▶ *Keynote presentation*

K-1102 Phosphorus acquisition of Proteaceae and Cyperaceae: a strategy on severely phosphorus-impoverished soils

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Western Australia, like South Africa's Greater Cape, is a rare region that has been above water for 90 million years, with prolonged oceanically buffered climates. Hence soils in these regions are severely phosphorus (P) impoverished. The southwest of Western Australia and South Africa's Greater Cape are also hotspots of higher plant species diversity; they offer a unique opportunity to study plant adaptations to nutrient-poor conditions. A relatively large proportion of the species in Western Australia and South Africa cannot produce a symbiotic association with mycorrhizal fungi, including most species belonging to the Proteaceae and Cyperaceae. Instead, many species in these families produce cluster roots: "proteoid" roots (Proteaceae) or "dauciform" roots (Cyperaceae) (Shane & Lambers 2005; Shane et al. 2005).

Cluster roots release large amounts of carboxylates (e.g., citrate, malate), whose role is that of mobilisation of P (Lambers et al. 2006). The combination of the structure and functioning allows for major accumulation of carboxylates in the rhizosphere. Root clusters exude carboxylates in an 'exudative burst' (Shane et al. 2003, 2006, Playsted et al. 2006), thus minimizing consumption by microorganisms before P has been mobilised. We have investigated carbon metabolism of the cluster roots of *Hakea prostrata* (Proteaceae) (Shane et al. 2004) and dauciform roots of *Schoenus unispiculatus* (Cyperaceae) (Shane et al. 2006), including respiration and carboxylate exudation during their entire development. Respiration peaks at an early stage, providing the metabolic energy for rapid growth early in the development. Citrate and malate exudation peaks later, lasting a few days only. Active cluster roots of *H. prostrata* show enhanced expression of the alternative oxidase, probably to enable oxidation of NADH that is produced during carboxylate production, when there is little requirement for ATP.

Many Proteaceae are readily killed by P fertilisation. Species of the Proteaceae are highly susceptible to P fertilisation (P-toxicity). We recently discovered that the extreme P sensitivity of *H. prostrata* (Proteaceae) is due to its very low capacity to reduce its P-uptake capacity at elevated P levels in the rhizosphere which is in tune with the P-impoverished soil conditions in Western Australia.

▶ *Oral presentations*

O-824 Localised supply of nitrate and phosphorus increases root proliferation and rhizosphere pH of acid subsoil under aluminium-tolerant and sensitive wheat

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The soil pH in the vicinity of the roots can be changed by the presence of either a predominant anion or cation supply. A soil column experiment was carried out to examine the effects of localised supply of N and P on plant growth and pH change of a Podosol (pH 3.6 in 0.01M $CaCl_2$ and pH buffering capacity 0.81 cmol/kg/pH). Nitrate ($Ca(NO_3)_2$) and P (NaH_2PO_4) fertilizers were applied alone or in combination to either the top 0-5 or 10-15 cm layer of the soil column. Aluminium-tolerant (ET8) and Al-sensitive (ES8) wheat (*Triticum aestivum* L.) genotypes were grown for 38 days. Plant height, water use and tiller numbers were measured during the growth period. Root length, bulk soil pH and rhizosphere pH were measured at the final harvest. On average, ET8 had a higher shoot biomass, root length and water use than ES8. The highest shoot biomass and water use was achieved where N and P were applied together at 0-5, followed by N plus P at 10-15 cm and lowest where N was applied at 0-5 and P at 10-15 cm. Root length density was highest in the subsoil where N and P were applied together, followed by N alone, and lowest with supply of P alone. The effect of localized fertilizer supply was greater on rhizosphere pH than bulk soil pH. The application of N and P together to topsoil and subsoil layer increased rhizosphere pH by 0.4 and 0.5 units, respectively, compared to the corresponding layers of the control. Rhizosphere pH was similar under both genotypes although ET8 produced more roots than ES8 in soil profiles. The results suggest the combined application of nitrate and P is necessary to maximise root proliferation and pH increase in acid subsoil.

O-808 Phosphatase and phytase activities in nodules of common bean genotypes at different levels of phosphorus supply

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Increased activity of acid phosphatases and phytases in the rhizosphere of plants grown at limited P supply can enhance the hydrolysis of organic-P compounds in the soil and hence plant P acquisition. However, little information is available about the role of these enzymes for internal plant metabolism under limited-P conditions. This work intended to measure the activities of acid phosphatases and phytases in the nodules of common bean (*Phaseolus vulgaris* L.) genotypes at different levels of P supply. The experiment was carried out in hydroponic culture, in a 5?5 factorial block design with 4 replicates, comprising 5 common bean genotypes and 5 P levels (20, 40, 80, 160 and 320 µM P $plant^{-1}$ $week^{-1}$). Root seedlings were inoculated with the strain CIAT 899 of *Rhizobium tropici*, and plants were grown in 1 L glass bottles with nutrient solution replaced weekly. Samples of nodules were carefully detached at 39 days after transplant and frozen. Each nodule sample was ground with an acetate-buffer solution and centrifuged, and the supernatant was taken for enzymes assays using p-NPP and phytate as substrates. Plants were harvested by pod setting. The polynomial model adjusted to the data indicated that the maximal shoot mass was obtained at a level of 194 µM P and the maximal nodule mass at 206 µM P. Whereas shoot mass increased 1.7 fold between the levels of 20 and 160 µM P, the nodule mass increased 7.5 fold. Bean genotypes differed significantly for nodule mass and number but only at 80 µM P, where cultivar Carioca was superior, and at 320 µM P, where cultivar Iraí was inferior. The activities of acid phosphatases and phytases in nodules decreased strongly as P supply was raised from 20 to 80 µM P, remaining almost stable at higher P levels. Phosphatase activity ranged from 1150 nmol min^{-1} g^{-1} (nodule fresh weight) at 20 µM P to 406 nmol min^{-1} g^{-1} at 80 µM P, while the phytase activity ranged from 67 nmol Pi min-1 g-1 at 20 µM P to 14 nmol Pi min^{-1} g^{-1} at 80 µM P. Bean genotypes differed for nodule enzyme activities but only at the lowest P level, where cultivars Carioca and Rio Tibagi showed higher phosphatase activity than the lines 115 and 147, and Carioca higher phytase activity than Iraí. Primers of acid phosphatase were designed and used successfully with *in situ* RT-PCR on nodules sections. The acid phosphatase transcripts were localized in vascular traces and the nearby layers of cells surrounding the infected zone, namely the inner cortex. These results demonstrate that the low P supply stimulated the activities of phosphatases and phytases in bean nodules, suggesting that these enzymes could be associated with a greater P cycling within the nodules under P stress.

O-720 **Effects of plant species richness versus plant functional diversity on soil nitrifiers and denitrifiers: results from a large plant-assemblage experiment**

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During the last decades, major advances have been made in understanding the relationships between soil microbial communities and plant species. Most studies have focused on the differential effects of individual plant species or ecotypes on microbial communities. In contrast, few studies have evaluated the effects of the diversity of the plant species on microbial communities using adequate experimental designs. Furthermore, no study has unravelled the role of plant species richness per se versus that of plant functional diversity. We characterised the relative importance of plant species richness and plant functional diversity on the activity, size and diversity of soil nitrifiers and denitrifiers at the Jena experiment site. At this site, we studied 130 grassland plant communities which have been assembled as mixtures including 1 to 60 plant species. The number of plant functional types present varies at a given plant richness level (up to 4 types can be present: legumes, grasses, small herbs and tall harbs). A composite soil sample was obtained for each plot. Denitrifying and nitrifying activities were measured for each composite soil sample. The size of the ammonia-oxidizing and nitrite-reducing communities was measured on each sample by quantitative PCR targeting group-specific sequences. The diversity of these communities was evaluated by clone-screening via DGGE followed by sequencing. Key environmental drivers for these microbial communities (soil moisture, mineral N, organic matter...) were also measured on each plot. Our results show that denitrification increased with increasing plant species richness and was also influenced by plant functional diversity. In contrast, plant species richness per se had no effect on nitrification, whereas plant functional diversity had a strong effect. Our results also allowed us (1) to study to what extent plant diversity-induced changes in microbial activities were linked to changes in the size and/or diversity of microbial communities, and (2) to show that the key mechanisms and environmental drivers explaining the observed effects of plant diversity strongly differed between soil nitrifiers and denitrifiers.

▶ *Poster presentations*

P-552 Investigation of traits related to root under effect of mycorrhizal fungus different strains in Barley (*Hordeum vulgare* L.)

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Mycorrhizal fungus are important in sustainability of agroecosystems rhizosphere and plays important role in phosphorus and other nutrients uptake and help to plants in stress conditions. These functions have relation to the influence of these microorganisms on root properties. In order to investigate the effect of different strains of mycorrhizae on alfalfa root traits, a pot experiment with five treatments [*Glomus mosseae*, *G. etanicatum*, *G. intraradices*, combination of some strains (*G. mosseae*, *Gigarpora hartiga*, *G. fasciculatum*) and control] and four replications was conducted. After harvesting of shoot, we washed the roots with tap water. Mycorrhizal colonization was measured with Grid line intersect method. Also, we measured root length, root dry weight, root length : root dry weight ratio and total dry weight of mycorrhizal roots. The results of analysis of variance showed that different strains had significant effect on colonization index, total dry weight of mycorrhizal roots and root dry weight. Also, the results Duncan's test showed that *G. etanicatum* had the largest percentage of colonization (62 %) (α=0.01) and *Glomus mosseae* and *G. intraradices* strains had highest rate of total dry weight of mycorrhizal roots (8.67) (α=0.01). In this investigation *G. etanicatum* had the largest root length: root dry weight ratio (α=0.01). Correlations indicated this trait had negative correlation with root dry weight and total dry weight of mycorrhizal roots.

P-475 Is genotypic variability in P use efficiency for symbiotic nitrogen fixation associated with variation of proton efflux in cowpea rhizosphere?

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The adaptation to low P availability in tropical soils is known to vary among cowpea genotypes. The aim of this study was to investigate whether this genotypic variability relates with variation in P use efficiency for symbiotic nitrogen fixation and with proton efflux from nodulated root. Two cowpea genotypes, 26-73 and Danila, were grown in glasshouse in hydroaeroponic culture at sufficient versus deficient P supplies during 4 weeks and thereafter transferred upon a thin soil layer in a rhizobox for 2 weeks of growth before harvest. Nodule and shoot biomass decreased with P deficiency, although less for 26-73 than for Danila and nodulation required more P than other organs. Under P deficiency the proton efflux for the tolerant genotype 26-73 was 43% and 60% higher than for the sensitive Danila in hydroaeroponic while in soil, it induced an increase in nodule specific respiration, this increase being 115% higher for Danila than for 2673. It is concluded that the genotypic variability in phosphorus use efficiency for symbiotic nitrogen fixation is associated with a variation in the proton release in cowpea rhizosphere, and that these parameters should be measured for a larger number of genotypes contrasting in their adaptation to low P soils.

P-696 Rhizopheric effect of two *Holcus lanatus* accessions with different aluminium tolerance under different levels of exchangeable Al in soil

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The aim of this work was to study *Holcus lanatus* L., strategies to dominate grassland plant community in Chilean volcanic acid soils. As first stage, 100 *Holcus lanatus* accessions were collected in volcanic soils in the south of Chile and were evaluated and classified according to their susceptibility to Al in solution through a rapid screening. As second stage, two accessions, classified as tolerant and susceptible, were evaluated on their performance using different levels of exchangeable Al (very low, medium and high) and determine the rhizopheric effect used as a strategy to diminish Al phytotoxicity.

The methodology used as rapid screening of the accessions to Al toxicity was similar to that used by Liu et al. (1996), with three levels of Al in solution (0, 100 and 320 μM). To discriminate between accessions four variables were used: shoot length, root length, shoot weight and root weight. From the rapid screening a less sensitive (named as 47) and more sensitive of *Holcus lanatus* accession (named as 62) were selected to study rhizospheric effect using the method of minirhizobox (Hinsinger et al., 1992). The soil used was a Chilean Andisol (Valdivia soil, Duric Hapludand) treated previously with hydrated aluminum sulfate ($Al_2(SO_4)_3$ 14 H2O) to obtain three different levels of exchangeable Al (0.06, 0.25 and 1.09 $cmol_+$ Al kg^{-1}). The evaluations on the plant were shoot and root dry matter, concentration and uptake of Al and P and the plant capacity to exude organic acids. In rhizospheric and non rhizospheric soil level of nutrient availability and acidity conditions variables were measured. Results confirmed the classification previously obtained by rapid screening for the two accessions selected as shown for dry matter yield when different soil acidity conditions were used. Also, different changes in rhizosphere soil acidity conditions were measured (pH, exchangeable Al and exchangeable base cations) because of different adaptation of the two accessions. Results strongly suggest that the accession which is more sensitive to Al toxicity does not have a particular rhizospheric effect and only used tolerance strategy (uptake of Al which is then concentrated in the roots) while less sensitive accession presented both tolerance and exclusion (a particular rhizospheric effect) as adaptation mechanisms, depending on the level of exchangeable Al present in the soil.

P-710 **Research for foremost characteristics of short period aluminum-induced root exudations in Soybean (*Glycine max* L.)**

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Recently, secretion of citrate in an Al tolerant cultivar of soybean (*Glycine max* L.) has shown a specific response to Al stress. However, the other components in Al-induced secretion remain unclear. In this study, we investigated the potential effects of organic acid, amino acid, isoflavone, phenolic acid, carbohydrate as well as the activity of enzymes, pH and electroconductibility in Al induces exudation from soybean roots. 19 soybean cultivars were analysed and found to differ considerably in Al resistance. The cultivars Zhechun No.2 (Al-resistant) and Zhechun No.3 (Al-sensitive) were selected, as well as 3 different concentration of aluminium (Al^{3+}), 3 time durations of Al treatment and 3 periods of root exudates collection were set for further analysis. Experiments performed with plants grown in full nutrient solution for 30 days showed that the Al-induced amino acid, isoflavone, phenolic acid, carbohydrate and electroconductibility paralleled with concentrations of Al^{3+}, while secretion of citric acid became largest at 50μM Al^{3+}; the 6 indexes increased with increasing Al treatment time duration. However, the activity of acidity phosphatase and succinic dehydrogenase were changing differently due to the various treatment time of Al and the collection period of exudation. It is worth to notice that all the indexes were high after the collection period of 6 hours, and then the change kept smooth until 8 hours. Taken together, these results suggest that the effects of Al stress on soybean exudation had began after 2-h induration period, yet Al had a continuous effect on all these components of soybean exudation when roots were removed from Al treatment solution within 6-h. Results demonstrates again the important role of citrate in the mechanism for Al resistance in soybean; in the same time, it indicated the characteristics of other components in aluminum-induced root exudations in soybean plant for the first time.

P-583 **Acclimation of *Brassica* cultivars to phosphate (Pi) deprivation by enhancing solubilization and acquisition of sparingly soluble P sources *via* Pi starvation inducible biochemical and metabolic adjustments under Pi stressed environmental conditions**

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Plants display an array of complex but sophisticated strategies to maintain phosphate (Pi) homeostasis and to maximize Pi acquisition under Pi starved environmental conditions. Acclimation to Pi deprivation *via* highly coordinated Pi-starvation induced (PSI) classical biochemical mechanisms such as copious quantities of H^+ and carboxylates (OAs) exudation would reduce or eliminate our current overreliance on expensive, polluting, and nonrenewable Pi-fertilizers. Pi-starved roots possesses enhanced H^+-ATPase and PEPCase which could enhance H+ and OAs exudations in the root vicinity. This would lead to the rhizosphere acidification, which thereby contribute to the solubilization and mobilization of mineral Pi from ambient environment. PSI pH changes were compared in hydroponically grown *Brassica* cultivars [group I: P-tolerant (Brown Raya and Con-1), and group II: P-sensitive (Toria and B.S.A)] with differing ability to mobilize sparingly soluble P sources [e.g. rock P and $Ca_3(PO_4)_2$]. Group I cultivars showed a decrease in pH to the tune of two points, while the group II cultivars showed only a slight decrease in media pH. Higher P uptake by group I cultivars was significantly related to the drop in root medium pH, which was presumably owing to H^+ efflux from the roots supplied with sparingly soluble P sources. To visualize the dissolution of sparingly soluble Ca-phosphate and rhizospheric pH changes (*in situ*), genetically diverse cultivars were grown on agar media. Newly formed Ca-phosphate was suspended in agar containing other essential nutrients. With NH_4^+ applied as the N source, the precipitate dissolved in the root vicinity and this was ascribed to acidification. No dissolution occurred with NO_3- nutrition. In order to observe the pH changes at the media-root interface (rhizosphere), images were recorded after embedding the roots in agar containing bromocresol purple as pH indicator. Efficient cultivars showed greater decrease in pH than P-inefficient cultivars in the culture media (appearance of typical patterns of various colors of pH indicator along the roots). Hydroponically grown group I cultivars exuded 2-3 fold more total OAs than group II cultivars. However, the exudation rate of both resistant and sensitive cultivars decreased with time. The highest exudation rate was found after the first four hour of collection and then tended to decrease. These elegant PSI mechanisms provided basis of P-stress tolerance under P-starvation.

P-739 **The effect of temperature on germination of various species of annual Medics**

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Nowadays the improvement of agriculture and range lands for decreasing of soil erosion, fertility and enhancement of forage production are achieved by the modifier species. One of these species is annual medic whose growth and propagation depend closely on climatic and edaphic factors. Annual medics having potential benefits such as soil conservation, soil fertility improvement, weed control and forage production, can play a significant role in land improvement. In order to reach successful improvement in an area, we must recognize the various stages of their growth in different temperatures. Six species were tested in four different temperatures during a period of 21 days and the factors under investigation were the number of hard seeds, abnormal seeds, cotyledon emergence, and radicle emergence. The results indicated that there is a significant difference in the condition of germination in various species due to the differences in temperature. In all species the needed time for the emergence of radicles decreased with increasing temperature. The percentage of germination in all various species was increased through the increase of temperature. The percentage of hard seeds in all species showed no significant reaction to temperature. Based upon the previous researches, fourteen species of annual medic grown naturally in some regions of Iran where the annual average temperature is between 5°C up to above 20°C. The species under investigation started their germination under the temperature of 5°C in the time span of 7-11 days, and in the case of some species cotyledon never traced. So in the regions where the temperature in germination stage is maximum 5°C , the period of germination is long and it would result in seeds decaying. The best situation for cultivation of annual medics is the regions where the minimum average of temperature is above 5°C.

P-425 A comparison of growth and root characteristics in relation to nitrogen source in three Pine species seedlings

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N source utilization varies widely among tree species; the differences in soil inorganic N forms may be a key determinant of species distribution patterns. Knowledge of the basic patterns of N source utilization by tree species is important for understanding species distributions and adaptation to soil habitat condition. *Pinus densata*, a diploid hybrid is a Chinese native pine species distributing at high mountain elevations in southwestern China and the Tibetan plateau. Up to now, there is little knowledge about whether the natural hybrid species have the higher fitness and heterosis in the different habitats soil. In this study, we investigated the nitrogen form preference of three Pines specie seedlings supplied with nitrate, ammonium (at two different pH regimes), and ammonium nitrate as the nitrogen source in a controlled environment, and to attempt to examine in patterns of seedling root characteristics in species of different N environments across evolutionary lineages.

Our results suggested the *P. densata* showed higher total biomass when supplied with nitrate and NH_4NO_3 than with ammonium without $CaCO_3$ addition. Similar nitrogen form effects were also observed in root shoot ratio, total root length, root surface area and N uptake rate. In contrast to their two parental species, total biomass in *P. densata* seedling was between them when supplied with nitrate and ammonium nitrate, whereas it markedly decreased when supplied with ammonium at two different pH regimes. N uptake rate of *P. densata* seedling was less than its two parental species particularly in ammonium with and without $CaCO_3$ treatments, whereas N use efficiency was significant high in all treatments. In summary, *P. densata* exhibited a preference for nitrate, showed higher total biomass, root shoot ratio, total root length, root surface area and N uptake rate when supplied with nitrate and NH_4NO_3 than with ammonium without $CaCO_3$ addition. Most of its various morphologic parameters were between thos of the two parental species; only N use efficiency was significantly higher than other two species under four treatments. Thus, in the Restoration Farmland to Forests Project in China, especially in western of China, the bulk soil are generally neutral or calcareous, and nitrate is often considered the dominant form of N supplied to plant in these ecosystems, *P. densata* perhaps has more competition and a wider adaptation to this kind of soil habits.

P-781 Do semi-dwarfing genes affect root growth of temperate cereals?

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The aim of this project is to characterise the effects of semi-dwarfing genes on root development and growth in barley and wheat. Cereal cultivars containing semi-dwarfing genes have a reduced stem height phenotype compared to wildtypes which is caused mainly by an interruption of gibberellic acid biosynthesis or gibberellic acid signal transduction. Semi-dwarfing lines have a reduced coleoptile length, which can affect the early vigour and establishment of temperate cereals, but little is known about the effects of semi-dwarfing genes on root growth. There are conflicting reports about whether and how semi-dwarfing genes affect the root systems of temperate cereals.

Near isogenic lines of wheat (cv Mercia) and of barley (cv Bowman) containing semi-dwarfing genes and putative height reducing genes were grown in gel chambers and in soil. Weighed seeds were individually surface sterilised, pre-germinated on filter paper and two seedlings planted in a gel chamber. The plants were grown at 15°C for 10 days. The number of seminal root axes was counted and root length and diameter recorded by scanning with “WinRhizo” and “Carl Zeiss Vision Imaging Systems” at two day intervals. At final harvest, the plants were removed from the chambers and the dry weight of roots and shoots measured. Preliminary experiments have focussed on the effects of dwarfing genes and seed mass as there appears to be an association between these factors in some Mercia lines.

P-474 The effects of soil microorganisms on the formation of cluster roots in white lupin

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It is well known that white lupin forms cluster roots, which are highly dense and clustered roots arising from the secondary roots, under phosphorus (P) deficiency. The cluster roots greatly contribute to P acquisition from soils in white lupin by secretion of acid phosphatase (APase) and organic acids. It has been reported that various factors regulate the induction of cluster root formation, and one of a controversial issued is whether any soil microorganism has a role to induce cluster roots. In this study, we focused on the effects of soil microorganisms on the formation of cluster roots in white lupin by using aseptic rhizobox experiment.

The P deficient soil was put into a closed rhizobox and sterilized by using gamma-ray (25 kGy) (S treatment). As control, non-sterile soil and sterile soil with the addition of soil suspension solution were used as NS and SS treatments, respectively. Seedlings of white lupin were grown aseptically, then transplanted to each rhizobox. Plants were grown in plant growth cabinet for 48 days. After the cultivation, cluster root formation, growth and P uptake of plants, and APase activity in the rhizosphere were examined.

When white lupin was grown in S treatment, the number of cluster root decreased compared to that in NS and SS treatments, suggesting that soil microorganisms participate in cluster root formation. While there were no significant difference in plant shoot growth in all the treatments, root grown in S treatment was larger than that in other treatments. P accumulation in white lupin followed the same trend as plant growth. This decrease in root growth and P accumulation in NS and SS treatments might be caused by nutrient competition between plant roots and soil microorganisms in the rhizosphere of white lupin during early growth stage. APase activity in the rhizosphere of cluster root was lower in S treatment than other treatments. This result suggested that the ratio of APase derived from soil microorganisms was higher than that from white lupin in the rhizosphere of cluster roots. It was also thought that soil microorganisms stimulate the APase activity in the rhizosphere of cluster roots in NS and SS treatments. This study supports the possibility of the effects of soil microorganisms on the formation of cluster roots in white lupin. Furthermore, it was also shown that soil microorganisms contribute to APase activity in the rhizosphere of cluster roots.

P-500 **Strong relationship between soil phosphorus and species richness in grasslands partly explained by higher phosphorus utilization efficiency**

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The richness and composition of plant species in an area is governed by a range of different parameters, some of which are less well understood. The influence of soil phosphorus (P) availability on species richness is little known. Mowing, grazing, parasitism and low to intermediate nutrient levels in soils may prevent high biomass production that otherwise would lead to a shift from competition for belowground resources towards strong competition for light among grassland species. Competition for belowground resources (e.g. nutrients) offers a higher potential for niche separation among plant species, which may prevent competitive exclusion and decreased species richness. Soil P is a resource of particular importance in niche separation due to its diverse speciation into a large number of compounds and its low mobility in soils.

In a field experiment in southern Sweden, designed with pairs of lower and higher species richness grassland sites, we have studied the effect of extractable soil P and nitrogen (N) on species richness. We also studied whether the community biomass and nutrient uptake were affected by species richness.

We found lower levels of easily available (Bray1 extractable) and potentially available soil P (Na-Oxalate extractable) in sites with higher species richness. Furthermore we observed strong negative linear relationships between easily available soil P and species richness. KCl extractable soil N was also lower in sites with higher species richness, but in contrast to soil P no linear decrease in species richness with increasing soil N was found. Interestingly, the efficiency of P uptake (uptake relative to the extractable soil P) clearly increased with increasing species richness. The P uptake efficiency was increased even though plants in communities with higher species richness experienced more intense competition for P, observed as less total P uptake and less biomass. Nitrogen utilization was not affected by species richness.

Our results highlight the importance of soil P in governing grassland diversity. The results also indicate differences in how soil P and N affect grassland diversity and how the utilization of these nutrients is affected by species richness.

P-726 **Responses of two Tunisian chickpea (*Cicer arietinum*) varieties to iron deficiency**

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Iron is an essential micronutrient for plant growth and development. Its availability depends on the soil pH and redox state. In calcareous soils, iron availability is often limited because of its low solubility at alkaline pH. In these soils, plants belonging to strategy I developed physiological and biochemical responses to increase iron availability in the rhizosphere. In the present study, we investigated morpho-physiological and biochemical parameters in two chickpea varieties (INRAT88, tolerant and Chetoui, sensitive), in response to direct or induced iron deficiency. Cultures were conducted in a greenhouse under controlled conditions. After germination and pre-treatment, plants were transferred on continuously aerated solution. Three treatments were retained: 20 µM Fe (control), 0 µM Fe (direct iron deficiency) or 20 µM Fe + 7 mM bicarbonate (induced iron deficiency). Daily measurements of the nutrient solution pH and chlorosis score were performed. Plant growth, chlorophyll content, acidification, Fe reduction capacities and Fe content were measured after 21 days of treatment when the chlorosis score reached the highest value (plants clearly suffering of iron deficiency).

Induced iron deficiency effects were more pronounced than those of direct iron deficiency. A significant variability to iron deficiency was also displayed. Regardless the nature of the Fe deficiency, INRAT88 showed higher potentialities of growth, acidification and iron reduction capacities than Chetoui. These findings suggest that the relative tolerance of INRAT88 may be linked to a high potentiality of proton extrusion which constitutes a favourable condition for Fe(III)-chelate reductase activity and a higher Fe-use efficiency.

P-523 **Root exudation and rhizosphere acidification in response to iron deficiency of two provenances of *Medicago ciliaris***

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The availability of Fe can be a major constraint to plant growth especially in calcareous soils. Plants take up iron through the rhizosphere which constitutes a dynamic microenvironment continually renewed by root growth and the substances released by the root. Indeed, rhizosphere pH has an important impact on the mobilization of mineral nutrients such as Fe. Under limited Fe availability, many changes occur in dicotyledonous plants to enhance the absorption of iron from the soil. In particular, the increase in root biomass and the acidification of rhizosphere by root exudates (organic acids) or ATPase-mediated net H^+ extrusion. The amount of polyphenols in roots and exudates were also enhanced which represent an important source for chelation of Fe^{3+}. The objectives of this research were to investigate, in two *Medicago ciliaris* provenances (T.N 11.11 from Mateur, T.N 8.7 from Soliman) (i) the effect of iron deficiency on root biomass, on the rhizosphere acidification in relation to the active extrusion of protons, the exudation of organic acids and polyphenols and their accumulation in the roots, and (ii) the changes under Fe deprivation conditions in the activities of several enzymes related to organic acid metabolism (malate dehydrogenase: MDH) and to extrusion of protons (H^+-ATPase).

After pre-treatment, plants were transferred in hydroponics culture under three treatments: +Fe (control, C), -Fe (direct Fe-deficiency, DD) and +Fe +$NaHCO_3$ (induced Fe-deficiency, ID). Our results showed an increase in root biomass especially in the presence of bicarbonate. Omission of Fe or addition of bicarbonate salts to the nutrient solution resulted in an increase in H^+-ATPase activity especially in T.N.11.11 plants; this could explain the observed decrease of pH in the medium by active extrusion of H^+. Roots grown in iron deficiency conditions showed an increase in organic acid and polyphenols synthesis and a stimulation of MDH activity especially in T.N.11.11 plants (75% and 41% respectively in T.N.11.11 and T.N.8.7.). Citrate, malate and polyphenols were detected in the root exudates of plants growing under iron deprivation conditions. Citrate exudation from the root of Fe-stressed plants was 195% and 168% respectively in T.N.11.11 and T.N.8.7 that of control plants.

P-619 **Nodule acid phosphatase and phytase activity of common bean (*Phaseolus vulgaris* L.) under phosphorus deficiency**

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Phosphorus (P) is one of the least available major nutrients to the plants in many cropping environments. P deficiency is more critical in highly weathered soils of tropics and subtropics, as well as calcareous/alkaline soils of Mediterranean basin. The production of acid phosphatase and phytase is a potential way for plants to enhance P availability, as a large proportion of soil P (up to 80%) occurs in organic forms.

The effect of phosphorus availability on nodule acid phosphatase and phytase activity was studied in 2 lines of common bean (BAT 477 and Coco blanc) under symbiotic nitrogen fixation. Acid phosphatase activities were increased by P deficiency (15 µmol P) in 2 lines, this increase was more pronounced in BAT 477 than in Coco. Under P deficiency, phytase activity was higher in BAT 477 than in Coco, despite this parameter representing only 5 % of that of acid phosphatases, in the 2 lines studied, independent of the P regime. These findings suggest that phytases may be a group of enzymes that constitute acid phosphatases. Regardless of P supply in the culture medium, the content of total P was higher in nodules than in shoots for 2 lines, BAT showed the higher values. P deficiency affected this parameter in nodules, this effect was more pronounced in Coco than in BAT 477 respectively (-30%) and (-20%). Under 15 µmol P, the nodule acid phosphatase activity and the content of total P in nodule were positively correlated. These results suggest that acid phosphatases are involved in hydrolysis of organic phosphorus resulting in elevation of the (Pi) phosphorus pool.

P-454 **Contribution of phytosiderophore release in the rhizosphere to increase trace metal bioavailability**

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Trace element bioavailability is a consequence of a range of processes occurring in the rhizosphere, such as redox potential, citrate secretion, acidification, root hair proliferation, or exudation of chelating compounds. In calcareous soils, Fe and Zn deficiencies in plants are widespread. In strategy II plant species, it has been evidenced that Fe deficiency can result in increased bioavailability of trace metals in calcareous soils, as related to the enhanced secretion of phytosiderophores. Contrarily to Fe and Zn low availabilities in alkaline soils, Cu one is not affected. Furthermore, as a consequence of phytosiderophore release induced under Fe and Zn deficiencies, Cu becomes increasingly accessible to plants, which leads to a Cu phytotoxicity. The aim of the present work was to evaluate the influence of Fe-deficiency and phytosiderophore exudation on the acquisition of Cu and Zn by a Tunisian barley cultivar (*Hordeum vulgare* L. cv. Manel). For this purpose and in order to simulate the constraining conditions of calcareous soils, seedlings of barley were cultivated under controlled environmental conditions in a nutrient solution without Fe. The chlorophyll content of young leaves, iron, zinc, and copper status, biomass production, and phytosiderophore release rates by roots were assessed. Plants subjected to Fe deficiency exhibited a severe chlorosis accompanied by a significant biomass reduction. Fe starvation resulted in an enhanced release of phytosiderophores in plants and in elevated Cu and Zn concentrations in shoots and roots. At the end of the experiment, we found that leaf Cu reached toxic concentrations. Thus, plants grown on alkaline soils suffer not only from ion deficiencies but also from some ion toxicities.

P-539 **Contribution of three halophytes in desalination of their rhizosphere in saline soils under non-leaching conditions**

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The aim of this investigation was to evaluate the ability of two Tunisian native halophytes (*Arthrocnemum indicum* (Willd.) Moq. and Suaeda *fruticosa* (Forsk) to desalinize a poorly-drained saline soil on which they grow in their natural biotope. Soil samples of the upper 20 cm were taken in the driest period of the year from inside and outside halophyte tufts and analyzed for electrical conductivity of the saturation paste extract (ECe) and soluble sodium (Na) content. Decreases in these two parameters were observed in the intra-tuft soil samples as compared to the inter-tuft ones showing the high capacity of the two halophytes to desalinize their rhizosphere.

Seedlings of these two native halophytes and the introduced one *Sesuvium portulacastrum* L. were grown on a saline soil under greenhouse conditions in pots containing 8 kg of saline soil each and irrigated with tap water during 170 d without leaching. Irrigated pots without plantation were used as controls. At the harvest, shoot Na content was determined and soil samples from each pot were analyzed.

Our results showed that soil salinity was significantly reduced in pots in which the three halophytes were grown as compared to the control. In addition, *S. portulacastrum* plants, which were the most productive of them, were able to accumulate in their shoots nearly 30 % of the Na content of each pot during 170 d. These results confirmed that among the three studied species, *S. portulacastrum* seems to be the most convenient to be used for this aim in arid and semi-arid regions where precipitations are too low to leach salts from the rhizosphere.

P-461 Different characteristics of root mucilage in aluminium adsorption between *Melastoma malabathricum* and *Zea mays*

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Plant roots exude various chemical compounds. Mucilage is the gelatinous high molecular weight compound, which consists mainly of polysaccharides, and is exuded from the outer layers of the root cap. One of the suggested roles of mucilage for plant growth is detoxification (fixation) of toxic metal cations, including aluminium (Al) (Horst et al. 1982). Polysaccharides in mucilage contain uronic acids, of which carboxyl groups may adsorb and inactivate the cations in the rhizosphere (Mench et al. 1987). In the present study, characteristics of root mucilage were compared between *Melastoma malabathricum* (Al accumulator) and *Zea mays* (Al non-accumulator), with emphasis on Al adsorption.

Selectivity for the absorption of Al, La, and Ba in the isolated mucilage was determined to know its characteristics as the cation exchangers. Mucilage of *M. malabathricum* adsorbed more Al and La (trivalent cation) than Ba (divalent cation). On the other hand, the cation adsorption affinity of *Z. mays* mucilage was in the following order; Ba>La>Al. The ^{27}Al NMR spectrum of the Al-adsorbed mucilage indicated that Al was concentrated in the mucilage of *M. malabathricum*, and binds very weakly to the mucilage. These results suggest that roots of *M. malabathricum* can easily absorb concentrated Al in the mucilage and the mucilage helps Al-hyperaccumulation in this species. In contrast, it has been reported that Al binds very tightly to the mucilage in *Z. mays* (Li et al. 2000).

Total sugar concentrations in the mucilage are significantly higher in *M. malabathricum* than in *Z. mays*, and the mucilage of *M. malabathricum* contained a lower proportion of fucose and arabinose and higher proportion of xylose and glucuronic acid than that of *Z. mays*. Whereas glucuronic acid (uronic acid) is the primary monosaccharide component of *M. malabathricum* mucilage, the degree of methylation was significantly lower in *Z. mays* than in *M. malabathricum*. These differences may be related to the different characteristics in Al adsorption between *M. malabathricum* and *Z. mays*.

Horst WJ et al. 1982. Z. Pflanzenphysiol., 109, 95-103
Li XF et al. 2000. Physiol. Plant., 108, 152-160
Mench M et al. 1987. Biol. Fertil. Soils, 3, 165-169

P-716 Response of root border cells to Al toxicity in Soybean

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The response of root border cells to Al toxicity in soybean can account for Al resistance mechanism at the level of border cells. Experiments were performed with two soybean cultivars (Zhuchun No.3 and Liaoxian No.3) under aeroponic culture. Border cells shape of both soybean cultivars at the initial stage was spherical and small. As cells developed, they became ellipsoidal or spectacular and long in shape. The number of border cells reached the maximum value (3 000 for Zhuchun No.3 and 3800 for Lianxian No.3) when soybean was 15-25 mm in length. The number and viability of border cells released from roots with 100, 200, 300, 400 μM Al treatment were less than that from roots without Al treatment, the production and viability was seriously inhibited with high Al concentration. The PME activity increased with 200 μM Al and 300 μM Al for 4 h, whereas it remarkably decreased with 400 μM Al treatment. These results suggested that high Al concentration inhibited the production and release of soybean, decreased PME activity. Response of border cells to Al in Liaoxian No.3 was more sensible than in Zhechun No.3. The number and cell viability, PME activity of border cells were higher in Zhechun No.3 than that in Liaoxian No.3, the differential Al toxicity response accounted for Al resistance mechanism in Zhechun No.3.

P-713 Interactions between low pH and Al toxicity on properties of root border cells in buckwheat

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Plant roots release a large number of border cells into the rhizosphere, which act as a chemical, physical and biological interface between roots and their surrounding environment. This study examined interactive effects of low pH and aluminum toxicity on the root growth and border cell characteristics. Buckwheat was grown in aeroponic culture for 12h with Al supply of 0, 50 and 100 μM, solution pH was adjusted to 3.5, 4.5 and 5.5. Root elongation, border cell viability and mucilage layer were measured. Increasing Al concentration to 50 ÌM and 100 μM decreased root elongation by 18.6% and 31.9% at pH 3.5, by 18.9% and 26.8% at pH 4.5, and both by 8.5% at pH 5.5. Decreasing pH value to 3.5 decreased border cell viability by up to 28.6%, and resulted in no significant change in mucilage layer. Al treatment at 100 μM significantly induced a thicker mucilage layer around border cells, and the thickness increased to 64.6%. Decreasing pH exacerbated the effect of aluminum toxicity on root growth and border cell characteristics. Lowest activity of border cells and the thickest mucilage occurred under the treatment of pH 3.5 and 100 μM Al^{3+}, which indicated the significant interactions between pH and Al^{3+}. The results suggested that a combination of low pH and aluminum toxicity impaired border cells, and encased mucilage layer around border cells played a role in protecting border cells from Al-induced damage.

P-626 Aluminum tolerance is not always the primary strategy for better growth of rice in long-term under low ionic strength conditions

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To make new crop plants which can practically be applicable to acid soils, we need to isolate the primary factor from complicated acid soil factors and analyze the tolerance mechanism. Short-term Al tolerance screening: 20μM $AlCl_3$±0.2mM $CaCl_2$ (pH 4.9) for 24h using 48 rice cultivars including cv. Sasanishiki pedigree 18 cvs. Long-term water culture experiment: Four treatments for 5 weeks with daily pH adjustment under weekly renewal; (i) Adequate nutrients (AN) (pH 5.2, 0.26mM P), (ii) AN+Al (pH 4.3, 4.8μM average soluble P, 42μM average soluble Al), (iii) Low nutrients (LN) (pH 5.2, 0.05mM P), (iv) LN+Al (pH 4.3, 4.8μM average soluble P, 36μM average soluble Al); ionic strength (IS) of AN = 22.6mM, IS of LN = 4.5mM. Definition of each tolerance: Al tolerance in AN condition, AN+Al/AN; Al tolerance in LN condition, LN+Al/LN; low nutrient tolerance, LN/AN; combined tolerance, LN+Al/AN.

Al tolerance of young seedling in short term was positively correlated with that in long-term Al tolerance in both nutrient conditions. Al tolerance of roots was negatively correlated with Al content in roots. Tolerances to low nutrient and combined conditions were not correlated with Al tolerance. Al-tolerant cv. Rikuu 132 was also tolerant to combined conditions, but Al-tolerant cv. Sasanishiki was most sensitive to combined conditions. Conversely, highly Al-sensitive cv. BR34 was most tolerant to combined conditions. Combined tolerance of shoot was positively correlated with Ca content of shoot. The following points were suggested: Al tolerance is not always the primary strategy to obtain better rice production in most acid soils; the recommended strategy will be dependent on the differences in Al tolerance, low nutrient tolerance of rice cultivars, concentrations of Al and/or available nutrients in soils.

P-432 The response of *Arabidopsis thaliana* to P additions in soil – a microarray study

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To study the *Arabidopsis thaliana* response on the transcriptional level to P additions to the rhizosphere *Arabidopsis thaliana* was grown in rhizoboxes with a soil low in P. The roots and leaves of the plants were collected 45 min, 3, 6, 12 and 48 hours after phosphate was sprinkled to the soil surface. In order to compensate for time effects like diurnal changes in plant physiology untreated samples were collected at each sampling occasion. The response of the plants was determined by extracting the RNA from the tissue and analysing the m-RNA using c-DNA microarray. In this procedure the expression intensity of 22810 genes is determined in one single analysis. The results show that a significant part of the genes were affected by the P addition even though the levels were low as compared to the levels used in hydroponic cultures. There was also a root specific response that could be separated from the general or leave specific response. More details about the response will be presented at the conference.

P-836 Modulation of root architecture and acid phosphatase activity of *Medicago ciliaris* L. by phosphorus availability in the medium

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Phosphorus deficiency is known as a major abiotic constraint affecting plant growth and crop yield especially in arid and semi-arid areas. To overcome P shortage, plants develop several strategies, including the well-known one of secreting acid phosphatase (APase) into the rhizosphere to improve P availability in the soil. Another strategy of P-deficient plants is to uptake P efficiently from the soil solution. Consequently, plant root systems display an array of physiological, morphological, and architectural responses to low phosphorus availability. These responses enhance the ability of the root to explore the soil for nutrient uptake particularly phosphorus.

In this study we focus on change of root architecture and acid phosphatase activity of *Medicago ciliaris* with phosphorus level in the medium using the software named IMAGE J to estimate root architecture and Para Nitrophenyl Phosphate technique to determine APase activity.

Results showed that dry matter production in this species depend upon the phosphorus availability in the nutrient solution. However, phosphorus deprivation (0 and 60μM P) induces a better root development characterized by a large number of lateral ramification. Under these conditions, acid phosphatase activity was also increased. Those modifications are analysed in the context of plant adaptation to phosphorus deficiency.

P-379 Photosynthetic activity and water relation in three Tunisian Chickpea genotypes subjected to drought

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Most plants are exposed to water stress due to extreme soil water deficits in arid and semi arid environment. Adaptation to water stress in plants involve the reduction of cell dehydration by avoidance (leaf shedding, leaf rolling and low stomatal conductance) or tolerance through osmotic adjustment. Osmotic adjustment refers to the lowering of osmotic potential due to the net accumulation of solutes in response to water deficits or salinity. It is an important mechanism in drought tolerance as it enables a continuation of cell expansion, stomatal and photosynthetic adjustments and better plant growth by lowering their water potential in response to decreasing soil water.

Chickpea, a lesser-studied grain legume, is being investigated due to its ability to endure and grow in relatively low soil water contents making it a model legume crop for the study of agronomic response to drought stress. The present study was designed to understand the changes in plant photosynthetic activity, water status, proline and carbohydrate contents and mineral nutrition of three Tunisian chickpea genotypes subjected to drought, and to determine some useful criteria of drought tolerance in chickpea.

Obtained results Show that water deficit decrease net photosynthesis activity, stomatal conductance, relative water content and leaf water potential leading to a significant decrease of plant growth. Regarding all these parameter, Amdoun genotype remain the less affected by drought. It seems maintain a better tissues hydration by developing the highest osmotic adjustment capacity.

P-748 The fate of glyphosate in the rhizosphere

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Glyphosate (Tradename: Roundup) is a widely-used, non-selective, systemic herbicide, disrupting the turn-over of shikimate for biosynthesis of the essential, aromatic amino acids. It is easily translocated from shoot to roots and released into the rhizosphere, where it is rapidly immobilized by adsorption or microbially degraded. As phosphonated compound, glyphosate shows similar sorption characteristics in soils as phosphate and can form stable complexes with di-, and trivalent cations. A potential risk may arise from re-mobilization by root-induced changes in rhizosphere chemistry (pH-, redox-changes, root exudates) of non-target plants, with negative side effects particularly on soils with low micronutrient availability, associated with increased susceptibility to diseases, as reported from field observations.

Model experiments with glyphosate-treated target plants (*Lolium perenne*, glyphosate-resistant soybean) and subsequent or simultaneous cultivation of non-target plants (e.g. sunflower seedlings), revealed growth inhibition and glyphosate-induced intracellular shikimate accumulation in non-target plants up to 3 weeks after glyphosate application on a weakly-buffered sandy soil (Arenosol) and even after 8 weeks on a calcareous soil with high buffering capacity and P fixation (C horizon of a Luvisol). On the same soils however, no glyphosate-induced shikimate accumulation was detectable in non-target plants, when glyphosate was applied directly to the soils 1-3 weeks prior to sowing with subsequent addition of NH_4^+-fertilizers or citrate to induce glyphosate remobilization by rhizosphere acidification or by complexation with organic chelators. The results suggest differential stabilization of glyphosate in the rhizosphere compared with the bulk soil with a potential role of target plant residues, which will need a stronger consideration in future ecological risk assessment.

P-804 Effects of phosphate availability and salinity on the root system architecture and phosphatase activities of *Catapodium rigidum* plants

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Low availability of P is a major constraint for crop production in many low input systems of agriculture worldwide, especially in calcareous soils and saline ecosystems where crop productivity is severely compromised through lack of available P. Plants can actively improve their acquisition of P by increasing the absorbing area of the root system and exuding phosphatases which catalyses the mineralization of organic phosphorus. The present study aims to analyse the effects of phosphorus nutrition and salinity on root growth and architecture and phosphatases activities of one halophytic plant belonging to Poacea family: *Catapodium rigidum*.

Seedlings were grown to maturity in pots on a sandy soil which contain a range of inorganic phosphate concentrations (0, 15, 60 and 180 µM KH_2PO_4) with or without 100 mM NaCl. Results showed that, in the absence of salt, dry matter production depend upon the phosphorus availability in the nutrient solution. *Catapodium rigidum* seedlings reached maximum biomass from 60µMP. Under low phosphorus availability (0 and 15µM P), plants increase the soil volume exploited by increasing root length, root/shoot ratio, root hair length and the number of lateral ramification that provides larger root area and thus a better exploration of the rhizosphere leading to an increase in phosphorus uptake. Acid phosphatase activity increased also at low phosphorus treatments and was greater under salt treatment.

The addition of P to plants cultivated in presence of 100 mM NaCl improves the growth of plants. This improvement was associated with an increase in foliar and root phosphatase activity leading to an increase in P contents of plants.

P-404 Flavonoids released from cluster roots and root tips: their role on P- and Fe-mobilization by white lupin

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Nutrient mobilization and flow towards the roots in the rhizosphere are critical steps in plant nutrient acquisition. A good example of an efficient acquisition strategy is that adopted by P-deficient white lupin plants which release large amount of carboxylates to mobilize P from sparingly soluble soil sources. In addition to organic acids, under limited soil P availability, white lupin accumulates and releases into the rhizosphere also large amounts of flavonoids. These compounds have been shown to be crucial for nodulation, but their impact on other soil microorganisms is largely unknown. The aim of the present work was to evaluate the capability of flavonoids extracted from P-deficient white lupin cluster roots and root tips to directly affect the macronutrient availability through mobilization of Pi from sparingly-available soil sources, and/or indirectly by modulation of the microbial activity in the rhizosphere.

Isolated flavonoids were shown to increase the availability of Pi in a solution (pH 6.0) in which a dialysis tube containing a gelatinous suspension of (^{59}Fe)-vivianite was placed; these compounds also exhibited Fe^{3+}-reducing capacity towards different Fe-sources. Considering the known Fe^{3+}/$Fe2^{+}$ complexation capability of flavonoids, one may assume that the mobilization of Pi from sparingly soluble Fe-phosphate occurs via reduction to ferrous ion (i.e. the form preferentially involved in the flavonoid complexation) and subsequent chelation of Fe^{2+}.

Flavonoids were able to affect soil basal respiration and thus to limit the activity of soil microflora, particularly when exogenous citrate was added. This phenomenon was not associated with a parallel modification of the microbial biomass content, as revealed by the ATP-content measurements. Moreover, flavonoids decreased the activities of soil enzymes, such as alkaline phosphomonoesterases and phosphodiesterase. These results suggest that the presence of white lupin flavonoids in the rhizosphere might limit the mineralization of root exudate (particularly citrate) through modifications of the soil microflora metabolism. This effect was particularly evident in the cluster root regions where a massive organic acid exudation occurs. In conclusion, the results presented show that flavonoid extrusion can represent a valid strategy of white lupin to improve the mobilization of Pi from sparingly soluble soil sources. Work supported by grants from Italian CNR and MUR.

P-651 Genetic variation and interactions of root traits involved in plant:soil physical interactions

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Soil structure and water content interact to produce a complex and heterogeneous environment for plant root growth. Physical impedance to root growth results from the roots having insufficient water or oxygen, or a large mechanical resistance to deformation of the soil. Changes in the distribution and intensities of rainfall events associated with climate change will interact with the soil cultivation regime to alter the stresses experienced by plant root systems throughout the growing season.

The ability of plants to respond to, avoid or adapt to these constraints has a significant effect on plant growth and ultimately crop yield. For example, responses to increased mechanical impedance include increased border cell production, increased mucilage production, increase in root diameter and changes in root system structure (e.g. changing branching patterns). We are exploring the genetic variability of and interactions between, such traits in response to soil physical constraints.

We have characterised a number of barley lines for root traits, along with above-ground architecture. Lines were chosen to include winter and spring cultivars with a range of introduction dates, plus mutant lines of the cultivars Bowman and Optic. Border cell numbers, root hair length, root numbers and growth rate have been recorded for seedling plants. Overall root mass and rooting depth profiles have been recorded for mature glasshouse-grown plants. Significant, and sometimes large, differences in overall root mass, root mass distribution with depth, and meristem characteristics (e.g. border cell numbers) have been found between lines. Interestingly the Bowman cultivar and mutants exhibited as wide a range in overall root mass as all the other selected spring cultivars. Links between above and below ground partitioning are also being investigated.

Further research using barley lines which exhibit extremes of rooting traits is being undertaken to explore the relationship between rooting traits and the ability of these lines to thrive in soil imposing specific physical constraints.

P-872 Effects of catch crops on grain yield, nitrogen uptake and root development of succeeding spring wheat at high and low nitrogen supply

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Catch crops can reduce N losses by leaching in cereal cropping systems. However, the effects of catch crops on a succeeding cereal crop are not well understood. The objectives of this study were to evaluate uptake of N of spring wheat, the spatial and temporal characteristics of root development and how these characteristics are affected by the presence of catch crops in a two year intra-annual succession at two levels of N supply.

Spring wheat (*Triticum aestivum* L. cv. Toronit) was grown in a two-year experiment after white mustard, phacelia, sunflower or after bare soil (fallow) as the control treatment. The main nitrogen (N) input (20 or 270 kg N ha^{-1} for LN and HN, respectively) was applied during the spring wheat season. Number of roots (roots cm^{-2}) was obtained at 0.10, 0.25, 0.45, 0.80 and 1.00 m from minirhizotrons. The cumulative number of roots (CNR) was fitted to a logistic equation and used to calculate mean root depth.

Catch crops increased wheat yield in 2001 and the uptake of N in 2002 at HN but not at LN. At LN the grain yield was lower after sunflower than after white mustard. Furthermore, catch crops changed the development and mean depth of the roots of the succeeding spring wheat in both years. Wheat produced from 0.33 to 1.72 more roots at 0.10 m after white mustard, than the other treatments. Sunflower induced a later development of the root system at 0.10 and 0.45 m at LN in 2002. CNR of wheat after sunflower was significantly correlated with the CNR of the previous sunflower, indicating a differential effect of this catch crop on the root development of spring wheat. In conclusion, the catch crops, especially sunflower and white mustard, modified the root development and the grain yield and the uptake of N of spring wheat. Catch crops increased grain yield and N uptake only when the supply of N was high.

P-873 Effect of nitrate supply on root uptake, microbial metabolism and soil enzyme activities

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Kinetic and modulation of mineral nitrogen uptake by roots are important factors controlling plant nutrition and can affect the efficiency of the entire process. Most of the knowledge concerning the mechanisms involved in the plant nitrogen uptake has been obtained in hydroponic culture. However, in the soil a fundamental role is likely to be played by conditions occurring at the rhizosphere where root activities, micro-organisms and soil constituents closely interact.

Experiments were performed growing two inbred maize lines, that differ for nitrogen use efficiency when grown at low inputs of fertilizers (Lo5 and T250, high and low efficiency, respectively), in rhizoboxes containing a soil with low-N content. Changes in root nitrate uptake, soil enzyme and microorganism activities in bulk and rhizospheric soil were assessed at time intervals following nitrate soil fertilization.

Soil analyses showed that the microorganisms respiration was higher in the rhizosphere than in the bulk soil. Nitrate fertilization significantly enhanced this microbial activity in the rhizospheric soil with the most pronounced effect when Lo5 inbred maize line was considered. Measurements of dsDNA revealed higher microorganism quantities in the rhizosphere than those determined in bulk soil; the effect was more pronounced in N-fertilized conditions and in Lo5 inbred maize line. Soil enzyme activities (urease, alkaline and acid phosphatases) showed the same pattern.

Classical modulation of root net nitrate uptake (induction and de-induction) in response to nitrate supply was clearly evident in soil-grown plants. Maximum level of anion uptake was observed 2 h and 12 h after nitrate supply for Lo5 and T250 maize lines, respectively. Parallel to the induction of anion uptake increases in activity (P-hydrolysis) and quantity (Western blot) of plasma membrane H^+-ATPase were observed.

In conclusion this work shows that N-fertilization can modify root physiology, soil enzymes activities and rhizosphere microorganisms. Furthermore, N-efficient maize line Lo5 appears to respond more promptly to soil nitrate fertilization and to have a higher influence on the rhizosphere microorganisms and soil enzymes. Work supported by grant of Italian M.U.R.

P-784 Effect of crop rotation on biological and chemical parameters of Wheat rhizosphere

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The objective of this study was to determine the effect of crop rotation on microbial species and inorganic and organic status of wheat rhizosphere. Crop rotations arranged in randomized complete block design with four levels in three replications and studied for 2 years in Saveh (Iran). Crops were wheat, canola, fodder corn, and fodder sorghum and rotations were 1-canola-corn-wheat-corn, 2-canola-sorghum-wheat-sorghum, 3-heat-sorghum-canola-corn and 4-wheat-corn-canola-sorghum. Biological parameters (total population and dominant species of bacteria, fungi and Actinomycets) and organic-inorganic nutrients (nitrogen, phosphorus, potassium and organic carbon) at first and third wheat were measured. Results indicate that, time placement of wheat in rotation had a significant effect on soil biological and chemical properties. Also, previous crop had significant effect on biology of wheat rhizosphere. Biodiversity in sorghum–wheat were higher than corn–wheat sequence. But *Rhizopus* pathogen was dominated in the first year. Crop rotation had not effect on Actinomycets species. Total microbial, bacterial and Actinomycets population were higher in sorghum–wheat than corn–wheat sequence. In addition, total nitrogen and phosphorus availability in wheat rhizosphere were higher in sorghum–wheat than corn-wheat. On the contrary, soil organic carbon was higher in sorghum–wheat than other. But potassium availability did not differ between sequences. Results show that, not only wheat has significant effect on soil biology and chemical parameters, but also were affected by previous crops.

P-951 The expression of the seminal and adventitious root systems under the water deficit in wheat, consequences on rhizosphere

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The root system of wheat plant is constituted, after tillering, of a seminal part and of an adventitious part. The seminal part is proceeded from six primordial already differentiated in the embryo from the caryopse; they give six seminal roots under favourable conditions. The definitive number of first primary seminal roots is reached towards the stage of three leaves. These roots remain almost during the whole life of the plant according to Grignac (1965). The adventitious part develops from the primordia situated in the base of the two first nodes differentiated from the principal stem or the master shoot. The corresponding roots of this part are arised from the tray of tiller where the first rough become visible with the appearance of the tiller buds. Situated at the base of every single leaf, it's formed of 3 or 6 pairs of adventitious roots. New roots may be formed until the beginning of re-erecting of stem and their growth last until the flowering. In this way, the number of nodal roots can reach 30 main primary roots.

In our study on the behaviour of the two root systems separately under water deficit conditions, in one hand, we isolated root adventitious system in order to prevent its development and leave the expression of the seminal system only. In the other hand, at the same time, we pinched the rhizome between the tillering plate and the seminal root system to conserve only the adventitious system.

The related results of the studied root parameters are analysed. They allowed the emergence of the adventitious root system, more voluminous and less sensitive to the effect of the water deficit, impress its kinetics growth on the total root volume in the Hedba 3 genotype at the moment when the kinetics growth of Clairdoc genotype follow the seminal system evolution.

Rhizophere is the soil volume occupied or influenced by the root system of the studied genotypes. So, what would be the part of influence of each root system on this volume? What will be then in the case of non tillering of wheat?

P-803 Root exudates composition of wheat and sugar beet at low and high K supply and mobilization of K in soil by exuded amino acids

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Sugar beet and wheat can take up sufficient K under low soil K supply and therefore are uptake efficient for K. High K uptake efficiency in wheat is mainly due to its large root system. Sugar beet has few roots, but it seems to increase the K solubility in soil by exuding organic compounds. To study the root exudation pattern, wheat and sugar beet plants were grown in quartz sand supplied with modified Hoagland nutrient solution of low and high K levels at two growing conditions, one in screen house under natural environmental conditions and another in growth chamber under control conditions. Root exudates were collected by percolation method. Root exudation rate was many-fold higher under low K compared to high K supply in both the crops and was higher in young plants and at natural sun light, perhaps due to higher light intensity in the greenhouse. HPLC analysis of the root exudates showed that exudation rate of organic acids, amino acids and sugars was higher under low K supply in both crops and it was higher in wheat compared to sugar beet. Arginine was the amino acid detected only in root exudates of sugar beet.

The results of mobilization of K in a K fixing soil by amino acids, as found in root exudates showed that total K desorbed by Arginine was the highest. Arginine might work like long chain n-alkyl ammonium compound, which could widen the interlayer of clay mineral resulting in a higher soil solution K concentration. Though amino acids can desorb K in K fixing soil, but degree of desorption does not seem to be sufficient to explain the differences in soil solution K concentration in the rhizosphere of wheat and sugar beet.

Non-targeted metabolite profiling was done by separating the root exudates collected from wheat and sugar beet grown in the growth chamber by HPLC coupled with ESI-MS. Several signals and change in intensity of certain signals specific for root exudates from K deficient plants were found. Signal corresponding to m/z value 475 was relatively stronger under low K supplied sugar beet. From KEGG data base, one of the possible structures for m/z 475 was Amastatin ($C_{21}H_{38}N_4O_8$), which resembles to n-alkyl ammonium compound in chemical structure. Further investigation is needed to identify the compounds corresponding to the signals and to study their effect in desorbing K in low K soil.

P-525 Factors affecting rhizosphere processes in young silver birch stands on abandoned agricultural land

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In the last 10-15 years a clear increase in abandoned agricultural lands (AAL) has been noted in Eastern Europe with frequent occurrence of rapid natural afforestation with silver birch (*Betula pendula* Roth.). Factors affecting rhizosphere processes in these stands have still been poorly investigated. In 2006 seven 8-yr-old birch stands in AAL were investigated with the aim of assessing the response of short root morphological parameters as well as rhizosphere and bulk soil microbial characteristics to soil properties. One stand in Glossic Podzoluvisol was studied in a droughty (2006) and in a wet year (2004) to reveal the effect of moisture on short root morphology. Short root morphological parameters: specific length (SRL, m g^{-1}), specific root area (SRA, m^2 kg^{-1}) and root tissue density (RTD, kg m^{-3}), root tip frequency per mass unit (RTFM tips mg^{-1}) and mean diameter (D, mm) were determined using WinRhizo TM PRO 2003b. Biolog Ecoplates (Biolog Inc.) were used to determine the community-level physiological profiles of culturable bacterial samples and average well color development (AWCD) in the rhizosphere and bulk soil. In bulk soil substrate-induced respiration (SIR) and microbial respiration activity (BAS) were measured, and the metabolic quotient $q(CO_2)$=BAS/SIR was calculated. Stands soil pHKCl and N varied from 3.8 to 7.0 and 0.07 to 0.26%, respectively. SIR (0.39-1.51) increased linearly with soil N (R^2=0.88) and exponentially with soil pH (R^2=0.85); $q(CO_2)$ was low (0.18-0.28). SIR and $q(CO_2)$ values were most probably affected by drought. Rhizosphere/Bulk AWCD ratio (1.4-4.7) decreased hyperbolically with increasing soil pH (R_2=0.86). Rhizosphere pH increased with the increase in soil pH (R_2=0.86); the pH difference between soil and rhizosphere varied between -0.2 and 1.5. Short root D decreased with the increase in soil N (R_2=0.66). The differences in short root parameters between stands decreased in the following order: RTFM>SRL>SRA>RTD>D. In a droughty year short root SRL, SRA, RTD, RTFM and D values varied between 60-106, 64-102, 137-185, 55-111 and 0.31-0.37, respectively. The impact of soil moisture on short root morphology was significant – in a wet year, SRA and SRL were 2-3 times higher and RTD lower than in a droughty year. Hence, in young birch stands, both morphological adaptations of short roots and support of rhizosphere communities are used intensively to provide mineral nutrition.

P-987 Growth and citrate exudation of white lupin (*Lupinus albus* L.) in response to aluminum in a solution culture

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White lupin (*Lupinus albus* L.) well adapted to acidic low-fertility soils has been widely used as a model system to study the morphology and physiology of cluster roots in P acquisition and utilization. Much work on the mechanisms of adaptation of white lupin to P deficiency stress has been done, but little information is available about the response of white lupin to Al toxicity accompanied by P deficiency in acid soils. In this study, we aimed to examine the effect of Al concentrations on white lupin (*Lupinus albus* L. cv. Kiev Mutant) growth, and further investigated citrate exudation in response to interaction of P deficiency and Al toxicity. White lupin grew well in 0, 10 30 and 50 μM Al (Al0, Al10, Al30 and Al50) nutrient solution. After 12 days Al treatment, there was no visible difference and Al toxicity symptom in the shoot growth between control (Al0) and all the Al treatments (Al10, Al30 and Al50). The root growth was improved by low Al supply at 10 μM Al, but was inhibited by the 50 μM Al. The total root length and root areas were also increased by Al10, but were dramatically decreased by 50 μM Al supply. The similar pattern was found for shoot and root dry weigh. Phosphorus deficiency induced citrate exudation, but had no effect in the P sufficient plants after 20 days P treatment. Aluminum significantly further increased the citrate exudation under P deficiency condition and also induced citrate exudation from the P sufficient white lupin plants. The concentration of Al in acid soil solution ranges from 10 to 100 μM, and organic anion exudation is one of Al tolerance mechanisms. The results indicated that white lupin has Al tolerance ability in moderate acid soils, and Al-induced citrate exudation probably accounts for Al tolerance of white lupin.

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P-493 Effect of straw management and nitrogen fertilization on root growth and root characteristics of Wheat through raised bed system on a low N calcareous soil of Bangladesh

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A field research was conducted at the Regional Wheat Research Centre, Rajshahi Bangladesh, during November 2004 to March 2005 in order to study the effect of raised bed, straw management and nitrogen fertilization on the root growth and root characteristics of wheat. The experiment was executed in the strip split-plot design comprising the combination of the two methods of tillage options arranged as a main plot as horizontal basis, two levels of straw management as a sub plot as vertical basis and five rates of nitrogen application distributed to a sub sub plot. Tillage options, straw management and N application have created a remarkable impact on root length density, root weight density and root-to-shoot ratio of wheat. Root length density and root diameter in the surface layer increased with raised bed, straw mulch and N application. Root growth in the subsurface layers increased when either straw mulch or N application was limited while the other was in the optimum level. Root-to-shoot ratio was negatively correlated with straw mulch and N application. Raised bed and straw mulch have remarkably reduced soil strength in the surface layer, but N application could not create any impact on soil strength.

P-1015 **Natural nitrification inhibition by plants – A novel genetic strategy to combat nitrification and N_2O emissions from agricultural systems**

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Nitrification, a microbial process, is an integral part of the nitrogen (N) cycle, results in substantial losses of mineral N. In most natural ecosystems, nitrification is reduced to a relatively minor flux with a minimal loss of N. In contrast, nitrification is rapid and becomes a major process in N cycling of high production agricultural systems with the resulting N losses and inefficiencies. In addition, nitrification and denitrification are the primary sources of N_2O emissions, a powerful, third most important greenhouse gas that has global warming potential of 300 times that of CO_2. Some plants can suppress nitrification by releasing inhibitory compounds from roots, a phenomenon termed as "biological nitrification inhibition (BNI)". With the recent development of an assay using recombinant luminescent *Nitrosomonas europaea* that can detect and quantify nitrification-inhibitor activity (BNI activity, expressed in AT units), it is now possible to characterize and quantify the BNI-capacity of plant roots. A number of plant species including tropical and temperate pastures, cereals, and legumes were surveyed for BNI-capacity. The tropical forage grasses - *Brachiaria humidicola* and *B. decumbens*, showed the highest BNI-capacity. Significant genotypic variability for BNI-capacity in *B. humidicola* was detected; with specific-BNI levels ranging from 6.5 to 46.3 AT units g^{-1} root dry wt. d^{-1}. Several high- and low-BNI genotypes of *B. humidicola* were identified. Laboratory soil incubation studies indicated that the inhibitory effect of BNI compounds on nitrification is functionally stable for at least 60 days. The synthesis and release of BNI compounds from *B. humidicola* roots is a highly regulated process requiring the presence of NH_4^+ as a signal in the root environment. In recent field studies soil nitrification and N_2O emissions were suppressed in *B. humidicola* plots. These results demonstrate the feasibility of genetic strategies based on biological approaches to combat nitrification and N_2O emissions from agricultural systems. Development of next generation of crops and pastures with a genetic ability to combat nitrification will contribute towards economically and environmentally responsible use of N fertilizers, and reduce greenhouse gas emissions from agricultural production.

P-727 **Manganese efficiency of bread (*Triticum aestivum* L.) and durum (*T. durum* L.) wheat cultivars**

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It is well established that durum wheat is less Mn efficient than bread wheat. The hypotheses we wanted to test were whether differences in Mn efficiency might be due to chemical mobilization, differences in root growth at low Mn supply or to differences in Mn uptake kinetics. A pot experiment was set up with a Mn deficient soil (pH 7.4, DTPA-Mn 3.8 mg/kg soil) at two Mn levels (unfertilized and fertilized with 1 mmol Mn/kg soil) using two bread (PBW-343 and PBW-502) and two durum (PDW-274 and PDW-233) cultivars. Two harvests were performed, one at 16 and another at 23 days after sowing. Plant measurements were shoot dry weight (SDW), shoot Mn concentration, root length and root radius. Soil measurements were Mn concentration in soil solution and DTPA extractable Mn. SDW of durum wheat was only 30 to 40 % of that of bread wheat and shoot Mn concentration was 7 and 11 mg/kg respectively, confirming that durum wheat is less Mn efficient. This was not because of a smaller root system since the root-shoot ratio (cm root per mg SDW) was even somewhat higher, i.e. 19 to 21 as compared to 15 to 17 for bread wheat. The lower Mn efficiency of durum wheat was because of a smaller Mn influx (mol/(cm^2 root surface area • s)), which was only 20 to 25% of that of bread wheat. Manganese concentration in soil solution was 37 nM in the unplanted unfertilized soil. It was reduced to 29 nM under bread and to 32 nM under durum wheat. The higher Mn influx of bread wheat was apparently not because of a Mn mobilisation. The calculated Mn influx for cv. PBW-343 (only cv. for which uptake kinetic parameters were available) based on mass flow, diffusion and Michaelis-Menten uptake kinetics came close to the measured values. Furthermore, Mn concentration in soil solution at the root surface was reduced to only 60% of that of the bulk soil which is indicative that differences in uptake kinetics among cultivars would equally affect the Mn influx from soil. Therefore uptake kinetics may be a major factor determining Mn efficiency of plants.

P-483 **Isothermal DNA amplification renders identification of a broad spectrum of bacteria and fungi in *Eleutherococcus* spec. plant tissue cultures**

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Although originating from surface sterilized leaf tissue, *in vitro* cultures of *Eleutherococcus sieboldianus* were found to be associated with several microorganisms within the rhizosphere and inside root hair cells. For comparison, tissue cultures of *E. gracilistylus* and *E. senticosus* were included in our studies. A methodology was established for analysing 16 S rDNA of cultivated and non-cultivated bacteria, and to gain internal transcribed spacer regions (ITS) of fungal ribosomal DNA from different tissue types of E. spec in vitro cultures. Amplification, cloning and sequencing of prokaryotic 16 S rDNA resulted in the identification of various genera within Firmicutes and gamma-proteobacteria. In addition, a similar procedure carried out with the eukaryotic ITS regions and 18 S rDNA helped to identify a broad spectrum of fungal species. To exclude the possibility of accidental contamination, the experiments were repeated with new *in vitro* cultures of *E. sieboldianus* in a different laboratory and under microscopical control mediated by a 3D micromanipulator. Again, both bacterial and fungal species were identified which were taxonomically related to - if not identical with – those sequences initially obtained.

P-947 Root exudation of two genotypes of common bean (*Phaseolus vulgaris* L.) as affected by *Rhizobium* inoculation and P nutrition

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The role of root exudation in rhizosphere interactions is hard to overestimate. Root exudates contain nutrient sources and signaling molecules to interact with the microbial population and play an important role in the mobilization of nutrients. A complex interplay of external and internal factors affect the composition of root exudates. In this study root exudation of organic acids was compared of two bean genotypes (BAT477 and DOR364) uninoculated or inoculated with *Rhizobium etli* CNPAF512 and at two levels of P supply: 1µM and 100µM P. The plants were grown in an hydroponic culture system in the greenhouse and organic acid exudation was measured at 7, 14 and 21 days after inoculation using high-performance liquid chromatography (HPLC). It was observed that *Rhizobium* inoculation provoked a differential response in organic acid exudation among the two genotypes. *Rhizobium* inoculation increased organic acid exudation (per gram of root dry weight) significantly of BAT477 plants, while DOR364 plants were not or much less affected by *Rhizobium* inoculation. Interestingly, the differential response to *Rhizobium* inoculation in root exudation was most pronounced under P deficient conditions and in particular for the organic acids citric acid, oxalic acid and tartaric acid. These organic acids are thought to play a role in P mobilization. Consistently with these data it was observed that *Rhizobium* inoculation enhanced significantly the capacity of BAT477 plants, and not of DOR364 plants, to solubilize and to use rock phosphate as a P source.

P-1029 Fine root dynamics in Fagus *sylvatica*: A comparison with *Picea abies* and the influence of elevated ozone concentrations

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Year by year, perennial plants experience the seasonal changes in soil water content and soil temperature. As a result, the potential benefits a root could acquire also fluctuate seasonally. In the same time, fine roots are replaced continuously (i.e. turnover) thereby causing high construction costs below ground. The timing and degree of fine root dynamics therefore is an important component in plant functioning.

The high spatial plasticity in fine root systems is well known: But what is the relationship between fine root turnover and the temporal variations in the soil environment: Do perennial plants adapt similarly to the seasonal changes in soil water and temperature?

Ozone is an air pollutant with increasing importance and it causes a severe curtailment in C-supply to the fine root system.: Do increasing ozone loads affect the magnitude or timing of fine root turnover?

In the present study, fine root dynamics of mature *Fagus sylvatica* (European beech) were observed using minirhizotrons and comparisons were drawn to *Picea abies* (Norway spruce) and a plot with elevated ozone concentrations. The study revealed different temporal patterns of soil exploitation and turnover between the plots. *F. sylvatica* formed short lived fine roots that were invested preferentially in favourable seasons. Fine root losses increased synchronously, indicating accelerated turnover during favourable conditions. *P. abies* contrasted to this as there was no significant relationship between root growth and changes in the soil environment. Rather root growth peaked during severe summer drought and decreasing soil temperature. Also, fine root losses were fairly constant throughout the year. Differences in fine root longevity are discussed as the primal reason for the different temporal patterns.

Increased ozone concentrations did not affect the magnitude in fine root turnover rate in *F. sylvatica* but the temporal patterns. Accordingly, the significant relationship between fine root growth and soil parameters vanished for root growth but not for mortality. Main root growth occurred with a pronounced delay and thus during summer drought indicating decreased efficiency for the whole fine root system.

Collectively, the data suggest a species-inherent phenology of fine root turnover which, however, can be altered by increasing ozone loads.

P-1075 Use efficiency of natural iron complexes by tomato plants

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Soluble Fe sources available for plants are mainly represented by a cocktail of complexes between the micronutrient and organic ligands; these molecules include organic acids and phytosiderophores released by the roots, microbial siderophores as well as fractions of humified organic matter. While the molecular mechanisms of Fe-acquisition by plants have been thoroughly investigated, information on the relative contribution to this process of the natural chelates that are likely to be present in the rhizosphere is still scarce. These aspects are particularly important for plants which rely on a Fe^{III}-chelate reduction-based mechanism to take up the micronutrient. In this work, we studied the capacity of Fe-deficient tomato plants to use different Fe-sources, such as Fe-citrate, Fe-phytosiderophores (PS), Fe complexed to a water extractable humic substances fraction (Fe-WEHS).

All the three ligands were able to solubilize Fe from barely soluble $^{59}Fe(OH)_3$. Short-time (1h) uptake experiments showed that plants could utilize the different ^{59}Fe-complexes (provide separately at 1 µM Fe, pH 7.5) at the same level. On the other hand, prolonging the uptake up to 24h Fe accumulation was 4-5 times higher supplying Fe as Fe-WEHS than as Fe-PS or Fe-citrate. Similar results were obtained adding the three Fe-complexes to the assay solution at the same time. The higher use efficiency of Fe-WEHS was dependent on a reductive mechanism and appeared to be due neither to a higher extraplasmatic loading nor to a higher resistance of WEHS to microbial degradation.

Supply of the different Fe-complexes to deficient plants induced a transient up-regulation of Fe transporter genes, LeIRT1 & 2, while a down-regulation of the FER gene, a transcription factor involved in the Fe-deficiency responses, was observed. In Fe-WEHS fed plants a much higher up-regulation of LeIRT1 & 2 was evident 1h after the starting of the treatment; furthermore, in these plants a much slower decrease in FER transcript abundance was recorded.

Data of the present work demonstrate that Fe from Fe-WEHS could be efficiently acquired in a mixture of natural Fe-complexes possibly occurring in the rhizosphere. The molecular approach suggests the involvement in this phenomenon of an altered expression of Fe uptake related genes.

P-894 Influence of plant species identity on soil microbial communities and soil activities

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Few studies have shown that plant species identity influence the microbial diversity in the rhizosphere suggesting that the quantity and the quality of plant tissues and exudates released are species dependant. In this study we tested whether annual and perennial herbaceous species have contrasted effects on microbial diversity and activities and whether these differences are associated to root traits related to morphology and chemical composition.

Seventeen Mediterranean annual and perennial species were grown in monocultures in a common garden experiment. After three years of growth, soil cores were taken in each monoculture during the growing season. Root traits were measured and the effect of species on soil microbial diversity and activities was assessed using Biolog EcoPlate, assays of soil potential respiration (SIR), nitrifying (NEA) and denitrifying (DEA) enzyme activities.

Annuals exhibited less biomass per unit of soil volume than perennials; their roots had a high specific root length (SRL) and nitrogen concentration (RNC) but a low tissue density (RTD) and diameter as compared to perennials. The number of substrates oxidized and the catabolic activity were lower in annual monocultures than in perennial ones, while SIR, NEA and DEA were insensitive to species identity and plant life history. Interspecific differences in the number of substrates used and in catabolic activity were negatively correlated with the specific root length and positively correlated with the root tissue density. These results suggest that perennial roots which have high tissue density released a larger range of organic compounds via rhizodeposition.

P-689 Salt sensitivity in *Setaria verticillata*

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The responses of growth, development and nutrition to salt stress are examined in short cycle *Setaria verticillata*.For these, two experiments are set up. The first intended to study the effects of various concentrations of NaCl on the parameters of growth and nutrition during the vegetative phase. Fifteen-day-old planlets were grown on commercial peat irrigated with pure NaCl solutions (0 to 300 mM), with 16 h of photoperiod (100 µmol m^{-2} s^{-1} PAR) and temperature comprised between 25°C (day) and 19°C (night). After 3 weeks of culture, the plants were collected and divided into roots and shoots. The fresh and dry matter masses of the various bodies are given. The second experiment was intended to study the effect of different concentrations of NaCl on crop plants until maturity. The culture was led under the same conditions as the preceding one, but for 3 months until the end of the cycle (production and maturation of the seeds). At harvest, the plants were separated in roots, shoots and grains. During all the development cycle, *Setaria vertillata* was very sensitive to salinity. The concentration of NaCl which caused an important reduction of dry weight production was about 75 mM. Dry matter was more diminished in roots than shoots. This action does not seem related to a difficulty in water absorption. Indeed, the reduction of the production of growth observed between 0 and 100 mM NaCl seems associated with a higher accumulation of Na in shoots and with a deficient K supply of organs. Sodium appears well sequestred inside the vacuole, which makes it possible the plants to be osmotically adjusted to the medium. Although the plant remains selective in favour of K, whatever the richness of the medium in Na. The K/(K+Na) ratio decreases with salinity, explaining the strong sensitivity of the plant to salt stress. During the reproductive phase, salt affects the components of the output and induces variability on the level of the production of biomass as significant as that noted during the phase of vegetative growth. Lastly, capacity of germination of seeds was strongly dependent on the salt concentration of the culture medium of the mother plants, a total loss of viability appearing at collected on crop plants in the presence of NaCl 300 mM.

P-1142 Strawberry growth and roots characteristics at rhizosphere conditions modified by superabsorbent

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Necessity of frugal and efficient water use in agriculture involves new ways of its rational management. Supersorbents allows to retain a part of plant available water within the rhizosphere and diminish its use. It is foreseen however that application of supersorbents as combined with lowered water amount may modify the root system. The appropriate measurings of plants were undertaken in order to evaluate an effect of supersorbent and water limitation on strawberries with a special attention on their roots. An experiment was carried out under greenhouse conditions. Two cultivars of strawberries i.e. Senga Sengana and Kent were planted out as frigo seedlings into 1 dm^3 pots filled with 70/30 sphagnum peat/sand mixture. There were two doses: 1 kg and 4 $kg.m^{-3}$ of supersorbent Stockosorb Agro (SsbA) added into the peat/sand mixture. The substrate with none supersorbent added served as control. Watering of plants was diversified for three levels: optimal and limited by 15% and 30%. Roots dimensions were measured by Hewlett-Packard root-scanner operated by software Delta T – Scan. Influence of supersorbent doses as combined with different amounts of supplied water on plants growth, yield of fruits as well as development of strawberry roots dimensions were observed.

P-1214 Role of root-mediated interactions in phytotoxic interference of *Ageratum conyzoides*

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Ageratum conyzoides (Billy goat weed; Family Asteraceae) is an annual invasive weed native to Tropical America. It has now invaded several tropical and subtropical parts of the world including China, Japan, and India and has become a serious weed of arable lands, pastures and grasslands. The present work investigated the role of root-mediated allelopathic interference of *A. conyzoides* against rice and mung bean. Early growth (in terms of radicle and shoot/coleoptile elongation) of test crops reduced significantly in the rhizosphere of *A. conyzoides*. It indicated the presence of inhibitory metabolites that possibly release from roots of the weed. The incorporation of weed root residues into the soil medium severely reduced the seedling growth (length and dry weight) of test plants. However, the addition of activated charcoal resulted in amelioration of growth retardatory effect of residues incorporated into the soil. Further, the amendment of root residues into the soil did not reduce the amount of available nutrients; rather there was enrichment. It indicated a definitive role of the allelopathy in determining root-mediated interactions of *A. conyzoides*. Aqueous extracts prepared from the root residues reduced the germination, radicle growth and seedling growth of test plants. Aqueous extracts, rhizosphere soil and residue-amended soil were rich in phenolics, the putative phytotoxins involved in allelopathy. These were identified as ferulic acid, gallic acid, p-coumaric acid, p-hydroxybenzoic acid and anisic acid. The study concluded that roots of *A. conyzoides* exude / release water-soluble phenolics as putative allelochemicals that play a significant role in determining interactions in the rhizosphere soil.

P-492 Organic nitrogen uptake and metabolite profiling of sorghum seedlings grown in sterile culture

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An ability of plants to take up organic nitrogen (N) such as amino acids, peptides and proteins would give advantages in the competition for soil N acquisition and in the saving of the energy for N metabolism, compared to the uptake of inorganic N such as ammonium and nitrate. In this study the uptake capability of different forms of organic N and the changes in the metabolite patterns were investigated in sorghum (*Sorghum bicolor*) grown under sterile conditions to prevent microbial mineralization of the organic *N. Sorghum* seedlings were aseptically grown for 84 d without N (Control) or with 0.4 mmol N pot^{-1} as ammonium nitrate (IN), glycine (GLY), glutathione (GSH), or bovine serum albumin (BSA). *Sorghum* exhibited a wide range of abilities to acquire N from different N sources without microbial mineralization. The N uptake of sorghum was highest in the IN treatment, followed by the GLY, GSH, BSA and Control treatments, indicating that sorghum preferentially absorbed less complex forms of N. Profiling of primary metabolites of sorghum roots was performed using gas chromatography-mass spectrometry. Principal component analyses of the hydrophilic metabolites could separate the Control and BSA treatments from the other treatments. Levels of several metabolites were considerably increased in the latter treatments, such as aspargine in the IN and GSH treatments, glycine and serine in the GLY treatment and glutamine in the GSH treatment. Changes in the metabolites are discussed in relation to the metabolic pathways of plant N assimilation.