Bearbeitet von/ Compiled by:
Silvia Haneklaus[1], Eduardo Rosa[2], Ewald Schnug[1]

# 24th International Symposium of the International Scientific Centre of Fertilizers
# Plant nutrition and fertilizer issues for specialty crops
# Coimbra (Portugal), September 6-8, 2016

[1]Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants
Institute for Crop and Soil Science

[2]CITAB - University of Trás-os-Montes and Alto Douro (UTAD), Department of Agronomy, Vila Real, Portugal

Berichte aus dem Julius Kühn-Institut

185

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



**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.2016.185.000**

## Table of Contents

## Preface

Founded in 1933, CIEC (Centre International Engrais Chimique) has accomplished to be one of the oldest scientific organizations that promote the implementation of scientific knowledge in the field of fertilizer research into crop production. The 24th International CIEC Symposium in Coimbra (Portugal) hosted by the University of Coimbra (UC), the Institute for Interdisciplinary Research of the University of Coimbra (IIIUC) and the Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB), Vila Real takes place first time in its history in Portugal. The bandwidth of topics that could have been addressed is extremely wide as are soil and climatic conditions which challenge agricultural production. Perhaps even more striking is the variety of specialty crops which are grown on the Iberian Peninsula such as grapevine, cork oak, eucalyptus, olives, almonds and citrus fruits. Accordingly the symposium has been thematically dedicated to plant nutrition and fertilizer issues for specialty crops. Environmental conditions, for example drought, salinity and micronutrient deficiency cause regularly stress conditions for plants. In a climatically changing environment the demands towards agricultural production will increase distinctly in future and the maintenance of crop productivity will be an important contribution towards global food security. Specialty crops deliver regularly a higher economic return than common plants, but are also more demanding with view to a crop-specific input of resources. Here, the significance of targeted fertilizer applications with regard to type, rate and timing will be of prime relevance for growing high-yielding specialty crops of prime quality. Advanced precision agriculture technologies as for instance remote sensing devices are a big promise towards an efficient use of fertilizers which benefit farmers, natural resources and environment. In invited lectures *Prof. Shiping Wang* (Institute of Tibetan Plateau Research of the Chinese Academy of Sciences, Beijing, P.R. China), *Prof. João Santos (*Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal), *Dr. Elke Bloem* (Julius Kühn-Institut, Institute for Crop and Soil Science, Braunschweig, Germany) and *Prof. Dr. Javier Tardáguila* (University of La Rioja, Logroño, Spain) present cutting-edge research and state-of-the-art facts on the different themes mentioned above.
Last, but not least we would like to thank the local organizers who make the 24th CIEC Symposium an unforgettable event for all participants!

Ewald Schnug
**President of CIEC**

Silvia Haneklaus
**Secretary General of CIEC**

# Influence of abiotic and biotic stress on plant growth parameters and quality of specialty crops

**Elke Bloem[1*], Silvia Haneklaus[1], Maik Kleinwächter[2], Jana Paulsen[2], Dirk Selmar[2], Ewald Schnug[1]**

[1]Institute for Crop and Soil Science, Julius Kühn-Institut (JKI), Bundesallee 50, 38116 Braunschweig, Germany, mail*: elke.bloem@julius-kuehn.de

[2]Institute for Applied Plant Science, Technical University Braunschweig, Mendelssohnstraße 4, 38106 Braunschweig

Plants under stress react with changes in their primary and secondary metabolism which directly can affect quality aspects. Many herbs and spices develop a stronger aroma and taste under Mediterranean in comparison to humid climate. Reasons are most likely moderate drought stress in combination with a higher UV irradiation.
In the current research the hypothesis was tested if it is possible to increase valuable plant ingredients by applying controlled stress conditions. Crops from different plant families which contain secondary plant metabolites from different classes were tested. Test crops were thyme (*Thymus vulgaris*), greater celandine (*Chelidonium majus*), nasturtium (*Tropaeolum majus*), parsley (*Petroselinum crispum*), and St John´s wort (*Hypericum perforatum*). With these plants the following classes of secondary plant compounds could be investigated in response to stress: essential oils, alkaloids, glucosinolates, polyphenoles, and hypericine. Stress parameters that were applied to the plants in pot experiments were drought, salt stress and the simulation of biotic stress by application of the phytohormones methyljasmonate (MeJA) or salicylate (SA). Both phytohormones are involved in pathogen defense. Plants were harvested at different growth stages and a selection of stress parameter and secondary plant compounds as well as the biomass development was recorded. It was shown that with drought stress and MeJA application it was possible to increase the concentration of most secondary compounds (Bloem et al., 2014; Kleinwaechter et al., 2015; Paulsen et al., 2014) but drought stress always reduced biomass development. Therefore the overall yield of secondary compounds was lower in plants grown under water deficit. Application of MeJA caused an increase in the

concentration of valuable compounds in the dry matter and very often as well in the overall yield of the compounds when harvesting the plants. SA and salt stress revealed a positive effect on vegetative growth of parsley and St John´s wort and increased metabolite yield via increasing the total vegetative biomass.

The results show that it is possible to adjust metabolite concentrations in plant parts by applying stress to the plant but plants react differently to stress and it is important to know the species-specific mechanisms of stress related secondary metabolite accumulation.

## References

Bloem E, Haneklaus S, Kleinwaechter M, Paulsen J, Schnug E, Selmar D (2014) Stress-induced changes of bioactive compounds in *Tropaeolum majus* L. Industrial Crops and Products 60:349-359

Kleinwaechter M, Paulsen J, Bloem E, Schnug E, Selmar D (2015) Moderate drought and signal transducer induced biosynthesis of relevant secondary metabolites in thyme (*Thymus vulgaris*), greater celandine (*Chelidonium majus*) and parsley (*Petroselinum crispum*). Industrial Crops and Products 64:158-166

Paulsen J, Kleinwaechter M, Selmar D, Bloem E, Schnug E (2014) Beneficial Impacts of Drought Stress on the Contents of secondary metabolites in plant-derived Commodities. Zeitschrift für Arznei- und Gewürzpflanzen 19:193-195

# Potential benefits of kaolin and salicylic acid on olive tree performance and mineral composition of fruits under rainfed conditions

**Cátia Brito[1*], Lia-Tânia Dinis[1], Ermelinda Silva[1], Helena Ferreira[1], Luís Rocha[1], Ana I.R.N.A. Barros[1], Carlos Matos[2], Isabel Q. Ferreira[3], José Moutinho-Pereira[1], Manuel Ângelo Rodrigues[3], Carlos Correia[1]**

[1]CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences, Universidade de Trás-os-Montes e Alto Douro, Apt. 1013, 5000-801 Vila Real, Portugal, mail*: cvqbrito@utad.pt

[2]Chemistry Department, University of Trás-os-Montes and Alto Douro, 5000-801 Vila Real, Portugal

[3]CIMO - Mountain Research Centre–ESA, Instituto Politécnico de Bragança, Bragança, Portugal

The projected changes in climate in the Mediterranean region, that include low rainfall, excessive heat load and high daily irradiance, are of utmost relevance for rainfed olive orchards, since are expected negative consequences on physiology, growth, productivity and quality. To overcome these problems, it is imperative to develop adjustments in agronomic practices.Young olive trees of a rainfed orchard in Bragança, Northeast Portugal, were sprayed with 100 μM salicylic acid (SA), a stress signaling phytohormone, or with 5% kaolin (KL), a heat and irradiance reflecting clay. Both protective agents demonstrated a significant positive effect on net $CO_2$ assimilation rates, especially in the most stressful period of the summer season, due to lower stomatal and non-stomatal limitations. The positive response of the photosynthetic activity, as well the improvement of tree water status, contributed to the higher fruit yield presented by the trees treated with SA, and in higher extent with KL. The mineral characterization of fruits demonstrate that SA and KL treatments influenced some mineral levels positively, highlighting the Mg, Ca, Zn and Mn concentrations in response to SA and K, Mg, Ca and Zn concentrations in reaction to KL application. These responses suggest an improvement of the nutritional value of the olives that may be associated with the best water status presented by those trees. Additionally, the application of SA and KL did not contribute to the increase in the

levels of heavy metals, verifying even a reduction in a few of them. It is noteworthy that Al concentration did not increase in fruits from KL treated trees, what could be a concern due to their presence on the product ($Al_4Si_4O_{10}(OH)_8$). Based on these results, KL and SA revealed to be effective on olive tree performance and mineral composition of fruits under rainfed conditions. Future studies are needed to strengthen these promising results and to clarify the mechanisms behind these potential benefits.

## Acknowledgements

The authors acknowledge the financial support provided by the FCT-Portuguese Foundation for Science and Technology (Cátia Brito - PD/BD/ 52543/2014), under the Doctoral Program “Agricultural Production Chains – from fork to farm” (PD/00122/2012).

## Phosphorus utilization in mixed cropping systems with legumes

**Bettina Eichler-Löbermann[1*], Phillipp Stahn[2], Stephanie Busch[1], Konrad Miegel[2], Maria Peter[1], Ralf Uptmoor[1]**

[1] Faculty of Agricultural and Environmental Sciences, University of Rostock, Agronomy, Justus von Liebig Weg 6,18059 Rostock, Germany; mail*: bettina.eichler@uni-rostock.de

[2] Faculty of Agricultural and Environmental Sciences, University of Rostock, Hydrology, Satower Str. 48, 18059 Rostock

The application of mixed cropping systems can contribute to an efficient, complementary utilization of growing factors. This in turn leads to increased efficiency of water and nutrient use and to more stable yields. Mixed cropping systems with legumes are of special interest due to the potential of additional nitrogen fixation in the soil.

The research project at Rostock University has been investigating the performance of different sole and mixed cropping systems under controlled and semi-controlled conditions as well as in a field experiment. The latter was established in 1998 to investigate the effects of different phosphorus (P) fertilizer strategies. Since 2012, the following crops have been cultivated: maize (*Zea mays*) and sorghum (*Sorghum bicolor*) alone, as well as combinations of monocots and legumes in which maize or sorghum were combined with runner bean (*Phaseolus coccineus*), blue lupin (*Lupinus angustifolius*), Andean lupin (*Lupinus mutabilis*), broad bean (*Vicia faba*) or soybean (*Glycine max*).

Differences in yields between sole and mixed cropping were found depending on the level of P supply. Under optimal P supply, the single cultivated maize and sorghum showed the highest biomass yields. However, under P deficiency, the respective combinations with legumes resulted in comparable or even higher yields. In addition, the mixed cropping systems exhibited higher yield stability and were less affected by differences in fertilizer or water supply. Enzyme activity in the soil also differed between sole and mixed cropping systems: higher activities of enzymes such as acid phosphatase were usually found in mixed cropping treatments. Bio-available P concentrations were also higher in soils of mixed crops.

The results of the present study indicate an increased mobilization of less available P sources in cropping systems combining different crop species. Monocots appear to profit directly from legumes. Furthermore, the combination of crops with legumes reduces the demand for nitrogen fertilizer.

## *Vitis vinifera* cell wall in response to restriction in major mineral elements

**João C. Fernandes, Luis F. Goulao, Sara Amâncio**

LEAF, *Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal*

Grapevine (*Vitis vinifera* L.) is one of the most important crops worldwide from an economic point-of-view, due to a global consumer acceptance. The berry is used as table grape, raisins and, above all, in winemaking industry.

The plant cell wall (CW) is a complex and heterogeneous structure of polysaccharides, glycoproteins and enzymes, which surrounds the protoplast. The deposition and remodeling of CW material plays an essential role during plant growth, determining the cell size and shape, and providing protection against abiotic and biotic stress, enabling the cells to adapt to different physiological and environmental situations.

Nitrogen (N), phosphorus (P) and sulfur (S), are major elements connected to primary plant metabolism - amino acid and nucleotide biosynthesis, protein phosphorylation or protein disulfide bonds. N, P and S deficiency can reduce plant growth and crop yield, nutritional and organoleptic quality of the agronomic product, affecting anatomical and developmental patterns. Despite the diversity in plant species, a generic “stress–induced” response to abiotic stresses including mineral stress can be revealed through the inhibition of cell elongation, localized stimulation of cell division and alterations in cell differentiation status. However, notwithstanding the importance of mineral nutrition in plant development, its influence on the synthesis and modifications of the CW is not fully documented. To address this issue in *V. vinifera*, callus and young shoots, respectively as unorganized and organized tissues, were used as model systems to study CW responses to depletion of each major element (-N,-P or –S).

Using the callus system, changes in CW composition triggered by mineral stress were firstly investigated by Fourier–Transformed Infrared Spectroscopy (FT-IR). The overall results suggested changes in all main CW components. Modifications in the biosynthesis or rearrangements of cellulose microfibers, matrix linked glycans, pectin biochemistry and in the amounts of structural proteins were among the most striking indications. A further

detailed biochemical analysis of the stress responses revealed a significant reduction in cellulose content under –N and –P. In shoots, the primary response of plant CW under mineral deficiency, particularly –N, was also the impairment in CW cellulose. Due to the role of the CW for environment adaptation, plants are equipped with compensatory mechanisms to reinforce their CWs after the biosynthesis and/or deposition of cellulose is impaired. Low levels of cellulose are associated to a decrease in pectin methyl esterification, mainly in the long stretches of the homogalacturonan (HG), as spotted by in situ immunolocalization in both systems. Under mineral stress, this pattern of de-esterification was suggested to reinforce the CW conferring additional stiffening without alterations in CW elastic deformation. Basic PMEs, which promotes the formation of HG $Ca^{2+}$-linked gel structures and thereby stiffening and reducing CW extensibility, showed compatible gene expression patterns. Xyloglucans (XyG) also play an important role in CW and influence its characteristics. Most drastically in -N shoots, the CW XyG increase was evidenced by immunolocalization techniques. This increase can also be explained as a CW reinforcement mechanism. Simultaneously, -N shoots increased the levels of tightly bonded arabinose to pectic polysaccharides side chains. The observed decrease in cellulose and increase in arabinans may be a general response to mineral stress.

Lower cellulose levels led us to investigate the expression of the cellulose synthase (CesA) gene family. Most of these genes showed an increased transcript accumulation, which conflicts with the observed reduction in cellulose content. Nevertheless, CesA activity is known to be insufficient to produce cellulose, requiring the combined action with members from other families, such as the classes C of the glycosyl hydrolase family 9 (GH9). Supporting this assumption, in –N or –S callus *VvGH9C2* expression was severely down-regulated.

Taking into account the overall results, the impact of -N stress on the CW points to a more pronounced response, supporting the primary role of this major nutrient in plant development and metabolism.

# Vitamin B6 ameliorates germination and early growth of *Triticum durum* L. under water stress conditions

**Tiago Ferreira[1], Ivo Pavia[2*], Miguel Baltazar[1], Luís Rocha[2], José Moutinho Pereira[2], José Lima-Brito[1,3], Carlos Correia[2]**

[1]Universidade de Trás-os-Montes e Alto Douro, Apt. 1013, 5001-801 Vila Real, Portugal
[2]CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences, Universidade de Trás-os-Montes e Alto Douro, Apt. 1013, 5001-801 Vila Real, Portugal, mail*: ivo.mmp@gmail.com
[3]BioISI – Biosystems & Integrative Sciences Institute, Faculdade de Ciências, Universidade de Lisboa, C8 BDG Campo Grande, Lisboa, Portugal

Dryland wheat farming can be heavily dependent on winter precipitation and overwinter water storage in the soil. Low soil water potential limits germination and emergence of rainfed durum wheat (*Triticum durum* L.). In some regions, future water requirements are predicted to exceed water availability. Thus, the identification of methods to enhance germinate and growth under lower water potential is of importance. Vitamin B6 is an indispensable compound for plant survival and is known as a cofactor for numerous central metabolic enzymes and for playing a role in several stress responses, particularly in association with oxidative stress. Seed priming has been described as a cost effective and reliable method to enhance rapid and uniformed emergence and to achieve better yields in field crops. Our objective was to quantify and compare seed germination and early growth of durum wheat cv. Marialva primed with vitamin B6 (pyridoxine) under water stress conditions. For this purpose, seeds were hydro-primed (control) and primed with 0.01, 0.1, 1 and 10 mM of pyroxidine solution during 8 hours. Twenty seeds per treatment (×4 repetitions) were placed in 90mm Petri dishes with moister filter paper with osmotic solutions of polyethylene glycol 6000 of 0 and -1 MPa and germinated in the dark at 25ºC. Germination was annotated daily during a period of 8 days. Root and shoot growth, as well as fresh and dry weight, were measured 5 days after germination. Fresh and dry weight and water content showed no significant difference among the primed treatments. Pyridoxine priming at 1mM has shown the biggest mean root and shoot size at 0 MPa, as

well as the biggest mean shoot size at -1 MPa. The Tukey HSD test showed significantly differences in the mean shoot size at -1 MPa of the pyridoxine-treat seeds with 1mM when compared with control. However, mean root and shoot size at 0 MPa have not proved significantly different from control. Contrastingly, germination speed was highly influenced by the pyridoxine priming at -1 MPa. Additionally, mean germination speed was decreased *c.a.* 28%, in seed primed with 0.01mM pyridoxine, till 77% in seeds primed with 0.1mM pyridoxine, when compared with control. These results have practical implications since seed priming with pyridoxine solution seems to enhance germination speed and promotes a more uniform germination of durum wheat in low water conditions.

## Acknowledgements

The authors acknowledge the financial support provided by the FCT-Portuguese Foundation for Science and Technology (Ivo Pavia - PD/BD/113611/2015 and Luis Rocha - PD/BD/113612/2015), under the Doctoral Program “Agricultural Production Chains – from fork to farm” (PD/00122/2012).

## Modeling climate change impacts on nitrogen stress for the Portuguese viticulture

**Helder Fraga, Aureliano Malheiro, João A Santos**

Centre for the Research and Technology of Agro-environmental and Biological Sciences, CITAB, Universidade de Trás-os-Montes e Alto Douro, UTAD, Vila Real, Portugal

Nitrogen (N) is essential for crop growth. For viticulture, a suitable nitrogen supply is key to attain high yields and quality attributes. A limitation in nitrogen uptake reduces photosynthetic activity, resulting in production losses and unbalanced ripening. Conversely, N excess also results in detrimental impacts, not only for the grapevine physiology but also for the environment. Excess N may run-off or infiltrate water bodies. For vine growers, N application depends on vine status and seasonal weather conditions. Given the strong relationship between N demand and edaphic-climatic factors, climate change may impose additional threats. Herein, an assessment of present (1980-2005) and future (2041-2070) N stress/demand for viticultural activities, is provided over mainland Portugal. The STICS crop-soil model is calibrated using regional climate, soil, topography, viticultural practices and varieties. Additionally, the crop model was coupled with 4 regional climate models under the RCP4.5 future scenario. Results point at stress increases over Beira-Atlântico, Douro/Porto, Minho, Terras-de-Cister, Terras-do-Dão and Trás-os-Montes, and decreases over Alentejo, Algarve, Península-de-Setúbal and Tejo. The results provide future projections for N demand over the Portuguese viticultural regions, highlighting the need for suitable climate change adaptation measures.

# Opportunities and challenges of subsurface fertilizer application in specialty crops in Bangladesh

**Yam Kanta Gaihre*, Badirul Islam, Ishrat Jahan, Josh DeWald**

International Fertilizer Development Center (IFDC), Dhaka, Bangladesh, mail*: ygaihre@ifdc.org

Subsurface application of fertilizer (commonly called fertilizer deep placement 'FDP') in lowland rice cultivation has been widely recognized as an effective management practice that reduces fertilizer (urea) use by 25-40% and increases yield by an average of 15-20%. With significant reduction in fertilizer use, FDP increases farm profitability and reduces government subsidy payments in countries where N fertilizer subsidies exist. It is widely used in Bangladesh and some African countries, particularly in rice cultivation.

Research conducted across different countries demonstrated that FDP is an efficient fertilizer management technology that increases grain yields and offers sustainable soil fertility solutions for lowland rice cultivation. However, the long-term effects of FDP in upland cropping systems – and particularly in speciality crops - are not yet clear. This is important in the context of increasing crop diversification in rice-based cropping systems by using high value specialty crops including vegetables, fruits, and cash crops. Decreasing economic returns from rice due to increased labour shortages and reduced water availability - and in some cases grain price fluctuation and land fragmentation - are among the drivers for the crop diversification in Asian countries. Diversification to specialized crops in formerly flooded rice-based cropping systems poses a challenge to maintaining soil fertility and crop productivity. Therefore, there is a need for efficient nutrient management solutions to maximize the benefits of crop diversification, and FDP use in specialized crops could be one method to achieve these efficiency improvements.

In addition to rice and maize, deep placement of urea or multi-nutrient fertilizer briquettes containing NPK has also been tested in different vegetables and fruits in Bangladesh, comparing results to farmers' practice. Since many farmers do not practice balanced fertilization, deep placement of multi-nutrient fertilizer briquettes offers the potential for higher yields and improves fertilizer use efficiency through the balanced use of nutrients and reduced nutrient losses. In these trials, FDP increased vegetable and fruit yields by

10-20% while using 10% less fertilizers. Farmers report that deep placement improved the quality of fruits and vegetables (colour, shape), and these practices were found to significantly increase net economic returns. Farmers now use deep placement in several specialty crops, including eggplant, cabbage, cauliflower, potato, tomato, taro, bitter gourd, cucumber, papaya, guava, and watermelon. Relatedly, research conducted by Bangladesh Agriculture Research Institute (BARI) showed that FDP increased Betal leaf (*Piper beetle*) yields by 15% with 10% less fertilizers, while evidence supports similar results from the use of FDP in sugarcane.

In addition to yields, nutrient use efficiency and the environmental impacts of subsurface fertilizer placement, we will also discuss the challenges and opportunities of larger-scale adoption of FDP. In Bangladesh, where FDP technology is widely disseminated, the majority of farmers are small land holders (<2 ha). Therefore, FDP technology is being disseminated by the Government of Bangladesh in partnership with IFDC by developing micro-enterprise briquette producers, and applied manually in fields. Each local entrepreneur who owns a briquetting machine – many of whom are fertilizer dealers - produces fertilizer briquettes amounting to approximately 1 mt per day. Farmers access fertilizer briquettes through retailors' networks. This approach is effective in small scale farming where household labour is sufficient for cultivation, but requires modification to work in larger scale farming systems where labour availability is an issue, where supply chain and mechanization dynamics are different, or where national (rather than localized) results are desired. Due to the increasing trend of labour outmigration, the availability of labour has become one of the major issues of FDP adoption. Therefore, for large scale dissemination of this technology for speciality crop production in various countries, government and/or private sector actors must work together to promote wide-scale adoption by farmers through industrial-level briquette production and mechanized on-farm deep-placement solutions.

# Key aspects of fertilizers and fertilization for closing the anthropogenic and agricultural phosphorus cycle

**Silvia Haneklaus*, Ewald Schnug**

Institute for Crop and Soil Science, Federal Research Institute for Cultivated Crops, Bundesallee 50, D-38116 Braunschweig, Germany, mail*: silvia.haneklaus@julius-kuehn.de

Phosphorus (P) is an essential plant nutrient and a sufficient P supply is required in order to maintain a high level of crop productivity. P has an eminent and well-known relevance as an ecological contaminant, too. Thus it is vital for sustainable crop production to develop strategies and measures which maintain crop productivity without detrimental environmental impact. This can only be achieved if the agricultural and anthropogenic P cycles are closed.

About 236,000 t P accrue annually with farmyard manure in Germany, an amount sufficient to satisfy the entire P demand of agriculture. 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, P rates outreach crop demand by far. It is necessary to limit upper P load to the average off-take of 22 kg/ha P by agricultural crops in order to avoid P accumulation in soils. In addition, recycling chains for excess manure need to be implemented.

With mineral P fertilizers about 110,000 tons P are applied in Germany each year. Sewage sludge ashes could provide approximately 66,000 tons P annually. Thus this P source might replace up to 60% of the mineral P fertilizer input if fully utilized. Urban mining of P and its beneficiation into a suitable fertilizer product will not only contribute to alleviate P supply bottlenecks and price volatility of mineral P fertilizers, but also to preserve natural phosphate rock deposits. Mono-incineration of sewage sludge combined with technical processing should deliver a product that contains P in completely plant available form and that will not yield accumulation of heavy metals in soils.

The concept of Phosphorus: 100% Zero summarizes the most important claims for a sustainable handling of the finite resource P: P in all fertilizers, mineral and recycled, must be completely (100%) plant available and without (zero) contamination of organic

xenobiotics and heavy metals. In case of heavy metals the loads should not exceed off-take by harvest products in order to avoid accumulation in soils. P fertilizer rates irrespective whether applied in mineral or organic form should match the off-take by harvest products on sufficiently with P supplied soils. Only then the input of P is truly balanced and P losses by erosion and surface run-off to water bodies will be reduced effectively.

# Productivity of winter wheat (*Triticum aestivum* L.) cultivars depending on N-fertilization

**Borbála Hoffmann[1*], Fruzsina Szira[2], István Monostori[2], Attila Vágújfalvi[2], Sándor Hoffmann[1]**

[1]University of Pannonia, Georgikon Faculty, Deák F. u. 16. H-8360 Keszthely, Hungary, mail*: hoff-b@georgikon.hu

[2]Agricultural Institute, Centre for Agricultural Research, Hungarian Academy of Sciences, Brunszvik u. 2., H-2462 Martonvásár, Hungary

A major consideration for the sustainable increase in productivity of crops is the dependency on nitrogen fertilizer, which is a substantial cost factor and a potential environmental pollutant as well. Hence, increased interest is being shown worldwide in cultivars that are more efficient in utilizing soil resources and better fitted to low-input ecosystems. Among cereals hexaploid winter wheat (*Triticum aestivum* L.) is considered as a species with higher requirements for nutrients, especially nitrogen. Furthermore, modern European wheat cultivars were developed under favourable or even luxurious fertilization regimes without selection pressure for components of nutrient use efficiency. Thus, identifying wheat cultivars with good adaptation to less favourable environments or breeding new varieties with higher NUE has gained importance.

The main objective of our study was to investigate and characterize the N-use efficiency of winter wheat cultivars under our agroecological conditions. Cultivars representative of old and modern wheat germplasm of various origins were evaluated under two N-fertilization regimes. Based upon the previous two growing season's results [ninety-six winter wheat cultivars were investigated under field condition in growing season 2013/14 at the Agricultural Institute, Martonvásár] 20 cultivars were chosen for further examination on the experimental fields of Georgikon Faculty at Keszthely in the growing season 2014/15. The soil of the experimental field is a lessivated brown forest soil (Eutric cambisol) with low organic material, medium K- and P content. Soil samples were taken in early spring and after harvest. The experiment was set up as a split block design, two fertilizer rates as main plots and with 3 replications and the cultivars as sub-plots. N was applied at rates 0-,

and 120 kg N $ha^{-1}$. Agronomically important morphological and physiological characters were measured. Statistical analysis was made by using SPSS 16.

Agronomically important characters were measured (grain yield, spike number, thousand grain weight, plant height, heading time, biomass and harvest-index) and physiological parameters: intensity of photosynthesis and water potential were evaluated in growing season 2014/15. The efficiency of nitrogen use (NUE; defined here as the grain yield per unit of the soil-N) is calculated. The first-year dataset of our experiment is presented.

The growing season 2014/15 was dry in Hungary. To check on the N-status of plants chlorophyll content was measured with a SPAD 502 Plus Chlorophyll Meter at Zadoks scale 51-55. We found significant differences among varieties within N-treatments.

The activity of the two key enzymes in N-use: nitrate reductase (NR) and glutamine synthetase (GS) were measured. There was no correlation for NR activity among genotypes in N-null treatment, but a negative correlation was found in N-120 treatment between NR activity and grain yield.

To find out which genotype is recommended for intensive and which one is for extensive cultivation, cultivars are also ranked based on the increased level of their performance depending on nitrogen supply, we calculated Tolerance Index (TI): grain yield of wheat varieties in N-0/N-120 treatments. According to our results varieties lost 56-72% of their yield in N-0 treatment compared with the yield in N-120 treatment.

## Acknowledgment

This work was supported by the Hungarian Research Fund (OTKA K101794).

## Protecting the water environment from overused fertilizers

**Xia Jiang, Binghui Zheng, Hui Yu, Kun Wang, Jinzhi Wang**

State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environment Sciences, Beijing 100012, China

Non-point source (NPS) pollution has been increasingly serious in China in last 30 years. In the pursuit of higher agricultural productivity to feed the growing population and intensive livestock production with the decreased farmland occupied by construction, China is the world's largest consumer of fertilizers. Taking Taihu River Basin as an example, on the average the annual amount of nitrogen (N) and phosphorus (P) fertilizer applied were 570-600 kg/hm$^2$ and 79.5-99 kg/hm$^2$, respectively. However, the average utilization rate of fertilizer was only 30-35%. Excessive fertilizer input increases the background value of N and P in the soil, and increases the risk and loss of N and P to the water body, thereby putting aquatic ecosystems downstream at risk of eutrophication. The planting pollutants loads including TN, TP, and ammonia are the main pollutant sources in Taihu River Basin, accounting for 38%, 23%, and 21% of total pollutants at the end of 2010. The Chinese State Council issued "Action Plan for Prevention and Control of Water Pollution" (GF[2015] No.17) on April 2nd, 2015, which proposed the aims of controlling agricultural NPS pollution, namely by 2020, coverage of soil testing and fertilizer recommendation technology should reach more than 90%, with fertilizer utilization rate increasing to above 40%. Therefore, to solve the environmental problems induced by overused fertilizer, in this study we compared and analyzed different technologies to mitigate agricultural NPS pollution.

# Phosphorus–induced zinc deficiency in vegetable grown in weak acid soils in typical vegetable growing areas of Dianchi catchment

**Meng Li[1, 2], Zhengyi Hu[1, 2, 3, *]**

[1]College of Resources and Environment, Sino-Danish College, University of Chinese Academy of Sciences, Beijing 100049, China, mail*: zhyhu@ucas.ac.cn,
[2]Sino-Danish Center for Education and Research, Beijing 100190, China
[3]Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

Zinc (Zn) deficiency not only affects the growth of vegetables, but has also an impact on the nutritional quality as Zn is an essential mineral nutrient for both, plants and humans. Zn deficiency in vegetables is more common on calcareous soils, but may also occur on acidic soils because of a phosphorus (P)-zinc antagonism induced by excessive P enrichment, for example after excessive P fertilization and on bio-geochemical basis. In total, 28 sites within an area of 7.46 $km^2$ was selected for taking samples of rhizosphere soil, fine root, and leaves of vegetables (*Pisum sativum, Broccoli, Cucurbita pepa, Zea Mays*) at each site in order to to examine the P-Zn relationship in the rhizosphere soil, fine roots, and vegetable leaves. There was a linear positive relationship between the Zn content in fine roots and the Zn content in leaves ($R^2$=0.96, $p$< 0.001). A power function existed for the relationships between the P content in fine roots (x) and the Zn content in fine roots and/or leaves (y), and the P content in the rhizosphere soil (x) and and the Zn content in fine roots and leaves(y), respectively (Figure 1, and Figure 2). The P-induced Zn deficiency threshold value was 2.65 mg/g P in the soil based on a critical nutrient value for Zn that characterizes Zn deficiency of 35 mg/kg Zn in vegetable leaves. In 43% of all samples the soil P status was higher than the threshold value of 2.65 mg/g P and the Zn concentrations in the vegetable leaf material below 35 mg/kg Zn. Soil P enrichment could be contributed to biogeochemical P enrichment (phosphorus ore) and excessive P fertilization. Thus it is important to correct Zn deficiency in vegetables in order to improve the nutritional quality and to prevent a Zn deficiency induced decline of nitrogen use efficiency which in return will increase nitrogen losses into water bodies.

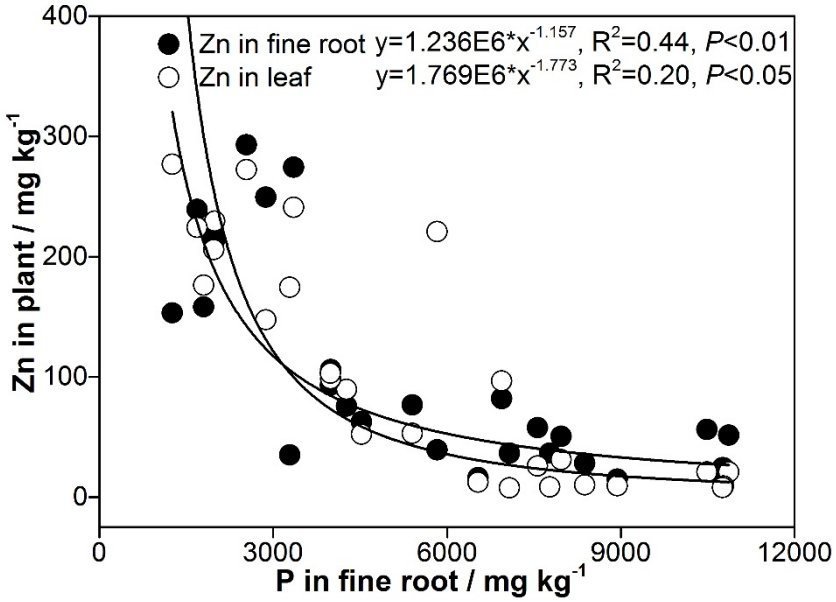


Figure 1. Relationship between the P content in fine roots and the P and Zn content in fine roots and leaves of vegetables.

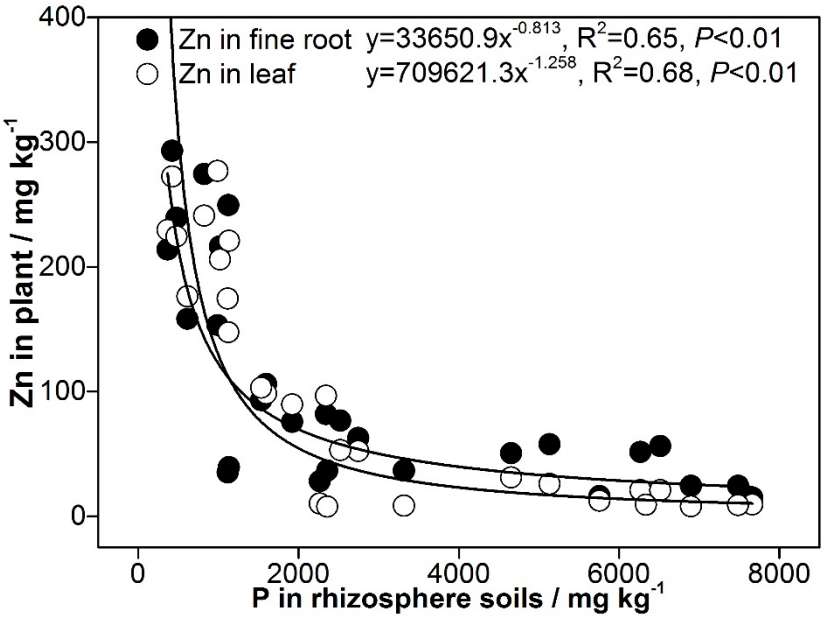


Figure 2. Relationship between the P content in the rhizosphere soil and the Zn content in fine roots and leaves of vegetables.

# New data sources for precision agriculture – blessing or curse?

**Holger Lilienthal*, Heike Gerighausen, Ewald Schnug**

Institute for Crop and Soil Science - Julius Kühn-Institut (JKI)- Federal Research Centre for Cultivated Plants, Bundesallee 50, D-38116 Braunschweig, Germany, mail*: holger.lilienthal@julius-kuehn.de

Up-to-date information on the status of crops is an important prerequisite for crop management and the development of site specific measures. Often miscellaneous data sources are already available on farms, for example tractor-mounted sensors, or yield and soil mapping facilities. A major drawback of this type of technology is that the farmer has to pass over his fields with his machinery to acquire this information. This is only economically beneficial if an application is performed at the same time (e.g. fertilizing, pest control, harvest). However, continuous monitoring of the cropland of farmers would be desirable to identify required urgent management actions at an early stage.

Remote sensing offers new opportunities to receive valuable information on current crop properties. The European Copernicus programme will launch up to ten earth observation satellites for different applications until 2020. The Sentinel-1 (radar) and Sentinel-2 (optical) satellites are already in orbit. They are very interesting for agricultural applications due to their high temporal (5-6 days revisit time) and spatial (10-20 m) resolution. In addition the EU follows an open data policy, so all data are available at no costs. However, the high spatial resolution results in huge datasets. The smallest radar dataset is 1 GB in compressed size, a tile of optical data is about 7GB in size. The resulting data volume sums up to several peta-bytes per day (full expansion stage: radar data every 2 days, optical data every 3-4 days), creating a huge demand on the data access, processing, infrastructure and interpretation. At present, the Sentinel data as provided by the European Space Agency is not applicable for agricultural practice.

So far, optical satellite remote sensing products have been sparsely used in practical farming. High costs of data purchase and data processing on the one hand, and uncertain data availability due to high cloud cover frequencies in Germany on the other hand, limited the use to research and a few financially strong companies.

With the project “AGRO-DE”, a consortium composed of Julius Kühn-Institut (JKI), the German Aerospace Centre (DLR), and the private companies EOMAP (remote sensing) and Hanse Agro (agronomic consultant), will prepare the Copernicus Sentinel-1 and Sentinel-2 satellite data for farmers and their specific needs and applications.

This way, it will be possible to reach farms that have not yet been in the focus of remote sensing applications due to their size and technical resources. In particular, small-scale farms and farms with organic farming will then gain the opportunity to participate in the technological development. Further, they will be able to test resource-efficient, site-specific management practices without a large start-up investment.

In the past years, another remote sensing technology, unmanned aerial vehicles (UAV) also known as drones, has taken an exciting technological development. The technology is driven by robotics and the complex technology has been made so simple to use, that everybody can run an autonomous drone after some hours of training. An UAV is simply just a platform to carry imaging sensors. The simplest way is a digital photo camera which can produce geo-coded image mosaics and digital elevation models at the same time. By now, software is available that enables everybody to perform complex photogrammetric analysis just with a few clicks and a powerful computer, and without having a deeper technical background. One big drawback for UAV operation is the limited battery power, resulting in short flight times and low ground coverage. Thus, UAVs are more suitable for small businesses with little acreage or large enterprises that require fast information on specific but restricted areas. For a routine monitoring, UAVs are not yet appropriate. A second weak point by now is the limited use of multi- and hyperspectral cameras in practical applications due to their tremendous costs. However, hyperspectral imaging has proven several advantages over multispectral imaging.

The times to retrieve up to data of agricultural fields have changed very positively. Huge data sources are available at low costs, but assistance is needed to prepare the available raw data to meaningful information for farmers. We do not have a lack of data; we have a lack of value-added information!

# Effects of different nitrogen fertilisers and application rates on the growth and caffeic acid derivative contents of *Echinacea purpurea* (L.) Moench

**Yi Lu, Ren-Shih Chung, Pi-Hui Suzi Chang***

Department of Agricultural Chemistry, National Taiwan University, Taipei 10617, Taiwan, ROC, mail*: suzichang@ntu.edu.tw

*Echinacea purpurea* (L.) Moench (commonly known as purple coneflower) is a native North American perennial herb that has been used to treat upper respiratory tract infections and some inflammatory conditions for hundreds of years. The main bioactive compounds with pharmacological effects in *E. purpurea* are caffeic acid derivatives (CADs), such as caftaric acid, chlorogenic acid, cichoric acid, cynarin and echinacoside. Few researches have been performed to explore the relationships between fertiliser management and the contents of bioactive constituents in *E. purpurea* under the cultivation conditions in Taiwan. In this study, a pot experiment was conducted in a greenhouse located in northern Taiwan in order to examine this issue. The aims of this study were: (1) to investigate the effects of chemical (Chem) and organic (Org) fertilisers with different nitrogen (N) application rates on the growth and plant nutrition of *E. purpurea*, and (2) to evaluate the contents of phenolics together with CADs in *E. purpurea* at both vegetative (150 days after transplanting, hereafter 150 DAT) and flowering (180 days after transplanting, hereafter 180 DAT) stages of growth. Treatments in this study included four replicates of the following: Control (0 N), Chem 1 (0.4 g N $pot^{-1}$), Chem 2 (0.8 g N $pot^{-1}$), Chem 3 (1.2 g N $pot^{-1}$), Org 1 (0.8 g N $pot^{-1}$), Org 2 (1.6 g N $pot^{-1}$) and Org 3 (2.4 g N $pot^{-1}$). At 150 DAT, biomass was measured and plant samples (roots and shoots) were collected and analysed to determine the concentrations of total N, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and phenolics, and five types of CADs (i.e. caftaric acid, chlorogenic acid, cichoric acid, cynarin and echinacoside). Soil samples were then collected and analysed to determine pH, electrical conductivity (EC), organic matter (OM), total N, inorganic N, Mehlich III extractable P and cations (i.e. K, Ca, Mg, Fe, Mn, Cu and Zn). The same procedure was repeated at 180 DAT. The results showed that soil pH decreased with the increase in application rate of chemical fertiliser throughout the whole

cultivation period. However, soil pH seemed to increase along with time, so all the values of soil pH were between 5.1 and 5.5 at 180 DAT. The concentrations of soil OM, total N, Mehlich III extractable P, Ca, Mg, Fe, Mn and Zn were higher in the Org treatments than in the Chem treatments at 150 DAT. Although a similar phenomenon was found at 180 DAT as well, the differences between Org and Chem treatments became less significant in soil total N, Mehlich III extractable Ca, Mg, Fe and Zn. On the other hand, soil EC and the concentrations of inorganic N and Mehlich III extractable Cu were higher in the Chem treatments than in the Org treatments throughout the whole cultivation period. As per plant growth, although biomass showed no significant differences between treatments at both stages of growth, almost all concentrations of the nutrients in *E. purpurea* were higher in the Org treatments than in the Chem treatments, except for total N of roots and shoots at both stages of growth, and total Ca of shoots at 180 DAT. Because the concentrations of chlorogenic acid, cynarin and echinacoside were trace or undetectable in this study, only the concentration of total CADs was taken into account. The concentrations of secondary metabolites of total phenolics and total CADs in *E. purpurea* were generally higher in the Org treatments, which had levels similar to untreated Control, compared with the Chem treatments. In conclusion, organic fertiliser seemed to be a good source of nutrients, not only of N but also other essential elements, for *E. purpurea* even though there was no significant change in biomass. Moreover, in *E. purpurea* grown with organic fertiliser, the high concentration of total phenolics suggested that there was a good defence system to ensure product quality, while the high concentration of total CADs suggested a remarkable pharmacological effectiveness.

## Microbial interactions in legumes: perspectives for improvement of biofertilizers

**Guilhermina Marques[1], Sandra Pereira[1], Ângela Mucha[1], Rui Oliveira[2,3], Aleš Látr[4], Eduardo Rosa[1]**

[1]CITAB - University of Trás-os-Montes and Alto Douro (UTAD), Department of Agronomy, Vila Real, Portugal

[2]Department of Environmental Health, Research Centre on Health and Environment, School of Allied Health Sciences, Polytechnic Institute of Porto, Vila Nova de Gaia, Portugal

[3]Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Coimbra, Portugal

[4]Symbiom Ltd., Lanskroun, Czech Republic

Legumes establish beneficial interactions with several soil microorganisms which improve plant growth and increase tolerance to unfavorable environmental conditions. Associated organisms include the symbiotic nitrogen-fixing bacteria rhizobia, and arbuscular mycorrhizal fungi (AMF). Biological nitrogen fixation (BNF) provides a valuable contribution to agricultural production, with legumes representing 25-35% of the world's protein. Increase of BNF is recognized as one of the most important mitigation actions to reduce greenhouse gases emission in agriculture and this is an important reason to increase the use of legumes in rotations or intercropping.

Several studies reported inconsistent results of inoculation in some legume crops due to the indigenous rhizobia and the low competitive ability of the inoculated strains. Therefore, the knowledge of the diversity and effectiveness of indigenous rhizobial populations is fundamental for selecting competitive and efficient N2-fixers for preparing highly effective inoculants, adapted to particular environmental stresses. These inoculants could also include arbuscular mycorrhizhal fungi (AMF) and plant growth promoting rhizobacteria (PGPR) which are either nitrogen-fixing or not and present several beneficial activities that stimulate the plant growth and protects against phytopathogens. PGPR belong to different

genera such as *Azospirillum*, *Bacillus*, *Burkholderia*, *Enterobacter*, *Paenibacillus*, *Pseudomonas*, among others.

The selection of appropriate rhizobia, AMF and PGPR can optimize the efficiency of BNF, reduce the use of synthetic agrochemicals and increase the performance of legumes in a scenario of global climatic changes.

# Impact of using a biofertilizer in chestnut productivity

**Tiago Marques[1*], Rosário Anjos[2,5], Teresa Pinto[2,5], Alice Vilela[3,5], Luís Martins[2,4], Fernando Raimundo[2,5], Jorge Ferreira-Cardoso[1,2,5], André Pereira[6], José Gomes–Laranjo[2,5]**

[1]University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal, mail*: tiagofcmarques@gmail.com
[2]CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
[3]CQ-VR Chemistry Research Centre University of Trás-os-Montes and Alto Douro (UTAD), Vila Real, Portugal
[4]CIFAP-ECAV – University of Trás-os-Montes and Alto Douro (UTAD), Department of Forest Sciences and Landscape Architecture, P-5001 801 Vila Real, Portugal
[5]DeBA-ECVA – University of Trás-os-Montes and Alto Douro (UTAD), Department of Biology and Environment, P-5001 801 Vila Real, Portugal
[6]Agro Rio Bom, Lda., Rua das Felgueiras, nº 1, 5445-083 Valpaços, Portugal

The chestnut tree (*Castanea sativa* Mill.) has a high economic importance in Portugal, especially in mountain regions, between 500-1100 m of altitude, where its cultivation occupies large areas.

Despite the importance for farmers, *C. sativa* suffers from several vulnerabilities which reduce the chestnut production, mainly, climatic exchanges, low fertility soils, ink disease or chestnut blight. In order to minimize the impact of biotic or abiotic agents on chestnut orchards, the present study analyzes the efficacy of the biofertilizer “Ergofito”.

Ergofito is a biofertilizer that promotes the growth and resistance of plants to pests and diseases. This biofertilizer is a combination of microbial diversity that naturally occurs in healthy soils as well as various mineral nutrients required for plant development. The composition of the product is diverse, and for this study was selected the product more suitable for chestnut trees.

The application of the product was made into two moments and it was applied either, in young and adult trees. In order to evaluate the chestnut productivity due to the use of

Ergofito a biochemical, mineral and physiological analysis on leaves as well as biometric and sensorial evaluation on chestnut fruits was conducted.

The results showed that there are no differences in sensorial properties in chestnut fruits although on chestnut fruits from plants treated with the biofertilizer the content of soluble sugars and crude protein increased compared to the control.

The young chestnut trees biofertilized have a higher content of nutrients in the leaves, highest rate of transpiration and photosynthesis, higher performance index and a higher content of metabolites, including chlorophylls, phenols and proteins. In adult chestnut trees the presence of Ergofito benefited the mineral content in leaves as well as the rate of photosynthesis and transpiration.

# The influence of long-term nitrogen and phosphorus fertilization on winter wheat and maize productivity

**Maria Negrilã, Emilian Negrilã, Jeni Mãdãlina Cojocaru**

Agricultural Research and Development Station-Teleorman, Drãgãnesti-Vlasca, 147135, Romania, mail: scda@scdatr.ro

The mineral fertilization of crops proved to be necessary in order to increase crop productivity, yield quality and soil fertility. The scientific results are based on the long-term fertilization with nitrogen (N) and phosphorus (P) experiments which started in autumn of 1976. Plots were not irrigated in the 5 year crop rotation of peas- wheat-sunflower-maize-wheat. The soil was a cambic chernozem at the ARDS -Teleorman, placed in the south of Romania with an average temperature of 10.8 °C and mean precipitation of 539 mm.

N and P fertilization caused consistently an increase of yield during the past 38 years of experimentation. To winter wheat sown after maize, in years with 500-600 mm rainfall, 80-120 kg/ha N + 80 kg/ha $P_2O_5$ were applied. The yield was > 5.4 t/ha which equals a surplus of < 2.4 t/ha when compared to the control. The utilization coefficient for N was 70% and < 20% for P. In dry years, N and P rates of 40-80 kg/ha N+ 40 kg/ha $P_2O_5$, repsectively proved to be sufficient for a maximum yield of 4.2 t/ha. The maximum yield was 1.7 t/ha higher than that of the control. The utilization coefficient for N was < 55% and that of P <20 %.

For winter wheat sown after peas, in the years with common rainfall 90 kg/ha N + 80 kg/ha $P_2O_5$ were applied. The yield was >5.8 t/ha with a surplus of >2 t/ha compared to the control. The utilization coefficient was 60% and that of P <15%. In the dry years, 30 kg/ha N and 40 kg/ha $P_2O_5$, proved to be sufficient to achieve the maximum yield. In all treatments the yield was reduced significantly compared to years with average precipitation.

In case of maize, for an average grain yield of 5.9-6.8 t/ha 100 kg/ha N + 80 kg/ha $P_2O_5$ were required. Yield was 1.5-1.7 t/ha higher than in the control plots in common years (May-August-over 300 mm rainfall). In dry years, the maximum yield was 2.2-2.4 t/ha and only 0.5-0.7 t/ha higher than in the control.

The N utilization coefficient varied between 42-47% in normal years and 15-17% in dry years. The utilization coefficient for P was 12-15% in normal years and 2-5% in dry years. The N and P removals from the soil were 120-140 kg/ha N and 49 kg/ha $P_2O_5$ in case of winter wheat in common years. In dry years the respective values were 95 kg/ha N and 35 kg/ha $P_2O_5$. Maize took off on average 50-230 kg/ha N and 32-97 kg/ha $P_2O_5$ with the harvest products.

The results of the field experiments showed that moderate N and P rates were sufficient to achieve the site-specific yield potential and that N and P rates should be adopted to rainfall events.

# Effect of the incorporation of cowpea residues on the yield and greenhouse gas emissions of a following cereal crop

**Miguel Oliveira[1], Carlos Castro[1], João Coutinho[2], Eduardo Rosa[1], Henrique Trindade[1]**

[1]Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB)

[2]Centro de Química (CQVR), Universidade de Trás-os-Montes e Alto Douro, (UTAD), Vila Real, Portugal

The inclusion of legume crops in rotations can contribute to the sustainability of agricultural systems due to the ability of these plants to fix atmospheric nitrogen (N) directly to the soil-plant system via symbiotic association with bacteria of the genus *Rhizobium*. The legume post-harvest residue is high in N and C, having the potential to increase the soil fertility if incorporated into the soil and thus to improve the yield of the following crop. A decrease in the use of mineral N based fertilizers can therefore be achieved. Conversely, these residues can greatly stimulate soil microbial activity, which may result in the loss of N by nitrate ($NO_3^-$) leaching and nitrous oxide ($N_2O$) emissions, a potent greenhouse gas.

A field experiment with cowpea crop from May to September followed by triticale for forage from October to June was conducted during two years (May 2014 – May 2016). The effects of the removal vs. incorporation into the soil of the legume straw immediately after pulse harvest were evaluated in terms of transfer of fixed N to the triticale crop and in terms of $N_2O$ emissions.

Nitrogen present in the cowpea straw reached 65.9 kg N $ha^{-1}$ in the first year. In this first crop rotation, triticale grown after cowpea achieved the production of 7420 kg DM $ha^{-1}$ when the legume straw was incorporated, a value that, albeit higher, was not significantly different from that obtained when the straw was removed (6928 kg DM $ha^{-1}$). Total N loss via $N_2O$ emissions was 0.28 kg N-$N_2O$ $ha^{-1}$ when straw was removed and 0.52 kg N-$N_2O$ $ha^{-1}$ when incorporated into the soil. The 2nd year of rotations will end in the end of May 2016 and the results will be presented at the poster.

It is expected that the differences in yield between the two treatments will increase in the 2nd year of rotation due to the cumulative effect of that year's incorporated residue and the

mineralization of the slowly degradable fraction of the first year's residue. When straw was incorporated into the soil, $N_2O$ emissions were almost double comparing to when it was removed. However, both treatments showed low N losses via this gaseous compound.

# The effect of vermicompost on the growth and quality of basil

**Margit Olle**

Estonian Crop Research Institute, J. Aamissepa 1, Jõgeva alevik, 48309, Estonia, mail: margit.olle@gmail.com

## Introduction

Vermicompost is the excreta of earthworm, which are capable of improving soil health and nutrient status. Vermiculture is a process by which all types of biode- gradable wastes such as farm wastes, kitchen wastes, market wastes, bio-wastes of agro based industries, live- stock wastes etc. are converted while passing through the worm-gut to nutrient rich vermicompost. The aim was to find suitable substrate to grow basil.

## Materials and methods

The experiments were carried through in company K. Compos glassgreenhouses in Estonia from December 2015 to February 2016. In present investigations green basil variety 'Genovese' was grown. The seeds in first experiment were sown on 5 December 2015 and plants harvested togehter with registration of growth results on 3 January 2016. In the second experiment the seeds were sown on 7 of January 2016 and plants harvested and results notified on 2 of February 2016.

Treatments were followed (Company K. Compos do not want to give accurate recepies as it remains their property right):

1. 30% vermicompost, peat, sand and if needed dolomite stone
2. 25% vermicompost, peat, gravel, perlite.
3. 25% vermicompost, peat, gravel, concrete block.
4. Growth substrate bought from a shop in Estonia (seller did not allow to usage the name of the brand).
5. 20% vermicompost and organic matter rich claysoil.

In the end of experiment on basil the height of shoots, length of roots and number of leaves were measured.

The contents of nitrogen, phosphorus, potassium, calcium and magnesium were determined.

Analyses of variance were carried out on the data obtained using Excel. In order to make results more clear to understand in the results section first experiment data are given, as the second experiment gave similar results.

## Results

Growth parameters of basil

The length of shoots was lowest in treatment 5 compared to all other treatments. The length of roots is lowest in treatment 5 compared to all other treatments. The length of shoots was lowest in treatment 5 compared to all other treatments. The highest number of leaves was in treatments 1 and 2. Basil growth parameters are showing that best growth substrates to grow this plant are treatments 1 and 2.

## Nutrient content in basil

The content of Nitrogen was lowest in treatment 2 compared to all other treatments. The content of Phosphorus in basil dry matter was not statistically different. The content of Potassium was highest in treatments 1 and 3, lowest in treatment 5 compared to all other treatments. The content of Calcium was lowest in treatments 1 and 2. The Calcium content was highest in treatments 4 and 5. The content of Magnesium was lowest in treatment 2. The Magnesium content was highest in treatments 3 and 5. The nutrient content of basil plants shows that best suitable growth substrate is treatment 3.

## Conclusion

It can be summarized that for basil the best growth substrate, regarding growth parameters and nutrient content, is treatment 3: 25% vermicompost, peat, gravel, concrete block.

# The effect of effective microorganisms on yield and quality of peas

**Margit Olle**

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

## Introduction

Effective microorganisms (EM) comprise a mixture of live cultures of microorganisms isolated from fertile soils in nature that are useful during crop production. The principle of EM is to increase the bio-diversity of soil microflora, thereby increasing crop yield. Photosynthetic bacteria, the major components of EM, are reported to work synergistically with other microorganisms to provide the nutritional requirements of the plant and to reduce disease. EMs interact with the soil-plant ecosystem to suppress plant pathogens and agents of disease, to solubilise minerals, to maintain soil microbial-ecological balance, and to fix biological nitrogen. The aim of present investigation was to evaluate the effect of EMs on the yield and chemical composition of peas.

## Materials and methods

Experiments were carried out in the fields of at Estonian Crop Research Institute in 2014. In present investigation field pea variety ‘Mehis’ was grown.

Treatments: 1. with EM – 1:500 activated EM solution; 2. control – with water. In EM variant the plants were sprayed with EM 1:500 solution from 21.05.2014 to 25.06.2014 with weekly intervals. The plants in control were at the same time sprayed with water.

A completely randomized experiment design was used with 4 replicates. Plot size was 10 $m^2$. Soil humus content was 3.15% and pH was 5.76. Soil type was soddy-calcareous podzolic soil according to the Estonian classification system, soil texture - sandy-clay. The preceeding crop was winter rye. Conventional cropping system was used with ploughing in autumn 2013, and cultivation twice before sowing. Seeds were sown on 28 April 2014 at a rate of 120 seeds per $m^2$ for all varieties and a depth of 4 cm. Plant spacing was 12.5 × 6.7 cm.

Fertilization was done with Yara Mila 7-12-25 (300 kg $ha^{-1}$) and weeds were controlled by Activus 330 (pendimethalin 330 g $L^{-1}$) EC 1.5 l $ha^{-1}$ + Basagran 480 (bentazon 480 g/l) 1.5 l $ha^{-1}$, on 21 May 2014. No control measures against insects and diseases were applied.
The weather during 2014 was characterized by a cold spring. Peas were harvested on 11 August 2014, dried and the yield data (determined at moisture content of 14-15%) recorded for each plot and finally calculated for t $ha^{-1}$. Samples were analyzed for their content of nitrogen, phosphorus, potassium and magnesium. Analyses of variance were carried out on the data obtained using the program Excel. Statistics was carried through with ANOVA using Excel and differences were deemed to be significant at $P<0.05$.

## Results and discussion

In most cases EMs increased the yield of vegetables crops (Olle and Williams 2013). Similarly in our investigation the yield of peas increased by 43% in the EM variant compared to the control treatment. Accordingly Olle (2013) found that the yield of Swedes increased by 27% and the yield of red beets by 31% in the EM treatment compared to control.
Application of Ems increased the nitrogen content increased by 2%, which can be explained by a higher nitrogen uptake from the soil solution (Subadiyasa 1997). The phosphorus, potassium and magnesium content increased by 28%,8% and 12% respectively in the EM variant. EMs help to solubilize soil minerals (Subadiyasa, 1997) thus promoting a higher nutrient uptake of crop plants.

## Conclusion

Effective microorganisms (Ems) increased yield and nutrient content of peas. Yield increases after EM application have been found in most investigations with agricultural crops. A higher nutrient content can be explained by solubilisation of soil minerals which is of special interest with respect to nitrogen.

## Acknowledgements

This investigation was part of the project EUROLEGUME. It received funding from the EU 7th FP for Research, Technological Development and Demonstration under grant agreement no. 613781.

## Literature

Olle M (2013) Efektiivsete mikroorganismide mõju köögiviljade saagile, kvaliteedile ja säilivusele. Aiandusfoorum 10 - 13

Olle M, Williams IH (2013) Effective microorganisms and their influence on vegetable production – a review. - Journal of Horticultural Science & Biotechnology 88(4): 380 - 386

Subadiyasa NN (1997) Effective microorganisms (EM) technology: its potential and prospect in Indonesia. – Majalah Ilmiah Fakultas Pertanian Universitas Udayana 16: 45–51

# Nutrient demand and nutrient cycling with fast growing trees and options for integration in organic farms

**Hans Marten Paulsen**

Thünen-Institute of Organic Farming, Trenthorst 32,23847 Westerau, Germany, mail: hans.paulsen@thuenen.de

Fast growing trees have a potential for regional bioenergy production, for an increase in landscape biodiversity, wind protection and carbon sequestration in soil. They might be used as shelter for poultry and also transfer of soil nutrients via biomass ashes is possible. Additionally they can be used for phytoremediation of soils contaminated with trace elements and for waste water application. Organic farming aims at developing regional production and use of food and fibre and looks for local nutrient recycling and natural keeping conditions for livestock. To adress these goals short rotation coppices with fast growing trees in areal and strip form are an interesting option. Nutient uptake of short rotation coppices can be high, but 60-80% of nutrients and carbon remain on sites via litterfall. Options for optimal integration of fast growing trees in organic farms, their nutrient demand and uptake are reviewed from literature and suitable growing regimes in organic farming are discussed.

# Zinc priming changes germination, early growth and cytogenetic stability of *Triticum aestivum* L. under water stress conditions

**Ivo Pavia[1*], Tiago Ferreira[2], Miguel Baltazar[2], Luís Rocha[1], José Moutinho Pereira[1], José Lima-Brito[2,3], Carlos Correia[1]**

[1]CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences, Universidade de Trás-os-Montes e Alto Douro, Apt. 1013, 5001-801 Vila Real, Portugal, mail*: ivo.mmp@gmail.com
[2]Universidade de Trás-os-Montes e Alto Douro, Apt. 1013, 5001-801 Vila Real, Portugal
[3]BioISI – Biosystems & Integrative Sciences Institute, Faculdade de Ciências, Universidade de Lisboa, C8 BDG Campo Grande, Lisboa, Portugal

Zinc (Zn) partakes in critical physiological roles during early seedling development and is essential for protection and structural maintenance of cell membranes stability as well as protection of the plant from soil-borne pathogens. Seed priming with zinc has been described as a cost effective and reliable method for crops agronomic biofortification. Since, in some regions the future of water requirements is predicted to exceed water availability it is of importance to identify methods of agronomic biofortification able to enhance germination and growth under lower water potential. The effects of water stress on seed germination, early growth and cytogenetic stability of winter wheat (*Triticum aestivum* L.) cv. Jordão primed with Zn was evaluated using osmotic solutions of polyethylene glycol 6000 of 0 and -1 MPa. Seeds were hydro-primed, as control, and primed with solutions with 0.2, 0.4 and 0.8% of Zn during eight hours. Twenty seeds per treatment (×3 repetitions) were placed in Petri dishes with moistened filter papers and germinated in the dark at 25ºC. Germination was recorded daily for a period of eight days. Root and shoot growth, as well as fresh and dry weight, were measured in five seedlings per Petri dish five days after germination and, similarly, at the end of the experiment. Root-tips of a separate set of seeds, subjected to the same treatments and germination conditions, were collected to perform chromosome spreads. Mitotic index and chromosome instabilities were annotated. Seedlings grown at -1 MPa constantly showed a higher mean time of germination, lower values for root and shoot size as well as fresh

weight than those at 0 MPa. Zn-priming increased the mean time of germination at both water potentials, but it did not affect the total percentage of germinated seeds. Measurements performed five days after germination showed a not significant decrease in fresh weight and water content at both water potentials. Root and shoot sizes of Zn-primed seeds were significantly smaller than control at both water potentials. At the end of the experiment, seeds primed with 0.4 and 0.8 % Zn solutions showed higher dry weight and lower fresh weight at 0 MPa. At -1 MPa there were no significant differences in dry and fresh weight between seeds primed with Zn and the control. At both water potentials, seed subjected to the highest Zn concentration solution showed significantly lower values of water content as well as root and shoot size when compared with the other treatments. Mitotic index progressively decreased with higher concentrations of Zn, whereas cytogenetic instabilities tended to increase. These include micro-nucleus, anaphase bridges, sickness, vagrants and multi-polarity anaphases, among others. Although the Zn concentrations used here are in line with other researches in cereals, where the priming proved beneficial, we found that all of the tested concentrations are detrimental for seedling development. Furthermore, Zn priming treatment was sufficient to cause cytogenetic anomalies and early growth impairment.

## Acknowledgements

The authors acknowledge the financial support provided by the FCT-Portuguese Foundation for Science and Technology (Ivo Pavia - PD/BD/113611/2015 and Luis Rocha - PD/BD/113612/2015), under the Doctoral Program “Agricultural Production Chains – from fork to farm” (PD/00122/2012).

# The dynamics of compost mineralization in a sandy soil

**Tünde Erzsébet Remenyik, Imre Vágó***

University of Debrecen, Institute of Agricultural Chemistry and Soil Science, H-4032 Debrecen, Böszörményi Street 138, Hungary, mail*: vago@agr.unideb.hu

The protection, maintenance and preservation of fertility of sandy soils deserve special attention in Hungary as the 20 % of the utilized agricultural area is sandy soil (KÁDÁR et al., 2012). There is a great need for improvement of the water and nutrient management of the humic sandy soils between the both rivers Danube and Tisza (KÖHLER, 1984).

In order to optimize the nutrient management of this kind of soils, it can be used composted agricultural residues and by-products to replace the solids and plant origin nutrients.

Utilization of composts has a significant amount of positive effects on soils: In terms of chemical and biological effects, it enhances the biological activity of the soils; the migration of nutrients is slow, there is little possibility of nutrient leaching; because of its great adsorption ability it grows the nutrient holding capacity of the soils; $CO_2$ generated by the mineralization of the organic materials assimilates by the plants; because of the ferments that are produced by the acids and microorganisms from the humus decomposition, the plants can take up the poorly soluble mineral nutrients as well; hormonal substances in the compost stimulate the plant growing; the resistance of plants against pathogens and pests rises.

In terms of physical effects, stable soil is formed, which can reduce the danger of deflation and erosion; the management of water and air of the soils improves (HARTMAN et al., 2001).

Last but not least, the compost is an excellent alternative plant nutrient which can (partly) replace the mineral fertilizers – this is a significant contribution to the sustainable plant production.

The main goal of our examinations was, to observe the pH shifting effect with the usage of different compost dosages on humic sandy soils, to define the exploration rate of some nutrients (N-forms, P, K, Mg and Mn), to propose the appropriate dosage of compost, with

these we can clarify and widen our knowledge on nutrient-management. All these are highly important because instead of using different fertilizers, we can apply organic materials to replace nutrients and we can also facilitate the solution of waste disposal problems.

The experiments were performed in the greenhouse and laboratories of the Institute of Agricultural Chemistry and Soil Science at the University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management.

For the experiments was a neutral [pH($CaCl_2$) = 7.21] sandy soil from northern part of the area between the Danube and the Tisza, nearby the village Őrbottyán, used. The calcium carbonate content of the soil in the upper layer (0-20 cm) is 7.8-8.0 %, and in the lower one (20-40 cm) is 9.3 %. The soil used for the experiment originated from the cultivated layer (0-30 cm).

The row materials of the compost used in the experiment are sewage sludge, additives (sawdust, wood chips, straw, street-side green waste) and a multi-component complex vaccine as an inoculant.

The date of mixing was 1st of April 2014. The carbonate containing sandy soil and the compost were measured by their volume in five different ratio in four replications. The pots were located randomly. To replace the water loss caused by evaporation, we made it for 60% of total water capacity, daily, with weight supplement method. We took soil samples 6 times for measurements. The experiment ended on 6th of June 2014.

From the original sandy soil, from the compost and from the different ratio mixture of them, in order to determine the element content, from the samples after extraction with 0.01 M $dm^{-3}$ $CaC1_2$ the pH value and the amount of different N-forms as well as P-, K-, Mg- and Mn-contents were measured.

The results of our measurements were statistically evaluated in two different ways. First we used a two-factor analysis of variance with the help of a Microsoft Excel 2007 program written in Macro by László Tolner. The basis of the program was the algorithm written by SVÁB (1981). The other method was the application of the measurement model repeated with the R-program. With this second model we tested the differences in time in the case of the certain treatments, so we can assess that the samples that contains the same amount of compost, in terms of pH and element content changing in time are the same or not.

After running the variance analysis, from the results of the certain samples taken at different sampling times we classified groups. With the Duncan test we could determine

the significant differences between the groups and the levels of the different treatment combinations.

Our experimental results confirmed by the analysis of variance prove that the nutrient management should be done consciously, in moderation, knowing the release time of the certain nutrients and bear in mind this at utilization is subservient to do.

## References

Hartman M, Alexa L, Dér S, Schád P (2001) Hulladékok a mezőgazdaságban, az erdészetben, a gyümölcsösben és a szőlészetben. Budapest. Mezőgazdasági Szaktudás Kiadó. (Wastes in agriculture, forestry, orchard and vineyard. (in Hungarian)

Kádár I (2012) Növénytáplálás, trágyázás, elemforgalom. Agrokémia és Talajtan. Budapest. 61. Supplementum, 147-162. (Plant nutrition, fertilization, cycle of elements. (in Hungarian)

Kovács A, Tóth M, Somogyi F, Tolner L, Czinkota I, Béres A, Wilk T, Aleksza L (2015) The effect of biodiesel by-products on germination and plant growth. Applied Ecology and Environmental Research 13. 4. 1171-1181.

Köhler M (1984) A homoktalajok termőképességének növelése dúsított agyagos komposzt-trágyák felhasználásával. Agrokémia és Talajtan. Budapest. 33. 1-2, 214-216. (Increasing the productivity of sandy soils by using of compost fertilizers enriched with loam. (in Hungarian)

Sváb J (1981) Biometriai módszerek a kutatásban. Mezőgazdasági Kiadó, Budapest. (Biometric methods in research. (in Hungarian)

# Determination of essential minerals in quinoa seeds cultivated under drought and salinity conditions

**Wafa Rjeibi[1,2], Georg Hörmann[3], Mohamed Hachicha[2]**

[1] Department of Biology, Faculty of Sciences, University of Tunis, El Manar, Tunisia
[2]National Institute of Research of Rural Engineering, Waters and Forests of Tunis, 17 Hédi Karray rute, Box n_10, 2080 Ariana, Tunisia
[3]Department of Hydrology and Water Resources Management, Institute of Natural Resource Conservation, Kiel University, Germany

Crop and food safety of many countries in arid and semi arid areas is threatened by climate change. A reduced productivity and decreasing crop quality are the most severe problems caused by increased drought and salinity. Therefore, it is important to find new crops which grow under severe climate conditions and which have a nutritional value equal or higher than cereals (Wheat, Barley, Corn, etc).

*Chenopdium quinoa* Willd, a pseudo-cereal and pseudo-grain originates from Andean region. It has intolerance to abiotic stresses and it can grow in saline soil as a halophyte plant and with limited water quantity and quality. Quinoa seeds also have excellent nutritive properties, are used to fight malnutrition and hunger and to maintain food security. All these positive properties make it a good candidate as an additional cash crop for Tunisian agriculture.

In this paper, we studied the effect of two different irrigation management strategies on the nutritional value of quinoa seeds. The first group grew under different deficit conditions with 100%, 70% and 50% irrigation. The irrigation water of the second group contained different amounts of salt (Fresh water: 0.9 g $l^{-1}$, 6 g $l^{-1}$ and 12 g $l^{-1}$). The variables analyzed were seed production and mineral content. We found out that a decrease of irrigation to 50% of the full amount induced an increase in seed yield from 10.94 g to 13.62 g per plant and from 2.25g to 2.51g 1000 seeds weight compared to the control (100% of full irrigation). The reduced irrigation did not negatively affect the accumulation of minerals; there was even an increase of some elements such as potassium and phosphorus. Furthermore, the irrigation with 6 g $l^{-1}$ of salt content increased seeds yield weight from

8.43 g per plant to 20.57 g per plant, the 1000 seeds weight from 1.85g to 2.34 g compared to the control without NaCl. The mineral composition of the plant irrigated with salty water showed an increase in sodium content in seeds but also an important variation of the majority of macroelements (P, $K^+$, $Ca^{2+}$, $Mg^{2+}$).

# Effects on germination and early growth of *Triticum aestivum* L. cv. "Jordão" under different concentrations of selenium

**Luís Rocha[1*], Ermelinda Silva[1], Helena Ferreira[1], Ivo Pavia[1], Miguel Baltazar[1], Tiago Ferreira[1], Carlos Correia[2], José Lima-Brito[1,3], José Moutinho-Pereira[2]**

[1]CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes and Alto Douro, Apt. 1013, 5001-801 Vila Real, Portugal
[2]University of Trás-os-Montes and Alto Douro, Apt. 1013, 5001-801 Vila Real, Portugal
[3]BioISI – Biosystems & Integrative Sciences Institute, Faculdade de Ciências, University of Lisboa, C8 BDG Campo Grande, Lisboa, Portugal, mail*: luisrocha24@gmail.com

Currently, it is estimated that the deficit of micronutrients in food affects several hundred million people worldwide. Selenium (Se) is a micronutrient that is usually ingested in lower amounts than the daily dose prescribed by the Food and Agriculture Organization. The consumption of dietary supplements allows you to adjust the proper amount of Se and other essential and beneficial micronutrients for our well-being. Insufficient intake of Se has been linked to various health problems such as reduced fertility and immune system, problems associated with oxidative stress and increased risk of cancer. Wheat is one of the most important cereal crops for human food. So, the wheat seed fortification with Se can be one of the main actions to overcome this specific need. However, this approach promotes greater availability of inorganic form of Se in organic form, not adding high nutritional value of the food. On the other hand, the selenium supplementation during germination can be an alternative for the production of Se-proteins, which, besides being able to promote an increase in the production of grain and biomass can further mitigate the effect of several abiotic stresses and to increase the grain nutrition value. This work intended to evaluate the effect of wheat seed priming with Se during the early stages of development in bread wheat plants cv. "Jordão". The seeds were placed in various solutions with different concentrations of sodium selenate (0, 75, 150, 750 and 7500 µM) for 15 h and washed in distilled water and germinated in Petri dishes (with moist filter

paper) at 25 °C in the dark for 48 h. Then the percentage of germination (number of seed germinated, number of roots and root length) were evaluated and the seedlings were placed in vials for hydroponic experiments with different concentrations of sodium selenate (0, 6, 12 and 50 µM) in the Hoagland solution. The "Jordão" plants are kept for 4 weeks in a growth chamber, and the hydroponic solution was replaced weekly. At the end of experiment, leaf gas exchange and chlorophyll fluorescence were determined and the plants were harvested for growth analysis, relative water content (RWC) and electrolyte leakage measurements. All data were processed using the software IBM SPSS statistics (ANOVA and Tukey HSD test). In general, all treatments had a germination rate higher than 97% when evaluating the different concentrations, showing that wheat seeds can adapt and germinate in high concentrations of Se. Among the various parameters analyzed, leaf fresh and dry weights, and leaf number, tiller number and leaf area showed significant differences ($P < 0.05$) for all treatments. The measurements of gas exchange and chlorophyll fluorescence showed significant differences ($P < 0.05$) for all parameters. In contrast, the analysis of RWC and electrolyte leakage showed no significant differences ($P > 0.05$) among the Se treatments. The stability of the membranes was not affected by higher Se concentrations, which reveals that the concentrations applied for a few hours did not cause stress to the balance intake of solutes. Overall, our results showed that “Jordão” wheat seems to tolerate high concentrations of Se priming and this approach is important to plant development, contributing to fortification of the plant and yield increase.

## Acknowledgements

The authors acknowledge the financial support provided by the FCT-Portuguese Foundation for Science and Technology (Ivo Pavia - PD/BD/113611/2015 and Luís Rocha - PD/BD/113612/2015), under the Doctoral Programme “Agricultural Production Chains – from fork to farm” (PD/00122/2012).

## Influences of climate change on agri-forestry systems

**João A Santos, Helder Fraga, Ricardo Costa, Chenyao Yang**

Centre for the Research and Technology of Agro-environmental and Biological Sciences, CITAB, Universidade de Trás-os-Montes e Alto Douro, UTAD, Vila Real, Portugal

The physiological development of most plants is largely controlled by atmospheric parameters, such as air temperature, precipitation, moisture, radiation and wind, among others. Furthermore, many environmental conditions (e.g. soil moisture) are considerably influenced by atmospheric parameters, thus underling indirect plant-atmosphere relationships. These relationships are far from being linear, as the plant response to a given atmospheric perturbation is a function of optimal growing conditions and limiting thresholds, which are also variety-dependent. Overall, agri-forestry systems tend to be highly sensitive to both climate (long-term changes in atmospheric parameters) and weather (short-term changes in atmospheric parameters), including their extremes. The most sensitive systems may also be more vulnerable to climate change, whereas the less sensitive may be more resilient. For each location, plants are gradually selected either by natural processes or by human-decisions, often based on the suitability of local conditions to their growth, also envisioning economic revenue and sustainability. Bioclimatic indices are commonly-used tools to assess plant-relevant climatic features, as they take into account specific climatic measures that have been related to plant physiological development, phenology, yields and quality attributes. The spatial patterns of these indices can thereby be relevant variables in explaining the current distribution of different plant species. Under future climates, these patterns are projected to undergo shifts. These shifts may help assessing the impacts of climate change on agri-forestry systems, promoting the development of guidelines and measures to adapt and mitigate detrimental impacts, e.g. by alleviating biotic and abiotic stress or through the selection of more suitable crops/varieties for future conditions.

For the specific case of Portugal, a ‘hot spot’ of climate change in Europe, significant warming and drying trends are projected under different greenhouse gas emission scenarios. As an illustration, some examples of bioclimatic assessments under present and future conditions in Portugal will be presented, giving particular emphasis to

economically-relevant crops, such as grapevines, fruit trees (e.g. olives, almonds, citrus fruits, pears, apples and cherries) and forest species (e.g. cork oak, eucalyptus and pine trees). State-of-the-art observational datasets (E-OBS and WorldClim) and regional climate model ensembles (CMIP5 Euro-CORDEX), with experiments for both past and future periods, are used for this purpose. Model runs for future periods are forced by two Intergovernmental Panel on Climate Change (IPCC) representative concentration pathways – RCP4.5 and RCP8.5, which provide greenhouse gas emission scenarios until the end of the 21st century.

Bioclimatic indices at very high spatial resolution (~1 km grid spacing), using a combination of dynamical and statistical downscaling strategies (spatial interpolation techniques and pattern downscaling), will be presented. An overview of the likely climatic shifts will be provided and some potential impacts for different agri-forestry systems will be discussed. In fact, these shifts may trigger biotic and abiotic stresses that need to be timely and adequately tackled. Amongst the different abiotic stresses driven by climate change in Portugal, water stress is expected to become the most prominent, urging e.g. for improvements in water use efficiency, irrigation re-scheduling, use of cover crops, changes in soil management, adaptation of agricultural practices and selection of more drought-resistant varieties. Furthermore, there is a rather complex interplay between plant growth, water stress, nutrient stress and fertilization. As such, in order to assess potential climate change impacts on specific plants and to test different adaptation measures, process-based (dynamic) crop models (INRA-STICS and FAO-AquaCrop), already calibrated and validated for some Portuguese crop-variety pairs, are used. These models are indeed important decision support systems for agri-forestry sectors. Preliminary modelling results regarding climate-induced abiotic stresses on some crops in Portugal will be presented. However, further and sustained research, including model and field experiments, is critical for a better understanding of the climate-plant relationships and of the mechanisms underlying climate change, as there are still considerable uncertainties in the climate change impacts. Lowering uncertainties is essential for decision-making.

## The progress of research on Chinese stabilized fertilizer

**Yuanliang Shi*, Jie Li, Lingli Wang, Xiaoyu Shi, Xudong Zhang**

Chinese Academy of Science, Shenyang Institute of Applied Ecology, CAS, 72 Wehnua Road, 110016 Shenyang, P.R. China, mail*:Shiyl@iae.ac.cn

Fertilizers are largely consumed resources in agricultural production contemporarily and China has become a leading country in fertilizer production and consumption on the global market. High fertilizer doses together with a low nutrient utilization rate and a high loss of nutrients already resulted in a series of negative environmental impacts such as eutrophication in surface and underground water bodies in China. In addition, the $NO_3^-$ content in vegetables exceeds the safety limit on a regular base; greenhouse gas emissions such as $N_2O$, NO increase. For the purpose of avoiding and mitigating these environmental issues, China raised investments and efforts on research so that after years of continuous investigations and technical improvements, stabilized fertilizer products have been developed which are a leading force among new fertilizer types.

# Boron nutrition affects membrane leakage and the chemical composition of leaves and fruits of *Olea europaea*

**Ermelinda Silva[1*], Cátia Brito[1], Lia Dinis[1], Luís Rocha[1], Isabel Q. Ferreira[2], Helena Ferreira[1], Luís M. M. Ferreira[3], José Moutinho-Pereira[1], Manuel Ângelo Rodrigues[2], Carlos Correia[1]**

[1] CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal, mail*: emsilva@utad.pt

[2] Mountain Research Centre (CIMO)–ESA, Instituto Politécnico de Bragança, Bragança, Portugal

[3]CECAV – Animal and Veterinary research Centre, University of Trás-os-Montes and Alto Douro, Vila Real, Portugal

Boron (B) is an essential microelement for plants, being its deficiency the most frequent micronutrient disorder in olive tree. The main functions of boron are related to cell wall strength and development, membrane function, cell division, fruit and seed development, water relations, sugar transport and hormone development. The study conducted in Bragança (Northeast Portugal), under rainfed conditions, shows that application of B-fertilizer decreased the symptoms of oxidative stress on leaves, both in summer and, with higher extent, in winter. In fact, B-treated trees presented lower electrolyte leakage, in a closely association with higher concentration of total thiols. Moreover, boron increased the concentration of soluble sugars, while decreased the accumulation of starch in both seasons. Meanwhile, total soluble proteins and total phenols levels were higher in B-fertilized plants during the summer period, whereas in winter, after frost events, the concentration of phenols was higher in B-starved trees. The chemical composition of fruits at final harvest revealed that B-supply increases the soluble sugars and the pulp ash content, decreases organic matter and dietary fiber, whilst the crude protein concentration was similar between treatments. Thus, the present study showed that addition of B-fertilizer affects the metabolism of olive tree and give new insights about the effect of

boron on plant physiology and biochemistry that will help to refine the improvement in B-fertilizer recommendations for olive growing areas.

# Use of seaweed extracts from *Sargassum muticum* and *Ascophyllum nodosum* (Phaeophyceae) as a possible fertilizer

**Luís Daniel Silva[1], Kiril Bahcevandziev[2],Leonel Pereira[1]**

[1]MARE - Centro de Ciências do Mar e do Ambiente, Departamento de Ciências da Vida, Faculdade de Ciências e Tecnologia da Universidade de Coimbra

[2]CERNAS, IIA, Instituto Politécnico de Coimbra, Escola Superior Agrária, Bencanta, 3045-601 Coimbra

Nowadays, with awareness of the needs to preserve the environmental resources and reduce the use of synthetic chemicals to improve the quality and productivity of agricultural crops, especially those used as a food, various studies have been developed, including the use of extracts from seaweeds that demonstrate possible potential as biofertilizer.
Several studies indicate that seaweeds are a rich source of many compounds such as macro- and micronutrients, amino acids, vitamins, and plant growth regulators, beneficial for plant development, conferring to seaweeds a great potential as a biofertilizer.
This study aimed to evaluate the potential of liquid extracts from two macroalgae, *Sargassum muticum* and *Ascophyllum nodosum* (infest seaweed to the Portuguese coast), as biofertilizers. Different varieties of *Oryza sativa* and *Lactuca sativa* were studied with extracts of seaweeds at different concentrations (0, 25, 75 and 100 %) applied for seed germination and plant development, in pots, and in hydroponics in the case of lettuce. It was found that extracts with lowest concentration (25%) favored the seed germination, increased soil mineral content, improved plant nutrient absorption and amended soil pH. Different extract concentrations also favored the plant development. The extracts obtained from a seaweed *Sargassum muticum* performed better results as biofertilizers.

# Molybdate toxicity and sulfur and nitrogen metabolism in Chinese cabbage

**C. Elisabeth E. Stuiver[1], Erica I. Zuidersma[1], Tahereh Aghajanzadeh[1], Dharmendra H. Prajapati[1], Saroj Parmar[2], Malcolm J. Hawkesford[2] and Luit J. De Kok[1*]**

[1]Laboratory of Plant Physiology, Groningen Institute for Evolutionary Life Sciences, University of Groningen, Groningen, The Netherlands, mail*: l.j.de.kok@rug.nl

[2]Plant Biology and Crop Science Department, Rothamsted Research, Harpenden, U.K.

Molybdenum (Mo) is an essential micronutrient for plant growth, which requirement is the lowest of all mineral nutrients. Mo is taken up by the root as molybdate and incorporated into molybdopterin-cofactor (Moco). This cofactor is essential for the activity of nitrate reductase, sulfite oxidase, aldehyde oxidase and xanthine dehydrogenase. High concentrations of molybdate in the root environment may negatively affect plant growth, though the physiological basis for its phytotoxicity is largely unsolved. Mo is sometimes described as a 'heavy metal', though it appears to be much less phytotoxic than other potential toxic metals *viz*. copper and zinc. If Chinese cabbage (*Brassica pekinensis*) seedlings were exposed 50, 100, 150 and 200 µM sodium molybdate, leaf chlorosis and a decreased plant biomass production occurred at ≥100 µM. Root growth was relatively more affected by molybdate than shoot growth. Exposure resulted strongly enhanced Mo contents of the plant, but it only substantially affected the overall mineral nutrient composition of root and shoot at 200 µM. It is presumed that high concentrations of molybdate as chemical analogue might negatively interfere with the uptake and reduction of sulfate in plants. However, molybdate exposure of Chinese cabbage resulted in an increase in sulfate uptake at ≥100 µM and to a lesser extent also that nitrate, though only when expressed on a root fresh weight basis and not on a plant fresh weight basis. Similarly, there was an increase sulfate uptake capacity (activity of the sulfate transporters) but again only expressed a root fresh weight basis. However, the expression of the sulfate transporter Sulftr1;2, which is the primary transporter for the uptake of sulfate by the root, was decreased at ≥100 µM. Molybdate exposure did not affect the nitrate reductase activity, whereas total nitrogen and nitrate content were decreased in both roots and shoot but only at 200 µM. The total sulfur, sulfate and water-soluble non-protein thiol

(GSH) content and the expression of APS reductase, the key regulating enzyme of the sulfate reduction pathway, in both root and shoot were hardly affected upon molybdate exposure. There was only a slight increase in the sulfate content at 200 µM. In conclusion, Mo toxicity in Chinese cabbage was unlikely directly due to the direct interference of molybdate with sulfate uptake and its assimilation.

## Profitable applications for Precision viticulture

**Javier Tardáguila**

Televitis, University of La Rioja, Logroño, Spain, mail: javier.tardaguila@unirioja.es

Sustainable viticulture requires an objective and continuous monitoring of the vineyard, and that is possible only by applying new technologies. Recent advances in information technology, communications and electronics have enabled the development of new sensors to monitor the vineyard. The possibilities of these new technologies to monitor the vineyard and quantify parameters such as yield, leaf development, disease incidence and / or detection of different stress factors (water, nutrition, etc.) are enormous.

Importantly, the non-destructive nature of many of these technologies implies the absence of damage or modification of plant material analyzed. Among the main non-destructive ground sensors advanced detection used for monitoring the crop and / or composition of the fruit are as follows: RGB and thermal sensors, multi and hyperspectral cameras, based on chlorophyll fluorescence sensors and spectroscopy. All this information can be obtained so geo-referenced, which could be used to determine the spatial variability of the vineyard, in the context of precision viticulture.

In this paper some examples of important viticultural estimation parameters are presented by different non-destructive technologies in precision viticulture.

# Influence of foliar application of magnesium, calcium and boron on some yield parameters of apple

**Imre Vágó*, Zoltán Katona, János Kátai**

University of Debrecen, Institute of Agricultural Chemistry and Soil Science, H-4032 Debrecen, Böszörményi Street 138, Hungary, mail*: vago@agr.unideb.hu

The largest quantity of fruits which are grown in temperate zones of the Earth is apple (*Malus domestica*). Around 20 % of the world's full areas of apple orchards, one million hectare, are in Europe, the yearly yield of the continent is hovering around 16 million tons.

Hungary's climate is excellent for growing apples, despite that the area of apple orchards is only 48,000 ha, which the annual apple harvest is between 0.6 million and 0.8 million tons. The 71 % of apple growing area is concentrated in the north-eastern region of Hungary, where the apple orchards are mostly on the low to moderate humus content, acidic sandy soils with magnesium and boron deficiency and low buffer capacity is installed. Therefore, the proper nutrient supply of plants is of utmost importance.

**Magnesium** has an important role primarily as a constituent of chlorophyll, when it is deficient, photosynthetic activity is reduced. In addition, it has a significant effect on phosphorilation and carbon-dioxide assimilation as an enzyme activator, too. **Calcium** has a significant influence on the characteristics of plasma colloids and their osmotic potential. It promotes longitudinal growth and cell division in meristematic tissues, has a specific effect on cell elongation and differentiation. **Boron** is one of the most important micronutrients for plants. Its peculiarity is that (differently from most of the microelements, but similarly to molybdenum) it can be found in the soil and in the plant as an anion. Among the microelements, boron has the greatest effect on the yield quality and quantity of plants. If it is not available in the necessary amount, then problems can be detected in flower formation and fertility, furthermore, carbohydrate and lipid formation and the cell wall stability is inhibited, too.

Apple, similarly to other dicots, requires **boron** for normal development and fruit formation. It is especially valid for crops produced sugar and starch content. In winter apple, calcium

and magnesium supply is also important in addition to that of boron, since the deficiency or improper ratio of these elements can reduce yield and storability.

When selecting the **method** of fertilization, it should be considered that large applied amounts of lime might have a negative effect on yields. A further problem is that trees can uptake the mezo- and micronutrients applied to the soil only partially and after a relatively longer way. An alternative is the application of water-soluble nutrients as a leaf fertilizer. The advantage of this method is, in addition to the practically immediate availability of nutrients, that the losses in the soil due to binding and leaching can be avoided.

The experiment was carried out in a six-year old apple orchard with cv. 'Golden Spur' on humus sandy – sandy loam soil in Nagykálló in north eastern Hungary. The visible color of the soil was heterogenous, therefore, the size of the plots was selected to be 250 $m^2$ with 14 trees per plot. For enabling statistical evaluation, all treatments were performed in 4 replications. There was a row for isolation between the treated rows, so that the high-pressure spray application could not reach the trees of a different treatment. Treatments were applied three times with 400 $dm^3$ $ha^{-1}$ spray volume. The total amount of sprayed nutrients per ha was 2.4 kg boron, 3.6 kg calcium and 12 kg magnesium.

In addition to the control, six treatments and treatment combinations were applied. The mono-elemental treatments were Solubor (sodium octaborate), calcium nitrate and Epsom salt (magnesium sulfate), the combined treatments were Solubor + calcium nitrate, Solubor + Epsom salt, and calcium nitrate + Epsom salt.

At harvest, the total yield and the diameter of apple fruits were measured. The statistical evaluation was calculated by analysis of variance with the help of a Microsoft Excel 2010 program written in macro by László Tolner. The basis of the program was the algorithm written by SVÁB (1981).

The average apple yield was 33.3 t $ha^{-1}$. The highest yield was achieved by the combined application of boron and calcium. The obtained yield was 7.3 t $ha^{-1}$ higher than that of the control (significance level was P = 0.1 %). This can be explained by the synergistic effect of boron and calcium as also observed earlier by other plants too.

The overall average diameter of the apples was 77.1 mm. The biggest diameter, 83.8 mm in average, was measured by the sodium octaborate treatment. Most of the treatments reduced fruit size as compared to the control, but the probability level was lower than 90 %

(not significant). The determination of the reason of the observed phenomenon needs further investigation.

The penetration resistance on different places of fruits influenced by the mentioned plant nutrition combinations and the storage at 1-4 °C, was also determined.

Summing up, it can be stated about foliar boron, calcium and magnesium fertilization under field conditions, that the combined application of sodium-octaborate (Solubor) and calcium-nitrate increased the apple yield by the highest amount on an acidic humous sandy soil with low boron and magnesium content. Our results reconfirm, that the best yields are obtained under harmonic plant nutrient supply.

# Emissions of ammonia and greenhouse gases during the vermicomposting of duck manure

**Jinzhi Wang, Binghui Zheng, Xia Jiang, Hui Yu, Kun Wan**

State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environment Sciences, Beijing 100012, China

The reed wetland of Baiyangdian catchment in China is an important duck farm base with about 8 million ducks, which produces more than 213,300 tons manure each year. Most of the duck manure ends up in the water system, causing eutrophication of surface water. Combined traditional composting and vermicomposting has shown potential for reclamation of solid wastes. However, disposal of poultry manure inevitably involves emissions of ammonia ($NH_3$) and greenhouse gases (GHGs), including nitrous oxide ($N_2O$), methane ($CH_4$), and carbon dioxide ($CO_2$), which contribute to global warming. Deposition of emitted $NH_3$ and $N_2O$ in aquatic and terrestrial systems can cause eutrophication and acidification. Emissions of $NH_3$ and GHG also decrease the quality of end-products as fertilizers. Therefore, there is a need to develop the practical technologies to mitigate $NH_3$ and GHGs emissions. In this study, we firstly investigated the influence of different amendments on emissions of $NH_3$ and GHG during the storage of duck manure from a duck farm in Baiyangdian, Hebei province to select the optimal amendments for the reclamation of duck manure. Subsequently we compared emissions of $NH_3$ and GHGs in two systems for the disposal of duck manure in order to develop a sustainable technique.
We firstly tested the single and combined effects of addition of reed straw, zeolite, and superphosphate on the emission of $NH_3$ and GHG emissions from stored duck manure. The results showed that reed straw and/or zeolite can be recommended as amendments to reduce GHGs emissions during the storage of duck manure; however, superphosphate is more effective in reducing $NH_3$ emissions.
Subsequently, we tested the effects of addition of reed straw and combined addition of reed straw and zeolite on $NH_3$ and GHG emissions during pre-composting of duck manure, either with or without a follow-up phase of vermicomposting. Results showed that

cumulative $N_2O$, $CH_4$, and $CO_2$ emissions during pre-composting and vermicomposting ranged from 92.8, 5.8, and 260.6 mg $kg^{-1}$ DM to 274.2, 30.4, and 314.0 mg $kg^{-1}$ DM, respectively. Earthworms and amendments significantly decreased $N_2O$ and $CH_4$ emissions. Emission of $CO_2$ was not affected by earthworms, but increased in responses to addition of reed straw. Cumulative $NH_3$ emission ranged from 3.0 to 8.1 g $kg^{-1}$DM, and was significantly decreased by reed straw and zeolite addition. In conclusion, combined precomposting and vermicomposting with reed straw and zeolite addition would be strongly recommended in mitigating emissions of $N_2O$, $CH_4$, and $NH_3$ from duck manure, and providing nutrient-rich products that can be used as a fertilizer.

# Effects of climate change, fertilization and grazing on grassland productivity in the Tibetan plateau

**Shiping Wang[1], Caiyun Luo[2], Jichuan Duan[2], Xiaoxue Zhu[2]**

[1]Key Laboratory of Alpine Ecology and Diversity, Institute of Tibetan Plateau Research of the Chinese Academy of Sciences, Beijing 100101, China
[2]Key Laboratory of Adaptation and Evolution of Plateau Biota, Northwest Institute of Plateau Biology, Chinese Academy of Sciences, Xining 810008, China

Uncertainty about the effects of warming and grazing on soil nitrogen (N) availability, species composition and aboveground net primary production (ANPP) limits our ability to predict how global carbon sequestration will vary under future warming with grazing in alpine regions. Through a controlled asymmetrical warming (1.2/1.7 °C during daytime/nighttime) with grazing experiment from 2006 to 2015 and nitrogen fertilization from 2010 to 2015 in an alpine meadow, we found that warming alone and moderate grazing did not significantly affect soil net N mineralization. Although plant species richness significantly decreased by 10% due to warming after 2008, we caution this may be due to the “transient occurrence or disappearance” of some rare plant species in all treatments. Warming significantly increased graminoid coverage, except in 2009, and legume coverage after 2008, but reduced non-legume forbs coverage in the community. Grazing significantly decreased coverage of graminoids and legumes before 2009 but increased forb coverage in 2010. Warming significantly increased ANPP regardless of grazing, whereas grazing reduced the response of ANPP to warming, but its effect decreased with increase of warming years. N addition significantly affected ANPP in both warming and grazing treatments after 2012. Grazing stimulated organic N uptake by plants, which counteracted the effect of warming. Our findings suggest that change of plant composition determines ANPP under simulated warming and that heavy grazing rather than warming causes degradation of the alpine meadows.

# Assessment of optimal N fertilizer use on Portuguese maize yield using the STICS crop model

**Chenyao Yang [1], Helder Fraga [1], Wim van Leperen[2], João A Santos[1]**

[1]Centre for the Research and Technology of Agro-environmental and Biological Sciences, CITAB, Universidade de Trás-os-Montes e Alto Douro, UTAD, Vila Real, Portugal

[2]Group Horticulture and Product Physiology, Wageningen University, Netherlands

The optimal mineral N fertilizer use (timing and rate) for corn (*Zea mais* L.) yield has been known to vary regarding different environmental conditions. Previous research has shown that a primary N requirement should be met before the V8 stage, while the first two N applications should occur around seedling and stem elongation. Nonetheless, due to the high spatial variability of irrigated maize crop growth, it becomes rather difficult to assess optimal N application, which simultaneously consider variability of soil N supply (storage and mineralization) and N uptake efficiency. As such, the present study tries to integrate and model all of these factors to evaluate maize yield response to a multitude of possible mineral N treatment combinations (timing and amount). For this purpose, STICS, a state-of-the-art process-based crop model, was used to reproduce temporal changes in the soil-crop mineral N pool at three different sites in Ribatejo, Portugal, over the period of 1986–2005. The first two applications were fixed at the Julian Day (JL) 120 (seedling stage) and at JL 140 (stem elongation), with a typical value of 40 kg/ha. The impact of last N application on yield, ranging from 0–120 kg/ha (10 kg/ha step) and from JL 140–180 (10-day interval), was assessed under the historical pedoclimatic conditions. Soil mineralization and N uptake efficiency were also simulated. Our results indicate that JL 150 was the best timing for the third application in all sites. Ribatejo soils presented 200–300 kg/ha of mineralized N and a mean crop uptake efficiency of 65% was found for all possible combinations. Meanwhile, we found that the best amount was of 80-100 kg/ha, depending on the region. In Portugal, the prevailing Mediterranean-like climatic conditions favour the mineralization process, by which a large proportion of crop N demand could be satisfied. Nevertheless, further local field experiments are required to validate and complement our study outcomes.

# Valorization of treated wastewater in high saline and waterlogging soil by agroforestry species

**Marwa Zouari[1,2], Dalila Souguir[1], Georg Hörmann[3], Belgacem Hanchi[2], Omar Jouzdan[4], Mohamed Hachicha[1]**

[1]Institut National de Recherches en Génie Rural, Eaux et Forêts, 17 rue HédiKarray, BP n°10 Ariana 2080, Université de Carthage, Tunisia

[2] Faculté de Sciences de Tunis, Université de Tunis El Manar, Campus Universitaire, 1060 Tunis, Tunisia

[3]Department of Hydrology and Water Resources Management, Kiel University, Olshausenstr. 75, D-24098 Kiel, Germany

[4]ACSAD, Arab League – Syria

The increasing scarcity of water and the rapid population growth in urban areas require the use of non-conventional water and appropriate management practices. Treated wastewater (TWW) is considered as an additional water resource especially in arid and semi-arid countries. In Tunisia, the use of TWW is part of a national strategy to mobilize and use the water resources. It contributes to the protection of the environment, the sustainability of agricultural production, is saves water and facilitates the expansion of irrigated areas. It also contributes to the reduction of saline water intrusion in coastal areas through groundwater recharge. In addition, the reuse of TWW for irrigation provides nutrients, reduces the total needs of chemical fertilizers and thus increases the income of the farmers. In Tunisia, 110 treatment plants (WWTP) produced 243 Mm³ of wastewater. However, only a small fraction (about 24%) is reused for the agricultural irrigation, the rest is released into natural environment (sea, sebkhas and rivers). It is therefore important to find other possibilities for the reuse of TWW in irrigation. One alternative is the irrigation of forest species. Thus, the main objective of this study is to test the suitability of TWW for agroforestry. The reuse of TWW started in 2012. We irrigated six forest trees species growing on a saline soil affected by a shallow saline water table and covered with halophytes. The parcel is located close to the WWTP of the village of Kalaât Landelous (30 km North of Tunis City, semi-arid region, 450 mm of rain/year, close to the Mediterranean Sea). Because the parcel is located on the area affected by a shallow and

saline water table, the soil was lifted about 1 m above the surface.The forest trees species tested are *Eucalyptus gomphocephala, Atriplex nummularia, Acacia cyanophyllia, Casuarina glauca, Pinus halepensi and Cupressus sempervirens.* The TWW used for irrigation is basic (pH =8.3) with a moderate salinity (EC = 4.1dS/m). The content of metallic traces elements (MTE) allows the reuse of TWW in agriculture according to the the Tunisian standard (NT 106.03). After 4 years of irrigation with TWW, we observed a decrease of soil salinity from 22.1dS/m to 16.2 dS/m in the surface layer (0-30 cm). The MTE of the soil was very low. The water table was characterized by a basic pH (7.5) and a high salinity exceeding90 dS/m. The water contains essentially sodium and chloride, and its MTE concentration did not exceed the Tunisian Standard for TWW (TN106.02). Besides the soil reclamation caused by under rain and irrigation with TWW, another positive effect is observed on plants which depends on the species *Atriplex nummularia* was as the most tolerant and *Pinus halepensis* the most sensitive species to hydro-pedological conditions. The parameters analysed were: morphological criteria (high and diameter) of the plants, mineral composition of the leafs and root distribution, concentrations of salt and heavy metalsin leaves and roots, mortality and morphological and anatomical changes. The preliminary results show significant differences between forest species.

„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 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.

Heft 184, 2016 23rd International Symposium of the International Scientifi c Centre of Fertilizers Plant nutrition and fertilizer issues for the cold climates. Son (Norway), September 8-10, 2015, 30 S.


JKI
Julius Kühn-Institut
Bundesforschungsinstitut für Kulturpflanzen