ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 62 17 Number 1, 2014

http://dx.doi.org/10.11118/actaun201462010161

THE INFLUENCE OF DIGESTATE AND MINERAL FERTILISERS ON YIELDS AND CONTENT OF NITRATES AND ASCORBIC ACID IN KOHLRABI BULBS

Tomáš Lošák[1], Tereza Zlámalová[1], Monika Vítězová[1], Jaroslav Hlušek[1], Petr Škarpa[1], Jiří Fryč[2], Tomáš Vítěz[2], Jan Mareček[2]

[1] Department of Agrochemistry, Soil Science, Microbiology and Plant Nutrition, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

[2] Department of Agriculture, Food and Environmental Engineering, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

Abstract

LOŠÁK TOMÁŠ, ZLÁMALOVÁ TEREZA, VÍTĚZOVÁ MONIKA, HLUŠEK JAROSLAV, ŠKARPA PETR, FRYČ JIŘÍ, VÍTĚZ TOMÁŠ, MAREČEK JAN. 2014. The Influence of Digestate and Mineral Fertilisers on Yields and Content of Nitrates and Ascorbic Acid in Kohlrabi Bulbs. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 62(1): 161–166.

In a one-year vegetation pot experiment we compared the effect of the digestate from a biogas plant and mineral fertilisers on yield and quality parameters of kohlrabi, variety Moravia. Four treatments were used in the trial: 1) untreated control, 2) urea, 3) digestate, 4) urea, triple super phosphate, KCl, $MgSO_4$. The rate of N was the same in treatments 2–4, i.e. 1.5 g N/pot. In treatment 4 the rate of P, K and Mg corresponded with the rate of these nutrients in the digestate treatment (3).

The inhibited growth of kohlrabi after the application of NPKMg (4) was obviously the consequence of early planting after the application of fertilisers (5 days) and of the salinity of the small content of soil in the pot and resulted in the lowest weight of single bulbs (69 g), followed by the unfertilised control treatment (75 g). After the application of the digestate (treatment 3) the weight of single bulbs significantly increased (126 g) compared to the urea treatment (101 g) and all the other treatments. The content of ascorbic acid in the fertilised treatments did not differ (441–458 mg/kg) but it increased significantly compared to the unfertilised treatment (398 mg/kg). There were significant differences among all the fertilised treatments (1–2–3–4) in the bulb nitrate content (346–1,147–815–1,091 mg NO_3^-/kg fresh matter, respectively). After digestate application their content decreased significantly to 815 mg NO_3^-/kg fresh matter. Digestate treatment resulted in comparable or better yields and qualitative parameters compared to all the other treatments.

Keywords: digestate, urea, mineral fertilisers, kohlrabi, yields, ascorbic acid, nitrates

INTRODUCTION

In addition to the benefits of biomass transformation regarding renewable energy sources, the residues of the anaerobic digestion process also provide a valuable source of nutrients (N, P, K, S, among others) to be recycled in crop production (Fouda *et al.*, 2013; Lošák *et al.*, 2013). Biogas and digestate are final products of anaerobic digestion of organic raw material which contributes to the increase in renewable energy consumption. Anaerobic digestion has been known for centuries, but rising prices of fossil fuel and increasing atmospheric pollution have boosted an interest in this process over the last few years (Holm-Nielsen *et al.*, 2009; Weiland, 2010) and has made anaerobic digestion attractive for investors and users (Midillia *et al.*, 2006; Angelidaki, 2011).

However, wide-scale biogas production presents a number of new questions, including the subsequent use of anaerobic fermentation residues – digestate (Cigánek *et al.*, 2010). Field and pot trials to date report positive effects of digestate application to arable land in terms of yields (Stinner *et al.*, 2008; Arthurson, 2009; Gunnarsson *et al.*, 2010; Lošák *et al.*, 2011, 2013) or no significant effects (Ross *et al.*, 1989; Bath and Elfstrand, 2008). Experts are divided in their opinions on the properties and possibilities for practical use of digestate as an organic fertiliser (Möller *et al.*, 2010, 2011; Odlare *et al.*, 2008; Kolář *et al.*, 2008, 2010; Lošák *et al.*, 2011). Digestion is associated with large losses of organic C (Möller, 2009). During the digestion process, 24–80% of organic dry matter is transformed to methane and carbon dioxide (Amon and Döhler, 2004). However, the digestate produced is rich in N and has a high NH_4^+-N/total N ratio, making it potentially suitable as a fertiliser.

The aim of the vegetation pot experiment was to compare the effectiveness of the digestate and mineral fertilisers on yields and content of nitrates and ascorbic acid in the bulbs of kohlrabi.

MATERIALS AND METHODS

The vegetation pot experiment was established on 16 May 2013; Mitscherlich vegetation pots were filled with 6 kg of medium heavy soil characterised as fluvial soil; Tab. I gives the agrochemical properties. The experiment involved 4 treatments given in Tab. II.

The digestate (C/N ratio 4/1) was obtained from a biogas station which uses pig slurry as the input raw material (ca 10 t a day) and maize silage from hybrid KWS 1393 (ca 16 t a day). Tabs. III and IV give the analysis of the digestate for the content of nutrients and hazardous elements. The contents of all the hazardous elements (Cd, Pb, Hg, As, Cr, Cu, Mo, Ni, Zn) were below the limit specified in Regulations No. 474/2000 Coll.

Mineral fertilisers and digestate were applied in the form of watering and were thoroughly mixed with the entire amount of soil in the pot. Two seedlings of early kohlrabi variety Moravia were planted 5 days after fertilisation. The pots were watered to a level of 60% of the maximal capillary capacity and were kept free of weeds. The bulbs were harvested at full maturity on 15 July 2013. Immediately after harvest the individual bulbs without leaves were weighed. Nitrate concentration (mg NO_3^-/kg) was determined in the fresh matter of bulbs with a potentiometer using a ion selective electrode (ISE). The content of ascorbic acid was determined in fresh matter using the capillary izotachoforesy method.

The results were processed statistically using variance analysis followed by testing according to Scheffe (P = 95%).

I: *Agrochemical characteristics of soil prior to trial establishment (Mehlich III)*

pH/ $CaCl_2$	mg/kg			
	P	K	Ca	Mg
7.6	49	166	12,111	342
alkali	low	satisfactory	very high	good

II: *Treatments of the experiment*

Treatment No.	Scheme	Rates of nutrients (g/pot): N-P-K-Mg	Fertiliser
1	untreated control	0	-
2	N	1.5	urea
3	digestate	1.5-0.18-0.69-0.08	digestate
4	NPKMg	1.5-0.18-0.69-0.08	urea, triple superphosphate, KCl, $MgSO_4$

III: *Chemical analysis of the digestate for nutrient content*

%	nutrients				
	N	P	K	Ca	Mg
in fresh matter	0.72	0.09	0.31	0.13	0.04

IV: *Chemical analysis of the digestate for the content of hazardous elements and maximally admissible amounts*

	mg/kg dry matter								
	Cd	Pb	Hg	As	Cr	Cu	Mo	Ni	Zn
content	0.1	2.4	0.2	0.2	9.1	99	4.6	8.6	481
max.*	2	100	1	20	100	250	20	50	1200

*maximal admissible amount pursuant to Regulation No. 474/2000 Coll.

RESULTS AND DISCUSSION

a) Weight of single bulbs

A typical character of kohlrabi is their high uptake of nitrogen from the soil (Feller and Fink, 1997) the deficiency of NO_3-N in the soil subsequently reducing yields (Steingrobe and Schenk, 1991). Sharof and Wier (1994) studied the minimum amount of N required for vegetable crops, including kohlrabi, in relation to components of N balance in the soil and found that N requirements were invariably lower than values from field trials.

As early as the first stages of growth in this pot study there was a visible difference between the fertilised treatments and the unfertilised control. The plants in the latter treatment had a lighter colour and growth of the aboveground biomass was markedly slower. At harvest, symptoms of P deficiency (violet discolouration) were detected on bulbs of the control treatment, which was the result of a low P supply in the soil and unsuitable pH value for P uptake. Inhibited growth of kohlrabi was visually evident during the entire vegetation period also in the treatment where mineral fertilisers were applied (treatment 4) and was obviously the consequence of planting out early after fertiliser application (5 days) and the effect of salinity seen in the small volume of the pot (the effect of fertilisation and high supply of Ca in the soil). The stress was strong to that extent that it was greatly reflected in the yields at harvest when treatment 4 gave the lowest yields. Naturally, it could be a question of the variety because in earlier experiments with the kohlrabi variety Segura F1 (and same methods) these problems were not seen. By contrast a considerable proportion of the total nutrients in digestates is bound organically.

The weight of single bulbs is shown in Tab. V. The weight of the unfertilised bulbs (treatment 1) was by 25.8% lower than in the treatment fertilised with nitrogen only (2). This means that N is the decisive element in terms of yields, as Hlušek *et al.* (2002), Feller and Fink (1997) pointed out. The weight of single bulbs fertilised with the digestate (treatment 3) was significantly higher, i.e. by 24.7%, than those fertilised with nitrogen only (treatment 2). Obvious is the positive synergic effect of additional nutrients (especially P, K, Mg) on yield formation in digestate, treatment 3 (in soil with a low or satisfactory supply of P and K). Lošák *et al.* (2011) reached the same conclusions with the kohlrabi variety Segura F1; after application of the digestate the yields increased by 19.4% compared to the application of the same rate of N in urea. In experiments lasting several years Stinner *et al.* (2008) also reported positive effects of three different digestates (fermented clover-grass mixture, cover crops and post-harvest residues) on wheat yields. In the same way Bath and Elfstrand (2008) reported that yields of leek were the highest after the application of the digestate compared to fertilisation with compost. On soil with a low or satisfactory supply of available nutrients Cigánek *et al.* (2010) discovered that grain yields of winter wheat increased by 30.0–63.9% and seeds of winter rape by 38.5–57.7% compared to the unfertilised control.

b) Content of ascorbic acid in bulbs

Vitamin C, including ascorbic acid and dehydroascorbic acid, is one of the most important nutritional quality factors in many horticultural crops and has many biological activities in the human body. The content of vitamin C in vegetables can be influenced by various factors such as genotypic differences, pre-harvest climatic conditions and cultural practices, maturity and harvesting method, and post-harvest handling procedures (Lee and Kader, 2000).

V: *Weight of single bulb*

Treatment No.	Scheme	Weight of one bulb	
		g	rel. %
1	untreated control	75 a	74.2
2	N	101 b	100.0
3	digestate	126 c	124.7
4	NPKMg	69 a	68.3

Different letters (a, b, c) indicate significant differences among treatments

VI: *Content of ascorbic acid and nitrates in kohlrabi bulbs*

Treatment No.	Scheme	Content of ascorbic acid		Nitrate content	
		mg/kg FM	rel. %	mg/kg FM	rel. %
1	control	398 a	87.8	346 a	30.1
2	N	453 b	100.0	1,147 c	100.0
3	digestate	458 b	101.1	815 b	71.0
4	NPKMg	441 b	97.3	1,091 c	95.1

FM – fresh matter; different letters (a, b, c) indicate significant differences among treatments

Tab. VI shows the contents of ascorbic acid. The content of ascorbic acid in the fertilised treatments did not differ (441–458 mg/kg) but it increased significantly compared to the unfertilised treatment (398 mg/kg). Various literary sources differ in their approach to the effect of nitrogenous fertilisation on the content of vitamin C. Mozafar (1993) reported that nitrogen fertilisers, especially at high rates, seem to decrease the concentration of vitamin C in many different vegetables. According to Smatanová *et al.* (2004) the content of ascorbic acid in spinach decreased from 57.5 to 51.9 ppm when the rate of nitrogen increased from 0.6 to 0.9 g N/pot. By contrast Nilsson (1980) reported that nitrogen fertilisation did not affect the content of vitamin C in cauliflower. Maurya *et al.* (1992) showed that with a higher dose of nitrogen cauliflower contained significantly more vitamin C. With kohlrabi variety Segura F1 Lošák *et al.* (2011) also discovered no differences in the content of ascorbic acid among the fertilised treatments (772–789 mg/kg); however the content in all treatments increased significantly compared to the unfertilised treatment (511 mg/kg).

c) Content of nitrates in bulbs

Kohlrabi is a vegetable prone to a higher risk of nitrate accumulation in tissues (Hlušek *et al.*, 2002). The concentration of NO_3^- in plants is affected primarily by the vegetable species, level of N fertilisation, the respective plant organ, growth stage and the S concentration in tissues (Lošák *et al.*, 2008; Marschner, 2002).

The lowest nitrate content (Tab. VI) was observed in the unfertilised treatment (346 mg/kg of FM) and the second lowest nitrate content in the digestate treatment (815 mg/kg of FM). The reason could be that the digestate contains a specific proportion of organic N (25–50%) which is subject to mineralisation after a certain period (Kirchmann and Witter, 1992). It can be assumed that during the short period of kohlrabi growth (approx. 7 weeks) only part of the organically bound nitrogen was mineralised. Therefore mineral N-NH_4^+ from the digestate (or after its nitrification N-NO_3^-) was available to the plants and was sufficient for yield formation, but did not increase the nitrate content in the bulbs to the level of treatments using mineral fertilisers. The nitrate content was the highest in the two treatments fertilised with nitrogen in the form of urea (1,147 mg/kg of FM – treatment 2 and 1,091 mg/kg of FM – treatment 4 respectively). Urea is a readily soluble mineral fertiliser and plants can take up N from urea in the form of whole molecules or after decomposition as NH_4^+ or NO_3^- (Mengel and Kirkby, 2001).

CONCLUSIONS

The results of one-year trials showed that the nutrients from the digestate were more useful in terms of yield and quality parameters of kohlrabi than urea. Digestate application and incorporation in the soil prior to planting out kohlrabi can be recommended. The application of digestates can therefore save considerable costs for the purchase of mineral fertilisers. However digestates are poor in labile organic substances and the soil must be supplied from other sources – farmyard manure, straw, green manure, compost.

SUMMARY

In a one-year vegetation pot experiment we compared the effect of the digestate from a biogas plant and mineral fertilisers on yield and quality parameters of kohlrabi, variety Moravia. Four treatments were used in the trial: 1) untreated control, 2) urea, 3) digestate, 4) urea, triple super phosphate, KCl, $MgSO_4$. The rate of N was the same in treatments 2–4, i.e. 1.5 g N/pot. In treatment 4 the rate of P, K and Mg corresponded with the rate of these nutrients in the digestate treatment. The inhibited growth of kohlrabi after the application of mineral fertilisers (NPKMg) was most probably the consequence of planting out early after the application of fertilisers (5 days) and of the effect of salinity in the small volume of soil in the pot and resulted in the lowest weight of single bulbs (69 g) and was followed by the unfertilised control treatment (75 g). After the application of the digestate the weight of single bulbs significantly increased (126 g) compared to the urea treatment (101 g) and all the other treatments. After the application of the digestate the yields were affected not only by nitrogen but also by the other nutrients (P, K, Mg). The content of ascorbic acid in the fertilised treatments did not differ (441–458 mg/kg) but it increased significantly compared to the unfertilised treatment (398 mg/kg). There were significant differences among all fertilised treatments (1–2–3–4) in the bulb nitrate content (346–1,147–815–1,091 mg NO_3^-/kg fresh matter, respectively). After digestate application their contents decreased significantly to 815 mg NO_3^-/kg fresh matter. It is the consequence of only partial mineralisation of organically bound N in the digestate during the short vegetation period. Digestate treatment resulted in comparable or better yields and qualitative parameters compared to all other treatments.

Acknowledgement

The study was financed by the Internal Grant Agency of the Faculty of Agronomy MENDELU in Brno No. TP 11/2013.

REFERENCES

AMON, T. and DÖHLER, H., 2004: Qualität und Verwendung des Gärrestes. In: Fachagentur Nachwachsende Rohstoffe e.V. (ed.) *Handreichung-Biogasgewinnung und –nutzung*. Darmstadt: KTBL, pp. 153–165. ISBN 3-00-014333-5

ANGELIDAKI, I., KARAKASHEV, D., BATSTONE, D. J., PLUGGE, C. M. and STAMS, A. J. M., 2011: Biomethanation and its potential. *Methods in Enzymology,* 494: 327–351. ISSN 0076-6879.

ARTHURSON, V., 2009: Closing the global energy and nutrient cycles through application of biogas residue to agricultural land-potential benefits and drawbacks. *Energies*, 2, 2: 226–242. ISSN 1996-1073.

BATH, B. and ELFSTRAND, S., 2008: Use of red clover-based green manure in leek cultivation. *Biological Agriculture & Horticulture*, 25, 3: 269–286. ISSN 0144-8765.

CIGÁNEK, K., LOŠÁK, T., SZOSTKOVÁ, M., ZATLOUKALOVÁ, A., PAVLÍKOVÁ, D., VÍTĚZ, T., FRYČ, J. and DOSTÁL, J., 2010: Ověření účinnosti hnojení digestáty z bioplynových stanic na výnos ozimé řepky a ozimé pšenice. *Agrochémia*, 50, 3: 16–21. ISSN 1335-2415.

FELLER, C., and FINK, M., 1997: Nitrogen uptake of kohlrabi, estimated by growth stages and an empirical growth model. *Journal of Plant Nutrition and Soil Science*, 160, 6: 589–594. ISSN 0044-3263.

FOUDA, S., TUCHER, S., LICHTI, F. and SCHMIDHALTER, U., 2013: Nitrogen availability of various biogas residues applied to ryegrass. *Journal of Plant Nutrition and Soil Science*, 176, 4: 572–584. ISSN 1436-8730.

GUNNARSSON, A., BENGTSSON, F. and CASPERSEN, S., 2010: Use efficiency of nitrogen from biodigested plant material by ryegrass. *Journal of Plant Nutrition and Soil Science*, 173, 1: 113–119. ISSN 1436-8730.

HLUŠEK, J., RICHTER, R. and RYANT, P., 2002: Výživa a hnojení zahradních plodin. 1 ed. Praha: *Zemědělec*, 81 p. ISBN 80-902413-5-2.

HOLM-NIELSEN, J. B., SEADI, T. AL. and OLESKOWICZ-POPIEL, P., 2009: The future of anaerobic digestion and biogas utilization. *Bioresource technology,* 100, 22: 5478–5484. ISSN 0960-8524.

KIRCHMANN, H. and WITTER, E., 1992: Composition of fresh aerobic and anaerobic farm animal dungs. *Bioresource Technology*, 40, 2: 137–142. ISSN 0960-8524.

KOLÁŘ, L., KUŽEL, S., PETERKA, J., ŠTINDL, P. and PLÁT, V., 2008: Agrochemical value of organic matter of fermenter wastes in biogas production. *Plant, Soil and Environment*, 54, 8: 321–328. ISSN 1214-1178.

KOLÁŘ, L., KUŽEL, S., PETERKA, J., and BOROVÁ-BATT, J., 2010: Agrochemical value of the liquid phase of wastes from fermenters during biogas production. *Plant, Soil and Environment*, 56, 1: 23–27. ISSN 1214-1178.

LEE, S. K. and KADER, A. A., 2000: Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology*, 20, 3: 207–220. ISSN 0925-5214.

LOŠÁK, T., HLUŠEK, J., KRÁČMAR, S. and VARGA, L., 2008: The effect of nitrogen and sulphur fertilization on yield and quality of kohlrabi (*Brassica oleracea*, L.). *Revista Brasileira de Ciencia do Solo*, 32, 2: 697–703. ISSN 0100-0683.

LOŠÁK, T., ZATLOUKALOVÁ, A., SZOSTKOVÁ, M., HLUŠEK, J., FRYČ, J. and VÍTĚZ, T., 2011: Comparison of the effectiveness of digestate and mineral fertilisers on yields and quality of kohlrabi (*Brassica oleracea*, L.). *Acta Univ. Agric. Silvic. Mendelianae Brun.*, 59, 3: 117–122. ISSN 1211-8516.

LOŠÁK, T., VÍTĚZOVÁ, M., MUSILOVÁ, L., ZATLOUKALOVÁ, A., VÍTĚZ, T., FRYČ, J., MAŇÁSEK, J. and PROKEŠ, K., 2013: Comparing the effectiveness of a digestate from a biogas station with mineral fertilisers when fertilising silage maize. *Agrochemistry,* 17, 1: 3–6. ISSN 1335-2415.

MARSCHNER, H., 2002: *Mineral nutrition of higher plants*. 2nd edition. London: Academic Press, 889 p. ISBN 978-0-12-473542-2.

MAURYA, A. N., CHAURASIA, S. N. S. and REDDY, Y. R. M., 1992: Effect of nitrogen and molybdenum levels on growth, yield and quality of cauliflower (*Brassica oleracea* var. Botrytis) cv. Snowball-16. *Haryana Journal of Horticultural Sciences,* 21, 3–4: 232–235. ISSN 0970-2873.

MENGEL, K. and KIRKBY, E. A., 2001: *Principles of Plant Nutrition*. 5th ed. Dordrecht / Boston / London: Kluwer Academic Publishers, 849 p. ISBN 978-94-010-1009-2.

MIDILLIA, A., DINCERB, I. and AYA, M., 2006: Green energy strategies for sustainable development. *Energy Policy,* 34, 18: 3623–3633. ISSN 0301-4215.

MÖLLER, K. and STINNER, W., 2009: Effect of different manuring systems with and without biogas digestion on soil mineral nitrogen content and on gaseous nitrogen losses (ammonia, nitrous oxides). *European Journal of Agronomy,* 30, 1: 1–16. ISSN 1161-0301.

MÖLLER, K., SCHULZ, R., MÜLLER, T., 2010: Substrate inputs, nutrient flows and nitrogen loss of two centralized biogas plants in southern Germany. *Nutrient Cycling in Agroecosystems,* 87, 10: 307–325. ISSN 1385-1314.

MÖLLER, K., SCHULZ, R., MÜLLER, T., 2011: Effects of setup of centralized biogas plants on crop acreage and balances of nutrients and soil humus. *Nutrient Cycling in Agroecosystems,* 89, 2: 303–312. ISSN 1385-1314.

MOZAFAR, A., 1993: Nitrogen fertilizers and the amount of vitamins in plants: a review. *Journal of Plant Nutrition,* 16, 12: 2479–2506. ISSN 0190-4167.

NILSSON, T., 1980: The influence of soil type, nitrogen and irrigation on yield, quality and chemical composition of cauliflower. *Swedish*

Journal of Agricultural Research, 10, 2: 65–75. ISSN 0049-2701.

ODLARE, M., PELL, M. and SVENSSON, K., 2008: Changes in soil chemical and microbiological properties during 4 years of application of various organic residues. *Waste Management,* 28, 7: 1246–1253. ISSN 0956-053X.

ROSS, D. J., TATE, K. R., SPEIR, T. W., STEWART, D. J. and HEWITT, A. E., 1989: Influence of biogas-digester effluent on crop growth and soil biochemical properties under rotational cropping. *New Zealand Journal of Crop and Horticultural Science,* 17, 1: 77–87. ISSN 0114-0671.

SHAROF, H. C. and WIER, U., 1994: Calculation of nitrogen immobilization and fixation. Gartenbau Hannover Germany. *Bodenkunde,* 157, 1: 11–16.

SMATANOVÁ, M., RICHTER, R., HLUŠEK, J. 2004: Spinach and pepper response to nitrogen and sulphur fertilization. *Plant, Soil and Environment,* 50, 7: 303–308. ISSN 1214-1178.

STEINGROBE, G. and SCHENK, M. K., 1991: Influence of nitrate concentration at the root surface on yield and nitrate uptake of kohlrabi (*Brassica oleracea – gongyloides*, L.) and spinach (*Spinacia oleracea*, L.). *Plant and Soil*, 135, 2: 205–211. ISSN 0032-079X.

STINNER, W., MÖLLER, K. and LEITHOLD, G., 2008.: Effects of biogas digestion of clover/grass-leys, cover crops and crop residues on nitrogen cycle and crop yield in organic stockless farming systems. *European Journal of Agronomy*, 29, 2–3: 125–134. ISSN 1161-0301.

VYHLÁŠKA č. 474/2000 Sb., o stanovení požadavků na hnojiva, ve znění pozdějších předpisů.

WEILAND, P., 2010: Biogas production: current state and perspectives. *Applied Microbiological Biotechnology,* 85, 4: 849–860. ISSN 1432-0614.

Contact information

Tomáš Lošák: losak@mendelu.cz
Tereza Zlámalová: tereza.zlamalova@mendelu.cz
Monika Vítězová: szostkov@node.mendelu.cz
Jaroslav Hlušek: hlusek@mendelu.cz
Petr Škarpa: petr.skarpa@mendelu.cz
Jiří Fryč: fryc@mendelu.cz
Tomáš Vítěž: vitez@mendelu.cz
Jan Mareček: marecekj@mendelu.cz