Bearbeitet von/ Compiled by:
Silvia Haneklaus[1], Peder Lombnæs[2], Ewald Schnug[1]

23rd International Symposium of the International Scientific Centre of Fertilizers Plant nutrition and fertilizer issues for the cold climates Son (Norway), September 8-10, 2015

[1]Julius Kühn-Institut (JKI), Bundesforschungsinstitut für Kulturpflanzen
Institut für Pflanzenbau und Bodenkunde
[2]Norwegian Institute of Bioeconomy Research (NIBIO)

Berichte aus dem Julius Kühn-Institut

184

Julius Kühn-Institut
Bundesforschungsinstitut für Kulturpflanzen

Kontaktadresse/ Contact
Dr. Silvia Haneklaus
Federal Research Centre for Cultivated Plants
Institute for Crop and Soil Science
Bundesallee 50
38116 Braunschweig
Germany

Telefon +49 (0) 531 596 2121
Telefax +49 (0) 531 596 2199

Wir unterstützen den offenen Zugang zu wissenschaftlichem Wissen.
Die Berichte aus dem Julius Kühn-Institut erscheinen daher als OPEN ACCESS-Zeitschrift.
Alle Ausgaben stehen kostenfrei im Internet zur Verfügung:
http://www.jki.bund.de Bereich Veröffentlichungen – Berichte.

We advocate open access to scientific knowledge. Reports from the Julius Kühn Institute are therefore published as open access journal. All issues are available free of charge under http://www.jki.bund.de (see Publications – Reports).

Herausgeber / Editor
Julius Kühn-Institut, Bundesforschungsinstitut für Kulturpflanzen, Braunschweig, Deutschland
Julius Kühn Institute, Federal Research Centre for Cultivated Plants, Braunschweig, Germany

Vertrieb
Saphir Verlag, Gutsstraße 15, 38551 Ribbesbüttel
Telefon +49 (0)5374 6576
Telefax +49 (0)5374 6577

ISSN 1866-590X
DOI 10.5073/berjki.2016.184.000

Disclaimer

The opinions expressed in this publication are the sole and entire responsibility of the authors. The publication has been subjected exclusively to basic technical editing.

Table of Contents

Preface

Founded in 1933, CIEC (Centre International Engrais Chimique) has accomplished to be one of the oldest scientific organizations that fosters the implementation of scientific knowledge in the field of fertilizer research into crop production. The 23rd International CIEC symposium in Son (Norway) hosted by the Norwegian Institute of Bioeconomy Research (NIBIO) and the Norwegian University of Life Sciences (NMBU) was the northernmost venue in its history. Accordingly it was thematically dedicated to plant nutrition and fertilizer issues for the cold climates. Plant production in northern latitudes is characterized by a number of limiting factors such as short vegetation periods with harsh temperature conditions, and often also extreme soils, high in clay and organic matter. All these factors impede the efforts of plants to acquire water and nutrients and the utilization efficiency of fertilizers. The region around Son belongs to one of the marine environments most affected by agricultural activities. This made the conference an important platform for presenting and discussing research on issues for identifying and limiting the diffuse contamination of water bodies with nutrients from agriculture, in particular phosphorus and nitrogen. The negative impacts of climate change are well-known, however, beneficial effects on agricultural production in the cold climates are less often addressed. Degradation of soils is regularly accompanied by losses in soil organic matter. A site-specific fertilizer management needs to preserve the natural status of the organic matter content in soils. On bog soils fertilization needs to overcome effectively for example severe copper deficiency. In invited lectures *Dr. Peter Dörsch* (University of Life Sciences, Institute for Plant and Environment, Ås, Norway), *Prof. Dr. Bal Ram Singh* (Agricultural University of Norway, Department of Soil and Water Sciences, Ås, Norway), *Dr. Andrea Ulrich* (Federal Office for Agriculture FOAG, Bern, Switzerland) and *Dr. Hans Marten Paulsen* (Thuenen Institute, Institute of Organic Farming, Trenthorst, Germany) presented cutting-edge research and state-of-the-art facts on the different themes mentioned above.
Last, but not least I would like to thank the local organizers who made the 23rd CIEC Symposium an unforgettable event for all participants!

Ewald Schnug	Silvia Haneklaus
President of CIEC	**Secretary General of CIEC**

Nitrification inhibitors as tool for reduction of greenhouse gas emissions

Nils Berger

EuroChem Agro GmbH, Reichskanzler-Müller-Straße 23, D-68165 Mannheim, Germany, nilsberger@eurochemagro.com

The use of nitrification inhibitors (NI) in combination with ammonium based fertilizers is a proven method to improve nitrogen use efficiency, to reduce nitrogen losses through nitrate leaching and to reduce greenhouse gas relevant emissions of nitrous oxides in agriculture. Nitrous oxide (N_2O) is a potent greenhouse gas, with approximately 294 times higher warming potential than CO_2. The first step of nitrification is the oxidation of ammonia into nitrite in the soil by the enzyme ammonia monooxygenase (AMO). AMO is present in soil borne chemolithoautotrophic ammonia-oxidizing bacteria (AOB) with the genera *Nitrosomonas*, *Nitrosovibrio*, *Nitrosolobus* or *Nitrosococcus*, and ammonia-oxidizing archaea (AOA). Literature suggests that the enzymatic activity of AOB is the main driver of nitrification activity in the soils, rather than AOA. This is observed in studies with NI´s, which show that they have a much stronger effect on AOB than on AOA. The inhibition of AMO by NI decreases directly the nitrification rate, and reduces indirectly the nitrate concentration in the soil which serves as substrate of the denitrification. These are two main pathways of nitrous oxide (N_2O) production in the soil. Due to their efficient blocking by using NI´s the agricultural borne N_2O emissions are considerably reduced. Compared to other agronomic measures NI´s have the greatest potential in reducing the emission of nitrous oxide emissions from agriculture. Measurements in several studies were able to prove this consistently. Akiyama et al. (2010)[1] reviewed 85 studies of 2008 and earlier, which showed a reduction in nitrous oxide emissions between -14% to -51%, or 38% in average of six commercial available nitrification inhibitors used during vegetative growth periods. The reduction potential seems realistic for temperate, Mediterranean and

[1] Akiyama H, Yan X, Yagi K (2010) Evaluation of effectiveness of enhanced-efficiency fertilizers as mitigation options for N2O and NO emissions from agricultural soils: meta-analysis. Global Change Biology 16:1837-1846

tropic climates, but regions with colder climate, intense frost or thaw cycles lack of studies to confirm this reduction potential.

Combined use of manure and mineral fertilizers in conventional grain production

Anne Kari Bergjord Olsen

NIBIO - Norsk Institutt for Bioøkonomi, Postboks 115, N-1431 Ås, Norway, annekari.bergjord@nibio.no

Both in Central Norway and parts of the South-Eastern Norway many farms combine grain production and animal husbandry. Knowledge about how to exploit the available manure effectively when used in combination with mineral fertilizers in grain fields has, however, been a scarcity. The amount and kind of mineral fertilizer should be adjusted according to the nutritional value of the manure in order to achieve a best possible balance between the plants' demand and the total supply of nutrients. Plants suffering of sulphur deficiency will for instance not be able to make full use of the given fertilizer's content of plant available nitrogen. In order to examine to what extent manure from milk cows and pigs met the nutritional demand of a grain field, field trials with different combinations of amount and kind of manure and mineral fertilizer were performed at Kvithamar research station in Central Norway (63°29' N, 10°52' E, 26 m a.s.l.) during the years 2010-2013. For two of the years, the spring was cold, and hence both root development and mineralization of the given manure was slow. In these years there were clear differences between plots which, in addition to the manure, were given mineral fertilizer with or without sulphur content, respectively. Plots without sulphur had got a lighter green colour, reduced growth, and a lower yield level. The differences were most pronounced where the given amount of manure was low. In years with a warmer spring, the effect of adding sulphur through a mineral fertilizer was lower and only significant where the lowest amount of manure from milk cows was used. The results also indicated that manure both from milk cows and pigs seemed to cover the plants' demand for other nutrients than nitrogen and sulphur.

The significance of sulfur nutrition and metabolism in the detoxification of excessive levels of copper, zinc and molybdenum in plants

Luit J. De Kok, Mariana I.F. Neves, Dharmendra H. Prajapati, Muhammad Shahbaz, Tahereh Aghajanzadeh and C. Elisabeth E. Stuiver

Laboratory of Plant Physiology, Groningen Institute for Evolutionary Life Sciences, University of Groningen, P.O. Box 11103, 9700 CC Groningen, The Netherlands, l.j.de.kok@rug.nl

Copper, zinc, manganese and molybdenum are essential plant nutrients, however, elevated concentrations of these metals in the root environment are potentially phytotoxic and may disturb metabolic functioning and plant biomass production. The primary cause of their phytotoxicity is still largely unresolved. Exposure of plants to excessive levels of toxic metals may interfere with the regulation of uptake, reduction and assimilation of sulfur in plants. They might compete with the uptake and reduction of sulfate (e.g. MoO_4^{2-}) or react with sulfur metabolites and/or induce the formation of sulfur-rich proteins and peptides (e.g. Cu^{2+}, Zn^{+}), which might be involved in metal sequestration in order to avoid disturbance of cellular homeostasis of these metals. The impact of elevated Cu^{2+}, Mn^{2+}, MoO_4^{2-} and Zn^{2+} concentrations in the root environment on physiological functioning and uptake, distribution, reduction and assimilation of sulfur was studied in detail in Brassicaceae. This in order to get more insight into the physiological background of the toxicity of high tissue levels of these essential metals, and the significance of sulfur nutrition and metabolism in their detoxification.

Impact of Climate Change on N-cycling in colder climates

Peter Dörsch

Dept. Environmental Sciences, Norwegian University of Life Sciences (NMBU), NMBU Nitrogen Group (http://www.nmbu.no/nitrogengroup/), Postbox 5003. N-1432 Ås, peter.doersch@umb.no

High latitude ecosystems are undergoing rapid change as climate warms, precipitation patterns change and extreme weather events increase in frequency. These changes may significantly impact boreal agriculture and will eventually lead to new cropping strategies in the North. Little is known about how Climate Change will affect nutrient cycling and losses in managed soil-plant systems in cool climates. At the same time, improved understanding of nutrient use efficiency is at the heart of sustainable crop production needed for food, fiber and renewable energy in a new "green economy" to come. In this lecture I will focus on soil nitrogen (N) cycling and its sensitivity to changing climatic perturbation regimes at high latitudes. Soil N cycling is known to be temporarily disrupted by drought, soil freezing and other climate-induced perturbations, resulting in measurable losses of reactive N to waters and the atmosphere. At high latitudes, Climate Change is expected to be most pronounced during winter. Recent data on over-winter N losses in Norwegian grassland systems will be presented and discussed in the context of N use efficiency and anticipated Climate Change.

Phosphorus utilization in mixed-cropping systems

Bettina Eichler-Löbermann[1], Christine Brandt[1], Phillipp Stahn[2], Stephanie Busch[1], Timo Prange[1] and Ralf Uptmoor[1]

[1]Agronomy and Crop Science, Justus-von-Liebig-Weg 6, D-18059 Rostock, Germany; [2]Hydrology, University of Rostock, Satower Str. 48,D-18059 Rostock, bettina.eichler@uni-rostock.de

The combination of crops in mixed cropping systems can lead to a complementary utilization of growing factors and in an increase of the nutrient and water use efficiency. Legumes as a cultivation partner are especially useful because of the additional fixation of nitrogen. The performance of different crops in sole and mixed cropping are investigated under controlled, semi-controlled and field conditions.
In a field experiment, which was established in 1998 to investigate the effects of phosphorus (P) fertilizer strategies, the following crops were cultivated from 2013 till 2015: Maize (*Zea mays*), sorghum (*Sorghum bicolor*), maize + runner bean (*Phaseolus coccineus*) and Sorghum + blue lupin (*Lupinus angustifolius*) (2013) and Andean lupin (*Lupinus mutabilis*) (2014, 2015). Under optimal P supply maize and sorghum had higher biomass yields than the respective combinations with the legumes. However, under suboptimal P supply the mixtures of maize or sorghum with the legumes had comparatively or even higher biomass yields. Furthermore, the effect of the fertilizer supply was lower in the mixed cropping treatments. Usually higher activities of enzymes and higher bio-available P concentrations in soil were found in the mixed cropping treatments. These facts point to a potential of mobilization of less available P sources when different crop species are cultivated together.

Acknowledgement: The authors thank the Federal Ministry of Food and Agriculture in Germany for the financial support of this project.

Potential of manure injection to increase N and P use efficiencies in maize

Carl-Philipp Federolf*, Matthias Westerschulte, Hans-Werner Olfs and Dieter Trautz

Osnabrueck University of Applied Sciences, Am Kruempel 31, D-49090 Osnabrueck, Germany, *c.federolf@hs-osnabrueck.de

In northwestern Germany, broadcast application of liquid manure usually covers nutrient demand of maize (*Zea mays*). To compensate for the poor nutrient bioavailability due to low root zone temperatures, farmers additionally apply nitrogen (N) and phosphorous (P) starters at planting, leading to nutrient balance surpluses and a thread to the environment.

In 2013 and 2014 series of field trials was established to test the possibility to replace starters by manure injection in placed bands close to the seedlings. Broadcast (BC) application with side dressed starter fertilizer (23-10 kg N-P ha^{-1}) was compared to injection treatments (with and without nitrification inhibitor) on seven sites.

Plant samples at V8 stage showed reduced growth for injection treatment, compared to broadcast treatment. However, relative to BC, injection with nitrification inhibitor led to equal early growth. At harvest, no differences in yield and quality were observed for BC and injection treatments, but injection treatments showed higher N uptake, being significant for nitrification inhibitor treatment (+7% in 2013 and +6% in 2014, respectively).

These results show increased N and P use efficiencies when manure is injected and therefore the possibility to reduce nutrient surpluses in maize growing. Thus, manure injection is beneficial for farmers and environment.

Organic wastes as phosphorous fertilizers in organic agriculture

Bente Føreid

Norwegian Institute of Bioeconomy Research (NIBIO), P.O. Box 115, NO-1431 Ås, Norway, Bente.Foreid@nibio.no

Phosphorous (P) should be recycled from organic wastes as much as possible to reduce mining of P reserves and eutrophication. In stockless organic agriculture P input is needed. Here we assessed 7 organic residues and compared them to mineral P fertilizer and rock phosphate (allowed in organic agriculture). Barley was grown with optimal fertilization of all other nutrients in a sand/peat mixture. Total P in organic P sources and rock phosphate equaled optimal supply if all was available. This was compared to no P, half optimal and optimal supply of mineral P. The best availability was found in digested liquid manure (growth 95% of that with optimal P supply). Wood ash, fish sludge composted solid manure and composted food waste sustained growth of 65-79% of that with optimal P supply. Meat and bone meal and the commercially available product ladybug and rock phosphate had low P availability (growth 30-35% of optimal) at the same level as no P (32%). The results indicate that that some organic phosphorous sources can supply the crop with sufficient P without leading to P accumulation, but some commercially available sources performed poorly.

Variable rate application of manure – gain or pain?

Silvia Haneklaus, Judith Schick, Sylvia Kratz and Ewald Schnug

Institute for Crop and Soil Science, Julius Kühn-Institut (JKI), Bundesallee 50, D-38116 Braunschweig, Germany, Silvia.Haneklaus@jki.bund.de

In intensive agricultural livestock production manure is often treated as a waste problem rather than an organic fertilizer and source of nutrients. Even if maximum loads will not exceed an upper limit of 170 kg/ha nitrogen, its use is not sustainable as phosphorus is applied at rates that outreach crop demand by far. With view to worldwide finite mineral rock phosphates efficient measures to close the agricultural phosphorus cycle are required and the revision of current practices of manure application is urgently requested. A solution to the problem offers the variable rate application of manures if upper nutrient loads are restricted to an average phosphorus off-take of 22 kg/ha by agricultural crops and recycling chains for excess manure are implemented. The presented study demonstrates the problem of phosphorus accumulation in soils of livestock farms, addresses the spatial variation of plant available phosphorus in soils, identifies relevant factors that influence the mineral composition of manure and provides algorithms for a balanced, variable rate fertilization of manure.

Phosphorus management and material flow analysis

Ola Stedje Hanserud

Norwegian Institute of Bioeconomy Research (NIBIO), P.O. Box 115, NO-1431 Ås, Norway, ola.s.hanserud@ntnu.no

To manage phosphorus (P) on different spatial scales there is a need to know its flows and stocks: between which compartments is P moving in the food chain and where is it stored? One important use of such information is to identify potentials for recycling of secondary P. For this, material flow analysis (MFA) is a well suited method based on the principle of mass balance. Examples from Norway of the application of MFA on the national and regional level are presented as well a possible integration of P quality aspects, i.e. plant availability, with the MFA method. It seems to be a great theoretical potential for recycling of secondary P in Norway.

Control of NH_3 volatilization and nitrogen leaching by application of coated urea associated with properties of the coated materials

Zheng-yi Hu, Hui-hui Wang, Jing Mu, Xiang-ru Zhang and Guox-xi Wang

College of Resources and Environment, College of Sino-Danish, University of Chinese Academy of Sciences, 19A, Yuquan Road, Beijing, 10049, China, zhyhu@ucas.ac.cn

Reducing nitrogen loss is most important for the agricultural sustainable development and the protecting water body quality. The main pathway of nitrogen loss from field soils is NH_3 volatilization and nitrogen leaching. The application of controlled release urea was observed to obviously decrease loss of nitrogen in soil via NH_3 volatilization and nitrogen leaching. Understanding the contribution of nitrogen loss via various pathway after fertilization has important significance to develop control loss of nitrogen in field soils. One field trial including three nitrogen sources (PCR-polymer-coated urea, BCU-biochar-coated urea, and urea) at vegetable rotation (snow pea – squash - Sweet corn) for one year was used to investigate the loss of nitrogen via NH_3 volatilization and nitrogen leaching from field soils after application of 300 kg N/ha as 100% basal (PCR), as 50% basal and 50% topdressing (BCU), and 20% basal, and 80% for three topdressing (30%, 30% , and 20%) (urea) ,respectively, in Dianchi catchment, China. Results indicated that application of coated urea could significantly decrease loss of nitrogen in soils. Compared to urea, application of PCR decreased loss of nitrogen by 45.99kg N/ha (57.6% from NH_3 volatilization reduction) at the first season, by 79.45kg N/ha (49.0% from NH_3 volatilization reduction) at the second season, by 45.2kg N/ha, (76.6% from NH_3 volatilization reduction) at the third season; application of BCU decreased loss of nitrogen by 47.31kg N/ha (42.3% from NH_3 volatilization reduction) at the first season, by 88.81kg N/ha (27.0% from NH_3 volatilization reduction) at the second season, by 54.46kg N/ha, (32.9% from NH_3 volatilization reduction) at the third season. It could be concluded that BCU is to reduce nitrogen loss by controlling nitrogen leaching at the rainy season (the first and third season) and the dry season (the second season); however, PCR is to reduce nitrogen loss by controlling NH_3 volatilization at the rainy season (the first and third season), and by controlling nitrogen leaching at the dry season (the second season). The loss of nitrogen in

soils with applied urea was greater at the dry season (172.63kg N/ha) than those at the rainy season (152.48-161.69kg N/ha). On the contrast, the loss of nitrogen in soils with applied coated urea was greater at the rainy season (106.49-116.49kg N/ha for PCR, 105.17-107.23kg N/ha for BCU) than those at the dry season (93.18kg N/ha for PCR, 83.82kg N/ha for BCU). The difference of relative contribution of decreasing NH_3 volatilization and nitrogen leaching among coated urea could be contributed to properties of the coated materials, because biochar has adsorption capacity of NO_3^- in soils. The present results suggested that BCU should be recommended to use at the rainy season, and BCU or PCR should be recommended to use at the dry season in order to effectively reduce loss of nitrogen from field soils.

The suitability of soil temperatures on the Baltic coast for viticulture

Juha Karvonen

Department of Agricultural Sciences, Faculty of Agriculture and Forestry, University of Helsinki, P.O.Box 62, FI 00014 University of Helsinki, Finland, juha.i.karvonen@helsinki.fi

In consequence of the warming of the Northern European climate, the cultivation of grapevines is expanding to the Baltic coast states. In these countries the risk of frostbite for vine roots is assumed to be higher than in Central Europe during the coldest months. To investigate this issue the soil temperatures of three vineyards in the region of Helsinki (Finland), Pärnu (Estonia), and Tervete (Latvia) were monitored at a depth of 25 cm using waterproof temperature loggers, which saved the soil temperatures to memory every six hours between 1 December and 30 November over the course of a year. The lowest soil temperature of 0.2 °C was recorded in Helsinki in March, while in Pärnu it was 0.0 °C in February, and in Tervete in February it was 0.5 °C. The annual average soil temperature in Helsinki was 7.2±6.6 °C, while in Pärnu it was 7.7±6.6 °C, and in Tervete it was 8.7±7.1 °C. From this it can be concluded that the risk of frostbite in vine roots that have been planted to a depth of 25 cm is low and existing soil temperatures do not restrict viticulture with suitable varieties on the Baltic coast.

Use of multiple sensors to determine multiple, co-occurring wheat stressors

Audun Korsaeth[1], Krzysztof Kusnierek[1], Therese With Berge[2], Andrea Ficke[2], Jan Netland[2]

[1]NIBIO, Systems Analysis and Agricultural Technology, N-2849 Kapp, Norway; [2]NIBIO, Plant Health and Plant Protection Division, N-1430 Ås, Norway, audun.korsaeth@nibio.no

Simultaneous indirect measurement of water status, nitrogen deficiency, leaf diseases, and weed patches in the field may allow us to correct N application rates according to the true needs of the crop plants. For comprehensive assessment of a cropping system multi-sensory data collection and data fusion are the emerging technologies.
This study represents the final stage of a four-year research project (Multisens; www.bioforsk.no/multisens), exploring the use of indirect sensor measurements for determination of water and nitrogen status, and disease and weed infestations in wheat. We present the results from field trials, aiming to assess methods for determining the co-occurring stressors.
The field trial included different combinations of stressors: N-demand, sub-optimal water status, weeds and leaf diseases. We used sensors for indirect canopy measurements (spectroradiometers, thermal camera, fluorometer and an RGB camera), which were operated partly from a robot and partly from a drone. The sensor measurements were conducted at various growth stages with subsequent reference plant status registrations. A selection of data pre-processing, and multivariate analysis methods were used.
Our study gives a novel demonstration on how the combination of multiple sensors may provide information needed to separate and identify various crop stressors under field conditions.

Optimal use of phosphorus in cereals under Nordic conditions

Annbjørg Øverli Kristoffersen

NIBIO, Arable Crops, N-2849 Kapp, Norway, annbjorg.kristoffersen@nibio.no

The phosphorus (P) fertilizer recommendations in Norway are based on a balanced P application strategy. This implies adding the same amount of P as that removed by the yield at an optimum soil P-level. The recommendations were adjusted in 2007. Until then a surplus of P was recommended, based on assumptions of P adsorption in the soil. Over many years this strategy led to increasing amounts of plant available P in soil, which in some cases was undesirable for environmental reasons.

The amount of P removed in grain is determined by the yield level and the concentration of P in its dry matter (DM). The P concentration in grain varies from year to year and site to site, but 0.4 % P was selected as an average value. A yield of 4 Mg grain ha^{-1} thus removes 14 kg P ha^{-1}. If straw is also removed, it is recommended to increase the amount of P fertilizer by 3.5 kg P ha^{-1}.

To estimate the amount of plant available P in soil, the P-AL method (Egner *et al.* 1960) is used as the standard test for agricultural soils. In 2007 a new system was introduced to adjust P recommendations according to the P-AL level. P-AL 5-7 is now defined as an optimal level, at which a balanced P fertilizer strategy is recommended. Where the soil P level is below this, it is recommended to apply more than the P-balance, in order to raise the P-AL level. Where the soil P-AL level is above the optimal level, it is recommended to decrease P fertilization. A linear decline is adopted, reaching zero P application at P-AL 14. Above this level, the soil is expected to supply crops with sufficient plant available P.

The new correction system has a stronger reduction in P fertilization than before at high to very high P-AL levels, with the aim of a faster lowering of P-AL in such cases. It is expected that the new P fertilizer norm and new correction system will reduce P fertilizer use in cereals by around 50 %. Statistics on fertilizer use confirm that farmers on the whole follow the new recommendations. It will nevertheless take many years before there will be a significant reduction in the P-AL levels in agricultural soils in Norway.

In Norway band placement of compound fertilizer is recommended. Favourable placement of P in relation to plant roots enables plants to make better use of the applied fertilizer. The use of starter fertilizer is also recommended on silty soils, where root growth or nutrient uptake is often limited during the first weeks after sowing due to low soil temperature. Starter fertilizer means placing some P (and N) in the immediate vicinity of the seed.

Field trials and pot experiments have recently been conducted to examine crop responses to P fertilization relative to the soil's P-AL value. The results show that the responses decrease with increasing P-AL level, and confirm the soil's ability to supply plants with sufficient P when P-AL is above 14.

More research is going on to further improve the interpretation of P-AL values. The soil's adsorption capacity plays an important role in controlling the amount of plant available P, and this topic is being studied at present. Better utilization of P from organic fertilizer sources, in order to further reduce the use of mineral P, is also a future challenge.

Hyperspectral, multispectral or index – How much spectral resolution do we need for vegetation parameter estimation from spectral data?

Holger Lilienthal, Heike Gerighausen and Ewald Schnug

Institute for Crop and Soil Science, Julius Kühn-Institut, Bundesallee 50, D-38116 Braunschweig, Germany, holger.lilienthal@jki.bund.de

Rapid non-destructive in-vivo methods for chemical and physical determination of crop parameters are needed for a wide range of applications in crop production (e.g. breeding, precision farming). Spectral reflectance measurements offer a fast way to retrieve this information on different spatial scales (e.g. leaf, canopy and region). With the availability of high resolution field and imaging spectrometers, the spectral reflectance can be measured in many small spectral bands. Unfortunately, spectral reflectance in the hyperspectral domain is often inter-correlated resulting in redundant information and huge datasets with a high demand of storage capacity. Therefore, several strategies have been developed to determine the optimal spectral setup for different vegetation parameters. They comprise pure statistical optimisation techniques, not taking into account the biophysical or biochemical properties of plants, as well as adopted band selection techniques such as selection of specific absorptions features from e.g. pigments.

In this study, the prediction quality for several vegetation parameters (e.g. pigment content, N-status, biomass and leaf area) using several spectral configurations for different crops have been examined. Having identified the optimal spectral bands low-cost spectral solutions for the rapid determination of vegetation parameters can be developed.

Implications of chemical waste water treatment on efficient P cycles in food production

Anne Falk Øgaard

NIBIO - Norsk Institutt for Bioøkonomi, Postboks 115, N-1431 Ås, Norway, Anne.Falk.Ogaard@nibio.no

There is a growing awareness of the limitations in global mineral phosphorus (P) reserves, increasing the need to create efficient P cycles in food production. In Norway, about 1800 tons P is collected in waste water treatment plants each year, and 50-60% of collected P is returned to agricultural areas. For comparison, 8-9 000 tons mineral P are yearly applied in Norwegian agriculture. There are large uncertainties regarding plant availability of P in sewage sludge generated from chemical waste water treatment with aluminium (Al) and/or iron (Fe) as coagulants. Therefore, we performed a pot experiment with 11 different types of sewage sludge to study the relative P fertilisation effects of sludge compared with mineral P fertiliser. Further, six different extraction methods were tested in terms of their ability to predict plant-available P in sewage sludge in a short and longer term perspective. Plant-availability of P in these sludges was low compared to mineral fertilizer, also in a longer term. In sum of six harvests of ryegrass, P uptake from sludge ranged from 13 – 40% of P uptake from mineral P. Increasing concentration of Al in sludge had a clear negative impact on P availability, especially in short term. Fe also showed a negative impact on P availability, but to a lesser extent compared to Al. P extracted with 2% citric acid was the method that best predicted P availability (R^2 = 0.69).

The influence of silicic acid on the chemical content of field peas of variety Mehis

Margit Olle

Estonian Crop Research Institute, J. Aamisepa 1, 48309, Jogeva alevik, Estonia, margit.olle@gmail.com

The purpose of this investigation was to look at the influence of silicic acid on the chemical content of field peas. There were two treatments: 1. stabilized silicic acid treatment, 2. untreated control. The silicic acid was applied as an aqueous spray applied from the 2-3 true leaf stage at two-weekly intervals on 21 May, 4 June, 18 June and 2 July 2014. The amounts sprayed were as follows: first spray 1.5 L ha^{-1} silicic acid and 750 L ha^{-1} water, second 3 L ha^{-1} silicic acid and 1500 L ha^{-1} water, third 4.5 L ha^{-1} silicic acid and 2250 L ha^{-1} water, fourth 4.5 L ha^{-1} silicic acid and 2250 L ha^{-1} water. The water used was demineralised with a neutral pH; the pH of the spray solution was 5.5. Control plants were untreated. The variety of field peas used was Mehis. Silicic acid partially improved the quality of field peas of variety Mehis: the content of phosphorus and potassium in field pea dry matter was higher in the silicic acid treatment than in the control treatment. The content of nitrogen, calcium and magnesium in field pea dry matter did not differ significantly between treatments.

Marine protection and fertilizer strategies

Hans Marten Paulsen

Thünen-Institute of Organic Farming, Trenthorst 32, 23847 Westerau, Germany, hans.paulsen@ti.bund.de

Marine ecosystems are affected by nutrient (N, P), silicon (Si) and pesticide loads from agriculture. The substances are transported in solution, bound to soil particles via water and wind. Whereas pesticides and its residues might enrich in food chains and environment with detrimental effects, Si is essential for diatom growth and N and P contribute to eutrophication. Misbalancing N:P:Si ratios influence phytoplankton communities and might affect carbon sequestration in oceans. Especially in coastal areas, estuaries and in regions with low water exchange nutrient loads and related algae growth might be followed by oxygen losses and dead zones.

Agricultural soils and landscapes in intensive agricultural areas are loaded with nutrients. Especially P emits over years, variably influenced by management and changing climate. Agriculture must balance N and P released from fertilizers, plant material and soils to the actual plant demand. P soil reserves must be addressed actively, e.g. by phytomining. Those nutrients must be kept in the system, preferably by biological uptake and conversion. Technical measures to avoid nutrient losses and inefficiencies can be seen in adequate timing and application technique of suited organic and mineral fertilizers, erosion prevention, adequate cropping and ploughing regime as well as feeding regimes for livestock and also in landscape and field margin design. The evaluation of entire farm nutrient flows and field balances give important help to avoid and address spatial nutrient imbalances.

The Danish experience: The consequences of reducing the nitrogen input below the optimal rates of the crops

Carl Aage Pedersen

SEGES, Agro Food Park 15, 8200 Aarhus N, Denmark, cap@seges.dk

Since 1980, Danish agriculture has reduced its environmental impact remarkably. The loss of nitrogen to the sea has been reduced by 50 per cent, and the nitrogen content of the ground water is decreasing. The main reason for that is a much better utilization of the nutrients in organic manure. In the 1980s, nitrogen in farmyard manure and slurry was hardly taken into account when calculating the need for chemical fertilizers.
30 years ago, the capacity for storage of slurry and the application machinery was insufficient for optimal application. Much of the slurry was applied in the autumn with heavy losses and insufficient benefit for the crops. Due to lack of knowledge concerning the exact fertilizing effect, farmers often on top on that applied too much nitrogen to be sure that the crops had been sufficiently supplied. During the1980s and 1990s a lot of research and trial activities was conducted, which made it possible for us to describe how to get the maximum benefit of the slurry which reduced the need for supplementing chemical fertilizers.

The drivers

There were more drivers for this evolution.

- Farmers were, like other responsible people, more and more aware of the need for reducing the loss of nutrients to the environment
- The loss of nutrients was also loss of money.
- New R&D and field trials demonstrations had shown how to do it.
- Political water protection plans including 9 month of storage capacity for animal manure, maximum norms for nitrogen application to the individual crops and a minimum utilization of nitrogen in organic manure.

Until 1999, the yields of the crops were only slightly reduced due to the reduced input of nitrogen, and most farmers were happy (Figure 1).

The political disaster

In 1999, the Danish Parliament decided to reduce the maximum norms by 10-20 percent. The result is that the trend of yield increase has slowed down, and the protein content of the crops is extremely low (Figure 2). The result is that, every year, the Danish farmers lose 100-250 Euros per hectare, on average.

A new regulation is needed

To make Danish agriculture competitive again it is necessary to ensure enough nutrients for the crop. We have to re-evaluate what is necessary to implement the Water Frame Directive. The new government is probably going to accept optimal amounts of nitrogen within 3 years, and the details for that have to be settled in the near future.
There is a growing agreement that it shall be possible again to supply the crops with their need for nutrients. If this results in too high a load of nitrogen to the coastal waters, new measures will be needed.

For the time being a lot of R&D is going on. Concerning for example:

- Re-establishing of eelgrass in the coastal waters
- Production of mussels and seaweed to clarify the water and to remove nutrients
- Constructed wetlands
- Intelligent buffer zones
- Controlled drainage
- Early sowing of winter cereals
- Catch crops

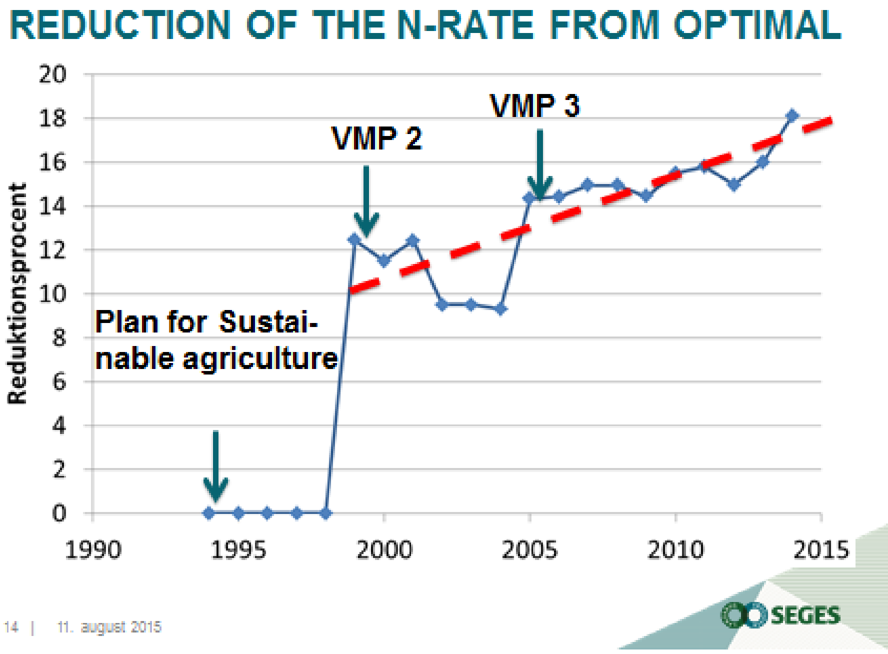

Figure 1. Reduction of the N rate from optimal (1995-2015)

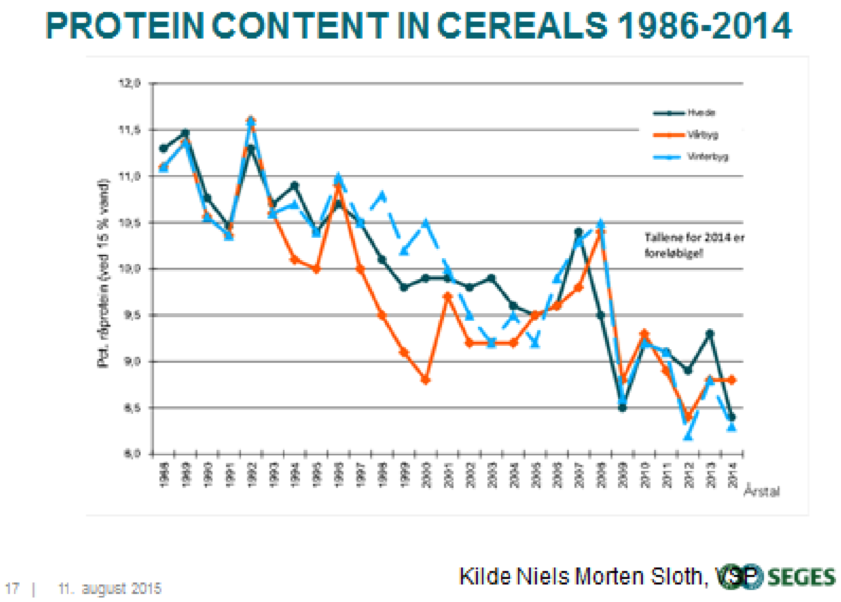

Figure 2. Protein content in cereals (1986-2014)

Nutrient interactions serve extra benefit: improving uptake, minimizing losses through balanced nutrient ratios

Maksim Poltoradnev and Tatyana Grebennikova

URALCHEM OJSC, Presnenskaya naberezhnaya, 10, Moscow, 123317, Russia, maksim.poltoradnev@uralchem.com; tatyana.grebennikova@uralchem.com

Undertime vegetation period, high precipitation rate exceeding evaporation, as well as light textured soils, are the major concerns on the way to improved crop production in the northern European countries. Legislations on reducing chemicals application, rapidly increasing world population and limited land availability for crop cultivation pushes agriculture to seek new ways to achieve the most effective nutrition of plant varieties, characterized with enhanced yields. The fertilizer use efficiency is controlled by plant nutrient assimilation and nutrients mobility in soil. To achieve a great profit not only fertilization timing and rate should be considered, but also nutrient ratios and interactions. NS 30:7 and SAN 33:3 are fertilizers with balanced combinations of nutrients. Their application provides the developing plant with vital nitrogen, and give a powerful charge for intensive growth, higher roots absorptive capacity and enhance accumulation of basic and micro elements. Latest results on pot and field trials will be demonstrated. Also mechanisms leading to a positive effect will be discussed. For more details see the extended manuscript enclosed.

Economic and environmental optimization of nitrogen fertilizer recommendations for cereals in Norway

Hugh Riley, Bernt O. Hoel and Annbjørg Ø. Kristoffersen

NIBIO, Arable Crops Division, Apelsvoll, Nylinna 226, N-2849 Kapp, Norway, hugh.riley@bioforsk.no

Results of ca. 300 annual N fertilizer trials performed between 1991 and 2014 in spring and winter cereals have been used to evaluate optimum nitrogen fertilizer rates for cereals in Norway, in terms of both economic returns and the balance between N supply and removal. On average, spring barley and oat yields increased little beyond 120 kg N ha^{-1} in fertilizer. Somewhat higher optimum fertilizer rates were found for spring and winter wheat. Regression equations for yield and N uptake in grain and straw were derived, related to N fertilizer input and the yield level obtained in individual trials. The latter was used as an indicator of yield expectancy, which in Norway is the basis for N fertilizer recommendations to cereals. These equations accounted for around 90% of the variation in yield and 80% of that in N uptake. Quadratic N responses were significant in all cases, as were interactions between N responses and yield level. The yield equations were used to calculate economically optimum N fertilizer levels with varying ratios of product price to fertilizer cost at contrasting levels of yield. The optimum N fertilizer level for barley and oats was found to increase by ca. 8 kg N ha^{-1} per Mg increase in expected yield. The equivalent figure in wheat was ca. 16 kg N ha^{-1}. In the case of barley and oats, optimum N fertilizer levels decreased by ca. 4 N ha^{-1} per unit increase in the cost/price ratio. For wheat the corresponding figure was ca. 7 N ha^{-1}.

The equations for N uptake were used to calculate simple N balances between fertilizer input and removal in crop products. Large N surpluses were indicated at low levels of yield expectancy, but the surpluses decline markedly with increasing yield level, despite greater N fertilizer inputs at high yield. Calculations made for national average yield levels in recent years showed N surpluses of 50–60 kg N ha^{-1} when only grain is removed, but somewhat less when straw is removed also. Limiting N input to obtain zero balance

between N supply and N removal reduces yields considerably at average levels of yield expectancy. If one assumes that a certain level of surplus supply is acceptable in order to compensate for the ‘unavoidable’ N losses that occur even in the absence of fertilizer, the gap between economic and environmental optimum fertilization becomes smaller.

Residual value of inorganic fertilizer and farmyard manure for crop yields and soil fertility after long-term use on a loam soil in Norway

Hugh Riley

NIBIO, Arable Crops Division, Apelsvoll, Nylinna 226, N-2849 Kapp, Norway, hugh.riley@bioforsk.no

Use of mineral NPK fertilizer and farmyard manure has been compared since 1922 in a mixed arable crop rotation on loam soil. During the period 1982- 2003, cattle manure at rates of 20-60 Mg ha^{-1} yr^{-1} gave yields that were 80-90 % of those obtained using mineral fertilizer at 100 kg N : 25 kg P : 120 kg K ha^{-1} y^{-1}. Approximate balance between nutrient supply and removal was achieved at the lowest manure rate, but higher manure rates resulted in large surpluses of all three nutrients. In order to study residual effects of these surpluses, no manure was applied from 2004 to 2007 and mineral fertilizer was withheld from some NPK plots. Residual effects were evaluated both in relation to plots without any nutrient supply since 1922 and plots that still received 100 kg N, 25 kg P and 120 kg K ha^{-1} each year. No residual effect of mineral fertilizer was found, but the previous use of manure gave large residual effects on both yield and nutrient uptake, with yields remaining at around 85 % of those obtained with mineral fertilizer. Soil analyses in 2007 showed effects of both mineral fertilizer and manure on available nutrients, pH and soil organic matter. Applications of manure and fertilizer were resumed in 2008 on most plots, but not in those with the highest manure rate, where residual effects were measured until 2013. This treatment continued to show large residual responses in both yields and nutrient uptakes throughout the period.

Organic matter dynamics and carbon sequestration in relation to fertilizer use in temperate regions

Bal Ram Singh

Department of Environmental Sciences, Norwegian University of Life Sciences, 1432 Ås, Norway, balram.singh@nmbu.no

Soil Organic Matter (SOM) dynamics are fundamental soil biological processes, which govern the retention and supply of plant nutrients and lead to improve soil quality and in consequence plant growth. SOM consists of both active and passive pools, while most changes occur in the *active* pool. Therefore assessment of both quantity and quality of SOM as affected by land use change, fertilizer use , and crop and soil management under short and long terms conditions is very important for the overall quality and productivity of soils . Land use changes can result in rapid carbon losses, whereas carbon gains accumulate more slowly. The potential of soil organic carbon (SOC) in agro-ecosystems depends on soil management practices (e.g. conservation tillage, reduced soil erosion) coupled with improved cultivation practices (e.g. judicious fertilizer use, crop rotation, cover crops). Among several improved farming practices, the retention of crop residues, manure application strongly contributed to the restoration of SOC, but the synergistic effect between N fertilization rate and crop yield on increase in SOC was variable. The long-term quantitative and qualitative effects on SOM suggest that adopting no-till system and including grass in crop rotation and manure in fertilizer application may contribute to preserve soil fertility and mitigate climate change. Experimental evidences and case studies will be utilized to illustrate the importance of SOM dynamics and SOC sequestration in agro-ecosystems and strategies to enhance SOC will be suggested.

Phosphorus recycling through fertilizers

Andrea Ulrich

Federal Office for Agriculture (FOAG), Mattenhofstrasse 5, CH-3003 Bern, Switzerland, andrea.ulrich@blw.admin.ch

Advances in nutrient recovery from anthropogenic, renewable sources is promising. Technology and processes exist, particularly to recycle phosphorus (P). Over the last years, efforts to recover nutrients have also gained importance in Switzerland. Currently, the waste legislation is being completely revised, in order to respond to the demands of a modern waste policy. For the first time, it will become mandatory to recover P with a transition period of 10 years. This generates new demands on the material and energy utilization of P from secondary sources. Such sources are municipal wastewater, sewage sludge from wastewater treatment plants, sewage sludge ash, or meat and bone meal. Calculations have shown that the recoverable amount of P equals the amount of imported P. This substitution potential can be tapped and used for fertilizer production and application, on consideration of agronomic usefulness and acceptable eco-toxicological risk levels. The presentation gives an outline of the general situation and highlights the regulatory developments.

Soil nitrogen dynamics in maize field trials after slurry injection compared to broadcast application using a new sampling strategy

Matthias Westerschulte, Carl-Philipp Federolf, Dieter Trautz and Hans-Werner Olfs

University of Applied Sciences Osnabrueck, Am Kruempel 31, D-49090 Osnabrueck, Germany,M.Westerschulte@hs-osnabrueck.de

Slurry injection below the maize seeds is a new application technique developed to improve the nitrogen use efficiency. However, better understanding of the soil mineral nitrogen (SMN) dynamics is essential. We developed a soil sampling strategy, in which the soil profile is sampled grid-like to a depth of 90 cm. Around the injection zone soil monoliths (SM) are sampled using a purpose build shovel, while below the SMs and in the interrow space an auger procedure is performed. This sampling strategy was used in a maize field trial on a sandy soil in lower Saxony (Germany) on several dates in 2014 to compare broadcast application to slurry injection below the maize row. In the slurry broadcast treatment most of the applied nitrogen leached out of the 0 – 30 cm layer until six leaf stage due to heavy rainfall occurring after planting. Especially nitrogen in the interrow space was lost for maize nutrition. Also in the slurry injection treatment nitrogen leaching was determined, but the displacement out of the injection zone was delayed und thus nitrogen was available for maize over a longer period. Based on the new soil sampling strategy it was revealed that reduced leaching is one reason why slurry injection enhances nitrogen use efficiency in maize.

„Berichte aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft"
erscheinen seit 1995 in zwangloser Folge

Seit 2008 werden sie unter neuem Namen weitergeführt:
„Berichte aus dem Julius Kühn-Institut"

Heft 159, 2011:	Handbuch. Berechnung der Stickstoff-Bilanz für die Landwirtschaft in Deutschland, Jahre 1990 – 2008. Martin Bach, Frauke Godlinski, Jörg-Michael Greef, 28 S.
Heft 160, 2011:	Die Version 2 von FELD_VA II und Bemerkungen zur Serienanalyse. Eckard Moll, 34 S.
Heft 161, 2011:	Netz Vergleichsbetriebe Pflanzenschutz - Jahresbericht 2010 - Analyse der Ergebnisse der Jahre 2007 bis 2010. Bearbeitet von Bernd Freier, Jörg Sellmann, Jürgen Schwarz, Marga Jahn, Eckard Moll, Volkmar Gutsche, Wolfgang Zornbach, 86 S.
Heft 162, 2011:	Viertes Nachwuchswissenschaftlerforum 2011 - Abstracts - , 62 S.
Heft 163, 2012:	Bewertung und Verbesserung der Biodiversität leistungsfähiger Nutzungssysteme in Ackerbaugebieten unter Nutzung von Indikatorvogelarten. Jörg Hoffmann, Gert Berger, Ina Wiegand, Udo Wittchen, Holger Pfeffer, Joachim Kiesel, Franco Ehlert, 215 S. , Ill., zahlr. graph. Darst.
Heft 164, 2012:	Fachgespräch: „Kupfer als Pflanzenschutzmittel" Berlin-Dahlem, 1. Dezember 2011. Bearbeitet von Stefan Kühne, Britta Friedrich, Peter Röhrig, 102 S.
Heft 165, 2012:	Nationaler Aktionsplan zur nachhaltigen Anwendung von Pflanzenschutzmitteln – Bericht 2008 bis 2011. Bernd Hommel, 162 S.
Heft 166, 2012:	Netz Vergleichsbetriebe Pflanzenschutz - Jahresbericht 2011 - Analyse der Ergebnisse der Jahre 2007 bis 2011. Bearbeitet von Bernd Freier, Jörg Sellmann, Jürgen Schwarz, Bettina Klocke, Eckard Moll, Volkmar Gutsche, Wolfgang Zornbach, 104 S.
Heft 167, 2012:	Fünftes Nachwuchswissenschaftlerforum 2012, 4. - 6. Dezember in Quedlinburg, 50 S.
Heft 168, 2013:	Untersuchungen zur Bildung von Furocumarinen in Knollensellerie in Abhängigkeit von Pathogenbefall und Pflanzenschutz. Andy Hintenaus, 92 S.
Heft 169, 2013:	Pine Wilt Disease, Conference 2013, 15th to 18th Oct. 2013, Braunschweig / Germany, Scientific Conference, IUFRO unit 7.02.10 and FP7 EU-Research Project REPHRAME – Abstracts –. Thomas Schröder, 141 S.
Heft 170, 2013:	Fachgespräch: „Kupfer als Pflanzenschutzmittel", Berlin-Dahlem, 7. Dezember 2012. Bearbeitet von Stefan Kühne, Britta Friedrich, Peter Röhrig, 89 S.
Heft 171, 2013:	Sechstes Nachwuchswissenschaftlerforum 2013, 27. - 29. November in Quedlinburg - Abstracts - , 52 S.
Heft 172, 2013:	Netz Vergleichsbetriebe Pflanzenschutz, Jahresbericht 2012, Analyse der Ergebnisse der Jahre 2007 bis 2012. Bearbeitet von Bernd Freier, Jörg Sellmann, Jörn Strassemeyer, Jürgen Schwarz, Bettina Klocke, Hella Kehlenbeck, Wolfgang Zornbach, 111 S.
Heft 173, 2014	Statusbericht Biologischer Pflanzenschutz 2013. Johannes A. Jehle, Annette Herz, Brigitte Keller, Regina G. Kleespies, Eckhard Koch, Andreas Larem, Annegret Schmitt, Dietrich Stephan, 117 S.
Heft 174, 2014	47th ANNUAL MEETING of the SOCIETY FOR INVERTEBRATE PATHOLOGY and INTERNATIONAL CONGRESS ON INVERTEBRATE PATHOLOGY AND MICROBIAL CONTROL, 176 S.
Heft 175, 2014	NEPTUN-Gemüsebau 2013. Dietmar Roßberg, Martin Hommes, 44 S.
Heft 176, 2014	Rodentizidresistenz. Dr. Alexandra Esther, Karl-Heinz Berendes, Dr. Jona F. Freise, 52 S.
Heft 177, 2014	Siebentes Nachwuchswissenschaftlerforum 2014, 26. - 28. November in Quedlinburg - Abstracts -, 57 S.
Heft 178, 2015	Netz Vergleichsbetriebe Pflanzenschutz, Jahresbericht 2013, Analyse der Ergebnisse der Jahre 2007 bis 2013. Bearbeitet von Bernd Freier, Jörg Sellmann, Jörn Strassemeyer, Jürgen Schwarz, Bettina Klocke, Hella Kehlenbeck, Wolfgang Zornbach, 103 S.
Heft 179, 2015	Fachgespräch: „Kupfer als Pflanzenschutzmittel" Berlin-Dahlem, 21. November 2014. Stefan Kühne, Britta Friedrich, Peter Röhrig, 56 S.
Heft 180, 2015	Fachgespräch: „Gesunderhaltung von Pflanzen im Ökolandbau im Spannungsfeld von Grundwerteorientierung, Innovation und regulatorischen Hemmnissen" Berlin-Dahlem, 20. November 2014. Stefan Kühne, Britta Friedrich, Peter Röhrig, 40 S.
Heft 181, 2015	Achtes Nachwuchswissenschaftlerforum 2015, 19. - 21. Oktober in Quedlinburg - Abstracts -, 42 S.
Heft 182, 2015	Netz Vergleichsbetriebe Pflanzenschutz, Jahresbericht 2014, Analyse der Ergebnisse der Jahre 2007 bis 2014. Bearbeitet von Bernd Freier, Jörg Sellmann, Jörn Strassemeyer, Jürgen Schwarz, Bettina Klocke, Silke Dachbrodt-Saaydeh, Hella Kehlenbeck, Wolfgang Zornbach, 42 S.
Heft 183, 2016	Pflanzen für die Bioökonomie – Welche Herausforderungen ergeben sich für die Qualität nachwachsender Rohstoffe? 50. Vortragstagung - Abstracts - , 94 S.

Julius Kühn-Institut
Bundesforschungsinstitut für Kulturpflanzen