seeding and nitrogen rates of barley were reduced by one third (from 500 to 333 seeds per m^2 and from 90 to 60 kg ha^{-1} N). When the seeding rate of barley was not reduced, the seed yield of red clover cultivar 'Varte' decreased only by 0.1–4.1% at fertiliser rate of 60 kg ha^{-1} N, whereas the seed yield decreased by 3.6–10.3% at a fertiliser rate of 90 kg ha^{-1} N.

Seeding rates of red clover 'Varte' between 2–8 kg ha^{-1} did not affect the seed yield of the first harvest year significantly. However, the seed yield tended to increase till the seeding rate of 6 kg ha^{-1}, but declined at the rate of 8 kg ha^{-1}. The same trend has been observed in previous trials at Jõgeva (Kotkas, 1969). Havstad and Øverland (2017) reported a similar negative tendency in Norwegian trials.

Table 4. The effect of cover crop treatment of spring barley cultivar 'Maali' and seeding rate of undersown red clover on the seed yield of cultivar 'Varte' in 2014

Red clover seeding rate kg ha^{-1}	Cover crop treatment, seeding rate: 333 seeds per m^2, 60 kg ha^{-1} N	500 seeds per m^2, 60 kg ha^{-1} N	500 seeds per m^2, 90 kg ha^{-1} N	333 seeds per m^2, 90 kg ha^{-1} N	LSD_{05}
2	389	374	349	387	44
4	402	397	377	390	70
6	413	411	398	392	49
8	389	388	374	383	46
LSD_{05}	49	57	59	35	
Effect of cover crop treatment on the seed yield %					
2	100.0	95.9	89.7	99.3	
4	100.0	98.8	93.7	97.0	
6	100.0	99.5	96.4	95.0	
8	100.0	99.9	96.4	98.7	
Effect of seeding rate on the seed yield %					
2	100.0	100.0	100.0	100.0	
4	103.3	106.4	107.8	101.0	
6	106.0	109.9	113.8	101.4	
8	99.8	104.0	107.2	99.2	

Seed yield of late red clover was affected by continuous rainfall before harvest and as a result, some seeds germinated in flower heads and the seed yield was reduced. Based on visual assessment, losses were bigger in denser stands which did not dry out between repeated rainfalls. Nevertheless, late red clover cultivar 'Ilte' produced similar seed yields as early cultivar 'Varte' (Table 5). The seed yield of late red clover 'Ilte' varied between 345–402 kg ha^{-1}. The highest seed yields of red clover were obtained from the treatments where both seeding and nitrogen fertiliser rates of the cover crop were reduced. Using the cover crop seeding and nitrogen rates applied in large-scale production significantly reduced the seed yield of the late red clover cultivar 'Ilte' if sown 2 and 4 kg ha^{-1}. Among the other cover crop treatments the differences between the seed yields cannot be considered statistically significant.

Table 5. The effect of cover crop treatment of spring barley cultivar 'Maali' and seeding rate of undersown red clover on the seed yield of the cultivar 'Ilte' in 2014

Red clover seeding rate kg ha^{-1}	Cover crop treatment seeding rate				LSD_{05}
	333 seeds per m^2, 60 kg ha^{-1} N	500 seeds per m^2, 60 kg ha^{-1} N	500 seeds per m^2, 90 kg ha^{-1} N	333 seeds per m^2, 90 kg ha^{-1} N	
2	373	353	345	368	25
4	402	365	356	355	40
6	374	374	366	384	67
8	390	358	356	381	52
LSD_{05}	31	29	24	30	
Effect of cover crop treatment on the seed yield %					
2	100	94.6	92.6	98.7	
4	100	90.7	88.5	88.4	
6	100	100.1	97.9	102.9	
8	100	92	91.3	97.8	
Effect of seeding rate on the seed yield %					
2	100.0	100	100	100	
4	107.9	103.5	103.2	96.6	
6	100.3	106.1	106	104.5	
8	104.6	101.7	103.1	103.6	

The red clover seeding rate of 6 kg ha^{-1} was mostly justified in the case of late cultivar 'Ilte'. Only in one treatment, where seeding and nitrogen rate of the cover crop were reduced, red clover seeding rate of 4 kg ha^{-1} was sufficient. Increasing the seeding rate up to 8 kg ha^{-1} did not guarantee extra yield. Similar results have been obtained in previous trials at Jõgeva (Bender, 2015).

The trial results suggest that tetraploid red clover cultivars bred at Jõgeva, Estonia have a good seed yield potential. Tetraploid cultivars generally produce approximately 40% lower seed yield than diploid cultivars (Sjödin, Ellerström, 1986). A good seed yield refers to 400–500 kg ha^{-1} from diploid cultivars and 200–400 kg ha^{-1} from tetraploid cultivars (Taylor, Quesenberry, 1996; Boller et al., 2010). In Norway, according to the statistics bureau, the average seed yield of tetraploid cultivars was 164 kg ha^{-1}, that of diploid cultivars 247 kg ha^{-1}. The respective indices in Sweden were 225 and 300 kg ha^{-1} (Amdahl et al., 2016 a; b). Average seed yield of diploid cultivars was 110.4 kg ha^{-1} and that of tetraploid cultivars 94.9 kg ha^{-1} in the trials carried out in Lithuania in 2003–2011 (Liatukas, Bukauskaite, 2012).

Treatment of cover crop and red clover seeding rate did not remarkably affect the quality of the clover seed. A thousand seed weight of the cultivar 'Varte' was between 2.847–3.054 g and for cultivar 'Ilte' it ranged between 2.823–2.938 g (Table 6). The seed germination rates of both red clover cultivars were very good and varied between 96–99% for all treatments tested. The very good seed germination rate of late red clover was surprising as the yield was affected by continuous rainfalls and seeds germinated partially in flower heads in heavily lodged stand.

Economic calculations. Of production inputs in the year of sowing, major costs were related to phosphorus-potassium compound fertiliser (price 350 € t^{-1}), ammonium nitrate (300 € t^{-1}), certified seed of spring barley, 1st generation category (C1 – 0.52 € kg^{-1}) and basic seed category (B) of red clover (E 10 € kg^{-1}). If the cover crop was seeded at the rate of 500 seeds per m² and fertilised at 90 kg ha^{-1} N, the inputs per hectare needed for the establishment of seed crop cost 387 € (Table 7). Reduction of the seeding rate of spring barley by one third reduced the establishment costs by 11.5%, and reduction of nitrogen fertiliser rate by one third lowered the establishment costs by 6.9%. Altogether, the reduction of both seeding rate and fertiliser rate reduced the establishment costs by 20.2% (here and hereafter the costs of machinery work are not included).

Based on the price level of 2015, the price of fodder barley crop was 147 € t^{-1}, the yield of tetraploid cultivars of red clover as certified (C) seed category was 6 € kg^{-1}. The variable costs for establishing seed production stand, and monetary value of seed yield of cover crop and red clover sown at 4 kg ha^{-1} are provided in Table 7. Based on the trial data, the economically most

Table 6. Seed quality of red clover in 2014

Red clover seeding rate kg ha^{-1}	Cover crop treatment							
	seeding rate							
	333 seeds per m^2, 60 kg ha^{-1} N		500 seeds per m^2, 60 kg ha^{-1} N		500 seeds per m^2, 90 kg ha^{-1} N		333 seeds per m^2, 90 kg ha^{-1} N	
	1000 seed weight g	germination %	1000 seed weight g	germination %	1000 seed weight g	germination %	1000 seed weight g	germination %
Early red clover cultivar 'Varte'								
2	2.980	99	2.995	99	3.038	96	2.908	96
4	3.045	97	2.956	99	2.961	96	2.857	99
6	3.048	97	3.054	99	3.025	98	2.892	99
8	3.028	99	2.998	99	2.977	96	2.847	97
Late red clover cultivar 'Ilte'								
2	2.854	99	2.916	98	2.903	99	2.938	98
4	2.840	98	2.867	99	2.915	99	2.838	99
6	2.823	97	2.881	99	2.894	98	2.859	98
8	2.863	99	2.846	99	2.935	99	2.878	97

Table 7. Economics per hectare in 2013–2014 based on the red clover seeding rate of 4 kg ha^{-1}

Cover crop treatment	Variable costs €	Income from sales of production €	Net profit €	+ / − control
Early red clover cultivar 'Varte'				
333 seeds per m^2, 60 kg ha^{-1} N	322	2939	2617	control
500 seeds per m^2, 60 kg ha^{-1} N	362	2923	2561	–56
500 seeds per m^2, 90 kg ha^{-1} N	387	2881	2494	–123
333 seeds per m^2, 60 kg ha^{-1} N	347	2943	2596	–21
Late red clover cultivar 'Ilte'				
333 seeds per m^2, 60 kg ha^{-1} N	322	2950	2628	control
500 seeds per m^2, 60 kg ha^{-1} N	362	2738	2376	–252
500 seeds per m^2, 90 kg ha^{-1} N	387	2806	2419	–209
333 seeds per m^2, 90 kg ha^{-1} N	347	2734	2387	–241

rational practice was to reduce the seeding rate of cover crop and nitrogen fertiliser rate by one third if red clover seed field is established. Similar results were obtained at the remaining seeding rates of red clover.

Conclusions

1. Among cover crop treatments, the nitrogen rate had a greater effect than seeding rate on barley. The effect appears in elongation of generative tillers, increasing plant density, higher grain yield and crude protein content. In order to compensate the adverse effect of cover crop sown at a rate of 500 seeds per m² and fertilised with 90 kg ha^{-1} N, the seeding rate of red clover should be increased.

2. When the weather conditions for plant growth were favourable in the establishing year (if cover crop did not lodge), the cover crop treatments had little effect on the next year's red clover seed yield. Without reducing the seeding rate of the cover crop, the seed yield decreased by up to 4%, without reducing the nitrogen fertiliser rate, the seed yield decreased by up to 5% and without reducing both previously mentioned factors, the seed yield decreased by up to 10%.

3. The seeding and fertilisation rates of the cover crop and the seeding rate of red clover did not remarkably affect the quality of seed yield.

4. If the seeds of red clover were sown uniformly, the seeding rate of tetraploid red clover between 2–8 kg ha^{-1} had little effect on the red clover seed yield. The trial results showed that it is practical to establish the seed production stand of red clover with a seeding rate of 4–6 kg ha^{-1}.

5. The trials indicated that it is possible to sow the intermediate two-row barley cultivars instead of the currently recommended cultivars of early six-row barley when the seed production field of red clover is established with a cover crop.

6. Economic analysis based on the variable costs incurred for establishing the seed production stand, monetary value of cover crop and next year's red clover seed yield indicated that it is practical to reduce cover crop and nitrogen fertiliser seeding rate by one third.

Acknowledgements

The research work was carried out in the framework of an applied research project "The effect of cover crop, sowing rate and nitrogenous fertiliser rate on the yield ability of the red clover seed herbage in the first crop year" ordered and financed by the Ministry of Agriculture of the Republic of Estonia.

Received 27 06 2017
Accepted 30 01 2018

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ISSN 1392-3196 / e-ISSN 2335-8947
Zemdirbyste-Agriculture, vol. 105, No. 2 (2018), p. 133–140
DOI 10.13080/z-a.2018.105.017

Tetraploidinių raudonųjų dobilų sėklų derlius priklausomai nuo antsėlio auginimo agrotechnikos

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Santrauka

Sėklai auginami raudonieji dobilai dažniausiai sėjami su įsėliu. Šiltėjant klimatui keliama hipotezė, kad įrengiant raudonųjų dobilų sėklinius pasėlius, kaip antsėlis šešiaeilių miežių veislės gali būti pakeistos dvieiliais. Tirti šie vasarinio miežio (*Hordeum vulgare* L.) veislės 'Maali' kaip antsėlio variantai: 1) sėklos norma – 333 daigios sėklos m², tręšimo norma – 60 kg ha^{-1} N, 2) sėklos norma – 500 daigių sėklų m², tręšimo norma – 60 kg ha^{-1} N, 3) sėklos norma – 500 daigių sėklų m², tręšimo norma – 90 kg ha^{-1} N, 4) sėklos norma – 333 daigios sėklos m², tręšimo norma – 90 kg ha^{-1} N. Veislių 'Varte' (ankstyva) ir 'Ilte' (vėlyva) tetraploidiniai raudonieji dobilai 2, 4, 6 ir 8 kg ha^{-1} buvo pasėti keturiais pakartojimais, pagal randomizuotų schemą. Miežių aukštis ir generatyvinių ūglių tankis, grūdų derlius ir kokybė, raudonųjų dobilų skaičius m² buvo vertinti sėjos metais. Pirmaisiais derliaus metais buvo nustatyta raudonųjų dobilų sėklų derlius ir kokybė. Ekonominiai skaičiavimai buvo paremti kainomis, galiojusiomis 2013–2014 m. Azoto trąšų ir sėklos normos turėjo esminės įtakos generatyvinių ūglių tįsimui bei augalų tankio didėjimui, grūdų derliui ir baltymų kiekiui. Padidinta antsėlio sėklos norma (500 daigių sėklų m²) ir gausesnis tręšimas (90 kg ha^{-1} N) dobilų sėklų derlių sumažino iki 10 %. Vien dėl padidintos antsėlio sėklos normos dobilų sėklų derlius sumažėjo iki 4 %. Didesnė norma azoto (90 kg ha^{-1} N) antsėliui miežius pasėjus tankiau (500 daigių sėklų m²) ir rečiau (300 daigių sėklų m²) dobilų sėklų derlių sumažino iki 5 %.
Tyrimo duomenys parodė, kad įrengiant raudonųjų dobilų sėklinį pasėlį verta sėti nuo 4 iki 6 kg ha^{-1} sėklos. Remiantis tyrimo duomenimis darytina išvada, kad, be šiuo metu naudojamų šešiaeilių miežių veislių, taip pat rekomenduotinos dvieilių miežių veislės. Ekonominė analizė parodė, kad verta trečdaliu sumažinti antsėlio sėklos ir azoto trąšų normas.

Reikšminiai žodžiai: antsėlis, azoto ir sėklos normos, derlius, dobilai, miežiai.