▶ *Keynote presentation*

K-1158 Plant responses to overcome adverse water - nutrient interactions

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Soil water content influences nutrient uptake of plants. As soils dry low soil water content becomes a limiting factor for nutrient delivery whereas excess water can leach nutrients away from the root. More complex soil chemical processes may alter nutrient availability in relation to soil water status. Micronutrient availability in particular is affected via changes in soil pH, redox state and soil organic matter while the availability of N and P may change as water status affects associations with soil microorganisms. Plants react to such changes by increasing root interception of limiting nutrients or by actively altering rhizosphere conditions to increase nutrient availability.

The severity of phosphorus (P) deficiency generally increases in drying soil. Studies with different rice genotypes identified QTLs for tolerance to P deficiency. Near isogenic lines (NILs) containing tolerance QTLs increased P uptake two to four fold relative to the intolerant parent with biggest benefits of QTLs seen in drying soil. This was caused by the ability of NILs to maintain higher relative root growth rates under P deficiency. Model simulations demonstrated that root growth was not necessarily the primary factor responsible for higher P uptake of NILs. Such differences could be achieved if small differences in P acquisition efficiency would provide enough additional P to maintain root growth; root growth thus being a subsequent effect.

Excess water on the other hand is known to induce zinc (Zn) deficiency in lowland rice. Complete crop losses can occur in intolerant genotypes if the additional stress factors high pH and high bicarbonate content aggravate the induced Zn deficiency. We identified tolerant genotypes with low seedling mortality and subsequent rapid recovery, even under severe Zn deficiency. Planting density experiments suggested a concentration-dependent rhizosphere process to be of importance since intolerant genotypes recovered fully if planted at high density. A possible tolerance mechanism is the exudation of carboxylates that was strongly induced by Zn deficiency in tolerant genotypes. However, these genotypes also showed better root growth, which again raised the question whether root growth was a causal or subsequent effect. Ongoing genetic experiments combining QTL with microarray data are discussed in an attempt to resolve these cause-effect relations.

▶ *Oral presentations*

O-450 Interaction of phytases in the rhizosphere and hydrolysis of inositol phosphates

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Adsorption of enzymes to soil solid constituents is reported to reduce their affinity for substrates and thus reduce their effective activity. Despite this, adsorption may be important for the long-term persistence of enzymes in soil by protecting them from degradation. Inhibition upon adsorption of enzymes has been shown to be soil specific. For example, after being adsorbed for 28 days, more than 40% of the activity of an added phytase (phosphomonoesterase with specificity to inositol phosphate) remained in a sandy soil while just 5% was left in a soil dominated by clay. Where extracellular phytase remains active upon adsorption, immobilisation to the solid phase will limit its ability to interact with inositol phosphates, particularly if these are also immobilised through adsorption and precipitation reactions.

Phytase collected from the roots of plants expressing a phytase gene (phyA) from *Aspergillus niger*, was completely adsorbed in a range of soils at pH 4.5. In contrast, adsorption declined with increasing pH such that all remaining activity was recovered in solution at pH 7.5. With this in mind, less adsorption of phytase was observed in a rhizosphere soil compared to an equivalent bulk soil. This was attributed to changed biochemical environment within the rhizosphere, specifically modified pH or competition for adsorption sites by organic anions and proteins. Partitioning of enzyme activity to the solution phase with increased pH is likely due to enthalpic forces causing electrostatic repulsion above the isoelectric point (pI) of the protein. When adsorption characteristics of two phytases with different pI were compared in acidic soils, significant differences were observed. Phytase with a more acidic pI (pH 3.6, from *Peniophora lycii*) remained in solution in a range of soils (pH 4.5 to 5.0), whereas phytase with a less acidic pI (pH 4.8, from *Aspergillus niger*) was adsorbed (George et al. 2007 Soil Biol. Biochem. 39:793-803). Importantly, the phytase with low pI was twice as effective in hydrolysing myo-inositol hexakisphosphate in acidic soil suspensions and released more inorganic P from endogenous soil organic P. Recently genes for the production of phytases with differing pI have been expressed in plants. This will allow better understanding of the factors that contribute to the biological availability of inositol phosphates in the rhizosphere and potentially improve the ability of plants to acquire P from this source.

O-555 Competition for amino acids in the rhizosphere using nano-scale secondary ion mass spectrometry

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Amino acids are an important source of N for plants and microorganisms and are a major factor regulating ecosystem productivity. ^{15}N- and ^{13}C-labelled amino acids are often used to determine the relative competition between plants and microorganisms for dissolved organic N. However, it remains challenging to distinguish between direct and indirect (amino acids first mineralized to NH_4^+) uptake by roots. Existing methods also lack adequate sensitivity for data collection at appropriate spatial scales. Nano-scale secondary ion mass spectrometry (NanoSIMS) is a novel imaging approach that links isotopic analysis at high sensitivity with high resolution microscopy; levels of spatial analytical resolution are better than 50nm. Our recent development of NanoSIMS for soil studies in the Centre for Microscopy, Characterisation and Analysis at UWA showed tracing of ^{15}N isotopes into individual bacterial cells. NanoSIMS gives an opportunity to quantify and study the location of uptake and immobilisation processes at a micro- to nano-scale within the rhizosphere.

In this study we have combined traditional isotopic pool dilution techniques with these ^{15}N/^{14}N imaging approaches to investigate the competition between roots and microorganisms for amino acids in the rhizosphere. Wheat (*Triticum aestivum* L.) was grown in specially designed 'rhizocosms' for 3 weeks (roots ca. 30 cm long) which ensured that the root hairs and roots fully occupied the soil volume. Highly enriched labelled solutions containing N as either NH_4 or amino acid were injected along the zone of root elongation. Rhizocosms were sampled sequentially over a 24 hour period. Subsamples allowed the determination of ^{15}N/^{14}N isotopic ratios for roots, soluble N pools and residual soil. Data indicate significant differences in rates of turnover and uptake of amino and NH_4 sources. In addition samples were rapidly fixed and resin embedded so that ^{15}N/^{14}N isotopic ratio image maps for cross-sections of the rhizocosms could be obtained. Data indicate differential enrichment of roots and microbes and show clear spatial patterns within the rhizocosm. We will discuss the ecological importance of the direct uptake of amino acids by roots.

O-895 Soil clay minerals-plants potassium transfer as seen by X-ray diffraction

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Potassium (K) availability influences many processes in cultivated and natural ecosystems. In particular, potassium deficiency could strongly limit yields in cultivated ecosystems. Several studies suggest that K+ ions fixed in 2:1 clay mineral interlayers contribute significantly to plant nutrition. Interlayer K+ ions are known to be often anhydrous in clays, collapsing clay layers to a 1 nm spacing. Interlayer K+ ion uptake by plants may therefore decrease the amount of 1 nm layers, whereas interlayer K+ ion fixation may increase 1 nm layer quantity. We investigated qualitatively and quantitatively these two opposite scenarios, using X-ray diffraction techniques, observing laboratory and field experiments.

We established that new methods of observing X-ray diffraction patterns allow a quantification of short-term 2:1 clay mineral changes through K addition in solution and removal of interlayer K in the rhizosphere of growing plants (*Lolium multiflorum*). A significant relationship ($p<0.0001$, $r^2=0.95$) between an indicator calculated from X-ray diffraction pattern characteristics (position of the centre of gravity of X-ray diffractogram in the 2:1 clay mineral range) and analyzed clay K content was established (Barré et al., Plant and Soil, in press).

We then used a long term fertilization experiment (INRA Grignon, France) to compare soil clay fractions from fertilized and unfertilized plots. The centre of gravity of the X-ray diffractograms appeared to be highly correlated ($p<0.001$, $r^2=0.66$) with the K balance (K added as fertilizer minus K exported in crop yields) in the different plots. As in laboratory experiments, this indicator was also well correlated with analyzed clay K content ($p<0.001$, $r^2=0.68$).

Our results showed that X-ray diffraction should be considered as an appropriate tool to monitor clay mineral modifications qualitatively and quantitatively which are induced by soil K balance. This tool may allow rapid progress for our understanding of plant K nutrition from rhizosphere to field scale.

O-708 Influence of root exudation on metal solubility and speciation in the rhizosphere of *Lupinus albus*

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The goal of this study was to investigate the influence of root exudation on nutrient and metal species in the rhizosphere of *Lupinus albus*. Using a modified rhizobox system, we found that large amounts of metal cations were mobilized in the rhizosphere of cluster roots during the exudative burst of citrate (up to 10 mM citrate). The DOC concentration (dissolved organic carbon without organic anions) also increased with increasing organic acid concentrations. Speciation calculations with ECOSAT revealed that the presence of organic anions (mainly citrate) and of increased DOC had a strong impact on the complexation of metals. For Ca, Mn and Al organic anions were a stronger complexing agent in the rhizosphere solution than DOC. For Fe and Zn we could observe that the complexation with DOC decreased as the organic acids increased, however the DOC was more important for complexation most of the time. Uncomplexed Cu and Pb were almost inexistent and these two metals were unaffected by organic anions and strongly complexed by DOC. Citrate was complexed in the following order: Ca > Al > Fe > Mg > Mn. The results show that the effect of citrate on metal solubility is twofold: on the one hand some metals are directly mobilized and complexed by citrate (Zn, Fe, Al) and on the other hand citrate is mobilizing DOC which in turn is then complexing the metals (e.g. Cu and Pb).

O-866 Microbial influence on Al speciation in the rhizosphere of forest soils

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The transfer of metals from soils to plants is a fundamental flux in the biogeochemical cycle of forested ecosystem. This transfer is regulated by active processes in the rhizosphere, a substantial fraction of which are controlled by microorganisms. Unfortunately, our knowledge of the influence of microorganisms on metal distribution and speciation in soils is sparse, especially for Al, although Al is considered to be ubiquitous in forest soils. Previous studies in forest soils revealed the strong affinity of Al for organic substances and the accumulation of total water-soluble Al (WSAl) in the rhizosphere. In this context, the objectives of this study are: 1) to contrast Al speciation between the rhizosphere and the bulk components for a range of forest soils and 2) to identify the processes linking microbial activity in the rhizosphere and the speciation of dissolved Al.

Soils were collected on three sites near a smelter in the Rouyn-Noranda area (~ 600 km NW of Montreal, Canada) in august 2004 and on three sites near industrial facilities in the Monteregian area (S of Montreal) in august 2005. At each site, the rhizosphere and bulk components were sampled in clayey Luvisols under trembling aspen (*Populus tremuloides*) and separated in the field by hand agitation of roots. Total microbial biomass C and N, active microbial biomass C, dehydrogenase and urease activities were measured. WSAl and monomeric inorganic Al were analysed on water extracts, whereas concentrations of free Al-ion and of inorganic and organic monomeric Al were calculated with MINEQL+ v.4.5.

Results for WSAl concentrations span over less than one order of magnitude and reveal higher, although not significantly different, concentrations in the rhizosphere compared to the bulk component. Moreover, discriminant analysis made with microbial and chemical variables showed a sharp statistical contrast between the rhizosphere and bulk soil components ($p < 0.01$). The higher concentrations of dissolved Al in the rhizosphere appear to be regulated by microbial activity and by the abundance of organic materials. Those two variables increase in the rhizosphere and seem to contribute to reduce the availability of dissolved Al to plants.

O-636 Developing the DON paradigm: the role of high molecular weight proteins and peptides in plant and microbial nutrition in Antarctic soils

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Until recently the focus of research into plant uptake of N has focused on inorganic species (i.e. NO_3- and NH_4^+). Current research focused on the role of amino acids in plant and microbial nutrition has confirmed that higher plants can capture N from amino acids in cold climate and other soils (e.g. Schimel and Chapin 1996). This direct uptake of organic N provides an effective short circuit of the N cycle removing the need for ammonification and nitrification (e.g. Schimel and Chapin 1996; Jones et al. 2005; Bardgett et al. 2003). It was thought that in order for DON uptake to occur, all proteins and peptides undergo enzymatic cleavage into constituent amino acids. Results in this laboratory suggest that scientists may have overlooked the most important N uptake pathway, that of direct peptide uptake (i.e. amino acid chains of ca 2-20 unit lengths) by plants and soil microorganisms. Peptide transport in microorganisms is well documented and recent evidence has demonstrated the presence of a range of peptide transporters in plants (Williams and Miller 2001). Our results indicate that peptide uptake rates by soil microorganisms are of the same order or faster than that of amino acids and that under controlled conditions plant roots can take up exogenously applied peptide as sole source of N for growth. In this paper we suggest a short circuit whereby plants and microorganisms may directly utilise complex organic N sources.

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O-848 Forest tree rhizosphere increase soil mineral weathering: an *in situ* approach

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In forest ecosystems, the principal source of nutrients for tree derives from the release of elements by soil mineral weathering. The ability of plants and associated microorganisms to increase mineral weathering has been underlined in many *in vitro* experiments. However, several studies have yet clearly demonstrated great discordances between the controlled condition and *in situ* experiments, notably concerning the mineral dissolution kinetics. The objective of this work was therefore to determine *in situ* the impact of forest tree rhizosphere on the chemical and mineralogical soil properties.

For that purpose, we have sampled rhizosphere and bulk soil in an experimental site planted on an acidic soil in 1976. The roots of oak (*Quercus petraea* Lichl.) and Norway spruce (*Picea abies* Karst.) were removed manually and the soil which freed itself spontaneously from the roots after drying at 30°C corresponded to the rhizosphere. The bulk soil corresponded to the soil non-adhering to the roots. On the clay fraction (< 2µm), total chemical analysis and selective extractions of Al and Fe were realised and the mineralogical composition was studied using an X-ray diffractometer.

The results obtained with these different methods were consistent and showed:

(i) oak and Norway spruce rhizospheres have increased clay mineral weathering:

- the clay transformation process was more important in oak and Norway spruce rhizospheres: the rhizosphere clays had lost greater amounts of Al hydroxide and presented a higher proportion of mica-like-layer than those of the bulk soil, suggesting an interlayer Al polymer destabilisation and fixation of K on the rhizosphere clay fraction

- the clay dissolution process was more important in oak and Norway spruce rhizospheres: the rhizosphere clays contained more Si and less Fe and Al than those of the bulk soil, showing a dissolution of the minerals containing Fe and Al.

(ii) The two species seemed to accelerate clay mineral weathering by different mechanisms. In fact, the increase in clay mineral weathering in the Norway spruce rhizosphere appeared to be principally due to the exudation of large quantities of acid compounds to balance predominant uptake of nitrogen under NH_4^+ form. In return, our results showed that the oak did not acidify the surrounding environment implicating that different processes of clay mineral weathering occurred in the oak rhizosphere.

O-814 Ectomycorrhizal use of the coarse soil nutrient pool for spruce seedling nutrition

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Soil stones were formerly seen as the inert matrix that actually dilutes the nutrient pool, but the stones have an important function as habitat for soil organisms and act as long term nutrient pool for trees. The coarse soil fraction holds sufficient available nutrients, and ectomycorrhiza might transport these nutrients. Ectomycorrhizal hyphae increase the amount of soil exploited by tree roots, but it remains unclear whether this does result in increased weathering. Recently the hypothesis that ectomycorrhiza could “eat rocks” by excreting low molecular weight organic acids (LMWOA´s) was rejected but several studies indicate that at least some ectomycorrhiza are able to transport nutrients from minerals to trees. We have seen hyphae in newly eroded cracks in rock, indicating to some extent a tendency of these hyphae to solubilize the rock.

A pot-experiment was set up to study the effect of ectomycorrhiza on seedling nutrition and mineral weathering. The coarse soil fraction (2-6,3 mm diameter) of an acid forest soil (Black Forest, SW Germany) was the only nutrient pool available to the seedlings (*Picea abies*) apart from a nutrient solution with concentrations of NH_4NO_3 and KH_2PO_4 similar to site soil solution. Seedlings were inoculated with *Laccaria laccata*. Controls were either without ectomycorrhiza and/or coarse soil fraction.

By measuring the in- and output of nutrients during the experiment and analysing nutrient content of seedlings and substrate before and after the experiment, a nutrient balance could be established. LMWOA´s were analysed throughout the experiment. This balance allows us to determine nutrient fluxes in the seedling-ectomycorrhiza-coarse soil system that is applicable for forest soils of the temperate regions worldwide.

The early results show that ectomycorrhiza exuded mostly the LMWOA oxalate as weathering agent. Without ectomycorrhiza oxalate production was minimal. The biomass of seedlings on nutrient rich stones was much higher than of those on quartz only, indicating seedlings are able to use the coarse soil fraction as nutrient pool. The seedlings without ectomycorrhiza had clearly less root biomass compared to ectomycorrhizal seedlings.

▶ *Poster presentations*

P-915 **Dynamics of P fractions in the rhizosphere of common bean (*Phaseolus vulgaris* L.) and durum wheat (*Triticum turgidum durum* L.) grown in monocropping and intercropping systems**

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The main objective of the present study was to investigate P dynamics in the rhizosphere of durum wheat (*Triticum turgidum durum* L.) and common bean (*Phaseolus vulgaris* L.) grown in monocropping and intercropping systems. Wheat and common bean were grown either alone or in association in a novel minirhizotron with a thin (1 mm) soil layer sandwiched between large root mats, with either the same plant species on each side (monocropping) or a different plant species on each side (intercropping) of the cropping device. We compared the dynamics of empirically defined pools of P (inorganic and organic P fractions) in the rhizosphere, as assessed according to Tiessen and Moir (1993). We also measured the net proton release of plants grown in different systems according to rhizosphere pH changes and soil pH buffer curve.

Soil pH decreased by 1.66 and 1.13 units in the rhizosphere of common bean in monocropping and intercropping, respectively, while little, unsignificant increase in rhizosphere pH was found for by wheat. Proton release by common bean roots increased by 46% in intercropping relative to monocropping, when expressed on a per plant basis. Common bean and wheat also exhibited a completely different behavior when considering the dynamics of the various P pools in their rhizospheres. Changes of P fractions in intercropping were generally intermediate between those found in monocropped wheat and monocropped common bean. Monocropped common bean significantly depleted the acid-soluble inorganic P pool which is in good agreement with its ability to acidify its rhizosphere, while no significant change was found for monocropped wheat or the intercropping system. More remarkably, monocropped wheat significantly depleted all alkaline-soluble organic P pools while an increase of these pools was systematically observed in the rhizosphere of monocropped common bean, and no significant changes were found in the intercropping system. As wheat and common bean had obviously access to different P fractions, they hardly competed at all for P acquisition when intercropped, thus contributing to the efficiency of intercropping and possibly to the increased yield of wheat in the intercropping system, relative to wheat monocropping.

P-576 **Zinc densed rice grains: physiological and molecular breeding approaches**

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Zinc (Zn) and iron (Fe) are the two most frequently deficient among essential trace elements from the point of plants, human and animal health perspective. Strategies to improve the levels of these two elements in plants and especially in the economic part, the approaches needs to be different, because iron is available in the soil in plenty whereas Zn is poor in soils. Both are co-factors for numerous enzymes and play an important role in plant growth and development. Although Zn is needed only in small amounts by the human body, some people are vulnerable to mild to moderate Zn deficiency especially in developing countries, since the staple foods constitute the major diet and due to less buying power, they cannot afford for diversified food. Higher densed Zn grains will not only improve the human nutrition, but they are going to improve the productivity of the crops, when they are sown in soils containing low amount of this trace element.

Several attempts are made globally, to improve Fe content in food grains, but attempts to improve Zn are minimal. In this direction the study has been carried out to assess the concentration of zinc and iron in rice (*Oryza sativa*). Around 450 germplasm lines, varieties and wild species including 100 world core collection of rice were used for the assessment of mineral levels. Zn and Fe content were estimated in grains. Zn content was found to be in the range of 1.25 to 5.5 mg/100g and it is 3.6 to 6.16 mg/100mg in wild species. Fe content was in the range of 0.62 to 3.2 mg/100g. Effective crossings have been made between contrast lines of Zn to develop the mapping population and also between high Zn containing lines and agronomically superior varieties to increase the Zn content. F2 seeds are harvested and this F2 population will be used to develop molecular markers and also the high Zn containing lines will be forwarded after assessing the Zn content and also with the assistance of molecular markers.

P-468 **Are root-induced decomposer growth and plant N uptake positively associated among grassland plants?**

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Decomposition of soil organic matter (SOM) is a major determinant of nitrogen (N) availability in terrestrial ecosystems. Plant species can affect the abundance, activity and composition of soil decomposer communities and thus presumably also SOM decomposition and N mineralisation in soil. Based on a hypothesis that root-induced growth of soil decomposers leads to accelerated decomposition of SOM and increased plant N availability in soil, we hypothesised that the abundances of soil decomposers in rhizospheres of different grassland plant species should be positively associated with the amount of N these species acquire from SOM. To evaluate the consequences of this on interspecific plant-plant competition for nutrients in grasslands, we further hypothesised that those plant species that induce lower abundance of decomposers benefit from sharing soil with species inducing higher decomposer abundance. We established replicated grassland miniecosystems, each consisting of two plant individuals, a natural soil decomposer community and ^{15}N-labelled plant litter as an organic N source. To test the first hypothesis, we compared the rhizosphere decomposer communities and litter-N uptake of three plant monocultures – a grass *Holcus lanatus*, a herb *Plantago lanceolata* and a legume *Lotus corniculatus*. To test the second hypothesis, we established two-species combinations and compared the ability of each species to acquire litter-N when living in a monoculture vs. living in the species combinations. We found that the three species induced dissimilar soil decomposer communities and had different litter-N uptake. However, the results did not support our hypotheses since while *Lotus* induced the most abundant decomposer community, *Holcus* had the highest uptake of N from the added litter. Likewise, *Holcus* and *Plantago* did not benefit, in terms of higher litter-N uptake, from the more abundant microbial community of *Lotus* rhizosphere when growing together with *Lotus*. It appears that plant species-specific effects on decomposer communities are not linked to SOM decomposition and plant N availability in a way we predicted. This suggests that other plant traits - such as competitive ability for mineral N - are more important in plant acquisition of soil organic matter N than their ability to induce decomposer growth in the soil.

P-587 Transformation of fibrous clays to kaolinite in the rhizosphere of alfalfa, barley and canola

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Palygorskite and sepiolite are fibrous clays commonly occurring in soils and sediments of arid regions. While too many investigations have been carried out on the distribution and environmental conditions for the stability of these clays, no information is yet available on the transformation of these minerals in rhizosphere (or soils <3mm from root). This study was conducted to determine the changes in fibrous clays under rhizospheric conditions of selected agricultural crops and to compare the ability of plants to extract structural Mg from these minerals. Alfalfa, barley and canola were grown in a pot experiment under growth chamber conditions. Growing medium contained a mixture of sand-sized Ottawa sand (pure quartz) and clay-sized Florida palygorskite or Spanish sepiolite. Pots were irrigated with distilled water and/or Mg-free Hoagland nutrient solution for a period of 3 months. At the end of experiment, both plant roots and shoots were collected, washed, dried and weighed and their Mg content was measured by ICP after digestion with microwave. Also, clay was separated from sand and analyzed by XRD and TEM. XRD patterns clearly showed the presence of kaolinite in the rhizosphere of all the three crop plants. Hexagonal particles of kaolinite were also observed under transmission electron microscope. Plant analysis indicated that all the 3 crops could extract significantly higher amount of Mg from sepiolite as compared to palygorskite which shows the higher instability of latter compared with the former. Kaolinitization of palygorskite and sepiolite in the rhizosphere appears to be mainly due to (i) a much lower pH of the rhizospheric environment, (ii) destabilization of fibrous clays as a result of Mg uptake by plants, (iii) the chelation properties of organic compound exuded by plant roots and microorganisms. The results of this study clearly shows that the presence of kaolinite in agricultural soils of arid and semiarid regions are partly due to neoformation from the weathering of fibrous clays in addition to sole inheritance from parent material, as previously envisaged.

P-387 Seasonal changes in microbial biomass in rhizosphere soils under palmarosa (*Cymbopogon martinii*) and menthol mint (*Mentha arvensis*)

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Nutrient dynamics in rhizosphere soil is influenced by several physical, chemical and biological factors. Similarly, the type of soil, crop, temperature, moisture, fertilizer and other amendments and contaminants are the key factors in influencing the microbe-mediated transformation of nutrients like C, N, P and S etc. The microbial biomass in soil is closely related to the total soil organic C content and is considered to be highly sensitive pool and any change in rhizosphere micro-environment is reflected in the biomass faster than in the total organic matter. In the tropical and subtropical climates, due to wide seasonal variation in climatic conditions and cropping, biomass is expected to vary. The present investigation deals with evaluation of changes in soil microbial C, N and P in two rhizosphere soils, with similar fertility and physico-chemical properties but supporting different crops, one cropped with palmarosa (*Cymbopogon martinii*) an essential oil bearing aromatic grass and the other with menthol mint (*Mentha arvensis*), a rich source of menthol.

Soils samples (0-15 cm) were collected from the two fields at approximately monthly intervals over a period of one year. Soil microbial biomass C was determined using chloroform fumigation-extraction method (Vance et al, 1987) and soil microbial biomass N and P were determined following the methods of Brookes et al (1985) and Brookes et al (1982), respectively. Shade dried samples were analysed for soil organic C (Walkey and Black, 1934).

The results indicate that both the season and type of cropping had a significant influence on changes in soil microbial biomass. In general, soil microbial biomass C, N and P were higher in summer months and lowest in mid winter. Soil microbial biomass levels and microbial C : N and C : P were higher and N : P ratios lower under palmarosa soil than under mint. Higher soil organic C contents also coincided with maximum plant growth. The organic C content was higher in palmarosa soil, probably because the aromatic grass contributed more organic matter to the soil. The proportion of soil organic C as microbial biomass C was higher in palmarosa soil than in mint soil. Similarly, the proportion was significantly higher in post-harvest soil under both the crops.

P-646 Interactions between different organic acids in the rhizosphere

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Plant roots have the ability to change their chemical and biological surroundings through the uptake (e.g. water, nutrients) and release (e.g. CO^2, H^+, organic acids, enzymes) of various molecules. Organic acids released by roots are assumed to perform many beneficial functions in soil including enhanced nutrient acquisition, metal detoxification, stimulation of microbial chemotaxis and accelerated mineral weathering (Jones 2003). Since organic acids represent one of the most labile sources of C in soil, once released into the soil solution, these low-molecular-weight compounds may be quickly taken up and mineralised by the soil microbial community. In addition, solid phase sorption of organic acids can alter their half-life and behaviour in soil. Their functional significance in soil therefore depends on the characteristics of the solid phase, the activity of the rhizosphere microbial community, the chemical attributes of the individual organic acid and the cocktail of other exudates released from the root. As plants release various organic acids simultaneously, it has been suggested that preferential mineralisation and sorption might enhance the longevity and nutrient mobilization capacity of some organic acids. The objective of this study was therefore to investigate the reactions of three organic acids implicated in nutrient mobilization (i.e. citrate, malate, oxalate) in the presence of two organic acids implicated as regulators of soil microbial activity and/or sorption processes (i.e. malonate, shikimate). Our results showed that the biodegradation of citrate, malate and oxalate in a range of agricultural soils was not influenced by the presence of large quantities of either shikimate or malonate. This suggests that the individual organic acids possess different microbial uptake mechanisms (either transport pathways or uptake by different components of the microbial community). The results also suggest that both shikimate and malonate do not greatly influence the sorption of citrate, malate and oxalate in soil. Overall, our results showed little significant interaction between the observed organic acids.

P-462 Plant growth promotion mechanism of *Burkholderia* sp. Flap1 analyzed by using gnotobiotic water culture system

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The utilization of phytic acid by crops is generally limited under field conditions, since phytic acid forms insoluble phytate and shows high stability in soil. Therefore, phytate accumulates in cultivated lands and become major components of soil organic phosphorus (P). In Rhizosphere 2004, we reported that we have isolated over 300 isolates by using phytic acid as the sole applied carbon and P source from rhizosphere of *Lupinus albus* L., and one of these isolates; *Burkholderia* sp. Flap1, demonstrated particular high growth promoting effects for *Lotus japonicus* MG-20. In this study, we conducted following study aiming to elucidate plant growth promotion mechanisms of Flap1 as a basis for increasing the efficiency of phosphorus utilization by crops.

To analyze the interactions between Flap1 and plants strictly, we applied gnotobiotic water culture system, which cultured plant and bacteria in autoclaved transparent plastic bag containing 3 L-sterilized culture solution. Prior to test, plants were grown in sterile condition for 14 days (*L. albus*) or 21 days (*L. japonicus*), after that seedlings were transferred to fresh culture solution that contained Flap1. Control plants were also grown aseptic with phytic acid or inorganic P. In all treatments, water culture solutions were changed every week and P sources were supplied as filter-sterilized solutions at levels equivalent to a final concentration of 0.1 mM Pi. The solution was checked for contamination by SCD agar except for Flap1 treatments, and if the contamination was positive the sample was discarded.

Dry weight and P uptake of plants were increased by inoculation of Flap1. In addition, Flap1 inoculation caused lateral root branching of *L. japonicus* and cluster root formation of *L. albus*. As *L. albus* is known to have vigorous growth under low soil P condition than other plant species by its developed mechanisms to solubilize sparingly available soil P, involving the cluster root formation. Thus, it is suggested that some microorganisms living in the rhizosphere soil such as Flap1, might contribute *L. albus*'s ability to absorb P from soil. In addition, with a view to analyze the plant response by Flap1, we conducted transcriptome analysis with oligo-DNA microarray of *L. japonicus*. From this analysis, we extracted 140 probes as directly affected by Flap1 inoculation, and they included some response elements related to enhancement of root growth in seedlings.

P-401 Acid phosphatase activity detected in the hyphal exudates of arbuscular mycorrhizal fungi

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A large fraction of the total phosphate is in organic forms in many soils and these forms are unavailable to most plant species. Mineralization of organic phosphate by extracellular phosphatase of arbuscular mycorrhizal (AM) fungi has been suggested but not well understood. It is necessary to develop a method for collection of the hyphal exudates of AM fungi in order to detect extracellular AM fungal phosphatases. In the present study, we designed the compartmentalized pot culture system in combination with the mulite ceramic tubes to collect the hyphal exudates and demonstrated phosphatase activity in the exudates.

Sterilized Andisol was packed in pots that were separated into the mycorrhizal and hyphal compartments with a nylon mesh bag of 30 μm pore size. Onion (*Allium cepa* L.) plants inoculated with AM fungus, *Glomus clarum* were grown in a growth cabinet. The control plants were not inoculated with the fungus. The mulite ceramic tubes (50 mm x 2 mm) connected with a Teflon tube were buried in the soil of both compartments before sowing. The plants were irrigated with deionized water to maintain the water potential at –0.03 MPa. Soil solution was collected from each compartment through the tubes by decompressing with a syringe. Acid phosphatase activity in the solutions was assayed based on the amount of p-nitrophenol released by hydrolysis of p-nitrophenylphosphate after incubation at 27°C for 60 min. For the qualitative analysis of phosphatase, the soil solutions were concentrated and loaded on a 10% SDS-polyacrylamide gel without heat-denaturation, and acid phosphatase activity was detected by the azo dye method.

Onion plants were well colonized with AM fungi. Adhesion of external hyphae to the surface of the mulite ceramic tubes in both compartments was observed. Shoot phosphorus concentration was higher in the onion plants inoculated with *G. clarum* than that in the uninoculated plants. Acid phosphatase activities in the soil solutions collected from the mycorrhizal and hyphal compartments of the mycorrhizal plants were higher than those of the uninoculated plants. Mycorrhiza-specific phosphatase activity was detected by the electrophoretic analysis. These observations suggest that not only the exploitation of bulk soil by the external hyphal network of mycorrhizal fungi but also the exudation of acid phosphatase contribute to the enhanced uptake of phosphate in mycorrhizal plants.

P-728 Phosphate solubilising bacteria effects on nutrient uptake and growth of wheat on low phosphorus soil

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Phosphorus (P) is one of the essential plant nutrients and in soil it is not easily available due to its low solubility and fixation. Many soil bacteria predominately of genus *Bacillus* possess the ability to solubilise sparingly soluble phosphates, thereby, causing growth promotion in certain crops. The dissolution of insoluble P in soil may be due to acidification, chelation and exchange reactions. The present investigation was undertaken with the objective of mass multiplication of immobilised P solubilising bacteria (PSB) to study their effect on P availability and wheat growth on low P soil. The highly efficient antibiotic resistant bacteria viz. 5 *Bacillus* M, 42 *Bacillus* M, 5 *Bacillus* M + 42 *Bacillus* M along with their parents were immobilised in carageenan for delivery in green house conditions. Wheat (*Triticum aestivum* cv. PBW 343) was grown on soil low in available P (5.26 mg P kg^{-1} soil). A basal dose of 120 mg N kg^{-1} soil through $CO(NH_2)_2$ and 25 mg K kg^{-1} soil through KCl was mixed with soil in all the pots. Phosphorus was applied at the rate of 30 and 60 mg P kg^{-1} soil through $Ca(H_2PO_4)_2$. The enumeration of PSB was carried out after 20, 35, 50 and 70 days of inoculation. Shoot biomass, total N and P of dried shoots and available P in soil were determined at 70 days after sowing. Inoculation with 42 *Bacillus* M represented highest population counts followed by 5 *Bacillus* M + 42 *Bacillus* M. In all these inoculated treatments, the population count significantly increased at 35 days while minor changes were recorded thereafter up to 70 days of inoculation. Maximum population count was recorded when 30 mg P kg^{-1} soil applied with all the PSB. In no P treatment, inoculation with 42 *Bacillus* M produced 92% of the maximum shoot dry weight and 86% and 82% of the maximum N and P uptake, respectively. Application of 30 mg P kg^{-1} soil along with 42 *Bacillus* M produced maximum shoot biomass (1.99 g $plant^{-1}$), N uptake (3980 mg $plant^{-1}$) and P uptake (716 mg P $plant^{-1}$) after 70 days. The available soil P increased from 5.35 mg kg^{-1} soil to 6.69 mg kg^{-1} soil after inoculating 42 *Bacillus* M in the low P soil. Field experiment is in progress with 42 *Bacillus* M and the population count is also reported to be higher in soil after its inoculation along with lower dose of P. Wheat crop will be harvested in April 2007 and the data will be presented.

P-790 The size and composition of microbial community in abandoned agricultural land in the central region of Loess Plateau, China

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Microbial community responses to different types of vegetation may be indicative of soil quality change. Microbial populations, however, have received less study on restoration after agricultural land abandonment than aboveground vegetation communities. As different composition of microorganisms respond differently to prevailing environmental conditions, different vegetation cover influences the composition of the soil microbial community in a specific way. We hypothesized that different types of vegetation select for microorganisms with specific environmental requirements. Different types of vegetation might select for microorganisms with specific soil microbial communities.

In this study, five fallow sites which include 5-, 6-, 9-, 10-, and 26-year fallow, an arable land and two nature vegetations were selected. Fatty acid methyl ester (FAME) profiles were determined to describe the composition and size of the soil microbial communities. With vegetation succession organic carbon (OC), total nitrogen (TN), ratio of organic C/ total P (C/P), ratio of total N/total P (N/P), total FAMEs, fungal biomass, ratio of fungal to bacterial biomass, and Gram-negative bacterial biomass in the topsoil (0-10cm) increased gradually. The chemical and microbial properties measured in soil were significantly higher in the virgin vegetation than those of arable land, with various fallows being intermediate. Soil organic C and total N in the topsoil showed a positive correlation with total FAMEs, suggesting that there was close relationship between soil fertility and microbial biomass (FAMEs) and total FAMEs were potentially good indices of soil fertility in study area. With soil depths, the OC, TN, total FAME, and Gram-negative bacterial biomass readily decreased, actinomycetes biomass and Gram-positive bacterial biomass gradually increased except for arable land and virgin vegetation facing east which were higher in the 10-30cm than other depths, suggesting that microbes inhabiting the deeper soil horizons were more carbon limited than surface-dwelling microbes. Therefore, the results showed that the increased of soil fertility may be related to the size and composition of microbial community, while total P may become the limiting factor relative to C and N with vegetation succession after abandoned arable land.

P-823 Root exudates of *Brachiaria humidicola*, a tropical pasture grass, and its effect on nitrification and soil microorganisms

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Nitrification is an important biological process in global nitrogen cycling whereby ammonia is converted to nitrite and nitrate by nitrifying bacteria (species of *Nitrosomonas*, *Nitrospira* and *Nitrobacter*). The nitrification products are vulnerable to leaching and denitrification: an estimated 45% of applied fertilizer is lost by leaching and 10% to 30% by denitrification. If the nitrification process is inhibited or slowed, then plants have adequate time to take up fertilizer N; N recovery and uptake are substantially improved and NO_3^- pollution problems are reduced. JIRCAS in collaboration with International Center for Tropical Agriculture, Columbia reported lower levels of NO_3-N in fields of *B. humidicola* than in fields of other forage grasses and the compounds released from the roots of *B. humidicola* are mainly responsible for its inhibitory effect on soil nitrification. The present investigation is aimed at determining the influence of BNI (biologically produced nitrification inhibitors) compounds released from *B. humidicola* roots on nitrification, natural soil micro flora and plant growth promoting soil microorganisms.

Several soil incubation/pure culture studies were conducted to test the influence of root exudates on nitrification, soil micro flora and plant growth promoting microorganisms. Two soil types of contrasting total nitrogen, carbon and pH characteristics, Andosol and Terrace yellow soil, were used in the soil incubation studies. Root exudates were collected in distilled water, after the plants were exposed to 1mM NH_4Cl, and concentrated before incorporated into the soil/pure culture studies. Microbial counts (ammonium oxidising bacteria, nitrite oxidising bacteria, total cultivable bacteria, aerobic spore former, fluorescent pseudomonas, gram-negative bacteria, actinomycetes, fungi and plant growth promoting microorganisms) were done by MPN method; NH_4 and NO_3 analysis were done at regular intervals in an auto analyser as per the standard procedure.

P-825 Phosphorus acquisition by cotton, wheat and white lupin under P stress

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We have conducted two rhizobox experiments to examine if cotton is physiologically efficient at acquiring phosphorus, in particular by exuding organic acids, phenolics or protons. Cotton, wheat and white lupin were grown in small PVC tubes filled with sand-soil mixture to create a dense root mat against a 53 µm polyester mesh at the bottom. For each species, two P treatments (0 and 30 mg P/kg soil) were applied to the sand-soil mixture. When a growth difference between the P treatments was visible, plants were harvested. Rhizosphere soil under the root mat and the root exudates were collected. Results suggested that cotton shoots and roots growth were less responsive to the P treatment than wheat during the early growth stage. By collecting root exudates, noticeable organic acid and proton release was only detected for white lupin. Increased acid and alkaline phosphatase activity was measured in the rhizosphere of cotton under P starvation. The rhizosphere of wheat also showed an increase in acid phosphatase irrespective of P treatment. Soil P was fractionated to investigate differences among species in their ability to access various P pools. The study revealed a relatively consistent trend: $NaHCO_3$ extracted P was depleted for all species under P starvation. The inorganic P extracted by NaOH remained relatively unchanged in the rhizosphere soil when compared with the bulk soil for all species. HCl-extracted soil P decreased near the root mat of wheat and white lupin when no P was supplied. Interestingly, wheat depleted both $NaHCO_3$-P and HCl-P to a significant level even with the P supply, possibly due to its higher root coverage on the mesh and extensive root hairs. It is concluded that similar to the release of organic acid from white lupin, the formation of longer root hairs is likely the major reason for the P efficiency of wheat. Organic P probably is the major source for the P-deficient cotton due to the higher activity of acid and alkaline phosphatases in the rhizosphere soil.

P-714 Developmental characteristics and response to iron toxicity of root border cells in rice seedlings

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To separate the Fe^{2+} effect from those on root tips in rice plant, experiments were carried out using border cells in vitro. The border cells were pre-planted in aeroponic culture and detached from root tips. Most of border cell have a long elliptical shape. Number and viability of border cells *in situ* reached the maximum of 1600 and 97.5% at 20~25 mm root length. This mortality was more pronounced at the first 1 to12h exposure to 250 mg/L Fe2+ than the last 12 to 36h, After 36h, the cell viability exposed 250 mg/L Fe^{2+} decreased to nought, whereas cell viability was 46.5% at 0 mg/L Fe^{2+}. Increased Fe^{2+} dosage stimulated the death of detached border cells from rice cultivars. After 4h Fe^{2+} treatment, the viabilities were ? 80% at 0, 50 mg/L Fe treatment and were <62% at 150, 250 and 350mg/L Fe^{2+}, the viability of border cells decreased 10% separately when the Fe^{2+} concentration increased to 100mg/L. After 24h Fe^{2+} treatment, the viabilities of border cells at all the Fe^{2+} levels were < 65%. The viability of border cells decreased by 20% when the Fe concentration increased 100mg/L. The decreased viabilities of border cells indicated that Fe^{2+} dosage and treatment time would cause deadly effect on the border cells. The increased cell death could protect the root tips from toxic harm. It may protect root from the damage caused by harmful iron toxicity.

P-524 Transport of potassium by two arbuscular mycorrhizal fungi evaluated by rubidium as tracer

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While the capacity of arbuscular mycorrhizal (AM) fungi to transport potassium (K) remains unknown, the transport of other major elements, i.e. phosphorus and nitrogen, has been clearly demonstrated. It was nevertheless suggested that K could be associated to P during its transport by AM fungi to maintain osmosis in both symbionts. The fact that the capacity of AM fungi to transport K has not yet been demonstrated could be mainly ascribed to the difficulty of using isotopic tracers of K. In the present experiment, we used rubidium (^{86}Rb) as K tracer. Rb is an analogue of K and has been widely used to study the transport of K in plants and fungi (Rb^+ for K^+ or $^{86}Rb^+$ as a tracer for K^+). Using an *in vitro* compartmented culture system, in which ^{86}Rb was only accessible to the extraradical mycelium of either *Glomus intraradices* or *Glomus clarum*, we tested the capacity of both AM fungi to transport ^{86}Rb. In this system, *Medicago truncatula*, which developed under autotrophic conditions, was used as host of the AM fungi. Our results showed that *G. intraradices* and *G. clarum* took up 31 ± 6% and 29 ± 3% of the initial ^{86}Rb supplied in the hyphal compartment, respectively. Translocation to the plant represented 51 ± 15% and 45 ± 5% of the ^{86}Rb taken up by these AM fungi, respectively. Transfer from the AM intraradical mycelium to the roots cells was also demonstrated as 86Rb was found in the shoot of *M. truncatula*. Distribution of ^{86}Rb in plants was 80 ± 8% in roots and 20 ± 8% in shoot when colonized by *G. intraradices* and 70 ± 4% and 30 ± 4% with *G. clarum*, respectively. These later values were significantly different between roots and shoot of *M. truncatula* colonized by both fungi. However, root and shoot specific activities (i.e. $Bq.mg^{-1}$ fresh weight) were not significantly different. These results undoubtedly demonstrated that both AM fungi were able to transport ^{86}Rb to their host and thus support the assumption that AM fungi can transport K.

P-694 Sulphur-mobilisation in the rhizosphere of rape and ryegrass

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Sulphur (S) is one of the 16 nutrients essential for plants, animals, and men. During the last three decades, S deficiencies have been reported with increasing frequency throughout the world. Main reasons are the desulphurisation of industrial flue gas, the use of low-S containing fertilisers and the cultivation of S-demanding plants. These factors result in an urgent need for an adequate S fertilisation, especially concerning S-demanding crucifers. As SO_4-S is very mobile in soils, a surplus supply may result in leaching. Therefore, S-fertilisation has to be adjusted to the S-requirements of the cultivated crops; in doing so, the additional delivery of the soil has to be included. Common test procedures only consider soluble and adsorbed sulphate which only represents a small amount of the total S in the soil; about 90 % of soil-S are organically bonded, either as rather labile sulphate esters or more stable as directly C-bonded S. Therefore, the aim of our investigations is to achieve deeper knowledge about fluxes between the different S fractions in soil and their importance concerning plant nutrition with special attention to the mobilisation of S in the rhizosphere.

Rape and ryegrass were cultivated in a Rhizosphere Study Container. This container is composed of three segments (soil, sand, soil) separated by gaze (1 µm diameter) and enables us to obtain root-free soil samples in defined distances (1 mm) from the root surface. Two different soil treatments (mineral and compost fertilisation) were used. Total S was determined in plant samples; in soil samples inorganic (sequential extraction with H_2O; 0,032 M NaH_2PO_4; 1 M HCl) as well as organic S-fractions (ester sulphate, C-bonded S) were determined.

The different inorganic and organic S fractions reveal a differentiated behaviour in the rhizosphere. While water-extractable S is mobilised within the first 3 mm from the root, the organic S-fractions obviously influence the S-delivery even in the bulk soil. Additionally, S-mobilisation differs in the rhizosphere of rape and ryegrass and is also influenced by the different soil treatments. The results will be discussed in view of their consequences for the S nutrition of plants.

P-722 Manganese efficiency and Mn uptake kinetics of raya (*Brassica juncea* L.) in comparison to wheat and oat

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Manganese deficiency is reported worldwide and often decreases crop yield. However, plant species differ in their susceptability against Mn deficiency. Graminaceae are often inefficient, whereas brassicaceae seem to be efficient in Mn uptake. The reasons for this differences in Mn efficiency are not well understood, yet. The objective of this paper is to determine the relevance of Mn uptake kinetics for differences in Mn efficiency of soil grown wheat, oat and raya.

The plants were grown for 23 days in pots filled with 3kg of a loamy soil low in Mn availability (pH(CaCl2) 7.4, DTPA-Mn 3.8 mg/kg). The soil was fertilized with 0, 1, 2, 4, and 8 mmol Mn/kg soil. These treatments resulted in Mn soil solution concentrations ranging from 44 up to 84 nM. Raya achieved highest yield already in the unfertilized treatment and showed a slight (non-significant) yield reduction in the fertilized treatments. The graminaceae needed at least a fertilization of 1 mmol/kg for highest yield and showed a yield reduction of about 40% in the unfertilized treatment. Manganese concentration in the shoot dry matter was always higher in raya compared to wheat and oat, e.g. 22 mg/kg compared to 10 mg/kg in the unfertilized treatment, respectively. Hence, raya was more Mn uptake efficient than the graminaceae.

According to the relation X = In 1/RGR L/W (Bhadoria et al. 2002) the nutrient concentration in shoot dry matter (X) can be calculated by influx (In), relative growth rate (RGR) and root/shoot ratio (L=root length, W=shoot dry weight). For raya, the higher Mn concentration in shoot compared to wheat and oat was only due to a higher inflow; RGR and L/W were similar between the species. Uptake kinetics parameters of the three species measured in nutrient solution culture confirmed a three times higher maximum influx (Imax) of raya compared to wheat and oat. However in the unfertilized soil, raya could even realize a higher influx than in solution at a comparable Mn concentration, whereas there were no differences for wheat and oat. This indicates that raya was also able to increase Mn availability in the soil. This can be due to a higher reduction capacity of raya roots, especially at Fe shortage, which is probably also given in a soil of high pH value.

Bhadoria PS et al., 2002: Phosphorus efficiency of wheat and sugar beet seedlings grown in soils with mainly calcium, or iron and aluminium phosphate. Plant Soil 246, 41-52.

P-420 **Using *Arabidopsis thaliana* gene trapping lines to develop plant bioindicators for monitoring plant sulfur nutritional status and/or sulfate availability in the rhizosphere**

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The gene trapping strategy is a powerful tool to reveal functional aspects of essential genes along with their tissue specificity and inducibility; we are exploiting this strategy to identify genes specifically regulated by sulfur plant nutritional status. In the last years the occurrence of sulfur-deficiency in agricultural crops increased a lot, causing loss of yield and/or negative consequences on crop quality, because of the essential roles played by sulfur in plant physiology. In order to gain useful information to more specific and efficient fertilisation strategies, the development of diagnostic indicators for the continuous monitoring of the plant sulfur nutritional status is needed. To this purpose, we are screening a collection of *Arabidopsis thaliana* gene trapping lines generated by "EXOTIC" (Exon Trapping Insert Consortium), by insertional mutagenesis with a modified maize Ds transposable element, carrying the promoter-less beta-glucuronidase (GUS) gene as a reporter. In lines having GUS inserted within or near a chromosomal gene, GUS expression mimics that one of the tagged gene. In particular, we are searching for lines that show a differential expression of GUS when grown in the presence or absence of sulfate, the main sulfur source for plants. To date we have identified a line showing GUS expression in the root apexes and shoots only when grown under sulfate starvation. The growth of this line on media lacking in others nutrients (N, P, K, Mg, Ca, Fe) was not able to induce GUS expression, showing the reporter activation as a specific response to sulfur withdrawal. Time course analyses showed that GUS expression was evident from the third day from sulfate deprivation. The genomic sequences flanking the transposon insertion were identified by TAIL–PCR as the intergenic region between AT1G12030 (gene of unknown function) and AT1G1040 (leucine-rich repeat/extensin like protein). RT-PCR analyses showed that the expression of the flanking genes was not influenced by the transposon insertion, suggesting that the observed behaviours were due just to the presence or absence of sulfate in the growing medium and not to a general alteration of the transcriptional responses of the line. Taken as a whole, results suggest the usefulness of gene trapping approaches to identify DNA sequences able to induce the transcription of a reporter gene under sulfate starvation, and thus exploitable for developing plant bioindicators of sulfur nutritional status.

P-840 **The fate of nitrogen at the soil – root interface: A comparison between beech and spruce.**

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The below-ground competitiveness of two important European tree species, *Fagus sylvatica* and *Picea abies*, was quantified in a 50-60 year old mixed stand by determining space-related cost-benefit ratios. In particular, the uptake of nitrogen was investigated per root biomass, per associated mycorrhiza, and per occupied space.

In a first approach, fine roots of the mature trees were enclosed into rhizotrons (size: 32 x 22.5 x 1 cm; homogenized soil from the research site, irrigation via suction cups) during the growing season while still attached to the trees. After four months, the roots of the rhizotrons were fed by a solution of $^{15}NH_4{}^{15}NO_3$ for fourteen days before being harvested. The fate of labelled nitrogen was examined in the different fractions of coarse and fine root biomass, mycorrhized root tips and soil in different distances from the application points. Both, beech and spruce roots were found to have occupied the whole rhizotron with extensive mycorrhizal colonization. Within the time of labelling, most of the incorporated ^{15}N was found in the root fractions of up to 10 cm distance from the application area for both species. In spruce, the label was slightly stronger than in beech roots, which might be due to the higher biomass of the spruce roots within the rhizotrons. In a second approach, whole beech and spruce trees on the same site were labelled directly in the field with $^{15}NH_4{}^{15}NO_3$. Four weeks after labelling, the ^{15}N enrichment could already be detected in leaves and needles, but with uneven distribution within the crowns. Fifteen months later, roots and soil were sampled. The allocation of biomass as well as the uptake of ^{15}N by roots, mycorrhiza and soil microorganisms were investigated. Results of the examined parameters are presented and their contribution to the competitive ability of these tree species is discussed emphasizing different traits of the rhizosphere between beech and spruce.

P-406 **Changes in inorganic phosphorus fractions and availability in rhizosphere soil of rice after P addition**

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Changes in inorganic phosphorus fractions and availability in the rhizosphere of rice (*Oryza sativa* cv Khazar) with P application in paddy soils of North of Iran were investigated in a greenhouse experiment. The study was performed as a 14?2 factorial experiment in a randomized complete block design with 2 factors of soil at 14 levels (10 calcareous and 4 non-calcareous) and cultivation at 2 levels (cultivated and uncultivated), each level with 2 replicates. After a period of 3 months, specially designed soil tubes which had been buried in the beginning of the experiment, were simultaneously drown out of the cultivated and uncultivated pots and were immediately analyzed according to the P fractionation methods by Jiang and Gu (1989) and Kuo (1996) for calcareous and non-calcareous soils, respectively, and available-P was determined by Olsen method. In all 14 soils, the available soil P (Olsen-P) in the rhizosphere of rice was significantly lower than the non-rhizosphere soil (uncultivated). In calcareous soils, 0.25M $NaHCO_3$ extractable P (dicalcium-phosphates), 0.5M NH_4OAC extractable P (octacalcium-phosphates), and 0.5M NH_4F extractable-P (Al-phosphates) in the rhizosphere of rice were significantly lower than in the non-rhizosphere soil; whereas 0.25M H_2SO_4 extractable P (apatite-P), citrate-bicarbonate-dithionite extractable P (occluded-P) and (0.1N NaOH + 0.1N Na_2CO_3) extractable-P (Fe-phosphates) in the rhizosphere of rice were not significantly different from the non-rhizosphere (uncultivated) soil. In non-calcareous soils, 1M NH4Cl extractable-P (readily soluble-P), 0.1N NaOH extractable-P (Fe-phosphates), and 0.5M NH_4F extractable P (Al-phosphates) in the rhizosphere of rice were significantly lower than the non-rhizosphere soil; whereas 0.25M H_2SO_4 extractable P (Ca-P) and citrate-bicarbonate-dithionite extractable P (occluded-P) were not significantly different from the non-rhizosphere soil. In all soils, the pH of water on the surface of the soils in cultivated pots was significantly lower than uncultivated soils at the end of the growth period.

P-442 **Response of *Pisum sativum* L. to iron deficiency: Effects on growth, chlorophyll content, and root ferric chelate reductase activity**

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Fe deficiency was imposed by omission of Fe (-Fe), or by addition of bicarbonate (supplied as 10 mM $NaHCO_3$) as well as seedlings treated with adequate Fe (30 µM Fe^{III}-Na-EDTA) in the nutrient solution in two contrasting ecotypes of pea (*Pisum sativum* L., Merveille de kelvedon; tolerant to Fe deficiency and Lincoln; sensitive to Fe deficiency) for 5 weeks. The degree of tolerance to Fe deficiency was evaluated by determining root FCR activity, leaf chlorophyll index, Fe concentration in recently mature leaves, and fresh and dry weighs. Omission of Fe resulted in an increase in the activity of root Fe^{III}-chelate reductase (FCR) in both varieties, while FCR activity was generally lower in Merveille de kelvedon than in Lincoln. Shortage of Fe decreased the leaf chlorophyll index, the growth and the Fe concentration in leaves less in Merveille de kelvedon than in Lincoln which was found to be more sensitive to Fe chlorosis than Merveille de kelvedon.

P-859 **Exudates of maize and wheat: fate of ^{13}C-organic matter in soil during a short-term incubation**

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A broader knowledge of the contribution of carbon (C) released by plant roots (exudates) to rhizosphere microorganisms and soil is a prerequisite for understanding the role of exudates.

This study shows the contribution of constantly-applied ^{13}C-labelled maize and wheat exudates to microbial biomass-C (MB-C), CO_2-C evolution and water extractable organic carbon (WEOC), during a 25-day-incubation of agricultural soil material. The CO_2-C evolution and respective δ^{13}C values were measured daily. The WEOC and MB-C contents were determined weekly and a newly developed method for determining δ^{13}C values in soil extracts was applied.

Around 26% of exudate-C of both plants was recovered after the incubation, in the order WEOC.

P-557 **Effects of natural organic substances on nutrient flows in the rhizosphere**

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This work aimed at applying different innovative techniques for the assessment of nutrient flows in the rhizosphere. Experimental trials were carried out in order to evaluate the effects of 14 different natural organic substances (humic and fulvic acids) on rhizodeposition processes of maize plant. The selected humic and fulvic acids were previously characterized.

Plants were grown in rhizobox systems in a phytotron, in three replicates for each treatment. The organic substance was applied in the upper compartment only at the beginning of the experiment (sowing time). At full root development (after about one month from sowing) each rhizobox was sampled and rhizosphere was separated from bulk soil. On each sample (rhizosphere, bulk soil and upper compartment) chemical analysis of organic carbon and of main organic acids and sugars was performed. Bioassays with reporter genes biosensors were also carried out. Total microbial biomass counts and isolation of bacterial species to be used as bioindicators were performed as well, if necessary. All the results were normalized to the root weight.

The obtained data were statistically analyzed in order to highlight possible correlations between the structure of the organic substances investigated and their effect on root and microorganisms activity.

P-529 N and K distribution in *Olea europea*'s rhizosphere

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The nitrogen and potassium distribution in bulk soil and rhizosphere of *Olea europea* was studied. Soils and leaves were collected in the middle of June on different soil parental material. Mineral N (NH_4^+-N, NO_3^-N,) was extracted from fresh soil with KCl N. K fractions were extracted with water (soluble K), $AcNH_4$ N (exchangeable K) and boiling HNO_3 N (non exchangeable K). Student Fisher test enabled to confirm a significant difference between rhizosphere and bulk soil. The C and N organic contents were higher in the rhizosphere but soil pH values were lower than the corresponding bulk soil values. Rhizospheric soils showed an enrichment in soil extractable NH_4^+ and NO_3^- with NH_4^+-N predominating. NO_3-N in bulk soil was linearly and positively related to foliar nitrogen. All K fractions were much larger in rhizospheric soils. Foliar K was linearly and positively correlated with soluble K in the rhizosphere. The results obtained indicated that the root system of *Olea europea* induced changes in soil N mineral and K fractions but nitrogen and potassium levels surrounding roots appeared as inadequate to *Olea europea* for normal growth.

P-530 Dynamic of phoshorus in *Olea europea*'s rhizosphere.

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The aim of this work was to study the root-induced chemical changes occurring in the rhizosphere of Olea europea that can influence the dynamic of phosphorus. Bulk, rhizospheric soils and leaves were collected in 10 *Olea europea* orchards in winter. P-soluble was obtained by extraction with water, P-available by the Olsen method and P- total extracted with concentred $HClO_4$. The rhizosphere soil showed a significantly higher concentration of organic-carbon and total nitrogen. The concentrations of all phosphorus fractions in the rhizospheric soil were significantly lower than those in bulk soil. A P-available deficiency was measured in bulk and rhizospheric soil and confirmed by foliar P. P-available correlated both with P-soluble (r=0.85**) , P-total (r=0.76**) and P-total with P-soluble (r=0.71**) in the rhizosphere. The uptake of phosphate by tree root induced a depletion of all P fractions in the rhizosphere .

P-590 Method for selection of wheat on possibility of nitrogen fixation

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Wheat (*Triticum aestivum* L.) is a non-leguminous plant requiring optimal growing conditions in order to achieve high yield of good quality grain. A limiting factor and therefore one of the most important elements necessary for the synthesis of organic matter in wheat is nitrogen. In order to realize its yield genetic potential the wheat satisfies its demands for nitrogen mainly in two ways: from the soil and from the air.

This is the method for selection of plant species *Triticum aestivum* L. on atmospheric nitrogen binding ability and diazotrophs selection for investigated genotypes of wheat. Effective association genotype-diazotroph and nitrogen binding in accessible form for plants regulated with nitrogenase enzymatic complex has been studied. The procedure was conducted in lab conditions. It consisted of three successive passages of diazotrophs through the generations of plants. The wheat plants were grown in hydroponic cultures, in test tubes, with the addition of nitrogen-free solution Reid-York. With this method it is possible to increase the amount of nitrogen in soil and improve environmental protection while the investment in agricultural production decreases.

P-914 Soluble organic N and microbial processes in the rhizosphere of a lowland tropical rainforest in Australia

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Nitrogen (N) availability commonly regulates biomass production as well as species composition and contributes to the long-term stability of natural forest ecosystems. The objective of this study was to investigate the rhizosphere effects on pool size and dynamics of soluble organic N (SON) and associated microbial processes in a lowland tropical rainforest in Australia. The field research site was located within Australian Canopy Carne Research facility at Cape Tribulation, North Queensland, Australia, with an elevation of 40 m, an annual average rainfall of 3500 mm and average daily temperature of 22-36°C. Vegetation is complex mesophyll vine forest, with dominant trees belonging to Proteaceae, Meliaceae and Sapinadaceae. Rhizosphere and bulk soil samples were randomly collected with a conventional hand-shaking method from five designated areas (10 m x 10 m each). Results from this study showed that rhizosphere soils had higher soil total C and N and available mineral N contents than bulk soils. The NH_4^+-N was dominant form of mineral N (over 95%) in bulk soils, while similar amounts of NH_4^+-N and NO_3^--N were found in rhizosphere soils. Rhizosphere soils had greater concentrations of SON (in KCl extracts) (222 mg kg^{-1}) with lower C:N ratios, compared with bulk soils (189 mg kg^{-1}). But SON only comprised 29% of total soluble N in rhizosphere soils, while it amounted to 37% in bulk soils. Average concentration of potential production of SON during a 3 day anaerobic incubation was greater in rhizosphere soils (49 mg kg^{-1}) than bulk soils (33 mg kg^{-1}). Microbial biomass C was greater in rhizosphere soils (average 1996 mg kg^{-1}) than in bulk soils (1582 mg kg^{-1}), while there was no difference in microbial biomass N between rhizosphere and bulk soils. Microbial activity measured during a 2 week incubation (22°C) was also much greater in rhizosphere soils (average 6.2 mg CO_2-C kg^{-1} h^{-1}) than bulk soils (2.0 mg CO_2-C kg^{-1} h^{-1}). Carbon substrate utilization profiles measured by Biolog GN2 plate reading were distinct between rhizosphere and bulk soils, with higher values of average well color development (AWCD), substrate richness and Shannon's diversity index in rhizosphere soil. The above results strongly demonstrated that rhizosphere microbial processes play an important role in the N cycling in this tropical rainforest.

P-932 Root uptake of N containing and N free low molecular organic substances

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Many studies investigating uptake of nitrogen (N) from organic substances by plants were conducted with amino acids. It was frequently concluded that in some ecosystems with limited mineralization rates (water saturated soils, low temperatures, low pH etc.) amino acids may significantly contribute to the N demand of plants and that roots have special transporters to re-uptake amino acids released from the root into the rhizosphere by exudation or secretion. However, the relevance of organic N uptake can be evaluated only by comparison of the uptake of N-containing and N-free organic substances.

We compared the uptake and distribution between roots and shoots of maize of three substances representing main groups of root exudates: alanine for amino acids, glucose for sugars, and acetate for carboxylic acids. To trace the uptake in organic form the substances were labelled with ^{14}C and ^{15}N. These substances were injected into the rhizosphere of maize in rhizosphere relevant concentrations. To compare the uptake of organic and mineral N, ^{15}N labelled KNO_3 was added to the treatments with glucose and acetate. The dynamics of ^{14}C and ^{15}N in five root zones and in shoots were measured during 9.5 days after substance addition.

^{14}C from alanine was taken slightly higher than ^{14}C from glucose and acetate. However the total ^{14}C in shoots and roots was less than 1.0% of the added ^{14}C. Dynamics of ^{14}C in shoots suggests that one third to half of the substances allocated in shoots was used for respiration. ^{14}C in roots was nearly constant (0.1-0.15% of added ^{14}C) and did not changed significantly during 9 days. Furthermore, the distribution in plants of ^{14}C originating from the three substances was similar.

The uptake of ^{15}N from added alanine and from KNO_3 was about 10 to 50 times higher than that of ^{14}C. However, plant uptake of nitrate (23.6 to 35.2% of ^{15}N input) always exceeded the uptake of ^{15}N from alanine (9.6 to 28.8%).

The results of ^{14}C uptake from three sources clearly show that maize did not prefer N-containing to N-free organic substances. The main uptake of N from amino acids occurs after their mineralization. Therefore, we conclude that under soil conditions the uptake of organically bound N occurs mainly by passive flow driven by transpiration. The contribution of specific amino acids transporters is of minor importance.

P-949 Response of microbial respiration and DNA on glucose addition to root-free and rhizosphere soil at different N levels

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Effect of two factors: distance from plant roots and nitrogen content - on respiration activity, microbial dsDNA content, microbial biomass and maximal specific growth rate (μm) on glucose has been studied in field experiment. Two crops with different root systems: sugar beets and winter wheat were investigated in field experiment of the Institute of Agroecology (FAL, Braunschweig, Germany). The plots with full and 50% of recommended rate of N fertilizers (126 and 63 kg N ha^{-1} $year^{-1}$, respectively) were chosen for comparison of N effect on microbial communities of root free and rhizosphere soil.

All investigated microbial parameters were significantly affected (two-way ANOVA) by both factors: root proximity and N content. The main differences between microbial communities of root-free and rhizosphere soil were the overall increase of microbial biomass, DNA content, maximal specific growth rate and therefore, the fraction of microorganisms with r-strategy in rhizosphere soil compared to bulk soil. Compared to 50% fertilization significant increase by 100% N amendment were measured for microbial biomass, μm, response time for substrate addition and DNA content both in rhizosphere and bulk soil. The rhizosphere effect for microbial respiration, biomass and specific growth rate was more pronounced for plots with half-rate of N fertilizer compared to full N addition. The DNA content was significantly lower in bulk compared to rhizosphere soil both before and during microbial growth initiated by glucose amendment. Addition of glucose to the soil strongly increased the amount of CO_2 respired per DNA unit before glucose addition. However, the quantity of CO_2 evolved per unit of new formed DNA was constant in growing microbial biomass and was not significantly different in bulk and rhizosphere soils. This reflects the equal substrate use efficiency for microbial communities of root-free soil and rhizosphere during exponential phase of growth.

P-444 Seasonal chemical changes in rhizospheric and bulk soil under maize in open field

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Nutrient concentrations in the vicinity of plant roots often differ from concentrations in the root-distant soil. Accumulation of nutrients in the rhizosphere occurs when the rate of nutrient supply from soil is higher than nutrient uptake by plant roots; in the converse situation depletion of nutrients takes place. Despite the abundance of recent studies on the rhizosphere, there are still some important knowledge gaps. For instance, most investigations are performed in laboratory and thus cannot adequately reproduce some key environmental conditions, such as short periods of observations, absence of mycorrhizal fungi and limited soil volumes. The specific objectives of this investigation were to compare chemical properties (pH, organic C, exchangeable cations and CEC) of the rhizosphere and the bulk soil in open field under maize (i) unfertilized and fertilized with organic and inorganic P and with N as urea, (ii) in the presence of indigenous mycorrhizal fungi and of introduced *Glomus intraradices*; and finally (iii) to evaluate whether these variables were modified during the growing season and nutrient uptake by maize.

The soil was a clay loam, alkaline (pH 8.5, 1:2.5 soil:water) and classified as a Vertic Xerofluvent, containing 60 mg kg^{-1} total $CaCO_3$. Soil (rhizosphere and bulk soil) and plant samples were collected at 40, 80, and 120 days after sowing (das). In all treatments, rhizosphere pH was significantly lower than in the bulk soil, especially at 40 and 80 das (0.4-0.5 pH units) and in fertilized plots. In unfertilized plots, smaller $\triangle$pH (-0.2) were found. The rhizosphere processes led to an enrichment in root environment. This zone was richer in organic C, CEC and in exchangeable base cations (K, Mg). The accumulation achieved maximum values at the end of growing season. K and Mg concentrations increased during the growing season in all treatments but with a different trend in the rhizospheric and bulk soil of inoculated plots compared to uninoculated plots. In the unfertilized plots, the trend was similar as compared with fertilized but smaller differences were found between rhizosphere and bulk soils and between the beginning and the end of the growing season. Nutrient uptake was higher in plants inoculated with *G. intraradices*.

P-989 A study on inorganic phosphorus fractions in five super-xerophytic shrubs rhizosphere of the Alashan Desert

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The phosphorus (P) availability in soils of the Alashan desert region (Inner-mongolia, China) is extremely low. Many shrubs in this region, however, grow well there. The objective of this study was to investigate the characteristics of inorganic P fractions in rhizosphere of five super-xerophytic shrubs. Soil pH values in rhizosphere of all five shrubs were decreased. Total P concentrations in the rhizosphere of all five shrubs were greater than those in the corresponding bulk soils. Olsen P concentrations were greater in the rhizosphere of *Zygophyllum xanthoxylum*, *Ceratoides holmgern*, *Atraphaxis bracteata* and *Tetraena mongolica* than those in the corresponding bulk soils. In the rhizosphere of *Reaumuria soongorica*, however, Olsen P concentration was lower than that in the bulk soil. The concentrations of dicalcium phosphate (Ca_2–P) in the rhizosphere of all five shrubs were lower than those in the corresponding bulk soils. There were no significant differences in hydroxyapatite (Ca_{10}–P) concentrations between the rhizosphere and the corresponding bulk soils, except in *T. mongolica* with greater Ca_{10}–P concentration in the rhizosphere. In the rhizosphere of *Z. xanthoxylum* and *A. bracteata*, concentrations of octocalcium phosphate (Ca_8–P) and strengite (Fe–P) were significantly lower than those in the corresponding bulk soils. Furthermore, variscite (Al–P) concentration in the rhizosphere of *R. soongorica* was greater than that in the bulk soil. In contrast, the concentrations of Al–P in the rhizosphere of other four shrubs were lower than those in the corresponding bulk soils. The concentrations of occluded phosphate (O–P) in the rhizosphere of *R. soongorica* and *T. mongolica* were lower than those in the corresponding bulk soils, and greater in the rhizosphere of *Z. xanthoxylum* than that in the bulk soil. The results indicated that soil pH affects P availability and those super-xerophytic shrubs virtually acquired P from all inorganic P pools tested.

P-1004 Cobalt effects on root nodulation, nutrient content and yield of faba bean (*Vicia faba* L.)

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It has been known that cobalt is an essential element for humans, animals and microorganisms. The essentiality of Co in plants has not been recognized, although it is needed by rhizobia in root nodules of leguminous plants. The mechanisms by which Co affects plants are not yet clearly known, although it is known, that Co inhibits many physiological processes, such as photosynthesis, seed germination, plant growth and yield (Walsh, 1995; Liu et al., 2000). The present investigation was to study the influence of rates from Co on nodulation, nutrients content and yield of faba bean (*Vicia faba* L.) cv. Giza 461.

In a preliminary experiment we studied different rates of Co addition to faba bean plants. We found that over 20 mg kg^{-1} cobalt inhibited growth of faba bean. Based on our preliminary experiment we used 5 rates of Co. The rates of Co addition were 0, 5, 10, 15 and 20 mg kg^{-1} at 14-days old at nursery. The seeds of faba bean cv. Giza 461 were sown in nursery. One week later faba bean plants were transplanted to the field in two successive seasons 2004/05 and 2005/06. The plants of faba bean were grown in sandy loam soil at Nubarai Experimental farm, National Research Centre, Egypt. At flowering, one sample was collected for morphological, physiological and biochemical investigation. The total N concentration in plants was estimated by macro Kjeldahl method.

Co addition increased plant height, stem diameter, branch number, leaf number/plant and leaf area/plant and the increase was in parallel with increasing Co rates. Co increased significantly ($p < 0.05$) root nodule number and nodule dry weight/plant. Root, shoot and total biomass and their TN (%), and TN (mg/plant) of sample at flowering stage were significantly increased with increasing Co rates. Co addition resulted in increasing nutrients content (P & K (%), and Co, Fe, Mn, Zn and Cu (mg kg^{-1})) of roots and shoots of plants at flowering, Co addition increased significantly ($p < 0.05$) total biomass, seed yield and seed content of nutrient (P, K, Fe, Mn, Zn, & Cu) at harvest. In addition, content of seeds from TSS %, total crude protein% at harvest was significantly ($p < 0.05$) increased due to application of cobalt.

Liu J., Reid R.J, Smith F.A.2000.The mechanism of cobalt toxicity in mung beans. Physiol. Plant. 110: 104-110.
Walsh K.B. 1995. Physiology of the legume nodules and its response to stress. Soil Biol. Biochem., 27 (4/5): 637-655.

P-533 **The influence of the tamarisk on the distribution pattern of soil salinity and moisture in northern Taklamakan desert, Xinjiang, China**

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We analysed the soil Na^+, K^+, EC, pH and moisture contents beneath the tamarisk shrub in saline meadow which in margin of alluvial fan, the shrubland in alluvial plain include middle, middle-lower and lower part, and the edge of Taklamakan sandy desert. These landscape locations belong to three typical landscape in southern Xinjiang arid zone. We also determined Na^+, K^+ contents in shoot of tamarisk. Results suggested that the tamarisk induced soil salinity to the patchy distribution pattern beneath its canopy, namely islands of salinity. The tamarisk also changed the ratio of Na/K and increased soil alkalinity The higher content of salinity in its shoot may play important role in the formation of island of salinity. The effect of island of salinity was most significant in middle alluvial plain, in which the soil salinity and moisture content was medium in five landscape locations. But such effects disappeared in middle-lower alluvial plain and the edge of sandy desert, in which the soil salinity and soil moisture content was highest and lowest in five landscape locations, respectively. Results suggested that in the landscape location with higher soil salinity content such as saline meadow and middle-lower alluvial plain, there was negative correlation between island of salinity and soil salinity, but significantly positive correlation with soil moisture content. While in the landscape locations with medium or lower salinity such as middle, lower alluvial plain and the edge of sandy desert, there was significant correlation between the effect of island of salinity and soil salinity, soil moisture content. These results showed that the significance of island of salinity was closely relate to the soil salinity and moisture content. So the island of salinity was most significant in the landscape location with medium groundwater table that appropriate for tamarisk growth. In addition, the tamarisk decreased the soil moisture content beneath its canopy. The influence of tamarisk on distribution pattern of soil salinity and soil moisture can be attributed to the effect of tamarisk rhizosphere on the uptake of Na^+, K^+ from groundwater, which produced negative effect on revegetation of salinization desert in arid zone.

P-887 **Comparative transcriptomic analysis under phosphorus deficiency among three model plants**

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Phosphorus (P) is one of the essential elements for plant growth. While in soil, P is usually bound with metals or organic compounds which make it the most difficult nutrient for the plant to utilize. Under P deficient conditions (-P), plants are known to have developed several strategies to absorb P directly from these compounds, for example, by secreting organic acids. However, the strategy varies between plant species. We investigated comprehensive adaptive responses of plants by comparing transcriptomic analysis on rice, *Lotus*, and *Arabidopsis* grown in hydroponically under P-sufficient and P-deficient conditions.

Genes which are known to be involved in obtaining external P such as phosphate transporter and phosphatase were highly up-regulated in all plants. In addition, the glycolysis pathway was accelerated in all plants as reported in past studies. Interestingly, there was variation between plant species in terms of flavonoid biosynthesis. In the *Arabidopsis* shoot, flavonoid biosynthesis was strongly accelerated by -P, and genes of anthocyanin synthesis were highly up-regulated. Flavonol synthase was also highly up-regulated, and suggested that flavonol glycoside biosynthesis might be accelerated. In rice root, flavonoid biosynthesis was highly accelerated by -P. Most strongly up-regulated were phenylalanine ammonia-lyase (PAL), cinnamate 4-hydroxylase (C4H), 4-coumalate-CoA ligase (4-CL), chalcone synthase (CHS), chalcone isomerase (CHI). Unlike *Arabidopsis*, the expression of flavonol synthase in rice was strongly down-regulated, which suggests repressed flavonol glycoside biosynthesis. In the *Lotus* shoot and root, PAL, C4H and CHS were strongly down-regulated by -P, suggesting that secondary metabolism was repressed by -P. However, the expression of flavonol synthase was up-regulated, suggesting that flavonol glycoside biosynthesis could be accelerated by -P. In conclusion, there was a distinct change in secondary metabolism as a result of -P, and the pattern of change varied with plant species. Most notably, the distinct pattern of change in the secondary metabolism of *Lotus* implied that *Lotus* may have different -P adaptive mechanisms from other plants. Flavonoids are secondary metabolites and some of them are known to act as a signaling molecule in plant-microbe interactions. It is suggested that -P might increase the production and subsequent secretion of flavonoids from roots, and may regulate the activity of rhizosphere microbes.

P-1014 The rhizosphere effects of different age alfalfa on nitrogen supply on saline soil

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Alfalfa, the crucial perennial legume forage in the northwest China, could accumulate soil organic matter, improve physical and chemical characteristics of soil, and fix nitrogen from the air. Plenty of researches have shown that legume forage could improve soil fertility. The present study investigated the characteristics of rhizosphere nitrogen under different age alfalfa on saline soil.

The study was carried out in June 2006 at the Linze Grassland Faming Experimental Station (Hexi Corridor, western Gansu province), where the elevation is 1390m. The mean annul air temperature was 7.6°C and annual precipitation was 121.5mm, respectively. Five plots (55X33m^2) with alfalfa planted in 1998(8 years), 2001(5 years), 2002(4 years), 2003 (3 years), 2004 (2 years) respectively were selected for sampling. 10 seedlings were randomly selected within each plot. The rhizospheres and bulk soils were collected by shaking method. Total N concentrations were measured by Kjeldahl method and nitrite N concentrations were measured by ion chromatography.

Whatever the ages of alfalfa, the total N concentrations in the rhizosphere were significantly higher than that in the bulk soils. The total N concentrations in the bulk soils were decreased noticeably from 2 years to 4 years. However, the total N concentration increased from 4 to 8 years. The total N concentrations in rhizosphere were significantly higher than that in bulk soils. It is surprising that the total N concentrations in rhizosphere of 4 years and 8 years alfalfa under which the total N concentrations in bulk soils were the lowest and the highest respectively were significantly higher than that in the rhizosphere of others.

The nitrite N concentrations in rhizospheres were significantly higher than that in the bulk soil in all plots. The nitrite N concentrations in bulk soil increased with the age of alfalfa. But nitrite N concentration in the rhizospheres under 4 years alfalfa was the highest among all plots. In conclusion, the rhizosphere effect of alfalfa on saline soil was one of crucial factors for the N supply in soil. Furthermore, the effects of different age alfalfa were significantly different.

P-865 Does rhizospheric activity explain forest ecosystem sustainability?

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Temperate forests are mainly developed on non-fertilized and nutrient-poor soils where the nutrient availability is a tree growth limiting factor. A hypothesis for sustainable forest development proposes that tree roots adapt to the conditions of nutrient availability in the soils. To test this hypothesis, we have performed *in situ* experiments in oak, beech and spruce stands.

First, we incubated during 4 years different test-minerals in the rhizosphere and the bulk soil of a beech stand, which had been or not previously fertilized. We observed a higher dissolution of the minerals in the beech rhizosphere compared to the bulk soil, but in the non-fertilized ie nutrient-poor soil conditions only. Secondly we compared the functional structure of the soil bacterial communities potentially involved in mineral weathering in the oak, beech and spruce stands (mycorrhizosphere vs bulk soil). We showed that in the oak and beech stands, where the pH of the tree rhizosphere does not differ from that of the bulk soil, oak and beech, roots mycorrhized with *Scleroderma citrinum* select soil bacterial strains efficient for mineral weathering. This structuring effect does not exist in the *S. citrinum*-Norway spruce mycorrhizosphere. Interestingly, the pH of the spruce rhizosphere is more acid than that of the bulk soil due to a massive release of H^+ by the roots to balance predominant NH_4^+ absorption. Because the production of H^+ is one of the main mechanisms responsible for mineral weathering, our results suggest that oak and beech do not use the same strategy as spruce for accessing nutrients from soil minerals. Indeed contrary to spruce which roots can directly weather minerals by the release of H^+, oak and beech have developed indirect strategies for mineral weathering which rely on the selection of mycorrhizosphere bacterial communities with high weathering potential.

From these results, we propose a conceptual model to account for mineral weathering processes in forest soils and tree rhizosphere. It hypothesizes the preponderance of physical and chemical weathering in soils where the nutrient availability is high. However when the nutrient availability is too low, biological weathering take the reins in the rhizosphere. This model suggests a strong plasticity of the rhizospheric activity in forest soils, in relation with the weathering processes and the nutrient availability, which could explain the sustainability of forest ecosystem.

P-886 Weathering of horticultural vermiculite and perlite by ectomycorrhizal fungi : effect on nutrient and metal cations

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Ectomycorrhizal fungi (EF) are widely recognized as controlling the cations availability to plant roots, including those of potentially toxic metal cations. EF adopt several stategies depending on the implied cation, the host-root and the soil conditions (CEC, pH, amount of exchangeable Ca2+). Taking ectomycorrhizal fungi as an example, *Tuber melanosporum* prevents toxic metal pollutions by storing the metal in its cell structures, even at a senecent stage, while Hebeloma cylindrosporum facilitates the root tolerance by enhancing sorption of other major nutient cations. These nutrition and detoxication functions are generally studied in short periods of time (1h to 72h) comparing *in vitro* young rhizospheric systems incubated in diluted (0,02 up to 0,5M) cations salt solutions (chloride, sulfate or nitrate). Nonetheless, either in natural or hortical context, major and metal cations are mostly provided in the long term by weathering of soil minerals.

The present study examine the *in situ* EF impact on weathering of two commonly used horticultural minerals : vermiculite and perlite. The two minerals were first analysed in their unweathered commercial form. Rhizospheric weathering was experimentally induced by *Quercus pubescens* seedlings grown within 6-months in individual greenhouse planters filled with same horticultural mix of 1/3 of perlite volume, 1/3 of dry expanded vermiculite and 1/3 of wet peat moss. Three treatments were compared : 1) non mycorrhized trees, 2) trees naturally collonized by *Hebeloma cylindrosporum* and 3) trees initially infected by *Tuber melanosporum*. Weathered minerals were then handly separated. Morphological and chemical features were characterized by scanning electron microscopy (SEM-EDS) and electron microprobe (EMPA). Alteration was followed by X-ray diffraction (XRD).

In the studied soil-tree micro-symbionts, the Ca rich-perlite sharply breakdown. Mycorrhized roots are generally covered by Ca-rich fine particles. Morphology of the identified hydroxy-interlayer vermiculite is rather preserved. However, XRD patterns indicate different effects for the two implied ectomycorrhizal fungi. According to the first microscopic chemical analyses, *Tuber melanosporum* affects the realease of K and Mg. This could also affect the location of Ti, Cr, and Mn initially present the vermiculite.

P-1053 Effect of sulphur fertilization on root development of tea plants

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Sulphur fertilization is important for growth, yield and product quality of tea. Main focus of the research has been on the development of aerial portions of tea. Healthy development of feeder roots is essential for efficient absorption and utilization of native fertilization on growth of the roots of tea plants. Nursery seedlings of the variety Kangra Asha were used in this study where, sulphur was applied in quantities equivalent to 50, 100, 150 kg/ha while comparing no sulphur treatment. Several sources of sulphur were compared namely elemental sulphur, gypsum, iron pyrites, aluminium sulphate, ammonium sulphate and single super-phosphate. Root volume was measured by volume displacement method at three intervals in a year, representing three important seasons of the crop.

Study indicated that application of sulphur (average of all sources) at the dose of 50 kg/ha significantly increased root volume as compared to no sulphur application. There was no remarkable increase in volume beyond this dose, irrespective of the sources tried. However, seasonal variation and variation among sources was observed and there was an interaction between these factors. This study suggests different sulphur management options for effective root development.

P-512 Pseudomonad siderophore promotes iron nutrition of *Arabidopsis thaliana*

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Most aerobic organisms have developed an active strategy for iron uptake. In dicotyledon plants, this strategy involves (i) the excretion of protons, (ii) the reduction of Fe(III) by reductases, and (iii) plasmalemma transport of Fe(II) by iron transporters. In microorganisms, this strategy is based on the synthesis of siderophores and ferri-siderophore membrane receptors, in iron stress conditions. Pyoverdines are the major class of siderophores synthesized by fluorescent pseudomonads. Taking into account the strong iron competition in the rhizosphere and the high affinity of pyoverdines for Fe(III), these molecules are expected to interfere with the iron nutrition of plants, as they do with rhizospheric microbes.

The impact of Fe-pyoverdine on iron nutrition of *Arabidopsis thaliana* was compared to that of Fe-EDTA. Iron chelated to pyoverdine was incorporated in a more efficient way than when chelated to EDTA leading to an increased plant growth and chlorophyll content. Over accumulation of iron in an over-expressor ferritin transgene of *A. thaliana* was enhanced upon supplementation with Fe-pyoverdine compared to Fe-EDTA. A transgene knockout iron transporter IRT1 of *A. thaliana* showed a significant lower iron and chlorophyll content when supplemented with Fe-EDTA than the wild-type, but not when supplemented with Fe-pyoverdine. This observation indicates that in contrast with iron chelated to EDTA, iron from pyoverdine was incorporated through a different transporter than IRT1. Incorporation of iron from Fe-pyoverdine was consistent with the presence of pyoverdine *in planta* as shown by ELISA and by tracing ^{15}N of ^{15}N-pyoverdine.

Altogether, these data demonstrate the acquisition of iron from Fe-pyoverdine by *A. thaliana* and indicate that this acquisition could be related to an as yet undescribed pathway. Researches are underway to identify this pathway and to localise pyoverdine *in planta*.

Vansuyt G., Robin A., Briat J.-F., Curie C., Lemanceau P. 2007. Iron acquisition from Fe-pyoverdine by *Arabidopsis thaliana*. MPMI. (in press).

P-832 P availability, fine root properties and functional mycorrhizal diversity across *Pinus pinaster* stands with different productivity in South-western France

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The *Pinus pinaster* forest in South-western France covers 0.9 million hectares, with mainly acidic, sandy, nutrient-poor spodosols. This forest produces the fifth of French wood and is characterized by a large variation in productivity. We aimed at linking these variations to the nutritional status of soils and a range of plant root parameters.

Twenty-seven sites were selected so as to cover a range of site productivity, phosphorus (P) and water availability levels. These include fertilizer trials and other monitoring sites both on humid and dry environments. Site productivity was estimated from a standard forest inventory operated in 2005. In April and November 2006 eight pairs of sample points were chosen in the tree lines and between the tree lines close to randomly distributed trees. Soil P status (Olsen P and total organic P), amount of fine roots, diversity and phosphatase activities of ectomycorrhizae (ECM) and their associated bacteria were determined in 15x8 cm soil cores.

Differences between sites were striking. Grouping samples according to sample position, fertilization regime, stand age or water availability showed that P forms were greater in April than November. Olsen P level was significantly larger only between the tree lines of annually fertilized plots, compared to all other plots. The measured root parameters, i.e. fine root length density (FRLD), specific root length (SRL), vitality of apices, mycorrhizal colonization degree and ECM phosphatase activities were significantly greater in November than April. Only SRL and vitality of apices increased as a response to P fertilization. On the contrary, P-solubilizing capacities of mycorrhizospheric bacteria were greater in control plots with no P fertilizer. ECM pNNPase activities were always measurable and tended to decrease as a response to fertilization. Multivariate statistical analyses of the data will be presented in order to draw the possible relationships between tree productivity, biotic and abiotic factors in the root environment.

P-828 The response specificity of oxalic acid exudation and acid phosphatase secretion with the internal plant P status in *Brachiaria* grasses

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The breeding of phosphorus (P) efficient genotypes adapted to low-input agricultural ecosystems has become a matter of priority. The elucidation of P efficiency mechanisms will contribute towards the design of appropriate selection criteria to permit the screening of genetic recombinants in the *Brachiaria* breeding program. Genotypic differences in P acquisition efficiency are related to adaptive changes in root morphology, biochemistry and physiology.

We investigated a possible link between the P nutritional status and physiological markers for P stress in *B. decumbens* (signalgrass) and *B. ruziziensis* (ruzigrass). Field studies indicated that signalgrass is better adapted than ruzigrass to acid soils. The contribution of both organic acid exudation and acid phosphatase secretion during the development of limiting plant P concentrations were examined. In addition, changes in biomass and root length production as well as root biomass allocation, acting as morphological markers for P deficiency, were studied.

The brachiariagrasses were grown hydroponically. In terms of phosphorus nutrition, the novel hydroxyapatite/dialysis pouch system which permits the pH-dependent release of phosphate from an apatite was implemented. Before each of three harvest times (3 weekly intervals), root exudates were collected.

Our results suggest that the temporal induction of oxalic acid exudation and acid phosphatase secretion are linked to decreases in internal plant P concentrations. Species differed with regard to the magnitude of the tissue P concentration required for the induction of these root-mediated rhizospheric mechanisms for P acquisition. Evidence will also be presented showing that the manifestation of these biochemical markers for phosphate stress preceded the appearance of P limited plant growth.

It is possible that oxalic acid exudation might provide a dual ecological solution to alleviate the effects of P deficiency and Al toxicity, two major co-existing soil constraints for *Brachiaria* pasture productivity. Acid phosphatases involved in the hydrolysis of organic P, is another important way for tropical plants to enhance P availability, particularly as a large proportion of soil P occurs in organic forms. Indeed, functional synergism between oxalic acid exudation and acid phosphatase secretion in brachiariagrasses for P acquisition cannot be excluded.

P-1110 **The content of mobile phosphorus and phosphatases in rhizosphere soils under different management of fertilizer application**

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Significant decrease of livestock units has been observed in the Czech Republic for the last 15 years. The alternative to lower the negative organic matter balance is the application of stabilized sewage sludge with minimal pollutants contents. Besides increasing the organic matter content in the soil, sewage sludge also increases soil nutrient status (especially P).

At 5 different sites in the Czech Rep., long-term experiments with different organic matter application regimes have been carried. For rhizobox experiments, the following variants were included: (a) control variant (without any fertilization); (b) sewage sludge (applied once in three years before potatoes in a rate corresponding to 330 kg N ha^{-1} and 240 kg P ha^{-1}); (c) manure (applied once in three years before potatoes in a rate corresponding to 330 kg N ha^{-1} and 70 kg P ha^{-1}). Rhizobox experiments were carried out with soils after three completed experimental cycles (9 years). A Cambisol with the following parameters was chosen for the experiment:

(a) control; pH–5.0; P content (mg kg^{-1}): H_2O–12.0; Mehlich 3–105; aqua regia–678
(b) sewage sludge; pH–5.1; P content (mg kg^{-1}): H_2O–16.2; Mehlich 3–216; aqua regia–878
(c) manure; pH–5.1; P content (mg kg^{-1}): H_2O–16.2; Mehlich 3–174; aqua regia–758

The tested plant species included winter wheat (*Triticum aestivum* L.), oilseed rape (*Brassica napus* L.) and white lupin (*Lupinus albus* L.). The experiments were carried for 8 weeks. Rhizosphere soil was separated into 1-mm layers. Both fertilized variants (sewage sludge, manure) reflected higher biomass yields of roots as well aboveground parts and higher P uptake by plants. The results showed a decrease of soil pH only in the close vicinity of oilseed rape roots (1–3 mm). In the case of winter wheat and oilseed rape, a zone with a significant depletion of mobile P was observed. Furthermore, significantly higher enzymatic activities of acidic and alkaline phosphatases were found in rhizosphere soil compared to bulk one and in both fertilized variants compared to the control one. The results concerning easily extractable C (0.01 M $CaCl_2$) suggest that a significantly higher concentration of C was found in the close vicinity of roots (<1 mm). From our results it is possible to assume that a different P sorption in soil occurs in variants treated with sewage sludge compared .to manure treated variants.

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P-580 **Investigation of *Azotobacter* and Mycorrhiza efficiency at different levels of phosphorus in corn field**

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Nitrogen and phosphorus are essential nutrients for increasing plants growth and yield. Deficiency of these nutrients in soil usually compensate with application of chemical fertilizers. The chemical fertilizers have detrimental effects on environment and decrease quality of agriculture products. The present study conducted to evaluate *Azotobacter* and Mycorrhiza as biofertilizers at different levels of phosphorus (super phosphate) as chemical fertilizer. Effects of these three factors including *Azotobacter* (without and with inoculation – *Azotobacter chrococcum*), Mycorrhiza (without and with inoculation-*Glomus intraradices*) and phosphorus (50 kg P/ha, 100 kg P/ha and 200 kg P/ha) evaluated by a factorial experiment in the form of completely randomized block design with three replications in agriculture research center of markazi province in Iran. Effects of these three factors and their interactions investigated on some parameters such as ear weight, ear diameter, plant height, forage yield (wet biomass), ear length (without cover), root colonization percentage, Nitrogen percentage, mineral concentration in stalk (P, K, Ca, Fe, Zn, Cu and Mn), growth physiological index (leaf area index, growth rate, relative growth rate and leaf area ratio), Acid Detergent Fiber (ADF), Organic Matter (OM) and Crude Protein (CP). Results showed that application of Mycorrhiza and Azotobacter increased some of parameters such as yield components ,wet biomass (5.4% for Mycorrhiza and 7.01% for *Azotobacter*), plant height (2.6% for Mycorrhiza and 5.4 for *Azotobacter*), colonization percentage (25% by application of Mycorrhiza), plant nitrogen (4.5% for Mycorrhiza and %7.2 by *Azotobacter*), plant protein (3.7% for Mycorrhiza and 6.5% by *Azotobacter*) and physiological growth index especially leaf area index (by application of Mycorrhiza and *Azotobacter*) significantly in comparison with control. Furthermore in order to positive effect of *Azotobacter* on plant shoot and increasing of biomass yield, mineral concentration (including Fe, Mn, Cu, P and K) decreased significantly. Interaction of Mycorrhiza and *Azotobacter* (Application two inoculants together) in comparison with effect each one had the most effect on studied parameters, specially wet biomass, plant height, root colonization percentage, nitrogen percentage, protein percentage, organic matter percentage and phosphorus percentage significantly and increased mentioned parameters.

P-1185 Liquid ammonium fertilized spring barley (*Hordeum vulgare* L.) yield responses to different growth temperatures

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A pot experiment was conducted in controlled conditions to evaluate the effect of different soil temperatures on barley crop growth parameters and attainable grain yield. In addition, yield forming structures as well as shoot and root biomass accumulations under controlled uptake long term ammonium nutrition (CULTAN) fertilization were also assessed. Three growth chambers representing low, medium, and high temperature regimes were adopted and subjected to stepwise temperature increases at four different barley crop growth stages to mimic the gradual temperature increases from early spring to late autumn during the cropping season as is common within the temperate regions. Crop growth stages considered included seedling stage to the end of tillering, start to end of booting, flowering commencement to its end and finally end of flowering till grain maturity at harvest. Each temperature regime represented a separate growth environment constituted of two replicates of three nitrogen treatments namely, non-fertilized control, sole nitrate and injected ammonium nutrition.

The study found that barley crops fertilized with highly concentrated liquid ammonium nutrition developed intensive root networks around injection-points. In contrast, this feature was not observed in the rhizospheric zones of sole nitrate and non-fertilized control treatments. Both ammonium and nitrate fertilized crops responded to decreasing growth temperatures by increasing surviving tiller numbers which consequently resulted into more grain yields. Both root and shoot biomass accumulations also expressed a similar increasing trend with diminishing temperature ranges. A positive correlation was observed between root biomass and grain weights on one hand, while a negative correlation was seen between grain weights and numbers on the other. It was also observed that barley grown under low temperatures took longer durations (180 days) to attain maturity compared to those under high temperatures (120 days). Even though both forms of nitrogen supported higher below and aerial biomasses with reducing growth temperatures, ammonium nutrition remained superior to nitrate fertilizer. The study has demonstrated that growth temperatures interact with nitrogen nutrition especially soil injected liquid ammonium nutrition to cause a suite of growth responses especially within the roots to impact on attainable grain yield and shoot biomass accumulations in spring barley.

P-1195 Bioavailability of Si in cultivated soils from Boigneville (Essone, France)

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While silicon is the second most abundant element in the Earth crust, it is not considered essential in the plants realm. However, Si is taken up by many plants and has proved to be beneficial to them. Even though Si can be found under numerous forms in soils, not all of them are taken up by plants. Agronomists define bioavailable silicon as 0.01M $CaCl_2$ -extractable Si or acetate-extractable Si (pH=4), without worrying about the Si speciation in soils. The most available source of Si for plants should be the most soluble silicates. Phytoliths (amorphous silica particles formed in plants) are one of the most soluble forms of Si in soils and therefore one of the best source of Si for the growing plants. In cultivated areas, part of the Si taken up by plants is exported at harvest from the fields, unlike in natural conditions. We speculate that a decrease of the phytolith stock should lead to a decrease in bioavailable Si and a possible impact on crop yields unless amendments are provided. Here we present the first results on three experimental plots located at Boigneville (Arvalis experimental station, Beauce region, France). The same crop rotation was applied (wheat, maize for 12 years followed by sugar beet, wheat and peas during 9). Cereal straw was either removed or incorporated into the soil and plots were either ploughed to 25 cm before sowing or directly sown. Our goal was to assess the possible effect of straw incorporation and direct seeding on Si stocks. First, XRD was used for a mineralogical assess of the three soils. They offer similar composition: mainly quartz, feldspaths, micas and clays, in relatively similar proportions. Phytoliths extracted by the gravimetric method show the same morphotypes in the three soils but are not found in the same proportions. Some are attributed to wheat, others are common to many types of gramineae. The semi-quantification performed by this method showed that the soil with straw exportation was poorer in phytoliths. In order to gain a better determination of the amount of soil phytoliths we started to use chemical extractants. The first results using Tiron do not show any differences between the three soils but further calibration experiments are required.

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P-1305 Phosphorus efficiency of field grown maize (*Zea mays* L.) cultivars at different stages of growth

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Plant species and even cultivars of same species differ in P efficiency. To assess P efficiency of maize cultivars (Paras and JH 3459), field experiment was conducted at Indian Institute of Technology, Kharagpur, India on sandy loam soil, having pH 5.1, OC 4.1 g kg^{-1} soil and available P 11.2 kg ha^{-1}. Phosphorus was applied at a rate of 0 (low P) and 400 kg P ha^{-1} (high P) with and without the application of fungicide Benomyl (500 kg ha^{-1} for eradication of arbuscular mycorrhiza, AM). Maize plants were harvested at 24, 48, 74 days after sowing (DAS) and final harvest was taken at maturity. In low P soil without Benomyl, cv Paras produced 29, 18 and 69%, while cv JH 3459 produced 19, 9 and 57% of their maximum shoot dry weight (SDW) at 24, 48 and 74 DAS, respectively. This indicates that relative SDW varies with growing stages. Therefore, grain yield should be used to assess P efficiency. At maturity maize cv Paras and JH 3459 produced 91 and 71% of their maximum grain yield, respectively. The results indicate that cv Paras was more efficient than cv JH 3459. Root growth of both the cultivars was restricted under P deficiency conditions; however, cv Paras produced 1.4-2.4 times more root length than cv JH 3459 at different stages of growth. The results also indicated that cv Paras had lower internal P requirement than cv JH 3459. At low P supply conditions, maize cultivars had lower P influx during early growth stage (24-48 DAS), which probably had been the reason for its poor shoot yield at early growth stage. However, during the middle growth stage (48-74 DAS), P influx increased by about 4 times. Between cultivars, Paras had lower P influx than JH 3459, but it was more P efficient because of more roots, lower internal P requirement and higher root length/shoot dry weight ratio. In low P soil, Benomyl application reduced the growth of cultivars by 18-41 % and the maximum reduction of growth was at 48 DAS. In high P soil, Benomyl application had no significant effect on DMY of both cultivars. Application of Benomyl fungicide was completely effective in suppressing AM infections up to 48 DAS. Its effect started diminishing thereafter and some infection even occurred, which however was significantly less than that observed in untreated plots. Thus the yield difference between Benomyl treated and untreated plots can be attributed to the contribution of AM.

P-1260 Cadmium effects on the induction of nitrate uptake in maize roots

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It is well known that cadmium (Cd) can induce modifications in plant metabolism, including alteration in proton fluxes, absorption of water and nutrients by roots. Considering the effects of Cd on nitrate acquisition, it has been shown that it restricts the accumulation of the anion in different plant tissues, possibly as a consequence of a lower nitrate reductase activity. On the other hand it has been proposed that this effect might be related to an alteration of root cell membrane properties. Furthermore, it has been shown that Cd can affect the activity of root plasma membrane H^+-ATPase and expression of nitrate transporter genes. In this work, we studied the effects of Cd on the component of nitrate uptake that is induced when roots are exposed for the first time to the anion; mechanisms at the basis of this process were analyzed.

To this purpose, 4-days old seedlings of maize were treated for 24 hours with nitrate in the presence or absence of 1μM $CdSO_4$. In time-course experiments, the rate of nitrate uptake and the activity of the PM H^+-ATPase were monitored in the roots. Results show that the addition of cadmium blocked the development of a higher nitrate uptake rate (induction) and in parallel it greatly limited the increase of the PM H^+-ATPase activity. Cadmium also inhibited nitrate uptake in roots not treated with the heavy metal, especially when plants were induced for nitrate uptake. Expression of genes codifying for proteins (transporters and proton pumps) involved in the absorption of the nutrient will be analyzed. In conclusion data indicate that low levels of Cd can affect the capability of roots to respond to changes in the concentration of nitrate in the external medium, limiting the development of a higher uptake rate of the anion.

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P-1238 Evaluation of sulfur and *Thiobacillus* application affecting the yield and quality of *Triticum aestivum*

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This experiment was carried out for evaluation of sulfur and *Thiobacillus* on the yield and quality of *Triticum aestivum*. The experiment based on a randomized complete block design with three treatments and three replications. The treatments were:1-control, 2-sulfur, 3- sulfur and *Thiobacillus*. Results indicated that the application of sulfur and *Thiobacillus* improve the yield and mineral nutrition as compared with the control. Therefore application of sulfur and *Thiobacillus* can increase yield and mineral nutrition of *Triticum aestivum*.

P-1343 Synthetic micro rhizo environments for assessing the influence of soil microsite heterogeneity on plant nutrition

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Rhizosphere is a very complex micro environment influenced by (i) biological, (ii) chemical and (iii) physical characteristics of aggregates or microsites surrounding the roots. In case of low nitrogen availability, the competition between plant and microbes depends on the characteristics of the microsites. We assume that spatial organization of these microsites is also an important factor. The objective of our study was to develop synthetic micro environments to control and mimic the influence of either the nature or the organization of microsites in rhizosphere by controlling the nature of the nitrogen, the kinetics of nitrogen release and the spatial organization. The synthetic microsite was achieved with modified silica-based beads. Two types of silica-based beads with known porosities were impregnated with nutrient solution to provide controlled release of nitrogen to the plant. The beads were organized in plant-growth laboratory setups as the single root environment and nitrogen supply. A 2^3 full factorial design was applied and replicated five times, where the nitrogen source (nitrate and alanine), the nutrient release rate (two different mixtures of bead porosities) and the physical organization of the micro environment (random and organized) were independent variables. Following initial development of the seeds, wheat was grown on a total of 60 experimental setups and the nitrogen contents in beads and in plants (roots and shoot) after three days was quantified as the dependent variable. Statistical analysis of the factorial design allowed us to clearly decipher between the three factors as well as their interactions on plant nutrition. Results are helpful to rank the importance of the various factors and will be further used to develop a model representation of the rhizo-environment to interpret results. The use of synthetic micro environments appears to be an interesting way to evaluate the influence of microsite characteristics in order to study plant microbe interactions at the rhizosphere scale.

P-516 Soil pH modifications in the rhizosphere : a real impact on P availability in soil ?

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The variation of pH is one of the major rhizosphere processes able to modify the solubility of different elements such as phosphorus. A pH variation can alter P-adsorption and the precipitation/dissolution of P minerals. Nevertheless, the prevalence of the pH changes over other rhizospheric functions on P mobility is still matter for debate. To determine the relative importance of pH and other rhizospheric functions, we compared the distributions of P fractions measured (i) after controlled pH changes and (ii) after contact with two varieties of wheat cultivated with two forms of nitrogen i.e. ammonium or nitrate to further alter the pH. Samples collected in the top layer of a chromic cambisol from south of France were air dried and sieved at 2 mm. Alkali or acid was added as solution to obtain 26 levels of pH and soil water content was adjusted to 56 % (dry basis). Soils were incubated at 25°C during 84 hours. Height pH levels (4.95; 6.50; 6.93; 7.22; 7.34; 7.72; 7.93 and 8.29) were selected to analyse the P distribution according to a Hedley fractionation (as modified by Tiessen) scheme. The P concentration (P-water, and P- $CaCl_2$) of others pH levels were analysed. Three samples exhibiting different pH values (5.08; 6.04 and 6.80) were used to grow two varieties of wheat during 10-days or 15-days and to analyse the P distribution according to the same fractionation scheme. Without soil-plant contact; the inorganic phosphorus fractions (Pi) of NaOH, bicarbonate and resin extractions were increased by acidification or alkalinization although alkalinization appeared more effective (p-value 0.05). The highest concentrations of Pi were obtained at the 7.93 and 8.29 levels. Particular case of resin-P is noticed because any modification of pH increased the resin-P concentration. For organic P (Po), only the NaOH-Po and HCl-Po were similar. After soil-wheat contact, the varieties and pH had both significant effects on P fractions (p value < 0.05) but not on bicarbonate-Po, NaOH-Pi, HCl-Pi and concentrated HCl-Pi fractions. Both varieties induced a similar increased of about 3.5 $mg.kg^{-1}$ of resin-P. A significant effect of one variety was found with NaOH-Po. Plants induced changes in P fractions that can not be attributed to pH changes only.

P-975 Influence of various insoluble P sources on rhizosphere pH

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Though many soils have large reserves of total Phosphorus (P), P is one of the least available mineral nutrients to the plants in many cropping conditions. Because P formed sparingly soluble iron and aluminum phosphate in acid soil, calcium phosphate in alkaline soil. The potential rhizosphere acidification of various insoluble P sources was not well understood. This study evaluated the influence of four insoluble P sources ($FePO_4$, $AlPO_4$, Ca-P (hydroxyapatite) and NaH_2PO_4 (as P-sufficient control) on rhizosphere pH in 15 genotypes (5 genotypes from strongly acid red soils; 5 genotypes from alkaline soils and 5 genotypes from mildly acid to neutral soils). When supplying Ca-P source to 15 soybean genotypes, the rhizosphere pH among all genotypes had a significant difference. Comparing the mean pH planted 5 genotypes soybean from same local origin, the rhizosphere pH of northeast was biggest, which was 6.17, then south was 6.01, the lowest was northwest, 5.81. Statistics showed that genotypes significantly affected rhizosphere pH. The changes of pH were corrected with amount of Ca-P uptake. The more Ca-P was uptake, the more cation ions content. Thus many H+ was released to rhizosphere, decreased pH. Under Fe-P supply, northeast pH was 6.24, northwest was 6.30 and south was 5.96. When Al-P was supplied, northeast was 5.93, northwest was 5.95 and south was 5.78. When Na-P was supplied, northeast was 6.40, northwest was 6.30 and south was 6.27. However, irrespective of P source, rhizosphere pH was south > northwest > northeast under same local origin genotypes. It is because genotypes suitable to environment for a long time. To compare the P source, rhizosphere pH increased Al-P, Ca-P, Fe-P and Na-P, irrespective of genotype from local origin.