Yield comparison of Italian ryegrass and winter rye sown as cover crops after forage maize

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Abstract

Italian ryegrass (*Lolium multiflorum* L.) and winter rye (*Secale cereale* L.) sown as cover crops after forage maize, may produce an early cut before a new (maize) crop is installed. We report on the performance of a diploid and a tetraploid variety of both crops sown in early, mid and late October 2012. Aboveground and belowground biomasses were determined at regular intervals from December till April 2013. Aboveground biomass (cut to ground level) was significantly affected by time of sowing: at any moment, the yield of the cover crops sown early October was at least four times higher than that of the cover crops at the end of October. Similar results were found for belowground biomass. Total biomass of rye was always significantly higher than that of ryegrass, regardless of the time of sowing. By the end of April 2013, the DM yields (above 5 cm) of early sown winter rye and Italian ryegrass were 2,504 and 1,393 kg DM ha^{-1} respectively. The ploidy of the crops did not affect biomass. This study suggests that winter rye as a cover crop is clearly more productive than Italian ryegrass, sown in October after forage maize harvest.

Keywords: belowground biomass, *Secale cereale*, *Lolium multiflorum*

Introduction

Cover crops can contribute to a more sustainable forage maize production: nitrate leaching and soil erosion are decreased and soil organic matter is increased (Zavatarro *et al.*, 2012). Eventually the cover crop can be harvested as feed before growing a next (forage maize) crop. When the forage maize is harvested, at the end of the summer or at the beginning of the autumn in NW Europe, day length is too short for dicot cover crops to allow a successful development. Crops like Italian ryegrass (*Lolium multiflorum*; Lm) and winter rye (*Secale cereale*; Sc) can still be sown successfully at that time of the year (Vos *et al.*, 1997). As both crops are frost tolerant under NW European conditions and both are characterized by an early regrowth after winter, they are particularly suited for an early spring cut, e.g. for forage or for feedstock in biogas installations. Although the use of Italian ryegrass as a cover crop is more common in NW Europe, some winter rye varieties bred for biomass production have been shown to have a higher potential biomass production (Verhelst, 2011). The aim of this trial was to answer the following research questions:

1. Which crop has the highest biomass production in winter?
2. How large is the influence of sowing?
3. Which crop produces most forage in spring?

Materials and methods

A trial was established in October 2012 on a sandy loam soil in Merelbeke, Belgium comparing a diploid and a tetraploid variety of Lm ('*Meroa*', Lm2 and '*Melchior*', Lm4 respectively) and a diploid and a tetraploid variety of Sc ('*Protector*', Sc2 and '*Jobaro*', Sc4 respectively) sown on three different days (1 October, S1; 22 October, S2 and 31 October, S3). The selected varieties were the highest yielding varieties in former research (Verhelst, 2011). The trial was a split plot design with three replicates; individual plot size was 30 m^2. Sowing date was the main plot factor and the four cover crop varieties formed the subplot factor. Lm and Sc were sown at densities of 1,500 and 340 germinable seeds per m^2 respectively using a 3-m wide conventional seed drill. On five occasions (Table 1) during autumn and winter, the

aboveground biomass was measured by hand cutting the seedlings in a square of 1.5 m^2 per plot just above the soil surface. The harvested biomass was washed with water to remove soil. In the beginning of April, all plots were fertilised with 90 kg N ha^{-1}. On 25 April, the cover crops were cut at 5 cm height using an Agria cutting-bar mower. Dry matter yield was determined by drying samples for 16 h at 75 °C.

Because of their labour-intensive requirements, measurements of root biomass were limited to three occasions (Table 2) and to the tetraploid varieties. A soil cube with an edge of 0.2 m was dug out up to a depth of 20 cm using a steel mould. Samples were washed on a sieve with mesh 0.8 mm and dried for 16 h at 75 °C.

ANOVA for the dry matter yield was performed using the *aov()* function in R. The hierarchy of the split plot design and the nesting of the varieties within species were taken into account in the model. Multiple comparisons of species averages within the N levels were performed using the TukeyHSD() function.

The period October till December was very wet, with 318 mm of rain instead of the normal 231 mm. The period from January till March was colder than usual. Especially in March the average temperature was only 2.9 °C instead of 6.8 °C normally.

Results and discussion

No significant differences between the varieties of a species were found at any harvest date, so results are presented as average values per species (Table 1). Irrespective of harvest date, aboveground DM yield was at least 4 times lower (P<0.001) when crops were sown at S3 compared to S1. The development of the cover crops sown on S3 was so slow that the seedlings were too small to harvest on the first harvest date. On all harvest dates, Sc significantly outyielded Lm (P<0.001), with the gap in DM yield between Sc and Lm increasing with later sowing dates. Only on 04/02/2013 was there a significant interaction sowing date × cover crop (P=0.03).

Results for root dry matter yield were similar: significantly lower yield (P<0.01) on later sowing dates, Sc significantly outyielding Lm on the first two harvest dates (P<0.05) (Table 2). Total biomass yield (above ground biomass + root biomass) on 11 April 2013 was between 1,860 kg DM ha^{-1} for Sc sown on S1 and 289 kg DM ha^{-1} for Lm sown on S3. Except for Sc sown on S1, root biomass had a higher contribution than aboveground biomass to total biomass.

From the biomass yield, it can be expected that the potential reduction of nitrate leaching is higher with Sc compared to Lm. But as shown by Dam (2006), sowing date has a greater influence on the potential nitrate uptake than the sown species.

Table 1 Above ground biomass (kg DM ha^{-1}) of winter rye (Sc) and Italian ryegrass (Lm) sown on 1/10/2012 (S1), 22/10/2012 (S2) and 31/10/2012 (S3), harvested on several occasions during the winter and spring 2012-2013.

Harvest date	S1		S2		S3	
	Sc	Lm	Sc	Lm	Sc	Lm
18/12/2012	288	137	88	27	-[1]	-
04/02/2013	434	221	126	53	75	28
28/02/2013	614	340	176	74	127	44
21/03/2013	734	435	220	125	160	72
11/04/2013	1,030	652	295	211	219	110

[1] - = not harvestable.

Table 2. Root (0-20 cm) biomass (kg DM ha^{-1}) of winter rye (Sc) and Italian ryegrass (Lm) sown on 1/10/2012 (S1), 22/10/2012 (S2) and 31/10/2012 (S3), harvested on several occasions during the winter and spring 2012-2013.

Harvest	S1		S2		S3	
	Sc	Lm	Sc	Lm	Sc	Lm
04/02/2013	224	209	165	78	75	37
21/03/2013	269	269	190	104	96	46
11/04/2013	829	785	361	405	332	179

Forage yield, measured at the end of April (25/04/2013) was still negatively influenced by late sowing (P=0.025) and higher for rye than for Italian ryegrass (P<0.001), but there was interaction between sowing date and cover crop (P=0.045). When sown on S1, the highest and lowest yields were obtained with Sc2 (2,750 kg DM ha^{-1}) and Lm4 (1,229 kg DM ha^{-1}), respectively. When sown on S3, the highest and lowest yields were obtained with Sc4 (800 kg DM ha^{-1}) and Lm2 (314 kg DM ha^{-1}), respectively.

According to Maraval *et al.* (1978), winter rye has a slightly lower feed value than Italian ryegrass when harvested at a similar physiological stage. In a trial similar to ours, harvested on 19/04/2012, De Vliegher (pers. comm.) found DM yields of 3,244 (Sc) kg DM ha^{-1} and 2,703 (Lm) kg DM ha^{-1} with corresponding net energy content for lactation of 6,951 kJ $(kg\ DM)^{-1}$ and 7,138 kJ $(kg\ DM)^{-1}$. As Sc is heading earlier, it can be harvested earlier than Lm providing the bearing capacity of the soil is sufficient; this allows an earlier sowing of the following maize crop, which is an important advantage on soils prone to drought.

Conclusions

Regarding our research questions, we can conclude that:

1. Winter rye produced more biomass than Italian ryegrass in winter. Particularly the aboveground biomass of rye was higher.
2. Delaying the sowing of the cover crops by one month resulted in a four-times lower DM yield. Rye yielded more than Italian ryegrass on every sowing date.
3. In spring, just before maize sowing, rye had a DM yield that was about 2.5 times higher than that of Italian ryegrass.

References

Dam M. (2006) *Understanding the reduction of nitrogen leaching by catch crops*. PhD Thesis, Wageningen University, Wageningen, the Netherlands, pp. 171.

Maraval B., Morhain B. and Blanchet G. (1978) Le seigle en culture dérobée: utilisation en ensilage par les vaches laitières. *Fourrages* 73, 81-101.

Verhelst J. (2011) Winterrogge en Italiaans raaigras voor groenbedekking (in Dutch). Master thesis. Ghent University, Ghent, Belgium, pp 74.

Vos J. and Van der Putten P.E.L. (1997) Field observations on nitrogen catch crops. 1. Potential and actual growth and nitrogen accumulation in relation to sowing date and crop species. *Plant and Soil* 195, 299-309.

Zavattaro L., Monaco S, Sacco D. and Grignani C. (2012) Options to reduce N loss from maize in intensive cropping systems in Northern Italy. *Agriculture, Ecosystems and Environment* 147, 24-35.