Leaf mass of clover-like legumes as a protein source in organic pig nutrition

HENDRIK SOMMER[1], ALBERT SUNDRUM[1]

Key words: protein supply, digestible crude protein, organic pig nutrition, clover, alfalfa

Abstract

Due to the outgoing transitional arrangements for the use of conventional protein sources for monogastric animals in organic livestock farming, alternatives are urgently needed. The aim of this study was to investigate the suitability of the leaf mass of clover-like legumes in the diet of pigs. Therefore the yields of digestible protein per hectare of the investigated plant samples were compared to those of faba beans, lupines and peas as established organic protein sources. The yields of digestible crude protein per hectare of the clover-like legumes are higher than those of faba beans and peas. Although the faba beans and peas have some higher crude protein digestibility of about 80%, the examined plant samples are due to the higher content of protein in the leaf mass rich in digestible crude protein. The results indicate that the recovery of the leaf mass is a lucrative protein source for organic pig farming.

Introduction

The availability of organically and regionally produced protein is becoming more and more important due to the expiring transitional arrangements for the use of conventional protein sources. The well-balanced dietary supply of organic held pigs especially with essential amino acids is restricted to the use of grain legumes and in individual cases of press cake derived from processing oilseeds (Baumgärtl et al. 2013). The current research project is designed to investigate the question under which conditions native clover-like legumes can contribute to cover the need of protein in the diet of organically fed pigs. It is mentioned that the separation of the leaf mass of alfalfa (Popovics et al. 2001) and other clover species selected from the stem will increase the concentration of crude protein content. Therefore the quality and quantity of digestible protein of the investigated leaf mass samples are compared to that of faba beans and peas as established organic protein sources.

Material and methods

Seeds of alfalfa, red clover, white clover, crimson clover and Persian clover have been harvested from 4 experimental field trials. The results are based on the harvest in 2012.The harvested fresh masses of the samples were weighed and charged with the area size of the trial plots. The fresh mass yield per hectare was determined in this way. Afterwards it was multiplied by the dry matter content of each sample to determine the dry matter yields. The fresh weight samples were packed in crispin bags and then dried at 60°C to constant weight. Each variety had a total of up to eight sample bags which were weighed and dried. Two samples were milled as whole plant. The remaining six samples were each separated in leaf and stem mass. The Penn State Forage Separator was used with two different sieve hole sizes (upper sieve 1.9 cm, middle sieve 0.75 cm). The crumbled sample was placed into the top sieve of the assembled screen box. On a smooth surface the screen box was shaken five times, then it was rotated by 90° and shaken again. The process was repeated until the box was once rotated 360°. Stem mass remained in the upper screen box. In the middle screen frame a mixture of stems and leaf mass accumulated and in the bottom box the leaf mass was sift out. For a second passage the procedure was repeated, omitting the upper screen frame. At the end of the procedure the separated stem mass as well as the leaf mass remaining in the bottom was weighed. Than the stem and leaf mass fractions were calculated.

The dry matter yields were subsequently charged with the leaf fractions for determination of leaf production yield. In the next step, the whole plant and leaf mass nutrient yields for crude protein were calculated from the respective dry matter yields in conjunction with the dry mass-based nutrient concentrations. The digestibility of the leaf mass was determined with the in vitro method according to Boisen and Fernández (1997), modified according to Sappok et al. (2009). After the enzyme treatment, the remaining feed residue is weighed and subtracted from the originally weighed material quantity. The difference is called the apparent digestibility of organic mass. In the remaining feed rest the crude protein content is determined and subtracted from the crude protein content in the feed sample. This difference characterizes the apparent

[1] Department of Animal Nutrition and Animal Health, University of Kassel, Nordbahnhofstraße 1a, 37213 Witzenhausen, Deutschland, hendriksommer@uni-kassel.de, uni-kassel.de/cms/tiereg

digestibility of crude protein. The data for faba beans and peas have been reviewed by literature and the corresponding yields were calculated the same way.

Results

The proportion of leaf mass of the whole plant depends on the seed and cut number. For crimson and Persian clover a decreasing trend in leaf mass fractions from the first to third cut can be determined. In alfalfa and white clover the leaf mass fraction increased from the first to the second cut. For red clover the leaf mass fraction from the second cut was higher than at the first and third cut, however, were the only outlier here to watch. Figure 1 gives an overview of the leaf mass fractions of the species examined, differentiated by the cuts.

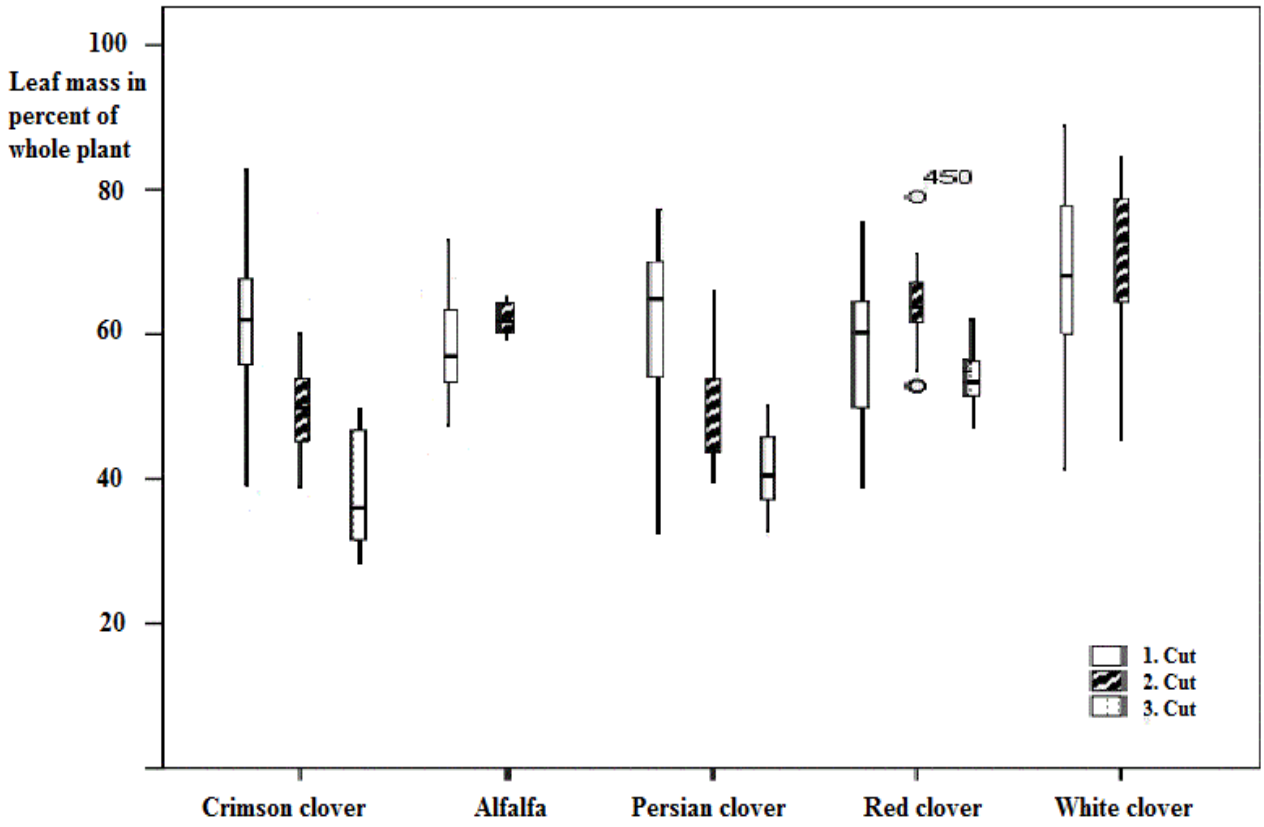

Figure 1: Proportion of the leaf mass on the whole plant differentiated into three cuts.

The digestibility of crude protein in whole plant (WP) and leaf mass (LF) differed only to a small extent. In Persian clover (79% LM - 74% WP), in alfalfa (74% LF - 70% WP) and in red clover (75% LM - 73% WP), the mean solubility was higher in the leaf mass than in the whole plant. While the solubility of crude protein in the leaf mass and the whole plant in white clover is identical (77%), in the whole plant of crimson clover (75%) it was at least 2 percent higher compared to the leaf mass solubility. However, the corresponding variability of the results relativizes these estimates.

The lowest cumulative dry matter yields of leaf mass were recorded in Persian clover and crimson clover. Here, the average dry matter yield was 35 dt ha^{-1} and 42 dt ha^{-1}, and is quite competitive to faba beans. The average dry matter yield of white clover was 48 dt ha^{-1}. The highest yields were observed on alfalfa and red clover with about 60 dt ha^{-1}. Due to the distribution of the yield to several cuts the yield risk is significantly reduced. The average yield of Peas was reported from Ehlers (2001) between 31.0 -34.0 dt ha^{-1}, Pietsch at al. (2003) between 14.4 – 20.8 dt ha^{-1} and Pietsch et al. (2004) between 11.0 – 19.00 dt ha^{-1}.

By separating the leaf mass, a concentration of crude protein in the leaf mass was found in all studied species. The highest mean leaf crude protein mass was observed in Persian clover with 28.3 g XP 100 g DM^{-1}, followed by alfalfa with 28.0 g XP 100 g DM^{-1}. The analyzed content of red clover was 27.0 g XP 100 g DM^{-1}, of white clover 26.3 g XP 100 g DM^{-1} and of crimson clover 25.4 g XP 100 g DM^{-1}. The crude protein

content of faba bean was assumed with 25 g XP 100 g DM^{-1} (23.1 – 26.0 g XP 100 g DM^{-1}, Sauermann et al. (2013 a) and that of pea with 20 g XP 100 g DM^{-1} (19.6 – 22.8 g XP 100 g DM^{-1} Sauermann et al. (2013 b)).

The cultivation of clover-like legume for the production of leaf mass leads to higher leaf mass crude yields compared to faba beans and peas (see Table 1). The cultivation of faba beans leads to a crude protein yield of 8-10 dt ha^{-1}, depending on location and weather influence. The cultivation of Peas leads to lower crude protein yields in the range of 2.2 to 7.8 dt ha^{-1}. The crude protein yield of leaf masses of crimson clover and Persian clover are of the same order of magnitude as is the case in the field bean.

Table 1: Crude protein yield (dt ha^{-1}) of the leaf mass of the studied species differentiated into cuts and accumulated compared to the range of faba bean and pea.

	Alfalfa			Red clover			White clover			Crimson clover			Persian clover			Faba	Pea
	dt ha^{-1}	∂		dt ha^{-1}	∂		dt ha^{-1}	∂		dt ha^{-1}	∂		dt ha^{-1}	∂		dt ha^{-1}	dt ha^{-1}
	min-max		n	min-max		n	min-max		n	min-max		n	min-max		n	min-max	min-max
1. Cut	5.6	1.8		5.8	2.7		4.8	1.1		3.9	1.2		6.2	2.0			
	3.8 9.5		*40*	*0.0 10.9*		*48*	*3.0 6.9*		*24*	*2.1 6.3*		*40*	*2.5 11.9*		*42*		
2. Cut	5.9	0.9		5.4	0.8		4.0	0.4		2.5	0.8		3.0	0.6			
	4.6 8.1		*12*	*4.1 7.2*		*28*	*3.2 4.7*		*18*	*1.8 4.0*		*12*	*2.2 4.3*		*24*		
3. Cut	5.5	0.8		4.0	1.2		3.8	1.4		2.0	0.9		2.6	1.2			
	4.6 7.2		*18*	*1.9 6.0*		*36*	*2.1 7.4*		*40*	*0.7 2.9*		*18*	*1.5 5.2*		*24*		
∑	**17.0**			**15.2**			**12.6**			**8.5**			**11.8**			**9**	**4.2**
	13.0 24.8			***6.0 24.1***			***8.3 19.0***			***4.6 13.2***			***6.1 21.4***			**8 10**	**2.2 7.8**

The yields of digestible crude protein are also higher than that of faba bean and pea in the clover-like legumes (see Table 2). Although the faba bean and pea have some higher solubility of about 80%, the examined plant samples are due to the higher content of protein in the leaf mass rich in digestible crude protein.

Table 2: Digestible crude protein yield (Mean, dt ha^{-1}) of the leaf mass of the studied species differentiated into cuts and accumulated compared to the range of faba bean and pea.

	Alfalfa	Red clover	White clover	Crimson clover	Persian clover	Faba	Pea
	dt ha^{-1}	dt ha^{-1}	dt ha^{-1}	dt ha^{-1}	dt ha^{-1}	dt ha^{-2}	dt ha^{-3}
1. Cut	4.1	4.4	3.7	2.8	4.9		
2. Cut	4.4	4.1	3.1	1.8	2.4		
3. Cut	4.1	3.0	2.9	1.5	2.1		
∑	**12.6**	**11.4**	**9.7**	**6.2**	**9.3**	**6.8**	**3.1**

Discussion

The main problem in the cultivation of legumes is the large variation of the feed value and yield. Factors of the type, location and methods of cultivation are the main sources of variance. The higher the qualities of usable protein sources, the better are they suited to be part of the feed ration. So far, the use of clover-like

(green) legumes in monogastric rations is of minor importance. The suitability of appropriate feed for pigs is mainly limited by the fiber content and the associated reduction in the digestibility of the organic mass (Schubiger et al., 1998). The leaf protein yield obtained here is considerably higher than the yield of protein from beans or peas (Sommer 2010). The results indicate that the recovery of the leaf mass is a valuable and expandable protein resource for organic pig nutrition because of increasing the concentration of crude protein. It provides a considerable potential as a regional source of protein and requires further examination.

Acknowledgements

A special thanks to the Federal Agency for Agriculture and Food (BLE) for funding the project and the LFL Bavaria, Department of Crop Production and for the experimental station Steinach for the transfer of the sample material.

References

Baumgärtl, T., Wölfel, S., Guddat, C., Degner, J., Gräfe, E. Müller, J., Dunkel, S., Heinze, A., Peyker, W. und T. Graf (2013): Potenzialstudie zur Erhöhung des Anteils einheimischer Eiweißpflanzen und anderer heimischer Eiweißquellen in der Tierfütterung in Thüringen. Hrsg. Thüringer Landesamt für Landwirtschaft, Jena

Boisen, S. and J.A. Fernández (1997): Prediction of the total tract digestibility of energy in feedstuffs and pig diets by in vitro analyses. Anim. Feed Sci. Technol. 68:277-286.

Ehlers, Barbara (2001) Einfluß der Sorte und Bestandesdichte auf Ertrag und Unkrautbesatz bei Futtererbsen. [Influence of variety and plant density of peas on yield and weed growth.] In: Reents, Hans Jürgen (Hrsg.) Von Leit-Bildern zu Leit-Linien: Beiträge zur 6. Wissenschaftstagung zum Ökologischen Landbau, Freising, Verlag Dr. Köster, Berlin.

Pietsch, G.; Gabler, C.; Wagentristl, H. und Freyer, B. (2004) Ertragsentwicklung von Erbsen sowie Sommergerste in Reinsaat und in Mischung mit Leindotter oder Koriander im Ökologischen Landbau. Mitt. Ges. Pflanzenbauwiss. (16), S. 147-148.

Pietsch, Gabriele; Surböck, Andreas; Friedel, Jürgen K.; Wagentristl, Helmut und Freyer, Bernhard (2003) Sortenvergleich von Körner- und Futtererbsen in Reinsaat und Gemenge. [Comparison of cultivars of grain and field peas in pure stands and mixtures.] In: Freyer, Bernard (Hrsg.) Beiträge zur 7. Wissenschaftstagung zum Ökologischen Landbau "Ökologischer Landbau der Zukunft", Institut für Ökologischen Landbau, Universität für Bodenkultur, Wien, S. 493-494.

Popovic, S., M. Stjepanovic, S. Grljusic, T. Cupic und M. Tucak (2001): Protein and fibre contents in alfalfa leaves and stems. In Delgado I. (ed.), Lloveras, J. (ed.). Quality in lucerne and medics for animal production = Qualité de la luzerne et des medics pour la production animale. Zaragoza (Spain) : CIHEAM-IAMZ, 2001. p. 215-218.

Sappok, M., W. Pelikaan, M. Verstegen und A. Sundrum (2009): Assessing fibre-rich feedstuffs in pig nutrition – comparison of methods and their implications. J. of the Science of Food and Agriculture 89:2541-2550.

Sauermann, W. (2013 a): Rohproteingehalte von Ackerbohnen – Unterschiede bei den Sorten. Bauernblatt, 23. Februar 2013, S. 38-39.

Sauermann, W. (2013 b): Hohe Rohproteingehalte erreicht – Futterwert von Futtererbsen nutzen. Bauernblatt, 9. März 2013, S. 36.

Schubiger, F. X., H.-R. Bosshard und J. Lehmann (1998): Futterwert von Rotklee. Agrarforschung 5 (4): 181-184.

Sommer, H. (2010): Untersuchungen zur Steigerung der Produktionsintensität im ökologischen Landbau am Beispiel des Lehr- und Versuchsbetriebes Gladbacherhof. Dissertation, Justus-Liebig-Universität Gießen. Verlag Dr. Köster, Berlin.